Northern Colorado Plateau Vital Signs Network and Prototype Cluster
Plan for Natural Resources Monitoring
Phase I Report

National Park Service
U.S. Department of the Interior

Arches National Park
Black Canyon of the Gunnison National Park
Bryce Canyon National Park
Canyonlands National Park
Capitol Reef National Park
Cedar Breaks National Monument
Colorado National Monument
Curecanti National Recreation Area
Dinosaur National Monument
Fossil Butte National Monument
Golden Spike National Historic Site
Hovenweep National Monument
Natural Bridges National Monument
Pipe Spring National Monument
Timpanogos Cave National Monument
Zion National Park

October 1, 2002
In Two Volumes

(Cover & Background) *Heterotheca villosa* (hairy goldenaster) – a widespread perennial distributed throughout western North America. This species is characteristic of a variety of important habitats in the Northern Colorado Plateau Network. Photo by Neal Herbert.

NORTHERN COLORADO PLATEAU
VITAL SIGNS NETWORK AND PROTOTYPE CLUSTER
PLAN FOR NATURAL RESOURCES MONITORING

PHASE I REPORT
October 1, 2002

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VOLUME 2

Summary of Natural Resource Inventory and Monitoring

PART I - Overview of Natural Resource and Stressor Monitoring and Monitoring Needs in Northern Colorado Plateau Network Parks

PART II - Status Summary of Natural Resource and Stressor Monitoring in Northern Colorado Plateau Network Parks

PART III - Summary of Natural Resource Inventory and Monitoring within Northern Colorado Plateau Network Parks

PART IV - Summary of External Monitoring Programs and Projects of Interest to the Developing Northern Colorado Plateau Network Inventory & Monitoring Program

PART V - Summary of Geospatial Data Catalogued by the Northern Colorado Plateau Network

PART VI - Sample Maps of Active Monitoring Locations in Northern Colorado Plateau Network Parks

VOLUME 2, PART I

Overview of Natural Resource and Stressor Monitoring and Monitoring Needs in Northern Colorado Plateau Network Parks

This table provides an overview of the status of resource monitoring and monitoring needs in network parks. For each resource or stressor category and park a ‘yes,' ‘past’ or ‘need’ is indicated. A ‘yes’ indicates that monitoring is presently occurring in a park, where ‘past’ indicates that monitoring has previously occurred for a given resource or stressor. A ‘need’ indicates that park resource staff feel that monitoring is needed. Occasionally a ‘need’ may also be associated with another completed field, this indicates that additional monitoring is needed. A blank field indicates that monitoring has not been conducted, nor is it identified as needed by the park.

Overview of Natural Resource and Stressor Monitoring and Monitoring Needs in Northern Colorado Plateau Network Parks

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	ARCH	BLCA	BRCA	CANY	CARE	CEBR	COLM	CURE	DINO	FOBU	GOSP	HOVE	NABR	PISP	TICA	ZION
POPULATIONS/SPECIES																
AQUATIC																
native fish		NEED		PAST	NEED			PAST	YES							
TES fish species - general	YES	NEED		YES				NEED	YES							YES
Aquatic Invertebrates	YES	YES	PAST	YES	YES			YES	PAST			YES	YES	NEED		NEED
		NEED	NEED		NEED											
Amphibians -general	NEED	NEED	NEED	NEED	NEED		NEED	NEED	NEED	NEED		NEED	NEED	NEED		NEED
Periphyton		PAST						PAST								
Phytoplankton								PAST								
Zooplankton								PAST								
TERRESTRIAL																
Birds																
neotropical migrants-general	YES	YES	PAST	YES	YES	NEED	PAST	YES	YES			NEED	YES	NEED		YES
									NEED							PAST
Raptors-general	YES		PAST	YES			PAST			NEED		NEED	YES			
Raptors-nesting										PAST						
TES Bird Species - general	YES			PAST			PAST					NEED	YES			
Southwestern willow flycatcher	PAST		YES	PAST								NEED	NEED			YES
sage grouse			PAST					YES	NEED	YES		NEED				
										NEED						
peregrine falcon	YES	YES	YES	PAST	YES	PAST	YES	YES	YES	PAST			YES			YES
Mexican spotted owl		NEED	PAST	YES	YES	NEED		NEED?	YES			NEED	NEED			YES
																NEED
bald eagle	PAST	YES		PAST				YES	YES							
golden eagle	YES	YES		YES			NEED	YES	NEED			NEED	NEED			
Northern goshawk			PAST		NEED	PAST							NEED			PAST
																NEED
Western burrowing owl	YES			NEED			NEED		NEED							

Overview of Natural Resource and Stressor Monitoring and Monitoring Needs in Northern Colorado Plateau Network Parks

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	ARCH	BLCA	BRCA	CANY	CARE	CEBR	COLM	CURE	DINO	FOBU	GOSP	HOVE	NABR	PISP	TICA	ZION
	NEED															
Waterfowl								PAST								
Great Blue Heron								YES								
Mammals																
Large mammals -general	PAST		NEED	PAST	NEED	NEED	NEED									
Small mammals -general	PAST		NEED	PAST	NEED	NEED	NEED	PAST	PAST			NEED	PAST	NEED		PAST
																NEED
bison					YES											
ungulates			PAST	PAST		NEED			YES	YES						YES
									NEED	NEED						
predators	YES	NEED		YES	NEED	NEED	NEED		NEED	NEED		NEED	NEED			
bighorn sheep	YES	NEED		YES	YES		PAST	YES	YES							PAST
																NEED
carnivores																NEED
mountain lion																NEED
gray fox and ringtail																PAST
black-footed ferret	NEED															
Northern river otter	PAST	NEED		PAST				NEED	NEED							
Mule Deer					PAST											PAST
																NEED
Elk																YES
Utah prairie dog			YES		PAST											
prairie dog	NEED						NEED	NEED								
beaver				PAST					PAST	YES						
										NEED						
bats	NEED	NEED	YES	NEED	NEED	NEED	NEED	NEED	NEED			NEED	NEED	NEED	NEED	YES
																NEED

Overview of Natural Resource and Stressor Monitoring and Monitoring Needs in Northern Colorado Plateau Network Parks

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	ARCH	BLCA	BRCA	CANY	CARE	CEBR	COLM	CURE	DINO	FOBU	GOSP	HOVE	NABR	PISP	TICA	ZION
Plants																
T & E Species																
Astragalus erectimus var. *ampullarioides* (Shivwits Milkvetch)																NEED
Astragalus harrisonii (Harrison's milk-vetch)					YES											
Cycladenia jonesii (Jones cycladenia_					NEED											
Cymopterus beckii (Pinnate spring-parsley)				NEED	YES											
Erigeron maguirei (Maguire's daisy)					YES											
Gilia caespitosa (Rabbit Valley gilia)					YES											
Pediocactus winkleri (Winkler cactus)					YES											
Salix arizonica (Arizona willow)						NEED										
Schoencrambe barnebyi (Barneby's reed mustard)					YES											
Sclerocactus wrightiae (Wright fishhook cactus)					YES											
Spiranthes diluvialis (Ute ladies' tresses orchid)					NEED				YES							
Townsendia aprica (Last Chance townsendia)					NEED											
Sensitive Plant Species																
Sensitive plants-general		NEED	YES	NEED	NEED		NEED	NEED	YES						NEED	YES
Allium passeyi (Passey Onion)											NEED					
Aquilegia fosteri																NEED
Asplenium adiantum-nigrum																NEED
Astragalus lentiginosus var. *salinus* (Sodaville Milkvetch)										NEED						
Carex haysii																NEED
Carex speculifera (Navajo Sedge)				NEED									NEED			

Overview of Natural Resource and Stressor Monitoring and Monitoring Needs in Northern Colorado Plateau Network Parks

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	ARCH	BLCA	BRCA	CANY	CARE	CEBR	COLM	CURE	DINO	FOBU	GOSP	HOVE	NABR	PISP	TICA	ZION
Ceanothus martinii (Martin Ceanothus)										NEED						
Cuscuta occidentalis (Western Dodder)										NEED						
Draba asprella var. zionensis																NEED
Epilobium nevadense																NEED
Erigeron kachinensis (Kachina Daisy)													YES			
Erigeron canaani																NEED
Erigeron religiosus																NEED
Erigeron sionis																NEED
Eriogonum jamesii var. rupicola																NEED
Eriogonum thompsoniae var. albiflorum																NEED
Eriogonum thompsoniae var. matthewsiae																NEED
Eriogonum zionis var. zionis																NEED
Gilia tenuis (Mussentuchit gilia)					NEED											
Habenaria zothecina (Alcove Bog-Orchid)	NEED			NEED	NEED				NEED				NEED			
Heterotheca jonesii																NEED
Jamesia americana var. *macrocalyx* (Wasatch Jamesia)															NEED	
Jamesia americana var. zionis																NEED
Lepidium integrifolium var. *integrifolium* (Entire-Leaved Peppergrass)										NEED						
Lomatium bicolor var. *bicolor* (Wasatch Biscuitroot)										NEED						
Lomatium latilobum (Canyonlands lomatium)	YES															
Lomatium triternatum var *anamalum* (Ternate Desert-Parsley)										NEED						
Lupinus latifolius ssp. leucanthus																NEED
Lygodesmia entrada (Entrada rushpink)	NEED			NEED												
Oreoxis trotteri (Trotter's oreoxis)	NEED			NEED												
Pediomelum pariense(Paria breadroot)			PAST													NEED

Overview of Natural Resource and Stressor Monitoring and Monitoring Needs in Northern Colorado Plateau Network Parks

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Resource or Stressor of Concern	ARCH	BLCA	BRCA	CANY	CARE	CEBR	COLM	CURE	DINO	FOBU	GOSP	HOVE	NABR	PISP	TICA	ZION
Penstemon humilis ssp. obtusifolius																NEED
Penstemon leonardii var. higginsii																NEED
Penstemon paysoniorum (Payson Beardtongue)										NEED						
Phacelia cephalotes																NEED
Phacelia rafaelensis																NEED
Physaria condensata (Tufted Twinpod)										NEED						
Sphaeralcea janeae (Jane's Globemallow)				PAST												
Sphaeromeria ruthiae																NEED
Viola charlestonensis																NEED
Zigadenus vaginatus (Alcove Death Camas)	PAST			NEED									NEED			
Other Plant Species of Concern																
Picea engelmanii, Engelmann spruce						NEED										
Pinus longaeva, Bristlecone pine					NEED	NEED										
Reptiles																
lizards	NEED		PAST	NEED	NEED		PAST					NEED	NEED			PAST
Desert tortoise																YES
General reptiles	NEED			NEED	NEED				NEED			NEED	PAST	NEED		NEED
Invertebrates																
Terrestrial Invertebrates	NEED			NEED	NEED	NEED	PAST		NEED			NEED	NEED			NEED
ECOSYSTEMS																
Riparian-Wetland and Aquatic Ecosystems																
Aquatic Ecosystems-general	YES	YES	NEED	YES	NEED			YES	NEED	PAST		YES	YES			YES

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Resource or Stressor of Concern	ARCH	BLCA	BRCA	CANY	CARE	CEBR	COLM	CURE	DINO	FOBU	GOSP	HOVE	NABR	PISP	TICA	ZION
																NEED
wetlands	NEED	NEED	NEED	NEED	NEED			PAST	NEED	NEED		NEED	NEED			NEED
								NEED								
riparian zone	YES	NEED		YES	NEED		NEED	PAST	YES	NEED		NEED	YES			NEED
								NEED								
seeps, springs, & hanging gardens	NEED	NEED	PAST	NEED	NEED	YES	NEED	NEED	NEED	NEED		NEED	YES	YES		YES
			NEED											PAST		NEED
Upland Ecosystems																
Vegetation communities-general	YES	YES	PAST	YES				YES			NEED	YES	YES	NEED		YES
forest			PAST				NEED			NEED						
grasslands	YES			YES	NEED		NEED		PAST	NEED	NEED	YES				
shrublands	YES			YES	NEED				PAST	NEED	NEED	YES	YES			
relict areas	NEED	NEED	PAST	NEED	NEED		PAST						PAST			NEED
													NEED			
breaks vegetation			PAST													
Cave Ecosystems																
cave environmental conditions															YES	
Water Quanity															YES	
Water Quality															NEED	
Biological Communities															NEED ?	
Cave Formations															YES	
															NEED	
Cave soundscape															NEED	
ECOLOGICAL RESOURCES OR CONDITIONS																
air quality conditions	PAST	YES	YES	PAST	YES	NEED	PAST		NEED		NEED ?	YES			PAST	YES
															NEED	PAST

Overview of Natural Resource and Stressor Monitoring and Monitoring Needs in Northern Colorado Plateau Network Parks

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Resource or Stressor of Concern	ARCH	BLCA	BRCA	CANY	CARE	CEBR	COLM	CURE	DINO	FOBU	GOSP	HOVE	NABR	PISP	TICA	ZION
climatic conditions	YES	YES		YES	NEED		PAST	YES	YES			YES	YES		YES	YES
				PAST												
general soil and soil crust	YES	NEED	YES	YES	NEED	NEED	PAST	NEED	NEED	NEED		YES	YES			NEED
							NEED									
water resources (very broad category; only resources needing monitoring are identified)	YES	NEED	PAST	YES	NEED	NEED		NEED	PAST	NEED		YES	YES	NEED	NEED	NEED
water quality	YES	YES	NEED	YES	PAST		NEED	YES	PAST	NEED	NEED ?	YES	YES		PAST	YES
				NEED	NEED				NEED							PAST
water quantity	YES	YES	NEED	YES	PAST		NEED	YES	YES	NEED		NEED	NEED	YES	YES	YES
					NEED											PAST
FEATURES AND OBJECTS																
paleontological resources	NEED		NEED	NEED	NEED		NEED	NEED	NEED	NEED		NEED	NEED			NEED
geologic objects - loss			NEED	NEED	NEED			NEED								
natural objects (antlers, rocks, etc.)					NEED				YES							
paleotological resources - biostratigraphy			YES													
SENSORY RESOURCES																
night sky	YES		NEED	YES	NEED		NEED		NEED			YES	YES			NEED
soundscape	YES	NEED	YES	NEED	NEED	NEED	PAST		PAST	PAST		NEED	NEED		NEED	NEED
PARK VISITORS																
airborne recreation	NEED		NEED	NEED	NEED											
aquatic recreation	NEED	NEED						NEED					NEED			
terrestrial recreation	NEED	NEED	NEED	NEED	NEED			NEED				NEED	NEED			NEED
collection and poaching					NEED											

Overview of Natural Resource and Stressor Monitoring and Monitoring Needs in Northern Colorado Plateau Network Parks

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Resource or Stressor of Concern	ARCH	BLCA	BRCA	CANY	CARE	CEBR	COLM	CURE	DINO	FOBU	GOSP	HOVE	NABR	PISP	TICA	ZION
fishing		NEED						NEED								
other visitor actions			PAST												NEED	
EXOTIC AND INVASIVE PLANTS AND ANIMALS																
Invasive Plant Species																
Invasive Plants - General	NEED	NEED	**YES**	NEED	NEED		NEED	NEED	NEED		NEED	NEED	NEED	NEED	**YES**	NEED
Ailanthus altissima (Tree-of-heaven)					NEED											
Alopecurus arundinaceus										NEED						
Bromus spp. (as a group)	NEED			NEED	NEED	NEED				NEED	NEED	NEED	NEED			NEED
Cardaria draba (White top)									NEED						NEED	NEED
Carduus nutans (musk thistle)										PAST						
Centaurea diffusa (Diffuse Knapweed)	NEED			NEED												
Centurea maculosa (spotted knapweed)										PAST					NEED	
Centaurea repens (Russian knapweed)	NEED			NEED								NEED	NEED			
Centaurea solstitialis (Yellow starthistle)																
Centaurea virgata (Squarose Knapweed)																
Centaurea species (knapweeds)				NEED												
Circium canadensis (Canada thistle)										PAST						
Cyglossum officinale (houndstongue)										PAST					NEED	
Eleagnus angustifolia (Russian Olive)	NEED			NEED	NEED				NEED			NEED	NEED			
Halogeton glomeratus (Halogeton)					NEED											
Lepidium latifolium (Perennial Pepperweed)				NEED					NEED						NEED	
Lythrum salicaria (Purple Loosestrife)	NEED			NEED												
Melilotus officinalis (yellow sweetclover)	NEED			NEED						PAST		NEED	NEED		NEED	NEED
Sonchus uliginosus (perennial sow-thistle)									NEED	PAST						
Tamarix ramossima (tamarisk)	NEED		PAST	PAST	NEED		**YES**		NEED			NEED	NEED			NEED
Verbascum thapsus (Woolly mullein)										PAST					NEED	PAST
Exotic plant/Native plant interactions	NEED	NEED	PAST				NEED	NEED	PAST	NEED	NEED				PAST	NEED

Overview of Natural Resource and Stressor Monitoring and Monitoring Needs in Northern Colorado Plateau Network Parks

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Resource or Stressor of Concern	ARCH	BLCA	BRCA	CANY	CARE	CEBR	COLM	CURE	DINO	FOBU	GOSP	HOVE	NABR	PISP	TICA	ZION
Invasive Animal Species																
exotic/introduced fish species	NEED	NEED		PAST	NEED	NEED		NEED	YES							NEED
brown-headed cowbird (exotic)	NEED		PAST	NEED								NEED	NEED			
exotic animal introduction															NEED	
HERBIVORY AND TRAMPLING BY LARGE MAMMALS																
Native Plants - Livestock Grazing		NEED	NEED		NEED			NEED	YES							NEED
Livestock					YES						NEED					NEED
Wildlife			PAST							NEED						
NPS DEVELOPMENT AND INFRASTRUCTURE																
facilities																
maintenance activities			NEED													
roads		NEED						NEED								
trail construction	NEED			NEED									NEED			
utility corridors								NEED								
other NPS development actions															NEED	
NPS MANAGEMENT ACTIONS																
fauna reintroductions			NEED													
vegetation rehabilitation	NEED	NEED	NEED	NEED				NEED		NEED	NEED	NEED	NEED	NEED		NEED
weed control	NEED	NEED	YES	NEED	NEED					NEED	NEED	NEED	NEED			NEED
elimination of grazing	NEED	NEED		YES	NEED					NEED						NEED
fire suppression		NEED						NEED		NEED						NEED
prescribed fire		NEED	YES					NEED	YES		YES					YES

Overview of Natural Resource and Stressor Monitoring and Monitoring Needs in Northern Colorado Plateau Network Parks

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	ARCH	BLCA	BRCA	CANY	CARE	CEBR	COLM	CURE	DINO	FOBU	GOSP	HOVE	NABR	PISP	TICA	ZION
agriculture																
other resource management actions															NEED	
reservoir operations		NEED	NEED					NEED								
flood control-stream channelization			NEED													NEED
ADJACENT LAND-USE ACTIVITIES																
dam operation		NEED						NEED	NEED							
agricultural water diversion		NEED						NEED								YES
agricultural chemical application		NEED			NEED			NEED								
soil chemistry/contamination		NEED				NEED		NEED		NEED						
agriculture - conversion to cropland		NEED						NEED								
animal control/hunting																
industrial pollution		NEED						NEED			NEED					
plants sensitive to air pollution			PAST				NEED									NEED
housing development		NEED						NEED			NEED					
forestry practices		NEED	NEED					NEED								
roads/utilities																
air traffic	NEED		NEED													
NATURAL DISTURBANCES																
natural disturbance, general												NEED	NEED			
fire							PAST		YES		NEED					
							NEED									
regeneration after burns	YES	NEED		YES				NEED	YES		YES	NEED				YES
flood									YES							YES
drought																

Overview of Natural Resource and Stressor Monitoring and Monitoring Needs in Northern Colorado Plateau Network Parks

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Resource or Stressor of Concern	ARCH	BLCA	BRCA	CANY	CARE	CEBR	COLM	CURE	DINO	FOBU	GOSP	HOVE	NABR	PISP	TICA	ZION
insects/pathogens			YES						PAST	NEED						
land slide																YES
MISCELLANEOUS																
climate change		NEED														
native plant communities below fruita water line (need better clarification)							PAST									
erosion/altered sedimentation (need better clarification)	NEED	NEED	NEED	NEED	NEED			NEED	NEED	PAST		NEED	NEED			

VOLUME 2, PART II

Status Summary of Natural Resource and Stressor Monitoring in Northern Colorado Plateau Network Parks

The following table takes the park overview information from Part I and adds additional summary information on the status of monitoring projects and monitoring needs. Summary information indicate total length of monitoring study; years of record; investigators; number of study locations in park, existing and potential cooperators and comments. Separate tables have been prepared for each park within the network. These tables provide a brief overview of monitoring information presented in Part III of this volume. This information will continue to be updated during Phase II of this project.

PART II Index **Page**

Arches NP (ARCH)	II – 1
Black Canyon of the Gunnison NP (BLCA)	II – 13
Bryce Canyon NP (BRCA)	II – 19
Canyonlands NP (CANY)	II – 29
Capitol Reef NP (CARE)	II – 39
Cedar Breaks NM (CEBR)	II – 47
Colorado NM (COLM)	II – 53
Curecanti NRA (CURE)	II – 59
Dinosaur NM (DINO)	II – 67
Fossil Butte NM (FOBU)	II – 77
Golden Spike NHP (GOSP)	II – 85
Hovenweep NM (HOVE)	II – 89
Natural Bridges NM (NABR)	II – 95
Pipe Spring NM (PISP)	II – 103
Timpanogos Cave NM (TICA)	II - 109
Zion NP (ZION)	II - 117

Arches National Park (ARCH) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	ARCH	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
POPULATIONS/SPECIES									
AQUATIC									
TES fish species - general	**YES**							Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin	Utah DWR, USFWS, and Colorado State University monitoring on Colorado River along park boundary
Aquatic Invertebrates	**YES**	5	1997-present	Charles Schelz, park biologist	5	yes		BLM Moab District aquatic invertebrate monitoring	Associated with SEUG water quality monitoring program
	YES	10	1993-present	Charles Schelz, park biologist	6	yes	UTAH DEQ Forest Service BLM	Utah State "Bug" Lab, Mark Vinson	# of sites has changed over past.
Amphibians -general	NEED							USGS ARMI program?	Program in nearby Canyonlands National Park
TERRESTRIAL									
Birds									
neotropical migrants-general	**YES**	10	1993-present	Sonya Daw (park biotech)	3	yes			Variable circular plot point counts in riparian habitats.
	YES	20	1983-present	Gary Salamacha (park ranger)	1		Cornell Lab of Ornithology		Breeding bird census plot.
	YES	14	1989-present	Gary Salamacha	50	no	USGS Patuxent Wildlife Research Center		Breeding Bird Survey (BBS) along park road.

Arches National Park (ARCH) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	ARCH	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Raptors-general	YES	20	1983-present	Gary Salamacha, William Sloan (park biotech) and others	not fixed	partial			Monitoring 8 taxa including 3 TES species; multiple investigators, monitoring techniques and objectives.
TES Bird Species - general	YES	20	1983-present	Gary Salamacha, William Sloan (park biotech) and others	not fixed	partial			Monitoring 8 taxa including 3 TES species; multiple investigators, monitoring techniques and objectives.
southwestern willow flycatcher	PAST	3	1999-2001	Matthew Johnson (NAU/USGS)		yes	Colorado Plateau Field Station (NPS, USGS & Northern Arizona University)		Study route along Colorado River boundary of park but no identified habitat patches within park.
peregrine falcon	YES	20	1983-present	Gary Salamacha, William Sloan, Damian Fagan, and others	not fixed	partial			
	PAST	3	1988-1991	William Sloan and others					Baseline surveys, monitoring of known eyries
bald eagle	PAST	6	1982-1987			no	National Wildlife Federation		Bald Eagle Midwinter Survey
golden eagle	YES	20	1983-present	Gary Salamacha, William Sloan and others	not fixed	partial			Monitoring 8 taxa including 3 TES species; multiple investigators, monitoring techniques and objectives.

Arches National Park (ARCH) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	ARCH	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
western burrowing owl	YES	20	1983-present	Gary Salamacha, William Sloan and others	not fixed	partial			Monitoring 8 taxa including 3 TES species; multiple investigators, monitoring techniques and objectives.
	NEED								
Mammals									
Large mammals -general	PAST								
Small mammals -general	PAST	7	1987-1993	Tim Graham (currently USGS ecologist)	3	no			Trapping webs (204 traps on 10 radiating lines) were sampled yearly.
predators	YES	1	1988	Kurt A. Johnson		no			Carnivore inventory compiled from 1975-1988 observations and 1988 scent survey stations. Recommendations for long-term monitoring.
bighorn sheep	YES	13	1990-present	William Sloan (park biotech)	not fixed	yes	Utah Division of Wildlife Resources		Ground surveys of radiocollared & other bighorn.
	YES	2 (with current methods)	1994, 1998	William Sloan (park biotech), Craig Hauke (park resource specialist)	not fixed	yes	USGS (Francis Singer and Michael Moses); Utah Division of Wildlife Resources		Aerial censuses associated with more frequent counts in CANY and with USGS development of a model interpreting population numbers from aerial counts.

Arches National Park (ARCH) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	ARCH	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
black-footed ferret	NEED							Colorado Division of Wildlife is monitoring ferrets reintroduced in NW Colorado in 11/2001.	
northern river otter	PAST	2	1988-1989	Nelson Boschen (Utah DWR)	on Colorado River along boundary	no	Utah Division of Wildlife Resources		Monitored pair of otters on Colorado River near park boundary in 1988; surveyed longer stretch of river in 1989.
prairie dog	NEED								
bats	NEED							Mammal survey with emphasis on bats, 1991. Michael Bogan	Bogan is project leader/ biologist with USGS and the University of New Mexico.
Plants									
T & E Species									
Habenaria zothecina (Alcove Bog-Orchid) sensitive	NEED							Survey of rare plant species in the Southeast Utah Group of national parks, 1993.	Included location data, habitat info, & population studies of H. zothecina in Arches. Ken Heil (San Juan College), Lisa Floyd-Hanna (Prescott College) & others.
Zigadenus vaginatus (Alcove Death Camas) sensistive	PAST	1	1984	Damian Fagan & Kim Tennyson	35+	UTM coordinates			Initial survey includes detailed maps of sites and population info.

Arches National Park (ARCH) Natural Resource and Stressor Monitoring Status Summary

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Resource or Stressor of Concern	ARCH	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
	NEED								
Sensitive Plant Species									
Lomatium latilobum (Canyonlands lomatium)	**YES**	14 (but minimal work some years)	1989-present	Lisa Floyd-Hanna (Prescott College) & others	several locations in 3 areas	yes	Prescott College and San Juan Community College		Permanent plots & finsurveys used for population studies. Fin surveys by park staff.
	YES	10	1993-present	Gary Salamacha (park resource manager), Karen McKinlay-Jones (park ranger)	10	yes	Lisa Floyd-Hanna, Prescott College		Monitoring paired populations near and farther from the popular Fiery Furnace trail for trampling impacts.
Lygodesmia entrada (Entrada rushpink)	NEED							Survey of rare plant species in the Southeast Utah Group of national parks, 1993.	Included some location data & habitat info for L. entrada in Arches. Ken Heil (San Juan College), Lisa Floyd-Hanna (Prescott College) & others.
Oreoxis trotteri (Trotter's oreoxis)	NEED								
Other Plant Species of Concern									
No Need									
Reptiles									
lizards	NEED								
Desert tortoise									
General reptiles	NEED								

Arches National Park (ARCH) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	ARCH	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Invertebrates									
Terrestrial Invertebrates	NEED							Butterfly inventory began in 2002, Clyde Gillette.	
ECOSYSTEMS									
Riparian-Wetland and Aquatic Ecosystems									
Aquatic Ecosystems-general	YES	5	1997-present	Charles Schelz, park biologist	5	yes		BLM Moab District aquatic invertebrate monitoring	Associated with SEUG water quality monitoring program
	YES	10	1993-present	Charles Schelz, park biologist	6	yes	UTAH DEQ Forest Service BLM	Utah State "Bug" Lab, Mark Vinson	# of sites has changed over past.
wetlands	NEED								
riparian zone	YES	4	1998-present	Charles Schelz, park biologist	5 transects	yes			Vegetation data, substrate data and stream profiles, measured every year or two.
	YES	10	1993-present	Sonya Daw (park biotech)	3	yes			Yearly late spring bird point counts in riparian habitats.
seeps, springs, & hanging gardens	NEED							Investigations of hanging gardens in Glen Canyon NRA.	John Spence (Glen Canyon park botanist).

Arches National Park (ARCH) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	ARCH	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Upland Ecosystems									
Vegetation communities-general	YES	20	1983-present	Charles Schelz, park biologist	13	yes			Modified Daubenmire transects, surveyed annually.
	YES	6	1996-present	Charles Schelz, park biologist	5	yes			Visitor impact, transects near trails. Same methods as above.
grasslands	YES	20	1983-present	Charles Schelz, park biologist	13	yes			Several transects in this program are in grasslands.
shrublands	YES	20	1983-present	Charles Schelz, park biologist	13	yes			Several transects in this program are in shrublands.
relict areas	NEED							Relict site descriptions for many Colorado Plateau parks, 1989-90, The Nature Conservancy.	Arches wasn't included in this study.
Cave Ecosystems									
No Need									
ECOLOGICAL RESOURCES OR CONDITIONS									
air quality conditions	PAST	6	1986-1992	Air Resources Division, NPS; park staff	1	yes	Colorado State University	Similar & expanded visibility monitoring continues in Canyonlands NP.	IMPROVE visibility data measured using aerosol sampler & camera.

Arches National Park (ARCH) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	ARCH	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
	PAST	5	1988-1992	Air Resources Division, NPS; park staff	1	yes		Ozone monitoring continues in Canyonlands NP.	Ground-level ozone measurements.
	PAST	7	1978-1985	Larry Reed (form-er park ranger)	1	no			Daily slide panorama from SW corner of park over nearby large tailings pile, monitoring visual air quality.
climatic conditions	YES	22	1990-present	park staff	1	yes	NOAA		Daily weather data from near visitor center.
	PAST	6	1987-1992	Air Resources Division, NPS; park staff	1	yes			Meterological station at Devil's Garden air quality site; measurements included solar radiation.
general soil and soil crust	YES	20	1983-present	Charles Schelz, park biologist	13	yes			Modified Daubenmire transects, surveyed annually.
	YES	6	1996-present	Charles Schelz, park biologist	5	yes			Visitor impact, transects near trails. Same methods as above.
water resources (very broad category; only resources needing monitoring are identified)	YES	10	1993-present	Charles Schelz, park biologist		yes	UTAH DEQ Forest Service BLM	Utah State "Bug" Lab, Mark Vinson	# of sites has changed over past.
water quality	YES	19	1983-present	Charles Schelz, park biologist	5	yes	Utah Division of Water Quality		Quarterly or monthly monitoring of springs, seeps and streams.

Arches National Park (ARCH) Natural Resource and Stressor Monitoring Status Summary

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Resource or Stressor of Concern	ARCH	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
	YES	10	1993-present	Charles Schelz, park biologist	6	yes	UTAH DEQ Forest Service BLM	Utah State "Bug" Lab, Mark Vinson	# of sites has changed over past.
water quantity	YES	2	2001-present	Jim Harte & Brad Gillies (NPS WRD), Mary Moran (park biotech)	3	yes	Utah Geological Survey		Monthly flow monitoring and hydrogeology study from four springs near western boundary of park.
	YES	10	1993-present	Charles Schelz, park biologist	6	yes	UTAH DEQ Forest Service BLM		# of sites has changed over past.
FEATURES AND OBJECTS									
paleontological resources	NEED								
SENSORY RESOURCES									
night sky	YES	new	2002-present	Charles Schelz, park biologist	1				Night sky light levels will be measured by a quarter-sky charged coupled device high-resolution camera.
soundscape	YES	new	2002-present	Skip Ambrose (Soundscapes Program Office, NPS)	2 permanent, 2 mobile	yes			Sound monitoring stations collect acoustic data for use in developing air tour/sound management plans.

Arches National Park (ARCH) Natural Resource and Stressor Monitoring Status Summary

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Resource or Stressor of Concern	ARCH	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
PARK VISITORS									
airborne recreation	NEED								
aquatic recreation	NEED								
terrestrial recreation	NEED								
EXOTIC AND INVASIVE PLANTS AND ANIMALS									
Invasive Plant Species									
Invasive Plants - General	NEED					some			Have pesticide-use records with GPS data in spread-sheet & some sketch maps but no systematic mapping.
Bromus spp. (as a group)	NEED								
Centaurea diffusa (Diffuse Knapweed)	NEED								
Centaurea repens (Russian knapweed)	NEED								
Eleagnus angustifolia (Russian Olive)	NEED								
Lythrum salicaria (Purple Loosestrife)	NEED								
Melilotus officinalis (yellow sweetclover)	NEED								
Tamarix ramossima (tamarisk)	NEED								

Arches National Park (ARCH) Natural Resource and Stressor Monitoring Status Summary

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Resource or Stressor of Concern	ARCH	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Exotic plant/Native plant interactions	NEED								
Invasive Animal Species									
exotic/introduced fish species	NEED								
brown-headed cowbird (exotic)	NEED								
HERBIVORY AND TRAMPLING BY LARGE MAMMALS									
No Need									
NPS DEVELOPMENT AND INFRASTRUCTURE									
trail construction	NEED								
NPS MANAGEMENT ACTIONS									
vegetation rehabilitation	NEED								
weed control	NEED								
elimination of grazing	NEED								
ADJACENT LAND-USE ACTIVITIES									
air traffic	NEED								

Arches National Park (ARCH) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	ARCH	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
NATURAL DISTURBANCES									
regeneration after burns	**YES**	3	1999-present	Charles Schelz, park biologist	1	yes	Henry Bastian, Zion Fire Effects Team		Vegetation monitoring using slightly modified Fire Monitoring Handbook protocol.
MISCELLANEOUS									
erosion/altered sedimentation (need better clarification)	NEED								

Black Canyon of the Gunnison NP (BLCA) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	BLCA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
POPULATIONS/SPECIES									
AQUATIC									
native fish	NEED							USFWS/CDOW	No work has been done on habitat potential
TES fish species - general	NEED							USFWS	No work has been done on habitat potential
Aquatic Invertebrates	YES	5	1995-2000	Matt Malick, Aquatic Ecologist	2	yes		NPS/WSC	Although some NPS sampling has been done, it is limited to one tributary and a few samples on the mainstem Gunnison
	NEED								
Amphibians -general	NEED								
Periphyton	PAST	2	1998-1999	Matt Malick, Aquatic Ecologist	Approx 14	yes			This study has been temporarily discontinued due to time constraints
TERRESTRIAL									
Birds									
neotropical migrants-general	YES	7	1996-present	Myron Chase, Nat. Res. Mgr.	4	yes			
sage grouse									

Black Canyon of the Gunnison NP (BLCA) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	BLCA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
peregrine falcon	YES	13	1990-present	Myron Chase, Nat. Res. Mgr. Gerald Craig, Raptor Biologist, CDOW	3	no	CDOW		
Mexican spotted owl	NEED							USFWS	
bald eagle	YES	9	1994-present	Myron Chase, Nat. Res. Mgr.	1	no	CDOW, USGS		
golden eagle	YES	9	1994-present	Myron Chase, Nat. Res. Mgr.	1	no	CDOW, USGS		
Mammals									
predators	NEED								
bighorn sheep	NEED							CDOW	
Northern river otter	NEED?							CDOW	
bats	NEED?								
Plants									
Sensitive Plant Species									
Sensitive plants-general	NEED								
Reptiles									
No Need									
Invertebrates									
No Need									

Black Canyon of the Gunnison NP (BLCA) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	BLCA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
ECOSYSTEMS									
Riparian-Wetland and Aquatic Ecosystems									
Aquatic Ecosystems-general	YES								
wetlands	NEED							NPS/Colorado Natural Heritage Program	
riparian zone	NEED							NPS/Colorado Natural Heritage Program	
seeps, springs, & hanging gardens	NEED							NPS/Colorado Natural Heritage Program	
Upland Ecosystems									
Vegetation communities-general	YES	7	1996-present	Danguole Bockus, Ecologist					
relict areas	NEED								
Cave Ecosystems									
No Need									
ECOLOGICAL RESOURCES OR CONDITIONS									
air quality conditions (ozone)	YES	9	1994-present	Myron Chase, Nat. Res. Mgr.	1	yes	NPS ARD		
climatic conditions	YES	6	1997-present	BLM	1	yes			Remote Automated Fire Weather Station

Black Canyon of the Gunnison NP (BLCA) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	BLCA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
general soil and soil crust	NEED								
water resources (very broad category; only resources needing monitoring are identified)	NEED							NPS/USGS	No work has been done on stream type or habitat enhancement for native fish
water quality	YES	7	1995-present	Matt Malick, Aquatic Ecologist	2	yes	NPS/USGS		
	YES	5	1996-present	Matt Malick, NPS, aquatic ecologist	2	yes	USGS		East Portal site sampled as part of NAWQA program from 1993 - 1999
water quantity	YES	7	1995-present	Matt Malick, Aquatic Ecologist	2	yes	NPS/USGS		Discharge measured has part of WQ program. USGS maintains one gage at East Portal
	YES	5	1996-present	Matt Malick, NPS, aquatic ecologist	2	yes	USGS		East Portal site sampled as part of NAWQA program from 1993 - 1999
FEATURES AND OBJECTS									
No Need									

Black Canyon of the Gunnison NP (BLCA) Natural Resource and Stressor Monitoring Status Summary

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Resource or Stressor of Concern	BLCA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
SENSORY RESOURCES									
soundscape	NEED								
PARK VISITORS									
aquatic recreation	NEED							NPS/WSC	
terrestrial recreation	NEED								
fishing	NEED							NPS/WSC/CDOW	
EXOTIC AND INVASIVE PLANTS AND ANIMALS									
Invasive Plant Species									
Invasive Plants - General	NEED								
Exotic plant/Native plant interactions	NEED								
Invasive Animal Species									
exotic/introduced fish species	NEED							CDOW	
HERBIVORY AND TRAMPLING BY LARGE MAMMALS									
Native Plants - Livestock Grazing	NEED							BLM	
NPS DEVELOPMENT AND INFRASTRUCTURE									
roads	NEED								
NPS MANAGEMENT ACTIONS									
vegetation rehabilitation	NEED								
weed control	NEED								

Black Canyon of the Gunnison NP (BLCA) Natural Resource and Stressor Monitoring Status Summary

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Resource or Stressor of Concern	BLCA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
elimination of grazing	NEED								
fire suppression	NEED								
prescribed fire	NEED								
reservoir operations	NEED								
ADJACENT LAND-USE ACTIVITIES									
dam operation	NEED							BOR/CSU/CDOW	
agricultural water diversion	NEED							Colorado Water Quality Control Division/USGS	
agricultural chemical application	NEED							Colorado Water Quality Control Division/USGS	
soil chemistry/contamination	NEED							USGS	
agriculture - conversion to cropland	NEED							USGS	
industrial pollution	NEED							USGS	
housing development	NEED							USGS, Counties	
forestry practices	NEED							US Forest Service/USGS	
NATURAL DISTURBANCES									
regeneration after burns	NEED								
MISCELLANEOUS									
climate change	NEED							NOAA, NWS	
erosion/altered sedimentation (need better clarification)	NEED								

Bryce Canyon National Park (BRCA) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	BRCA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
POPULATIONS/SPECIES									
AQUATIC									
Aquatic Invertebrates	PAST	2	1992-1993	Steven Weiss, Univ of Arizona		no			
	NEED								
Amphibians -general	NEED							Terry Schwaner SUU, Cedar City USGS - Graham	
TERRESTRIAL									
Birds									
neotropical migrants-general	PAST	8	1990-1999, intermittent	BRCA resource staff	1	no	Breeding Bird Survey		data stored at the USGS Patuxent Wildlife Research Center for BBS route 85-908
	PAST	7	1963-1969	BRCA resource staff	2	no	National Audubon Society		Christmas Bird Count
Raptors-general	PAST	4	1992-1995	BRCA resource staff	8	no			
Southwestern willow flycatcher	**YES**	6	1995-2002	BRCA resource staff: Foster, Neighbor, Schreier, Ames-Curtis, Cahill	3	2	Utah Division of Wildlife Resources and US Fish and Wildlife Service		

Bryce Canyon National Park (BRCA) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	BRCA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
sage grouse	PAST	20	1946-1967	BRCA resource staff	parkwide	no			data recorded for absence/presence
peregrine falcon	YES	11	1983-1985, 1989-1992, 1995, 1997, 1999-2000	BRCA resource staff: Hallows, Daw, Block, Collins, Fields, Ames-Curtis & Burch	10	no			
Mexican spotted owl	PAST	3	1993-1995	BRCA resource staff: Foster & Burch	3	no			none found in habitat monitoring activities
Northern goshawk	PAST	6	1993-2000	BRCA resource staff: Foster, Burch, Ames-Curtis & Parker	15	no			
Mammals									
Large mammals -general	NEED								
Small mammals -general	NEED								

Bryce Canyon National Park (BRCA) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	BRCA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
ungulates	PAST	27	1956-1969, 1981, 1988, 1998	BRCA resource staff: Crafts, Mermejo, Barraza	roadsides, exclosures	no	Utah Division of Wildlife Resources		
Utah prairie dog	YES								
bats	YES	1	1995	Dan Foster, BRCA	24	no	Utah National Forests, USGS Biological Resource Survey		
Plants									
T & E Species									
No Need									
Sensitive Plant Species									
Sensitive plants-general	YES	9	1988-1995, 1997	F.Peabody, Univ of SD; D. Roberts & G. Hallsten, USU; Nick Van Pelt & Ames-Curtis BRCA staff	33	no		BLM, Dixie NF	
Pediomelum pariensis (Paria breadroot)	PAST	3	1988-1990	Gregory Hallsten, Dave Roberts, Utah State Univ	1	no	Utah State University		

Bryce Canyon National Park (BRCA) Natural Resource and Stressor Monitoring Status Summary

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Resource or Stressor of Concern	BRCA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Other Plant Species of Concern									
No Need									
Reptiles									
No Need									
Invertebrates									
No Need									
ECOSYSTEMS									
Riparian-Wetland and Aquatic Ecosystems									
Aquatic Ecosystems-general	NEED								
wetlands	NEED								
seeps, springs, & hanging gardens	PAST	2	1981 & 1996	Nakashima, VIP; Amy Ott, So. Utah Univ.	16 & 33	yes			
	NEED								
Upland Ecosystems									
Vegetation communities-general	PAST	4	1988-1991	Dave Roberts, USU	parkwide	yes	Doug Wight, BLM, Moab, Utah		

Bryce Canyon National Park (BRCA) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	BRCA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
forest	PAST	45	1957-present	Buchanan and McKnight	266	no	Greybosch, Kimball Harper		10-12 monitoring interval
relict areas	PAST	1	1991	Van Pelt & Schelz	4	no	John Spence, GLCA	The Nature Conservancy	
Vegetation in the Breaks	PAST	1	1992	Spence	1	no			
Cave Ecosystems									
No Need									
ECOLOGICAL RESOURCES OR CONDITIONS									
air quality conditions	**YES**	14	1988-present	NPS Air Quality	2	yes	UC Davis Crocker Nuclear Lab		
general soil and soil crust	**YES**	3	1988-1990	Dr. Jayne Belnap, USGS-BRD, Moab, Utah	unknown	no			
water resources (very broad category; only resources needing monitoring are identified)	PAST	1& 2	1999; 1958 & 1963	Doremus & Kreamer; Wendell Marine	parkwide; 2	no			
	NEED								
Water quality	NEED								
Water quantity	NEED								
FEATURES AND OBJECTS									
paleontological resources	NEED								

Bryce Canyon National Park (BRCA) Natural Resource and Stressor Monitoring Status Summary

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Resource or Stressor of Concern	BRCA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
geologic objects - loss	NEED								
paleontological resources - biostratigraphy	YES	14	1988-present	Dr. Jeff Eaton of Weber State Univ, Ogden, Utah	26	yes	Dr. Scott Sampson, Utah Museum of NH; Dr. Dave Gillette of Museum of N. Arizona; Dr. Alan Titus of BLM	Dr. Howard Hutchison, UC Berkeley, ret.	
SENSORY RESOURCES									
night sky	NEED						Chad Moore, Pinnacles NM, CA		
soundscape	YES	3	2000-present	Skip Ambrose, NPS WASO	2 to 5	yes	NPS Soundscape Monitoring, Ft. Collins, CO		dose-response is reported; actual monitoring data is not yet analyzed
PARK VISITORS									
airborne recreation	NEED							Skip Ambrose, Soundscape Management, Ft. Collins, CO	
terrestrial recreation	NEED								
other visitor actions	PAST	1994-1999	6	BRCA resource staff	parkwide overlooks	no			

Bryce Canyon National Park (BRCA) Natural Resource and Stressor Monitoring Status Summary

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Resource or Stressor of Concern	BRCA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
EXOTIC AND INVASIVE PLANTS AND ANIMALS									
Invasive Plant Species									
Invasive Plants - General	**YES**	6	1992, 1997-present	BRCA resource staff: Buchanan, Schelz, Ames-Curtis, Jones	400+	yes			
Tamarix ramossima (tamarisk)	PAST	1	1992	BRCA Resource staff: Bradley	parkwide	no			
exotic plant/native plant interactions	PAST	5	1997-2002	Ames and Curtis	272	yes	Bloch, Lindh, Muller, Linton, Welch	BLM, Dixie NF	
Invasive Animal Species									
brown-headed cowbird (exotic)	PAST	3	1996-1998	BRCA Park staff: Schreier, Ames-Curtis, Neighbor	3	yes			as part of the study for Southwestern Willow Flycatchers
HERBIVORY AND TRAMPLING BY LARGE MAMMALS									
Native Plants - Livestock Grazing	NEED							USFS & BLM	

Bryce Canyon National Park (BRCA) Natural Resource and Stressor Monitoring Status Summary

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Resource or Stressor of Concern	BRCA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Wildlife	PAST	1956-1968 & 1988	13 & 2	BRCA Resource staff: Mermejo &	4-Feb	no		Utah Division of Wildlife Resources Division	
NPS DEVELOPMENT AND INFRASTRUCTURE									
maintenance activities	NEED								
NPS MANAGEMENT ACTIONS									
fauna reintroductions	NEED								
vegetation rehabilitation	NEED								
weed control	**YES**	6	1997-present	BRCA Resource staff: Buchanan, Ames-Curtis,	parkwide	yes			same as Exotic monitoring above
prescribed fire	**YES**	9	1988; 1990-1991; 1995-1996; 1999-present	BRCA Resource Staff: Mermejo, Johnson, Burch, Wilmore & Bastian of ZION	unknown	yes			
flood control-stream channelization	NEED								

Bryce Canyon National Park (BRCA) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	BRCA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
ADJACENT LAND-USE ACTIVITIES									
plants sensitive to air pollution	PAST	3	1988-1990	Jayne Belnap, USGS-BRD, Moab, Utah	1	no			
forestry practices	NEED								
air traffic	NEED								
NATURAL DISTURBANCES									
insects/pathogens	**YES**	8	1995-present	USFS Intermountain Research Lab, Ogden, Utah	8-May	unknown			
MISCELLANEOUS									
erosion/altered sedimentation (visitor and facility impact on geologic formation)	NEED							USGS, NPS-GRD	facilities and foot and horse traffic remove vegetation from the fragile canyon rim and inner canyon. Erosion is enhanced, but at what rate? Greater level of maintenance required. Is visitation causing features to be at risk?

Canyonlands National Park (CANY) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	**CANY**	Total Number of Years	Study Period(s)	Investigator	*Number of Study Locations in Park*	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
POPULATIONS/SPECIES									
AQUATIC									
native fish	PAST								
TES fish species - general	**YES**							Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin	Utah DWR, USFWS, and Colorado State University monitoring on Colorado River along park boundary
Aquatic Invertebrates	**YES**	5	1997-present	Charles Schelz, park biologist	*5*	yes		BLM Moab District aquatic invertebrate monitoring	Associated with SEUG water quality monitoring program
	YES	10	1993-present	Charles Schelz, park biologist	*9*		DEQ FS BLM USGS	Utah State "Bug" Lab, Mark Vinson	# of sites changed over time
Amphibians -general	NEED							USGS ARMI program?	Program in nearby Canyonlands National Park
TERRESTRIAL									
Birds									
neotropical migrants-general	**YES**	10	1993-present	Sonya Daw (park biotech)	*3*	yes			Variable circular plot point counts in riparian habitats.
Raptors-general	**YES**	20	1983-present	William Sloan (park biotech) and others	*not fixed*	partial			Monitoring 8 taxa including 3 TES species; multiple investigators, monitoring techniques and objectives.
TES Bird Species - general	**YES**	20	1983-present	William Sloan (park biotech) and others	*not fixed*	partial			Monitoring 8 taxa including 3 TES species; multiple investigators, monitoring techniques and objectives.

Canyonlands National Park (CANY) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	**CANY**	Total Number of Years	Study Period(s)	Investigator	*Number of Study Locations in Park*	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Southwestern willow flycatcher	PAST	3	1999-2001	Matthew Johnson (NAU/USGS)		yes	Colorado Plateau Field Station (NPS, USGS & Northern Arizona University)		Study route along Colorado River boundary of park but no identified habitat patches within park.
peregrine falcon	PAST	20	1983-present	William Sloan (park biotech) and others	*not fixed*	partial			
Mexican spotted owl	**YES**	10	1993-present	David Willey, Bill Sloan, David Svendsen	*not fixed*	yes	Colorado Plateau Field Station (NPS, USGS & Northern Arizona University)		Willey's PhD dissertation on MSO in CANY, Sloan's work was spradic, Svendsen did intensive inventory in 2002
bald eagle	PAST	6	1982-1987			no	National Wildlife Federation		Bald Eagle Midwinter Survey
golden eagle	**YES**	20	1983-present	William Sloan and others	*not fixed*	partial			Monitoring 8 taxa including 3 TES species; multiple investigators, monitoring techniques and objectives.
wetern burrowing owl	NEED								
Mammals									
Large mammals -general	PAST								

Canyonlands National Park (CANY) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	**CANY**	Total Number of Years	Study Period(s)	Investigator	*Number of Study Locations in Park*	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Small mammals -general	PAST	7	1987-1993	Charles Schelz, currently park biologist	*3*	no			Trapping webs (204 traps on 10 radiating lines) were sampled yearly.
ungulates	PAST								
predators	**YES**	1	1988	Charles Schelz, currently park biologist		no			Carnivore inventory compiled from 1975-1988 observations and 1988 scent survey stations. Recommendations for long-term monitoring.
bighorn sheep	**YES**	13	1990-present	William Sloan (park biotech)	*not fixed*	yes	Utah Division of Wildlife Resources		Ground surveys of radiocollared & other bighorn.
	YES	2 (with current methods)	1994, 1998	William Sloan (park biotech), Craig Hauke (park resource specialist)	*not fixed*	yes	USGS (Francis Singer and Michael Moses); Utah Division of Wildlife Resources		Aerial censuses associated with more frequent counts in CANY and with USGS development of a model interpreting population numbers from aerial counts.
Northern river otter	PAST	2	1988-1989	Nelson Boschen (Utah DWR)	*on Colorado River along boundary*	no	Utah Division of Wildlife Resources		Monitored pair of otters on Colorado River near park boundary in 1988; surveyed longer stretch of river in 1989.
beaver	PAST	2	1976-1977	Brazell et al	*not fixed*	no	Utah State Univ., Utah Div of Wildlife,		Mostly a preliminary survey
bats	NEED								

Canyonlands National Park (CANY) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	**CANY**	Total Number of Years	Study Period(s)	Investigator	*Number of Study Locations in Park*	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Plants									
T & E Species									
Carex speculifera (Navajo Sedge)	NEED								
Cymopterus beckii (Pinnate spring-parsley)	NEED								
Sensitive Plant Species									
Sensitive plants-general	NEED								
Cuscuta occidentalis (Western Dodder)									
Habenaria zothecina (Alcove Bog-Orchid)	NEED							Survey of rare plant species in the Southeast Utah Group of national parks, 1993.	Included location data, habitat info, & population studies of H. zothecina in Arches. Ken Heil (San Juan College), Lisa Floyd-Hanna (Prescott College) & others.
Lygodesmia entrada (Entrada rushpink)	NEED							Survey of rare plant species in the Southeast Utah Group of national parks, 1993.	Included some location data & habitat info for L. entrada in Arches. Ken Heil (San Juan College), Lisa Floyd-Hanna (Prescott College) & others.
Oreoxis trotteri (Trotter's oreoxis)	NEED								

Canyonlands National Park (CANY) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	**CANY**	Total Number of Years	Study Period(s)	Investigator	*Number of Study Locations in Park*	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Sphaeralcea janeae (Jane's Globemallow)	PAST	1	1991-1992	Lisa Floyd-Hanna, D. Hanna	*2*	No			2 year study was never continued even though permanent plots established
Zigadenus vaginatus (Alcove Death Camas)	NEED								
Other Plant Species of Concern									
No Need									
Reptiles									
lizards	NEED								
General reptiles	NEED								
Invertebrates									
Terrestrial Invertebrates	NEED							Butterfly inventory began in 2002, Clyde Gillette.	
ECOSYSTEMS									
Riparian-Wetland and Aquatic Ecosystems									
Aquatic Ecosystems-general	**YES**	5	1997-present	Charles Schelz, park biologist	*5*	yes		BLM Moab District aquatic invertebrate monitoring	Associated with SEUG water quality monitoring program

Canyonlands National Park (CANY) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	**CANY**	Total Number of Years	Study Period(s)	Investigator	*Number of Study Locations in Park*	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
	YES	10	1993-present	Charles Schelz, park biologist	*9*		DEQ FS BLM USGS	Utah State "Bug" Lab, Mark Vinson	# of sites changed over time
wetlands	NEED								
riparian zone	**YES**	4	1998-present	Charles Schelz, park biologist	*17 transects*	yes			Vegetation data, substrate data and stream profiles, measured every year or two.
	YES	10	1993-present	Sonya Daw (park biotech)	*3 transects*	yes			Yearly late spring bird point counts in riparian habitats.
	YES	1	2000	Charles Schelz, park biologist	*1*				
seeps, springs, & hanging gardens	NEED							Investigations of hanging gardens in Glen Canyon NRA.	John Spence (Glen Canyon park botanist).
Upland Ecosystems									
Vegetation communities-general	**YES**	20	1983-present	Charles Schelz, park biologist	*13*	yes			Modified Daubenmire transects, surveyed annually.
grasslands	**YES**	20	1983-present	Charles Schelz, park biologist	*13*	yes			Several transects in this program are in grasslands.
shrublands	**YES**	20	1983-present	Charles Schelz, park biologist	*13*	yes			Several transects in this program are in shrublands.

Canyonlands National Park (CANY) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	**CANY**	Total Number of Years	Study Period(s)	Investigator	*Number of Study Locations in Park*	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
relict areas	NEED							Relict site descriptions for many Colorado Plateau parks, 1989-90, The Nature Conservancy.	Arches wasn't included in this study.
Cave Ecosystems									
No Need									
ECOLOGICAL RESOURCES OR CONDITIONS									
air quality conditions	PAST	6	1986-1992	Air Resources Division, NPS; park staff	*1*	yes	Colorado State University		IMPROVE visibility data measured using aerosol sampler & camera.
	PAST	14	1988-2002	Air Resources Division, NPS; park staff	*1*	yes			NPS Gaseous Air Pollutant Monitoring Network
climatic conditions	**YES**	22	1990-present	park staff	*1*	yes	NOAA		Daily weather data from near visitor center.
	PAST	14	1988-2002	Air Resources Division, NPS; park staff	*1*	yes			NPS Gaseous Air Pollutant Monitoring Network
general soil and soil crust	**YES**	15	1987-present	Charles Schelz, park biologist	*29*	yes			Modified Daubenmire transects, surveyed annually.

Canyonlands National Park (CANY) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	**CANY**	Total Number of Years	Study Period(s)	Investigator	*Number of Study Locations in Park*	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
water resources (very broad category; only resources needing monitoring are identified)	**YES**	10	1993-present	Charles Schelz, park biologist	*9*		DEQ FS BLM USGS	Utah State "Bug" Lab, Mark Vinson	Various studies completed over many years generally beginning in 1983
water quality	**YES**	19	1983-present	Charles Schelz, park biologist	*9*	yes	Utah Division of Water Quality		Quarterly or monthly monitoring of springs, seeps and streams.
	YES	10	1993-present	Charles Schelz, park biologist	*9*		DEQ FS BLM USGS	Utah State "Bug" Lab, Mark Vinson	# of sites changed over time
water quantity	NEED								
	YES	10	1993-present	Charles Schelz, park biologist	*9*		DEQ FS BLM USGS		# of sites changed over time
FEATURES AND OBJECTS									
paleontological resources	NEED								
geologic objects - loss	NEED								
SENSORY RESOURCES									
night sky	**YES**	new	2002-present	Charles Schelz, park biologist	*1*				Night sky light levels will be measured by a quarter-sky charged coupled device high-resolution camera.
soundscape	NEED								
PARK VISITORS									
airborne recreation	NEED								
terrestrial recreation	NEED								

Canyonlands National Park (CANY) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	**CANY**	Total Number of Years	Study Period(s)	Investigator	*Number of Study Locations in Park*	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
EXOTIC AND INVASIVE PLANTS AND ANIMALS									
Invasive Plant Species									
Invasive Plants - General	NEED					some			Have pesticide-use records with GPS data in spread-sheet & some sketch maps but no systematic mapping.
Bromus spp. (as a group)	NEED								
Centaurea diffusa (Diffuse Knapweed)	NEED								
Centaurea repens (Russian knapweed)	NEED								
Centaurea species (knapweeds)	NEED								
Eleagnus angustifolia (Russian Olive)	NEED								
Lepidium latifolium (Perennial Pepperweed)	NEED								
Lythrum salicaria (Purple Loosestrife)	NEED								
Melilotus officinalis (yellow sweetclover)	NEED								
Tamarix ramossima (tamarisk)	PAST								
Invasive Animal Species									
exotic/introduced fish species	PAST								

Canyonlands National Park (CANY) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	**CANY**	Total Number of Years	Study Period(s)	Investigator	*Number of Study Locations in Park*	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
brown-headed cowbird (exotic)	NEED								
HERBIVORY AND TRAMPLING BY LARGE MAMMALS									
No Need									
NPS DEVELOPMENT AND INFRASTRUCTURE									
trail construction	NEED								
NPS MANAGEMENT ACTIONS									
vegetation rehabilitation	NEED								
weed control	NEED								
elimination of grazing	**YES**								
ADJACENT LAND-USE ACTIVITIES									
No Need									
NATURAL DISTURBANCES									
regeneration after burns	**YES**								
MISCELLANEOUS									
erosion/altered sedimentation (need better clarification)	NEED								

Capitol Reef National Park (CARE) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CARE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
POPULATIONS/SPECIES									
AQUATIC									
native fish	NEED							John Kirby, Mansfield Univ.	
Aquatic Invertebrates	YES	1	1988-1989	Tom O. Clark	1		State of Utah DEQ		
Aquatic Invertebrates	NEED							Dr. John MacDonald, Purdue Univ.	
Amphibians -general	NEED							USGS ARMI program?	Program in nearby Canyonlands National Park
TERRESTRIAL									
Birds									
neotropical migrants-general	YES	9 Desert View, 12 Notom	1987-present	Matt O'Bradovich, Sandy Borthwick, Tom Clark	2 routes; Desert View and Notom	no	USGS Patuxent Wildlife Research Center		Breeding Bird Survey (BBS) along two park/BLM roads.
	YES	7	1995-present	Tom Clark	1 station	no	The Breeding Bird Institute, Utah Department of Wildlife Resources		Mapping Avian Productivity and Survivorship (MAPS) station
peregrine falcon	YES	19	1977-present	various contractors and park staff	not fixed	yes		USGS, BLM, USFS, UDWR	
Mexican spotted owl	YES	9	1977-present	various contractors and park staff	not fixed	yes		USGS, BLM, USFS, UDWR	

Capitol Reef National Park (CARE) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CARE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Northern goshawk	NEED							UDWR, USFS	need for winter range assessment
Mammals									
Large mammals -general	NEED							USGS, UDWR	
Small mammals -general	NEED							USGS, UDWR	
Bison	YES	?	?	UDWR			UDWR		overflights to assess population size. Some animals travel into park
predators	NEED							UDWR, USFS, BLM, USGS, WS	
bighorn sheep	YES	7	1996-present	Bill Sloane, UDWR	not fixed	no	CANY, UDWR		Surveys to determine lamb/ewe ratios in middle park reintroduction area
	YES	18	1984-present	UDWR	not fixed	no	UDWR		Aerial surveys of the southern park population
	YES	6	1996-present	Tom O. Clark					Bioghorn sheep reintroduction data
	NEED							UDWR, GLCA, BLM	
Mule Deer	PAST	9	1985-1994	park staff	Fruita Area	yes			
Utah prairie dog	PAST	2	1980-1982	UDWR, USFWS	1	no			
beaver									
bats	NEED								

Capitol Reef National Park (CARE) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CARE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Plants									
T & E Species									
Astragalus harrisonii (Harrison's milk-vetch)	YES	6	1997-present	Debi Clark	4	yes	BLM		Monitoring study to determine impacts caused by visitor use
Cycladenia jonesii (Jones cycladenia_	NEED							GLCA has monitoring plots nearby	
Cymopterus beckii (Pinnate spring-parsley)	YES	6	1997-present	Debi Clark	4	yes	BLM		Monitoring study to determine impacts caused by visitor use
Erigeron maguirei (Maguire's daisy)	YES	6	1997-present	Debi Clark	4	yes	BLM		Monitoring study to determine impacts caused by visitor use
	PAST	8	1992-2001	Rene Van Buren, Utah Valley State College	2	no		2 plots in this study are located on BLM	Study plots for life history demographics
Gilia caespitosa (Rabbit Valley gilia)	YES	6	1997-present	Debi Clark	4	yes	BLM	Fishlake and Dixie National Forests	Monitoring study to determine impacts caused by visitor use
Habenaria zothecina (Alcove Bog-Orchid)	NEED								
Pediocactus winkleri (Winkler cactus) and *P. despainii* (Despain's cactus)	YES	4	1999-present	Debi Clark	1	yes	BLM	3 plots in this study are located on BLM	Monitoring study to determine impacts caused by cattle trampling

Capitol Reef National Park (CARE) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CARE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Schoencrambe barnebyi (Barneby's reed mustard)	YES	6	1997-present	Debi Clark	4	yes	BLM		Monitoring study to determine impacts caused by visitor use
Sclerocactus wrightiae (Wright fishhook cactus)	YES	4	1999-present	Debi Clark	1	yes	BLM	BLM has life history study plots nearby	Monitoring study to determine impacts caused by cattle trampling
Spiranthes diluvialis (Ute ladies' tresses orchid)	NEED								
Townsendia aprica (Last Chance townsendia)	NEED							BLM has one life history study plot nearby	
Sensitive Plant Species									
Sensitive plants-general	NEED							BLM and USFS	
Gilia tenuis (Mussentuchit gilia)	NEED							BLM	
Other Plant Species of Concern									
Pinus longaeva, Bristlecone pine	NEED							USFS	
Reptiles									
lizards	NEED							USGS	
General reptiles	NEED							USGS	

Capitol Reef National Park (CARE) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CARE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Invertebrates									
Terrestrial Invertebrates	NEED							USGS, UDWR	
ECOSYSTEMS									
Riparian-Wetland and Aquatic Ecosystems									
Aquatic Ecosystems-general	NEED								
wetlands	NEED								
riparian zone	NEED								
seeps, springs, & hanging gardens	NEED								
Upland Ecosystems									
grasslands	NEED								
shrublands	NEED								
relict areas	NEED								
Cave Ecosystems									
No Need									
ECOLOGICAL RESOURCES OR CONDITIONS									
air quality conditions	YES	2	2001-present		1	yes	Univ. of California, Davis, NPS ARD		IMPROVE station
	YES	8	1995-present	Dr. John Ray, NPS ARD	1	no			Passive ozone sampling

Capitol Reef National Park (CARE) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CARE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
	PAST	?	?	ARD ?	2 ?	no			Visual monitoring
climatic conditions	NEED								
	PAST	54	1948-present	Tom O. Clark					Climate data
general soil and soil crust	NEED								
water resources (very broad category; only resources needing monitoring are identified)	NEED								
water quality	PAST	2	1988-1989	Tom O. Clark					Fremont River riparian vegetation impacts
	NEED								
water quantity	PAST								
	NEED								
FEATURES AND OBJECTS									
paleontological resources	NEED								
geologic objects - loss	NEED								
natural objects (antlers, rocks, etc.)	NEED								
SENSORY RESOURCES									
night sky	NEED								
soundscape	NEED								

Capitol Reef National Park (CARE) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CARE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
PARK VISITORS									
airborne recreation	NEED								
terrestrial recreation	NEED								
collection and poaching	NEED							USFWS	
EXOTIC AND INVASIVE PLANTS AND ANIMALS									
Invasive Plant Species									
Invasive Plants - General	NEED								
Bromus spp. (as a group)	NEED								
Eleagnus angustifolia (Russian Olive)	NEED								
Tamarix ramossima (tamarisk)	NEED								
Halogeton glomeratus (Halogeton)	NEED								
Ailanthus altissima (Tree-of-heaven)	NEED								
Invasive Animal Species									
exotic/introduced fish species	NEED								
HERBIVORY AND TRAMPLING BY LARGE MAMMALS									
Native Plants - Livestock Grazing	NEED								
Livestock	YES						BLM		
NPS DEVELOPMENT AND INFRASTRUCTURE									
No Need									

Capitol Reef National Park (CARE) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CARE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
NPS MANAGEMENT ACTIONS									
weed control	NEED								
elimination of grazing	NEED								
ADJACENT LAND-USE ACTIVITIES									
agricultural chemical application	NEED								
NATURAL DISTURBANCES									
No Need									
MISCELLANEOUS									
erosion/altered sedimentation (need better clarification)	NEED								

Cedar Breaks National Monument (CEBR) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CEBR	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
POPULATIONS/SPECIES									
AQUATIC									
No Need									
TERRESTRIAL									
Birds									
neotropical migrants-general	NEED							Matthew Johnson, USGS/NAU, Priscilla Summers, USFS/Dixie NF	
peregrine falcon	PAST	5	1993-2000	Keith S. Day, Utah DWR, David T. Sinton, ZNP, Scott L. Staats, ZNP, Rick Boretti, ZNP	2	Unknown			
Mexican spotted owl	NEED							Sarah Rinkevich, USFWS/UNM, Keith S. Day, Utah DWR, Priscilla Summers, USFS/Dixie NF	

Cedar Breaks National Monument (CEBR) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CEBR	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Northern goshawk	PAST	Unknown	1992-?	USDA-Forest Service, Intermountain Region	Unknown	Unknown			A multi-year project to inventory and monitor known goshawk territories was initiated by the USFS in 1992 and included the Dixie NF, which surrounds CEBR on all sides. Results were included in the EA for the Utah Northern Goshawk Project. Locations within CEBR were inventoried and monitored, but the park does not have the detailed study results.
Mammals									
Large mammals -general	NEED							Jeff Grandison, Utah DWR, Mike Bogan, USGS/UNM	

Cedar Breaks National Monument (CEBR) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CEBR	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Small mammals -general	NEED							Keith S. Day, Utah DWR, Mike Bogan, USGS/UNM	
ungulates	NEED							Jeff Grandison, Utah DWR	
predators	NEED							Larisa Harding, USGS/UNM	
bats	NEED							Mike Bogan, USGS/UNM	
Plants									
T & E Species									
Salix arizonica (Arizona willow)	NEED							Ron Rodriguez, USFS/Dixie NF	
Sensitive Plant Species									
No Need									
Other Plant Species of Concern									
Picea engelmanii, Engelmann spruce	NEED							Ron Rodriguez, USFS/Dixie NF,	
Pinus longaeva, Bristlecone pine	NEED							Ron Rodriguez, USFS/Dixie NF	
Reptiles									
No Need									

Cedar Breaks National Monument (CEBR) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CEBR	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Invertebrates									
Terrestrial Invertebrates	NEED								
ECOSYSTEMS									
Riparian-Wetland and Aquatic Ecosystems									
seeps, springs, & hanging gardens	**YES**			Mike Ward CEBR Maint.					Potable water supply at 3 springs monitored for health protection
Upland Ecosystems									
No Need									
Cave Ecosystems									
No Need									
ECOLOGICAL RESOURCES OR CONDITIONS									
air quality conditions	NEED							NPS Air Resources Division	
general soil and soil crust	NEED								

Cedar Breaks National Monument (CEBR) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CEBR	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
water resources (very broad category; only resources needing monitoring are identified)	NEED							NPS Water Resources Division, Dave Sharrow, Hydrologist, ZION	
FEATURES AND OBJECTS									
No Need									
SENSORY RESOURCES									
soundscape	NEED								
PARK VISITORS									
No Need									
EXOTIC AND INVASIVE PLANTS AND ANIMALS									
Invasive Plant Species									
Bromus spp. (as a group)	NEED							Denise Louie, Botanist, ZION	
Invasive Animal Species									
exotic/introduced fish species	NEED							Dave Sharrow, Hydrologist, ZION	

Cedar Breaks National Monument (CEBR) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CEBR	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
HERBIVORY AND TRAMPLING BY LARGE MAMMALS									
No Need									
NPS DEVELOPMENT AND INFRASTRUCTURE									
No Need									
NPS MANAGEMENT ACTIONS									
No Need									
ADJACENT LAND-USE ACTIVITIES									
soil chemistry/contamination	NEED								
NATURAL DISTURBANCES									
No Need									
MISCELLANEOUS									
No Need									

Colorado National Monument (COLM) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	COLM	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
POPULATIONS/SPECIES									
AQUATIC									
Amphibians -general	NEED							USGS	
TERRESTRIAL									
Birds									
neotropical migrants-general	PAST						Rocky Mountain Bird Observatory		
Raptors-general	PAST						CO-DOW		
TES Bird Species - general	PAST						RMBO & Grand Jct. Audubon Society		
peregrine falcon	YES	7	1989-2002	Colorado Division of Wildlife	3		CO-DOW		
golden eagle	NEED							Grand Jct. Audubon Society	
Western burrowing owl	NEED							RMBO, CO-DOW & Grand Jct. Audubon Society	
Mammals									
Large mammals -general	NEED							CO-DOW	
Small mammals -general	NEED							CO-DOW	
predators	NEED							CO-DOW	
bighorn sheep	PAST						CO-DOW	CO-DOW	
prairie dog	NEED	1		Liz Rodgers	4			USFWS, RMBO	

Colorado National Monument (COLM) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	COLM	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
bats	NEED	2		Rick A. Adams				Bats International	
Plants									
Sensitive Plant Species									
Sensitive plants-general	NEED						Emily Hartman & Mary& Lou Rottman	BLM, Native Plant Society, Emily Hartman, Bill & Liz Rodgers	
Lomatium latilobum (Canyonlands lomatium)			1999-	Charles Schelz					
Reptiles									
lizards	PAST	3	1999-2001	Robert M'Closkey			Renata Platenberg		
Invertebrates									
Terrestrial Invertebrates	PAST	5	1994, 1998-2002	Boris Kondratieff (arthropods) Paul Opler (moths & butterflies),			Paul Opler	John Moore (COLM VIP)	

Colorado National Monument (COLM) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	COLM	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
ECOSYSTEMS									
Riparian-Wetland and Aquatic Ecosystems									
riparian zone	NEED							FWS, Tamarisk Coalition	
seeps, springs, & hanging gardens	NEED							?	
Upland Ecosystems									
forest	NEED							BLM, Fire pro	
grasslands	NEED							BLM, Fire pro	
relict areas	PAST		1989-1990	Charles Schelz					
Cave Ecosystems									
No Need									
ECOLOGICAL RESOURCES OR CONDITIONS									
air quality conditions	PAST		early 1990's					CO & Mesa County Dept of Health	some work done in the 1990's, unable to search for info at this time
	PAST	14	1978-1992	Dave Price					Air quality data

Colorado National Monument (COLM) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	COLM	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
climatic conditions	PAST	9	1983-1991	Dave Price					Meteorological Data, 1983-1991
general soil and soil crust	NEED							USGS	
	PAST								Soil survey of Mesa County area
water quality	NEED	2	2000-01	Paul vonGuerard, USGS			USGS	USGS	
water quantity	NEED							USGS, NPS-GRD	
FEATURES AND OBJECTS									
paleontological resources	NEED	5	1990-91 & 2001-02	George Engelmann ('90-'91), John Foster ('01-'02)			John Foster, Museum of W. Colorado	Museum of W. Colorado	
SENSORY RESOURCES									
night sky	NEED							Grand Jct Astronomy Club, NPS multi-park SEPAs	
soundscape	PAST	two	1990-91					NPS, Ft.Collins	
PARK VISITORS									
No Need									

Colorado National Monument (COLM) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	COLM	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
EXOTIC AND INVASIVE PLANTS AND ANIMALS									
Invasive Plant Species									
Invasive Plants - General	NEED	5	1997-2002	COLM RM staff			COLM Res.Mgmt.	Tamarisk Coalition	Tamarisk Coalition can be clearinghouse for work being done by other partners
Exotic plant/Native plant interactions	NEED							Tamarisk Coalition	
Invasive Animal Species									
No Need									
HERBIVORY AND TRAMPLING BY LARGE MAMMALS									
No Need									
NPS DEVELOPMENT AND INFRASTRUCTURE									
No Need									
NPS MANAGEMENT ACTIONS									
No Need									
ADJACENT LAND-USE ACTIVITIES									
plants sensitive to air pollution	NEED	?	early 1990's						Some monitoring of lichens was done in the '90's but unable to search for info at this time

Colorado National Monument (COLM) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	COLM	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
NATURAL DISTURBANCES									
fire	PAST			Dave Price					Fire History
MISCELLANEOUS									
native plant communities below fruita water line (need better clarification)	PAST	2?	1997-98	Pat Perrotti, COLM Res. Mgmt.					

Curecanti National Recreation Area (CURE) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CURE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
POPULATIONS/SPECIES									
AQUATIC									
native fish	PAST	1	1995	Dr. Kurt Fauch	3	no	CSU		Fauch et al looked at 3 tributaries to determine suitable reintroduction sites for native cutthroat trout. This study should be revisited to possibly implement recommendations. Essentially no work has been done on other tribs to determine extent of native fish populations
TES fish species - general	NEED							NPS/CDOW/CSU	
Aquatic Invertebrates	**YES**	10	1993-present	Matt Malick, Aquatic Ecologist	14	yes			This study has taken a temporary hiatus due to time constraints
	YES	9	1993-present	Matt Malick, NPS aquatic ecologist		yes			# of sites changed over years
Amphibians -general	NEED								
Periphyton	PAST	2	1998-1999	Matt Malick, Aquatic Ecologist	Approx 14	yes			This study has taken a temporary hiatus due to time constraints

Curecanti National Recreation Area (CURE) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CURE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Phytoplankton	PAST	2	1998-1999	Matt Malick, Aquatic Ecologist	7	yes			This study has taken a temporary hiatus due to time constraints. Results will be published in USGS pub
Zooplankton	PAST	6	1995-2001	Dr. Brett Johnson	?	no	CSU		
TERRESTRIAL									
Birds									
neotropical migrants-general	**YES**	11	1992-present	Myron Chase Nat. Res. Mgr.	5	Yes			
peregrine falcon	**YES**	12	1991-present	Myron Chase Nat. Res. Mgr.	3	No			
Mexican spotted owl	NEED?								
bald eagle	**YES**	10	1993-present	Myron Chase Nat. Res. Mgr.	1	No	CDOW/USGS		
golden eagle	**YES**	10	1993-present	Myron Chase Nat. Res. Mgr.	1	No	CDOW/USGS		

Curecanti National Recreation Area (CURE) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CURE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Waterfowl	PAST	4	1995-1998	Myron Chase Nat. Res. Mgr.	1	No			
Great Blue Heron	YES	14	1989-present	Ron Meyer	1	Yes			
Mammals									
Small mammals -general	PAST	3	1993-1995	Dr. Tim Graham	4	no			
bighorn sheep	YES	7	1996-present	Myron Chase Nat. Res. Mgr.	1	yes	CDOW		
Northern river otter	NEED							CDOW	
prairie dog	NEED							CDOW/BLM	
bats	NEED								
Plants									
T & E Species									
No Need									
Sensitive Plant Species									
Sensitive plants-general	NEED								
Other Plant Species of Concern									
No Need									
Reptiles									
No Need									

Curecanti National Recreation Area (CURE) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CURE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Invertebrates									
No Need									
ECOSYSTEMS									
Riparian-Wetland and Aquatic Ecosystems									
Aquatic Ecosystems-general	**YES**	9	1993-present	Matt Malick, NPS aquatic ecologist		yes	USGS		# of sites changed over years
wetlands	PAST	1	1995?	Lynn Cudlip					Limited Wetland riparian plots were examined. Some recent work with Colorado Natural Heritage Program
riparian zone	PAST	1	1995?	Lynn Cudlip					Limited Wetland riparian plots were examined. Some recent work with Colorado Natural Heritage Program
seeps, springs, & hanging gardens	NEED							Colorado Natural Heritage Program	

Curecanti National Recreation Area (CURE) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CURE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Upland Ecosystems									
Vegetation communities-general	YES	10	1993-2002	Danguole Bockus, Ecologist	5	Yes			Program is temporarily suspended pending review of procedures.
Cave Ecosystems									
No Need									
ECOLOGICAL RESOURCES OR CONDITIONS									
climatic conditions	YES	35	1967-present	NWS	1	No			
general soil and soil crust	NEED								
water resources (very broad category; only resources needing monitoring are identified)	NEED							NPS/USGS	No work has been done on stream type or habitat enhancement for native fish
water quality	YES	9	1993-present	Matt Malick, Aquatic Ecologist	19	Yes	USGS		
	YES	20	1982-present	Matt Malick, NPS aquatic ecologist	21	yes	USGS		4 projects complete; 1975-2000; Outstanding waters: current

Curecanti National Recreation Area (CURE) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CURE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
water quantity	YES	9	1993-present	Matt Malick, Aquatic Ecologist	14	Yes	USGS		Discharge measured as part of WQ program.
	YES	9	1993-present	Matt Malick, NPS aquatic ecologist		yes	USGS		
FEATURES AND OBJECTS									
paleontological resources	NEED								
geologic objects - loss	NEED								
SENSORY RESOURCES									
No Need									
PARK VISITORS									
aquatic recreation	NEED							WSC	
terrestrial recreation	NEED								
fishing	NEED							CDOW	
EXOTIC AND INVASIVE PLANTS AND ANIMALS									
Invasive Plant Species									
Invasive Plants - General	NEED								
Exotic plant/Native plant interactions	NEED								
Invasive Animal Species									
exotic/introduced fish species	NEED								

Curecanti National Recreation Area (CURE) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CURE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
HERBIVORY AND TRAMPLING BY LARGE MAMMALS									
Native Plants - Livestock Grazing	NEED								
NPS DEVELOPMENT AND INFRASTRUCTURE									
roads	NEED								
utility corridors	NEED							WAPA	
NPS MANAGEMENT ACTIONS									
vegetation rehabilitation	NEED								
fire suppression	NEED								
prescribed fire	NEED								
reservoir operations	NEED							BOR	
ADJACENT LAND-USE ACTIVITIES									
dam operation	NEED							BoR/CSU/CDOW	
agricultural water diversion	NEED							Colorado Water Quality Control Division/USGS	
agricultural chemical application	NEED							Colorado Water Quality Control Division/USGS	
soil chemistry/contamination	NEED							USGS	
agriculture - conversion to development	NEED							USGS	
industrial pollution	NEED							USGS	

Curecanti National Recreation Area (CURE) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	CURE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
housing development	NEED							USGS	
forestry practices	NEED							US Forest Service/USGS	
NATURAL DISTURBANCES									
regeneration after burns	NEED								
MISCELLANEOUS									
erosion/altered sedimentation (need better clarification)	NEED								

Dinosaur National Monument (DINO) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	DINO	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
POPULATIONS/SPECIES									
AQUATIC									
native fish	YES	?	?	Steve Petersburg			?		Fisheries inventory and trend information
TES fish species - general	YES	?	?	USFWS--Tim Modde and others			USFWS, UDWR, CSU		
Aquatic Invertebrates	PAST	16	1963-1979	Steve Petersburg					Aquatic invertebrate inventory
	NEED								
Amphibians -general	NEED								
TERRESTRIAL									
Birds									
neotropical migrants-general	NEED							Rocky Mountain Bird Observatory (RMBO)	
	YES	18	1964-present	Steve Petersburg and others	?	no			Fire Effects Monitoring
sage grouse	NEED							Colorado Division of Wildlife	May have done some monitoring in habitat adjacent to DINO
peregrine falcon	YES	?	197?-present	Steve Petersburg and others	approx. 17	no	CDOW-Jerry Craig	CDOW	

Dinosaur National Monument (DINO) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	DINO	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Mexican spotted owl	YES								Only one MSO has been detected in DINO; monitoring may not be possible
bald eagle	YES							RMBO	Winter only
golden eagle	NEED							RMBO	
Western burrowing owl	NEED							RMBO	
Mammals									
Large mammals -general									
Small mammals -general	PAST	?	?	Steve Petersburg and others	?	no			Fire Effects Monitoring
ungulates	YES			Steve Petersburg					Deer and Elk pellet group transects
	NEED								
predators	NEED							CDOW	
bighorn sheep	YES	52	1950-present	Steve Petersburg				CDOW	
Northern river otter	NEED							CDOW	
beaver	PAST			CSU--Stewart Breck					Research Project
bats	NEED								

Dinosaur National Monument (DINO) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	DINO	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Plants									
T & E Species									
Spiranthes diluvialis (Ute ladies' tresses orchid)	**YES**	0		Tamara Naumann		no	USU-Jack Schmidt & Paul Grams (geomorphology)	USFWS-Lucy Jordan	We have not implemented general monitoring, yet, but have developed some preliminary protocols.
	YES	8	1991-1998	Lynn Riedel & Tamara Naumann	1	no			Hog Canyon Restoration Project. Suspended due to workload.
Sensitive Plant Species									
Sensitive plants-general	**YES**			Lynn Riedel and Tamara Naumann		no			Developed a preliminary plan and protocols for rare plant monitoring. Suspended in 1996 due to workload.
Habenaria zothecina (Alcove Bog-Orchid)	NEED								
Other Plant Species of Concern									
No Need									

Dinosaur National Monument (DINO) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	DINO	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Reptiles									
General reptiles	NEED								
Invertebrates									
Terrestrial Invertebrates	NEED							CSU--Boris Kondratieff	
ECOSYSTEMS									
Riparian-Wetland and Aquatic Ecosystems									
Aquatic Ecosystems-general	NEED							USU-Mark Vinson	
wetlands	NEED								
riparian zone	YES			CSU--David Cooper					Various Research Projects
	YES								Deer Lodge Park wetland studied for development of HGM reference site, 1990s - Colorado Geological Survey
	PAST	1	1982	Steve Petersburg					Riparian vegetation data-Cottonwoods

Dinosaur National Monument (DINO) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	DINO	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
	PAST	1	1962	Steve Petersburg					Riparian vegetation data-Vascular plants of the Green River
	PAST	1	1982	Steve Petersburg					Riparian vegetation data- Response to fluctuating water levels
seeps, springs, & hanging gardens	NEED								
	PAST	2	1997-1998	CSU under contract to NPS					Upland ponds, springs, seeps studied
Upland Ecosystems									
grasslands	PAST								
shrublands	PAST								
Cave Ecosystems									
No Need									
ECOLOGICAL RESOURCES OR CONDITIONS									
air quality conditions	NEED								
climatic conditions	**YES**	38	1964-present	Steve Petersburg			NOAA, NWS		RAWS station, NOAA station, Fire Weather

Dinosaur National Monument (DINO) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	DINO	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
	YES	37	1965-present	Bruce Fields					Daily weather readings for fire risk assessment
general soil and soil crust	NEED							USGS	
water resources (very broad category; only resources needing monitoring are identified)	NEED								
water quality	PAST	3	1999-2000 1999-2002 10 yrs & ongoing	USGS	2	yes		USGS USFWS	USGS and USFWS conducting pH, sediment, temperature
	NEED								
water quantity	YES			USGS	1	yes	USGS		6 discharge stations in and outside park, 1 multi-parameter station
FEATURES AND OBJECTS									
paleontological resources	NEED								
natural objects (antlers, rocks, etc.)	YES								increased backcountry patrols during antler shedding season
SENSORY RESOURCES									
night sky	NEED								

Dinosaur National Monument (DINO) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	DINO	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
soundscape	PAST	1	1990	Steve Petersburg	?	no			Ambient sound monitoring-West Cactus Flat
	PAST	1	1990	Steve Petersburg					Ambient sound monitoring-Harper's Corner
PARK VISITORS									
aquatic recreation	PAST	?	?	?	?	no			
EXOTIC AND INVASIVE PLANTS AND ANIMALS									
Invasive Plant Species									
Invasive Plants - General	NEED							USU, Counties	
Cardaria draba (White top)	NEED								
Centaurea repens (Russian knapweed)	NEED								
Eleagnus angustifolia (Russian Olive)	NEED								
Lepidium latifolium (Perennial Pepperweed)	NEED								
Sonchus uliginosus (perennial sow-thistle)	NEED								
Tamarix ramossima (tamarisk)	NEED								
Exotic plant/Native plant interactions	PAST	?	?	David Cooper, CSU					research

Dinosaur National Monument (DINO) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	DINO	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Invasive Animal Species									
exotic/introduced fish species	YES			Tim Modde			USFWS		
HERBIVORY AND TRAMPLING BY LARGE MAMMALS									
Native Plants - Livestock Grazing	YES	41	1961-present	Steve Petersburg					Grazing records of use
	YES	0							Livestock Management Plan & EIS in progress--will require monitoring
NPS DEVELOPMENT AND INFRASTRUCTURE									
No Need									
NPS MANAGEMENT ACTIONS									
prescribed fire	YES	?	?	Steve Petersburg and others	?				Fire Effects Monitoring
ADJACENT LAND-USE ACTIVITIES									
dam operation	NEED								
NATURAL DISTURBANCES									
fire	YES	?	?	Steve Petersburg and others	?				Fire Behavior Monitoring and Fire Records

Dinosaur National Monument (DINO) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	DINO	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
regeneration after burns	YES	?	?	Steve Petersburg and others	?	no			Fire Effects Monitoring
flood	YES			USU--Jack Schmidt and others	?		USU		Various research projects
insects/pathogens	PAST	8	1984-1992	Steve Petersburg					Mormon Cricket population monitoring
MISCELLANEOUS									
No Need									

Fossil Butte National Monument (FOBU) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	FOBU	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
POPULATIONS/SPECIES									
AQUATIC									
Amphibians -general	NEED								
TERRESTRIAL									
Birds									
Raptors-general	NEED								
Raptors-nesting	PAST	14	1989-present	Fagnant, Fairchild, Heron, Kyte, & others; NPS staff	Park-wide and more limited surveys	partial			
sage grouse	NEED								
	YES	7	1995-present	Vincent Santucci					
peregrine falcon	PAST	1	1989-1989	Cain, Steven;Denver Regional Staff Biologist	undetermined	no			Survey limited to escarpments within the monument; S. Cain determined FOBU was probably unsuited for peregrine falcons.

Fossil Butte National Monument (FOBU) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	FOBU	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Mammals									
ungulates	YES	15	1988-present	Various NPS Staff & Seasonal Rangers	12 or less	no		Wyo. Game & Fish Dept.	WY G&F currently provide aerial count data for winter elk
ungulates	NEED								
predators	NEED								
beaver	NEED								
	YES	13	1990-present	Vincent Santucci					
Plants									
Sensitive Plant Species									
Astragalus lentiginosus var. *salinus* (Sodaville Milkvetch)	NEED								
Ceanothus martinii (Martin Ceanothus)	NEED								
Cuscuta occidentalis (Western Dodder)	NEED								
Lepidium integrifolium var. *integrifolium* (Entire-Leaved Peppergrass)	NEED								
Lomatium bicolor var. *bicolor* (Wasatch Biscuitroot)	NEED								
Lomatium triternatum var *anamalum* (Ternate Desert-Parsley)	NEED								

Fossil Butte National Monument (FOBU) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	FOBU	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Penstemon paysoniorum (Payson Beardtongue)	NEED								
Physaria condensata (Tufted Twinpod)	NEED								
Other Plant Species of Concern									
No Need									
Reptiles									
No Need									
Invertebrates									
No Need									
ECOSYSTEMS									
Riparian-Wetland and Aquatic Ecosystems									
Aquatic Ecosystems-general	PAST								
wetlands	NEED								
riparian zone	NEED								
seeps, springs, & hanging gardens	NEED								
Upland Ecosystems									
forest	NEED								

Fossil Butte National Monument (FOBU) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	FOBU	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
grasslands	NEED								
shrublands	NEED								
Cave Ecosystems									
No Need									
ECOLOGICAL RESOURCES OR CONDITIONS									
air quality	YES ?								
climatic conditions	YES	13	1990-present	Marcia Fagnant					
general soil and soil crust	NEED								
water resources (very broad category; only resources needing monitoring are identified)	NEED								
water quality	NEED								
water quantity	NEED								
FEATURES AND OBJECTS									
paleontological resources	NEED								
SENSORY RESOURCES									
soundscape	PAST								
PARK VISITORS									
No Need									

Fossil Butte National Monument (FOBU) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	FOBU	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
EXOTIC AND INVASIVE PLANTS AND ANIMALS									
Invasive Plant Species									
Alopecurus arundinaceus	NEED								
Bromus spp. (as a group)	NEED								
Carduus nutans (musk thistle)	PAST	9	1994	C. Kyte, NPS Seasonal Biotechnician	7+	yes			population count data for most years since 1994
Centurea maculosa (spotted knapweed)	PAST	9	1994	C. Kyte, NPS Seasonal Biotechnician	7+	yes			population count data for most years since 1994
Circium canadensis (Canada thistle)	PAST	9	1994	C. Kyte, NPS Seasonal Biotechnician	7+	yes			population count data for most years since 1994
Cyglossum officinale (houndstongue)	PAST	9	1994	C. Kyte, NPS Seasonal Biotechnician	7+	yes			population count data for most years since 1994
Melilotus officinalis (yellow sweetclover)	PAST	9	1994	C. Kyte, NPS Seasonal Biotechnician	7+	yes			population count data for most years since 1994
Sonchus uliginosus (perennial sow-thistle)	PAST	9	1994	C. Kyte, NPS Seasonal Biotechnician	7+	yes			population count data for most years since 1994
Verbascum thapsus (Woolly mullein)	PAST	9	1994	C. Kyte, NPS Seasonal Biotechnician	7+	yes			population count data for most years since 1994
Exotic plant/Native plant interactions	NEED								

Fossil Butte National Monument (FOBU) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	FOBU	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Invasive Animal Species									
No Need									
HERBIVORY AND TRAMPLING BY LARGE MAMMALS									
Wildlife	NEED								
NPS DEVELOPMENT AND INFRASTRUCTURE									
No Need									
NPS MANAGEMENT ACTIONS									
vegetation rehabilitation	NEED								
weed control	NEED								
elimination of grazing	NEED								
fire suppression	NEED								
ADJACENT LAND-USE ACTIVITIES									
soil chemistry/contamination	NEED								
NATURAL DISTURBANCES									
insects/pathogens	NEED								

Fossil Butte National Monument (FOBU) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	FOBU	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
MISCELLANEOUS									
erosion/altered sedimentation (need better clarification)	PAST	18	1985	Andrew Banta, FOBU Chief Ranger; Rick Inglis, WASO WRD Staff; Clayton Kyte, FOBU Seasonal Biotechnician	5+	a land survey made in 1995 exists, butthere are no GIS data			In 1995, the channel cross-section and longitudinal profile was surveyed in 5 locations along Chicken Creek in order to establish baseline conditions; erosion in other locations has been monitored photographically since 1985.

Golden Spike National Historic Site (GOSP) Natural Resource Monitoring Status Summary

YES *= current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed*

Resource or Stressor of Concern	GOSP	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
POPULATIONS/SPECIES									
AQUATIC									
No need									
TERRESTRIAL									
Birds									
sage grouse	NEED		?				UT - DWR	Need to contact	
Mammals									
No Need									
Plants									
T & E Species									
Sensitive Plant Species									
Sensitive plants-general									
Allium passeyi (Passey Onion)	NEED								
Reptiles									
No Need									
Invertebrates									
No Need									

Golden Spike National Historic Site (GOSP) Natural Resource Monitoring Status Summary

YES *= current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed*

Resource or Stressor of Concern	GOSP	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
ECOSYSTEMS									
Riparian-Wetland and Aquatic Ecosystems									
No Need									
Upland Ecosystems									
Vegetation communities-general	NEED								
grasslands	NEED								
shrublands	NEED								
Cave Ecosystems									
No Need									
ECOLOGICAL RESOURCES OR CONDITIONS									
air quality conditions	NEED ?								visibility
water quality	NEED ?								
FEATURES AND OBJECTS									
No Need									
SENSORY RESOURCES									
No Need									
PARK VISITORS									
No Need									

Golden Spike National Historic Site (GOSP) Natural Resource Monitoring Status Summary

YES *= current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed*

Resource or Stressor of Concern	GOSP	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
EXOTIC AND INVASIVE PLANTS AND ANIMALS									
Invasive Plant Species									
Invasive Plants - General	NEED								
Bromus spp. (as a group)	NEED								
Exotic plant/Native plant interactions	NEED								
Invasive Animal Species									
No Need									
HERBIVORY AND TRAMPLING BY LARGE MAMMALS									
Livestock	NEED								
NPS DEVELOPMENT AND INFRASTRUCTURE									
No Need									
NPS MANAGEMENT ACTIONS									
vegetation rehabilitation	NEED								
weed control	NEED								YNP, EPMT doing work at GOSP
prescribed fire	**YES**	3	2000-2002	Zion NP, Henry Bastin		5			Fire Effects Monitoring
ADJACENT LAND-USE ACTIVITIES									
industrial pollution	NEED								nearby industry
housing development	NEED								future concern

Golden Spike National Historic Site (GOSP) Natural Resource Monitoring Status Summary

YES *= current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed*

Resource or Stressor of Concern	GOSP	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
NATURAL DISTURBANCES									
natural disturbance, general									
fire	NEED								
regeneration after burns	**YES**	3	2000-2002	Zion NP, Henry Bastin		5			Fire Effects Monitoring

Hovenweep National Monument (HOVE) Natural Resource Monitoring and Stressor Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	HOVE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
POPULATIONS/SPECIES									
AQUATIC									
Aquatic Invertebrates	YES	3	1999-present	Charles Schelz, park biologist	3	yes		BLM Moab District aquatic invertebrate monitoring	Associated with SEUG water quality monitoring program
	YES	9	1993-present	Charles Schelz, park biologist	4	yes	Utah DEQ		
Amphibians -general	NEED								
TERRESTRIAL									
Birds									
neotropical migrants-general	NEED								
Raptors-general	NEED								
TES Bird Species - general	NEED								
Southwestern willow flycatcher	NEED								
sage grouse	NEED								
Mexican spotted owl	NEED								
golden eagle	NEED								
Mammals									
Small mammals -general	NEED								
predators	NEED								
bats	NEED								

Hovenweep National Monument (HOVE) Natural Resource Monitoring and Stressor Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	HOVE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Plants									
T & E Species									
No Need									
Sensitive Plant Species									
No Need									
Other Plant Species of Concern									
No Need									
Reptiles									
lizards	NEED								
General reptiles	NEED								
Invertebrates									
Terrestrial Invertebrates	NEED								
ECOSYSTEMS									
Riparian-Wetland and Aquatic Ecosystems									
Aquatic Ecosystems-general	YES	3	1999-present	Charles Schelz, park biologist	3	yes		BLM Moab District aquatic invertebrate monitoring	Associated with SEUG water quality monitoring program
	YES	9	1993-present	Charles Schelz, park biologist	4	yes	Utah DEQ		

Hovenweep National Monument (HOVE) Natural Resource Monitoring and Stressor Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	HOVE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
wetlands	NEED								
riparian zone	NEED								
	YES	9	1993-present	Charles Schelz, park biologist	4	yes	Utah DEQ		
seeps, springs, & hanging gardens	NEED								
Upland Ecosystems									
Vegetation communities-general	YES	3	1989-present	Charles Schelz, park biologist	4	yes			Modified Daubenmire transects, surveyed annually.
grasslands	YES	3	1989-present	Charles Schelz, park biologist	4	yes			Modified Daubenmire transects, surveyed annually.
shrublands	YES	3	1989-present	Charles Schelz, park biologist	4	yes			Modified Daubenmire transects, surveyed annually.
Cave Ecosystems									
No Need									
ECOLOGICAL RESOURCES OR CONDITIONS									
air quality conditions	YES								
climatic conditions	YES	22	1990-present	park staff	1	yes	NOAA		Daily weather data from near visitor center.

Hovenweep National Monument (HOVE) Natural Resource Monitoring and Stressor Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	HOVE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
general soil and soil crust	YES	3	1989-present	Charles Schelz, park biologist	4	yes			Modified Daubenmire transects, surveyed annually.
water resources (very broad category; only resources needing monitoring are identified)	YES								
	YES				4	yes	Utah DEQ		
water quality	YES	3	1999-present	Charles Schelz, park biologist	3	yes	Utah Division of Water Quality		Quarterly or monthly monitoring of springs, seeps and streams.
	YES	9	1993-present	Charles Schelz, park biologist	4	yes	Utah DEQ		
water quantity	NEED								
FEATURES AND OBJECTS									
paleontological resources	NEED								
SENSORY RESOURCES									
night sky	YES	new	2002-present	Charles Schelz, park biologist	1				Night sky light levels will be measured by a quarter-sky charged coupled device high-resolution camera.
soundscape	NEED								

Hovenweep National Monument (HOVE) Natural Resource Monitoring and Stressor Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	HOVE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
PARK VISITORS									
terrestrial recreation	NEED								
EXOTIC AND INVASIVE PLANTS AND ANIMALS									
Invasive Plant Species									
Invasive Plants - General	NEED								
Bromus spp. (as a group)	NEED								
Centaurea repens (Russian knapweed)	NEED								
Eleagnus angustifolia (Russian Olive)	NEED								
Melilotus officinalis (yellow sweetclover)	NEED								
Tamarix ramossima (tamarisk)	NEED								
Invasive Animal Species									
brown-headed cowbird (exotic)	NEED								
HERBIVORY AND TRAMPLING BY LARGE MAMMALS									
No Need									
NPS DEVELOPMENT AND INFRASTRUCTURE									
No Need									

Hovenweep National Monument (HOVE) Natural Resource Monitoring and Stressor Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	HOVE	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
NPS MANAGEMENT ACTIONS									
vegetation rehabilitation	NEED								
weed control	NEED								
ADJACENT LAND-USE ACTIVITIES									
No Need									
NATURAL DISTURBANCES									
natural disturbance, general	NEED								
regeneration after burns	NEED								
MISCELLANEOUS									
erosion/altered sedimentation (need better clarification)	NEED								

Natural Bridges National Monument (NABR) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	NABR	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
POPULATIONS/SPECIES									
AQUATIC									
Aquatic Invertebrates	YES	5	1997-present	Charles Schelz, park biologist	3	yes		BLM Moab District aquatic invertebrate monitoring	Associated with SEUG water quality monitoring program
	YES	10	1993-present	Charles Schelz, park biologist	4	yes	Utah DEQ		
Amphibians -general	NEED								
TERRESTRIAL									
Birds									
neotropical migrants-general	YES	10	1993-present	Sonya Daw (park biotech)	2	yes			Variable circular plot point counts in riparian habitats.
Raptors-general	YES	20	1983-present	William Sloan (park biotech) and others	not fixed	partial			Monitoring 8 taxa including 3 TES species; multiple investigators, monitoring techniques and objectives.
TES Bird Species - general	YES	20	1983-present	William Sloan (park biotech) and others	not fixed	partial			Monitoring 8 taxa including 3 TES species; multiple investigators, monitoring techniques and objectives.

Natural Bridges National Monument (NABR) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	NABR	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Southwestern willow flycatcher	NEED								
peregrine falcon	YES	20	1983-present	William Sloan (park biotech) and others	not fixed	partial			Monitoring 8 taxa including 3 TES species; multiple investigators, monitoring techniques and objectives.
Mexican spotted owl	NEED								
golden eagle	NEED								
Northern goshawk	NEED								
Mammals									
Small mammals -general	PAST	7	1987-1993	Charlie Schelz, Park Biologist	2	no			Trapping webs (204 traps on 10 radiating lines) were sampled yearly.
predators	NEED								
bats	NEED								
Plants									
Sensitive Plant Species									
Carex speculifera (Navajo Sedge)	NEED								

Natural Bridges National Monument (NABR) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	NABR	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Erigeron kachinensis (Kachina Daisy)	YES	12	1990-2001	Loreen Woolstenhulme	6	No	Brigham Young Univ.		These plots are monitoied approx. every 2 years.
	YES	2	1988-1989	Jayne Belnap	4	No			No followup after 1989
Habenaria zothecina (Alcove Bog-Orchid)	NEED								
Zigadenus vaginatus (Alcove Death Camas)	NEED								
Other Plant Species of Concern									
No Need									
Reptiles									
lizards	NEED								
General reptiles	PAST	3	1990-1993	Tim Graham	1	?			Rattlesnake monitoring near housing.
Invertebrates									
Terrestrial Invertebrates	NEED								

Natural Bridges National Monument (NABR) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	NABR	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
ECOSYSTEMS									
Riparian-Wetland and Aquatic Ecosystems									
Aquatic Ecosystems-general	YES	5	1997-present	Charles Schelz, park biologist	3	yes		BLM Moab District aquatic invertebrate monitoring	Associated with SEUG water quality monitoring program
	YES				4	yes	Utah DEQ		
wetlands	YES	10	1993-present	Charles Schelz, park biologist					
	NEED								
riparian zone	YES	10	1993-present	Charles Schelz, park biologist	4	yes	Utah DEQ		
	NEED								
seeps, springs, & hanging gardens	YES	12	1990-2001	Loreen Woolstenhulme	6	No	Brigam Young Univ.		These plots are monitoied approx. every 2 years.
	YES	2	1988-1989	Jayne Belnap	4	No			No followup after 1989
	YES	10	1993-present	Charles Schelz, park biologist	4	yes	Utah DEQ		
Upland Ecosystems									
Vegetation communities-general	YES	20	1983-present	Charles Schelz, park biologist	3	yes			Modified Daubenmire transects, surveyed annually.
forest									
grasslands									

Natural Bridges National Monument (NABR) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	NABR	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
shrublands	YES	20	1983-present	Charles Schelz, park biologist	3	yes			Modified Daubenmire transects, surveyed annually.
relict areas	NEED								
	PAST	1	1989	Charles Schelz, park biologist					Relict vegetation site descriptions
Cave Ecosystems									
No Need									
ECOLOGICAL RESOURCES OR CONDITIONS									
climatic conditions	YES	22	1990-present	park staff	1	yes	NOAA		Daily weather data from near visitor center.
general soil and soil crust	YES	20	1983-present	Charles Schelz, park biologist	3	yes			Modified Daubenmire transects, surveyed annually.
water resources (very broad category; only resources needing monitoring are identified)	YES								
	YES	10	1993-present	Charles Schelz, park biologist	4	yes	Utah DEQ		
water quality	YES	19	1983-present	Charles Schelz, park biologist	3	yes	Utah Division of Water Quality		Quarterly or monthly monitoring of springs, seeps and streams.

Natural Bridges National Monument (NABR) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	NABR	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
	YES	10	1993-present	Charles Schelz, park biologist	4	yes	Utah DEQ		
water quantity	NEED								
FEATURES AND OBJECTS									
paleontological resources	NEED								
SENSORY RESOURCES									
night sky	YES	new	2002-present	Charles Schelz, park biologist	1				Night sky light levels will be measured by a quarter-sky charged coupled device high-resolution camera.
soundscape	NEED								
PARK VISITORS									
aquatic recreation	NEED								
terrestrial recreation	NEED								
EXOTIC AND INVASIVE PLANTS AND ANIMALS									
Invasive Plant Species									
Invasive Plants - General	NEED								
Bromus spp. (as a group)	NEED								
Centaurea repens (Russian knapweed)	NEED								

Natural Bridges National Monument (NABR) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	NABR	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Eleagnus angustifolia (Russian Olive)	NEED								
Melilotus officinalis (yellow sweetclover)	NEED								
Tamarix ramossima (tamarisk)	NEED								
Invasive Animal Species									
brown-headed cowbird (exotic)	NEED								
HERBIVORY AND TRAMPLING BY LARGE MAMMALS									
No Need									
NPS DEVELOPMENT AND INFRASTRUCTURE									
trail construction	NEED								
NPS MANAGEMENT ACTIONS									
vegetation rehabilitation	NEED								
weed control	NEED								
ADJACENT LAND-USE ACTIVITIES									
No Need									
NATURAL DISTURBANCES									
natural disturbance, general	NEED								

Natural Bridges National Monument (NABR) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	NABR	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
MISCELLANEOUS									
erosion/altered sedimentation (need better clarification)	NEED								

Pipe Spring National Monument (PISP) Natural Resource and Stressor Monitoring Status Summary

YES *= current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed*

Resource or Stressor of Concern	PISP	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
POPULATIONS/SPECIES									
AQUATIC									
Aquatic Invertebrates	NEED								
Amphibians -general	NEED								
TERRESTRIAL									
Birds									
neotropical migrants-general	NEED								In consultation with the researcher who recently finished our baseline inventory (Matthew Johnson from CPCESU), while this **is** a need it would be most useful as part of a regional effort, ie, the entire Arizona Strip.
Mammals									
Small mammals -general	NEED								
bats	NEED								
Plants									
T & E Species									
No Need									

Pipe Spring National Monument (PISP) Natural Resource and Stressor Monitoring Status Summary

YES *= current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed*

Resource or Stressor of Concern	PISP	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Sensitive Plant Species									
No Need									
Other Plant Species of Concern									
No Need									
Reptiles									
General reptiles	NEED								
Invertebrates									
No Need									
ECOSYSTEMS									
Riparian-Wetland and Aquatic Ecosystems									
seeps, springs, & hanging gardens	YES	32	1970-present	Monument staff	3 to 4	unknown			Measurement of spring flows.
	YES		unknown	AZ Dept. of Water Resources	5	yes	AZ Dept. of Water Resources		Culinary water and springs are monitored for public health protection

Pipe Spring National Monument (PISP) Natural Resource and Stressor Monitoring Status Summary

YES *= current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed*

Resource or Stressor of Concern	PISP	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
	PAST	20	1977-1996	Richard Inglis, Water Resources Div.	4	unknown			Evaluation of Monitoring data of 4 spring flows within the monument and 3 well levels near the monument.
Upland Ecosystems									
Vegetation communities-general	NEED								A complete baseline plant inventory is still needed. We have secured funding for increasing native seed and restoring portions of the monument.
Cave Ecosystems									
No Need									

Pipe Spring National Monument (PISP) Natural Resource and Stressor Monitoring Status Summary

YES *= current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed*

Resource or Stressor of Concern	PISP	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
ECOLOGICAL RESOURCES OR CONDITIONS									
water resources (very broad category; only resources needing monitoring are identified)	NEED							Margot Truini, USGS Flagstaff	Several geohydrologic studies have been conducted to attempt to determine aquifer extent and flow paths. A monintoring plan incorporating spring flows, well levels, and precipitation needs to be developed.
water quantity	**YES**	>26 yrs	at least since 1976	PISP	4	**YES**			since 1976, park has documented decline in spring discharge
FEATURES AND OBJECTS									
No Need									
SENSORY RESOURCES									
No Need									
PARK VISITORS									
No Need									

Pipe Spring National Monument (PISP) Natural Resource and Stressor Monitoring Status Summary

YES *= current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed*

Resource or Stressor of Concern	PISP	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
EXOTIC AND INVASIVE PLANTS AND ANIMALS									
Invasive Plant Species									
Invasive Plants - General	NEED								
Invasive Animal Species									
No Need									
HERBIVORY AND TRAMPLING BY LARGE MAMMALS									
No Need									
NPS DEVELOPMENT AND INFRASTRUCTURE									
No Need									
NPS MANAGEMENT ACTIONS									
vegetation rehabilitation	NEED								We have secured funding for increasing native seed and restoring portions of the monument. Revegetation work occurs as an occasional result of maintenance activities.

Pipe Spring National Monument (PISP) Natural Resource and Stressor Monitoring Status Summary

YES *= current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed*

Resource or Stressor of Concern	PISP	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
ADJACENT LAND-USE ACTIVITIES									
No Need									
NATURAL DISTURBANCES									
No Need									

Timpanogos Cave National Monument (TICA) Natural Resource Monitoring and Stressor Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	TICA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
POPULATIONS/SPECIES									
AQUATIC									
No Need									
TERRESTRIAL									
Birds									
No Need									
Mammals									
bats	NEED								concern over status of bats in cave
Plants									
T & E Species									
No Need									
Sensitive Plant Species									
Jamesia americana var. macrocalyx (Wasatch Jamesia)	NEED								
Other Plant Species of Concern									
No Need									

Timpanogos Cave National Monument (TICA) Natural Resource Monitoring and Stressor Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	TICA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Reptiles									
No Need									
Invertebrates									
No Need									
ECOSYSTEMS									
Riparian-Wetland and Aquatic Ecosystems									
No Need									
Upland Ecosystems									
No Need									
grasslands									
Cave Ecosystems									
Cave environmental conditions	YES	11	1991 - present	Jon Jasper & park seasonals	6	yes			Temp/ rH monitoring, in selecteted cave locations.
	FUTURE		2003		TBD				new study on air and water flow in cave
Water Quantity	YES	11	1991- present	Jon Jasper, NPS					Cave Drip Rate Study; tip bucket
Water Quality	NEED								

Timpanogos Cave National Monument (TICA) Natural Resource Monitoring and Stressor Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	TICA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Biologic Communities	FUTURE		2003						cave microbial study; starts in 2003
	NEED								
Cave Formations	NEED	3	1999-present	Jim & Val Werker, retirees	110	yes	Canon		Long term Photomonitoring Points; TICA interested in assistance w/ photo monitoring plan
Cave Soundscape	NEED								concerned with noise from lights & people in cave
ECOLOGICAL RESOURCES OR CONDITIONS									
air quality conditions	PAST		1995-2001	Air Resource Specialist & UC Davis	1	no			Particulate and visualibilty; Lone Peak Station; Station Removed in 2001
	NEED								concerned with arsnic from Geneva Steele

Timpanogos Cave National Monument (TICA) Natural Resource Monitoring and Stressor Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	TICA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
climatic conditions	YES	11	1991-present	Rip Griffin, State Avalanche Forcaster	1	no			Automated Weather Station used before Avalache Forecasting, Station on USFS above TICA
water resources (very broad category; only resources needing monitoring are identified)	NEED								
water quality	PAST	1	1999	Water Resources Division	31	no		Uinta National Forest	Basic water quality
	YES	2	1990-1991	Water Resource Division, NPS					Other water quality study performed by FS and PacifiCorps, ? -present - outside park
water quantity	YES	?	?	USFS	?		USFS		gaging station upstream of TICA at Little Mill Campground
FEATURES AND OBJECTS									
No Need									

Timpanogos Cave National Monument (TICA) Natural Resource Monitoring and Stressor Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	TICA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
SENSORY RESOURCES									
soundscape (cave)	NEED								
PARK VISITORS									
other visitor actions	NEED								social trails in picnic area; restoration site
other visitor actions	NEED								unauthorized ORV & snowmobile use
other visitor actions (cave)	NEED								concerned with vandalism, & touching cave formations
EXOTIC AND INVASIVE PLANTS AND ANIMALS									
Invasive Plant Species									
Invasive Plants - General	**YES**	2	2000 - present	Jon Jasper - RM Specialist	3 to 7	partial		Uinta National Forest	GIS map of Invasive Plants and Photo plots
Cardaria draba (White top)	NEED								
Centurea maculosa (spotted knapweed)	NEED								
Cyglossum officinale (houndstongue)	NEED								
Lepidium latifolium (Perennial Pepperweed)	NEED								
Melilotus officinalis (yellow sweetclover)	NEED								

Timpanogos Cave National Monument (TICA) Natural Resource Monitoring and Stressor Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	TICA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Verbascum thapsus (Woolly mullein)	NEED								
Exotic plant/Native plant interactions	PAST								
Invasive Animal Species									
fauna introductions	NEED								concerned with introduction of mountain goats by state DWR
HERBIVORY AND TRAMPLING BY LARGE MAMMALS									
No Need									
NPS DEVELOPMENT AND INFRASTRUCTURE									
other NPS development actions	NEED								
NPS MANAGEMENT ACTIONS									
other NPS development actions	NEED								concerns assoc. with proposed interagency visitor center
ADJACENT LAND-USE ACTIVITIES									
No Need									

Timpanogos Cave National Monument (TICA) Natural Resource Monitoring and Stressor Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	TICA	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
NATURAL DISTURBANCES									
No Need									
MISCELLANEOUS									
No Need									

Zion National Park (ZION) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	ZION	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
POPULATIONS/SPECIES									
AQUATIC									
TES and native fish species	**YES**	9	1994-present	Rick Fridell, Utah D	2	no	VirginRiver Res. Mgt. And Recovery Program		Combined Native and T&E fish moniotoring. One additional site on North Creek is monitored downstream of the park. 3-4 additional sites are planned for 2002-2005 on N Fk Virgin River to monitor the effects of channel restoration.
	YES	9	1994-present	Rick Fridell, Utah Division of Wildlife Res.	2	no	VirginRiver Res. Mgt. And Recovery Program		Combined Native + T&E fish monitoring. One additional site on North Creek is monitored downstream of the park. 3-4 additional sites are planned for 2002-2005 on the N FkVirgin River to monitor the effects of channel restoration.
Aquatic Invertebrates	NEED								

Zion National Park (ZION) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	ZION	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Amphibians -general	NEED								
TERRESTRIAL									
Birds									
neotropical migrants-general	YES	5	1997-2001	Hunnicutt, Showler	10	yes		UT Division of Wildlife	point counts
	YES	UNK	unk-present?	UT Division of Wildlife	1	yes			Parunuweap
	YES	31	1962-present	Showler and other park personnel	1	no			Xmas Bird Count (15 mile diameter centered on HQ)
	PAST	3	1998-2000	Hunnicutt	5	yes	USGS - BRD (Van Riper)		mist nets
Southwestern willow flycatcher	YES	4	1998-2000, 2002-present	Hunnicutt, Friggens, Crow, Maller, Kim, etc.	1 to 4	yes		UT Division of Wildlife	
peregrine falcon	YES	28	1975-present	Tibbits, Hays, Hutchins, Hetzler, Sinton	2 to 19	yes		UT Division of Wildlife	
Mexican spotted owl	YES	11	1988, 1991, 1995, 1997-present	Hughes, Hetzler, Orth, Murphy	4 to 16	yes			
	PAST	2	1992-1993	Willey	2	no	Other NPS canyon parks		Juvenile spotted owls
	PAST	2	1997-1998	Swarthout, Steidl	11	no			Flush response to hikers

Zion National Park (ZION) Natural Resource and Stressor Monitoring Status Summary

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Resource or Stressor of Concern	ZION	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
	NEED							Dave Willey, U. of Montana	Need study looking at canyoneering use and effects on individual owls and territory use throughout time
Northern goshawk	PAST	3	1993, 1999-2000	Friggens, Orth, Sinton	8	yes			nests in GIS
	NEED								Consistent monitoring plan, especially regarding prescribed burns
Mammals									
Small mammals -general	PAST	5	1997-2000	Hunnicutt	8 to 11	yes			All sites done near roads or trails.
	NEED								Need robust, repeatable methodology. Will be combined with plants, possibly in 2003.
	NEED								Monitoring with respect to future Virgin River riparian restoration project.
ungulates	YES	5	1998-present	Sharon Kim					Elk and deer monitoring data

Zion National Park (ZION) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	ZION	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
bighorn sheep	PAST	3	1977-1979	McCutcheon	2	no			Aerial survey
	PAST	6	1991-1996	McCutcheon, Fedorchak, Hays, King, Viera	1	yes			Radiotelemetry and visual sightings
	PAST	2	1995-1996	Hart	1	no			habitat use & vigilance
	NEED							UT Division of Wildlife	Aerial survey
mule deer	PAST	3	1966-1968	Moorhead	2 of 3	no			summer and winter migration
	PAST	7	1979, 1982, 1986, 1988, 1990-1992	Mitchell, Argin, Cunningham, Manus	1	no			road census of main Zion Cyn.
	PAST	3	1992-1994	Fedorchak, Cooper, Pruett, etc.	1	no			pink eye disease surveillance
	NEED								To continue road census of main Zion Cyn. Due to increased aggression and food begging.
elk	**YES**	unk	unk-present	UT Division of Wildlife	1	no			Aerial survey done every 3 years in January or February.

Zion National Park (ZION) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	ZION	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
	YES	3	1998, 1999, 2001	Hunnicutt, Kim	4	yes			Elk use after burning. Methodology will be relooked at. May also be only done every other year.
carnivores	NEED								General monitoring project.
mountain lion	NEED								Monitoring of mountain lions in developed areas
gray fox and ringtail	PAST	2	1967-1968	Trapp	1	no			
bats	YES	5	1998-present	Haraden	4	no			Weeping Rock, Coalpits, Pond on K-T Road, Behind Haraden's house
	NEED								Robust design and representative coverage of entire park
Plants									
T & E Species									
Astragalus erectimus var. *ampullarioides* (Shivwits Milkvetch)	NEED	1 season in 2002 - April	mid to late April	Jason Alexander, Phd candidate Oregon State Univ and Denise Louie, ZION Veg Specialist	n/a	n/a	USFWS, Larry England - SLC office	Renee Van Buren, Utah Valley State College	We attempted a survey this spring but environ conditions were too poor for the plant to even emerge.

Zion National Park (ZION) Natural Resource and Stressor Monitoring Status Summary

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Resource or Stressor of Concern	ZION	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Sensitive Plant Species									
Sensitive plants-general	**YES**	4	1998 to 2001	Henry Bastian, ZION Fire Ecologist	3	yes			Related to prescribed fire.
Aquilegia fosteri	NEED								
Asplenium adiantum-nigrum	NEED								
Carex haysii	NEED								
Draba asprella var. *zionensis*	NEED								
Epilobium nevadense	NEED								
Erigerson canaani	NEED								
Erigeron religiosus	NEED								
Erigeron sionis	NEED								
Eriogonum jamesii var. *rupicola*	NEED								
Eriogonum thompsoniae var. *albiflorum*	NEED								
Eriogonum thompsoniae var. *matthewsiae*	NEED								
Eriogonum zionis var. *zionis*	NEED								
Heterotheca jonesii	NEED								
Jamesia americana var. *zionis*	NEED								
Lupinus latifolius ssp. *leucanthus*	NEED								
Pediomelum pariense	NEED								
Penstemon humilis ssp. *obtusifolius*	NEED								
Penstemon leonardii var. *higginsii*	NEED								

Zion National Park (ZION) Natural Resource and Stressor Monitoring Status Summary

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Resource or Stressor of Concern	ZION	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Phacelia cephalotes	NEED								
Phacelia rafaelensis	NEED								
Sphaeromeria ruthiae	NEED								
Viola charlestonensis	NEED								
Other Plant Species of Concern									
No Need									
Reptiles									
lizards	PAST	3	1997-1999	Sharon Kim	11	yes			Discontinued due to low success and need to look at different methodology.
Desert tortoise	**YES**	1	2002-present	Sharon Kim	1	yes			2002 was pilot year.
General reptiles	NEED								Robust methodology.
Invertebrates									
Terrestrial Invertebrates	NEED								
ECOSYSTEMS									
Riparian-Wetland and Aquatic Ecosystems									

Zion National Park (ZION) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	ZION	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Aquatic Ecosystems-general	YES	1997-present	6	Rick Freidell, State of Utah, DWR					
	NEED								
wetlands	NEED								
riparian zone	NEED								
seeps, springs, & hanging gardens	YES	5	1997thru present	Dr. Vicky Meretsky, Professor Indiana State Univ	4	yes	NPS - ZION	Larry Stevens, (consulting co.) and John Spence - GLCA	Southwestern springs vegetation: biogeography, human impacts, and restoration.
	YES								An independent researcher, Vicky Meretski from Univ. of Indiana has monitored wetland ecosystems at several springs and seeps in the park for 1998-2002. This work is not funded by NPS, and the park does not have the means to continue it now that Dr. Mere

Zion National Park (ZION) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	ZION	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
	YES	1 season, summer 2002	June, July	Jason Alexander, Amber Hughes, former ZION biotech, Denise Louie	16 gardens in Zion Canyon	Yes		John Spence, GLCA Ecologist	Work followed after Hanging Gardens of ZNP (Welsh 1989) to include photo monitoring and species lists. Particular focus was placed on the presence of exotic plant species.
	PAST	2	summer 1988; winter and spring 1989	Dr. Stanley Welsh, Professor BYU	20 Mostly in Zion Canyon	No	NPS Water Resources Division		
	NEED								
Upland Ecosystems									
Vegetation communities-general	YES			Elena Robisch					
relict areas	NEED								

Zion National Park (ZION) Natural Resource and Stressor Monitoring Status Summary

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Resource or Stressor of Concern	ZION	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
Cave Ecosystems									
No Need									
ECOLOGICAL RESOURCES OR CONDITIONS									
air quality conditions	YES			Dave Sharrow					
	YES	3	1999 thru 2001	BOR, Nature Serve	300+	yes	NPS - ZION	NPCN Network	I&M Veg Mapping Project established over 300 permanent plots with photo points and cover data.
	PAST	2	1996 and 1997	Laurie Kurth (former Zion Botanist)	33	no			Plots established mostly in PIPO and riparian ecosystems. We need assistance in how to continue this project in a meaningful way. No photos taken and permanency/repeatability of plots questionable.

Zion National Park (ZION) Natural Resource and Stressor Monitoring Status Summary

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Resource or Stressor of Concern	ZION	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
	PAST	3	1987thru 1989 (analyses of field data continues into 2002)	Dr. Kimball Harper, former professor BYU	289	yes	BYU, USDA Forest Service	BOR, Nature Serve	Vegetation mapping of ZION includes detailed analyes and descriptions of 10 vegetation communities
air quality conditions, passive ozone	YES	3	1995-present	NPS/AQD	3	unk	Research Triangel Institute (contractor)		Passive Ozone monitoring during the summer months. Plans are to begin continuous ozone monitoring in 2002 at one site.
air quality conditions, IMPROVE	YES	1	2000-present	NPS/AQD	1	unk			IMPROVE particulate and visibility monitor installed in the summer of 2000.
climatic conditions	YES	75	1928-present	USNOAA	1	unk	National Oceanic and Atmospheric Admin.		National Weather Service Site at ZION HQ. An automated RAWS site will be added near this location in 2002.

Zion National Park (ZION) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	ZION	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
climatic conditions	YES	37	1965-present	Zion NP	1	unk	none	NOAA	Lavapoint site. Manual 1965-1995. Automated RAWS site 1995 to present
water resources (very broad category; only resources needing monitoring are identified)	NEED								
water quality	PAST	2	2000-2001	Dave Sharrow					Zion bacterial water quality data
water quality	PAST	2	2000-2001	ZION NP	17	no	Univ. of Washington. Southern Utah Univ Water Lab.		NPS-WRD Funded study of bacterial water qulaity conditions. 375 samples analyzed, 83% from 8 sites.
water quality	YES	3	2000-present	Utah Division of Water Quality	2	no	Utah Div. Of Water Quality		State Water Quality Monitoring program. Several additional sites to be added soon.
	YES	1.5 yrs	2000-2001	Dave Sharrow, hydrologist, ZION				Utah DEQ Forest Service	
	NEED								
water quantity, North Fork Virgin R.	YES	75	1927-present	USGS	1	unk	USGS		

Zion National Park (ZION) Natural Resource and Stressor Monitoring Status Summary

YES = current monitoring in park; PAST = previous monitoring in park; NEED = monitoring needed

Resource or Stressor of Concern	ZION	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
water quantity, East Fork VR	YES	6	1997-present	USGS	1	unk	USGS. Utah Div. Of Water Res.		1/4 paid for by NPS, 1/4 paid for by State of Utah
water quantity, North Creek	PAST	15	1884-1993	USGS	1	unk			Site on North Creek downstream of park
	NEED							USGS	Several gages have been active in past
FEATURES AND OBJECTS									
paleontological resources	NEED								
SENSORY RESOURCES									
night sky	NEED								
soundscape	NEED								
PARK VISITORS									
terrestrial recreation	NEED	2	Summer 2000 and 2002	Pam Foti, Professor NAU	2	yes	NAU	Grand Staircase Escalante NM w/ Pam Foti; Univ. of Montana w/ Wayne Freimund; Grand Canyon-Parachant in future	No formal report has been delivered yet, study is still in progress.

Zion National Park (ZION) Natural Resource and Stressor Monitoring Status Summary

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Resource or Stressor of Concern	ZION	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
EXOTIC AND INVASIVE PLANTS AND ANIMALS									
Invasive Plant Species									
Invasive Plants - General	NEED	Needs include monitoring efficacy of control treatments; Rate of spread of Bromus sp. And Cardaria draba, Melilotus sp.; Early detection monitoring of highly invasive sp. Like knapweed and yellow starthistle;							
Bromus spp. (as a group)	NEED								
Cardaria draba (White top)	NEED								
Melilotus officinalis (yellow sweetclover)	NEED								
Tamarix ramossima (tamarisk)	NEED								
Verbascum thapsus (Woolly mullein)	PAST	2	2000, 2001	Clare Poulsen, former ZION Lead Biotech	5	yes		COPL EPMT	5 plots have been set up to monitor efficacy of control treatments. Monitoring is needed to determine trends of expansion or shrinking of infestation over time.
Exotic plant/Native plant interactions	NEED								Needed especially in riparian and wetland systems.
Invasive Animal Species									
exotic/introduced fish species	**YES**	10	1993-present	Frydell	2	yes	UT Division of Wildlife	Virgin River Technical Team	North and East Creek--includes all fish, native and non-native

Zion National Park (ZION) Natural Resource and Stressor Monitoring Status Summary

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Resource or Stressor of Concern	ZION	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
HERBIVORY AND TRAMPLING BY LARGE MAMMALS									
Native Plants - Livestock Grazing	NEED								Especially in Hop Valley along a perennial stream w/ private in-holding and trespass livestock on park land.
Livestock	NEED								
NPS DEVELOPMENT AND INFRASTRUCTURE									
No Need									
NPS MANAGEMENT ACTIONS									
vegetation rehabilitation	NEED							GLAC (has an elaborate restoration monitoring program)	Monitor success/failure of revegetation efforts and social trail obliteration efforts.
weed control	NEED								Efficacy of control treatments.
elimination of grazing	NEED								What is the lag time before previously grazed lands "recover"?
fire suppression	NEED								

Zion National Park (ZION) Natural Resource and Stressor Monitoring Status Summary

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Resource or Stressor of Concern	ZION	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
prescribed fire	YES	7	1995 - present	National Fire Effects Monitoring Program		yes			Zion Fire Effects Module also serves LAME, BRCA, GOSP, MEVE, GRBA, ARCH
flood control-stream channelization	NEED	Zion is preparing to dechannelize a 2 mile stretch of the N. Fork of Virgin River. Monitoring needs to be initiated for abiotic and biotic features before and after manipulation/restoration of the channel.							
ADJACENT LAND-USE ACTIVITIES									
agricultural water diversion	YES	?	?	Utah Division of Water Resources	2	some	TownofSpringdale, Springdale Connsol. Irrigation Co.		Water diversions at two stream diversion structures are monitored, loosely by the state, generally only inresponse to complaints by other water users.
plants sensitive to air pollution	NEED								
NATURAL DISTURBANCES									
regeneration after burns	YES	8	1995-present	Henry Bastian					Fire effects monitoring

Zion National Park (ZION) Natural Resource and Stressor Monitoring Status Summary

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Resource or Stressor of Concern	ZION	Total Number of Years	Study Period(s)	Investigator	Number of Study Locations in Park	Study Sites in GIS	Existing Study Cooperators	Potential Cooperators or Related Outside Monitoring	Comments
flood	YES	75	1928-present	USGS	2	no	USGS		flood monitoring is captured along with stream flow at two USGS Gages.
Land Slide	YES	12	1995-present (intermittent)	NPS	1	no	Federal Highways Administration		Monitoring of anactive landslide for movement during wet years. Past movement of the slide has blocked the Zion Canyon Scenic Drive 3 times over the last 80 years.
MISCELLANEOUS									
No Need									

VOLUME 2, PART III

Summary of Natural Resource Inventory and Monitoring within Northern Colorado Plateau Network Parks

The following pages present information that has been compiled by park and network staff on inventory and monitoring work conducted in Northern Colorado Plateau parks. Information is organized by natural resource category, and within each category by park unit. The general format is a narrative summary of inventory and monitoring work, which is then followed by a list of related citations and data sets.

Literature citations have been derived from the NPS NatureBib database, a service-wide Internet-based application developed by the I&M Program for managing bibliographic sources. Citations of related data sets have been produced from the Dataset Catalog, an MS-Access database developed by the I&M program for documenting data assemblages. (See Appendix E for more information on these databases.) Both of these databases have extensive additional fields documenting the information sources: what is represented here is only a small portion of the complete records (see Appendix F for examples of complete records).

These summaries represent information that has been compiled to date and are not definitive. As new sources and further information on existing sources are located, these documents and the associated databases will be updated.

In addition, gaps exist in this Phase I version, which are noted in the index below. For example, the section on Earth Sciences contains citations; however, accompanying narratives have not yet been written; some categories are missing information for Dinosaur National Monument; and for some park units there is either no information on file for certain categories or the resource category does not pertain to a park. Gaps will be completed in the Phase II document whenever possible.

PART III Index **Page**

Invertebrate Inventory and Monitoring III - 1
- *No data on file for Golden Spike NHS*

Fish Inventory and Monitoring III – 39
- *No significant fish resources for: Bryce Canyon NP, Cedar Breaks NM,, Colorado NM, Fossil Butte NM, Golden Spike NHS, Hovenweep NM,Pipe Spring NM, and Timpanogos Cave NM*

Reptile and Amphibian Inventory and Monitoring III - 61

Bird Inventory and Monitoring III - 93

PART III Index **Page**

Mammal Inventory and Monitoring III – 143

Vegetation Inventory and Monitoring III – 203
- Summaries not yet completed for Dinosaur NM

Paleontological Resource Inventory and Monitoring III – 297

Earth Sciences Monitoring III – 343
- references only, narratives not yet completed. No data on file for Golden Spike NHS

Climate Monitoring III – 367

Air Quality Monitoring III – 385

Water Quality and Water Quantity Monitoring III – 409

Soundscape Monitoring III – 459
- No data on file for Cedar Breaks NM, Curecanti NRA, Golden Spike NHS, Hovenweep NM, Pipe Spring NM, and Timpanogos Cave NM

Night Sky Monitoring III – 471
- Summaries for Arches NP, Canyonlands NP, Hovenweep NM, and Natural Bridges NM only

Arches National Park - Invertebrates

Aquatic Invertebrates

There have been several, historical faunistic surveys devoted to aquatic invertebrates in Arches National Park. MacMillan (1946) published his notes on southwestern mollusk species in the family Pupullidae presumably from sites in Arches, and Nielson (1970) identified aquatic organisms endemic to rock pocket environments. Selby and Holden (1979) presented preliminary information on the presence or absence of the most common invertebrate species observed at three locations in Salt Wash, and one in Freshwater Canyon. Conner and Kepner (1983) lend some invertebrate information in their single-month, late summer study on fish, invertebrates and water quality and quantity in Canyonlands. Webb (1988) described the aquatic invertebrates in Salt Wash, and a peripheral study was performed by Magnum (1988) which described the benthic invertebrate community in four streams in the vicinity of Arches National Park.

The bulk of the information concerning aquatic organisms in Arches National Park comes from concentrated studies on pothole ecology. Romney (1971) completed his Ph.D. dissertation on the bionomics of a rock pool mosquito (Diptera: Culicidae), which included the first comprehensive biosurvey of all flora and fauna occurring within desert rock pools in and around Arches National Park. Dodson (1987) published his study on animal assemblages in temporary desert rock pools together with an ecological investigation of a biting midge, (Diptera: Ceratopogonidae) from sites in Arches. Twenty years following Romneys' original work, Graham (1991, 1992, Graham et al 1991) began his baseline studies on the community structure and ecosystem processes of pothole ecosystems, using invertebrates as ecological models. This led to specialized studies on branchiopod ecology (Graham 1994, 1995, 1997, 1999, 2001 and Galvin et al 2001), and to the discovery of an undescribed ameronothroid (Acari: Ameronothridae) mite (Norton et al 1997, Graham et al 1998). Data for Grahams' studies is cataloged under DS-SEUG-038.

Long-term monitoring of aquatic macroinvertebrates was initiated in Arches in 1997 in conjunction with the water quality-monitoring program in the Southeast Utah Group national parks. There are five monitoring stations where water samples are collected and where data is gathered on aquatic invertebrates: Salt Wash, Freshwater Spring, Willow Spring, Lower Courthouse and Sleepy Hollow. From 1997 through 2001, sites were sampled four times per year in March, June, September and December. Since 2001, sites are sampled quarterly for aquatic macroinvertebrates in one out of every three consecutive years. Methods and previous efforts are documented by the Resource Management Division, 1994. The MS Access database is catalogued, DS-SEUG-010.1, from 1997 to the present. Schelz (2001) reported on the Salt Creek portion of this monitoring program in preparation for a 2002 Environmental Assessment. Finally, the Utah Division of Wildlife Resources (1998a, b) inventoried the sensitive species and ecosystems in Utah, and included aquatic and terrestrial mollusks from Arches in their species lists.

Terrestrial Invertebrates

Information on terrestrial invertebrates comes chiefly from hanging garden surveys conducted in and around Arches National Park. While these studies focused on the vascular flora associated with seeps and springs along canyon walls, they also identified bee (Superfamily Apoidea) species richness, relative abundance and species-occurrence patterns. Hartman et al. (1993) and Stanton et al (1995), reported on field studies from hanging gardens in Arches and other Colorado Plateau parks, and Fowler et al (1995) suggested management recommendations for hanging gardens in Arches and other plateau parks. Fowler (1995) completed his Ph.D. dissertation on the biogeography of hanging gardens on the Colorado Plateau, which included bee community studies. Bixler (1970)

associated ground dwelling wolf spiders (Lycosidae: Araneae) with various habitats in Arches, and Graham (1988), documented single-leaf ash tree damage by the true bug, *Tropidosteptes* sp. (Hemiptera: Miridae), and correlated the degree of damage with the nearness of trees to park roads. Russel and Guttman (1994) revised the beetle genus Polyphylla (Coleoptera: Scarabidae) north of Mexico which include specimens from Arches National Park.

The Utah Division of Wildlife Resources (1998a, b) inventoried the sensitive species and ecosystems in Utah, and included aquatic and terrestrial mollusks from Canyonlands in their species lists.

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Black Canyon of the Gunnison National Park - Invertebrates

Aquatic Invertebrates

Concern over the potential impacts of river regulation on the benthic community in the Gunnison River led to a study by researchers from the University of Montana, Flathead Lake Biological Station. Stanford and Ward (1989) published a report on the distribution and abundance of stoneflies (Plecoptera), caddisflies (Trichoptera), (Hauer et al 1989) and mayflies (Ephemeroptera), (Ward and Stanford 1990), in response to water regulations. Stanford and Ward (1991a,b) reported the occurrence and significance of the hyporheic zones in the Black Canyon of the Gunnison River, and examined changes in benthic faunal composition, abundance and richness through longitudinal gradients in the river.
Reed and Norton (1962) conducted the one, historical survey of the aquatic insects and plants in the Gunnison River.

Terrestrial Invertebrates

Emmel and Emmel (1964) provided a checklist of the butterflies found in Black Canyon, and another report (author, date unknown) examined the geographical barriers to gene flow in grasshopper species present in Black Canyon.

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Bryce Canyon National Park - Invertebrates

Aquatic Invertebrates

Dorr and Weiss (1994) conducted the only study on aquatic invertebrates in Bryce Canyon National Park. Their survey outlines the distribution and diversity of macroinvertebrate species collected and identified from four sites in the park.

Terrestrial Invertebrates

Mueller (1979) conducted a survey of the occurrence of swallowtail butterflies (Lepidoptera: Papilionidae) and their habitat in and around Bryce Canyon National Park. The data from this study is cataloged under DS-BRCA-0010.

Other studies have focused on economic insects related to baseline information or outbreak status. Raver (1980) documented an evergreen leaf defoliator, the pandora moth, (Lepidoptera: Saturniidae), occurrence in the park. Rasmussen et al (1995) submitted a report on the factors that most affect stand and landscape level susceptibility and risk to mountain pine beetle in southwestern ponderosa pine. Hansen (1997) established baseline information related to forest health by systematically surveying for western spruce budworm (Lepidoptera: Tortricidae), Douglas-fir beetle (Coleptera: Scolytidae) and the fir engraver beetle (Coleoptera: Scolytidae).

Studies on *Drosophila pseudoobscura* (Diptera: Drosophilidae) are documented by a release experiment at Bryce Canyon (Turner 1987), which led to a study to determine the effect this release had on chromosomal polymorphisms in the population (Jeffery et al 1992). The study attempts to correlate genetic changes and stability with long-term climatic factors and associated changes. This is a significant study because it is a continuation of a long-term study begun in the early 1940s by Theodosius Dobzhansky, and which is updated on a decade-ly basis by his co-workers and their students. Dobzhansky was a Russian geneticist who immigrated to the United States, joined Morgans' research group at Cal Tech, and became one of the key figures in the Modern Synthesis. He also collaborated with Sewall Wright in the 1930s and 40s, supplying field data on wild populations of *Drosophila* that Wright analyzed. The annual report details estimated funding for this project, project objectives, progress to date, significant findings, specimen status, and reports to date.

The Utah Division of Wildlife Resources (1998a, b) inventoried the sensitive species and ecosystems in Utah, and included aquatic and terrestrial mollusks from Bryce in their species lists.

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Data Sets

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Canyonlands National Park - Invertebrates

Aquatic Invertebrates

Contributions to the knowledge of the aquatic invertebrates in Canyonlands National Park generally fall into three categories: monitoring studies, studies on pothole ecology and studies associated with the Shiozawa laboratory at BYU. There has been one, historical faunistic survey devoted to aquatic invertebrates by Nielson, (1970), who identified aquatic organisms endemic to rock pocket environments.

Conner and Kepner (1983) lend some invertebrate information in their single-month, late summer study on fish, invertebrates and water quality and quantity in Canyonlands.
A peripheral study was performed by Magnum (1988) which described the benthic invertebrate community in four streams in the vicinity of Canyonlands National Park.
In a survey of the ichthyofaunal communities of the Colorado and Green rivers in Canyonlands National Park, Valdez (1993) associated invertebrate production to the dominant fish habitat types.
Haden et al (1997) conducted a cooperative study between the U.S. DOI and Northern Arizona University on the benthic ecology of the Colorado River system. The focus of the study was to determine the effects of the potential release of warm water on the benthic community in the Colorado River below Glen Canyon dam. The study also covered mass and structure of the benthic community above and below the dam, reaction of certain invertebrate species to elevated water temperatures, and the potential establishment of other macroinvertebrates below the dam in warmer waters.
Spense (1997) submitted a study plan to research the springs and seeps from three National Park service units along the Colorado River corridor: Canyonlands, Glen Canyon and Grand Canyon. His proposal included plans to conduct botanic and macroinvertebrate surveys, though the status of this study plan in unknown.

Long-term monitoring of aquatic macroinvertebrates was initiated in Canyonlands in 1997 in conjunction with the water quality-monitoring program in the Southeast Utah Group national parks. There are nine monitoring stations in the Needles and Maze districts where water samples are collected and where data is gathered on aquatic invertebrates. From 1997 through 2001, sites were sampled four times per year in March, June, September and December. Since 2001, sites are sampled quarterly for aquatic macroinvertebrates in one out of every three consecutive years. There are an additional nine stations in the Salt Creek portion of the Needles district where aquatic invertebrate monitoring occurs. Monitoring of these sites began in the fall of 1998. Schelz (2001) reported on the Salt Creek portion of this monitoring program in preparation for a 2002 Environmental Assessment. Methods and previous efforts are documented by the Resource Management Division, 1994. The MS Access database is catalogued, DS-SEUG-010.2, from 1997 to the present.

Much of the information concerning aquatic organisms in Canyonlands National Park comes from concentrated studies on pothole ecology. Romney (1971) completed his Ph.D. dissertation on the bionomics of a rock pool mosquito (Diptera: Culicidae), which included the first comprehensive biosurvey of all flora and fauna occurring within desert rock pools in and around Canyonlands National Park. Twenty years following Romneys' original work, Graham (1991) began his baseline studies on the community structure and ecosystem processes of pothole ecosystems, using invertebrates as ecological models. This led to specialized studies on branchiopod ecology (Graham 2001 and Galvin et al 2001), and to the discovery of an undescribed ameronothroid (Acari: Ameronothridae) mite (Graham et al 1998). Data for Grahams' studies is cataloged under DS-SEUG-060.

Invertebrate studies from the Green and Colorado rivers in Canyonlands National Park have been conducted in association with D.K. Shiozawa, a biology professor at Brigham Young University, his

colleagues and graduate students. Shiozawa et al (1994) proposed a study to quantify the aquatic invertebrates in selected habitats on these two rivers.
Wolz et al (1995) sampled small pools in the Needles district of Canyonlands National Park in a study with BYU. They identified 37 taxa, provided taxonomic keys for the specimens they collected, and introduced a semi-quantitative sampling protocol for aquatic invertebrates in desert pool habitats.
Jordan et al (1997, 1999) conducted a study in the Green and Colorado rivers in Canyonlands to establish baseline densities of benthic invertebrates in preparation for a long-term biomonitoring program. Four remote sites were sampled on each river and density estimates of meiofauna and macroinvertebrates were estimated. Dominant taxa are listed, together with their analysis of the interactions between habitat, river discharge levels and time. As part of this study, Bray and Shiozawa (1997) tested a semi-quantitative method to quickly evaluate the benthic community on-site. Their results indicated that the new procedure was not as effective when compared to other collection methods.

Terrestrial Invertebrates

With the exception of two biodiversity studies, and a single study on pest status, the terrestrial invertebrate knowledge from Canyonlands generally stems from monitoring studies.
Bixler (1970) associated ground dwelling wolf spiders (Lycosidae: Araneae) with various habitats in Canyonlands, and Opler (1995, 1997) provided a checklist of the butterflies and moths of Canyonlands National Park, though there is no information on methods or study design. Johnson (1983) completed a Ph.D. thesis on the ecology and biogeography of isolated butte communities on the Colorado Plateau. He studied the ant, mammal and reptile fauna of five buttes from sites in Canyonlands National Park and nearby sites in southeastern Utah.

Graham (1985) conducted a study to determine if the grasshopper species, *Schistocerca shoshone* (Orthoptera: Acrididae) was a potential biological control agent for the exotic tamarisk species which thrive in the riparian zones in the southwestern U.S. While he concluded that the grasshoppers' potential as a biological control is limited, he suggested that high insect population years might stress tamarisk populations, especially when coupled with other management techniques.

Hartman et al (1993) proposed a biogeography of invertebrates in hanging gardens of the Colorado Plateau, which included sites in Canyonlands. While these studies focused on the vascular flora associated with seeps and springs along canyon walls, they also identified bee (Superfamily Apoidea) species richness, relative abundance and species-occurrence patterns. Stanton et al (1995a,b) reported on field studies from hanging gardens in Canyonlands and other Colorado Plateau parks, and Fowler et al (1995) suggested management recommendations for hanging gardens in Canyonlands and other plateau parks. Fowler (1995) completed his Ph.D. dissertation on the biogeography of hanging gardens on the Colorado Plateau, which included bee community studies.
Kondratieff (1994) conducted a survey of the common arthropods of Canyonlands National Park and reported on his collection of approximately 5000 insects and arthropods. It is not clear if the study continued beyond the second year of investigation.

Graham and Hill (1998) surveyed grasshopper communities in native and nonnative grasslands of the Colorado Plateau, which included areas in or near Canyonlands National Park. The surveys are part of a preliminary investigation into interactions between grasses, insect herbivores, and insectivores on the Colorado Plateau. Information from this study is expected in the future.

Finally, Graham et al (2001) began an invertebrate study to compare riparian zone condition after a section of road in the Salt Creek area of Canyonlands National Park was closed in 1998. In preliminary comparisons, they noted differences in taxa among samples from the no road, closed road and open road segments of the canyon. Further analysis and study progress is expected. Graham's data is catalogued under DS-SEUG-060.

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Canyonlands National Park - Invertebrates

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Canyonlands National Park - Invertebrates

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Capitol Reef National Park - Invertebrates

Aquatic Invertebrates

Contributions to the knowledge of the aquatic invertebrates in Capitol Reef National Park generally fall into four categories: studies conducted in tinajas or other small water bodies, studies central to the Fremont River and its drainages, monitoring studies, and studies on insect biodiversity. One historical study was conducted in 1929, when Chamberlin and Berry (1930) performed a mollusk survey in the Henry Mountains and surrounding area, which included parts of Capitol Reef. They added new state records and a technical description of a freshwater pulmonate snail species (*Aplexa microstirata = Aplexa elongata*) new to science.

The majority of the information concerning aquatic species comes from studies of rock pools, tinajas, springs or seeps. Boyle (1986) applied for a research permit to collect algae, invertebrates and amphibians as part of a project to characterize the aquatic resources in the tinaja ecosystem of the Waterpocket Fold. The project appears to have been a joint effort between the NPS and the Water Resources Lab in Ft. Collins, Colorado to assess the impacts of grazing on the park's resources and provide basic ecological information about isolated aquatic systems. It is unclear what results came from this project. Galat (1987) submitted a research proposal to characterize the limnology and macroinvertebrate composition of the tinajas in the Halls Creek region of Capitol Reef National Park, with an emphasis on natural stressors and disturbance events. The status of this project is unknown. Haefner and Lindahl (1988, 1991a,b) proposed a study of the ecology of small pools in Capitol Reef to describe the major mechanisms of community organization in aquatic rock pool habitats and to assess any effects livestock may have on this system. The status of this project is unknown.
Baron et al (1993) requested a research permit in their proposal to study the biological and chemical characteristics of representative tinajas of Capitol Reef National Park. It is unclear what progress was made and if the study was completed. Lafrancois (1993, 1994 and 1996) and colleagues conducted a study of the biological and chemical characteristics of representative tinajas of Capitol Reef National Park with an emphasis on the response of these systems to disturbance. They took intensive samples from 20 pools located in five different drainages and documented twice as many macroinvertebrate and anuran species as had previously been recorded. The baseline biological and chemical data they acquired provides a baseline for later comparisons and for management decisions. Their data is catalogued under DS-CARE-0024. Anderson (1994) requested a research permit to study the life history of crustaceans in tinajas of Capitol Reef as part of a graduate program, though it is unclear what progress was made and if the study was completed.

As part of concentrated studies on pothole ecology, Graham et al (1998) surveyed the Entrada outcrops in Capitol Reef for the presence of an undescribed, ameronothroid (Acari: Ameronothridae) mite. The article states that no mites were found in pools on Entrada outcrops in the Capitol Reef area, though the map isn't detailed enough to indicate whether they were found in pools on other types of sandstone.

Finally, a macroinvertebrate list from the Cottonwood and Willow tanks exists by an unknown author/date. Included in the list are functional feeding groups and aquatic community information.

Studies associated with the Fremont River began when Woodbury and Musser (1963) conducted a limnological study of the Fremont River and analyzed their results as part of a University of Utah, Division of Biological Sciences research project. Winget et al (1975) performed an aquatic habitat evaluation of the Fremont River in a report to the Westinghouse Corporation. Baseline measurements included stream profile, discharge, water and air temperature, specific conductance, salinity, pH, and dissolved oxygen. Samples were taken of periphyton, zooplankton, phytoplankton, macrophytes, macroinvertebrates and fish. Reichert et al (1977) conducted a monitoring program for macroinvertebrates and water chemistry in the Fremont River as part of a Bureau of Water Pollution

Control study. Aquatic invertebrates were sampled to assess the impacts of a Rotenone spill that occurred in November 1991. Baumann (1981), a zoology professor at BYU, submitted an investigator's annual report on the aquatic insects of Capitol Reef with an emphasis on the caddisflies (Trichoptera). He also applied for a collection permit in 1988 to survey the macroinvertebrate fauna of the Fremont River (Baumann 1988, 1989, Baumann and Bean 1988). The objectives of these studies were to produce a list of the species present and to examine the health of the aquatic community. His data is documented under DS-CARE-0032.

The Bureau of Land Management (1991) conducted an aquatic ecosystem inventory and macroinvertebrate analysis of the Fremont River. Their report documented stream-sampling activities at three sites during the summer of 1988. They found that macroinvertebrate communities were usually dominated by taxa tolerant to sediment and organic enrichment and that grazing and agricultural return flows impacted the reaches that were sampled.

Magnum (1993) conducted an aquatic ecosystem inventory of the Freemont River for the Utah Department of Environmental Quality to interpret the effects of water pollution. while there is no long term monitoring plan for aquatic invertebrates in the park, there have been a number of studies that contribute to baseline information. Lindahl (1977) completed a faunal survey of Hall's Creek and documented some aquatic invertebrate species together with lizards and mammals.

The Utah Department of Natural Resources (1980) conducted an aquatic inventory of streams flowing across lands administered by the Bureau of Land Management. These surveys examined the chemical and biological condition of streams to help designate priority streams and to aid in management decisions. Brammer (1997) submitted a thesis report on his study of the aquatic insect fauna of Pleasant Creek. While he documented 147 species that inhabit the creek, it is unknown if his thesis work has been completed.

Kirby and McAllister (1999, 2000, and 2001) have been collecting benthic macroinvertebrate community data from sites on the Fremont River, Sulphur Creek and Pleasant Creek and report on their field seasons. They provide fish density estimates as well as macroinvertebrate species lists.
Schwarzbach (2000) documented the results of a stream study in Capitol Reef, which included fish sampling, benthic macroinvertebrate sampling, stream habitat characterization, and a description of the riparian vegetation. Methods, results and recommendations are discussed. Fremont River study site field data forms, site sketches and site photographs are catalogued under DS-CARE-0006.

Contributions to the knowledge of insect biodiversity come from McCafferty and MacDonald (1994) who published an article on new record distributions of two mayfly species, *Baetis flavistriga* (Ephemeroptera: Baetidae) and *Choroterpes inornata* (Ephemeroptera: Leptophlebiidae) in Capitol Reef, together with notes on their biogeography. MacDonald (1998) and MacDonald and Harkrider (1999) published articles on the differentiation of two larval species of dance flies (Diptera: Empididae) using morphological and DNA techniques. Presumably, they collected specimens for this study from parklands.
Earlier work by MacDonald (1992) requests a permit to conduct a faunistic survey of the aquatic insects of Pleasant Creek and Sulphur Creek, though the status of this survey is unknown.

Terrestrial Invertebrates

Terrestrial invertebrate studies generally fall into two categories: insect pest status and insect biodiversity. The U.S. Forest Service (1974, 1975) conducted a biological evaluation of the tent caterpillar, *Malacosoma incurvum discoloratum* (Lepidoptera: Lasiocampidae) along the scenic highway in Capitol

Reef. Their report recommended an egg mass survey the following fall to determine if population increases would occur. Their 1975 report detailed the results of the egg mass survey. Alston (1993) submitted a progress report on codling moth (*Cydia pomonella*) mating disruption trials in Capitol Reef that documents fieldwork conducted from 1990-1993. The report also included a description of the status of pesticide products under EPA review.

In an American Museum of Natural History revision of the Phyline Miridae of the western U.S., Schuh (1986) documents a new record for the true bug, *Merinocapsus ephedrae* (Hemiptera: Miridae) from sites in Capitol Reef National Park.

Stanton et al (1992) proposed a biogeography of invertebrates in hanging gardens of the Colorado Plateau, which included sites in Capitol Reef. While these studies focused on the vascular flora associated with seeps and springs along canyon walls, they also identified bee (Superfamily Apoidea) species richness, relative abundance and species-occurrence patterns. Hartman et al. (1993) reported on field studies from hanging gardens in Capitol Reef and other Colorado Plateau parks, and Fowler et al. (1995) suggested management recommendations for hanging gardens in Capitol Reef and other plateau parks. Fowler (1995) completed his Ph.D. dissertation on the biogeography of hanging gardens on the Colorado Plateau, which included bee community studies.

Alexander and Shoger (1993) submitted a proposal to study potential insect pollinators in Capitol Reef National Park. Their objective was to compare pollinators from disturbed areas of the park (orchards) versus pollinators found in undisturbed area, though their results are unknown.
Dobbler (1995) applied for a research permit to study the genetics and ecology of a herbivorous beetle, *Chrysochus auratus* (Coleoptera: Chyrsomelidae), though results of this study are unknown.
Sipes et al (1996) conducted a study on a rare plant, the Jones cycladenia, and implicated that insect pollinators dissociating from their host likely caused poor fruit set. The study covered 8 known populations of the rare plant, including one site in Capitol Reef, and listed the insect species that were observed visiting the plants.

Opler (1997) provided a checklist of the butterflies and moths of Capitol Reef National Park, though there is no information on methods or study design.

The Utah Division of Wildlife Resources (1998a, b) inventoried the sensitive species and ecosystems in Utah, and included aquatic and terrestrial mollusks from Capitol Reef in their species lists.

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Cedar Breaks National Monument - Invertebrates

Aquatic Invertebrates

There has only been one study on aquatic invertebrates in the park, a historical study on the snails (Gastropoda: Mollusca) of Cedar Breaks National Monument (Gregg 1941).

Terrestrial Invertebrates

Mueller (1979) conducted a survey of the occurrence of swallowtail butterflies (Lepidoptera: Papilionidae) and their habitat in and around Cedar Breaks National Monument. The data from this study is cataloged under DS-BRCA-0010. Nitman et al (1990) submitted a preliminary report on the arthropod fauna from the North Point site in Cedar Breaks National Monument. Madsen (1997) submitted a Utah Geological Survey publication on the exploratory paleoecology on the Markagunt Plateau, which includes some information about insects. The Utah Division of Wildlife Resources (1998a, b) inventoried the sensitive species and ecosystems in Utah, and included aquatic and terrestrial mollusks from Cedar Breaks in their species lists.

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Colorado National Monument - Invertebrates

Aquatic Invertebrates

Aquatic invertebrates found in the park are listed together with terrestrial invertebrates in a USGS (1994) inventory, and include representatives from mayflies (Ephemeroptera), damselflies and dragonflies (Odonata), stoneflies (Plecoptera), true bugs (Hemiptera), beetles (Coleoptera) and caddisflies (Trichoptera).
As a result of his ecological pothole studies, Graham (1998) found populations of an ameronothroid (Acari: Ameronothridae) mite new to science in and around the Colorado National Monument.

Terrestrial Invertebrates

Several studies have been devoted to documenting the biology and/or life history of rare or economically important insects found on the monument.

Richardson (1962) conducted a forestry study in Colorado National Monument that emphasized the then-current status of forest insect pests. Emmel (1964) documented the swallowtail butterfly *Papilio indra* (Lepidoptera: Papilionidae) in this early publication as one of the rarest in North America. The Nature Conservancy has since recognized this butterfly as a distinct subspecies, *minori*, occurring entirely or primarily on federal lands, and has elevated it to G5 status.

Gypsy moth (author unknown, 1986) monitoring was conducted from 1986-1989 though no moths were found in the traps.
Lanham (1987, 1988) discussed the evolutionary implications of two bee taxa (Hymenoptera: Apoidea, Andrenidae) based on observations and collections of the insects at sites in the campground and at the headquarters area of the park. Graham (1988) documented single-leaf ash tree damage by the true bug *Tropidosteptes* sp. (Hemiptera: Miridae), and correlated the degree of damage with the nearness of trees to park roads.

A guide to the common insects and other arthropods was completed in 1990 (Kondratieff). This is a publication primarily for visitor use and contains a brief explanation of the arthropods that may be encountered in the monument. A revised list was completed in 1994 by the USGS. Weissmann (1999) is involved in an ongoing project to document the butterfly and moth species that occur within the monument's boundaries, and provides a species list to date with frequency and habitat preference.

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Curecanti National Recreation Area - Invertebrates

Aquatic Invertebrates

The bulk of the information on aquatic invertebrates from Curecanti National Recreation Area stem from limnological studies, basic monitoring studies or graduate theses. One historical study was performed by Argyle et al (1962), who conducted a study on the mayflies (Ephemeroptera) of the Curecanti Reservoir basins on the Gunnison River. Their paper includes information on the geography, tributaries and habitats of mayflies, including collection, annotations and references.

Knight et al (1962) conducted a limited study of the limnological characteristics of the Gunnison River, and Cudlip et al (1986) conducted an historical review of the limnology of the Blue Mesa reservoir from 1965-1985. They report on the major ions and nutrients in the reservoir, as well as its biological parameters, hydrology, conductivity, phytoplankton and zooplankton.

A joint study between the NPS and Colorado State University (1986) focused on water and air quality data from Curecanti National Recreation Area. Included in this report is a survey on the benthic conditions, with information about phytoplankton, zooplankton and the benthic community.
Stanford and Ward (1991) reported the occurrence and significance of the hyporheic zones in the Black Canyon of the Gunnison River, and examined changes in benthic faunal composition, abundance and richness through longitudinal gradients in the river.
A study was conducted from 1993-1998 (authors unknown) which contains information on the benthic invertebrates of the Gunnison River. This appears to be a large study, however, the synthesis of the information on the invertebrates is unknown.
In a report to the USGS Water Resources Division, Deacon et al (1996) summarized the biological and contaminant investigations that have been conducted throughout the Colorado River basin.

Colborn (1981) completed a master's thesis using aquatic insects as measures of the trace elements cadmium and molybdenum.
Wise (1997) completed a master's thesis on the relative influence of predation by the kokanee salmon in controlling the abundance and population dynamics of *Daphnia pulex* (Crustacea: Cladocera), in Blue Mesa reservoir during 1994 and 1995.

While there is no long-term monitoring program for aquatic invertebrates at Curecanti, Park Service data from the water quality program conducted from 1993-1998 included invertebrate information. The data is cataloged under DS-CURE-0018. A species list of invertebrates in the park (National Park Service 1993), is cataloged under DS-CURE-0017.

Terrestrial Invertebrates

Information on terrestrial invertebrates in Curecanti National Recreation Area is scant.
Emmel and Emmel (1964) provided a checklist of the butterflies found in Black Canyon, which presumably include records from Curecanti, and the Park Service (1989) has records on the gypsy moth (Lepidoptera: Lymantriidae), though the status of this pest species is unknown.

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Data Sets

DS-CURE-0018	Aquatic Invertebrates. 1/1/1993 - 1/1/1998. (Microsoft Access). Originated by Myron Chase; status: Active
DS-CURE-0017	Invertebrate List. (Microsoft Access). Originated by Myron Chase; status: Active

Dinosaur National Monument - Invertebrates

Aquatic Invertebrates

Early studies of invertebrates at Dinosaur National Monument include Pearson (1967) and Peason et al (1968), who identified approximately 70 invertebrate forms which were collected in the Green River both before and after closure of Flaming Gorge Dam. Pearson noted that several taxa reported prior to September, 1962 (mostly mayflies and stoneflies), were not reported after the dam closed. At least 10 "new" invertebrate forms were collected from 1963-1965, most of which were more common to cool mountain tributaries. In addition to these forms, Pearson also found 11 different types of *Baetis* (mayfly) nymphs not previously recorded. Perhaps most importantly, he concluded (1) that species composition above Echo Park changed significantly after Flaming Gorge Dam closed, (2) species composition below Echo Park did not differ significantly from pre-impoundment studies, and (3) species diversity increased with increasing distance downstream from the dam.

Carlson et al (1979) identified approximately 100 taxa of aquatic insects in the Yampa River with mayflies and caddisflies as the most abundant orders. Stoneflies, true flies and beetles were other important orders, and Chironomidae (Diptera) was the most common family. This research also identified several non-insectan macroinvertebrates, of which Oligochaete worms and Hydracarina (water mites) were most common. Vinson (1990) resurveyed the upper Green River below Flaming Gorge subsequent to modification of Flaming Gorge releases in the 1990s. He found the reappearance of several native aquatic insects in response to a more natural hydrograph.

Terrestrial Invertebrates

A baseline inventory of terrestrial insects began in 1990 through Colorado State University, when Kondratieff and others made several collecting trips to the monument. Monument staff also assisted by operating light traps and malaise traps in several locations and habitats within the park. For the past several years, additional incidental collections have been sent to Kondratieff at CSU where the existing collection from the park is on loan to complete or verify identifications. Nearly 1500 species have been collected to date, including several new records and 50-100 species new to science (Durfee and Kondratieff 1994). One study (reference pending) has focused on collecting Ictalurid moths; over 350 species from this group alone have been collected.

The Mormon cricket (*Anabrus simplex*), a wingless grasshopper, irregularly recurs throughout much of the intermountain West. Populations may exist at low, relatively insignificant levels for several years in an area, then increase exponentially during a period of favorable years. At high population levels, Mormon crickets become gregarious and form bands that begin to migrate, often moving 25 to 50 miles in a season. In their food habits, these omnivorous insects show a marked preference for succulent plants and inflorescences but will eat almost any green plant available. The highest utilization typically occurs on shrubs and forbs such as sagebrush, rabbitbrush, arrowleaf balsamroot, death camas, locoweed and groundsel. Utilization of range grasses is disproportionately low compared to their availability. Recent research (MacVean 1987) indicates that Mormon crickets have a negligible impact on forage production even in "epidemic" numbers, except under severely deteriorated range conditions. Mormon crickets may be of greater significance on rangelands as "ecological cleansing agents" than as agricultural pests. Measurable economic impact by Mormon crickets on cultivated crops has been well documented. Mormon crickets provide an important source of food for many birds, small mammals and fishes. Tyus (1988) documented significant utilization by endangered fishes within the monument. Mormon cricket populations have reached gregarious/migratory levels within the monument only twice during the past 30+ years. During the mid-1970s, high populations were observed on Douglas Mountain. High populations occurred on Blue and Wild Mountains during the early 1980s.

Treatment programs were conducted outside the monument in both the 1970s and 1980s using carbaryl as a bran bait and aerial spray formulation, and malathion as an aerial spray. Although the reductions in populations were assumed to be considerable in treated areas, monitoring for efficacy was limited at best. Treatment within the monument occurred only in 1976 when a natural pathogen, *Nosema locustae*, was utilized in an experimental program (Henry and Onsager 1984). Despite many influences that reduced the viability of the spores, that particular test program was quite effective in reducing Mormon cricket population levels.

In 1985, another endemic pathogen (*Varimorpha* spp.) was discovered in Mormon cricket populations in the monument, though it has not yet been fully described. However, through both field observations and laboratory experiments, it has proved to be an extremely virulent pathogen in Mormon crickets. Population reductions subsequent to exposure to this pathogen have rivaled those observed with chemical agents. The major reduction in regional populations has been attributed to the effect of *Vairimorpha*. Monitoring surveys were conducted from 1984 through 1992. Data collected included band density, instar age, size/extent of bands, direction of band movement, and indications of mating and egg-laying. Data is displayed on data forms and mylar overlays (reference pending).

Other arthropods, including soil insects, are largely uninventoried. Some research had been conducted to identify the pollinators of the federally listed plant species, Ute's ladies tresses (*Spiranthes diluvialis*).

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Fossil Butte National Monument - Invertebrates

Aquatic Invertebrates

There have been no concentrated aquatic invertebrate studies in Fossil Butte, however a 1977 report (Rado) lists insects commonly found, which include the aquatic orders Ephemeroptera (mayflies), Odonata (damselflies and dragonflies) and Trichoptera (caddisflies).

Terrestrial Invertebrates

Feldmann et al (1981) examined twenty-three specimens of fossil decapod crustaceans from the Fossil Butte Member of the Green River Formation of early Eocene age. Eleven specimens formed the basis for description of a new species of freshwater palaemonid shrimp, *Bechleja rostrata*, and the remainders were assigned to *Procambarus* (Austrocambarus) *primaevus*. The fossil invertebrates might have lived near the mouth of a tributary to Fossil Lake.
Other fossilized invertebrates have been found in the monument, and are recorded with fossil remains in an NPS occasional paper on the geologic history of Fossil Butte (McGrew, no date).
Buchheim (1998) collected over 400 insect specimens from the sagebrush steppe habitat to develop a baseline inventory for the monument.

References

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Hovenweep National Monument - Invertebrates

Aquatic Invertebrates

Long-term monitoring of aquatic macroinvertebrates was initiated in Arches National Park in 1997 in conjunction with the water quality-monitoring program in the Southeast Utah Group national parks. At Hovenweep, there are three monitoring stations where water samples are collected and where data is gathered on aquatic invertebrates: Cajon Spring, Hackberry Spring and Square Tower. From February 1997 through December 2000, sites were sampled four times per year in March, June, September and December. Since 2001, sites are sampled quarterly for aquatic macroinvertebrates in one out of every three consecutive years. The MS Access database is catalogued under DS-SEUG-010.4.
Schelz (2001) reported on the Salt Creek portion of this monitoring program in preparation for a 2002 Environmental Assessment.

Terrestrial Invertebrates

As part of a Hovenweep archeological project, Rado (1974, 1975 and 1976) provided a checklist of the insects of Hovenweep National Monument. The Utah Division of Wildlife Resources (1998a, b) inventoried the sensitive species and ecosystems in Utah, and included aquatic and terrestrial mollusks from Hovenweep in their species lists.

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Data Sets

DS-SEUG-010.4 Aquatic macroinvertebrate data for springs, seeps, and streams in the SEUG parks, 1997-present. 2/19/1999 - . (MS Access; hard-copy field forms and field notebooks; photos). Originated by Schelz, Charlie; status: Active.

Natural Bridges National Monument - Invertebrates

Aquatic Invertebrates

Long-term monitoring of aquatic macroinvertebrates was initiated in Arches National Park in 1997 in conjunction with the water quality-monitoring program in the Southeast Utah Group national parks. At Natural Bridges, there are three monitoring stations where water samples are collected and where data is gathered on aquatic invertebrates: Kachina Bridge, Sipapu Bridge and Owachomo Bridge. From 1997 through 2001, sites were sampled four times per year in March, June, September and December. Since 2001, sites are sampled quarterly for aquatic macroinvertebrates in one out of every three consecutive years. Protocols and proposed changes to the program are outlined in Resource Management Division, 1994. The MS Access database is catalogued, DS-SEUG-010.3, from 1997 to the present. Schelz (2001) reported on the Salt Creek portion of this monitoring program in preparation for a 2002 Environmental Assessment.
As a result of his pothole ecology studies, Graham et al (1998), found populations of an ameronothroid (Acari: Ameronothridae) mite new to science in and around Natural Bridges National Monument.

Terrestrial Invertebrates

Information on the terrestrial invertebrates associated with hanging gardens comes from studies conducted in and around Natural Bridges National Monument. While these studies focused on the vascular flora associated with seeps and springs along canyon walls, bee (Superfamily Apoidea) species richness, relative abundance and species-occurrence patterns were also identified. Hartman et al. (1993) reported on field studies from hanging gardens in Natural Bridges and other Colorado Plateau parks, and Fowler et al. (1995) suggested management recommendations for hanging gardens in Natural Bridges and other plateau parks. Fowler (1995) completed his Ph.D. dissertation on the biogeography of hanging gardens on the Colorado Plateau, which included bee community studies. A peripheral study conducted by the Park Service (1985) on a lizard array trap includes counts of different invertebrates captured. Schwartz and Schuh (1999) published their collection of new genera and species of conifer-inhabiting plant bugs (Heteroptera: Miridae) from locations in Natural Bridges National Monument.

The Utah Division of Wildlife Resources (1998a, b) inventoried the sensitive species and ecosystems in Utah, and included aquatic and terrestrial mollusks from Natural Bridges in their species lists.

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Data Sets

DS-SEUG-010.3 Aquatic macroinvertebrate data for springs, seeps, and streams in the SEUG parks, 1997-present. 6/10/1997 - . (MS Access; hard-copy field forms and field notebooks; photos). Originated by Schelz, Charlie; status: Active.

Pipe Spring National Monument - Invertebrates

Aquatic Invertebrates

Oberlin (1998) performed a one-year, general survey of the aquatic invertebrates found at Pipe Springs National Monument. Approximately 41 species were documented.

Terrestrial Invertebrates

There is no information on terrestrial invertebrates for the monument.

References

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Timpanogos Cave National Monument - Invertebrates

Aquatic Invertebrates

While there is no long term monitoring of aquatic invertebrates in any of the Monument waterbodies, PacifiCorp and Stillwater Environmental Services (2001) conducted a benthic macroinvertebrate survey of the American Fork River as a FERC requirement to relicense the American Fork Hydroelectric Project.

Terrestrial Invertebrates

A checklist of insects collected from 1963-1964 in and around Timpanogos Cave was completed by Huntsinger (1964) and revised in 1970. Other general references include collections of aphids (Knowlton 1942), curculionid beetles (Tanner 1987), and benthic macroinvertebrates (McArthur and Barnes, 1985) taken from Mount Timpanogos, though it is unclear if they include collections made inside the park boundaries.

An unknown author compiled a checklist of insects from Timpanogos Cave National Monument (1970), though it is unclear if this is terrestrial, aquatic or both.

Finally, the Utah Division of Wildlife Resources (1998a, b) inventoried the sensitive species and ecosystems in Utah, and included aquatic and terrestrial mollusks from Timpanogos in their species lists.

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Zion National Park - Invertebrates

Aquatic Invertebrates

Studies on aquatic invertebrates at Zion National Park can be separated into four broad categories; Virgin River studies, studies on mollusks, studies associated with impacts to the aquatic system and studies associated with water quality and/or management plans.

Workman (1980, 1983) conducted an aquatic survey of the North Fork of the Virgin River and two of its tributaries in Zion and obtained baseline data on the invertebrate community, together with water quality data and descriptions of the riparian habitat. Anderson et al (1983) examined the ecological community present in the North Fork of the Virgin River immediately upstream from Zion National Park. A State of Utah biennial water quality report (Gunnell 1984) provided a list of organisms in the Virgin River in Zion. A study from a five-county association of governments (1989) included macroinvertebrate information when it examined the water quality in the Virgin River Basin. The report also includes information about precipitation, evaporation, total dissolved solids, dissolved oxygen, pesticide inputs. Finally, Boyle et al (1993) inventoried the aquatic resources of the Virgin River ecosystem, which included fish and macroinvertebrates.

A large part of the information base about invertebrates comes from both aquatic and terrestrial mollusk studies. Baseline information about the parks' mollusk species are documented by Woodbury (1927, 1929) who recorded fifteen species of gastropods collected in Zion, together with their distribution and habitat preferences. In 1929, Chamberlin and Berry conducted a survey in the Henry Mountains and surrounding area, which included parts of Zion National Park. They added new state records and a technical description of a freshwater pulmonate snail species (*Aplexa microstriata = Aplexa elongata*) new to science (Chamberlin and Berry 1930). Hamilton (1977) reviewed and updated these historical lists, included species collected inside park boundaries, and also published an article in Park Science on implications about the changing diversity of mollusk species (1994). Ng and Barnes (1982) conducted a survey of the major hanging gardens and associated water seeps for the presence of the Zion Snail, *Physella zionis* (Gastropoda: Physidae). Environmental parameters were also measured to determine their effect on the snail's distribution. While this species is not yet listed as Endangered by the State of Utah, it is entirely endemic to 2 connected canyons, Zion Canyon and Orderville Canyon, along the North Fork of the Virgin River in Zion National Park, a linear stretch of about 3.1 miles. Whipple (1988) added to the existing information when she conducted her master's thesis on the abundance and distribution of the Zion Snail in the park. Wu and Wu (1993) proposed a molecular and morphological study on this species, though it is unclear if it was completed.

Another gastropod species, the Kanab ambersnail, *Oxyloma haydeni kanabensis* (Gastropoda: Succineidae) was listed by the U.S. Fish and Wildlife Service as an endangered species in 1992. This subspecies is known from only three locations, two in southern Utah and one in Grand Canyon, Arizona. It is considered a land snail, but lives at the edge of water on damp substrates. Webb and Fridell (2000) conducted a distribution survey in the East Fork of the Virgin River in ZNP, though it is unclear if they found populations in the park.

Concern over the potential impacts of canyoneering on the benthic community in the North Fork of the Virgin River led to a cooperative study by the NPS and researchers from the University of Montana, Flathead Lake Biological Station. Stanford and Shakarjian proposed a study (1996) to look at zoobenthic biomass to determine if river recreationists were having an appreciable impact on the river ecosystem. They found a strong negative relationship between trampling intensity and zoobenthos biomass and concluded that the pressure imposed by recreationists will ultimately limit ecosystem productivity (Shakarjian and Stanford 1997). Shakarjian (1997) completed his master's thesis on the life history and

distribution of a rare stonefly, *Isogenoides zionensis* (Plecoptera: Perlodidae), which while rare throughout its range, thrives in the watered canyons of Zion National Park. Sappington (1998) did a similar thesis on the effects of recreational disturbance on the desert fish community in the North Fork of the Virgin River.

A comprehensive water quality management plan for the Virgin River system in the state of Utah was submitted by the Utah Water Research lab and the Bureau of Environmental Health (1974). The plan addresses benthic invertebrates, and outlines water quality standards, stream standards, point waste loads, low flows, and population predictions and wastewater treatment. Maddox et al (1977) did a bacterial analysis of the water resources of the North Fork of the Virgin River.

Zion does not have a long-term monitoring plan for aquatic invertebrates though there are records that suggest some invertebrate monitoring data exist (1995).

Terrestrial Invertebrates

Contributions to the knowledge of the terrestrial invertebrates in Zion generally fall into two categories, insect biodiversity and the status of insect pests.

In the early twentieth century, Tanner (1928) published the Coleoptera of Zion National Park, followed by Woodburys' (1929) checklist of the snails and spiders and aquatic and terrestrial true bugs. Ingham (1959) completed a master's thesis on the ants of the Virgin River Basin, together with a list and key of the known ant species of Utah. McCutchen (1976) did a reconnaissance study of Grapevine Spring that included invertebrate observations. Stanton et al (1991, 1992a,b) proposed a biogeography of invertebrates in hanging gardens of the Colorado Plateau, which included sites in Zion. While these studies focused on the vascular flora associated with seeps and springs along canyon walls, they also identified bee (Superfamily Apoidea) species richness, relative abundance and species-occurrence patterns. Hartman et al. (1993) reported on field studies from hanging gardens in Zion and other Colorado Plateau parks, and Fowler et al. (1995) suggested management recommendations for hanging gardens in Zion and other plateau parks. Fowler (1995) completed his PhD. dissertation on the biogeography of hanging gardens on the Colorado Plateau, which included bee community studies. Finally, Reeves (1994, 1995) conducted a preliminary survey of orbatid mites (Acari: Oribatida) and published a species checklist of mites inhabiting Zion National Park.

Clark (1991) conducted a survey on the status of selected land and freshwater gastropods in Utah, though results from his study are unknown. The Utah Division of Wildlife Resources (1998a, b) inventoried the sensitive species and ecosystems in Utah, and included aquatic and terrestrial mollusks from Zion in their species lists.

Two studies have been performed in Zion, which link invertebrates as vectors for disease and/or pests. Baker (1968, 1970) described the tent catepillar, *Malacosoma incurvum discoloratum* (Lepidoptera: Lasiocampidae) in Zion, including habitat preferences, locations it occurred in the park, general biological information, and emergence estimates for the spring of 1969. Sinclair et al (1993, 1994a,b) conducted research on the possible causes and effects of ash yellows disease (AshY) in the park, likely vectored by hemipteran species.

A peripheral study that includes insects concerned the Mexican spotted owl food habits and included some information on insect prey items (Rinkevich 1991).

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Arches National Park - Fish

General Fish Studies

Arches National Park, though adjacent to the Colorado River, does not legally include the river within its boundaries. Extensive studies have been performed on Colorado River fish, many of which are documented for Canyonlands National Park.

Within Arches, primary fish habitat is found in Courthouse Wash and Salt Wash. Holden (1978) compiled a checklist of fish that includes the Colorado River. The only extensive study conducted was by Selby and Holden (1979), who collected fish, benthic invertebrates, algal samples, and basic water chemistry data from three locations in Salt Wash and one in Freshwater Canyon, a tributary to Salt Wash. Native speckled dace and flannelmouth suckers, and non-native fathead minnows and plains killfish were documented. There are a number of additional exotic fish in Courthouse Wash and particularly in Salt Wash north of Wolf Cabin. Bluegill (*Lepomis macrochirus)* may have been sighted in these areas but this has not been verified.

Schelz (2000) maintains an annually updated list of the fish of Arches National Park based on personal observations and previous work.

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Black Canyon of the Gunnison National Park - Fish

General Fish Studies

Since the 1970s, the Colorado Division of Wildlife has stocked non-native sport fish in portions of the Gunnison River immediately above and below Black Canyon of the Gunnison National Park. Fishes of the Gunnison River include self-sustaining introduced populations of rainbow trout and brown trout, for which a popular recreational fishery exists from the upper boundary of the park downstream to the confluence of the Gunnison River and the North Fork of the Gunnison River near Delta, Colorado.

The section of the Gunnison River within Black Canyon of the Gunnison National Park was studied in 1964-1966 (Kinnear and Vincent 1967), who examined trainbow trout, brown trout, white sucker, bluehead sucker, flannelmouth sucker, speckled dace, and bonytail chub and their habitats. Wiltzius (1976) investigated the influences that have altered the Gunnison River (e.g., railroads, reservoirs) and changes in water temperatures, flows, and fish distribution. Wiltzius (1978) also examined the abundance of fish in the Gunnison River as related to historical stream flows, water quality, bottom fauna, and stream temperature. Stanford (1989) examined the effects of Gunnison River dams instream flows and trout populations. Behnke (1993) provided an historical perspective on the river and its changing fish fauna, and described fish environments, the native cutthroat trout, the the restoration potential for this species.

Colorado Division of Wildlife conducts shocking surveys in the Gunnison Gorge (BLM) below Black Canyon National Park, but these surveys do not extend into the Park.

Threatened, Endangered, or Sensitive Fish Studies

The endangered Colorado pikeminnow and razorback sucker are native to the Gunnison River further downstream, but these species have not been reported from the vicinity of the park.

McAda and Kaeding (1990) examined the effects of water development, water temperature, and sediment flow on endangered fishes, and Burdick (1995) documented a 3-year study of the fish community in the Gunnison River, examining the effects of construction and operation of the Aspinall Unit on Bonytail, Razorback sucker, Humpback chub, and Colorado pikeminnow. Endangered fish are also adddressed in a scoping report for the Gunnison River contract (U.S. Department of Interior 1993).

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Canyonlands National Park - Fish

General Fish Studies

Compilation of fish data in Canyonlands National Park began with Holden (1973), who wrote a dissertation on the distribution, abundance and life history of the fishes of the upper Colorado River Basin (which encompasses Canyonlands National Park). He also produced a species list for the park (Holden 1978).

Canyonlands National Park does not have a fish monitoring program and relies on work performed by other agencies in the upper Colorado River Basin; in particular, the U.S. Fish and Wildlife Service, Utah Division of Wildlife Resources, and the Colorado River Fishes Recovery Team. Surveys of the Colorado River through Cataract Canyon were first conducted from 1979 to 1981 by the U.S. Fish and Wildlife Service (Valdez et al. 1982). Eighteen species of fish were reported from the Colorado and Green rivers by Valdez and Williams (1993) in a survey conducted from 1985 to 1990; Valdez (1993) further described nine fish habitat types in the Colorado and Green rivers in the park. Rowlands et al. (1993) intensively surveyed the Green and Colorado rivers in and slightly above and below the park from 1988-1988; 31 species of fish were documented, including eight natives and 23 non-natives.

Schelz (1999-2002) compiles an annual fish species list for Canyonlands National Park based on all previous work. This list includes 30 species, of which only eight are native.

Threatened, Endangered and Sensitive Fish Studies

Most of the fish studies in Canyonlands have focused on the federally-listed species that occur in the upper Colorado. Tyrus et al. (1982) studied the distribution and life history of four endangered fish of the area, and his surveys revealed that the Canyonlands National Park region of the Colorado River Basin included the federally Endangered Colorado pikeminnow (*Ptychocheilus lucius*), humpback chub (*Gilia cypha*), razorback sucker (*Xyrauchen texanus)*, and bonytail chub (*Gilia elegans*). Additional surveys and monitoring were conducted by the Utah Division of Wildlife Resources (Chart et al. 1998).

The State of Utah Division of Wildlife has done yearly work since the 1980s on monitoring for various endangered fish species in and around the park, and the agency has also been involved with exotic fish control. Valdez et al. (1986) studied the significance of the Colorado River from Cataract Canyon to the Lake Powell inflow on Colorado pikeminnow, humpback chub and bonytail chub. Bio-West, Inc., in studies headed by Paul Holden and Richard Valdez, completed a number of studies on spawning locations of all endangered fish (Valdez 1990, 1993). They also concentrated on the Humpback chub in Cataract Canyon (Valdez 1990a, 1990b), and Colorado pikeminnow survival over winter (Citation pending).

Recovery plans have been drafted by the Colorado River Fishes Recovery Team (1978, 1990a, 1990b, 1990c) for the Colorado pikeminnow, bonytail chub and humpback chub, and reports from the interagency Recovery Implementation Program for Endangered Fish of the Upper Colorado River (1990, 1996, 1997) summarize research and monitoring findings of endangered fish. Data collected includes information on distribution, population, life history, movement, habitat, responses to flow, and effects of non-native fishes (DS-SEUG-051.1). Study areas include the Colorado River from western Colorado to the inflow of Lake Powell, which encompasses the stretch bordering Arches National park and a lengthy stretch through Canyonlands. McAda et al. (1994) provide a summary of the results of the standardized monitoirng program and Keleher et al. (2000) also provide abstracts for the latest research and monitoring efforts.

Species-specific studies conducted in Canyonlands include Valdez and Masslich (1990a, 1990b), who

conducted field work to assess the distribution and relative abundance of the humpback chub in Cataract Canyon; and Gutermuth et al. (1994), who studied age-0 razorback suckers. Foster and Mueller (1999) released razorback suckers into the Green River and tracked them with radio transmitters. Muth (1994) studied predation of larval razorback suckers by red shiners, and further researched survival rates of larvae in nursery habitats (1997)

The Colorado pikeminnow has been extensively studied. Valdez (1985) initially reported on the summertime importance of Cataract Canyon to the pikeminnow. McAda and Kaeding (1989) and McAda and Ryel (1999) analyzed data collected from 1982 through 1997 and correlated annual river discharge with relative abundance of the species. Bates et al. (1991) summarized results of 1986-1990 data on pikeminnow monitoring on the Colorado and Green Rivers. Osmundson (1996) and Osmundson et al. (1997a) studied adult growth and survival rates; Osmundson and Burnham (1996, 1998) evaluated frequency of reproduction and recruitment, looked at trends in size structure over several years, and examined historical accounts to determin vulnerability to extirpation. Osmundson et al. (1997b) investigated the effects of water temperatures and prey availability on dispersal patterns from 1991-1995. Dispersal patterns of subadult and adult fish were further addressed by Osmundson et al. (1998) and a summary of status and trends was produced in 1998 (Osmundson and Burnham 1998). Haines et al. (1998) estimated populations and survival rates of young Colorado pikeminnow using capture-recapture methods in two low-gradient stretches of the river known to be nursery areas, including one in Canyonlands. And Fairchild et al. (1999) studied the potential detrimental effects of the Atlas Mill uranium tailings pile near Moab, on the bank of the Colorado River, to the endangered fish species of the upper Colorado; in particular, juvenile Colorado pikeminnow.

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Capitol Reef National Park - Fish

General Fish Studies

Fish surveys at Capitol Reef National Park have documented that fish found in park waters are derived from both downstream, Colorado River associations (*e.g.*, suckers) and from more cold-water upstream sources (*e.g.*, sculpin). Eleven fish species are known from three streams on Capitol Reef (Berry et al. 1975, Kirby and McAllister 2001). Historically, the fish communities of waters in Capitol Reef National Park have been dominated by cyprinids (minnows) and catostomids (suckers). This is a typical fish community for mid-elevation, moderate gradient, variable discharge desert streams in the canyon country of the southwestern United States. Four cyprinid species, the speckled dace (*Rhinichtys osculus*), Utah chub (*Gila atraria)*, leather-side minnow *(Gila copei)* and red-side shiner (*Richardsonius balteatus*), and two catostomid species, the flannel mouth sucker *(Catostomus latipinnis)* and bluehead sucker *(Catostomus discobolus)*, have been found in the Fremont River within the park. Brown trout and Rainbow trout are also present. Three of these species, the rainbow trout, Utah chub, and red-side shiner, have been introduced into this ecosystem. The roundtail chub *(Gila robusta)* was located by McAda (1977), but its continued presence has not subsequently been confirmed. The mottled sculpin (*Cottus bairdi*) has also been documented in the park, and may have been introduced from the Bonneville River system (Capitol Reef Natural History Association 1984; Kirby and McAllister 2001).

Most early information on the fishes in the park are based on anecdotal observations (e.g., Kelly 1948), and more recently fish surveys have been conducted in the Fremont River, Pleasant Creek, Sulphur Creek, and Halls Creek. Fremont River surveys were initially conducted in response to the proposed construction of a dam (Hardy 1990, Hardy et al. 1989, Winget 1975, Murdock 1987). Additional surveys were initiated in response to a whirling disease infection of fish in the river (UDWR 1993). Further surveys were conducted in response to the subsequent 1991 fish kill caused by the Utah Department of Wildlife Resources releasing large quantities of rotenone and potassium permanganate upstream of the park but that flowed into park waters, killing most of the fish and macroinvertebrate fauna in and near the park (Borthwick, 1991, Hepworth et al. 1993). Surveys of Sulphur Creek, Pleasant Creek and Halls Creek were conducted to determine species presences (Anonymous. 1993, Hoddenbach 1977, UDWR 1980). Fisheries surveys were also conducted within Capitol Reef and surrounding areas by Utah State University (Berry et al. 1975; Personal communication, Chuck McAda, U.S. Fish and Wildlife Service, Grand Junction, Colorado) and by the Smithsonian Institute (Personal communication, Wayne Starnes, Curator of Fishes, Smithsonian Institute, Washington, D.C.). Berry et al. (1975) reported roundtail chub in the upper reaches of the Fremont River, but W. Starnes (Pers. comm.) failed to find this species. Woodbury (1963) conducted a limnological study of the Fremont River and most recently, Kirby and McAllister (1999, 2000, 2001) surveyed the Fremont River and Pleasant Creek as part of a broader project to assess fish and benthic community diversity and health (Schwarzbach 2000, 2001). They established permanent plots on the river that could be used to evaluate future changes in river habitats and fish populations (DS-CARE-0006).

Black bullhead (*Ictalurus melas)* and bluegill (*Lepomis machrochirus)* have been found in Halls Creek in Glen Canyon National Recreation Area (Lindahl, et al. 1977). Bullhead and speckled dace have been observed in the park in Halls Creek by park staff, and bluegill likely are present in the park as well.

Threatened, Endangered, or Sensitive Fish Studies

No listed fish species have been documented in park waters. The State of Utah, however, lists the roundtail chub and both suckers as threatened in the upper Colorado River basin. The Colorado River cutthroat *(Oncorhynchus clarki pleuriticus)* may have inhabited the Fremont River in the park prior to European settlement, as evidenced by bones found in archaeological digs near the Fremont Rivers origins

at Fishlake. Macroinvertebrate studies of the Fremont River indicate that portions of the river persist as high quality aquatic habitat.

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Curecanti National Recreation Area - Fish

General Fish Studies

Fishes of Blue Mesa Reservoir and Morrow Point Reservoir include rainbow trout, brown trout, lake trout, and the largest Kokanee Salmon fishery in the United States. There has a also been a recent, illicit introduction of yellow perch to Blue Mesa reservoir. The impact of this introduction to the fishery is not yet known. Speckled dace, bluehead sucker, and roundtail chub are found in downstream reaches of the Gunnison River. A great deal of stocking of non-native sport fish by the Colorado Division of Wildlife has occurred from the turn of the last century to present; some of the economic benefits and costs of stocking were examined by Johnson and Walsh (1987).

The fisheries in the park have been studied extensively. The section of the Gunnison River from the town of Gunnison to the historic town of Sapinero (portions now inundated by Blue Mesa Reservoir) was studied in 1889 (Jordan 1891), 1926 (Pratt 1937, 1938), and 1964-1976 (Wiltzius 1966, 1970, 1971). Wiltzius (1967 and 1974) also investigated the pre- and post-impoundment condition of the fishery in and around the Aspinall Unit, and further investigated the influences affecting fish distribution and abundance (Wiltzius 1976, 1978). Middleton studied the hybridization and distribution of catostomid fishes in Blue Mesa Reservoir and the upper Gunnison drainage. Kunkle et al. (1983) performed chemical analyses of fish for metal concentraions. Cudlip et al. (1987) provided an historical review of the limnology of Blue Mesa Reservoir, including biological chemical and physical data for a 20-year span and Stanford (1989) studied the effects of Gunnison River dams on instream flows and trout populations. The overall objectives of Curecanti's water reosurces management plan, including upstream infrastructure, fishery and recreation issues, and Gunnison River channel changes, are addressed in a water resource scoping report (National Park Service 1995).

The section of the Gunnison River from Blue Mesa Dam downstream to Cimarron (now inundated by Morrow Point Reservoir) was studied from 1968-1976 (Wiltzius 1970, 1971, 1974). The lower section of the Gunnison River within the Recreation area, from Cimarron to the recreation area boundary (this stretch is now inundated by Crystal Reservoir), was studied from 1964-1976 (Wiltzius 1966, 1967, 1970, 1971, 1974).

Van Buren and Burkhard (1991) studied the peaking power operation of Blue Mesa Reservoir and its impact on the Kokanee Salmon. Between 1995 and the present, Dr. Brett Johnson of Colorado State University has investigated the fishery of Blue Mesa Reservoir (Johnson et al. 1995). Johnson’s original emphasis was a thermodynamic model of the fishery and general trophic dynamics and limnology of the system. Recent work has shifted to address the issue of Lake Trout niche overlap and potential predation on Kokanee Salmon. Wise (1997) has examined the influence of the Kokanee Salmon in controlling the abundance and population dynamics of *Daphnia pulex* in Blue Mesa Reservoir, and Stockwell and Johnson (1997) developed a foraging model for Kokanee to forecast anthropogenic and climatic thermal effects on fish behavior and growth. Recent studies are focusing on the predator prey interaction between Mackinaw and Kokanee Salmon

Since 1993, Colorado Division of Wildlife (DOW) and the National Park Service has conducted an intensive creel survey to determine angler catch per effort as well as angler satisfaction. DOW also conducts intermittent shocking on tributaries to the Aspinall Unit. These data are used to determine overall fish biomass of these tributaries; however, the majority of these surveys are not on NPS property. DOW has conducted a Lake Trout population study (mark/recapture) on Blue Mesa Reservoir 2000-2002, which will be used to validate sonar population estimates. The agency has also investigated the spore load of the whirling disease organism (Myxobolus cerebralis) in the East Portal area.

Threatened, Endangered, or Sensitive Fish Studies

Fausch (1995) of Colorado State University looked at three potential reintroduction sites for native Colorado River Cutthroat Trout in tributaries of the Aspinall Unit, and Gowan and Fausch (1996) produced a preliminary feasiblility study for establishing self-sustaining populations. McAda and Kaeding investigated the physical changes such as water temperature and sediment flow in the Gunnison and Colorado Rivers resulting from construction of the Aspinall Unit, and the possible effects on Colorado Pikeminnow, Razorback Suckers, Humpback Chubs, and Bonytail.

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Dinosaur National Monument - Fish

General Fish Studies

Native and non-native fish in the Green and Yampa Rivers in Dinosaur National Monument have received intense research, inventory, and monitoring interest since prior to closure of Flaming Gorge Dam in 1962. The Upper Colorado River Endangered Fish Recovery Program has compiled a complete bibliography of reports; however, several are of particular interest to Dinosaur National Monument, both for their content and literature cited. Muth, et al. (2000) provides an excellent review of life history and ecology, an extensive literature cited, and an annotated bibliography. Bestgen and Crist (2000) provide the most recent information on fish communities. Tyus and Karp (1989) is an important work on the Yampa River.

A total of 26 species representing 9 families have been collected in the Green and Yampa Rivers during recent fishery investigations (Muth, et al. 2000). Of these, 9 were native (6 endemic to the Colorado River Basin) and 17 were non-native species. Four of the endemic species are endangered: Colorado squawfish, bonytail chub, humpback chub and razorback sucker. Flannelmouth sucker and roundtail chubs are considered rare and candidates for federal listing (already State-listed).

Many of the non-native species were introduced prior to 1900. Others, at least in terms of large population levels can be traced to recent releases. Some non-native species are of particular interest because of their potential or demonstrated impact on endangered fishes through predation or competition for selected habitats. Channel catfish, small mouth bass, and northern pike are important predators on certain life stages of the endangered species. The onset of northern pike problems can be traced to a substantial release of fish during a drawdown of Elkhead Reservoir in 1977. Although smallmouth bass had been observed in small numbers since 1992, another drawdown of Elkhead Reservoir in 1998 released large numbers of this species. Red shiner and fathead minnow are important competitors in Colorado squawfish nursery areas.

Threatened, Endangered and Sensitive Species

The Colorado pikeminnow (formerly Colorado squawfish), humpback chub, bonytail chub and razorback sucker are listed as endangered pursuant to the Endangered Species Act. The proximate cause of their collective decline is the construction of mainstem dams resulting in (1) flow modifications (timing, volume, water chemistry), (2) siltation and chemical pollution, (3) introduction of and predation by exotic species, (4) loss or modification of habitats and (5) loss of migratory routes. The respective Recovery Plans provide detail on present distribution and abundance, life history information, reasons for decline, etc (USFWS 1990a, 1990b, 1991, 1998). Recovery goals reports quantify population levels and other protections needed for downlisting and delisting (USFWS 2002a, 2002b, 2002c, 2002d).

The Yampa River, with its near-natural flows, is as the primary factor sustaining the continued existence of these species in the Upper Colorado River Basin. With modification of releases from Flaming Gorge Dam in the Green River, there is some ongoing colonization of Lodore Canyon by endangered fishes and at least a limited possibility of renewed spawning if releases are further modified as recommended by Muth, et al. (2000). The rivers in Dinosaur currently provide adult habitat, migration routes, spawning areas, and young-of-the-year and juvenile habitat for Colorado pikeminnow, humpback chub and razorback sucker. Bonytail have been reintroduced into both the Green and Yampa Rivers in 2000 and 2001. Young-of-the-year discoveries (e.g. Snyder 2001) have important implications for reserved water rights negotiations in the State of Utah.

Two large planning efforts are underway to address flows in the Yampa and Green Rivers (Yampa River water management plan; reoperation of Flaming Gorge Dam); the results of both will have a substantial

impact on the long-term status of the endangered fishes. Of particular concern is the FWS focus on Section 7(a)(2) of the Endangered Species Act – preventing extinction – whereas the NPS, in conformance with policy, focuses as well on Section 7(a)(1) – which relates to conservation and re-establishment in historic habitats.

Current threats to populations of endangered fishes in Dinosaur are more severe than in recent years. These include:

- Substantial increased predation and attempted predation by non-native fishes in the Yampa River with the apparent loss of the recruitment size class of Colorado pikeminnow since about 2000. Impacts to humpback chub have not been closely examined.
- Additional depletions from the Yampa River; being proposed in the Yampa River water management plan currently in preparation.
- Potentially insufficient releases from Flaming Gorge. The recommendations by Muth, et al. (2000) for flows describe thresholds to be exceeded under various hydrologic conditions. The USBR, in their NEPA process, is regarding these flow levels as targets to be reached but not exceeded.

Ongoing monitoring efforts include:

- Interagency Standardized Monitoring Program (ISMP); adult and young-of-the-year monitoring conducted by various universities and State and federal wildlife agencies).
- Larval drift of Colorado pikeminnow.

Ongoing research and management programs include:

- Population status and trend studies.
- Removal programs for channel catfish, northern pike and smallmouth bass.
- Habitat use and movements of Colorado pikeminnow in Lodore Canyon.
- Geomorphology studies on the Green and Yampa Rivers.

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Zion National Park - Fish

General Fish Studies

The hydrology of rivers and streams of Zion National Park has been little altered by human activities. As a result, the park's full complement of four native fish species dominate the fish fauna of the park. These species include Virgin spinedace (*Lepidomeda mollispinis*), flannelmouth sucker (*Catostomus latipinnis*), desert sucker (*Catostomus clarki*), and speckled dace (*Rhinichthys osculus*). An additional two species, woundfin (*Plagopterus argentissimum*) and Virgin River chub (*Gila seminuda*), are found downstream of the park in the Virgin River system, both of which are federally listed as endangered. Within the park the Virgin spinedace is being managed under a conservation agreement to avoid a federal listing. Park management of this species is the same as if it were listed. The flannelmouth and desert suckers are listed by the state of Utah as sensitive species. Gregory and Deacon (1994) observe that "stream habitats in and immediately below Zion National Park, for the present time, sustain a native fish assemblage that continues to resist being dominated by non-native fishes."

Investigations into the fish fauna of Zion National Park have consisted primarily of inventories and individual investigations into fish habitats, ranges and life histories. Interest in the Virgin River fish increased substantially following the listing of woundfin and Virgin River chub downstream of the park as endangered species in 1970 and 1978 respectively, and as a result of a lawsuit and subsequent Conservation Agreement for the management of Virgin spinedace in 1994. Regular monitoring of fish in the park began in 1994 with annual sampling on the NFVR, EFVR and North Creek by the Utah Division of Wildlife Resources.

Zion NationalPark falls entirely within the Virgin River Basin near its headwaters. The two largest rivers are the East Fork of the Virgin River (EFVR) and North Fork of the Virgin River (NFVR), both with perennial base flows of 20 to 60 cubic feet per second from groundwater discharge. Smaller tributaries that support fish are North Creek, Deep Creek, Goose Creek, Kolob Creek, Shunes Creek and Coalpits Wash (seasonally). LaVerkin Creek supports fish downstream of the park, but is fishless in the park due to a barrier fall. The hydrology of these streams is natural with the exception of Kolob Creek, which has a reservoir upstream of the park. Typically, the majority of the flow from these streams occurs as spring runoff from snowmelt. Short-lived flood peaks occur most often during the summer monsoon, but can occur any time of the year. Base flow occurs the remainder of the year, and all flow conditions show a considerable amount of year-to-year variability.

Threatened, Endangered, or Sensitive Fish Studies

In a 1962 report on the status of fishes in the Virgin River and Zion (Davis 1962) describes speckled dace and Virgin spinedace as common in the park, Blueheaded (desert) suckers as abundant, and Bigmouth (flannelmouth) suckers as present. A collection of Virgin spinedace by Miller and Hubbs in 1960 is noted. Rainbow Trout were stocked in the NFVR in the park in 1962, 1961, and 1960, even though such stocking was against NPS policy. Brook trout had been stocked in Emerald Pools and small water reservoirs in Birch Creek and near Angles Landing in 1930.

In 1969 Deacon, LaBounty and Bradly described the Virgin River as, "one of the rare examples of a relatively little-altered river system…" In a literature review and collections in 1965-66 they found 6 species of native fish and 11 introduced species, though two of the introduced species were based on questionable identifications of single individuals.

Zion National Park - Fish

In collections of fish at 77 stations throughout the Virgin River basin (nine in Zion) Cross (1975, 1985) found six native fish species and 13 introduced species. The diversity of species did not increase downstream as occurs in many other river systems.

Though he did not collect in ZION, Greger (1983, 1987) investigated the diets of native fish of the Virgin River. Virgin chub diets consisted of *Spirogyra* sp. and diatoms with a few associated invertebrates. Speckled dace were strictly insectivorous, consuming high numbers of small dipterans. Virgin spinedace consumed mostly insects. Woundfin were omnivorous.

In an effort to determine habitat preference for Virgin spinedace, Deacon, Rebane and Hardy (1991) sampled 11 stations on the NFVR, two on the EFVR and one on Shunes Creek within the park for spinedace and their habitat parameters. They concluded that within the park, the EFVR may be somewhat more favorable than the NFVR, though both have excellent populations of native fishes. In addition, adult spinedace prefer depths greater then .15 meter, current velocities of 0.3 to 0.9 m/second, and are relatively indifferent to substrate, except perhaps during spawning.

Valdez et al. (1991) assessed the distribution, abundance and status of Virgin spinedace with six sampling efforts between September 1986 and January 1990. They estimated that the historic range of Virgin spinedace had been reduced 40% from 143.9 river miles to 87.0 river miles. Of 13 populations in the basin they found three to be extirpated, six showing declines and facing persistent threats, and none of the remainder to be totally free of man-imposed threats. Large populations of Virgin spinedace were captured in North Creek downstream of the park, but the upstream extent of the fish's range appears to be at the park boundary due to a barrier fall. Five sites were sampled on the NFVR, two in the park and three upstream of the park. The two sites in the park yielded 21 and 51 Virgin spinedace over station lengths of 200 and 300 feet respectively. Electrofishing efforts upstream of Zion yielded only brook, cutthroat and rainbow trout. On the EFVR, two stations were sampled in the park, one downstream and two upstream. Large populations of Virgin spinedace were captured in the park and below, while no spinedace were found upstream of the park due to a barrier fall at the upstream park boundary. In Shunes Creek, a small tributary to the EFVR, Virgin spinedace were found, but the habitat is described as marginal due to the naturally low flow and in irrigation diversion (which has subsequently been relocated outside the park).

Building on the work of Valdez et al. (1991), Hardy and Addley (1993) conducted the most thorough inventory of fish in the Virgin River Basin. In 1992 they collected at 598 sites in the Virgin River basin, 71 of which are in Zion. In North Creek, speckled dace were most common, followed by desert suckers, both found at all stations, while Virgin spinedace were found only at the two lowest stations. Very small numbers of Rainbow Trout were also captured at 3 stations. Very small numbers of speckled dace, Virgin spinedace and desert suckers were captured in Coalpits Wash, though this stream is known to flow only seasonally. A total of 39 stations were sampled on the NFVR in the park. In the lower reaches speckled dace, Virgin spinedace and desert suckers were all abundant, and flannelmouth suckers less common. The abundance of all species drops off significantly in the Zion Narrows, and remains very low upstream of the park. A very few introduced trout were captured. In the deeply incised canyons of Orderville Gulch, Kolob Creek, and Deep Creek very low numbers of fish were found, predominately speckled dace. In the EFVR, all four native species were well represented in the 6 sample stations in the park and now introduced species were captured. Only speckled dace and desert suckers were found in the three stations upstream of Labyrinth Falls, and continuing further upstream out of the park. In Shunes Creek all of the native fish except flannelmouth suckers were found at 6 of the 9 stations.

Zion National Park - Fish

Annual monitoring of Virgin spinedace populations began in 1994 at one site each on the NFVR, EFVR and North Creek (Fridell and Curtis, 2002). Though the primary purpose of this monitoring by the Utah Division of Wildlife Resources is to monitor Virgin spinedace, all species are recorded. Spinedace populations in the EFVR were found to be consistently the highest in the fish's range, averaging an estimated density of 46 adult fish/100 m^2 sampled over the period of record. Adult spinedace in the NFVR and North Creek averaged 19.6 and 16.1 fish/100 m^2 respectively. Eight other stations are monitored in the basin outside of Zion. Production of young-of-year fish has been extremely variable, with only 2-3 years of high reproduction during the sampling period, and these not being consistent among the three streams in the park. Monitoring was not conducted in the EFVR and NFVR in 1998 due to high flow conditions. Other species commonly recorded include speckled dace, flannelmouth suckers, and desert suckers. Exotic fist are rarely recorded and have included brown trout, rainbow trout, and channel catfish. Results of this monitoring are also reported in Fridell, Comella and Hogrefe 2000.

In an effort to determine if recreational disturbances caused changes in the fish community, Sappington (1998) sampled fish assemblages in 22 pools on the NFVR in Zion. Each pool was sampled four times over the summer season, and fish species and size recorded. Pools experiencing high levels of wading and float tubing were found to have altered fish population distributions and community structures when compared to pools without these kinds of recreation. Food availability (algal biomass and macroinvertebrate drift density) was similar among all pools, but larval fish densities were reduced in pools experiencing recreational disturbance, as was the occurrence of desert sucker.

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Arches National Park - Reptiles and Amphibians

General Reptile & Amphibian Studies

An initial study of reptiles using array traps set up in three vegetation communities was carried out in Arches during the summer of 1983 (USDI 1983). Long-term monitoring of herpetofauna was initiated when Graham and Belnap (1989, 1990) began a long-term monitoring project in 1987 to inventory and monitor herpetofauna in Arches (DS-SEUG-019.2). This was a comprehensive program that monitored plant species richness, frequency and cover, bird numbers, small rodent densities, and herpetofauna numbers. Several methods were attempted and experimented with, including the use of Emlin strip transects. The herpetofauna component of the monitoring program was stopped in 1990 due to the low numbers of reptiles observed. In a report to all NPS Southeast Utah Group parks, Graham (1990) described population survey methods for amphibians in potholes and canyon riparian areas, outlined a concern in the western U.S. about an apparent unexplained decline in amphibian populations, and requested that all parks start surveys using the described methods.

An early reconnaissance of the area reported the collection of one amphibian and three lizard species (BYU 1947). A list of amphibians and reptiles in Arches and Canyonlands National Parks identified salamanders, frogs and toads, lizards, and snakes, and provided common and scientific name and preferred habitats (USDI 1991). A checklist of the animals of Arches National Park (USDI 1994) was also compiled from wildlife observation cards, long-term monitoring program data, and research and survey reports. Graham (2000) compiled a list of species known or likely to occur in Arches, based on personal observation, a species checklist compiled by Drogin (1991), and lists of reptiles and amphibians of the SEUG parks compiled by Schelz (2000, 2001). A further species list can be found in Hammerson (1999).

Peripheral or academic studies involving the herpetofauna of Arches include Hayward et al. (1958), who conducted a study on the zoology of the upper Colorado River basin. He included sections on the plants, animals, and community types in Arches National Monument, Capitol Reef National Monument, parts of what is now Glen Canyon National Recreation Area, and other sites in Utah. The report also included geologic and climate information, a discussion of distributional barriers and lanes of dispersal. A checklist gives common and scientific names for amphibians, reptiles, birds, and mammals with a general distribution according to basin subdivisions.

Kauffeld (1965) published an account of his search for a specimen of the midget-faded rattlesnake (*Crotalus viridis concolor*) to complete the Staten Island Zoo's collection of all thirty-two forms, species, and subspecies of rattlesnakes found in the United States, and his capture of one in Arches National Park. Dodson (1987) published his study on animal assemblages, which included reptiles and amphibians, in temporary desert rock pools together with an ecological investigation of a biting midge, (Diptera: Ceratopogonidae) from sites in Arches.

Graham (1992) published his work on pothole ecology in the Colorado Plateau, which focused on the sensitivity of pothole communities and ecosystems to acid deposition. He conducted experiments on the hatching success of amphibians and crustaceans at low pH's, and the short term effects of acid on larval amphibians, larval and adult crustaceans, and adult snails. The study also included effects on various stages of the intermountain spadefoot toad (*Spea intermontanus*) and red-spotted toad (*Bufo punctatus*).

Lastly, a survey of the herpetofauna of Arches National Park was initiated in 2002, conducted through the Northern Colorado Plateau Network Inventory and Monitoring initiative. Results should be available in 2003.

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DS-SEUG-019.2 Emlen strip transects for herpetofauna in the Southeast Utah Group National Parks, 1987-1990. Status: inactive.

Black Canyon of the Gunisson National Park - Reptiles and Amphibians

General Reptile & Amphibian Studies

An annotated species list of the reptiles and amphibians of Black Canyon of the Gunnison National Park was compiled in 1966 (McCoy, 1966). Graham (2000) has also compiled a list of species likely to occur in this park unit.

A survey of herpetofauna was conducted in 1997, which employed live trapping, search and noose, and personal observation methods at different locations within the park (Fallon, 1997, DS-BLCA-0007). Species such as the western leopard frog, listed in the 1966 survey, were not detected by any of the trapping methods used. Whether this was due to the paucity of the arrays, their location, or the actual presence/absence of the species in the park, is unknown and will remain unknown until more in-depth studies are completed.

There have been no other systematic surveys or studies of herpetofauna carried out at this park.

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Data Sets

DS-BLCA-0007 Herpetofauna survey, 1997. 6/22/1997-10/1/1997 (hand-written field sheets). Originated by: Sylvia Fallon; status: Inactive

Bryce Canyon National Park - Reptiles and Amphibians

General Reptile & Amphibian Studies

Studies of the herpetofauna in Bryce Canyon National Park began in the 1920s, and Tanner (1930) published a list of two amphibians, 3 lizards, and 2 snake species occurring within park boundaries from specimens he and park staff observed from 1927-1929. Walker (1939) compiled a brief, annotated checklist and key to the amphibians and reptiles of Bryce, Zion and Cedar Breaks. Wilhelm (1967) compiled a list of amphibians, reptiles and mammals of Bryce Canyon National Park. The area covered by the amphibian checklist includes the confines of the Park plus the territory east to the Paria River and west to the East Fork of the Sevier River.

Other lists include a Utah Division of Wildlife Resources publication (1981) which provides a general list of reptiles with on their distribution and habitats, and another by Hallows (1982), who compiled a list of the amphibians from an informal survey of the park during the 1982 summer. Hallows listed 3 amphibian species, none of which were observed within the park, but rather just outside, and four lizard and 3 snake species, all occurring within the park boundary. Graham (2000) also compiled a list of species likely to occur in this park unit.

A resource management plan for the park included a checklist of reptiles and amphibians, together with their current and proposed management actions and alternatives (Bryce Canyon 1977). In a U.S. Forest Service General Technical Report, Bogan et al. (1988) discussed the importance of biological surveys for amphibians, reptiles and small mammals. Burch (1994) conducted a herpetological survey of Bryce Canyon National Park using ten transect locations in different habitat types, including oak-woodland, pinyon-juniper, and sage-grass. He reported that no reptiles were seen on, or under any of the tiles on any of the ten transects. Only two species were seen incidental to surveying the transects, the Western fence lizard (*Sceloporus occidentalis*) and the short-horned lizard (*Phrynosom douglasii*).

In addition, a study on the herpetology of Bryce was conducted from March through September of 1997 to determine species presence and distribution (Kershaw et al. 1997). Ten sites were surveyed for the study. Reptiles observed were Northern sagebrush lizard (*Sceloporus graciosus*), Tree Lizard (*Urosaurus ornatus*), Mountain Short-horned Lizard (*Phrynosoma douglassi*), Great Basin Skink (*Eumeces skiltonianus utahensis*), Wandering Garter Snake (*Thamnophis elegans vagrans*), and the Great Basin Rattlesnake (*Crotalus viridis lutosus*). Amphibians observed were Tiger salamander (*Ambystoma tigrinum*), Northern leopard frog (*Rana pipiens*), and Great Basin spadefoot (*Scaphiopus intermontanus*). There were sufficient numbers of Sceloporus to indicate that it was common throughout the park. During heavy rains there were a number of sightings of *Ambystoma tigrinum*, and *Scaphiopus intermontanus*. But under conditions that lacked abundant moisture, none were observed or collected.

There have been two academic studies involving herpetological information. Edwards et al. (1990's) reported on their gap analysis study to estimate the spatial distribution of terrestrial vertebrate species. They used long-term species lists from 8 Utah parks including Canyonlands and, which presumably included some herpetofauna lists. Results from this study are unknown.

Most recently, a survey of the herpetofauna of Bryce National Park was carried out in 2001 and 2002, conducted through the Northern Colorado Plateau Network Inventory and Monitoring initiative (Nowak et al. 2001). This survey produced a preliminary list of 1 amphibian, 4 lizard and 2 snake species, and estimates of survey completeness; a final report is expected in early 2003.

Threatened, Endangered, or Sensitive Reptile & Amphibian Studies

There is one sensitive species that occurs in this locality, the boreal toad (*Bufo boreas boreas*), a candidate for listing under the Endangered Species Act of 1973. Although not actually recorded within the park boundaries, it occurs just outside the park to the west, in the drainages of the East Fork of the Sevier River in the Dixie National Forest. One study of this species was conducted in this locality, and describes some ecological relations of a population of boreal toads occurring just outside the park (Robinson et al. 1998). A more thorough study in this area is currently underway, including radio tracking of individuals from several populations in the East Fork drainages (S. Brazier, U.S. Forest Service, pers. comm. 2002). The Utah Department of Wildlife Resources (Wheeler 2001) has set up five boreal toad-monitoring stations. The presence of the disease-producing chytrid fungus has been confirmed in this locality (National Wildlife Health Center 2001), which has major implications to the conservation and management of this sensitive species and of other amphibians occurring in this area.

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Canyonlands National Park - Reptiles and Amphibians

General Reptile & Amphibian Studies

Most of the historical work on reptiles and amphibians in Canyonlands National Park is presented in the form of species lists, often with accompanying biological information. Holmgren et al. (1961) described the amphibians and reptiles in the area around Dead Horse Point State Park and included a species checklist with notes on the major sub-groups. Canyonlands National Park (1969) published a checklist of amphibians and reptiles observed from the Island in the Sky District of Canyonlands from 1965 to 1969. A record of wildlife observations (which presumably includes herpetofauna) from Canyonlands National Park (date unknown), Island in the Sky District from 1965 to 1985, included scientific and common name, date, location, habitat type of observation point and numbers observed. Jaenike et al. (1977) compiled an annotated checklist of amphibian and reptile species captured in the riparian habitats of the Green and Colorado Rivers within the boundaries of Canyonlands National Park. The list also includes location and description of microhabitats for specimens found. And anecdotal reports include a printout of individual sightings in the Maze District of Canyonlands National Park that documents birds, mammals, and reptiles (NPS 1980).

The National Park Service (1991, author unknown) complied a checklist of amphibians and reptiles found in Canyonlands National Parks, together with habitat preferences, and another checklist of animals of Canyonlands National Park was compiled from wildlife observation cards, long-term monitoring program data, and research and survey reports (DS-SEUG-037, USDI 1994). Fields include common name, scientific name, documentation type, presence, special status, origin, distribution, resident status, breeding, abundance, and database source. Graham (2000) provided a USGS Biological Resources Division reptile and amphibian species list to the National Park Service, Resource Management Division. and Schelz compiled a species list of reptiles (2000) and amphibians (2001) for the National Parks Service, Southeast Utah group of parks.

Johnson and Wessels (1975) described the habitat and breeding behavior of the desert toad (*Bufo punctatus*) in an overnight field trip in Canyonlands National Park; however a copy of their report has a handwritten note, "Contains erroneous info. about range of this amphib. Arches NP has a healthy Bufo punctatus population." Glenn (1979) provided a brief summary of data collected from observations of snakes in general and rattlesnakes in particular in Canyonlands National Park, with specific attention given to behavior and very toxic venom of the midget faded rattlesnake (*Crotalus viridis concolor*).

Long-term monitoring of herpetofauna was initiated when Graham and Belnap (1989, 1990) began a long-term monitoring project in 1987 to inventory and monitor herpetofauna in Canyonlands (DS-SEUG-019.1). This was a comprehensive program that monitored plant species richness, frequency and cover, bird numbers, small rodent densities, and herpetofauna numbers. Several methods were attempted and experimented with, including the use of Emlin strip transects. The herpetofauna component of the monitoring program was stopped in 1990 due to the low numbers of reptiles observed. In a report to all NPS Southeast Utah Group parks, Graham (1990) described population survey methods for amphibians in potholes and canyon riparian areas. He outlined a concern in the western US about an apparent unexplained decline in amphibian populations and requested that all parks start surveys using the methods he described.

Long-term monitoring resumed when an eight-mile section of a rough four-wheel drive road through an important riparian/wetland corridor (Salt Creek, Needles District, Canyonlands National Park) was closed in 1998 (Schelz 2001). This report briefly describes and summarizes studies predating the closure, the functions of riparian systems and wet meadow vegetation and the scientific body of knowledge on the ecological effects of roads in arid and semi-arid environments and its relationship this system. Most of

this report is dedicated to describing methods and presenting results of an extensive monitoring program initiated since 1998. Monitoring elements include riparian vegetation, stream channel characteristics, permanent photopoints, aquatic macroinvertebrates, amphibians, water quality sampling, and riparian birds (DS-SEUG 075). Schelz makes recommendations for management and further monitoring.

Graham (2001) summarized the results of amphibian sampling and invertebrate collections at Salt Creek in the Needles District of Canyonlands National Park during summer, 2000. The report emphasized the importance of this monitoring to ongoing political and resource management controversies over use of the creek area for motorized travel. In particular, the Salt Creek ecosystem has seen heavy use, most recently by off-road vehicles (ORVs) and the research being done by Graham and Earthwatch volunteers is is focusing on the potential effects of 4WD vehicles on amphibians (DS-SEUG-060).

There have been several important publications which peripherally involve reptiles and amphibians from Canyonlands. West (1983) devoted a book chapter to a description of the ecosystem that occurs in the lowest, driest portions of the Colorado Plateau, including Arches, Canyonlands and Grand Canyon national parks, and the Navajo Indian Reservation. The author provides details regarding the physical, biological, and human components of this ecosystem. Sections discuss climate and soils, primary producers and consumers, land-use history, and unsuccessful attempts to increase forage availability. A drawing shows the relationship of vegetation types to elevation and regolith in Canyonlands National Park. With maps, small photographs (including Pete's Mesa in Canyonlands, pipeline route at Arches, and blackbrush under Rainbow Bridge), diagrams, and a table of mammal, bird and reptile species with abundance codes.

Johnson (1983) completed his Ph.D. dissertation on the animal inhabitants of five isolated buttes (and one non-isolated control butte) in southeastern Utah. Three of the buttes were within or near the boundary of Canyonlands National Park, the other three on BLM land east of Canyonlands. The static species composition and undisturbed nature of these areas is unique, and allowed for the testing of some biogeographic theories. The author referred to the sheer cliffs that bound the buttes as "filter-bridges," and concluded that the characteristics of cliffs and not summit areas were the predominant factor in determining which species of mammals, reptiles and ants lived on top. Reptilian species composition apparently substantially depended on other factors, such as butte area, food availability and competition (Johnson 1986).

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Data Sets

DS-SEUG-019.1	Emlen strip transects for herpetofauna in the Southeast Utah Group national parks, 1987-1990. (hard-copy data files). Originated by Tim Graham; status: Inactive.
DS-SEUG-037	Amphibian survey data from Horseshoe Canyon, Maze District, Canyonlands National Park, 1990 - present. (Excel workbook (1999-present); dBase or some other format (at least some of 1990-1993 data); hard-copy data sheets). Originated by Graham, Tim. Status: Active.
DS-SEUG-060	Amphibian inventory along and near a closed road in Salt Creek Canyon, Canyonlands National Park, 1999 - present. (MS Excel spreadsheet; hardcopy field forms). Originated by Graham, Tim; status: Active.

Canyonlands National Park - Reptiles and Amphibians

DS-SEUG-075	Amphibian research and monitoring, Canyonlands National Park, 2001-present. (Excel spreadsheets, GPS data, documents). Originated by Resource Management staff; status: Active.
DS-SEUG-076	Amphibian inventory in the park units of the Northern Colorado Plateau Network, 2001- present. (Excel and Access files,GIS coverages, reports). Originated by Northern Colorado Plateau Network; status: Active.

Capitol Reef National Park - Reptiles and Amphibians

General Reptile & Amphibian Studies

Many herpetofauna studies during the 1940s through the 1960s were devoted largely to paleological surveys (Kelly 1948, Colbert 1951, Lammers 1964).

Early work on extant species includes Kelly (1948) and Hayward et al. (1958), who conducted a study on the zoology of the upper Colorado river basin including sections on the plants, animals, and community types in Arches National Monument, Capitol Reef National Monument, parts of what is now Glen Canyon National Recreation Area, and other sites in Utah. The report also included geologic and climate information, a discussion of distributional barriers and lanes of dispersal. A checklist gives common and scientific names for amphibians, reptiles, birds, and mammals with a general distribution according to basin subdivisions. Hoddenbach (1977) conducted a preliminary biological evaluation of the Hall's Creek section of Capitol Reef, reporting on reptiles and amphibians in addition to fish, mammals, and potential nesting sites for peregrine falcons and habitats for spotted bats. He also noted vegetation in canyons, historical and cultural resources, wilderness characteristics and implied isolation, the fragile character of the area, and access routes. Lindahl (1977) completed a faunal survey of Hall’s Creek and compiled lists of mammals, birds, reptiles, amphibians, fish and invertebrates. The Capitol Reef Natural History Association (1984) produced a list of the reptile (turtles, lizards, and snakes) and amphibian (salamanders, fish, frogs, and toads) species identified in or near Capitol Reef National Park as well as species whose range includes the park. There are some observational records for mammals, birds, invertebrates, insects, reptiles and amphibians at Capitol Reef National Park taken from wildlife observation cards (NPS 1988), and most of these records have been catalogued (DS-CARE-0004).

A list of amphibian (salamanders, frogs, toads) and reptile (lizards, snakes) species either known or suspected to exist in Capitol Reef National Park was compiled in 1990 (National Park Service 1990). Bartholomew et al. (1990) also developed a list of reptile (lizards, snakes) species observations at Capitol Reef and Zion National Parks. The observations are grouped by animal behaviors: breeding, feeding, species records, and miscellaneous. Graham (2000) also compiled a reptile and amphibian species list for Capitol Reef.

There have been a number of academic studies on the herpetofauna of Capitol Reef, beginning with Woodbury and Musser (1963), who conducted a limnological study of the Fremont River and analyzed their results as part of a University of Utah, Division of Biological Sciences research project. They collected amphibians, fish, aquatic invertebrates and water samples and studied the physical characteristics of the river. Trimble (1977) looked at isolated waterholes and intermittent streams in canyons of the Colorado Plateau, as well aa frogs and toads in his discussion of the Halls Creek drainage in Capitol Reef National Park.

Aird (1982) applied for a research permit to collect specimens of midget-faded rattlesnakes (*Crotalus viridis concolor*) to study geographic variation between this species and the prairie rattlesnake (*Crotalus viridis viridisr*), with respect to environmental determinants, and Quinn (1985) proposed a study to compare and combine morphometric, electrophoretic, and mitochondrial DNA fragment analyses to form estimates of differentiation among midget-faded rattlesnake (*Crotalus viridis*) populations. So far as is known, these studies were never initiated.

Other studies related to herpetofauna include Boyle (1986), who assessed the aquatic resources in the tinaja ecosystems of the Waterpocket Fold and provided basic ecological information about isolated aquatic systems. H.D. Smith and Associates (1989) conducted a pre-manipulation study of the factors and organisms likely to be influenced by the proposed Fremont River WaterPower Project. The study was

undertaken to document avian and terrestrial vertebrates present in the project area and to address the possible impacts of the waterpower project. Dalton et al. (1990) published a Utah Division of Wildlife report on the fauna of southeastern Utah, which contains an initial discussion of the various ecosystems together with separate sections on fish, amphibians, reptiles, birds and mammal species. Tables show relative abundance, distribution by geographic area, and relative biological value of individual ecosystems for each group. An SCA volunteer conducted an amphibian survey during the summer of 1993, as part of an independent study project for Hiram College (DS-CARE-0031). The methodology consisted of walking a designated reach of a stream, identifying and counting all adult and juvenile amphibians seen. Areas surveyed included Sulphur Creek, the Oxbow, Pleasant Creek, Hickman Bridge drainage, Sheets Gulch, Lower Spring Canyon, Willow drainage, Burro Wash, the Tanks in Capitol Gorge, Cottonwood drainage, Fremont River, and the Fruita orchards and irrigation ditches. Total number of survey-days was approximately 17.

Between 1989 and 1992, crews conducted mammal surveys at 12 general locations in the park (Bogan and Ramotnik 1993) and also collected some herptile specimens and data (Bogan 1992).

Lafrancois (1994, 1996) and colleagues conducted a study of the biological and chemical characteristics of representative tinajas of Capitol Reef National Park with an emphasis on the response of these systems to disturbance. Flood impacts on the community, species diversity, life histories of aquatic communities, and recovery times are all discussed. Intensive sampling documented conditions in 20 pools located in five different drainages, including identification of twice as many macroinvertebrate and anuran species as found in previous studies in the area (DS-CARE-0024).

Nowak et al. (2002) reported their first-year results for herpetofauna surveys they conducted between May and September 2001. The list of reptiles potentially occurring in Capitol Reef contains 25 species: 12 are currently documented with specimens and one by observations. The list of amphibians potentially occurring within the park includes nine species, four of which are documented by vouchers and one by observations. A second year of inventory will be completed in 2002, with a final report expected in early 2003. The second year of inventory was completed in 2002, with a final report expected in early 2003.

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Capitol Reef National Park - Reptiles and Amphibians

Data Sets

DS-CARE-0004 Wildlife observations database Wildlife observations database. 1/1/1950 - . (MS Access 97 files, converted from Dbase files). Originated by Capitol Reef National Park; status: Active.

DS-CARE-0024 Tinaja survey data: 1993 and 1994 Tinaja survey data: 1993 and 1994. 10/12/1993 - 5/26/1994. (MS Access97 (converted from Dbase); associated paper files.). Originated by Capitol Reef National Park; status: Inactive.

DS-CARE-0031 Amphibian survey data. 5/24/1993 - 8/24/1993. (Paper field forms.). Originated by J. Kalamanides; status: Inactive.

Cedar Breaks National Monument - Reptiles and Amphibians

General Reptile & Amphibian Studies

There are two historical accounts of herpetofauna in Cedar Breaks National Monument. Walker (1939) compiled a brief, annotated checklist of the amphibians and reptiles within Cedar Breaks, and Tanner (1954) described reproductive observations of two short-horned (*Phrynosoma hernandesi*) lizard females collected at Webster Flats at Cedar Breaks. Graham (2000) compiled a list of species known or likely to occur in the monument.

A survey of the herpetofauna of Cedar Breaks National Monument was conducted in 2001 and 2002, through the Northern Colorado Plateau Network Inventory and Monitoring network (Nowak, et al. 2001). First-year results included survey results, a species list, and estimates of survey completeness. A final report that includes 2002 results is expected in early 2003.

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Colorado National Monument - Reptiles and Amphibians

General Reptile and Amphibian Studies

There has been a considerable amount of herpetological research carried out in Colorado National Monument, beginning in the 1960s. McCoy collected specimens (most likely located at the University of Colorado in Boulder) and carried out a number of studies on the herpetofauna in this park (McCoy et al. 1964, McCoy et al. 1967). Tinkle (1967) published the life history and demography of the side-blotched lizard based on collections made in Colorado National Monument. Corl (2002) conducted frquency dependency research into side-blotched lizards in the summer of 2002, a summary report has not yet been submitted. Luepschen (1981) published life history notes and a larval coloration study of the red-spotted toad (*Bufo punctatus*), presumably from collections made in Colorado National Monument.

More recently, M'Closkey from the University of Windsor, Ontario, has conducted lizard behavioral studies in the monument from 1988 to 1994, and has written several publications describing lizard interactions and habitat usage (M'Closkey et al. 1987, Deslippe and M'Closkey 1991, M'Closkey and Hecnar 1994, M'Closkey et al. 1997, M'Closkey et al. 1998 and M'Closkey and Hecnar 1998).

Hammerson has also undertaken extensive field studies of the herpetofauna of Colorado National Monument, some of which is reported in a Colorado field guide of herpetofauna (Hammerson 1999). There is also an annotated species list outlining the species present with habitat and location notes (Miller and Hammerson, date unknown). The Colorado Division of Wildlife has also carried out some surveys within the park (Creeden 1994), and Graham (2000) compiled a list of species known or likely to occur in the monument. Incidental observations of reptiles and amphibians, some dating to the early 1900s, are included in a database of wildlife reports submitted by park staff and visitors; however, the reliability of these observations can vary widely (DS-COLM-0006)

A survey of the herpetofauna of Colorado National Monument was carried out in 2002, conducted through the Northern Colorado Plateau Network Inventory and Monitoring Network. Results from this survey are expected in 2003.

References

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Data Sets

DS-COLM-0006 Wildlife observations, 1900-1996. Originated by Colorado National Monument staff. Status: Legacy.

Curecanti National Recreation Area - Reptiles and Amphibians

General Reptile & Amphibian Studies

There have been no systematic surveys or studies of herpetofauna carried out in Curecanti National Recreationa Area. During the summer of 1961 a crew from the University of Utah carried out ecological surveys of the reservoir basins of the Gunnison River, as part of the Curecanti Project. They published an annotated list of their herpetological observations, which included one amphibian, two lizard and one snake species (Stock 1962). Goldstein (1994) conducted a herpetology study in the area, and included descriptions of the smooth green snake (*Opheodrys vernalis blanchardi*), western terrestrial garter snake (*Thamnophis elegans*), and bullsnake (*Pituophis catenifer sayi*).

Graham (2000) compiled a list of species likely to occur in the area.

Curecanti has assembled various wildlife observations submitted by park staff and visitors, that include species name, location, date, time, weather, description/notes, and observer; however, the reliability of these observations can vary widely (DS-CURE-0015).

References

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Graham, Tim. 2000. Northern Colorado Plateau National Park Reptile and Amphibian Species List. USGS Biological Resources Division. Albuquerque, NM.

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Data Sets

DS-CURE-0015 Curecanti natural history sightings. 1/1/1963 - 1/1/2000. (Microsoft Access). Originated by Myron Chase; status: Inactive.

Dinosaur National Monument - Reptiles and Amphibians

General Reptile and Amphibian Studies

Herpetological inventory work occurred along the rivers in 1982 (Bogan, et al. 1983), and upland herpetological inventory work was conducted in 1991 and 1992 by Corn, with voucher specimens reposited with USGS-BRD in Albuquerque. Nineteen species; three other species suspected but not documented. There is currently no record of a final report by Corn.

Both Colorado and Utah wildlife agencies have published latilong reports on reptiles and amphibian (Hammerson and Langlois 1981; Langlois 1978; Schwinn and Minden 1979).

Research has been conducted on the distribution of midget faded rattlesnakes by Colorado State University (reference pending**).** No systematic monitoring is being conducted by park staff.

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Fossil Butte National Monument - Reptiles and Amphibians

General Reptile and Amphibian Studies

A survey of the herpetofauna of Fossil Butte National Monument was carried out in 2001 and 2002, conducted through the Northern Colorado Plateau Network Inventory and Monitoring initiative (Nowak, et al. 2001). First-year results of this survey has produced a list of five species (three amphibians, one lizard and one snake) and estimates of survey completeness; a final report should be available in early 2003. Prior to the onset of this survey, Graham (2000) compiled a list of species likely to occur in the monument. Other previous work at Fossil Butte includes observations made by Rado (1977) and a grazing impact study that included a list of the species present (Dorn et al. 1984). Both of these sources list the same five species documented in Nowak 2001.

References

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Nowak, Erika, Persons, Trevor, Platenberg, Renata and Graham, Tim. 2002. First-year results for herpetofauna inventories of southern and northern Colorado Plateau parks. USGS Biological Resources Division. Flagstaff, AZ. 70 pages.

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Golden Spike National Historic Site - Reptiles and Amphibians

General Reptile & Amphibian Studies

A survey of the herpetofauna of Golden Spike National Historic Site was carried out in 2001 and 2002 conducted through the Northern Colorado Plateau Network Inventory and Monitoring Network (Nowak et al. 2001). First-year results include a species list and estimates of survey completeness. Prior to the onset of this survey, Graham (2000) compiled a list of species known or likely to occur in the area. The staff at Golden Spike has been keeping notes on wildlife observations since 1999, which include several observations of snakes and toads, and this information has been incorporated into an annotated list of wildlife species occurring in the park unit. Eleven species of herpetofauna are included in this list. (USDI 2000).

References

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Hovenweep National Monument - Reptiles and Amphibians

General Reptile and Amphibian Studies

Graham (2000) compiled a list of species likely to occur in the monument, based on previous survey work conducted by Rado (1974, 1975, and 1976), and species lists for reptiles and amphibians compiled by Schelz (2000a, 2000b). A further list can be found in Hammerson (1999). The Park Service staff has summarized their work to date identifying animal species at Hovenweep, including reptiles and amphibians (NPS 2000).

Quinn (1984) undertook a study to identify rattlesnake subspecies (*Crotalus viridus*) in the monument, though results are unknown.

A survey of the herpetofauna of Hovenweep National Monument was initiated in 2001 and concluded in 2002, conducted through the Southern Colorado Plateau Network Inventory and Monitoring Program (Nowak, et al. 2001). This survey resulted in 12 species being detected, and an estimated inventory completeness of 48%.

References

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Schelz, Charlie. 2000a. List of Amphibians for Arches, Canyonlands, Hovenweep and Natural Bridges -- National Park Service Southeast Utah Group. 1 pages.

Schelz, Charlie. 2000b. List of Reptiles for Arches, Canyonlands, Hovenweep and Natural Bridges -- National Park Service, Southeast Utah Group. 2 pages.

Natural Bridges National Monument - Reptiles and Amphibians

General Reptile & Amphibian Studies

Graham (2000) compiled a list of species likely to occur in the monument, was based on personal observations, an annotated checklist of species at the monument (Persons 1990a, 1991, 1992), and a species list for the SEUG parks (Schelz 2000, 2001). A checklist in the newsletter of the Utah Association of Herpetologists (author unknown 1992) provides the genus, species, common name and where the specimens were found within the monument.

There has been considerable attention paid to the rattlesnake population at Natural Bridges National Monument. Rose (1989) described some general observations of the rattlesnakes in the monument. Subsequently, this population was the subject of a radio-tracking study carried out from 1989 to 1991, which was commissioned because of the high number of rattlesnakes found around the visitor center. Methods employed and attempted in this study were described by Beck (1989) and also appear in various reports on the results (Graham 1989a, 1989b, NPS 1990, NBNM 1991, Persons 1990b). Schaedla (1991) outlined the results of this study, and Graham (1991, 1992) provided ecological accounts and management recommendations. The raw data, in the form of datasheets, photographs of individual specimens, videotapes, and field notes, are on at the Southeast Utah Group (DS-SEUG-036). The temperature relations of the rattlesnakes were also examined (Graham al 1991, 1995 and 2001). Glenn (1991) reported on the results of a analysis of rattlesnake venom collected at Natural Bridges, which determined that the rattlesnake population of the monument appears to be an intergrade between the *concolor* (midget-faded) and *viridis* (prairie) subspecies of *Crotalus viridis*.

In addition to the rattlesnake work, other studies of herpetofauna carried out at Natural Bridges National Monument includes a study on the biogeography of canyon treefrogs (*Hyla arenicolor*), although the results of this study are not available for review (Murray 1993a, 1993b).

Some long-term monitoring lizard transects were set up in different vegetation communities in the mid 1980's at Natural Bridges but no significant data was collected (USDI 1985). Graham also performed Emlen strip transect surveys for herpetofauna in the Southeast Utah Group park units from 1987-1990 (DS-SEUG-019.3).

A survey of the herpetofauna of Natural Bridges National Monument was carried out in 2002, conducted through the Northern Colorado Plateau Network Inventory and Monitoring (Nowak et al. 2002). Final results of this inventory are expected in early 2003.

References

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Graham, Tim B. 1989a. Snake study. USDI, National Park Service. Moab, UT. 300? pages.

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Graham, Tim B., Persons, Trevor, Schaedla, William and Moore, Donald. 1991. Temperature patterns of rattlesnakes (Crotalus viridis) at Natural Bridges National Monument, Utah. 15 p.

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USDI, National Park Service. 1985. Lizard array: Natural Bridges National Monument. 25+ pages.

Data Sets

DS-SEUG-019.3 Emlen strip transects for herpetofauna in the Southeast Utah Group national parks, 1987-1990. (hard-copy data files; photographs; videos.). Originated by Grahams, Tim; status: Inactive.

DS-SEUG-0036 Rattlesnake data, Natural Bridges National Monument, 1983. (spreadsheet and dBase files).

Pipe Spring National Monument- Reptiles and Amphibians

General Reptile and Amphibian Studies

Probably the earliest records relating to reptiles and amphibians on Pipe Spring National Monument are the work journals of C. Leonard Heaton, the first monument superintendent, dating from 1928 to 1963 (with the years 1929 – 1934 missing), which contain various references to reptiles and amphibians observed during his tenure. Blair (1955) published his study on the distribution, variation and hybridization in a relict toad, (*Bufo microscaphus*) in southwestern Utah, and postulated that hybridization has occurred in the population. Fowlie (1965) mentions a locality record for *Crotalus viridis lutosis* (Great Basin rattlesnake) at Pipe Spring National Monument. Park staff have also maintained records of observations and relocations of snakes within the monument grounds (NPS 1993), and Graham (2000) compiled a list of species known or likely to occur in the monument.

A comprehensive survey of the herpetofauna of Pipe Spring National Monument was carried out in 2001 and 2002, conducted through the Northern Colorado Plateau Network Inventory and Monitoring Network (Nowak et al. 2001). First-year results of this survey include a list containing 14 species (3 amphibians, 8 lizards, and 3 snakes) and estimates of survey completeness. A final report is expected in early 2003.

References

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Fowlie, J. A. 1965. *The snakes of Arizona*. Azul Quinta Press, Fallbrook, CA

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Timpanogos Cave National Monument - Reptiles and Amphibians

General Reptile and Amphibian Studies

There has been one survey of the herpetofauna of Timpanogos Cave National Monument, carried out during 2001 and 2002, conducted through the Northern Colorado Plateau Network Inventory and Monitoring Network (Nowak et al. 2001). First-year results of this survey document four species (one lizard, three snakes) and estimate the level of inventory completeness.

Graham (2000) compiled a list of species known or likely to occur in the monument. There have been no other systematic surveys or studies of herpetofauna carried out at the monument. The monument's museum collection contains six preserved specimens, and there are some natural history notes contained on approximately 29 observation cards dating from 1963 to 1975. In addition, the interpretation rangers occasionally keep records of rattlesnake sightings and relocations.

References

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Zion National Park - Reptiles and Amphibians

General Reptile & Amphibian Studies

Species lists of the herpetofauna of Zion were begun in the early twentieth century. Woodbury (1927) was the first to publish a species list and descriptions of the amphibians of Zion National Park in the journal, Copeia, and the reptiles of Zion in a Dixie College publication (Woodbury, date unknown). He also listed the herpetofauna in two other Zion National Park species lists (Woodbury 1928, 1929). Walker (1939) compiled a brief, annotated checklist and key to the amphibians and reptiles of Zion, Bryce, and Cedar Breaks. Wauer (1963, 1964) also compiled a brief, annotated checklist of the amphibians and reptiles within Zion National Park, and discussed the ecology and habitat location for each amphibian and reptile species. Some observation information has been compiled from visitor and park staff reports; however, the reliability of these observations can vary widely (DS-ZION-0008). Graham (2000) provided a USGS Biological Resources Division reptile and amphibian species list to the National Park Service, ZION Resource Management Division. Overall the inventory of reptiles may be approximately 75% complete and amphibians may be approaching 90% (Nowak 2002). As with all species groups within the park, abundance and distribution information is not comprehensive.

There are over a dozen references devoted to information on tortoises, lizards and toads in Zion National Park. Moore (1994) conducted a biological survey of the desert tortoise (*Gopherus agassizii*) for Zion National Park. Desert tortoises were also surveyed in one small area in the southern portion of the park as part of a Section 7 (ESA) consultation for a construction project (Topham 1994). Grover and DeFalco (1995) outlined a status-of-knowledge report on the desert tortoise for the U.S. Forest Service, but it is not clear if the Zion population is included in the "St. George vicinity". McLuckie et al (2000) conducted a desert tortoise distribution survey in Zion for the Utah Division of Wildlife Resources and found seven individuals. The line-distance transect method used, however, did not give a precise population estimation and ranged from 4 to 59 individuals. ZION is monitoring desert tortoises through a quadrat design with observer bias as an error estimate (in progress) in order to get a more precise population estimate.

McKinney (1969) completed his Ph.D. dissertation on the gene exchange between subspecies of the side-blotched lizard, *Uta stansburiana* (Sauria: Iguanidae) from a number of study sites in Zion National Park. Tinkle (1970, 1972, 1973, 1993) published a population analysis of the sagebrush lizard, *Sceloporus graciosus* in southern Utah from the Kolob region of Zion National Park. He documented the reproductive rate, timing and survivorship of the population, and also provided a detailed annotated checklist of the reptiles and amphibians within Zion National Park (Tinkle 1971). Ferguson (1971) conducted a preliminary study and published his findings on the comparative behavior and interactions of two sympatric species of *Sceloporus* lizards, presumably from sites in Zion. Hunnicutt and Pruett (1999) began a series of lizard transects in 3 habitat types: riparian, pinyon-juniper woodland, and ponderosa pine, to assess trend information in lizard populations. Transects were run for 3 years (DS-ZION-0023). Hunnicutt (2000) reported on monitoring from 1997 through 2000. Sears (1997-present) has been researching the relationship of thermal, hydric, and varied resource gradients on the life history variation and population level effects for the sagebrush lizard, *Sceloporus graciosus.* Three field populations in different elevation gradients in the park are being researched, and the field experiments are being supplemented with lab experiments. (The park expects to have a dissertation copy when it is available.)

Blair (1955) published his study on the distribution, variation and hybridization in a relict toad (*Bufo microscaphus*) in southwestern Utah, and postulated that hybridization has occurred in the population. In a Southern Utah University report, Schwaner et al. (1988) studied the decline of toads from southern Utah by investigating their life history and population dynamics. Their report detailed short and long-range needs for understanding amphibian populations in southern Utah. Dahl et al. (2000) published their

findings on site selection and egg mass deposition behavior by mating pairs of Arizona toads (*Bufo microscaphus microscaphus*) in Oak Creek, Zion National. Park, between 26 April and 9 May 1998.

Studies on monitoring or assessments of reptiles and amphibians are numerous. Lindahl (1976) conducted an ecological reconnaissance of Grapevine Spring in Zion National Park to survey and identify its flora and fauna and their habitats. In a Utah State University report, Workman (1983) studied the North Fork of the Virgin River to obtain baseline data on the flora and fauna in the riparian zones within Zion National Park. Anderson et al. (1983) described an ecological inventory of a section of the North Fork of the Virgin River immediately upstream from Zion National Park in a University of Idaho study, which listed six reptile and two amphibian species. Jones (1990) conducted a spring survey of the amphibians of the North Fork of the Virgin River to the Narrows Gateway and found seven amphibian species, only four of which appeared to be current residents. Bartholomew (1994) conducted an amphibian and reptile survey of Zion National Park that included quantification and distribution of the preferred breeding habitat of amphibians and determination of the population status of amphibian and lizard species. Objectives also included the establishment of a tissue collection and determination of the taxonomic status of the parthenogenetic lizard, *Cnemidophorus velox*. Results from the first amphibian population survey were published in Intermontanus (Bartholomew 1995).

A study by the Utah Divison of Wildlife Resources (Fridell et al. 1998) was conducted to determine the inventory and distribution of Washington county sensitive amphibian and reptile species, and to submit a monitoring plan. Results of this study are unknown. And a 2000 report documents the inventory and distribution of amphibians in the East Fork of the Virgin River and the Upper Parunuweap canyon (Fridell et al. 2000). Nowak et al. (2002) reported their first-year results for herpetofauna surveys they conducted between May and September 2001 in conjunction with the Northern Colorado Plateau Inventory and Monitoring Network. Their report includes estimations of inventory completeness, a literature review, recommendations for future inventory and long-term monitoring work, and species lists. A final report that includes 2002 survey results is expected in early 2003.

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DS-ZION-0023	Lizard observation data 1997-1999. (Excel 97 Spreadsheet). Originated by Hunnicutt, Mary; status: Inactive.

General Bird Surveys

Archived and on-going records of bird observations since 1947 (Arches National Park Archives 1947-1988, Carter 1967) have contributed to the bird list for Arches. Several one-time surveys have also fortified the list, including surveys by Hayward (1947) and Hayward et al (1958), a one-time Christmas Bird Count conducted throughout Arches in 1978 (Borucki and Wimpfheimer), surveys by Williams (1983, 1991), and a walking survey by Wolfe (1984) documenting summer riparian avifauna at Arches.

Long-term monitoring of birds at Arches began in 1983 with the establishment of a 31-ha permanent Breeding Bird Census (BBC) plot in the pinyon-juniper habitat of Devil's Garden, which has been on-going through 2001 (DS-SEUG-028). The plot is a grid of 45 stations, separated by approximately 100 m from neighboring stations, which is surveyed 6-12 times in April-June each year. All birds detected within 50 m of the station are recorded on a grid map, for the purpose of determining breeding bird density and species composition in pinyon-juniper habitat. Ten-year results for this BBC plot were summarized in Graham et al. (date unknown [1993?]).

The Southeast corner of Arches, between the Colorado River and Courthouse Wash, has been annually surveyed by participants in the "Moab" Christmas Bird Count since 1986 (A. Brand, personal communication with S. Daw, 8/10/2000).

An on-going Breeding Bird Survey route, following United States Fish and Wildlife Service protocol, was established along the length of the Arches road beginning in 1989 (DS-SEUG-030; USGS 2000.) The Breeding Bird Survey (BBS), coordinated by the USGS Patuxent Wildlife Research Center, is conducted once in June across North America, at over 3500 routes, including this one in Arches. Routes are 24.5 miles long, with 3-minute point counts conducted at 0.5-mile intervals for a total of 50 stops. All birds heard or seen within a 0.25 mile (0.4km) radius of each stop are recorded. The purpose of the BBS is to estimate population change for songbirds across North America.

Informal breeding season raptor surveys have been conducted annually at Arches beginning in 1984 (DS-SEUG-029.2; Arches National Park, Resource Management files; Swanke 1986; Fagan 1988, 1989, 1990; Salamacha 1994, 1995).

As part of the Long Term Monitoring Program begun for all the Southeast Utah Parks, permanent Emlen strip transects, designed to sample all habitats within Arches, Canyonlands, and Natural Bridges, were annually monitored for avian species richness and abundance between 1987 and 1992 (DS-SEUG-033.3; Graham 1992;National Park Service 1992). These bird surveys used "Emlen strip census", strip transect, and point count distance sampling methods. Strip transects followed 1 mile to 2 km routes, recording all birds seen and some heard, out to 400 feet. Circular plots used lines of 10 points, spaced 100m apart. Points were surveyed for 3 minutes, recording all birds within 200 m (sic). Only visual encounters were recorded because of inexperienced observers. Problems with observer reliability and consistency led to the Emlen transects being replaced by permanent point-count transects in various riparian habitats throughout the 3 units, which have been on-going since 1993 (DS-SEUG-022.2; Fagan 1993, 1994, 1995, 1996, 1997; Daw 1998, 1999, 2000, 2001.) These variable circular plot point counts are conducted 3 times/year during the breeding season at eight transects, with 10 point count stations each (2 transects in Natural Bridges; 3 transects each in Arches, Canyonlands). Count periods are 8 minutes long, grouped into 0-3, 4-5, 6-8 minute periods. Surveys follow standard guidelines for distance sampling birds with point counts, and result in species richness and relative abundance data.

Mitchell and Woodward (1993) conducted a study of small mammal, bird, plant, and aquatic organism distributions and patterns of abundance with respect to human travel systems in Arches, Canyonlands, and Natural Bridges, during 1990-1992.

Great blue heron rookeries in the riparian zone of the Colorado River along the boundary of Arches National Park were first monitored by Gary Salamacha in 1997 and have been monitored each year since that time, with visits every week or two in order to document the number of active nests and the number that fledge from nest (DS-SEUG-062).

Finally, Schelz (2000) has created a synthesis of bird lists for all units within the Southeast Utah Group, providing a general overview of birds to be found in the Parks.

Threatened, Endangered, or Sensitive Bird Surveys

The Western burrowing owl (*Athene cunicularia hypugaea)* has been monitored in Arches since 1983 as a part of the general raptor surveys conducted by Park staff.

Peregrine falcon (*Falco peregrinus anatum*) territories were intermittently documented during the 1980's in Arches and Canyonlands as a result of informal surveys or incidental observations. Consistent inventory and monitoring (including limited banding and collection of prey remains in 1989) of peregrine falcons began in 1989 and has been on-going in all three Parks with active territories: Canyonlands, Arches and Natural Bridges (DS-SEUG-029.2). The majority of territories are in Canyonlands National Park, and only 1 territory, discovered in 1995, is known for Natural Bridges.

All three original units of the Southeast Utah Group were surveyed for Mexican spotted owls (*Strix occidentalis lucida*), with no detections in Arches (Willey 1995).

The southwest willow flycatcher (*Empidonax trailii extimus*) has been inventoried along the Colorado River portion of Arches in 1999, and the Green and Colorado River portions of Canyonlands in 1999 and 2000 (Johnson 1999, 2000). It is not clear whether the subspecies observed regularly within these Parks during migration, but not later during the breeding season, is actually the endangered subspecies, *E. trailii extimus*.

The Utah Division of Wildlife Resources began conducting statewide annual bald eagle (*Haliaeetus leucocephalus*) wintering surveys by aircraft in 1978, which included the Cataract Canyon section of the Colorado River through Canyonlands and a portion of Arches (Connor 1983, DeGruyter 1984; Livesay 1985; Walters Jr. 1986, 1987; Utah Division of Wildlife Resources 1988; Bates 1990). In conjuction, a midwinter bald eagle road survey was also conducted along the length of the Arches NP road in 1987 (Swanke).

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Data Sets

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DS-SEUG-028 Breeding bird census plot - Devil's Garden- Arches NP. 4/25/1983 - present. (hard copy data, reports; some data in electronic format at Cornell Lab of Ornithology and at ARCH). Originated by Salamacha, Mike; status: Active.

DS-SEUG-029.2 SEUG Raptor Observation Records. 1/1/1983 - present. (Microsoft Excel spread sheet and hard copy forms). Originated by Florian, Christine; status: Active.

DS-SEUG-030 Arches NP Breeding Bird Survey Route. 6/6/1989 - present. (Web-accessed data files and reports; Microsoft Excel spreadsheet at Arches NP; analog forms). Originated by USGS Patuxent Wildlife Science Center; status: Active.

DS-SEUG-033.3 Long term monitoring of birds using Emlen strip transects. 1/1/1986 - 1/1/1992. (hard-copy field data sheets). Originated by Graham, Tim; status: Inactive.

DS-SEUG-062 Great blue heron rookery monitoring data, Colorado River along the boundary of Arches National Park. 1997 - present. (dBase file (part) and hard-copy files). Originated by Salamacha, Gary; status: Active.

Black Canyon of the Gunnison National Park - Birds

General Bird Studies

An early record of information on bird species in Black Canyon of the Gunnison is an historical checklist provided by Dolson (1971) who revised an earlier checklist of the summer birds of Black Canyon National Monument. This revision stems from an original list by Beidleman (1960), though there are no records on file for the 1960 study. Also, natural history observations submitted by visitors and staff from 1963-2000 have been compiled; however, the reliability of these observation can vary widely (DS-BLCA-0001).

National Park Service staff initiated a long-term monitoring plan for avian species to document and detect changes in species composition and abundance in various vegetation types (1996). Point counts utilizing sight and sound were conducted in four locations in the park from 1996-1999; the plan includes data on numbers of species, vegetation associated with the monitoring sites, and plan protocols (DS-BLCA-0003). This monitoring effort is continuing and plans include evaluating its suitability for meeting park needs.

Threatened, Endangered, and Sensitive Bird Studies

TES bird studies have generally concentrated on two special status birds, the peregrine falcon (*Falco peregrinus*) and the Gunnison sage grouse (*Centrocercus minimus*).

Documentation of peregrine falcon activity in the park began when Krampetz et al (1989) reported their efforts in a joint monitoring venture with the Colorado Division of Wildlife. The report contains maps, survey sheets and field notes associated with peregrine falcon monitoring. In a joint study with the Colorado Division of Wildlife, Robert and Craig (1990) submitted a report on their peregrine falcon survey and monitoring efforts. Boretti (1990, 1991) conducted a study in Black Canyon and Curecanti to monitor falcons within the two parks to determine fledging success. Taylor (1991) submitted a peregrine falcon survey that contained information on monitoring, incubation, nesting and fledging, and Larsen (1999) summarized her observations of peregrine falcon eyries in the Black Canyon and Curecanti. Root (2001) submitted a NPS peregrine falcon summary that contained information on adult falcon observations, nesting, estimated times of egg laying, incubation, hatch and fledging.

The Office of Resource Stewardship and Science at Black Canyon of the Gunnison National Park initiated a long-term monitoring program for peregrine falcons in 1992. They monitor behavioral activity, including breeding, nesting, incubation, brood rearing and fledging (DS-BLCA-0002).

Information on Gunnison sage grouse (*Centrocercus minimus*) populations began when Commons (1997) completed a practicum from the University of Manitoba on the seasonal movement and habitat use of the Gunnison sage grouse, together with management recommendations.

The National Park Service (1997, 1998) began a process to establish a program to increase both the populations of the Gunnison sage grouse and their habitat. This is a complex monitoring effort that incorporates sage grouse trapping, ground tracking and habitat inventories to determine the seasonal habitat use of Gunnison sage grouse at the landscape level in the western portion of the Gunnison Basin. Data for this monitoring effort are cataloged under DS-BLCA-0005.

Black Canyon of the Gunnison National Park - Birds

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Data Sets

DS-BLCA-0001	BLCA Natural History Observations. 1/1/1963 - 1/1/2000. (Microsoft Access). Originated by BLCA staff; status: Inactive
DS-BLCA-0002	BLCA Peregrine Falcon Monitoring. 1/1/1992 - present . (handwritten field notes and Word documents). Status: Active
DS-BLCA-0003	BLCA Long-term Monitoring Program: Birds. 1/1/1996 - present. (Microsoft Access). Originated by BLCA staff; status: Active.
DS-BLCA-0005	BLCA Sage Grouse Monitoring. 1997- present. Originated by Chase, Myron; status: Active.

Bryce Canyon National Park - Birds

General Bird Studies

Several bird studies have been conducted to determine distribution and abundance of bird species in Bryce Canyon National Park. In an early survey, Gerstenberg trapped and banded birds habituating in the Ponderosa pine forest (1971, 1972, 1973). 28 species were documented, cavity nesters were observed and tree/snag densities were calculated. Hallows (1982) describes a basic inventory of avian species conducted from June through August of one year. Some of the information contained in the Hallows checklist is based more on understanding of species biology than on observations throughout the year. Hallows conducted a follow up sampling from September of 1982 until August of 1983 and reported no corrections to the initial checklist (Hallows 1983a, 1983b).

Records on file at Bryce indicate that Christmas Bird Counts were conducted annually between 1963 and 1969. Park records of the data gathered show that 24 to 37 species were observed each year for a cumulative total of 58 species.

During the field seasons of 1989-1991, songbird data were collected in four prescribed burn study units (DS-BRCA-0008). Data were collected following burning to evaluate fire effects in order to determine trends related to prescribed fire. The project was discontinued after 1991 and data were not analyzed. Johnson (1991a, 1991b) reported on a survey of bird species and their association with forest areas before they were burned by prescribed fire. The report describes study locations and methods for quantifying the species observed; however, there is no final report that summarizes the results and draws conclusions. Johnson's work documented the abundance of 27 bird species in one small area of the ponderosa pine forest community, but may be considered to be representative of this habitat type.

Breeding bird surveys have been conducted in the past but only 1990 (Hedges) and 1993 (Foster 1993a) records of observations were retained in the park. These need to be requested from the U.S. Fish and Wildlife Service. There is one BBS route in Bryce Canyon National Park (DS-BRCA-0002). This route (BBS route #85-908) begins at the eastern Park boundary on Highway 12. It runs west to the western Park boundary on Highway 12, with eight point-count stops within this section. This route was first surveyed in 1990, with subsequent surveys in 1992-1994 and 1996-1999. No surveys were conducted in 2000 or 2001. The route is in a heavily used tourist area with much potential disturbance during surveys; it may be discontinued as there is another route that parallels the park route approximately three miles away on U.S. Forest Service land.

Threatened, Endangered, or Sensitive Bird Studies

Peregrine falcon observations were documented by Hallows 1982. Observations include flight, roosts, nests, and discarded prey below the eyrie. Johnson et al. (1989) initiated systematic field surveys to detect peregrine falcons. Monitoring has been conducted at known territories most years since that time (Daw 1990, Collins 1991, Foster 1992, Burch 1995, Bloch 1997, Fields and Neighbor 1999, Ames-Curtis and Parker 2000). The park has supported from one to five active territories since 1985 (Fields and Neighbors 1999). Peregrine observation data from 1990 to present have been consolidated and entered into an Access database that includes information on observer, date, time, location, observation details, and remarks (DS-BRCA-0002). O'Neill et al (1997) summarizes multi-agency monitoring efforts that occurred in the Southern Region in 1997 and is a compilation of monitoring that was done by federal and state monitors. Peregrine population increases, fledging success and reclamation of territories has led to the delisting of the species (Day 1999).

Northern goshawks have been documented in Bryce Canyon NP since at least 1963, and inventory efforts began in 1993 with the establishment of 10 survey transects in the most promising habitat in the park (DS-BRCA-0003). In 1998, five additional transects were established to the north and east of the 1993 transects. Survey methods were based on protocol established by the Southwest Region of the U.S. Forest Service (Reynolds, et al. 1993). Goshawk activity was noted in six areas throughout the park in 1995, with a pair hatching in the same nest both in 1994 and 1995 (Burch 1994 and 1995). Foster 1993b conducted a pilot study to search for northern goshawks in Bryce Canyon NP, and a systematic inventory of forested habitats to detect northern goshawks was initiated in 1998 (Ames-Curtis et al. 1998, Ames-Curtis and Lloyd 1999). These transects were sampled in 1999 and 2000. One territory has been occupied each of years 1998-2000, and one new territory was discovered in 2000 (Ames-Curtis and Parker 2000). Goshawk monitoring projects were discontinued in 2001 because of a lack of funding and staff.

Mexican spotted owls were been observed on lands nearby Bryce Canyon National Park (Willey 1995); however, they have never been detected within the park. Staff developed a habitat suitability model based on work previously conducted in Zion National Park (Rinkevich 1991) to determine where potential habitat may be located (Foster, 1993b). In 1994 and 1995, five transects were sampled but no Mexican spotted owls were detected (Burch 1994a, Burch 1995a). It is likely that the elevation at Bryce is too high and habitat is unsuitable.

Information to document the distribution and abundance of southwest willow flycatcher is incomplete in southern Utah. Park staff have conducted surveys along two transects since 1995 (Foster, 1995) (DS-BRCA-0011). However, willow flycatchers have been detected in only two locations and none have been observed since 1996 (Schreier 1996, Neighbor 1997, Ames-Curtis 1999, 2000, Cahill 2002). Southern Utah population census and habitat review reveal greater pressures on documenting the presence of diminishing willow flycatcher populations (McDonald et al 1995, Peterson et al 1998).

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DS-BRCA-0006 North American breeding bird survey, Bryce Canyon route data. 6/28/1990 - 6/18/1999. (Web-accessed data files and reports .). Originated by USGS Patuxent Wildlife Research Center; status: Inactive.

DS-BRCA-0008 Songbird survey data, Bryce Canyon National Park, 5/1/1989 - 8/10/1991. (MS Access database with 3 tables. Paper field forms and paper reports.). Originated by Bryce Canyon National Park; status: Inactive.

DS-BRCA-0011 Southwestern Willow Flycatchers Surveys at Bryce Canyon NP. 1/1/1995 - present. (paper files, observation cards, GIS shapefile). Originated by Juli Ames-Curtis, Bill Schreier, Dan Foster; status: Active.

DS-BRCA-0035 Surveys for Mexican Spotted Owl in Bryce Canyon National Park. 05/06/1993-08/30/1995. (paper files, transect maps). Originated by Dan Foster. Status: inactive.

General Bird Surveys

On-going records of bird observations since 1964 (USDI National Park Service 1994) have contributed to the bird list for Canyonlands. Throughout all the Districts, scattered breeding season and year-round baseline monitoring was conducted by Park personnel between 1983 and 1985 (Canyonlands, Resource Management files.) An historical compilation of survey data for Canyonlands is also available in Boschen (1985).

Individual Districts within Canyonlands have conducted general bird surveys independent of each other. The Maze District of Canyonlands conducted year-round Emlen strip bird survey transects between 1976 and 1979 (DS-SEUG-031; Canyonlands National Park, Resource Management files.) This survey was a total count and mapping of birds encountered on 4 plots: two 40-acre plots surveyed by walking lines 200 feet apart, one 175 acre plot surveyed by following a canyon bottom, and one 185 acre plot, including the Colorado River, surveyed by a variable route. All plots were surveyed monthly for 3 years for the purpose of comparing relative abundance of bird species by season and year. These data were never analyzed.

Island in the Sky District was surveyed weekly for birds over the course of a full year by Boschen (DS-SEUG-032; Boschen 1986), using point counts for the purpose of identifying as many bird species as possible and associating them with seasonal occurrence. The district has also had 2 different Breeding Bird routes during the 1980's and 1990's. The Breeding Bird Survey (BBS), coordinated by the USGS Patuxent Wildlife Research Center, is conducted once in June across North America, at over 3500 routes, including this one in Arches. Routes are 24.5 miles long, with 3-minute point counts conducted at 0.5-mile intervals for a total of 50 stops. All birds heard or seen within a 0.25 mile (0.4km) radius of each stop are recorded. The purpose of the BBS is to estimate population change for songbirds across North America. The most well documented and currently on-going route at Island in the Sky District started in 1991, and yearly results are available from the USGS Patuxent Wildlife Research Center web site (DS-SEUG-034; USGS 2000). The district began a 20-ha on going Breeding Bird Census (BBC) plot in pinyon-juniper habitat in 1991 (DS-SEUG-027; Canyonlands National Park, Resource Management files), designed to be compared with the Devil’s Garden BBC in Arches. One other study of bird species diversity in pinyon-juniper habitat was done by Robins and Journet (1992).

The Needles District of Canyonlands collected nesting records specifically for Cooper's hawks (*Accipiter cooperii*) during 1987 and 1990 (Canyonlands National Park, Resource Management files), but no formal surveys have been done for this species.

As part of the Long Term Monitoring Program begun for all the Southeast Utah Parks, permanent Emlen strip transects, designed to sample all habitats within Arches, Canyonlands, and Natural Bridges, were annually monitored for avian species richness and abundance between 1987 and 1992 (DS-SEUG-033.1; Graham 1992). These bird surveys used "Emlen strip census", strip transect, and point count distance sampling methods. Strip transects followed 1 mile to 2 km routes, recording all birds seen and some heard, out to 400 feet. Circular plots used lines of 10 points, spaced 100m apart. Points were surveyed for 3 minutes, recording all birds within 200 m (sic). Only visual encounters were recorded because of inexperienced observers. Problems with observer reliability and consistency led to the Emlen transects being replaced by permanent point-count transects in various riparian habitats throughout the 3 units, which have been on-going since 1993 (DS-SEUG-022.1; Fagan 1993, 1994, 1995, 1996, 1997; Daw 1998, 1999, 2000, 2001.) These variable circular plot point counts are conducted 3 times/year during the breeding season at eight transects, with 10 point count stations each (2 transects in Natural Bridges; 3 transects each in Arches, Canyonlands). Count periods are 8 minutes long, grouped into 0-3, 4-5, 6-8 minute periods. Surveys follow standard guidelines for distance sampling birds with point counts, and result in species richness and relative abundance data.

Mitchell and Woodward (1993) conducted a study of small mammal, bird, plant, and aquatic organism distributions and patterns of abundance with respect to human travel systems in Arches, Canyonlands, and Natural Bridges, during 1990-1992.

Finally, Schelz (2000) created a synthesis of lists for all units within the Southeast Utah Group, providing a general overview of birds to be found in the Parks.

Threatened, Endangered, or Sensitive Bird Surveys

The first recorded study of Mexican spotted owls in Canyonlands was in 1977 (Johnson and Johnson). With the eventual discovery of several breeding pairs of Mexican spotted owls, and its listing in 1993 as a Threatened Species under the Endangered Species Act, intensive study was conducted throughout the 1990s (Willey 1992, 1995, 1996, 1998; Steidl 1996; Swarthout and Steidl 2000). These studies, using a variety of methods (including radio-telemetry) determined demographics, sensitivity to recreational disturbance, prey, home range size, habitat use, and natal dispersal of the birds.

Peregrine falcon (*Falco peregrinus anatum*) territories were intermittently documented during the 1980's in Arches and Canyonlands National Park as a result of informal surveys or incidental observations. Consistent inventory and monitoring (including limited banding and collection of prey remains in 1989) of peregrine falcons began in 1989 and has been on-going in all three Parks with active territories: Canyonlands, Arches, Natural Bridges (DS-SEUG-029). The majority of territories are in Canyonlands National Park, and only 1 territory, discovered in 1995, is known for Natural Bridges.

The southwest willow flycatcher (*Empidonax trailii extimus*) has been inventoried along the Colorado River portion of Arches in 1999, and the Green and Colorado River portions of Canyonlands in 1999 and 2000 (Johnson 1999, 2000). It is not clear whether the subspecies observed regularly within these Parks during migration, but not later during the breeding season, is actually the endangered subspecies, *E. trailii extimus*.

The Utah Division of Wildlife Resources began conducting statewide annual bald eagle (*Haliaeetus leucocephalus*) wintering surveys by aircraft in 1978, which included the Cataract Canyon section of the Colorado River through Canyonlands and a portion of Arches (Connor 1983, DeGruyter 1984; Livesay 1985; Walters Jr. 1986, 1987; Utah Division of Wildlife Resources 1988; Bates 1990).

Bald eagles have been the subject of various foot and boat patrols in Cataract Canyon between 1984-1990 (Hathaway and Zinn 1990). In addition, wintering bald eagle prey remains from Cataract Canyon were collected and formally analyzed in 1985 (Yasuda and DeBolt) and in 1991 (Zinn).

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Data Sets

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DS-SEUG-027 Breeding bird census plot - Island in the Sky Mesa - Canyonlands NP. 4/21/1991 - present. (hard copy data, reports; some data in electronic format at Cornell Lab of Ornithology). Originated by Graham, Tim; status: Active.

DS-SEUG-029.1 SEUG Raptor Observation Records. 1/1/2000 - present. (Microsoft Excel spread sheet and hard copy forms). Originated by Florian, Christine; status: Active.

Canyonlands National Park - Birds

DS-SEUG-031 Bird Surveys in Maze District of Canyonlands N.P.. 3/1/1976 - 10/1/1979. (hard copy field forms and summary tables). Originated by Connor, Jeff; status: Inactive.

DS-SEUG-032 Bird Surveys performed at the ISKY Mesa and Moab Sloughs in 1984 and 1985. 6/22/1984 - 6/22/1985. (hard copy analog forms only). Originated by Boschen, Nelson; status: Inactive.

DS-SEUG-033.1 Long term monitoring of birds using Emlen strip transects. 1/1/1986 - 1/1/1992. (hard-copy field data sheets). Originated by Graham, Tim; status: Inactive.

DS-SEUG-034 Canyonlands Breeding Bird Survey Route. 6/5/1991 - present. (Web-accessed data files and reports; analog forms). Originated by USGS Patuxent Wildlife Research Center; status: Active.

Capitol Reef National Park - Birds

General Bird Studies

Little information was gathered about the park's avifauna until the mid-1970's. After expansion in 1969 and national park designation in 1971, small, area specific studies were conducted that collected anecdotal descriptions and small lists of species observed in these newly acquired portions (Hoddenbach 1977, Camp 1978). Park staff began documenting bird observations in earnest in 1972 and that effort continues (DS-CARE-0004). A guide to birding at Capitol Reef, was published by Spence (1991) and concentrated on the riparian and orchard habitats in the Fruita Valley and describes the rare species found in the park. Capitol Reef has a published checklist of birds that documents 215 species (Spence and Southwick 1995) which is based on previous records from small studies, wildlife observations by park staff, and additional observations by the authors between 1991-93. Since 1994, ten additional species have been added to the list by staff and reliable visitor observations, bringing the number of bird species recorded in the park to 225.

A study to determine impacts of grazing on birds of arid and semi-arid shrublands and grasslands was done by Willey (1994) and describes many of the birds found in upland areas and less popular portions of the park. This was the first study to determine relative abundance of birds in the park and statistically determined habitat preferences of species.

Two Breeding Bird Survey (BBS) routes were established in 1987, one in the northern part of the park and one in the central portion (Sauer et al. 2000, USGS 2000). Both routes are in upland plant communities and are coordinated by the USGS Patuxent Wildlife Research Center. The BBS is conducted throughout North America in June; over 3500 routes are surveyed, including the two in Capitol Reef. Routes are 24.5 miles long, and 3-minute point counts are conducted at 0.5-mile intervals for 50 stops. All birds heard or seen within a 0.25 mile (0.4km) radius of each stop are recorded. The purpose of the BBS is to estimate population change for songbirds across North America.

As part of another national program, Capitol Reef and the Utah Department of Wildlife Resources (UDWR) are running a Mapping Avian Productivity and Survivorship (MAPS) station in riparian habitat along the Fremont River (DS-CARE-0018). The MAPS program is a cooperative effort among public agencies, private organizations and the bird banders throughout North America to provide critical long-term data on population and demographic parameters for selected landbird species. The program gathers breeding season data utilizing standardized, constant-effort mist netting and banding at ten 12-meter nets and standardized 1-kilometer point counts. The MAPS methodology provides annual regional indices of adult population size and post-fledging productivity, annual estimates of adult population size, adult survivorship, and recruitment into the adult population. UDWR has been running the point count portion of the project since 1993 and, since 1996, park staff has been doing the mist-netting and banding station. Information from this program is sent to the Institute for Bird Populations where they compile and interpret the results (DeSante et al. 2000).

Threatened, Endangered, or Sensitive Bird Studies

Three federally listed species of birds occur in the park: the Mexican Spotted Owl, *Strix occidentalis lucida*, threatened, the Southwestern Willow Flycatcher, *Empidonax traillii extimus*, endangered, and the bald eagle, *Haliaeetus leucocephalus*, threatened. The Yellow-billed Cuckoo *Coccyzus americanus*, is a candidate for Federal listing as endangered. Much work has been done at Capitol Reef on the distribution, ecology, and habitat utilization of both the recently de-listed Peregrine Falcon (Lenhart 2001a, 2002a, Grebence 1987, Teresa 1989, Willey 1989, 1990, 1991) and Mexican Spotted Owls (Lenhart 200b, 2002b, Willey 1993, 1995, 1997, 1998a, 1998b, Steidl 1996; Swarthout and Steidl 2000).

Nesting locations and reproductive success has been monitored intermittently since 1977 and, when funding is present, continues by park staff (DS-CARE-0001, DS-CARE-0002). There are eight known Peregrine Falcon eyries and nine Mexican Spotted Owl nesting locations.

The Southwest Willow Flycatcher has been seen in the park along the Fremont River during the breeding season almost every year since the early 1990's. These records consist of observations of individuals, pairs, and singing males but no nesting has been documented. Nesting of this species is suspected in the Halls Creek drainage, but has not been documented. Similarly, the Yellow-billed Cuckoo is observed sporadically in the park but nesting has not been recorded.

In addition to the three listed or candidate species, twelve of the bird species found in the park are listed by the state of Utah as sensitive species (UDWR 1998a, 1998b). Little is know about the park distribution and abundance for any of these species, but most are observed at least occasionally by park staff and visitors. Small numbers of Golden eagles (*Aquila chrysaetos*) have been documented nesting in the park, and more active management of populations of this species could become necessary shouldNative American Groupds express interest in collecting birds from park lands as the Hopi tribe has in Arizona.

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Capitol Reef National Park - Birds

Data Sets

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Cedar Breaks National Monument - Birds

General Bird Studies

A general listing of bird species for Cedar Breaks National Monument was compiled in the 1940s (Grater 1947); however, it encompasses terrain and communities for the plateau country in southern Utah, including Cedar Breaks, Bryce Canyon, and Zion. An unpublished checklist, completed by various seasonal interpreters over the years and containing 86 bird species, has been compiled for visitor use and as a guide for park employees.

Professional level surveys were conducted in the monument in 1993 for peregrine falcon (*Falco peregrinus anatum*), northern goshawks (*Accipiter gentilis atricapillus*), and Mexican spotted owl (*Strix occidentalis lucida*) (Boretti 1993). In addition, the monument is within the geographic extent of peregrine monitoring work conducted by the Utah Division of Wildlife Resources (Day 1999).

A systematic inventory of bird species within Cedar Breaks National Monument was begun in 2001 with the Northern Colorado Plateau Network avian inventory work conducted by Johnson of the USGS Colorado Plateau Field Station. 84 point count surveys were carried out in 3 main habitat types in addition to 15 areas search surveys. 45 species were detected in the course of the first year's inventory, including five additions to the park master species list (Northern pygmy owl, black-chinned hummingbird, Cordilleran flycatcher, plumbeous vireo and spotted towhee), bringing the number of confirmed species for the monument to 98 (Johnson et al. 2002). Fieldwork will continue in the summer of 2002 with results anticipated in early 2003.

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Colorado National Monument - Birds

General Bird Surveys

Informal surveys of the birds of Colorado National Monument and surrounding areas have been ongoing for decades, primarily through local Audubon Society chapters. An Audubon checklist was compiled in 1976 for Mesa County, in 1983 an informal monument checklist was produced, and in 1992 a list was produced for the Grand Valley and surrounding area. In addition, Audubon has been conducting surveys and Christmas Bird Counts in the monument for a number of years. In 1990, an updated monument species list was produced that consolidated various lists and data from the Grand Junction Audubon Society (Kaeding 1990). This list includes 127 species together with frequency of sightings for each of the four seasons. However, the earliest documented research permits issued for the monument date back only to the 1990s.

Anthony Leukering and Scott Hutchings conducted passerine bird banding for the Rocky Mountain Bird Observatory (RMBO) in 1995 and 1996 as part of the observatory's statewide bird monitoring project. Distance sampling was used by Giroir during Spring, 2000, to collect baseline breeding bird information. Data on 60 breeding bird species was collected, and report appendices include species distribution and abundance maps on 27 point transects and detailed transect maps (Giroir 2001).

During the 1999 field season, Giroir conducted ground searches and mapped the territories of singing males and pairs of gray and plumbeous vireos. 160 gray and 49 plumbeous vireo territories were found, vegetation variables within these territories were measured, and 23 Gray and seven plumbeous vireo nests were found and monitored. Breeding distribution and habitat use was also noted. This study resulted in a report on the breeding distribution and habitat utilization of the gray and plumbeous vireos at Colorado National Monument (Giroir 2001).

Threatened, Endangered, or Sensitive Bird Surveys

The Colorado Division of Wildlife and Monument staff has collected many years of site data for peregrine falcon (Falco peregrinus). Peregrine falcons had nested at Colorado National Monument until at least 1972; after a lapse, Colorado Division of Wildlife confirmed re-occupancy for 1986-89. A 1989 survey was conducted to locate previously undocumented nesting pairs, evaluate potential habitats for occupancy, monitor reproductive success of occupied sites and focus survey attention on the National Park Service lands in Colorado (Krampetz et al. 1989). Surveys were repeated in 1990, 1991, 1995, 2000, 2001 and 2002 (Robert and Craig 1990, 1991; Coleman and Tucker 1995). Data available for peregrines include a list of the site visitations and details of the observations, general survey forms, marked maps, location drawings, nesting and climbing visit forms, photocopies of all the handwritten field notes for the year, and photographs (photocopied). These data need to be consolidated.

David Willey summarized his study of Mexican spotted owls on the Colorado Plateau between 1990-1997, which includes the Colorado National Monument. This report summarizes survey effort and locations across the Colorado Plateau (Willey 1998).

Small populations of sage grouse in southwest Colorado are poorly understood. A study was undertaken by the Colorado Division of Wildlife to estimate the number of grouse in the region (including the monument), to provide insight into what habitats grouse use, and what factors may be limiting their numbers. A 1995 report includes capture and banding data, habitat transects, maps showing banding locations, and radio-marked grouse movements (Woods and Braun 1995).

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Curecanti National Recreation Area - Birds

General Bird Studies

The current bird checklist for Curecanti is derived from the *Checklist of Birds of Gunnison County, Colorado* (Hyde 1977), that lists species according to their habitat preferences.

Starting in 1992, the Resource Stewardship and Science staff began collecting long-term bird monitoring data at five locations (Cebolla, Pine Creek, Cooper's Ranch, Crystal Reservoir, and Morrow Point) within the recreation area (DS-CURE-0002). These data are collected to document, monitor, and detect changes in bird species composition and abundance in four plant community types: oak-fescue, douglas fir-oak, sagebrush, and grass-sedgeland mix. Ten points are established in each vegetation type, and point counts are conducted using sight and sound for species identification, and the species, number, and distance categories for each individual bird observed are recorded. This monitoring effort is continuing and plans include evaluating its suitability for meeting park needs.

Data have also been collected on the great blue heron rookery/colony along the Gunnison River in and adjacent to the recreation area (DS-CURE-009). Cook (1979) reported his field observations on two species of heron in Gunnison County, the great blue heron, (*Ardea herodias treganzai*), and the black-crowned night heron, (*Nycticorax nyticorax hoactli*). The report also detailed the history of these herons in Gunnison County, together with information on their distribution, prey selection, and predation by others. Graham and Meyer (1993) reported on their observations of a great blue heron colony within the recreation area, which included information on their nesting success, long-term survival, and future prospects for the colony. Graham et al (1995) reported their observations on a great blue heron colony from 1987 to 1993 in the proceedings from a National Park Service research conference. They documented heron rookeries in existence along the Gunnison River for the past 40 years, and the subsequent moving of the colony twice in the last 26 years. Also noted are nesting preferences, courtship behavior, and population growth. They concluded that the colony at its present site faced uncertainties due to changes in land ownership and habitat destruction due to cattle grazing. A 2001 publication (Graham et al.) documented these same findings.

The recreation area also has data on migratory waterfowl observations (DS-CURE-0016), in addition to a long-term monitoring plan for shorebirds (NPS 1994) with data sheets and summaries of surveys taken from 1994-1998 and 2000. Data is included on numbers and conditions of individual species and the time of day they were observed. Also included are maps to the sites and protocols. It is unclear if this monitoring effort is continuing.

Threatened, Endangered, and Sensitive Bird Studies

Information on peregrine falcons and other raptors began when Canterbury (1982) censused raptors within Curecanti National Recreation Area and included an analysis of the possible effects of the reintroduction of peregrine falcons to the area. Krampetz et al. (1989) reported their efforts in a joint monitoring venture with the Colorado Division of Wildlife. The report contains maps, survey sheets and field notes associated with peregrine falcon monitoring.
In a joint study with the Colorado Division of Wildlife, Robert and Craig (1990) submitted a report on their peregrine falcon survey and monitoring efforts. Boretti (1990, 1991b) conducted a study in Black Canyon and Curecanti to monitor falcons within the two parks to determine fledging success. Boretti (1991a) also performed a Mexican spotted owl (*Strix occidentalis lucida*) survey but was unable to confirm any observations. Canterbury (1993) reported on four weeks of study on winter populations of

bald eagle (*Haliaeetus leucocephalus*) populations within Curecanti, together with information on their habitats.

Larsen (1999) summarized her observations of peregrine falcon eyries in the Black Canyon and Curecanti, and Root (2001) submitted a NPS peregrine falcon summary that contained information on adult falcon observations, nesting, estimated times of egg laying, incubation, hatch and fledging. Burnham and Enderson (*no date*) conducted a peregrine falcon study for the Bureau of Land Management to determine habitat suitability for their release in and around Curecanti National Recreation Area. Also included are maps, tables, appendices and a brief history of peregrine falcon reintroduction within Colorado. Peregrine falcon occupancy and reproduction monitoring continue through the present (DS-CURE-026).

In a Curecanti National Recreation Area raptor management report, Hening (*no date*) described his observations and management recommendations for the burrowing owl, *Athene cunicularia hypugaea*, and Wallen (*no date*) conducted a study of cavity nesting sites along the Gunnison River to examine the effects of tree and shrub clearing on availability of nests.

Information on Gunnison sage grouse populations began when Hupp (1987), conducted a study to determine sage grouse distribution and habitat use within the Gunnison Basin from 1984-1986. Young (1990) conducted a study to investigate sage grouse mating barriers between populations, their long-term demography, critical nesting and brooding habitat, and female habitats before, during and after incubation. The NPS (1997, 1998) began a process to establish a program to increase both the populations of the Gunnison sage grouse and their habitat. Sewolt (1999) provided a comprehensive report detailing the vegetation inventory for Gunnison sage grouse nesting and early brood-rearing habitat in and around Curecanti, together with protocols used for data collection.

The Office of Resource Stewardship and Science at Curecanti National Recreation Area initiated a long-term monitoring program for sage grouse in *19xx*. This is a complex monitoring effort that incorporates sage grouse trapping, ground tracking and habitat inventories to determine the seasonal habitat use of Gunnison sage grouse at the landscape level in the western portion of the Gunnison Basin. Data for this monitoring effort are cataloged under DS-CURE-0005.

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Curecanti National Recreation Area - Birds

Data Sets

DS-CURE-0002	Curecanti NRA Long-term Monitoring Program: Birds. 1/1/1992 - present. (Microsoft Access). Originated by Myron Chase; status: Active.
DS-CURE-0005	Curecanti NRA Sage Grouse. 1997-present. (database, reports, maps). Originated by Chase, Myron; status: Active.
DS-CURE-0009	Curecanti NRA Great Blue Heron Observation Database. 1/1/1989 - 1/1/1997. (Microsoft Access). Originated by Myron Chase; status: Inactive.
DS-CURE-0016	Curecanti NRA Migratory Waterfowl Observations. 1/1/1995 - 1/1/1998. (Microsoft Access). Originated by Myron Chase; status: Inactive.
DS-CURE-0026	Curecanti NRA Peregrine Falcon Monitoring. 1/1/1992 - present. (field notes and Word documents). Originated by CURE staff; status: Active.

General Bird Surveys

Over 200 species are reported in Dinosaur's bird checklist. The checklist represents at best a partial catalog of birds using monument lands. Several species have been introduced by human activities. These include the house sparrow, starling, chukar, turkey and ring-necked pheasant. These generally do not present significant ecological or economic problems. There is, however, some information which suggests coccidiosis may be transferred from chukar to bighorn sheep.

Three types of studies have collected systematic information on general avian fauna: bird distribution latilong studies for both Colorado and Utah (Chase, et al. 1982, [Utah citation pending]; fire effects studies; and an ongoing general avian survey conducted by the Rocky Mountain Bird Observatory (Giroir 2001). In addition, the University of Wyoming reviewed fire effects bird monitoring protocols and analyzed historic data from the fire effects monitoring (Winslow 1999?; Olson, et al. *in press*).

The protocol for fire effects studies (established in the early 1980s) uses multiple passes through fixed width linear transects (about 700m x 40m) located in burned and adjacent unburned (control) areas. Although other methodologies now enjoy greater favor, this methodology has been currently retained for consistency. The University of Wyoming review (Winslow 1999?) concluded that the current methodology was only sensitive enough to detect about a 1 bird/hectare change. Consideration should be given to determining if this monitoring is if sufficient value to continue and, if so, whether or not a change in methodology is warranted.

Fire effects studies indicate that there is not a substantial change in bird numbers and diversity subsequent to fire, although there are some shifts in distribution of individual species (e.g. sagebrush obligates such as green-tailed towhee).

The Rocky Mountain Bird Observatory survey is intended to be a two-year systematic examination of all important habitats in the monument (Giroir 2001). A series of twenty 10-point transects with point intervals of 250 meters is used in primary habitats (sage shrubland, semi-desert shrubland, pinyon-juniper, and mixed conifer). Other methodologies employed include series of line transects in low elevation riparian habitats, informal surveys of patches of rare habitats, and informal surveys during spring and fall migration periods.

<u>Canada Geese</u>
Canada geese have developed a unique nesting strategy in Lodore Canyon on the Green River. Although most geese nest on islands, geese also nest on ledges in the canyon walls at heights of up to 30 feet above river level. The Colorado Division of Wildlife, Utah Division of Wildlife Resources and other agencies conducted annual monitoring along the Green River in the 1970s (Lead Investigator Mike Sczymczak, CDOW).

Since the closure of Flaming Gorge Dam in 1962, the Green River in Dinosaur seldom freezes over. Wintering geese on the Green River may exceed a thousand birds. Browns Park National Wildlife Refuge, situated just upstream from the monument on the Green River, is managed for Canada geese production. Birds usually do not overwinter in the refuge; it appears that they move into Lo-

dore Canyon when the Green River freezes over in Browns Park. It is unknown if the wintering population is comprised mainly of resident birds or migrants from other areas.

Goose biologists indicate that geese can probably tolerate one flushing from the nest (eggs left uncovered and more vulnerable to predation or mortality due to weather conditions) per day without serious impacts to reproductive success. Increased disturbances to nesting geese by boaters could result in reduced reproductive success and eventual displacement of nesting geese. River travel on the Green is therefore restricted to one launch per day prior to May 10 to minimize disturbances to incubating geese.

Threatened, Endangered, or Sensitive Bird Surveys

Those species which are of greatest management interest at Dinosaur include the endangered peregrine falcon and bald eagle. Prairie falcons, northern goshawks, burrowing owls, Canada geese, and ferruginous hawks are of concern because of questions about population status or unusual habitat utilization in the monument.

Peregrine Falcon

The peregrine falcon was listed as endangered largely because of the effects of DDE, a metabolic descendant of DDT. DDE causes eggshell thinning; mortality of embryos then results from egg breakage or desiccation. Population declines were so substantial that in 1976 and again in 1979 there were only four breeding pairs known in the State of Colorado. In 1976, one of those pairs was in Dinosaur National Monument; in 1979, two of the four known pairs were in Dinosaur.

Peregrine biology, ecology, decline, and recovery are discussed in five seminal works: *Peregrine Falcon Populations: Their Biology and Decline* (Hickey 1969), *The Peregrine Falcon* (Ratcliffe 1980), *American Peregrine Falcon Recovery* Plan (Craig 1985), *Peregrine Falcon Populations*: Their Management and Recovery (Cade et al. 1988), and *The Peregrines of Colorado* (Craig *in prep*).

The peregrine falcon recovery program began in Colorado in 1974 following statewide surveys of known (historical) eyrie sites. Components of the program have included inventory (eyrie searches), eyrie characterizations and photographs, monitoring, fostering, hacking, eggshell thinning studies, and pesticide analysis of prey species. Recovery efforts in other States on the Colorado Plateau have been confined to less intense and/or sporadic inventory, monitoring and hacking.

Active recovery efforts began in Colorado with experimental fostering in one eyrie in each of years 1974 and 1975. Dinosaur National Monument has participated in the full range of recovery program activities beginning in 1976. One eyrie was known in Dinosaur in 1976; a second eyrie was discovered in 1977 (park naturalist notes from the 1950s mentioned peregrines at this site). In 1984 a third territory was discovered during Colorado Plateau-wide surveys conducted by The Peregrine Fund under contract to the Regional Office. Additional eyries have been identified in succeeding years. As of 2002 there are 17 known territories in the Dinosaur area, three

of which are on adjacent BLM lands. Twelve to thirteen territories are occupied during most years. Of the occupied territories, 30-45% are annually not successful. They are either occupied by a single bird or, more often, by a pair whose nesting attempt failed.

Hack sites were operated at Deerlodge Park (the mouth of the Yampa Canyon; 1982, 1983, 1984) and Split Mountain (across from the boat ramp; 1984, 1886, 1987). Adult pairs occupied nearby territories within a couple years after termination of hacking; presumably a successful outcome of the hacking effort. A third hack site was established in Harding Hole though birds were not released from that site. All three hack boxes remain in place.

Although DDT is currently banned in the United States, it is still commonly used in Central America where both peregrines and prey species migrate for the winter. Further, replacement pesticides in the family of dicofols (e.g. Kelthane) contain DDT as an impurity (up to 40% by weight of the formulation). Analysis of pesticide residues in prey species and persistent egg-shell thinning in Dinosaur and elsewhere in Colorado suggest that peregrine populations may still be impacted by the metabolic derivative of DDT.

Documentation of the recovery and management effort at Dinosaur National Monument consists of annual notebooks with all recorded observations and summary annual reports (since 1980). Recorded information includes eyrie locations, eyrie search locations, behavioral observations, site manipulations, banding records, identification of prey remains, helmet sketches (as a means of determining loss and replacement of adult birds), eggshell thinning data, pesticide loading in prey species, fledging success, eyrie characterizations, eyrie photographs, State and federal permits, and miscellaneous reports and news articles. Virtually every observable eyrie is documented by a series of photographs pinpointing its location on the eyrie cliff.

The monitoring conducted at Dinosaur National Monument is consonant with that conducted by the Colorado Division of Wildlife. The Rocky Mountain/Southwest Peregrine Falcon Working Group recommended that intensive monitoring be conducted on certain groups of territories while monitoring in other areas post-recovery would be limited to determining of occupancy. Dinosaur National Monument was one of the core areas recommended for more intensive monitoring. The peregrine falcon was delisted in 1999. Intensive monitoring should continue through the 5-year post-delisting period, i.e. through 2004.

Bald Eagle

Concentrations of bald eagles are commonly observed in cottonwood bottoms along both the Green and Yampa Rivers from December through March. The primary concentration areas include Deerlodge Park, Gates of Lodore, Island Park and below Split Mountain. Deerlodge Park and Gates of Lodore are parts of larger concentration areas comprised of NPS and adjacent lands. It is not uncommon to see 10 to 20 bald eagles in the Deerlodge and Island Park areas. Smaller numbers are commonly observed at Lodore, below Split Mountain and along the entire lengths of both rivers in the monument.

Park management activities concerning bald eagles have been limited to protection of cottonwood groves (roosting areas) and participation in the annual Mid-winter Bald Eagle Survey.

Mexican Spotted Owl

Systematic surveys were conducted for Mexican spotted owls in 1991 through 1993 using standard methodologies (voice calling in apparently suitable habitat). One bird, a lone male, was located in slot canyon habitat north of the Yampa River in 1992 and 1993 (Willey 1994). This marks the northernmost known territory for the species. No monitoring has been conducted since the surveys, though there have been incidental records of owl calls from the known territory.

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Fossil Butte National Monument - Birds

General Bird Surveys

Before 2001, no comprehensive surveys for birds had been conducted on Fossil Butte National Monument.

Both Mountain West Environmental Services researchers and Diane Durkes appear to have made bird observations over an extended length of time. We believe Durkes compiled her list from observations she made during the summer of 1978 (Durkes 1978); her methods of observation and her credentials as a birder were either unrecorded or lost. The Mountain West Environmental Services researchers observed 72 species of birds during the course of their grazing impact study (Dorn et al 1984). The list probably includes the majority of the avian species that were breeding on the monument in 1984. These observations were made during 19 days in June and 3 days in December. The data are believed to be reliable due to the credentials and experience of the researchers.

From 1995 to the present, visitors, seasonal rangers and permanent staff members of the monument have completed wildlife observation cards; however, the quality and reliability of these data is variable. Other sources of information on the monument's avifauna are limited to specific areas or species groups. Annual data collected on raptors has been compiled (Fagnant et al 1999, DS-FOBU-013, DS-FOBU-11); and additional raptor surveys have been conducted by Kyte (2000), a seasonal biotechnician at Fossil Butte. Detections of songbirds from observation points located in a variety of vegetation types were compiled and submitted to the monument by Deno and Corbett (2000).

The first comprehensive survey for breeding birds on Fossil Butte National Monument was begun on the monument in 2001 (Johnson et al 2002), as part of the Northern Colorado Plateau Network Inventory and Monitoring Program. 39 point count stations were established, with a total of 85 species detected, including three that were new to the monument's master species list; the total number of confirmed bird species for the park is 140. Surveys will continue for a second year through the summer of 2002, with a final report expected in early 2003.

Threatened, Endangered, or Sensitive Bird Surveys

Cain (1989) conducted a peregrine falcon survey and habitat evaluation; in the ensuing trip report he noted that the monument contains marginal habitat for the species. Information on sage grouse has been compiled by Norris & Rosalie Tratnik (DS-FOBU-012), volunteers who have been conducting lek surveys on the monument every year since 1995 in cooperation with Wyoming Game and Fish. Data on historic and new leks are recorded, along with observations on predator behavior, mortality, behavior, and weather conditions.

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Fossil Butte National Monument - Birds

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Data Sets

DS-FOBU-011	Fossil Butte raptor nest surveys. 5/1/1989 - present. (Written reports, ArcView map and hand-drawn maps. Originated by Kyte, Clayton; status: Active.
DS-FOBU-012	Sage grouse lek counts/surveys. 2/1/1995 - present. (Form printed on 8 1/2" x 11" paper). Originated by Tratnik, Norris & Rosalie; status: Active.
DS-FOBU-013	Nesting raptor surveys. (hand-drawn maps; short, written reports). Originated by Banta, Andrew; status: Active

Golden Spike National Historic Site - Birds

General Bird Surveys

A general bird inventory was conducted from 1975-1981 by Boyce and by Van Vuren in 1981; resulting information was compiled in a species list that includes general information on abundance and, in some cases, locations (Van Vuren and Boyce 1981). Dates of sightings are also included for some of the less common birds. In 1993, Poe used random point counts and road counts in April and May to compile a bird species list and relative population numbers (Poe 1993). Golden Spike National Historic Site staff have maintained a checklist that incorporates their observations and that is periodically updated.

Bird inventory work on adjacent lands managed by the Bureau of Land Management has been documented in several Resource Management Plans (USDI 1986, USDI 1998), and may have relevance to Golden Spike because of geographic proximity.

Johnson conducted inventory work in 2001, as part of the Northern Colorado Plateau Inventory and Monitoring Program . Sixteen point count stations were established, resulting in detection of 46 species in the park, including six species that were additions to the park's species list. The total number of confirmed species is 67 (Johnson and Barr 2002). A second season of inventories will continue in 2002, with a final report expected in early 2003.

Threatened, Endangered, or Sensitive Bird Surveys

Golden eagles have been observed at Golden Spike, and immature bald eagles were observed in 1985 as part of a national 1985 Bald Eagle Midwinter Survey (Wagner et al. 1985). Other species of concern that occur at Golden Spike include peregrine falcon, burrowing owl, short-eared owl, and sage grouse (Johnson and Barr 2002).

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Hovenweep National Monument - Birds

General Bird Surveys

An early list of birds for Hovenweep National Monument is provided by Richart and Brandegee (1941), who did a general fauna and flora analysis of Hovenweep and Yucca House National Monument. Bird sightings were compiled several times afterwards in the form of checklists (Southeast Utah Group Resource Management files; Rado and Winter 1974.) The most current species list of birds occurring at Hovenweep is based largely on field notes from Marilyn Colyer, Biologist with Mesa Verde National Park, during the time that Hovenweep was associated with Mesa Verde National Park. Colyer visited Hovenweep several times per year between 1980 and 1997 to conduct informal field surveys, recording bird sightings as part of a general biological survey (Colyer 2000, personal communication with S. Daw; Southeast Utah Group, Resource Management files). Results of a formal bird survey by the Audubon Society during the mid-1980's at Hovenweep have not been located despite a concerted effort.

Threatened, Endangered, or Sensitive Bird Surveys

Although Mexican spotted owls occur throughout the Colorado Plateau, and surveys have occurred in surrounding areas (El Malpais National Monument, Colorado National Monument, Navajo National Monument, Natural Bridges National Monument) (Willey 1998) no surveys have been done in Hovenweep. Presumably, this is due to lack of habitat for the spotted owl (Elliot Swarthout, personal communication, August 2000).

Some uncommon and rare birds, as well as species of concern, such as the Gunnison sage grouse (*Centrocercus minimus*), or the southwest willow flycatcher (*Empidonax trailii extimus*), are potentially present at Hovenweep and may be detected if targeted in formal surveys (Colyer 2000, personal communication with S. Daw).

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Swarthout, E. 2000. Personal communication with Sonya Daw, August, 2000.

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General Bird Surveys

Because of its long history within the National Park System (established 1908), Natural Bridges has extensive records of bird sightings (Southeast Utah Group, Resource Management files), which include a variety of unusual species for the area, mostly seen at the residence area sewage pond during migration.

As part of the Long Term Monitoring Program begun for all the Southeast Utah Parks, permanent Emlen strip transects, designed to sample all habitats within Arches, Canyonlands, and Natural Bridges, were annually monitored for avian species richness and abundance between 1987 and 1992 (DS-SEUG-033; Graham 1992). These bird surveys used "Emlen strip census", strip transect, and point count distance sampling methods. Strip transects followed 1 mile to 2 km routes, recording all birds seen and some heard, out to 400 feet. Circular plots used lines of 10 points, spaced 100m apart. Points were surveyed for 3 minutes, recording all birds within 200 m (sic). Only visual encounters were recorded because of inexperienced observers. Problems with observer reliability and consistency led to the Emlen transects being replaced by permanent point-count transects in various riparian habitats throughout the 3 units, which have been on-going since 1993 (DS-SEUG-022; Fagan 1993, 1994, 1995, 1996, 1997; Daw 1998, 1999, 2000, 2001.) These variable circular plot point counts are conducted 3 times/year during the breeding season at eight transects, with 10 point count stations each (2 transects in Natural Bridges; 3 transects each in Arches, Canyonlands). Count periods are 8 minutes long, grouped into 0-3, 4-5, 6-8 minute periods. Surveys follow standard guidelines for distance sampling birds with point counts, and result in species richness and relative abundance data.

Mitchell and Woodward (1993) conducted a study of small mammal, bird, plant, and aquatic organism distributions and patterns of abundance with respect to human travel systems in Arches, Canyonlands, and Natural Bridges, during 1990-1992.

Finally, Schelz (2000) has created a synthesis of bird lists for all units within the Southeast Utah Group, providing a general overview of birds to be found in the Parks.

Threatened, Endangered, or Sensitive Bird Surveys

Mexican spotted owl surveys were conducted in 1994 (Willey) in Armstrong, Deer and White Canyons, and again in 1995 (Willey) in White Canyon and along the Natural Bridges road. No Mexican spotted owls were found in the Park.

Only 1 midwinter survey for bald eagles has been recorded for Natural Bridges (Connor 1984).

Peregrine falcon (*Falco peregrinus anatum*) territories were intermittently documented during the 1980's in Arches and Canyonlands National Park as a result of informal surveys or incidental observations. Consistent inventory and monitoring (including limited banding and collection of prey remains in 1989) of peregrine falcons began in 1989 and has been on-going in all three Parks with active territories: Canyonlands, Arches, Natural Bridges (DS-SEUG-029). The majority of territories are in Canyonlands National Park, and only 1 territory, discovered in 1995, is known for Natural Bridges.
All three original units of the Southeast Utah Group were surveyed for Mexican spotted owls (*Strix occidentalis lucida*), with no detections in Arches (Willey 1995) or Natural Bridges (Willey 1994, 1995). Several territories were found in Canyonlands, which are detailed below in the Individual Park Surveys section because of the extensive research effort that took place for this species in Canyonlands. No

surveys occurred in HOVE, presumably because of a lack of suitable habitat (Swarthout personal communication, August 2000).

The southwest willow flycatcher (*Empidonax trailii extimus*) has been inventoried along the Colorado River portion of Arches in 1999, and the Green and Colorado River portions of Canyonlands in 1999 and 2000 (Johnson 1999, 2000). It is not clear whether the subspecies observed regularly within these Parks during migration, but not later during the breeding season, is actually the endangered subspecies, *E. trailii extimus*.

The Utah Division of Wildlife Resources began conducting statewide annual bald eagle (*Haliaeetus leucocephalus*) wintering surveys by aircraft in 1978, which included the Cataract Canyon section of the Colorado River through Canyonlands and a portion of Arches (Connor 1983, DeGruyter 1984; Livesay 1985; Walters Jr. 1986, 1987; Utah Division of Wildlife Resources 1988; Bates 1990). In conjuction, a midwinter bald eagle road survey was also conducted along the length of the Arches NP road in 1987 (Swanke).

An historical peregrine falcon territory has been monitored annually at Natural Bridges since 1995 as part of the overall peregrine falcon monitoring program for the Southeast Utah Group (DS-SEUG-029; Southeast Utah Group, Resource Management files.)

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Natural Bridges National Monument - Birds

Data Sets

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DS-SEUG-029.3 SEUG Raptor Observation Records. 1/1/1983 - present. (Microsoft Excel spread sheet and hard copy forms). Originated by Florian, Christine; status: Active.

DS-SEUG-033.2 Long term monitoring of birds using Emlen strip transects. 1/1/1986 - 1/1/1992. (hard-copy field data sheets). Originated by Graham, Tim; status: Inactive.

Pipe Spring National Monument - Birds

General Bird Surveys

The work journals of the first monument superintendent (C. Leonard Heaton) spans 35 years and contains numerous references to bird species. In the 1960s, Pipe Spring was part of a broader four-year mid-winter bird survey that included Zion National Park, portions of Arizona, and the St. George area (Wauer 1966), resulting in a species list that included numbers counted as well as suggesting trends. Crawford and Herr (1973) created extensive checklists for American birds; also in the 1970s, Wilt recorded a total of 154 bird species occurring within a study circle 15 miles in diameter centered on the monument (Wilt 1973). In a subsequent report Wilt increased the total to 201 species within a 7.5-mile radius of the monument (Wilt 1976). Raptor surveys were conducted for northern goshawks, merlins, prairie falcons and golden eagles in Zion and Pipe Spring, with three species documented for the monument (Sinton 1995).

A focused three-year bird survey was undertaken by Matthew Johnson, biologist for the USGS BRD (Colorado Plateau Field Station). (Johnson 1998) Some bird banding data was collected by Zion Naitonal Park biologist Mary Hunnicut in the course of this project; records are contained in an Access database located at Zion NP (DS-PISP-0002).

Threatened, Endangered, or Sensitive Bird Surveys

A survey of peregrine falcons, in addition to northern goshawks and Mexican spotted owls, was conducted in Zion, Cedar Breaks, and Pipe Spring in 1993 (Boretti 1993).

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Pipe Spring National Monument - Birds

Data Sets

DS-PISP-0002 Bird banding data for Pipe Springs National Monument. 4/26/2001 - 4/27/2001. (MS Access97 database with one table only.). Originated by Hunnicut, Mary; status: Inactive.

Timpanogos Cave National Monument - Birds

General Bird Surveys

Observation records, intermittent and of varying quality, by monument staff and visitors have been collected from 1939 through 1985, with each record containing species name, date of observation, and any additional remarks (DS-TICA-006, DS-TICA-007).

In 1976, the Southwest Parks and Monuments Association produced an amateur birder publication using information collected from an unknown study performed in 1974. However, the publication includes information from the mouth of the canyon to Timpooneke and Granite Flats Campgrounds, both of which are far up canyon in distance and elevation (Southwest Parks and Monuments Association, 1976). Mosher studied raptors of Uinta National Forest around Timpanogos Cave National Monument in 1973 and 1974 (Mosher et al. 1974) but not within the monument itself. The only other general study is a portion of *The Visitor's Guide to the Birds of the Rocky Mountain National Park*, in which the author writes about his experiences of birding while visiting the monument (Wauer 1993).

The first comprehensive survey for breeding birds at Timpanogos Cave National Monument was begun in 2001, as part of the Northern Colorado Plateau Network Inventory and Monitoring Program. Because of the limited geographic extent of the monument, 10 area searches were conducted in all habitat types, including riparian and canyon woodlands, juniper woodland, mountain mahogany-oak shrublands, and mixed-conifer forest. Fifty-one species were detected during these searches, and one species, Brewer's sparrow, was added to the monument bird list (Johnson et al. 2002).

Threatened, Endangered, or Sensitive Bird Surveys

No species of concern are known to occur at Timpanogos Cave NM (Johnson et al. 2002).

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Mosher, J.A., Murphy, J.R. and White, C.M. 1974. Study of rare or endangered raptors on the Uinta National Forest. 20 page(s).

Data Sets

DS-TICA-0006 Bird Sightings At Timpanogos Cave National Monument. 4/1/1939 - 7/12/1969. (4 x 6 index cards). Originated by Tom Walker; status: Historic.

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Zion National Park - Birds

General Bird Surveys

Songbirds are among the best known groups in Zion National Park. Presnall (1935) authored the first checklist, Grater (1947) added additional species, and Wauer and Carter (1965) published the first book on the various species. Throughout the years many bird watchers have also worked in the park and many field notes are in the park's possession. In particular, Jerome Gifford left behind extensive field notes from his observations in and around Zion, including the town of Springdale. His observations include the date, location and number of every bird species found, and are incorporated into bird checklists compiled for the park (Carter et al 1975, 1981). Keller (1935), a park ranger, also documented his observations in Zion and Parunuweap Canyons. Wauer and Russell (1967) documented sightings of birds and their distribution in the Virgin River valley, including the Zion National Park area, from 1962-1965 (Wauer 1969). Other species-specific observations include the rufous-crowned sparrow (Wauer 1965b, Wauer 1967), eastern phoebe (Wauer 1966c), black hawk (Wauer 1965a), flammulated owl (Wauer 1966d), and Wied's crested flycatcher (Wauer 1968). The authoritative text for birds of Zion NP is currently Wauer (1997).

Wauer (1966b) also banded birds in the Oak Creek area from 1963-1965. Hunnicutt banded birds during migration periods from 1998-2000 in several different riparian areas in conjunction with Van Riper's Colorado River drainage riparian bird project (Hunnicutt and Pruett 1999, Hunnicutt 2000). In addition, Audubon Christmas Bird Count data has been collected in the park since 1966 (Wauer 1966). The Christmas Bird Count survey area runs in a 15 mile diameter circle around Zion park headquarters, including Zion park trails and the town of Grafton. Utah Division of Wildlife Resources (Parrish 1995) surveys birds annually in Parunuweap Canyon as part of their statewide bird monitoring effort. Scott and Gifford also did a bird survey during 1974 in a portion of Coalpits Wash. Various forms, reports, miscellaneous and unusual sightings, Christmas Bird Counts, and bird banding records from a 24-year period (1958-1962) have been collected and compiled at the Zion Resource Management offices (DS-ZION-0012)

From 1997-2001, Zion Resource Management personnel surveyed breeding birds in pinyon-juniper, riparian, and ponderosa pine habitat types (Hunnicutt and Pruett 1999, Hunnicutt 2000). Birds were surveyed using a point count method in 10 different transects of varying lengths (DS-ZION-0009). Bird point counts were not repeated in 2002, due to lack of time. In 1998 and 1999, Zion participated in an area-wide migratory bird study coordinated by the USGS BRD Colorado Plateau Field Station, to investigate the Colorado River as a migratory bird corridor. Birds were captured, banded, and released during the spring and fall migratory periods and associated data collected (DS-ZION-0015).

Threatened, Endangered, or Sensitive Bird Surveys

Raptors have been a well-monitored group in Zion National Park. Mindell and Mindell (1980) inventoried wintering raptors in the Virgin River drainage. Bald eagles were surveyed from 1988-1993 (Zion National Park 1993). Sinton (1995a) monitored raptors other than peregrines and spotted owls. Northern goshawk surveys have taken place in selected areas in 1993, 1999 (Orth 1999b), and 2000 (Hunnicutt 2000). In 2000, a GIS model was developed to predict occurrence of goshawks in Zion National Park. Unfortunately, even previously known territories did not support birds that year. The model was also flawed due to the inaccuracies in the base map for habitat type. Raptor monitoring data is in the process of being assembled in a standardized Access database for long-term management (DS-ZION-0016).

Peregrine falcons (*Falco peregrinus*) have been observed in Zion since 1939. The first known territory was found in 1975. Nesting activity and reproductive success has been monitored since 1975 (McCutchen 1976; Dotson and Hallows 1978; Enderson 1985; Tibbitts et al. 1984; Tibbitts et al. 1985; Tibbitts and Hays 1986; Hays 1989; Teresa 1989; Hutchins 1991, 1992; Boretti 1993; Pilkington 1994; Staats 1994; Sinton 1995b, 1996; Hunnicutt 1997; Hunnicutt and Pruett 1999; Orth 1999c; Hetzler et al. 2000; Hetzler and Maller 2001a). Although peregrine falcons were removed from the U.S. Fish and Wildlife's Endangered list in 1999, a stipulation that they be monitored for five years after the de-listing remains in effect. Furthermore, Zion monitors active eyries located in cliffs with climbing routes, which are closed until fledging occurs. As of 2001, 19 known territories were located and monitored, and sixteen of those territories were occupied by breeding pairs, producing a total of 33 fledglings (Hetzler and Maller 2001a). In 2002, the climbing cliffs were the main focus for monitoring, with a few selected remote sites.

Mexican spotted owls (*Strix occidentalis lucida*) have been observed in Zion National Park occasionally since 1928. Formal Mexican spotted owl surveys did not begin until the mid 1970's (Kertell 1976). The first major Mexican spotted owl study began in the late 1980's looking at owl distribution and reproductive, breeding cycle phenology, and habitat characteristics (Murphy 1988). Hughes (1988) performed another survey that focused on fifteen potential owl territories and provided baseline information. Rinkevich studied food habits, territory occupancy, habitat characteristics, and distribution (Gutierrez and Rinkevich 1990, 1991; Rinkevich 1991a, 1991b, 1991c, 1991d, 1991e; Rinkevich and Gutierrez 1996). Willey studied the metapopulation dynamics of the Colorado Plateau, including Zion NP looking at habitat ecology, home range, and movement patterns through radio telemetry (Willey 1992, 1994, 1998; Willey and van Riper 2000).

Zion has been monitoring Mexican spotted owl territory occupancy and nesting activity on a regular basis since 1995 (Hetzler 1995, 1996, 1997; Hetzler and Hunnicutt 2000; Hunnicutt and Pruett 1999; Orth 1999a). In 2001, 15 of the 16 known territories were occupied, with fledglings at one of the territories (Hetzler and Maller 2001b).

Noise and recreation impacts to Mexican spotted owls have also been studied at Zion. Howe et al. (1993) included Zion in a management plan looking at various impacts to spotted owls, including recreation, research, and fire management. Swartout and Steidl (Steidl 1996; Swarthout and Steidl 1998, 2000; Swarthout 1999) have studied the effects of backcountry recreation on Mexican spotted owls in the Colorado Plateau region, including Zion National Park. These projects document owl behavior around specific human stimuli, including provoking flush reactions by owls and distance for flushing.

The park surveyed southwestern willow flycatchers (Empidonax trailii extimus) in 1993, 1997-2000, and 2002. McDonald et al. (1995) and Peterson (1995) through Utah Division of Wildlife also surveyed various sites in southern Utah. These include survey results from Zion NP. One southwestern willow flycatcher was documented in 1999. The 2002 survey along the Virgin River in Zion yielded no southwestern willow flycatchers. Sogge did a willow flycatcher habitat assessment in 2002 to determine where surveys should occur. He found few areas of likely willow flycatcher habitat in Zion National Park, but those areas will be surveyed in 2003.

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Arches National Park - Mammals

General Mammal Studies

Forty-four mammal species are currently known from Arches National Park. The most extensive mammal studies have involved the live trapping of small mammals as part of the long-term monitoring program, and bighorn sheep monitoring *(Ovis canadensis*).

Small mammals have been studied and monitored by a number of researchers. Wadsworth (1967, 1969, 1972) investigated the life history of the Colorado chipmunk (*Eutamias quadrivittatus hopiensis*). He was primarily interested in reproductive behavior, growth and development, food habits, habitat preference, and daily and seasonal activity patterns. Clevenger et al. (1975), Clevenger and Workman (1977a, 1977b) and Elmore (1978) surveyed small mammal populations in campgrounds to determine human impacts on populations. Mitchell (1993) investigated human effects on riparian habitat and surveyed mammals as part of that study. Fowler (1995) surveyed small mammals in seeps and springs in Arches. Auger (1999) wrote a dissertation on the effects of resource availability and food preference on home range use and caching behavior of Ord's kangaroo rats (*Dipodomys ordii*) (DS-SEUG-074).

Extensive monitoring of small mammals started in 1987 and continued to 1993, as part of the long-term monitoring program for the Southeast Utah Group (Graham and Belnap, 1989, 1990; Graham 1988, 1991). Small mammals were selected due to their expected sensitivity to ecosystem changes and their quick response to changes in food availability. Data was collected at ten sites or webs in the three parks of the Southeast Utah Group, yearly from 1987 to 1992, with some data collected in 1993. Each capture was weighed, sexed, measured, marked or ear-tagged, and identified to species. Associated plants (within 1m of the trap) were recorded in descending order of cover. Graphs were generated to compare species and number of captures between years, as well as to present summary material. The dataset for the Southeast Utah Group (of which Arches is a part) includes at least 1000 pages of data sheets, summary sheets, and sketches (DS-SEUG-016.2). Small mammal monitoring was discontinued in 1993 due to the fear of Hantavirus and high variation of results.

Bogan has also studied small mammals in the park using live and snap traps (Bogan 1992, 1993).

Johnson (1988) summarized and evaluated all existing information (up to 1988) on carnivores in Arches National Park, to determine the presence/absence of the fifteen species known or suspected to occur in the park and determine their distribution. He also tested a variety of survey techniques made recommendations for long-term monitoring and future research priorities. No actual monitoring, however, was ever initiated.

Charlie Schelz, biologist for the Southeast Utah Group, has compiled and updates annually a mammal species list that consolidates information from past lists and studies (Schelz 2002).

Threatened, Endangered, or Sensitive Mammal Surveys

River otters are known to occur in Arches National Park along the Colorado River. Surveys by Boschen (1988, 1989) confirm river otter activity in areas of the Colorado River adjacent to the park.

Bighorn sheep monitoring at Arches National Park started in 1990. Haas et al. (1990) monitored the status and movements of transplanted bighorn sheep, from Canyonlands NP, focusing on mortality, population dynamics, seasonal distribution, home range characteristics, health status, and movements. In 1991 four habitat models were developed to differentiate between suitable and unsuitable habitat (Haas

1991, Haas and Workman 1991).

Sloan, a biological technician for the park, has monitored the bighorn sheep continuously since 1991 and written a number of annual reports, including a herd history of bighorn sheep in the park (Sloan 1995). His monitoring program includes a number of radio-collared sheep that he follows throughout the year and an annual aerial census (DS-SEUG-021.2). In addition, observation records by visitors and park rangers (DS-SEUG-020.2) and by Sloan et al. (DS-SEUG-017.2) are recorded and digitized. Sloan recommended against stock use of Salt Wash without extensive study (Sloan 1991), and during the summer and fall of 1991 he studied the number of sheep, general range, health, appearance, and herd composition (Sloan 1992). He has also analyzed the carrying capacity of suitable habitat and examined disease patterns, domestic sheep and cattle grazing and poaching (Sloan 1996a, 1996b, 1996f) and the effects of summer drought on ewe/lamb groups (Sloan 1996d, S-SEUG-035.2). Home range for the herds has both increased in size and moved up Salt Wash and up the Colorado River out of the park (Sloan 1996c, 1996e, 2000). Studies have also been conducted on the effects of human disturbance, and the duration and peak of the rut as it correlates with lambing dates (Sloan 1997, 1998).

Bogan et al. (1993, 1994) surveyed for bats at several sites within the park. In 2000, they investigated the occurrence of breeding colonies of big free-tailed bats (*Tadarida macrotis*). The first record for breeding individuals in the park was obtained in 1991 (Bogan 1992) and a radio-tracking study on the species was conducted at Arches NP in 1999 (Haymond et al., In preparation) with several maternity roosts identified in the central portion of the park. Voucher specimens for some species are in the Museum of Southwestern Biology in Albuquerque.

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Arches National Park - Mammals

Data Sets

DS-SEUG-021.2 Aerial annual/biannual census of desert bighorn sheep in Canyonlands and Arches National Parks and vicinity, 1992 - present. 11/1/1992 - . (Spreadsheet at USGS, Fort Collins. Paper data sheets at SEUG, NPS, Moab, UT). Originated by Sloan, William B.; stat

DS-SEUG-017.2 Desert bighorn sheep ground survey observation records for Canyonlands and Arches National Parks and vicinity, 1990 - present. 10/1/1990 - . (Excel workbook, ArcInfo point coverage, and hard-copy data sheets and field notes.). Originated by Sloan, Willia

DS-SEUG-074 Feeding behavior of Ord's kangaroo rat (Dipodomys ordii) and food resource availability in blackbrush habitat, Arches National Park, 1997 - present. - . (data format not known). Originated by Auger, Janene; status: Active.

DS-SEUG-016.2 Small mammal trapping webs from LTMP in the Southeast Utah Group national parks, 1987 - 1993. 5/6/1987 - 6/5/1993. (dBase III+ files converted to Excel; hard-copy documents). Originated by Graham, Tim; status: Inactive

DS-SEUG-020.2 Observations of desert bighorn sheep in Canyonlands and Arches National Parks, by visitors and park rangers, 1969 - present. 5/23/1969 - . (pre-1990 dBase III file). Originated by ; status: Active.

DS-SEUG-035.2 Desert bighorn sheep disease monitoring data, Arches and Canyonlands National Parks and vicinity, 1986 - present. 9/15/1986 - . (scattered reports and data sheets, correspondence, fields of observation data from other datasets). Originated by Sloan, Willi

Black Canyon of the Gunnison National Park - Mammals

General Mammal Studies

Very little mammal inventory work has been conducted in Black Canyon of the Gunnison National Park. The first and likely only inventory of mammals was compiled by Hoy (1966), a seasonal park naturalist at Black Canyon of the Gunnison National Monument. Miller, a former chief park naturalist, later verified the list yet it is unclear how extensive the original 1966 work was, and substantial lands have been added to the park since these inventories. Wildlife species observations, including mammal observations, made by the public and NPS employees have been catalogued from 1963-2000; however, these records vary widely in reliability (DS-BLCA-001). The general region surrounding the park is encompassed in regional faunal works such as Armstrong (1972). Bogan (2000) produced an updated mammal list for all parks within the Northern Colorado Plateau, including Black Canyon of the Gunnison.

Studies on specific mammal species in Black Canyon of the Gunnison National Park have focused on porcupines, bats, shrews, ungulates and otters. Kump (1983) examined the effects of the porcupine (*Erethizon dorsatum*) population on pinyon pines in the Black Canyon area, and Macdonald (1986) proposed a porcupine impact study to examine the population inhabiting the Black Canyon, though it is not clear if the study was performed, or what conclusions were made. Townley (1987) reported on damage to Pinyon pine trees by porcupines in the High Point area of Black Canyon of the Gunnison National Monument. Navo (1998) published a bat survey in western Colorado for the Colorado Division of Wildlife: the objective of the study was to document the presence of spotted bats (*Euderma maculatum*) and big free-tailed bats (*Nyctinomops macrotis*) in Black Canyon of the Gunnison National Park. It was confirmed that both species occur in the park.

In a Bureau of Land Management report, Capodice (1988) detailed elk and deer monitoring on winter range in the Gunnison area. The report also included a monitoring strategy, distribution and habitat use by deer and elk, and management recommendations.

Valdez et al. (2002) reported on the first-year results of a mammal inventory which was conducted in 2001 in conjunction with the Northern Colorado Plateau Network. The level of documentation (documented species/likely species) for Black Canyon was estimated at 65%, based on trap and mist net data. Valdez et al. found the deer mouse (*Peromyscus maniculatus*) to be the most commonly captured, followed by the brush mouse (*Peromyscus boylii*), bushy-tailed woodrat (*Neotoma cinerea*), and the least chimpmunk (*Eutamias minimus*). They also captured the Yuma myotis (*Myotis yumanensis*) which is the first known occurrence of this species in Montrose County, and the Hopi chipmunk (*Tamias rufus*) which they felt was the first capture for Black Canyon. They also observed, or documented by sign, Nuttall's cottontail (*Sylvilagus nuttallii)* rock squirrel (*Spermophilus variegatus*), porcupine (*Erethizon dorsatum*), coyote (*Canis latrans*), American black bear (*Ursus americanus*), mountain lion (*Puma concolor*), bobcat (*Felis rufus*), wapiti (*Cervus elaphus*) and mule deer (*Odocoileus hemionus*). They concluded that population numbers of small mammals were low on the plateau, based on recent climatic factors (e.g., low precipitation). Recommendations are made for year-two work in 2002, along with comments and the current species lists of mammals occurring in Black Canyon of the Gunnison National Park.

Threatened, Endangered, or Sensitive Mammal Studies

Long (1992) published the first recorded sighting of the Preble's Shrew (*Sorex preblei*) in Colorado from the Black Canyon. Preble's shrew is more commonly known from east central Oregon to eastern Montana. Populations from New Mexico and the Black Canyon appear to be highly isolated from the main distribution of the species.

Langolis and Sisk (1980) reported on the history of river otters (*Lutra canadensis*) in the Gunnison River that included areas in the Black Canyon. Also included were a habitat evaluation, their reintroduction status and a monitoring and recovery plan.

The bighorn sheep has been by far the most intensively studied mammal in the park based on over a dozen contributions to the park literature. An historical survey by Grater (1937) was the first effort to document the status of bighorn sheep (*Ovis canadensis*) at Black Canyon of the Gunnison National Monument. Durrant and Robinson (1962) published a paper on the mammals of the Gunnison River basin, which presumably includes bighorn sheep. It is unclear what the results of this paper are. After the 1960's, most of the literature is devoted to documentation of the reintroduced herd, which occurred from 1986-1988, and 1990.

Swift and Johnson (1991) conducted a bighorn sheep habitat evaluation in five national parks, which included Black Canyon of the Gunnison National Monument and Curecanti National Recreation Area. A report from five scientific advisory committees to the National Park Service (1991) detailed management plans for bighorn sheep and recommendations for their reintroduction and sustainability in Black Canyon of the Gunnison National Monument and Curecanti National Recreation Area. Ramey (1994) examined the phylogeny and evolution of bighorn sheep in the southwest, using a mitochondrial DNA sequence sample taken from sheep in the Gunnison area.

Bellew (1995) conducted a demographic study of bighorn sheep in the Gunnison River Gorge. Her report examined the history of native bighorn sheep in the area, their reintroduction, disease history, hunting and poaching issues, and current status. Sweaner et al (1995) reported a brief history of bighorn sheep populations in Curecanti National Recreation Area and Black Canyon of the Gunnison National Monument. They also discussed the proposed restoration program, described methods to be used, outlined the study area using GIS coverages, and suggested management implications.

A report on radio collared ewes written by the National Park Service (Spicer 1995), contains information on 12 ewes transplanted to the Black Canyon/Gunnison Gorge area between 1986-1990.

In a report to the National Park Service from five scientific advisory committees, Singer et al. (1996) discussed the status of bighorn sheep in each park that supported populations. The committees were convened to assess the research and management needs for bighorn sheep and to address commonality of needs on a regional, subregional, or metapopulation basis. A brief introduction on current studies in each park or region was outlined, followed by future study and management recommendations. Singer and Gudorf (1999) then published a three-volume report describing a seven-year regional initiative to conduct research and population studies on bighorn sheep, and to plan and carry out restoration plans in the national parks of the Intermountain and Midwest Regions. This first volume describes the planning process, the seven-step assessment and restoration process including GIS-based habitat assessments, recommended restoration procedures and considerations, a summary of restoration efforts in each park unit, and a summary of key findings. Also included are maps, a list of reports produced during this restoration initiative, and a lengthy reference list. Volume 2 provides a synopsis of research findings, and Volume 3 provides the research findings in full.

Singer et al (1999) surveyed all the state and federal agencies involved in bighorn sheep translocations conducted between 1923 and 1997 in order to analyze the factors contributing to successful restorations. They classified each effort into three categories based on population numbers in late 1997: unsuccessful (<29 animals), modestly successful (30-99 animals), and successful (100 or more animals). They documented thirty percent of the translocations as unsuccessful. Negative factors contributing to

unsuccessful translocations were the presence of domestic sheep within 6 km of the known bighorn sheep use area, and cattle grazing on bighorn range. Positive factors were habitat configurations that allowed or encouraged annual migrations by the translocated population, and indigenous herd sources. Bighorn sheep released into desert environments increased faster than those released into either Rocky Mountain habitat or prairie badlands habitat. They concluded this was due to the vast, inaccessible and rugged terrain of the northern Colorado Plateau, which has been relatively untouched by human disturbance, grazing and fire suppression.

Finally, Singer et al. (2000) published an article on their findings of the dispersal rates of 31 translocated populations of desert bighorn sheep (*Ovis canadensis nelsoni*) and Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*) into 79 nearby suitable, unoccupied habitat patches. Their statistical analysis showed that high dispersal rates and occupation of new patches can occur if bighorn sheep are placed in large habitat patches with few barriers to movements to other patches and with no domestic sheep present.

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Data Sets

DS-BLCA-001 BLCA Natural History Observations. 1963-2000. Microsoft Access database. Originated by BLCA resource staff; status: inactive

Bryce Canyon National Park - Mammals

General Mammal Studies

The majority of the studies on Bryce Canyon fauna have been conducted on mammals. Early work on the mammals of Bryce Canyon, Zion and Cedar Breaks was conducted by Presnall (1936) and by Presnall and Hall (1938). Stephenson (1961) produced a list of park mammals as did Hallows in the early 1980s (Hallows 1982), and Bogan (2000) produced an updated, unpublished in 2000.

Focused mammal studies were initiated at the park in 1988, in response to a park request for surveys of mammals in proposed prescription burn areas (Bogan 1990). Eventually, with the cooperation of the park and National Park Service Intermountain Region, the work was expanded to include baseline inventories of mammals. Surveys subsequently were conducted in proposed burn areas as well as at a variety of other locations in the park through the summer of 1991 (Bogan 1992a, 1992b). Study areas included Yovimpa Pass Meadow, Long Hollow, Water Canyon, Glory Cove, lower Bryce Canyon west of Tropic, Riggs Spring on lower Podunk Creek, and other areas. During these seasonal surveys (approximately 2-3 weeks per year) over four years, the presence of 47 species were confirmed, of an estimated 75 or so species believed to occur within the park. Upper elevations of the park were dominated by least (*Tamias minimus*) and Uinta chipmunks (*Tamias umbrinus*), and deer mice (*Peromyscus maniculatus*); there was high mammal species richness in the Yovimpa Pass area. The lower-elevation areas of the park also contributed considerable mammalian diversity to the park.

The park conducted small mammal population inventory and monitoring studies prior to conducting prescribed burns (Bryce Canyon NP 1990, 1991, 1995, 1996). Post-burn, staff measured fire-effects on small mammal numbers and habitat. Preliminary analysis of pre-burn and post-burn data revealed an increase in total animals captured on both the control plots in 1991 over 1990. The increase is attributable almost entirely to increases in deer mice (*Peromyscus maniculatus*). In August of 1995 two plots were designed to trap small mammals, using the Calhoun method of trapping, prior to the areas being burned. Each trap line was open for three nights. The traps were opened in the afternoon starting between 3:00 and 4:00 PM, and were checked and closed starting between 8:00 and 9:00 am the following day. This allowed plenty of time for diurnal as well as nocturnal species to be captured. In July of 1996 the same trap lines were trapped again nearly one year after the area was burned. The data was compared to the 1990 preburn data from Johnson 1991. This brief comparison showed that more small mammals were captured in the 1995 Yovimpa preburn area than in any of the 1990-91 preburn plots. However, species diversity was slightly higher in the 1990-91 areas. The methods should be copied for any future population census from trapping.

Studies begun in 1965 trapped and tested rodents at Bryce Canyon National Park for fleas and bacteria, which cause Sylvatic plague in rodents and bubonic plague in humans (Olsen 1965-1971). The researchers report rodent populations for each of years 1965-1971 to park management. After live trapping rodents, the animals were anesthetized with chloroform, therefore the rodents and the fleas were all anesthetized. The reports of fleas and hosts became more detailed as the study progressed. The fleas responsible were found mainly on the Uinta chipmunk (*Tamias umbrinus*) the first year of the study, and later the Least chipmunk (*Tamias minimus*) was found to host the offending fleas in smaller numbers. The second year of the study the researchers recommended park staff live-trap chipmunks, deer mice (*Peromyscus maniculatus*), and golden-mantled squirrels (*Spermophilus lateralis*) in an insecticide-laced bait-trap. The counts revealed that the plague-causing organism was kept in check, but never eradicated from the rodent population. The infestation numbers increased each year of the study. Through 1995 park staff routinely dusted bait-trapped rodents and rodent burrows with a variety of insecticides.

Bryce Canyon National Park - Mammals

As the result of a proposal to inventory bats at Bryce Canyon National Park (Toone 1993), Bryce Canyon National Park was included in a cooperative effort with the Dixie National Forest, Fishlake National Forest, Manti-La Sal National Forest, and the National Biological Service, to determine the species composition and the distribution of bats in high plateau forests of southern Utah. Over 250 bats were netted, representing 14 species, including ten species listed as Category 2 by the U.S. Fish and Wildlife Service. A list of the species netted in the study includes: Allen's big-eared bat (*Idionycteris phyllotis**), Big brown bat (*Eptesicus fuscus*), Big free-tailed bat (*Nyctinimops macrotus**), California myotis (*Myotis californicus**), Fringed myotis (*Myotis thysanodes**), Hoary bat (*Lasiurus cinereus*), Little brown *bat (Myotis lucifugus**), Long-eared myotis (*Myotis evotis**), Long-legged myotis (*Myotis volans**), Pallid bat (*Antrozous pallidus*), Silvery-haired bat (*Lasionycteris noctivagans*), Spotted bat (*Euderma maculatum**), Western small-footed myotis (*Myotis ciliolabrum**), and Yuma myotis (*Myotis yumanensis**). Those species marked with an asterisk (*) were in 1995 US Fish and Wildlife Service Category 2 species (Foster et al. 1995, DS-BRCA-007). Bogan (1994) addressed bat distribution on the Colorado Plateau, including Bryce Canyon.

Mule deer (*Odocoileus hemionus*) were thought to be over-abundant at one time. Censusing of the local portion of the population was conducted from 1956 to 1969 (Crafts 1969). The average number of deer observed on roadside counts during this time period ranged from 12 to 57 (Burch 1996). The same methods were used to census deer along the rim road in 1996, 1998, and 1999. Mean number of deer observed in these years was 7 to 10. No reports were written but data is filed in the park's Resource Management office (DS-BRCA-0032).

Schulman (1978) suggests that because of the non-resident nature of the deer population at the park and a lack of information about their winter range, standard censusing techniques are not practical. She proposes, in addition to roadside counts, counts at watering holes, sample strips, pellet counts, meadow counts, migration counts, vegetation exclosure, feeding preference studies on captive deer, and photographs.

After looking at deer movement, habitat use and public land use management, the Utah Division of Wildlife Resources determined in recommendations to Bryce Canyon National Park, that no censusing technique will do more than reflect how these factors are influencing the Paunsaugunt mule deer herd, as opposed to directly reflecting population size (Collins 1978).

Other ungulate studies have focused on the effects on park vegetation. An exclosure was erected in 1957 to determine the impact deer were having on woody vegetation. Photographic documentation and vegetative plot inventory were completed 30 years later by park biologists (Mermejo 1988). In 1998 again a photographic study was undertaken to document the effect of deer and elk browsing on vegetation (Barraza 1998).

Threatened, Endangered, or Sensitive Mammal Studies

The Utah prairie dog (*Cynomys parvidens*) was federally-listed as Endangered in 1973. The US Fish and Wildlife Service initiated a recovery plan calling for re-establishing colonies on protected public lands. Because this species was once common in the park, relocation of animals from private lands to the park began in 1974. Elmore et al. (1976, 1977) conducted an initial baseline study of the status of the Utah prairie dog, their activity, migration from the area, and factors that might influence their ability to survive. A total of 1,910 animals were released in the park through 1988 (the last year animals were transplanted); population monitoring began in 1975 using a standardized census protocol (DS-BRCA-001). Eleven sites are monitored, and counts are conducted in spring and early summer months, between adult emergence from hibernation and the emergence of young-of-the-year. Ideally, each colony is counted approximately once a month during the four-month period. (Elmore and Workman 1977a, 1977b). The park and the Utah Division of Wildlife Resources have conducted annual index counts of adults each spring since the introduction. Mean number of Utah prairie dogs observed in spring index counts from 1974 to 2000 range from 47 to 224 (Wallen 1999, 2000).

The prairie dog colonies have prompted a significant amount of additional research: Wright-Smith (1978) examined the ecology and social organization of the Utah prairie dog; Bushman (1983) completed a dissertation on Sylvatic plague in Western Utah; and transplant techniques were detailed by Coffeen and Pederson (1989). In addition, Bryant et al. (1995) researched the historic occurrence of plague in Bryce Canyon; Ashdown (1995) investigated the effects of park visitors on prairie dogs' avoidance responses; and Ritchie (1998) analyzed twenty years of annual counts from 20 different isolated local populations (colonies) in southern Utah. These prairie dogs populations exhibited large fluctuations and repeated extinctions at individual colonies during the census period. The frequency of extinction at a colony declined as researchers increased insecticide dusting for fleas. Hoogland (2000) has conducted studies of survivorship and behavior towards predators on one colony adjacent to the park “Mixing Circle” since 1994 (Hoogland 2000). Nall (1988) proposed to examine possible causes of transplant failure. She offered several site selection factors worth further study: vegetation, soil, topography, temperature, and precipitation. Biggins (2001) studied the success of translocated prairie dogs by examining the efficacy of visual barrier fences, electric fencing and release cages to temporarily confine the movements of prairie dogs; compared prairie dog preferences for multi-entrance and single-entrance burrow systems; evaluated the effectiveness of multi-entrance artificial burrows for deterring predation on prairie dogs by badgers; and assessed the effects of enzootic plague on small populations of translocated Utah prairie dogs.

The Garfield County Commission and Utah Division of Wildlife Resources (2001) developed a Utah prairie dog habitat conservation plan to address potential conflicts between non-federal land use and conservation efforts in Garfield County.

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Data Sets

DS-BRCA-0001	Utah prairie dog census in Bryce Canyon National Park. 7/22/1975 - present. (Paper field forms, plus summary data in MS Excel spreadsheet, GIS ArcView 3.2 shapefiles, hardcopy census protocols.). Originated by BRCA Park Staff; status: Active.
DS-BRCA-0007	Bat inventory data, Bryce Canyon National Park, 1995. 5/29/1995 - 7/29/1995. (Paper data sheets. Also MS Word reports.). Originated by Dan Foster, BRCA Resource Management; status: Inactive.
DS-BRCA-0032	Results of deer census along Rim Road, Bryce Canyon. 1956 - 1999. (format: MS Access 97 database; paper reports) Originated by: BRCA Park Staff . Status: Inactive

Canyonlands National Park - Mammals

General Mammal Studies

Small mammals in Canyonlands National Park have also been studied and monitored by a number of researchers. Armstrong (1973) started to study the ecological distribution and community structure of mammals the park in 1971; Armstrong (1974) studied woodrat (*Neotoma* spp.) habitat in the Needles District; and in 1976 Johnson completed a M.S. Thesis on small mammals on isolated buttes in Canyonlands NP. Johnson also worked as a ranger in the Needles district in the 1970s and contributed to our knowledge of mammals present through his field work and species lists (Johnson 1975, Johnson and Gnesios 1977, Johnson 1980, 1981). Armstrong (1979) compiled an excellent checklist of rodents based on his research on rodent distribution in six habitat types in the park. His book on the mammals of Canyonlands National Park is still used today as the definitive park guide to mammals and their habitats (Armstrong and Kane 1979). This publication emphasizes ecological distribution, reproduction and populations, food habits, ecto-parasites, and patterns of activity of the mammals of Canyonlands.

Clevenger and Workman (1977), and Elmore (1978) studied small mammal populations in campgrounds to determine human impacts on populations. Madsen (1985) initiated a mark-recapture survey on rodents to estimate populations using the Lincoln-Index method. Rosenstock (1990, 1996) did some small mammal trapping in ungrazed areas of the Maze District of Canyonlands in order to compare them with grazed areas in Capitol Reef National Park. Mitchell and Woodward (1993) investigated human effects on riparian habitat, and included mammal surveys as part of the study. Dolan et al. (1992) studied habitat use by small mammals in Canyonlands' hanging garden communities.

Extensive monitoring of small mammals followed in 1987 and continued through part of 1993, as part of the park's long-term monitoring program (Graham and Belnap, 1989, 1990). Small mammals were selected as part of the Southeast Utah Group long-term monitoring program (LTMP) due to their expected sensitivity to ecosystem changes and their quick response to changes in food availability. Each small mammal capture was weighed, sexed, measured, marked or ear-tagged, and identified to species (Graham 1988). Associated plants (within 1m of the trap) were recorded in descending order of cover. Data were computerized and a statistical program (Transect) was used to calculate density. Graphs were also generated to compare species and number of captures between years, as well as to present summary material (Graham 1991). The corresponding dataset for the Southeast Utah Group includes at least 1000 pages of data sheets, summary sheets, and sketches (DS-SEUG-016.1). This project was discontinued in 1993 due to concerns of Hantavirus and a high variation of results.

The only study of the large mammals of Canyonlands was by Schelz (1988). He researched and tested different monitoring techniques for large carnivores in Canyonlands NP; his report provides a list of large carnivores observed and recommendations on the most effective monitoring techniques. Mule deer (*Odocoileus hemionus)* numbers have been periodically counted in upper Salt Creek (USDI 1988) where transects were established: No final report has been produced. Wilson et al. (1975) of the University of Utah studied the possibility of reintroducing pronghorn antelope (*Antilocapra americana*); no reintroduction has taken place.

Clevenger (1975) of Utah State University studied the distribution and habitat requirements of the ring-tailed cat *(Bassariscus Astutus Arizonensis)* in Canyonlands National Park. Brazell (1977) studied the abundance and distribution of beaver (*Castor canadensis*) along the Green and Colorado River bottoms in the park to determine whether or not tamarisk (*Tamarix ramosissima*) was rapidly replacing willow, the beaver's primary food. His report includes a description of the unique ecology of the Park and includes management options, graphs, tables, bibliography, and a beaver study survey form.

Feral burros have been a constant problem in the Horseshoe Canyon section of Canyonlands National Park. A USDI (1988?) proposal to eliminate burros from Horseshoe Canyon was never acted upon. No formal study has been completed; however, the problem has become less serious now that boundary fences have been erected.

Canyonlands has the potential for a number of both common and rare bat species. No comprehensive bat inventory or monitoring has occurred in the park. Lengas (1996) surveyed nine abandoned mines in for roosting areas and found evidence that seven of the nine were being used as night roosts. He also recommended winter surveys be initiated to determine if these mines are being used as winter hibernacula.

Schelz (1999-2002) has organized a comprehensive list of mammals in Canyonlands National park based on all previous work and confirmed sightings. This list is updated annually.

Threatened, Endangered, and Sensitive Mammal Studies

The most extensive mammal monitoring done in Canyonlands NP has been with the desert bighorn sheep *(Ovis canadensis*). In the late 1960s, Follows (1969) attempted to determine the status of the bighorn sheep in the park and compiled a table of observations in the area from 1916-1968. In 1969, observation records submitted by park staff and visitors began to be collected; these records were consolidated into a database format that continues to be updated with new information (DS-SEUG-020.1). Dean (1975, 1977) looked at bighorn sheep general distribution and abundance in the mid-1970s; his study focused on habitat requirements and human encroachment impacts. The 1980s brought on an increase of bighorn sheep research due to the interest in relocating groups to areas throughout Utah where extirpation has occurred. Bates (1982) investigated habitat and forage utilization and estimated population size (1984); King and Workman (1981, 1982, 1983) reviewed the literature related to bighorn sheep in Southeast Utah and radio-collared seven sheep in 1981. They eventually collared more sheep and reported movements by individuals, habitat utilization, influence of livestock, mining recreation, human disturbance, and disease. Hull (1984a, 1984b, 1985) monitored the status and movements of bighorn sheep to determine their seasonal forage and effects of human disturbance on bighorn behavior. Scott (1987) investigated sheep die-off and its causes, and her research included the analysis of blood and biological samples taken. Douglas and Annable (1985) and Douglas (2001) developed a model of climatic variables affecting lamb survival; Douglas et al. also developed a management model for predicting fall lamb:ewe ratios. Papouchis et al. (1999, 2001) investigated the effects of increased recreational activity on bighorn populations. Other short-term bighorn survey and habitat investigations were undertaken by Gower (1989) and Brown (1993).

Sloan, a biological technician for the park, has monitored bighorn sheep continuously since 1991 and written a number of annual reports. His monitoring program includes a number of radio-collared sheep that he follows throughout the year and an annual aerial census each fall (DS-SEUG-017.1, DS-SEUG-021.1). Sloan surveyed the Needles District during the winter of 1990-91 for number of sheep, overall health, herd composition, range, and sheep easy to sample (Sloan 1991). Additional sheep were collared in the winter of 1993 (Sloan 1993a). He also prepared an extensive herd history for the Island in the Sky, Needles, Maze, Lockhart Basin, and Potash from various sources (Sloan 1995a, 1995b), and studied lambs and the effects of disease, predation, weather, accidents, and disturbance (Sloan 1994a, 1995c, 1995d, 1996a, 1996b, DS-SEUG-035.1). Sloan also studied the Lockhart Basin herd, a herd closely associated with the Needles and San Juan herds that intermingles with both of these (Sloan 1998, 1999), and investigated the effects of human disturbance on Bighorn Sheep and a study of the rut season (Sloan 1993b, 1993c, 1994b, 1994c, DS-SEUG-018).

River otters are known to occur in Canyonlands National Park and surveys by Boschen (1988, 1989) confirm river otter activity in the park and just north of the park on the Colorado River.

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Data Sets

DS-SEUG-016.1	Small mammal trapping webs from LTMP in the Southeast Utah Group national parks. 5/6/1987 - 6/5/1993. (dBase III+ files converted to Excel; hard-copy documents). Originated by Graham, Tim; status: Inactive.
DS-SEUG-017.1	Desert bighorn sheep ground survey observation records for Canyonlands and Arches National Parks and vicinity. 11/30/1990 - present. (Excel workbook, ArcInfo point coverage, and hard-copy data sheets and field notes.). Originated by Sloan, William; status: Active.
DS-SEUG-018	Human disturbance of desert bighorn sheep, study results from Canyonlands National Park and vicinity. 3/15/1993 - 11/15/1994. (Spreadsheet at USGS- BRD in Fort Collins, CO. Excel workbook & ArcInfo files (location data) & hard-copy field sheets. Originated by Sloan, William. Status: Inactive
DS-SEUG-020.1	Observations of desert bighorn sheep in Canyonlands and Arches National Parks, by visitors and park rangers. 5/23/1969 - present. (pre-1990 dBase III file; Maze District file in ArcInfo). Originated by Southeast Utah Group; status: Active.

Canyonlands National Park - Mammals

DS-SEUG-021.1 Aerial annual/biannual census of desert bighorn sheep in Canyonlands and Arches National Parks and vicinity. 11/1/1992 - present. (Spreadsheet at USGS, Fort Collins. Paper data sheets at SEUG,NPS, Moab, UT). Originated by Sloan, William B.; status: Active.

DS-SEUG-035.1 Desert bighorn sheep disease monitoring data, Arches and Canyonlands National Parks and vicinity. 9/15/1986 - present. (scattered reports and data sheets, correspondence, fields of observation data from other datasets). Originated by Sloan, William; status: Active.

Capitol Reef National Park - Mammals

General Mammal Surveys

Information on small mammal (lagomorphs, rodents, and bats) occurrence in the park is based largely on the work of Bogan (1991, 1992, 1993). Between 1989 and 1992, crews conducted surveys at 12 general locations in the park and documented 28 species of small mammals (12 bats, 2 rabbits, 1 shrew, and 13 rodents). This inventory work was conducted between elevations of 1,463 to 2,134 meters (4800 to 7000 feet). Bogan and Ramotnik (1993) summarized the results of their surveys and generated a mammal species list for the park. Small mammal work from 1992 to 2000 was minimal. Some small mammal surveys were conducted in the oxbow area of the Fremont River by park staff in 1998 and 1999 to determine if montane voles, a predator of a federally-listed orchid (*Spiranthes diluvialis*), were present. In 2001, trapping surveys were conducted as part of the Northern Colorado Plateau Network Inventory and Monitoring Program. Valdez et al. (2002) spent 77 person-days in the field at Capitol Reef during late May, June, and early July and amassed almost 2300 trap-nights and 58 mist-net nights. They captured or otherwise documented 33 species.

Based on Valdez et al. (2002), Bogan and Ramotnik (1993), Burt and Gossenheider (1976), Hall (1981), Durrant (1956), and park staff, 64 species of mammals are likely to occur in the park, of which 59 have reliable documentation. Hence, the current level of documentation (documented species/likely species) is approximately 92 percent. Excluding extirpated species, 16 additional species reported from various sources as possibly being present in the park remain undocumented, but few of these are likely to be found in the park.

Of those species to occurring or likely to occur in the park, larger carnivores are most lacking adequate documentation. Information on occurrence and distribution is based largely on wildlife observation card record, and many of these are minimally documented. Surveys during the summer of 2002 will assist in increasing our knowledge base on these species. Additional shrew species may be present in the park, and park staff will conduct surveys to attempt to locate these animals.

Surveys of deer numbers in the headquarters area of the park were conducted by park staff from 1985-1994 to examine population size, and determine if herd size in the Fruita Valley was unhealthily large; the data for the surveys is stored in an MS Access database within the park (DS-CARE-. Several studies have occurred in the park examining ecological and behavioral aspects of the yellow-bellied marmot (Van Vuren 1989, Hopkinson 1993, Blumstein et al. 1997a, 1997b, DS-CARE-0026)). These studies concentrated in the Fruita area, which contains the lowest elevation population of the species. A free-roaming bison herd exists in the Henry Mountains adjacent to the park and bison typically enter the park in fall and winter to forage and avoid hunting pressure. As bison are not historically known from the park, we do not consider this a native species. There have many studies done on distribution, ecology, and history of bison near the park (Winn and Collet 1959, Van Vuren 1979, 1982, 1983, 1984, 1992, Van Vuren and Bray 1983, 1986). Rosenstock (1992a, 1992b) studied the effects of grazing on small mammals at Capitol Reef, Canyonlands, and on BLM lands. At a macrohabitat scale, he found ungrazed areas had 50% more diversity and 80% more abundance than ungrazed areas.

Wildlife observations submitted by park staff and by visitors has been maintained since 1950. Information continues to be collected and managed; however, the reliability of the data can vary widely. (DS-CARE-0004).

Threatened, Endangered, or Sensitive Mammal Surveys

There are no federally listed mammal species in the park, and eight of the park mammals are listed as sensitive species by the state of Utah (UDWR 1998a, 1998b). An introduction of the federally listed Utah prairie dog occurred in 1980 in the northern portion of the park to test the efficacy of several habitat manipulation strategies (Player and Urness 1982) but the transplant failed and the last prairie dogs were seen in the mid-1980s. Although some discussions have subsequently occurred regarding attempting additional transplants, park staff think it is unlikely that this species occurred historically in the park.

Desert bighorn sheep were introduced into the southern end of the park in 1984 and 1985, and forty desert bighorn sheep were reintroduced to the central portion of the park in 1996 and 1997; sheep status in the park is discussed in Singer and Gudorf (1999). For two years, radio-collared bighorn were monitored by fixed-wing aircraft every other month and the location data entered into a GIS data system. In addition, park staff and an NPS biologist from the Southeast Utah Group have monitored sheep status from the ground. Their field notes contain the most current information on the status of bighorn sheep in the park (DS-CARE-0025).

Bogan surveyed two mines for bats in the summer of 1992 and found evidence that suggested the mines were used primarily as night roosts. An examination of these mines in the winter of 1998 revealed the presence of small numbers of *Corynorhinus townsendii*, a Utah sensitive bat species. The park biologist conducted bat surveys in 1999 and 2000, primarily in Hall's Creek. Sixteen species of bats have been documented in the park, and likely no more than one additional species remains undocumented.

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Capitol Reef National Park - Mammals

Data Sets

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Cedar Breaks National Monument - Mammals

General Mammal Studies

A mammal checklist for Cedar Breaks National Monument was compiled by Presnall (1938), and an unpublished checklist, completed by various seasonal interpreters over the years and containing 37 mammal species, has been compiled for visitor use and as a guide for park employees. Bogan (2000) also compiled a mammal species list as background for the Northern Colorado Plateau Network's Inventory and Monitoring Program. Some small-mammal monitoring was conducted on the adjacent Dixie National Forest (McDonald and Grandison, 1995, 1996); it is unclear how results may be relevant to the monument.

A comprehensive survey of mammal species within Cedar Breaks National Monument began in 2001 with the Northern Colorado Plateau Network's mammal inventory work conducted by Mike Bogan, Ernest Valdez, and Shauna Haymond of the USGS Midcontinent Ecological Science Center (Valdez et al. 2002). Mist-netting resulted in captures of three bat species, including the little brown bat (*Myotis lucifugus*), a relatively uncommon species in southwest Utah. Other bat species netted included the long-legged myotis (*M. volans*) and the big brown bat (*Eptesicus fuscus*). Trapping resulted in captures of 10 rodent species. Rodents and artiodactyls are relatively well-known at the monument, little data are available on shrews, bats and carnivores. Inventory work will continue in 2002, with final results expected in early 2003.

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Colorado National Monument - Mammals

General Mammal Studies

One of the earlier studies of mammals on Colorado National Monument was conducted by Miller (1964), who described their ecological distribution. Observation records, some dating from the early 1900s but most from the 1980s and 1990s, have been organized and compiled into a database (DS-COLM-006). Location to place-name, along with name of observer, is included with most records; however, the reliability of the data is highly variable.
Armstrong (1988) created an annotated checklist of the mammals of Colorado National Monument that included 64 species, of which 41 have actually been recorded in the monument. Bogan (2000) later produced a mammal checklist in conjuction with the Northern Colorado Plateau Inventory and Monitoring Network. There have been no extensive inventory or monitoring efforts with the exception of some focused studies of bison, desert bighorn sheep, and bats.

A herd of bison was introduced and intensively managed on the monument from 1925 until the herd's removal in 1983. Capp (1964) described the ecology of the bison on the monument The park archives contain various reports and data on the herd itself; many other other bison-related studies relate to their effects on native vegetation or ecosystems (Wasser 1977, Colorado National Monument 1984).

There is no data on population size and movements of large mammals such as mountain lions, black bear, mule deer or elk in the monument. Colorado Division of Wildlife (DOW) does some inventory and monitoring work for big game species in the general area, but nothing specific to the monument. In anticipation of potential conflicts between mountain lions and bears and people due to increasing urbanization along park boundaries, basic inventory data needs to be collected and maintained. Medium to small mammals such as coyotes, foxes, bobcats, skunks, etc. have not been inventoried at all. Richardson (1962) did a study related to the interrelations of forest conditions, insect infestations, and porcupines.

Threatened, Endangered, or Sensitive Mammal Studies

One study on the feasibility of reintroducing desert bighorn sheep was conducted by Bauer (1977) in his Master's thesis. Animals were reintroduced to the monument by the Colorado Division of Wildlife (DOW) in 1979 with additional releases in subsequent years. The small groups of bighorns have mostly moved west of the monument onto BLM lands and canyons; however, they continue to migrate in and out of the monument on a regular basis. DOW monitors the herd, although monitoring within monument boundaries is done mostly via incidental observations and reports. Armstrong (1988) completed a habitat inventory and monitored two populations; Sloan (1995) produced a history of the Colorado National Monument and Black Ridge herds; and Graham (1995) produced an update to the restoration management plan for the Black Ridge herd unit. Gudorf et al. (1995) prepared a habitat assessment of the greater Colorado National Monument area, and Gudorf (1995) used GIS to coordinate data from various sources to determine habitat quality and quantity, and to identify areas with high potential for reintroduction success.

Twelve bat species are known to be present in the monument and there is suitable habitat for five additional species (Perrotti 1995). The Townsend's big-eared bat (*Plecotus townsendii pallencens*) is listed as a Category 2 species by the U.S. Fish and Wildlife Service; it is the major impetus and focus of the Colorado Division of Wildlife's Bat/Abandoned Mine conservation project. The fringed myotis (*Myotis thysanodes*) and the big free-tailed bat (*Nictinomops macrotus*) are also considered rare in the State of Colorado. There is potential habitat for the endangered spotted bat (*Euderma maculatum*). Most

bat investigations have been conducted by Adams, beginning in 1989 and continuing through 1993 (Adams 1990, 1993, 1994).

Prairie dogs towns along the boundary with residential subdivisions were surveyed in 1991 as part of the Colorado National Monument Prairie Dog Management Plan (Paynter 1989) but no followup surveys have been completed since. It is very likely that prairie dogs have been extirpated; however a thorough survey would be needed to confirm this. The monument would be a good candidate for a prairie dog reintroduction effort.

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Curecanti National Recreation Area - Mammals

General Mammal Studies

Very little mammal inventory work had been conducted in Curecanti National Recreation Area before 2001. Einwater (1968) compiled the first and likely only inventory of mammals observed in Curecanti. The general region surrounding the park is encompassed in regional faunal works such as Armstrong (1972) and Fitzgerald et al. (1994). Bogan (2000) compiled an updated list of mammals know to occur or with the potential to occur in the recreation area. Natural history observations submitted by park staff and visitors ranging from 1963 to 2000 have been compiled; however, the reliability of these observations can vary widely (DS-CURE-015).

There have been two studies on ungulates in the recreation area: Baker's study (1961) on big game exclosures in Colorado, which included the Blue Mesa exclosure in Curecanti; and a Bureau of Land Management report by Capodice (1988), who detailed elk and deer monitoring on winter range in the Gunnison area. This report also included a monitoring strategy, distribution and habitat use by deer and elk, and management recommendations. Park Resource Stewardship and Science staff collected monitoring data at limited locations within Curecanti in 1992 (DS-CURE-024); however this effort was suspended because of the heightened concern over Hantavirus.

A two-year mammal inventory project was begun in Curecanti in 2001. The first-year results of this inventory (Valdez et al. 2002), indicate that 94% of the rodent species are likely documented and shrews are at 80%. The deer mouse (*Peromyscus maniculatus*) was the most commonly captured, followed by the least chimpmunk (*Eutamias minimus*), western jumping mouse (*Zapus princeps*), and montane vole (*Microtus montanus*). Valdez concluded that population numbers of small mammals were low on the Colorado Plateau, based on recent climatic factors (e.g.,low precipitation). Other species groups, especially carnivores and bats, remain poorly-documented and will be targeted in 2002 inventory work, with results anticipated in early 2003.

Threatened, Endangered or Sensitive Mammal Studies

A management program for Gunnison's prairie dog (*Cynomys gunnisoni*) was begun in Curecanti in the early 1980s. In a report accompanying the Gunnison's Prairie Dog Management Plan and Environmental Assessment, the Park Service examined the problem of plague-carrying prairie dogs in Curecanti (1982). This resulted in a study by Rayor (1984) who documented the plague outbreak. Rayor also published an article on the effects of habitat quality on growth, age of first reproduction, and dispersal in Gunnison's prairie dog populations (1985); her research included a site from Curecanti. She also published her findings on the social organization and space-use in prairie dog populations from a site near Blue Mesa reservoir in Curecanti (Rayor 1988). A U.S. Fish and Wildlife Service report discussed the ecology of plague in Gunnison's prairie dogs and made suggestions for the recovery of black-footed ferrets in the Curecanti area (Fitzgerald et al 1993). Barvitski (1994) outlined sampling protocols for prairie dog populations in six sites within CURE. Curecanti continues monitoring of prairie dogs, primarily for early detection of the presence of plague. Monitoring involves collecting flea samples from active prairie dog colonies, in close proximity to visitor use areas, on a biweekly basis. Samples are sent to the Centers for Disease Control for analysis. In addition, these colonies are inspected on a regular basis for evidence of epizootic outbreaks.

Most of the literature on bighorn sheep has been devoted to documenting a herd that was reintroduced to the area in 1974 and 1977. Swift and Johnson (1991) conducted a bighorn sheep habitat evaluation in five national parks, which included Curecanti National Recreation Area, and a report from five scientific advisory committees to the National Park Service (1991) detailed management plans for bighorn sheep

and recommendations for their reintroduction and sustainability in Black Canyon of the Gunnison National Monument and Curecanti National Recreation Area.

Ramey (1994) examined the phylogeny and evolution of bighorn sheep in the southwest, using a mitochondrial DNA sequence sample taken from sheep in the Gunnison area. A 1994 study (author unknown) provided a comprehensive and detailed history of two bighorn sheep herds, the Dillon Pinnacles herd and the Lake Fork herd. Included in the report is information on herd range, lambing areas, transplantation and tagging. Bellew (1995) conducted a demographic study of bighorn sheep in the Gunnison River Gorge. Her report examined the history of native bighorn sheep in the area, their reintroduction, disease history, hunting and poaching issues, and current status.
Sweaner et al. (1995) reported a brief history of bighorn sheep populations in Curecanti National Recreation Area and Black Canyon of the Gunnison National Monument. They also discussed the proposed restoration program, described methods to be used, outlined the study area using GIS coverages, and suggested management implications. And a report on radio collared ewes (Spicer 1995), contains information on 12 ewes transplanted to the Black Canyon/Gunnison Gorge area between 1986-1990.

In a report to the National Park Service from five scientific advisory committees, Singer et al (1996) discussed the status of bighorn sheep in each park that supported populations. The committees were convened to assess the research and management needs for bighorn sheep and to address commonality of needs on a regional, subregional, or metapopulation basis. A brief introduction on current studies in each park or region was outlined, followed by future study and management recommendations.
Singer and Gudorf (1999) then published a three-volume report describing a seven-year regional initiative to conduct research and population studies on bighorn sheep, and to plan and carry out restoration plans in the national parks of the Intermountain and Midwest Regions. This first volume describes the planning process, the seven-step assessment and restoration process including GIS-based habitat assessments, recommended restoration procedures and considerations, a summary of restoration efforts in each park unit, and a summary of key findings. Also included are maps, a list of reports produced during this restoration initiative, and a lengthy reference list. Volume 2 provides a synopsis of research findings, and Volume 3 provides the research findings in full.

Singer et al. (1999) surveyed all the state and federal agencies involved in bighorn sheep translocations conducted between 1923 and 1997 in order to analyze the factors contributing to successful restorations. They classified each effort into three categories based on population numbers in late 1997: unsuccessful (<29 animals), modestly successful (30-99 animals), and successful (100 or more animals). They documented thirty percent of the translocations as unsuccessful. Negative factors contributing to unsuccessful translocations were the presence of domestic sheep within 6 km of the known bighorn sheep use area, and cattle grazing on bighorn range. Positive factors were habitat configurations that allowed or encouraged annual migrations by the translocated population, and indigenous herd sources. Bighorn sheep released into desert environments increased faster than those released into either Rocky Mountain habitat or prairie badlands habitat. They concluded this was due to the vast, inaccessible and rugged terrain of the northern Colorado Plateau, which has been relatively untouched by human disturbance, grazing and fire suppression.

Singer et al (2000) published an article on their findings of the dispersal rates of 31 translocated populations of desert bighorn sheep (*Ovis canadensis nelsoni*) and Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*) into 79 nearby suitable, unoccupied habitat patches. Their statistical analysis showed that high dispersal rates and occupation of new patches can occur if bighorn sheep are placed in large habitat patches with few barriers to movements to other patches and with no domestic sheep present.

Finally, there was a study by Williams et al. (*date unknown*) who performed a preliminary survey for select diseases in wild bighorn sheep populations in the Rocky Mountain region, that included Curecanti National Recreation Area.

Starting in 2001, data on bighorn sheep and lamb observation have been gathered by Curecanti staff, with locations, numbers of ewes and rams, lamb-sheep ratio, nursing behavior, and the number of sheep associated with lambs being recorded (DS-CURE-023).

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Curecanti National Recreation Area - Mammals

Data Sets

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Dinosaur National Monument - Mammals

General Mammal Studies

Inventories of small mammals were conducted in the 1980s in river corridor and upland sites in Dinosaur National Monument. Bogan, et al. (1988) identified 65 mammalian species in Dinosaur National Monument based on specimen records and reliable sight records. Included on this list are 3 extirpated species (gray wolf, grizzly bear and bison). Excluded from the list were feral horses, house mice, black-footed ferret and wolverine (both of which may have occurred in presettlement times), and six species of small mammals which are listed in sight records but not substantiated by specimen records.

Four additional species have been documented since Bogan's inventory in the 1980s; thus the known fauna of Dinosaur includes a minimum of 69 native species. Finley and Bogan (1995) reported on several new records for the park area. Latilong reports (Bissell 1978, 1982; Meaney 1990) also document changes in known fauna for the area. Newmark (1986) noted 62 species, including 9 that are not known from the park. Earlier authors (Armstrong 1972, Lechleitner 1969, Warren 1942 and Cary 1911) suggested 30 to 50 species in the monument.

Bogan et al. (1988) notes that much of the apparent increase in species is due to better sampling methods. The presence of some species now in the monument is certainly due to range expansion. Racoon were not recorded prior to the 1950s; black-tailed jackrabbits were not documented until the mid-1980s. In other places (e.g. the eastern plains of Colorado), the appearance or increase in black-tailed jackrabbits coincided with a decline of white-tailed jackrabbits. This replacement has been associated with certain land use practices such as overgrazing and bringing land into cultivation. Indeed, the first black-tailed jackrabbits collected on the monument were found on range overgrazed by domestic livestock.

Long-term fire effects studies provide the only ongoing monitoring of small mammals within the monument. The study design consists of paired sets of Calhoun lines (2 each) in burned and adjacent unburned areas run for three consecutive nights. Specimens taken during the monitoring are deposited with the USGS (Dr. M.A. Bogan) at University of New Mexico for museum specimen prepatation and hantavirus studies. Winslow (2001) provided a review of the protocol. Olson, et al. (*in press*) concluded that small mammal populations are not substantially decreased following fire, though there are some changes in individual species distribution and abundance.

Threatened, Endangered, and Sensitive Species Studies

There are no federally-listed mammal species known within the monument, though State-listed species such as spotted bat and river otter occur in the area.

The Utah Division of Wildlife Resources, in concert with other agencies, initiated a river otter reintroduction program in the Green River in 1989 (Findlay, et al. 1991). Source stock originally came from Nevada, but with confirmation that otters throughout North America were genetically similar, most released otters eventually came from Alaska. Otters now occupy the full length of the Green and Yampa Rivers in Dinosaur National Monument. No monitoring is currently underway or planned.

In inventory efforts in the 1980s and incidental collections since then, 16 species of bats have been documented with specimen records. This represents an increase of 8 species over those known in 1980. Two species, the spotted bat (*Euderma maculatum*) and fringed myotis (*Myotis thysanondes*), are apparently rather rare. Spotted bats have been collected or otherwise recorded in several locations but their numbers are apparently very low. The fringed myotis has been collected from only one or two localities. Some habitats (e.g. roosts, hibernacula) may be limited and quite vulnerable to modification by visitor use or changes in land use.

At least two roost areas or hibernacula were identified in 1991 (Citation pending), one of which is very vulnerable to visitor disturbance.

Species of Management Concern

Bighorn Sheep

Bighorn sheep once ranged over most of Dinosaur National Monument. The population declined in the 1930s, largely due to diseases contracted from domestic sheep. Severe competition with domestic livestock contributed to that decline. By the late 1940s, bighorns were entirely extirpated (Barmore 1962, Bear and Jones 1973).

In 1952, 32 bighorn were transplanted in the Lodore Canyon area. The reintroduced population expanded its range to encompass most of Lodore Canyon. The population reached about 150 animals by the late 1950s, remained stable until the early 1970s and then began to decline rather markedly. Research in the late 1970s estimated the population at about 50 animals and suggested that inbreeding might be the cause of that decline (Skiba 1981, 1982).

The range occupied by this population apparently did not expand after 1959 or earlier; adjacent historic habitats were not been occupied. Grazing by domestic livestock and the bighorns' relative lack of pioneering tendencies are probably the primary reasons for the failure to occupy adjacent historic habitats. In an effort to repopulate other portions of the monument and to counteract potential impacts of inbreeding, an additional 19 bighorns from a different genetic source stock were released near Pool Creek in 1984. Within 2-3 years this group of bighorns moved from Harpers Corner into Whirlpool Canyon. By the late 1980s bighorns had expanded their range downriver through Split Mountain Canyon and upstream, probably mixing with the Lodore group, some 12-15 miles along the Yampa River.

In the early 1990s a NPS effort reviewed the status and population viability of bighorn sheep throughout the Colorado Plateau (Johnson, et al. 1999; Gudorf 1994). Subsequent to that study, about 40 additional bighorn sheep were transplanted on and near Tanks Peak (1998 and 2000) from other Colorado herds. Sporadic monitoring of radio-collared bighorns was conducted by the Colorado Division of Wildlife and Dinosaur National Monument.

Natural and prescribed fires on Wild Mountain and in Zenobia Basin have reduced sight barriers and induced pioneering by bighorn sheep back into historic summer ranges. Bighorns are now commonly observed in both of these areas.

Lungworm infestations are a common mortality factor in many herds of Rocky Mountain bighorn sheep. In Dinosaur, however, the rate of infection by lungworm is the lowest in the State of Colorado (cite Keiss, CDOW) during all seasons of the year. The apparent reason for lower infection rates is the arid climate which is not conducive to the alternate host, a land snail.

Recent management concerns include movement, particularly by young rams, outside the monument where they may then be exposed to pneumonia strains common in domestic sheep. While there is no specific monitoring to document these movements, bighorns have been reported on the Chew Ranch south of Split Mountain, south of Dinosaur, CO, and south of Blue Mountain, CO. In two of these three cases, the wandering rams have been killed by State wildlife agencies to reduce the possibility of an epizootic in the monument's population.

Dinosaur National Monument - Mammals

Elk

Recent history of elk populations in and around Dinosaur are described by Petersburg (1986). Elk are now distributed widely throughout the park. Some areas are used seasonally; other areas are used near year-around, and population levels within the park may reach or exceed 1,000 animals during some times of the year. This species is of management concern due to assertions by ranchers within the park that elk are competing strongly with livestock for available forage.

Elk pellet group transects were established throughout much of the park in 1984 to monitor trends in elk use. Data is collected annually from these transects as part of the long-term fire effects monitoring program. Recent research has documented movement and dispersal of juvenile bull elk from areas in and near the park (Petersburg 1997; Petersburg and Alldredge 1998; Petersburg, et al. 1997).

Mule Deer

Dinosaur provides both summer and winter range for mule deer. Summer ranges are primarily confined to areas of higher elevation (7,000+ft) near the monument boundaries on Blue Mountain, Douglas Mountain, Wild Mountain and Split Mountain. There are five distinct winter ranges in the monument at elevations of 4,700 ft to about 6,200 ft. The west end of the Yampa Bench and Island Park are relatively large critical winter ranges. Deerlodge Park, the Gates of Lodore and the south side of Split Mountain are smaller winter ranges. Franzen (1968) documented that most of the deer utilizing Dinosaur winter ranges migrate from outside the park.

Population levels on winter ranges have varied widely depending on overall deer populations and the severity of winters. Franzen (1968) reported maximum numbers of approximately 2,500 deer on the Yampa Bench range and approximately 1,000 deer on the Island Park range (both figures from the late 1940s). Average populations on these two areas in 1966 and 1967 were 700 and 300 deer respectively. In the early 1990s the Colorado Division of Wildlife drastically reduced the number of hunting licenses available in units around the park, moving from an over-the-counter system to a limited entry system. Although buck:doe ratios have rebounded, total population numbers – at least as reflected on the winter ranges – remain diminished. Speculative reasons for the population depression range from habitat availability and quality to predator pressure.

NPS management of mule deer populations in Dinosaur National Monument has been limited to monitoring and protection actions. Monitoring actions have included deer counts along prescribed routes, browse utilization studies, and pellet group transects. Data and associated recommendations are provided to the Colorado Division of Wildlife and Utah Division of Wildlife Resources for consideration in setting deer seasons and allowable harvest. Protection actions have included hunting and poaching patrols and patrols to prevent or minimize trespass grazing on winter ranges. For the past several years, staffing and funds have been insufficient to complete any of the monitoring actions except for a few deer counts. For the same reasons, hunting and poaching patrols have been reduced by approximately 75 per cent since the mid-1970s.

Pronghorn Antelope

Pronghorn antelope had been extirpated from Dinosaur National Monument. In January, 1983, the Colorado Division of Wildlife and Dinosaur National Monument cooperatively released 86 pronghorn antelope on the west end of the Yampa Bench (near the Success Burn). All animals were ear-tagged. During the spring of 1983 most of the released antelope moved up through Hells Canyon and/or over the Blue Mountain rim. Ear-tagged antelope were observed on the Yampa Plateau (Blue Mountain) during the summer of 1983 from Stuntz Ridge east to Disappointment Draw. By the winter of 1983-84, many of the tagged animals were located on low elevation winter ranges along U.S. Highway 40 from Massadona to Elk Springs.

During the severe winter of 1983-84, hundreds of pronghorn antelope migrated into various portions of the monument from the north (many from Wyoming). Several hundred animals were forced into Lodore Canyon; by early summer all of these antelope had died. Most of the antelope which appeared in other parts either died or left the area by early summer. Similarly, hundreds of antelope migrated into the Deerlodge Park/Lily Park area during the same winter. Literally hundreds died in that area in fences or snowdrifts.

Small numbers of pronghorn antelope are occasionally observed within the park on the Yampa Bench. Several factors, including predation, may be effective in keeping these numbers very low (total 10-20 animals). A rather substantial population now utilizes the Yampa Plateau along Moffat County 16. These are likely derived from the 1984 release on the Yampa Bench.

Management actions for pronghorn antelope are limited to recording of incidental observations within the monument.

Feral Horses

Nearly 700 feral horses were removed from Dinosaur national Monument and adjacent BLM lands on Douglas Mountain from 1977 through 1979. Neither agency has licensed range use for domestic horses after the interagency trapping effort. Any horses ranging on the area are regarded as trespass or feral animals and removed as expeditiously as possible.

In the 1960s and 1970s (and earlier) feral horses roamed freely over contiguous NPS and BLM lands on Douglas Mountain. Prior to passage of Wild Horse and Burro Act (P.L. 92-195) in 1971, roundups conducted by ranchers and/or the BLM held the population to tolerable levels. After passage of the Act, ranchers were prohibited from capturing these horses. They were also prohibited from rounding up private horses (ranged pursuant to grazing permits) which utilized the same ranges as did the feral horses. Horse numbers on Douglas Mountain were estimated at 150 animals in 1971, 350 animals in 1974, and 450 to 500 animals in 1976.

Pursuant to an interagency management plan, trapping operations were conducted from July, 1977, through November, 1977, and from August, 1978, through January, 1979. No trapping occurred during other months to avoid undue mortality to pregnant mares and young foals. Captured animals were placed in BLM's Adopt-a-Horse program unless they could be claimed by local ranchers under Colorado estray laws.

Range surveys conducted by the BLM in 1974 and 1976 showed significant range deterioration and downward trends in condition. Many ranchers on Douglas Mountain voluntarily reduced their authorized grazing by 30 to 50 per cent because of a lack of available forage. Subsequent to the 1976 range surveys, reductions in total use on federal range were imposed on Douglas Mountain permittees in 1978. Improvement in range conditions was quite evident as early as 1978 over large portions of Douglas Mountain. Range conditions have continued to improve through the present time.

Limited monitoring for horses has continued incidental to other protection and resource management activities. Any horses found on Douglas Mountain or other areas will be removed in accordance with 36 CFR 5.11 and other appropriate trespass procedures. Unclaimed animals may be removed by any appropriate means.

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Fossil Butte National Park—Mammals

General Mammal Studies

The combined efforts of park rangers, visitors, and other researchers have resulted in the documentation of 90% of the large mammals likely to occur at Fossil Butte National Monument. It is doubtful, however, that the number of species of small mammals, especially bats, has attained this level of completeness.

Clark (1977) conducted a preliminary survey of mammals at the monument and reported at least 45 species. Rado, a National Park Service employee, trapped small mammal several times at Fossil Butte (Rado 1976, 1977). He compiled a list of mammals from captured specimens, sightings and indirect evidence, and prepared study skins of some rodents and a lagomorph that are reposited at the monument.

The Mountain West Environmental Services staff compiled a list of 34 mammals that they either trapped, directly observed, or identified by the presence of scat or tracks. This list also includes seven species that were reported by Rado or monument staff (Dorn et al. 1984).

Since 1989, the FOBU staff has conducted large ungulate surveys intended to reveal general population trends. The number of large ungulates that can be seen from set observation points are tallied, and information regarding location, habitat type, ungulate activity, sex, and maturity is also recorded (DS-FOBU-002). Sightings of carnivores and mustelids observed during the large mammal survey are recorded as well. In addition, visitors and members of the FOBU staff record, in haphazard fashion, other mammal sightings on wildlife observation forms. Usually only spectacular mammals like moose or large male mule deer, rarely-seen mammals like large predators, or large herds of mammals are recorded on the cards (DS-FOBU-006).

Katzner (1994) studied the winter ecology of pygmy rabbits at Fossil Butte and confirmed that species' presence at the monument. Katzner and his associates also gathered and published information regarding the pygmy rabbit's movements, home range, and relationship to habitat quality (Katzner and Parker 1997, 1998, Parker and Katzner 1993).

Beaver surveys have been conducted periodically since 1990. Beaver populations are estimated from direct observations and the size of food caches. Relative numbers, sizes, and locations of ponds and beaver activity areas are also recorded by field observers (DS-FOBU-005).

A list of mammal species confirmed or potentially present at the monument was compiled for the Northern Colorado Plateau Network Inventory and Monitoring program (Bogan, 2000). In 2001, researchers under contract to the I&M Program began conducting a two-year mammal inventory designed to document 90% of the mammals species that occur on the monument. The results of the 2001 inventories indicate that 75% of the lagomorphs, 86% of the rodents, and 100% of the artiodactyls are documented; however, shrews (0%), bats (23%) and carnivores (45%) require additional inventory work (Valdez et al. 2002). These latter species groups will be the focus of 2002 inventories, with final results expected in early 2003.

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Data Sets

DS-FOBU-002	Large ungulate monitoring program. 1/1/1988 - 2001. (notebook; forms; cards). Survey conducted annually during the summer months at bi-weekly intervals; series originated by Fagnant, Marcia; status: Active.
DS-FOBU-005	FOBU beaver surveys. 6/1/1990 - 2001. (Series of annual reports (various authors) in 3-ring binder). Originated by Fagnant; status: Active.
DS-FOBU-006	Natural History Field Observation cards. 5/1/1985 - present. (3" x 5" cards (DOI, NPS form 10-254)). Originated by Fagnant, Marcia/General Population; status: Active.

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Golden Spike National Historic Site - Mammals

General Mammal Studies

Some mammal inventry work has been conducted on nearby lands managed by the Bureau of Land Management; this work is referenced in the BLM's Box Elder Resource Management Plan (USDI 1986, 1998). No other previous mammal work is known for Golden Spike. Bogan (2000) compiled a list of mammals known or potentially occurring on all park units in the Northern Colorado Plateau, including Golden Spike.

A two-year inventory of the site was begun in 2001 through the Northern Colorado Plateau Inventory and Monitoring Program (Valdez et al. 2002). A total of 55 mammal species was deemed likely to occur in Golden Spike given its small size and linear nature, and of this number only 25% have been documented. All mammal groups require additional inventory work, which will continue in the summer of 2002. Final results are expected in early 2003.

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Hovenweep National Monument - Mammals

General Mammal Studies

Few mammal studies have been undertaken in the Hovenweep National Monument area and those studies that have occurred have been primarily inventory projects. No long term monitoring of mammals has ever occurred at the monument.

Durrant (1952, 1953) gave a general description of the mammals of Utah and included some at Hovenweep, and Richart (1941) provided a list of the mammals of Hovenweep and Yucca House National Monuments. A master's thesis report by Zortman (1968) contains a listing of mammals present in the Rare Lizard and Snake Natural Area, located about 6 kilometers (4 miles) northeast of the Hovenweep NM ranger station. These studies yielded no information about the population dynamics and interactions of these animals in the different communities of the area. Winter (1974, 1975) studied small mammal distribution at Hovenweep NM and found that species diversity and density varied greatly between the major plant communities. He did not set up systematic trap grids, however, so his conclusions are tentative. He believed that grazing by domestic sheep in the sage mesa-top community had a profound detrimental effect on rodent diversity and distribution.

Rado (1977) performed the first systematic study of small mammals at the Square Tower Ruin Group at Hovenweep National Monument. He focused on rodents and set up a grid of quadrats that were trapped intensely. This study provides an excellent list of small mammals and their distribution in the different plant communities of the Square Tower area of Hovenweep National Monument. Rado (1975a,1975b) also put together a list of Mammals at Hovenweep National Monument. This is the primary source of mammal information we have for Hovenweep National Monument.

Valdez et al. (2002) began a two-year inventory of mammals beginning in 2001. Five of the seven units of the monument were covered in 2001, resulting in an estimated 41% of the mammal species being documented, including 67% of the lagomorphs and 60% of the rodents. Additional work will continue in 2002 with a final report anticipated in early 2003.

Schelz (1999-2002) has assembled a mammal list of 26 species based on personal observations, previous studies, and observations from knowledgeable people.

Threatened, Endangered, or Sensitive Mammal Surveys

No inventory or monitoring work on threatened, endangered or sensitive mammals has occurred.

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Natural Bridges National Monument - Mammals

General Mammal Studies

Nix (1977) has completed some of the most extensive mammal inventory work at Natural Bridges National Monument, where he spent an entire season trapping small mammals at 15 sites in four different habitats in the monument, and developed a checklist based on what he trapped and observed. Persons (1990) compiled a list of mammals known or suspected to be present on the monument, using observations reported by visitors and staff as well as published information. Bogan and Ramotnik observed and captured mammals at the monument in 1991, 1992 and 1993 (Bogan 1992, Bogan and Ramotnik 1993, 1994, Ramotnik and Bogan 1995), with special attention devoted to bats, and to addressing discrepancies between the various previous studies (primarily related to chipmunks and woodrats). And Mitchell and Woodward (1993) included the monument in their study on distribution and abundance of animals with respect to human travel corridors.

The general rodent fauna is reasonably well-known for the monument; however little is known of insectivores (shrews), and additional data on carnivores and ungulates would be useful. Several studies have been conducted related to deer impacts on vegetation; in particular, browse transects were established between 1974 and 1979 (Natural Bridges National Monument 1979), and a study on deer population fluctuations, and the ensuing effect on vegetation, was conducted by Lyons et al. (1975).

Small mammals were selected as part of a Southeast Utah Group long-term monitoring program (LTMP) due to their expected sensitivity to ecosystem changes and their quick response to changes in food availability (USDI 1993). The monument began extensive monitoring of small mammals in 1987 and continued to 1993 (Graham and Belnap 1989, 1990, Graham 1988, 1991). Captures were weighed, sexed, measured, marked or ear-tagged, and identified to species. Associated plants (within 1m of the trap) were recorded in descending order of cover. Data were computerized and a statistical program (Transect) was used to calculate density (DS-SEUG-016.3). This was discontinued in 1993, however, due to the concerns over Hanta virus and the high variation of results

Mitchell (1993) investigated human effects on riparian habitat and surveyed mammals as part of that study. Fowler (1995) surveyed small mammals in seeps and springs in Natural Bridges National Monument.

Bogan (2000) compiled a list of mammals known to occur or potentially occuring in the monument, and Schelz (1999-2002) assembled a mammal list for Natural Bridges NM based on past studies and reliable observations. This list is updated annually.

Threatened, Endangered, or Sensitive Mammal Studies

Bogan (1992, Ramotnik and Bogan 1995) trapped a number of species including many bats, and concluded that Natural Bridges is a "hotspot" for bat diversity. Bogan (1992) visited the park in 1991 and netted 10 species of bats at Owachomo and Sipapu bridges during two nights. Subsequently, Bogan and Ramotnik (1993, 1994) returned and worked in four areas (mesa top, canyon rim, canyon bottom, and slickrock) and netted bats near the three bridges. The mesa top and canyon bottom sites had the greatest diversity although all sites had similar fauna.
So far, Bogan has found 15 of the 18 known bat species in Utah at Natural Bridges NM. In 1999, Bogan and colleagues (Haymond et al., In preparation) returned to the park to net big free-tailed bats but were unsuccessful, perhaps due to the heavy precipitation during the visit. The bat fauna is well known in terms of species but little is known of where bats on the monument roost. Haymond et al. (2001) radio-tracked Allen's big-eared bat (*Idionycteris phyllotis*) and located several diurnal roosting sites.

Natural Bridges National Monument - Mammals

Bighorn sheep have been sighted in Natural Bridges National Monument but more ideal habitat lies in adjacent areas, especially closer to the Colorado River. Much work has been done in the general southeast Utah area that is also relevant to the monument. King and Workman (1981, 1982) reviewed desert bighorn-related literature, radio-collared seven sheep, and analyzed their movements, in an area bounded on the east by the monument. They also studied the behavior of sheep in areas of relatively high human disturbance as compared to areas of low disturbance (King and Workman 1984). Stanger et al. (1985) studied sheep and their response to human disturbance in an area west of the monument and near river corridors. Helprin et al. (1990) studied bighorns in the White and Red canyons area, west of the monument in response to an apparent decline in lamb-ewe ratios in previous years, and Brown (1993) observed and reported on herds on the south San Juan Mountains. Singer et al. (2000) studied survivorship of desert bighorns in Canyonlands National Park, with references to populations in Dinosaur National Monument and the south San Juans near Natural Bridges

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Pipe Spring National Monument - Mammals

General Mammal Studies

The work journals of the first Pipe Spring National Monument superintendent (C. Leonard Heaton) spans 35 years and contains references to animal species on the monument. No specific studies on the mammals of Pipe Spring have taken place, with the exception of a single night bat survey done by Bogan, biologist for the USGS Biological Resource Division in 1996 (Bogan 1996). Buildings were searched for roosting bats (some were found), and bats were netted at the pools near the 'castle.' A total of 27 bats of 6 species were identified that night, and one additional bat species was positively identified in 1997. Bogan (2000) also produced a mammal species list for the Northern Colorado Plateau network of parks, which includes Pipe Spring.

In 2001 Valdez et al. (2002) began the first year of a two-year mammal inventory project at the monument. Despite the small size of the monument (40 acres), 15 species were captured with bats accounting for roughly half the captures. Eighty-two individuals of nine species were mist-netted, dominated by the pallid bat (*Antrozous pallidus*) and Western pipistrelle (*Pipistrellus hesperus*). Several lactating Allen's big-eared bats were also captured, suggesting a maternity colony may be nearby. Bats, at 50% of the likely species documented, and rodents at 72% documented, are thus reasonably well-known; however, little information is currently available on other mammal species on the park. The overall mammal documentation rate is at 45%, which will likely increase as the project continues into 2002. Final study results should be available in early 2003.

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Timpanogos Cave National Monument - Mammals

General Mammal Studies

Species observation records, which include mammals, were collected between 1939 and 1966 have been compiled (DS-TICA-001). Most observations were made by monument staff and are random and intermittant. Each record contains scientific name, common name, month, date, and remarks concerning observation. Most sightings are where visitors and/or rangers frequent, and the quality of this data is highly variable.

A list of mammals observed in Timpanogos Cave National Monument was compiled in 1974 for the Southwest Parks and Monuments Association (SPMA 1974). As with the other lists, this list contains information obtained from the entire length of the canyon instead of the 101 hectares (250 acres) that make up the monument. Bogan (2000) created an updated mammal list for the monument.

Park staff are aware that there have been occasional records of bats using the areas near the cave entrances; however, large numbers of bats do not seem to be evident. Alteration of temperature and air flow in the caves (due to entrances and exits closed for security) may be a reason why bats do not seem to use the caves for roosting (Valdez 2002).

A two-year mammal inventory of the monument was begun in 2001 through the Northern Colorado Plateau Inventory and Monitoring Network. First-year efforts focused on areas outside of the monument's caves and extended into portions of the surrounding American Fork Canyon. 2001 results indicate that only about 19% of the mammals likely to occur in the monument have been documented, including 32% of the rodents, 14% of the carnivores, and 67% of the artiodactyls (Valdez et al. 2002). Work in 2002 will emphasize the more poorly-known groups, with results expected in early 2003.

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Datasets

DS-TICA-001 Mammal Sightings At Timpanogos Cave National Monument. 4/1/1939 - 7/12/1969. (4 x 6 index cards). Originated Tom Walker; status: Historic.

General Mammal Studies

Reports of mammals from Zion National Park (NP) date from Woodbury (1928, 1929) and Presnall (1938), each of whom reported on mammals at Zion, Bryce and Cedar Breaks as well as on other mammal records for the area. In 1931, a new species of pocket gopher was found in Zion NP (Burt 1931). Stock's (1965) study of the mammals of Washington County is an important contribution to our understanding of taxonomy and distribution of mammals of the area. Wauer (1963) also documented a checklist of mammals in the park. Ramotnik and Bogan (1996) confirmed the occurrence of about 40 species during their project. Bogan (2000) prepared an updated species list for the park. Since 1940, observations of mammals by park staff and visitors have been compiled and managed (DS-ZION-0008), and beginning in 2001, human-animal interactions have been recorded, in order to better address wildlife-visitor safety and human impact issues (DS-ZION-0010).

Inventories have been conducted in particular areas and habitats by various park staff and researchers. Keller (1935a, 1935b) was a park ranger who did informal surveys in Parunuweap Canyon and Zion Canyon and recorded life history information about the various mammals seen. Aquatic and riparian ecology was studied in the North Fork of the Virgin River, as well as Deep Creek-Crystal Creek tributary, and included small mammal communities (Workman 1980, 1982, 1983). Anderson et al. (1983) also studied the ecological community located in the North Fork and included small mammals. Hanging garden biogeography, including small mammal communities, have been surveyed by Stanton et al. (1992) and Fowler (1995). A relict area, Timber Top Mesa, was surveyed for vegetation communities and corresponding mammal and bird communities (Mason 1970). Grapevine Springs was also surveyed for small mammal communities (McCutchen 1976a).

Small mammals have been inventoried and monitored by Bogan (2000; Ramotnik and Bogan 1996) and Hunnicutt (2000; Hunnicutt and Pruett 1999). Prey-based studies have also indicated specific small mammal species (Rinkevich 1991; Ward 1995; Willey 1993). While most rodents are accounted for, it is thought that moles and shrews may not be adequately surveyed in the park. Also, some clarification needs to be done regarding which lagomorphs are present. Hunnicutt, over four years, had eight small mammal transects that covered four different habitats: pinyon-juniper, ponderosa pine, riparian, and sagebrush. Due to limited resources and staff, transects were located close to trails and to park developments (DS-ZION-0018). In 2003, the park plans on beginning a more statistically robust monitoring program for small mammals to draw inferences from relative abundance across the park.

In 2003, the future site of the Zion Virgin River riparian restoration project will be extensively studied to determine small mammal species and number present. Grids will be set up in both the channelized site (which will be restored) and the unchannelized site north of the restoration area. These will provide a baseline of comparison when restoration occurs.

Elk surveys are conducted by the Utah Division of Wildlife every 3 years (Utah Division of Wildlife Resources pers. comm.). Surveys are normally done in January or February. In Zion National Park, only the higher elevations which usually have snow in January or February are considered to be elk habitat. Four elk pellet plots were placed following a prescribed burn in the Pocket Mesa burn unit, to determine the elk use patterns on a burn area. These plots were set up in 1998 (Hunnicutt 2000) and have been monitored at least every other year (DS-ZION-0017).

The mule deer in Zion NP have been extensively studied over the past century. A deer census was conducted in 1937 (Sumner 1937), which included topography with respect to deer movement, deer population number, and possible reduction methods. In Zion Canyon, Presnall (date unknown) studied

the deer population for deer density, movement patterns, human effects, and diet. The Zion NP deer herd was also observed to determine their status (Low et al. 1966). Seasonal movements and abundance of mule deer were studied from 1966 to 1968 in eastern Zion National Park (Moorhead et al. 1966, Moorhead 1976). One hundred eleven deer were tagged and color-marked on winter habitats in and near the Park. Definite seasonal migration patterns were found, including significant northeasterly summer dispersal by part of the population frequenting the park. A total of 1000 pellet-plots were also sampled during two winters and an intervening summer to estimate deer abundance and the significance of seasonal changes in and out of the park. McCutchen (1975c) also studied summer/winter ranges of the West and East Zion Unit deer herds both within and without park boundaries.

Because of the high density and poor condition of deer in lower Zion Canyon, several disease studies have been conducted in the park. Cunningham (1992) studied the occurrence of disease and parasites as well as nutritional value of the mule deer diet. In 1992, an outbreak of pink eye occurred (Dubay 1996, Dubay et al. 1999, Taylor et al. 1996). From 1992-1994, mule deer, primarily those in Zion Canyon, were surveyed for the presence of pink eye disease, due to an outbreak in the herd. From 1992-1994, extensive surveys were done in Zion Canyon to determine the extent and duration of the outbreak. In 2001, during an incidence of Epizootic Hemorrhagic Disease (EHD) in Zion Canyon, a database was created to track the numbers of individual deer found dead or suspected to be suffering from EHD in the park, and to track necroscopy results from samples given to the Fort Collins Veterinary Pathology Lab (DS-ZION-0019).

Carnivores have not been extensively studied in Zion National Park. Trapp (1973) radio-collared ringtails and gray foxes to determine any niche separation and overlap in habitat, habitat use, and food habits. Mountain lions need to be studied in the park due to the high number of mule deer located in the vicinity of park developments in Zion Canyon. In July 2002, three deer were killed by mountain lions in high visitor use areas: off of Angel's Landing trail, at the Narrows trailhead, and across the scenic drive from the Zion Lodge.

Threatened, Endangered, and Sensitive Mammal Studies

Desert bighorn sheep were reintroduced to Zion NP from Lake Mead in 1972 as a captive herd (National Park Service 1972). While in captivity, several behavioral studies were conducted for ewe-lamb vocalizations and recognition (McCutchen 1975b, 1976b) and for minimum breeding age for females (McCutchen 1977b). In 1977, bighorn were released from the captive enclosure in Parunuweap and in 1979 bighorn were released from a holding pen in lower Zion Canyon. These reintroductions were closely monitored by McCutchen (1975a, 1976c, 1977a, 1978, 1979). After the reintroduction, behavioral ecology of the sheep was studied by McCutchen (1982a, 1982b). The National Park Service (1991), McCutchen (1994), and McCutchen et. al (1994) also later reassessed the reintroduction effort to determine long-term success or failure.

A GIS model of potential bighorn habitat was developed to predict bighorn occurrence in the park (Smith 1991, Smith and Flinders 1992). A bighorn demographic study began in 1991, examined specific drainages (e.g. Pine Creek, Gifford, Parunuweap, Lower Zion) focusing on age, sex, and reproductive success. Observations in 1992-1996 expanded to include activity patterns of the herd (DS-ZION-0002). In addition to the observations, radio telemetry data were collected on rams and ewes from 1992-1993. In 1993, a bighorn sheep management plan was contracted for Zion NP (Singer 1993). Restoration of bighorn sheep metapopulations was also studied for the Colorado Plateau and Rocky Mountain regions,

and included 14 other national parks besides Zion (Singer and Gudorf 1999a, Singer and Gudorf 1999b, Singer and Gudorf 1999c, Singer et al. 1999, Singer et al. 1993). Additionally, Jan Hart (2001) studied the Zion desert bighorn to determine their habitat use and corresponding vigilance behavior.

Bogan (2000; Romotnik and Bogan 1996) trapped bats in various locations within Zion National Park. Haraden (1998-2002) has continued trapping bats in Zion (Haraden, pers. comm.). The park now has documented 17 species. The bat inventory appears to be fairly complete, but remote sites will still need to be surveyed. These remote sites will be surveyed using the Anabat system and supplementary mist-netting in 2003, focusing on mapped water sources.

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Zion National Park - Mammals

Data Sets

DS-ZION-0002	Bighorn observation records and data. 9/15/1991 - 9/11/1996. (Five 3-ring binders with paper data sheets and maps (mostly photcopied from quads).). Originated by RM Zion National Park; status: Inactive
DS-ZION-0008	Wildlife field observations data. 1/1/1940 - present. (One MS Access97 databases). Originated by Zion National Park staff; status: Active.
DS-ZION-0010	Human-Animal Interaction Report at Zion (HAIRZ). 6/1/2001 - present. (MS Access97 database that stores information from paper forms.). Originated by Kim, Sharon; status: Active.
DS-ZION-0017	Ungulate (elk and deer) monitoring data. 7/9/1998 - present. (MS Access97 database with one table). Status: Active.
DS-ZION-0018	Small mammal trapping data. 6/18/1997 - present. (MS Access97 database with one table). Status: Active.
DS-ZION-0019	Deer capture and necropsy data. 9/16/2001 - present. (MSAccess97 database). Originated by Kim, Sharon; status: Active.

Arches National Park – Vegetation

General Plant Studies

Approximately 645 plant species occur in Arches National Park including many endemics. Harrison et al. (1964) began the first scientific effort to record the plants at Arches from specimens he started collecting in 1947. Hayward et al (1958) also described the plant communities of Arches National Park. Stanley Welsh served as a consultant for southeast Utah parks starting in the mid-1960s and collected plants in all areas. The vegetation of Arches was later classified by Allan (1977), with a quantitative description of the composition of the major plant communities, including a vegetation map. Collins et al (1983) published a comparative account of the life history and floral characteristics of desert and mountain floras in Utah using Arches National Park, the Mt. Nebo complex, and a subalpine meadow in the Uinta Mountains.

Various authors have compiled plant lists for Arches National Park. Fagan (1987) recorded five plants observed for the first time in Arches, giving scientific and common names, location, and an annotation for each. Malm (1992) constructed an identification guide that has been helpful to park naturalists. Schelz (1999, 2000, 2001 and 2002) releases an updated list annually.

Long-term vegetation monitoring began when Loope (1975) established a plant transect in Salt Valley as part of a study monitoring vegetation change after grazing phase-out. His plots were not permanently marked and thus cannot be reproduced faithfully.

In 1987, permanent vegetation transects were installed in all of the major plant communities in Arches National Park and have been monitored every year since installation (Graham and Belnap 1989, 1990; USDI 1990, 1991 and 1993; Schelz and Whitham 1999a, Schelz and Moran 2002). There are approximately 14 years of data concerning grass, forb and shrub frequency, cover and richness, in various plant communities and from various vegetation transects. The National Park Service (USDI 1993a) also reviewed the Southeast Utah Group long-term monitoring program from its inception in 1987 through 1993, examining some weaknesses of the program, and presenting proposals for some changes. Proposed changes are based on observations made by those involved in the monitoring, as well as reviews by outside scientists, and budgetary constraints. One proposed change was to monitor areas where perceived threats to the parks occur. Threats are listed, and include increased visitation, particular ecosystems and/or populations at risk, restoration problems, oil and gas development adjacent to parks, and trespass livestock grazing. Data from these studies are catalogued under DS-SEUG-007.1.

Since 1987, other transects have been installed that modified and improved the original protocols. Currently, 15 permanent vegetation plots at Arches are monitored annually. The purpose is to provide baseline vegetation information, and to document vegetation trends and natural vegetation variability, in a variety of vegetation communities in the park. The data set (DS-SEUG-007.1) is the result of annual spring monitoring of vegetation transects. Each transect consists of 100 (0.5m x 0.5m) quadrats, usually arranged in two lines of 50 quadrats each. In each quadrat, frequency and percent cover are recorded in the field for each substrate type and each vascular plant species present. The data set consists of summary data for every year and raw data for individual quadrats from 1998 to the present. In Arches, approximately 175 transect surveys were completed by the summer of 2002. Each transect survey consists of a frequency record and cover record for each plant species and ground cover component present, on each of 100 quadrats. Arches transects have diversities ranging from 14-41 plant species plus six to nine ground-cover components per transect. Another goal for several of the transects located in the newly acquired Lost Spring Canyon section is to document the vegetation recovery after almost a century of overgrazing (Schelz 2000a, 2001b).

Schelz (2002b) established 5 riparian transects in Arches NP between 1999 and 2002. The data set from this study (DS-SEUG-008.1) is a result of late summer-early fall monitoring of one transect in

Courthouse Wash and four in Lost Spring Canyon. Plans call for riparian transects to be monitored every three to five years in the future. Data is recorded along a line-intercept perpendicular to the stream channel, and includes plant cover, plant heights, and soil substrate, including ages of biological soil crusts. The stream channel profile along the transect is surveyed at the time of each census. This data set includes raw data for all transects and also raw, summary and comparison data in spreadsheets, tables and graphs, as well as protocol descriptions, discussion of purpose of ecological monitoring, maps and photographs. Vegetation data for the five Arches transects includes more than 1500 entries on plants or crust components occupying a stretch of a transect line, with starting and ending point for each, as well as height (for plants) or age (for crust) for each of these entries. Repeat photography at each transect location and elsewhere along the Lost Spring Canyon and Courthouse riparian zones complement this data set. Photographs number in the hundreds and are all re-photographed every 1-3 years. The goal is to measure recovery after 100 years of grazing and other impacts.

The National Park Service completed a draft-monitoring plan for social indicators described in the Visitor Experience and Resource Protection Implementation Plan (VERP) for Arches National Park (USDI 1995). It described in detail the survey methods for the various management zones and their specific locations in the Park. The biological portion of the VERP monitoring program was initiated in 1995 (Arches National Park 1995). Vegetation plots and permanent photopoints are an integral part of this program. Schelz and Whitham (1997, 1998, and 1999) wrote annual reports describing the program. Vegetation plots were established alongside trails with the same protocols as that of the permanent vegetation plots established elsewhere in the park and described above. McKinlay-Jones (2000) completed a M.A. thesis on developing and testing the VERP process at Arches. Summary data for the vegetation plots of the VERP program can be found in Schelz and Moran (2002). Data is catalogued under DS-SEUG-015.

There have been two studies in the park concerning relict vegetation. The Nature Conservancy (1990) conducted a relict area survey of Colorado Plateau National Park units. Results of this survey are unknown. Rowlands et al (1993) proposed setting up long-term ecological monitoring plots based on relict areas within select parks of the Colorado Plateau, including Arches National Park. This program was never established.

Belnap (1990, 1993, and Belnap et al 1991, 1994a, 1994b) and other researchers (Belnap and Harper 1995; Davidson 1995; Belnap and Hill 1998; and Harper and Belnap 2001) have investigated cryptobiotic soils and their ecological ties to the vegetation.

The blackbrush (*Coleogyne ramosissima*) has been an extensively studied plant in and around the park. From 1991-1993, Pendleton and his colleagues (Pendleton et al 1992, 1995, 1995a, Pendleton and Meyer 1994a, 1994b and Pendleton and Pendleton date unknown) began a series of long-term studies on blackbrush biology, establishing study sites across a large portion of the shrub's range. They examined blackbrush reproduction and recruitment through studies of factors influencing flowering and fruit set, pollination, seed germination, and seedling emergence, survival and growth rates. Other studies looked at population size and structure and community relationships. Seeds were collected from 30 locations from southeastern Nevada to eastern Utah. Seedling caches were examined for seedling emergence and survival studies. Fifteen long-term sites were used for studies of flowering, fruiting and community structure. Results of these studies indicated that blackbrush is wind-pollinated, and that moderate to heavy winter precipitation induces flowering. They found blackbrush to be a mast fruiting species with size of fruit crop a function of available stored resources, not simply precipitation history. Seed dormancy appears to be reduced by summer and fall rains and completely ends with winter chilling. Blackbrush has evolved ecotypes, at least for germination and establishment ecology, determined by a seedling experiment at Arches National Park and a site at Hurricane, Utah. Many seeds sprout from

rodent caches with seedlings more likely to survive outside of a mature blackbrush stands, indicating that mature stands limit available resources. Finally, they found blackbrush rarely reestablishes after fire.

Meyer and Pendleton (date unknown) published their findings on blackbrush populations within Arches and Canyonlands National Parks, including flowering, seed production, seed dispersal, germination, seedling emergence, and plant growth. Wylie and Kitchell (1984) reported on the presence and condition of blackbrush adults, intermediates, yearlings, and seedlings, as well as the presence and extent of other perennial and annual species from the 1979-1984 field season. Their data is cataloged under DS-SEUG-062. Graham (1993) studied blackbrush seedlings on three different substrate sites in Arches National Park from 1988-1991 to determine the factors that affect seedling survival. He described blackbrush as a paleoendemic that evolved in an environment no longer existing, and explained that climatic conditions at the northern end of its range in Arches National Park allow the plant to germinate only in unusual years. Discussion of results indicated that restoration of blackbrush communities in Utah's National Park Service areas would be difficult. In addition to getting seeds to germinate, recreating proper conditions is also necessary, and further work is needed to determine effective ways to do that over large areas of disturbed arid land. Data from Graham's study is catalogued under DS-SEUG-064.

Hanging gardens are unique ecological communities found within Arches National Park. Welsh (1989) first looked at these in the 1980's and published a paper on the distribution of hanging gardens in Utah, which included some in Arches NP. He discussed the geomorphology and geography of the gardens, and aspects of their diversity and distribution, together with a list of vascular plants and algae. Both Fowler (1993, 1995, and Fowler et al 1995) and Stanton (1995, and Stanton et al 1995, 1995a) completed their Ph.D. dissertations on hanging gardens and wrote extensive papers on the biogeography of hanging gardens on the Colorado Plateau, including some in Arches. They concluded that Arches had a significantly higher number of hanging garden endemic taxa per garden than the other six parks in his study. Hartman et al (1993) also reported on the biogeography of invertebrates and plants in hanging gardens in Arches National Park. May (1994, van Ripper 1995) studied the geologic and hydrologic features of the sandstone aquifers of the Colorado Plateau that provide the necessary conditions for hanging garden development. May and Hill (1998) classified hanging gardens in parks of the Colorado Plateau. Data from a hanging garden vegetation and water survey, conducted in Arches and Canyonlands National Parks, by Schelz and Spence, is catalogued under DS-SEUG-073.1

A classification and correlation of the soils of Grand County, Utah which included Arches National Park, was performed by the U.S. Department of Agriculture, Soil Conservation Service (USDA 1982). The survey describes each soil complex in full technical detail, lists characteristic plant communities and rangeland productivity. Hansen (1989) also conducted a soil survey of Grand County, Utah that included Arches National Park. Descriptions of individual soil types includes characteristics, example locations, permeability, human and wildlife uses of areas with this type of soil, general plant communities, suitability for rangeland seeding, and principal crops grown.

Mead et al (1989), Sharpe (1991), and Sharpe et al (1993) provided information on past vegetation communities in Arches National Park through their analysis of packrat middens. Limber pine (*Pinus flexilis*) and Douglas fir (*Pseudotsuga menziesii*) were the dominant plant remains from 20,000 to 12,500 year-old middens, indicating a wetter and cooler environment during that time.

Finally, a large portion of the vegetation literature at Arches National Park concerns resource management. Loope (1974) compiled a descriptive report on the flora and fauna of the national parks of the southeast Utah desert canyonlands, with recommendations for management and planning to preserve these resources. In a report on the fourth year of a breeding bird census in the Devils Garden section of Arches National Park, Salamacha (1986) described the vegetation (species, height), weather, and area

topography. Graham (1988) documented single-leaf ash tree (*Fraxinus anomala*) damage by the true bug *Tropidosteptes* sp. (Hemiptera: Miridae), and correlated the degree of damage with the nearness of trees to park roads. Mitchell and Woodward (1993) conducted a study on the effects to aquatic and riparian organisms by humans in Arches National Parks and two other Colorado Plateau parks from 1990-1992. They studied small mammal, bird, plant, and aquatic organism distributions and patterns of abundance with respect to human travel systems in the parks and included management recommendations and sampling protocols for the future.

A report by Edwards et al (1993) concerned gap analysis, a theory relating the distribution of terrestrial vertebrate species to the synthesis of wildlife habitat data. Long-term data from Arches were utilized to test this theory.
Graham et al (1993) studied the population dynamics of birds at Arches National Park by evaluating fluctuations and trends in pinyon-juniper woodlands from 1983-1992.
Rowlands (1994) produced a manual that presented a vegetation classification system developed for use in the Colorado Plateau park units, and addressed various concerns involved in planning and carrying out a vegetative assessment. Appendices include information on field techniques, calibrating cover estimates and preparing herbarium specimens, as well as sample field forms. It is unclear if Colorado Plateau network parks are currently following these protocols. Sweanor et al (1995) performed a bighorn sheep habitat assessment for the greater Arches and Canyonlands National Park area to identify patches of sheep habitat adequate to maintain a minimum viable population (125 sheep).

Binkley et al (1997) summarized the key features of air quality and potential impacts of air pollution on plants and aquatic ecosystems in Arches and eight other Class I air quality areas within the Colorado Plateau. Budelier (1999) submitted a restoration plan for a construction-related gas line explosion just west of Arches National Park in the winter of 1998-1999 that burned 21 acres, 6.6 of which were within the Park boundary.

A fire effects vegetation-monitoring program was initiated by Bastian and Cohen of the Zion Fire Effects Team. The team guided SEUG biologists in setting up vegetation monitoring after a 1999 fire in Salt Valley using a slightly modified Fire Monitoring Handbook (FMH) protocol. Monitoring by the SEUG Resource Management Division continues on a biennial schedule. Data for this program is catalogued under DS-SEUG-050.

Threatened, Endangered and Sensitive Plant Species

Approximately 20 species are endemic to the park though no federally listed threatened or endangered plant species have been found. Two species, Jones cycladenia (*Cycladenia humilis* var. *jonesii*), a Federally listed threatened plant and a rock daisy (*Perityle specuicola*) are found very close to park boundaries and may be within the park. There are also approximately nine sensitive plant species found, the most notable being the Arches biscuitroot (*Lomatium latilobum*). This species is presently being reviewed for threatened or endangered status.

There has been extensive work on the Arches biscuitroot. Floyd-Hanna (1993a, 1993b, Floyd-Hanna and Hanna 1992, 1996, 1998 and 1999) set up long-term monitoring plots and has worked recently on a habitat model with Bachrach (1995, and Bacharach et al 1998) and Hanna (Hanna and Floyd-Hanna 2000). *Lomatium latilobum* is a sensitive plant species restricted to rock fin areas, with the largest populations apparently concentrated in Arches National Park. Age of plants and defining an individual are problematic in *Lomatium latilobum*, which reproduces both clonally and sexually. Life-stage

classification and measuring the size of a cloned unit were employed to circumvent these problems, but some problems remain. Population studies in the park used two methodologies, permanent plots and fin surveys. The quicker fin survey method was used annually from 1990 to the present by trained Arches staff. This method compared recruitment and mortality in the heavily visited Devil's Garden area to the relatively inaccessible Tower Arch area in the Klondike Bluffs. In the method, two researchers walked between two rock fins, beginning at a specified spot and ending at the end of the shortest fin wall. Each clump of *Lomatium latilobum* was given a life-stage classification. The walls themselves were examined for individuals within cracks. Three permanent plots were established in Devil's Garden in 1989 (plot #1) and 1990 (plots #2 and 3). Floyd-Hanna and Hanna surveyed these twice yearly for more detailed information on populations, and to see if the fin survey method reflected a more reliable permanent plot method. They also established three plots in the Fiery Furnace in 1993 and 1994. They recorded life-stage, clone size, the number of new germinants, the number of inflorescences of each individual, and an evaluation of full and aborted fruit per inflorescence for a sample of 50 plants. The purpose was to determine patterns of resource allocation, survival, and effects of physical impacts on *Lomatium latilobum* populations in Arches. Data from these studies is catalogued under DS-SEUG-066 and DS-SEUG-068.1.

Five *Lomatium latilobum* pairs have been monitored in the Fiery Furnace since 1995. Each pair consists of one individual in or near the interpretive trail, exposed to trampling and other disturbances, and a nearby individual of similar size but in a relatively protected location. The plants are assigned a number from a 0-4-health scale, and comments on health, type of damage, and recent weather conditions are included. This monitoring has occurred approximately every two weeks during a season usually starting in March. The purpose is to provide a gauge to the overall population health of *Lomatium latilobum* in the Fiery Furnace and to guide management in this popular visitor attraction. Data from this study is catalogued under DS-SEUG-067.

Fagan and Tennyson (1984) investigated the alcove death camus (*Zygadenus vaginatus*) and mapped locations. A report by the Utah Native Plant Society (1987) lists possible endangered, threatened and sensitive plants in Arches National Park. The list includes nine sensitive plant species and 19 "endemics and other unusual plants". Topographic map of Arches (1:50,000 scale) show geologic formations and rare plants likely to occur on each. Heil et al (1993) and Vanderbilt (1994) conducted rare plant surveys. Their final reports give the status and extent of a number of species together with maps of population locations.

Exotic and Invasive Plant Species

Harrison et al (1964) compiled an annotated list of 322 vascular plants identified in Arches National Monument that included a section on introduced species. In a paper that included Arches National Park, Loope et al (1988) published their study on biological invasions of arid land nature reserves by non-native plants, animals, and fish.

Tamarisk (*Tamarix ramosissima*) was the first exotic plant management concern in Arches National Park. Evans et al (1981) conducted a comparative study to evaluate methods of controlling tamarisk compatible with Park Service policy on chemical use. Techniques included foliar spraying, cut-stump treatment, and spraying regrowth of cut and burned plants. Thomas et al (1987) provided a brief description of tamarisk control work and plans for the future.

In a conference proceedings on tamarisk control in southwestern United States (Kunzmann et al 1989), Thomas and Kitchell summarized the tamarisk control efforts in Canyonlands and Arches National Parks and Natural Bridges National Monument.

In order to identify seasons when the herbicide, Garlon 3A would be most effective in tamarisk control, Graham (1991) established twelve plots in desired tamarisk removal areas in late February 1988, near Salt Wash and the Wolfe Ranch parking area in Arches National Park. Preliminary results indicated that treating stumps in spring (late February), and especially summer (early June), is slightly more effective than treating in fall (October) or winter (late December). He concluded that stressors that could be combined with Garlon 3A treatment for maximum tamarisk control effectiveness might include drought, March to early June treatment, heavy herbivore load, fire, and/or nutrient imbalance. Data from this study is catalogued under DS-SEUG-061.

Salamacha, a ranger at Arches NP, has actively pursued tamarisk control throughout the 1990's to the present. He set up a permanent plant transect in Salt Wash and collects data annually. Budelier and Torrence, vegetation management specialists at the Southeast Utah Group, have been actively controlling tamarisk and other exotic species, primarily Russian knapweed (*Centurea repens*) from the late 1990's to the present. They have mapped a number of populations using GPS technology and use that as a method of monitoring exotic plant expansion. These data are catalogued under DS-SEUG-049.2

Budelier (1996) summarized the 1993-1995 revegetation work associated with the relocation of the Delicate Arch viewpoint parking lot. Techniques included native seed collection, salvaging of plants, ripping compacted roadbed, transplanting sod clumps, rock placement, spring and fall seeding, and weeding of exotic plants. Because a small wetland at the Salt Wash road crossing was disturbed, a comparable sized wetland was created nearby. The report compared survival rates of transplants and germination rates of seedlings and concluded that good topsoil used shortly after collection showed positive results, as did most transplanting, particularly if done in fall or winter. Budlier (1998) also summarized the 1996-1997 follow-up work and monitoring of the Delicate Arch viewpoint parking lot. Follow-up work included re-landscaping, seeding and additional transplanting of shrubs and grasses, especially shadscale (*Atriplex confertifolia*), greasewood, (*Sarcobatus vermiculatus*), willow (*Salix exigua*) and Indian ricegrass (*Stipa hymenoides*). Monitoring showed that willows planted near the Salt Wash crossing did not survive, but other wetland plants, both native and exotic, did come back. Planted shadscale shrubs had a 92 percent survival rate the first year with some supplemental watering. A table indicates survival rates of *Stipa*, *Hilaria*, shrubs and snakeweed (*Gutierrezia sarothrae*). Data from these studies is catalogued under DS-SEUG-047.

The Lake Mead Exotic Plant Management Team has been treating invasive and exotic plants in Arches from 1997 to the present. Their data is catalogued under DS-SEUG-072.1.

Gelbard (1999) completed a M.S. thesis that examined the spread of non-native plants based on studies in and adjacent to Colorado plateau parks. Native grasslands, woodlands, and shrublands are being dramatically affected by invasions of non-native grasses and forbs which reduce diversity of both plants and animals, disrupt many ecosystem processes, and lead to increased erosion of topsoil. He found that roads are one of the most significant factors in aiding the spread of invasive plants, and that road improvements dramatically widen the affected roadside corridor. The paper describes differences in ease of invasion according to level of protection (much more impact in lands managed for multiple use than in national parks), and by factors measured at several geographic scales. He concluded that documenting conditions that aid invasion or resistance to invasion provides information for land management, and that major opportunities remain to prevent invasions.

Schelz et al (2002) compiled a list of exotic plants in the Southeast Utah Group, including Arches National Park.

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DS-SEUG-008.1	Riparian vegetation data, substrate data, and stream profiles, Arches and Canyonlands National Parks, 1998 - present
DS-SEUG-015	Frequency and cover of vascular plant species and ground cover near trails in Arches NP, 1996 - present
DS-SEUG-047	Records of revegetation projects and revegetation monitoring, Arches National Park
DS-SEUG-049.2	Exotic plant location data and maps, Southeast Utah Group
DS-SEUG-050	Fire effects vegetation monitoring, Arches National Park
DS-SEUG-061	Experimental data on Garlon 3A effectiveness in tamarisk control during different seasons, Arches National Park
DS-SEUG-062	Blackbrush (Coleogyne ramosissima) transplant seedling survival data from closed roads in Arches National Park, Utah 1979-1984
DS-SEUG-064	Blackbrush (Coleogyne ramosissima) seedling establishment data from three substrate types in Arches National Park, 1988-1991
DS-SEUG-066	Lomatium latilobum (Canyonlands biscuitroot) population studies in Arches National Park, 1989 – present
DS-SEUG-067	Lomatium latilobum (Canyonlands biscuitroot) monitoring along the Fiery Furnace trail, Arches National Park, 1993 - present
DS-SEUG-068.1	Habitat data and modeling for Lomatium latilobum, Arches National Park, Colorado National Monument and vicinity
DS-SEUG-072.1	Lake Mead Exotic Plant Management Team treatment records, 1997 - present
DS-SEUG-073.1	Hanging garden vegetation and water surveys, Arches and Canyonlands National Parks, 1998

Black Canyon of the Gunnison National Park – Vegetation

General Plant Studies

In the early to mid-sixties, two plant studies were published concerning the status of the vegetation prior to construction of the dams that backed up the Gunnison River. Vincent (1966) reported on the river habitat types along the Gunnison River with reference to both pre and post dam environments. Woodbury et al (1962) studied the flora and fauna along the Gunnison River through Black Canyon and published the results of their survey that examined the flora and fauna to be inundated by the reservoirs soon to be built.

Because of the importance of the Gunnison River which runs through the park, a large part of the literature devoted to plant studies is concerned with riparian zone studies, flow regulation and sediment transport studies, and riparian vegetation studies.
Lichvar (1987) performed a riparian vegetation reconnaissance of the Black Canyon of the Gunnison and summarized potential impacts to the riparian community resulting from the reduction in stream flows. Auble (1991), a University of Colorado researcher, reported on the composition and response of riparian vegetation in the Black Canyon of the Gunnison River to selected hydrologic regimes based on a direct gradient assessment model. Wondzell et al (1993) presented a report at a conference concerning the growth and establishment of willows and cottonwoods in riparian zones in arid and semi-arid regions, which included Black Canyon National Monument.

Auble et al (1994) investigated demands on river water in arid regions and concluded that it was possible to cause substantial changes in riparian vegetation without changing mean annual flow, and also that riparian vegetation is especially sensitive to changes in minimum and maximum flows. Friedman and Auble (1999) conducted a study to explore how high flows limit the streamward extent of riparian vegetation in the Gunnison River through the Black Canyon. They measured the effect of sediment mobilization on extended inundation of box elder (*Acer negundo*) saplings, and modeled the maximum shear stress and number of growing-season days of inundation using plot data for two consecutive years. They concluded that box elders were killed either by inundation for more than 85 days during the growing season or by shear stress that exceeds the critical value for mobilization of the underlying sediment particles.
Construction of upstream reservoirs in the 1960s and 1970s reduced the proportion of the canyon bottom annually cleared of box elders by high flows. Furthermore, because the dams decreased the magnitude of high flows more than their duration, flow regulation has decreased the importance of sediment mobilization relative to extended inundation. The threshold functions and cross-section data were used to develop a response surface predicting the proportion of the canyon bottom cleared at any combination of flow magnitude and duration. This response surface allows vegetation removal to be incorporated into quantitative multi-objective water management decisions.
Kittel et al (1999) produced a users guide to a classification of riparian wetland plan associations for the Colorado Natural Heritage Program at Colorado State University.

Another large portion of the vegetation literature concerns studies involving plant resource management. Kump (1983) reported on the effects of the porcupine populations on pinyon pines in the Black Canyon area. Results of this study are unknown. Townley (1987) also examined the damage to pinyon trees by porcupines, specifically near High Point in Black Canyon.
Rowlands (1994) produced a manual that presented a vegetation classification system developed for use in the Colorado Plateau park units, and addressed various concerns involved in planning and carrying out a vegetative assessment. Appendices include information on field techniques,

calibrating cover estimates and preparing herbarium specimens, as well as sample field forms. It is unclear if Colorado Plateau network parks are currently following these protocols.

A joint report by the National Park Service and the Bureau of Land Management (1995) contains a bibliography covering published data pertaining to climate change, cultural resources, recreation, environmental documentation, ecology, geology, legislation, and water resources of the Gunnison River System. A study on human impacts to campsites resulted in a National Park Service report (1996a) that documented information on various attributes of a campsite, including vegetation in the area, picnic tables, firepits and diagrams of the sites.

Binkley et al (1997) summarized the key features of air quality and potential impacts of air pollution on plants and aquatic ecosystems in Black Canyon and eight other Class I air quality areas within the Colorado Plateau. Johnston and Huckaby (1999) classified the ecological types of the Upper Gunnison Basin from vegetation, soil and landform data collected from 1,666 points between 1982 and 1998.

There are six publications concerning plant species lists that were generally produced in the 1960's. Reed (1962) conducted a survey for the NPS on the aquatic insects and aquatic plants in the Gunnison River in Black Canyon of the Gunnison National Monument, and Rominger (1962) conducted a survey and checklist of the grass flora Black Canyon National Monument. Beidleman (1969) compiled a checklist of Black Canyon National Monument plants and Weber (date unknown) compiled a checklist of lichens found in Black Canyon National Monument. The Park (author, date unknown) and Friedman and Auble (1990) have compiled an annotated riparian plant species list for Black Canyon of the Gunnison National Monument.

The remaining literature is devoted to long-term monitoring studies, including the establishment of long-term photographic stations. Shelz and Van Pelt (1990) established long-term photographic stations for monitoring community change in Black Canyon of the Gunnison National Park. Van Pelt and Shelz (1991a) reported on this multi-faceted study to locate, survey and photograph relict vegetation areas on the northern Colorado Plateau. They described the sites located within Black Canyon of the Gunnison National Park, Curecanti National Recreation Area, Mesa Verde National Park, and Dinosaur National Monument. A section for each relict site describes the geologic and physical setting, applies a comprehensive classification of Colorado Plateau vegetation types to the site, and includes a vascular plant species list. The report includes discussion of regional significance and suggestions for management and future surveys, and lists that Colorado Plateau vegetation types are included in the sites and which are not included. Detailed description of field methods for various aspects of the study, as well as descriptions and maps of locations are included.

Van Pelt and Schelz (1991b) also wrote about the community site descriptions and unit analysis for Black Canyon of the Gunnison and Curecanti. Overflights, topographic maps, and reconnaissance were used in assembling plant lists. Bradshaw and Beetch (2000) submitted an end of season report on the vegetation-mapping project at Black Canyon. The report discusses the scope of the project, what has been completed thus far, and what remains to be accomplished.

The Nature Conservancy is involved in an effort to classify international ecological communities and reported on the terrestrial vegetation of the western United States (Community Ecological Group 2000). The report divides all terrestrial ecosystems into forest, shrubland, woodland, dwarf-shrubland and herbaceous vegetation with their own subsequent alliances. Provided under each alliance type is concept, range, states/provinces, USFS ecoregion code and references.

Black Canyon of the Gunnison National Park – Vegetation

A long-term monitoring program was initiated to document and detect changes in the vegetation composition in Black Canyon National Park (National Park Service 1996b). Data on species, frequency classes and cover classes were collected from 1996 through 1998 at four sites in the park. This monitoring effort is currently undergoing review to determine its suitability for meeting park needs. Data for this program in catalogued under DS-BLCA-0006.

Threatened, Endangered and Sensitive Species

Grey (1982) conducted graduate studies on the population and habitat analyses of two endemic Colorado plants under guidelines of the Endangered Species Act of 1973 (*Gilia pentstemonoides*, *Penstemon crandallii*). Results of his analyses for *Gilia pentstemonoides* indicated a center of distribution in the Black Canyon region, a requirement for granite, gneiss, or shale rock habitat, and low average densities. *Penstemon crandallii* occurred on open southerly slopes between 9000 and 11,800 ft in the Elk and West Elk Mountains, Colorado. Sites were typically steeply sloping and sparsely vegetated, with medium-coarse soils. There were no immediate threats to survival, though "sensitive" or "special concern" categories were recommended.

Exotic and Invasive Plant Species

There is no literature concerning these species at this time.

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Data Sets

DS-BLCA-0006 Long-term Monitoring Program: Vegetation. 1996 – 1998.

Bryce Canyon National Park - Vegetation

General Plant Studies

Plant Ecology

Bryce Canyon National Park has been a popular place for many different types of plant ecology research. In 1980 Mouat (et al.) published an investigation into 'prairie mounds' in the park. This work examined the geographic distribution of these mounds, their morphology, their spacing with respect to each other, the differences in the height of vegetation on mounds and between mounds, and the soil depth and profile in and adjacent to the mounds. Harper and Buchanan (1982) looked at the ecology of various shrubs in the park. Shrubs contribute more cover than either forbs or graminoides in the forests of Bryce Canyon National Park. *Purshia tridentata* or bitterbrush reaches maximum abundance in the ponderosa pine forests and declines steadily with increasing elevation. Bitterbrush is the major understory species in the low elevation forests. The study covers shrub mortality and establishment rates in six forest types over a 21 year period.

Roberts studied plant community distribution and dynamics in two separate studies over 10 years (Roberts, 1986; Roberts et al., 1992). The objective of these studies was: a) to map the potential and current distributions of rare and endangered species, b) to classify and map the land area as to current vegetation type, and potential vegetation type, c) to determine the where rare or endangered plants occur, and to determine the influence of succession, disturbance, or Agency management on the distribution of these species, d) to identify and map undisturbed plant communities to serve as baseline reference areas, e) to develop a comprehensive vegetation classification for all stages of vegetation development for all lands within the Park, and f) to develop a vital attributes succession model which relates the successional pathways and disturbance pathways from each community type to other community types and the climax. The data for both of these studies is associated with the DS-BRCA-0015 dataset.

Schelz and Van Pelt (1990) and Van Pelt (et al., 1991) inventoried and analyzed relict plant communities within Bryce Canyon National Park. This study found four relict areas within the park. These areas were surveyed for plant species and community structure. In addition, permanent photo points were set up as well. Roberts and Hallsten analyzed community composition and habitat of *Pediomelum pariense* in 1990. The distribution of *Pediomelum pariense* in Bryce Canyon National Park, Utah, and the vegetation and soils associated with it were described. Management suggestions were also presented. Foster and Foster (1992) accomplished a brief analysis of the distribution of major plant species at Bryce Canyon National Park. This work identified plant communities and developed a park vegetation map using air photos and by on-site quantitative studies, collected plant specimens to update park flora, and located rare plant species and their habitats. Spence (1992) initiated an inventory and monitoring program of the vegetation in the 'breaks' area of the park. This study was designed to detect long-term changes in vegetation related to climate change. It is felt that the Bryce Canyon 'breaks' are an ideal system to study the effects of climate change on vegetation. Because of the harsh conditions, including nutrient poor soils, high erosion rates, and drought conditions, many plant species are near their tolerance limits. Any changes in climate, that in turn could bring about changes in soil moisture levels or erosion rates, may have a rapid effect on the vegetation in the 'breaks'.

Plant Community Dynamics

Bryce Canyon is in the unique position of having 40+ years of data (by the same researcher) relating to plant community dynamics on the westside of the park. Hayle Buchanan has been studying the plant ecology of Bryce Canyon for his entire career. His first work on the subject is his Ph.D dissertation from 1960. The purpose of this study was to provide a report on the nature, extent and condition of the present plant communities of Bryce Canyon National Park, with an appraisal of the environmental factors that

support them. The sample plots used in this study were permanent to provide future opportunity for periodic opportunity to study changing conditions and trends. The second objective of this study was to evaluate the effects of the general, basic policies of the Northern Park Service. In 1971 Buchanan published an update looking again at the forests of Bryce Canyon. This work examines the changing conditions of forests within the park in light of impacts such as grazing, pests, and fire suppression. In 1981 Buchanan teamed up with Greybosch and Harper to assess the plant community changes at the park between 1957 and 1980. Re-analysis of forest study plots initially analyzed in Bryce Canyon National Park during the period 1957-59 demonstrates that forest succession is dramatically altering the biotic character of the Park. During a 21 year period, forest density increased 84% and forest basal area increased 82% on the average. Photographs document the changes and trends of forest community changes at Bryce Canyon National Park. They were taken at intervals of twelve and twenty-one years.

During the summer of 1991 work was begun on a project entitled "the Dynamics of Forest Succession in Bryce Canyon National Park". An interim report was published in 1992 (McKnight, Clark, & Babapulle). The final report was published in 1993 by McKnight and Buchanan. This project built on the previous work by Dr. Hayle Buchanan begun in 1957 and continued by Buchanan and Harper in 1980. The three main objectives of this new study were: 1) Provide a quantitative description of plant successional changes over the last 34 years; 2) Provide a pictorial record showing changes in Park landscape and plant communities over time; 3) Provide a quantitative description of the soil associated with the 266 forest study plots. In 2000 McKnight and Buchanan produced another analysis of the data from the early 1990's. This work again looked at the dynamics of forest succession in the park. All of the data from these studies is stored in the DS-BRCA-0012 dataset.

Forest Succession Modeling

In 1994 Betz modeled the forest dynamics of Bryce Canyon. A landscape scale computer simulation model, LANDSIM, was coupled with the Arc/Info GIS to simulate the interaction of forest fires and forest succession at Bryce Canyon National Park, Utah, and to produce maps of the predicted community types. The sensitivity of the model was tested with respect to the fire return interval, maximum neighbor spread, and the effect of slope upon the spread of simulated fires. The model predicts that each fire return interval will result in an unique distribution of community types upon the landscape. Roberts and Li-Bai (1996) modeled forest dynamics at Bryce using with vital attributes and fuzzy systems theory. The vegetation composition and structure define a fuzzy state space, and the system dynamics were determined by the simulated trajectory through the fuzzy state space. Model output was validated with respect to a typical mixed conifer forest (*Pinus ponderosa, Pseudotsuga menziesii, Abies concolor* and *Picea pungens,* with *Populus tremuloides*) from Bryce Canyon National Park. Simulations begin with early seral stands of *Populus tremuloides* in age classes 10-40 yr, with 40 yr fuel accumulation, and are run for fire return intervals of 25, 50, 100, 250 and 500 years. Sensitivity analysis of the model behaviour with varying vital attributes is used to analyse the ecological characteristics appropriate to plants in disturbed environments, and implications of the model for plant community diversity are also analysed. Roberts and Betz teamed up in 1999 to again simulate landscape vegetation dynamics of Bryce Canyon with the vital attributes / fuzzy systems model. The simulation attempted to determine the consequences of changes in the historical fire regime of Bryce Canyon, and the possible future composition and structure under varying fire regimes.

Fire Ecology

The first research concerning fire ecology was a fire history of Bryce Canyon National Park done in 1983 by Buchanan and Tolman. This report traces the fire history of Bryce Canyon National Park from its inception as a national park in 1928 to the present time. It includes photographs, tables, and maps. Roberts et al. (1989) completed a report of the historical vegetation and fuel loads of the park. It proposes

the idea that fire suppression has preserved species which would have been reduced or eliminated under a natural regime of repeated burning and this has led to an increase in fuel loads in many forested plant communities in the park. To return the landscape to a vegetation mosaic similar to that of the historic past information is needed. This report addresses the acquisition of this baseline information. This information is stored in a database (DS-BRCA-0015). In Johnson (1991) the park staff looked at documenting fire effects in a fire effects monitoring handbook. This handbook specifically addresses vegetation fuel load procedures, plot locations, database/statistical procedures, vegetation analysis, and the effects on small mammals and songbirds. In 1995 Bryant examined the ecological justification and effects of prescribed fire at Bryce Canyon National Park. The impacts of suppressing fire has resulted in high fuel loads, invasion of fire intolerant species, and the increased threat of high-intensity wildfires. The park has been conducting prescribed fires since 1990. These management-ignited fires have decreased fuel loading and resulted in mortality of overstory trees ranging from 10 to 22 percent. Jenkins (1995) is a fire history determination in the mixed conifer/aspen community of Bryce Canyon National Park. It reports a mean fire return interval from 7.5 to 45 years since 1900. Also included are dendochronology, species, diameter, and age class analysis, as well as fire management planning recommendations.

Forest Pathogens

A white pine blister disease survey and distribution study was done in 1965 by Park Service staff. 2 p. This survey aimed to document cases of blister rust disease if present in either park and to survey the distribution of white pine in both parks. Peterson (1966) inventoried limb rust damage to yellow pines in the park. This paper is a further review and extension of knowledge. It presents additional host, geographic, and biological data based on several years' observation. Included are results from a sampling in 1965 of limb rust in Bryce Canyon Nation Park, and comparisons with data taken in 1935 from the same transect. In 1997 Hansen inventoried insect and disease conditions in Bryce Canyon National Park. The major insect and disease agents found were Douglas-fir dwarf mistletoe, "Arceuthobium douglasii Engelmann"; western spruce budworm, "Choristoneura occidentalis Freeman"; Douglas-fir beetle, "Dendroctonus pseudotsugae Hopkins"; and fir engraver beetle, "Scoyltus ventralis LeConte". The implications of these insects and diseases and their role in prescribed fire management are discussed. The potential of future bark beetle outbreaks and the continued spread of dwarf mistletoes, especially Douglas-fir dwarf mistletoe, are two forest health issues which Bryce Canyon National Park personnel can address in developing prescribed burn plans.

Revegetation

Mackison (1988) detailed the revegetation efforts for distressed areas within Bryce Canyon National Park, specifically campground areas. In 1997 (Petersen et al.; Petersen) two years after the end of a major road project, a monitoring project was implemented to look at restoration of disturbed roadsides and other areas. Areas were evaluated to determine the success of plant establishment and survival on revegetated sites. Vegetation was sampled in 1995 and 1996. Seeded sites had greater density, cover and biomass than unseeded sites. Fertilizer increased seedling establishment and growth, while transplant growth rates were similar to unfertilized plants. Mulched sites were similar for all types. After 2 growing seasons, indigenous slender wheatgrass had greater density and cover than commercial varieties. Microsites were found to greatly enhance seed germination and seedling establishment on roughened slopes compared to plants growing on unprotected soil. In 1998, Petersen re-examined the same sites to further characterize restoration success and failures. This document, consisting of data collected during the fourth growing season, is a supplement to the two earlier reports.

Bryce Canyon National Park - Vegetation

Wildlife Habitat

In the early 1970's Gerstenberg (1971) inventoried for nesting birds of the yellow pine forest at Bryce Canyon National Park. This reports cover three field seasons. The first year information includes the documentation of nesting. The second year has a systematic census and a vegetative sample of the forest and third year to for data analysis. Crocker-Bedford (et al.) explored the habitat relationships of Utah prairie dogs in 1981. This report found that colonies are of three types: 1) High elevation (above 2,200m or 7,200 feet), 2) low elevation (below 2,200m), and 3) low elevation associated with alfalfa. Other aspects studied included the Utah prairie dog's life history, food preferences, and habitat relationships. The effects of prairie dogs on vegetation also were evaluated, and recommendations pertinent to the selection of prairie dog transplant sites were developed. In 1988 park staff looked at the effect of deer and elk browsing on vegetation at Bryce (Barraza). Photo points were used to assess vegetation within and outside a deer exclosure. Only slight differences were observed between inside and out.

Plant Lists

Various vascular plant lists have been generated for Bryce Canyon National Park over the years. The first was a commercial effort in 1958 (Jepson & Leland). The first scientific effort was a checklist of higher plants of the park in 1971 (Buchanan & Nebeker). This checklist of vascular plants includes 324 taxa, with general habitat information. Buchanan and Graybosch published a revised checklist in 1981. This checklist includes 122 additional records with collections and updates the nomenclature of the vascular plants presently known to occur within the boundaries of Bryce Canyon National Park. Hallsten and Roberts (1987) reported 27 new additional taxa collected in 1986 and 1987. The latest addition to the vascular flora of Bryce is from Spence and Buchanan (1993). They reported 458 species in 232 genera and 73 families.

Threatened, Endangered, and Sensitive Plants

Lester F. Ward, who was a member of Powell's later expeditions, made the first systematic botanical collections in this area in the 1870's. Ward collected and named a number of narrowly restricted endemics found in this area, including within Bryce Canyon National Park. Rupert Barneby also collected extensively across southern Utah (including Bryce) in the 1940's and 50's.

Robert Graybosch (Graybosch, 1981; Graybosch & Buchanan, 1983) accomplished the first modern work regarding the ecology and distribution of rare and endemic plants in the park in the early 1980's. This article provides information regarding the endemic plants that inhabit the eroded cliff areas of Bryce Canyon National Park. This research focused on the main amphitheater or "breaks" environment of the Park which is a narrow band of vegetation occurring on the badlands formed largely by the Red beds of the Claron formation along the eastern border of the Paunsaugunt Plateau. These studides divide the habitat into four vegetative types and list dominant species for each, including some endangered species. The aims of this study were to determine whether or not the "breaks" is divisible into plant communities, to study the typical habitats of the endemic plants, and to note the impact of visitation on the area. The paper includes information on distribution and factors influencing distribution, as well as recommendations for management.

Hallsten and Roberts (1990) specifically analyzed the community composition and habitat of *Pediomelum pariense* or Indian Breadroot. A detailed habitat description (including vegetation and soils) and the distribution of *Pediomelum pariense* in Bryce Canyon National Park, are described. Management suggestions are presented. This includes information required for planning and executing recovery programs, selection of possible transplant sites, and guidelines for vegetation manipulation to increase or improve habitat for Indian Breadroot.

Bryce Canyon National Park - Vegetation

Schelz (1990a) completed a reference project to identify the rare and endangered plant species of Bryce. Information collected included photos, descriptions, references, drawings, ecology, and known locations for each species. The location information was gathered from specimens in the Bryce Canyon and BYU herbariums. It was also gathered from the database of the Natural Heritage Program of the Nature Conservancy in Salt Lake City. In addition, the project lists names and addresses of people to contact about the rare plants of Bryce. The study also contains about 200 pages of photocopied material related to these rare plants.

In 1995 Peabody completed a comprehensive survey of all rare plant populations in the more accessible areas of the park. This work produced a list of category 2 plant taxa for Bryce Canyon National Park and located all category 2 plant taxa that were currently listed in the Federal Register. It also determined the distribution and abundance of these plant taxa, characterized the habitat parameters, and developed a long-term monitoring program for these plant populations. Park personnel (Ames-Curtis et. al, 1997a) re-monitored these plots 5 years after the original fieldwork in 1997. The field observations indicate an overall increase within the established plots for all rare plant species except *Townsendia montana* var. *minima*.

Exotic / Invasive Plants

Resource Management staff have been working on inventory and monitoring of non-native plant species off and on for the last 20 years. The first survey for Tamarisk was accomplished in 1980. The results of this survey and one from 1990 are reported in Downs (1991). These surveys covered east-side drainages in the northern portion of the park. Franz (1993) details the history of tamarisk control in Bryce Canyon National Park including pesticide use, locations/sites of plants, and the survey history within the park. In 1990(b), Schelz researched information and created binders for non-native plants found in Bryce at that time. This work included a discussion of non-native plants, recommendations for management, recommendations for treatment, a bibliography, and non-native plant contacts. In 1997(b), Ames-Curtis et al. initiated the first comprehensive survey for non-native plants in Bryce Canyon National Park. This effort included a park-wide inventory and the creation of a database for invasive plants. This database has allowed park to staff fully inventory and monitor non-native populations in the park and also monitor the efficacy of treatments. This database was entered into an Access format (DS-BRCA-0016) in 2001 by Bryce Canyon seasonal staff.

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Canyonlands National Park - Vegetation

General Plant Studies

Various well-known western botanists visited the Canyonlands National Park area in the late 19th and early 20th centuries. However, no in-depth study of the flora of Canyonlands National Park existed until the 1960's when Welsh and Moore (1965) published their annotated list of 234 vascular plants found in the Needles District of Canyonlands National Park and 92 vascular plant species found in Island-in-the-Sky Districts (Moore and Welsh 1965). Welsh (1970) also published a flora of Canyonlands in Great Basin Naturalist. The pre-grazing condition of the vegetation has been described anecdotally, but any scientific measurement or quantitative description is lacking from that period (pre-1880). Collections were also made along the Colorado River in Canyonlands during the hasty studies that preceded the building of the Glen Canyon dam and subsequent filling of Lake Powell. Some of this work was done within the boundaries of Canyonlands National Park but most was done in Glen Canyon National Recreation Area (Woodbury et al 1959).

Boschen (1985), a bio-technician with the park, put together a Canyonlands National Park plant list containing 429 species, based on his own observations and the work of Welsh and Moore. Belnap produced a plant list in the early 1990's (Citation unknown). Schelz refined it in 1997 and has issued an updated list every year since then (Schelz 1997, Schelz 2000b, and 2001a). In a conference proceeding from the Botanical Society of America, Tidwell et al (2000) reported on new flora from the lower Permian Cedar Mesa Sandstone near Canyonlands National Park. Currently, there are approximately 634 species listed for Canyonlands National Park (Schelz 2000b).

For the surrounding areas, Welsh (1984) prepared a flora of Glen Canyon National Recreation Area, Shultz et al (1987) published a flora of the Orange Cliffs adjacent to Canyonlands NP and Franklin (1988-citation pending) wrote a flora of the nearby La Sal Mountains.

The photographer E.O. Beaman was on board during Powell's second Colorado River expedition in 1872 and many of his original glass plates survive. These photos were taken primarily along the Green and Colorado River corridors but a few are in the uplands above the river. The historic and present vegetation along the Colorado and Green Rivers is currently being investigated by Belnap and Webb (personal comm. 1999), using Beamans' and other historic photographs. The Belnap and Webb study, of which a book is soon to be published, concentrates on the river environment without much analysis of the upland vegetation communities. Schelz, the SEUG Resource Botanist, has recently been funded for a two-year study to collect and analyze historic photos for historic vegetation change and to use these for the establishment of permanent vegetation photo points.

Detailed botanical work on vegetation within Canyonlands National Park progressed after Moore and Welsh in the 1960's when Kleiner and Harper (1972, Kleiner 1968) analyzed and compared the grasslands of the formerly grazed Chesler Park to the ungrazed Virginia Park in the Needles District. Virginia Park is considered a relict area, indicating that domestic livestock grazing never occurred there. Kleiner (1982,1983) also looked at successional trends in Chesler and Virginia Parks after a decade of his original measurements. This work has been continued and expanded by Belnap of the USGS Field Office in Moab.

W. Loope (1977) wrote his Ph.D. dissertation on the relationships of vegetation to environment in Canyonlands National Park and also produced a vegetation map that is presently used as the most detailed available. He described the vegetation from 157 plots located throughout Canyonlands and concluded that vegetation is strongly related to particular combinations of regolith thickness, bedrock composition, and depth to water table (W. Loope 1975, Loope and West 1977, Loope et al 1979). None of Loope's

plots were marked as permanent. Data from his studies is catalogued under DS-SEUG-065. More detailed vegetation mapping of Canyonlands National Park and environs has been funded and is scheduled to start in 2003.

A major turning point in the detailed analysis of the vegetation at Canyonlands NP came in 1987 with the establishment of the first permanent vegetation transects by Belnap (Graham and Belnap 1989, 1990). Transects had previously been established in 1983 by Kitchell and Conners but these were abandoned within 2-3 years due to faulty design (no report generated from this study). The Belnap transects were permanent as far as starting point but the exact location of the 100 quadrats per transect varied. Thus, the information from these transects from 1987 to 1996 contain high variability. The protocols were adjusted in 1997 by Schelz (Schlez and Whitham 1999) when all quadrats within each transect were permanently marked with nails that could be relocated easily with a metal detector. Permanent vegetation transects were installed in all the major plant communities in Canyonlands National Park and these have been monitored each year since (USDI 1990, 1991, 1993, 1993b; Schelz and Whitham 1999, Schelz and Moran 2002a, 2002b and 2002c). There are approximately 14 years of data.

Currently, there are 28 plots at Canyonlands National Park that are monitored annually. The data set (DS-SEUG-007.4) is the result of annual spring monitoring. Each transect consists of 100 (0.5m x 0.5m) quadrats, usually arranged in two lines of 50 quadrats each. In each quadrat, frequency and percent cover are recorded for each substrate type and each vascular plant species present. The data set consists of summary data for every year and raw data for individual quadrats from 1998 to the present. In Canyonlands, approximately 165 transect surveys in the Island in the Sky District were completed by the summer of 2001, 150 in the Maze District, and 80 in the Needles District. Each transect survey consists of a frequency record and cover record for each plant species and ground cover component present, on each of 100 quadrats. A transect may record over fifty plant species or as few as 8, together with 5-9 ground covers. The purpose is to provide baseline vegetation information, and to document vegetation trends and natural vegetation variability, in a variety of vegetation communities in Canyonlands National Park. Another goal for several of the transects is to document the vegetation recovery after fire and after almost a century of overgrazing.

Other grazing studies were completed by Parrish (date unknown), who compared the ecosystems and vegetation of a grazed grassland area and an ungrazed one in the Needles District of Canyonlands National Park. Rosenstock (1990) summarized the data he collected from two study plots in the Maze District of Canyonlands National Park, identifying small mammals trapped and soil and vegetation types. These ungrazed plots were used for comparison in a larger study he published on the effects of livestock grazing on small mammal fauna and habitats in Canyonlands and Capitol Reef National Park (Rosenstock 1996). Schafer et al (1992) studied vegetation patterns in three grasslands released from grazing pressure in Canyonlands National Park. The grassland pastures were released from grazing 25, five and one years prior to the study. Results suggested that species richness decreased as time from grazing release increased.

Schelz established 17 riparian transects in Canyonlands National Park between 1998 and 2000 (Schelz 2000c). The data set (DS-SEUG-008.2) is a result of late summer-early fall monitoring of thirteen transects in Salt Creek and 4 in Horse Canyon, both in the Needles District. Twelve of the transects in Salt Creek were re-measured in 2000 (Schelz 2001c). Plans call for riparian transects to be monitored every three to five years in the future. Data is recorded along a line-intercept perpendicular to the stream channel, and includes plant cover, plant heights, and soil substrate, including ages of biological soil crusts. The stream channel profile along the transect is surveyed at the time of each census. The data set (DS-SEUG-058) includes raw data for all transects and also raw, summary and comparison data in

spreadsheets, tables and graphs, as well as protocol descriptions, discussion of the purpose of ecological monitoring, and maps and photographs.

Another study paralleling the Salt Creek study summarized the total vegetation volume (TVV) along a controversial 4-wheel-drive road in Salt Creek, Needles District, Canyonlands National Park. Schelz initiated this study based on research in the southwestern U.S. that showed a high correlation between breeding bird densities and TVV. Schelz, Moran and Silva (2001) measured TVV at 40 sites along Salt Creek between Horse Canyon and Angel Arch Canyon during the fall of 2001, and measured the road area within the riparian zone along this same stretch. Sites were randomly selected and marked on a map before going into the field. In the field, a variation of a line-intercept method was used. A starting point was established by locating a point marked on the map, and two 20-meter tapes were laid out, following defined criteria designed to randomize line choices within the riparian zone but not include any road areas. Vegetation volume measurements were made every two meters along each of the two lines. A 7.5-meter collapsible surveyor's rod was held vertically at each point with the aid of a level. Each vertical decimeter section containing woody vegetation within 1 decimeter of the rod was called a hit. Height and plant species for each hit were recorded. A formula converts the data into TVV, with units of cubic meters per square meter. Schelz analyzed the results statistically, and found that the loss of vegetation due to the road indicates the displacement of 24-31 breeding bird pairs. The upper limit of the range includes vegetation volume represented by non-native tamarisk (*Tamarix ramosissima*); the lower limit excludes tamarisk from the TVV calculation.

Bunchgrass monitoring was initiated in 1994 in Canyonlands National Park. Data is derived from three locations in the Island in the Sky District of Canyonlands National Park in 1994, and at two locations in the Needles District in 1995 (DS-SEUG-011). The three sites at Island in the Sky have similar soils, receive similar moisture, and are occupied by similar grassland communities, dominated by needle and thread grass (*Stipa comata*) and Indian millet (*Stipa hymenoides*), though their grazing histories vary. Gray's Pasture was last grazed in 1964, Red Sea Flat was last grazed in 1976, and Big Flat, located immediately outside the park boundary on Bureau of Land Management land, continues to be grazed. The two Needles sites were both grazed until 1975. At four of the five locations, two transects have been established, ten meters apart. The fifth location has just one transect line. Each line is 150 meters long and marked with rebar at either end. The transects are monitored yearly in late spring. A tape is stretched between a pair of rebar, and a meter-square and quarter-meter square quadrat is nested with a corner of each at every fifth meter, for a total of 30 quadrat sets along each transect. Each quadrat has two corners that are permanently marked with nails. Bunchgrasses are counted and rated on a 1-3 scale for vigor within the square meter quadrats. Additionally, within the smaller quadrats, other grasses (non-bunchgrasses) are recorded using the 1-6 Daubenmire cover classes. Spreadsheets list grass data from each year for a total of 61 transects measured by 2001. Each transect measured has up to 23 entries for each of 30 quadrats along the transect line. The purpose is to compare recovery rates between areas with different grazing histories. The Needles sites allow a look at change through time in the boundaries of native bunchgrasses and non-native grasses in formerly grazed areas.

In 1990, Schelz and Van Pelt (1990) surveyed and photographed relict areas in Canyonlands National Park and in other parks in the northern Colorado Plateau of southern Utah and western Colorado. In these parks there are a number of areas of pristine plant communities located on buttes, mesas or canyons which are generally remote and/or steep-sided enough to have prohibited access by cattle and roads.

A cooperative agreement between the National Park Service and The Nature Conservancy resulted in a multi-faceted study to locate, survey, and photograph these relict areas (Van Pelt et al 1991). The purpose of the study was to establish long-term photo-points, learn about these rare relict areas, and to foster their

preservation, in part by applying for natural area designations for the best of them, especially for those with vegetation types not already represented in existing natural areas. The dataset (SEUG-DS-023.1) includes descriptions of each relict area's geologic and physical setting, application of a comprehensive vegetation-type classification, and a plant species list, usually from a one-day survey of the area, as well as location descriptions and maps. All of these are contained in volumes organized by park or groups of parks. The introduction contains descriptions of methods for the various aspects of the dataset and for two other datasets generated by this study, nested frequency vegetation data (dataset pending) and repeatable photography from permanent photo stations (DS-SEUG-024.1).

In 1993, Rowlands et al (1993) proposed setting up long-term ecological monitoring plots based on relict areas within select parks of the Colorado Plateau, including Canyonlands National Park. This program was never established. Schelz has re-taken the photos at a number of the relict areas in Canyonlands National Park in 2002 and will continue the project in 2003.

A number of unique environments in Canyonlands National Parks have been surveyed though no permanent plots have been established. Studies of these unique environments include hanging gardens (Dolan et al 1992, Fowler 1993, 1995, Fowler et al 1995, Hartman et al 1993, May et al 1994, May and Hill 1998, Spence 1997, Stanton 1995, Stanton et al 1991, 1995, 1995a, and van Riper et al 1995), Douglas fir (*Pseudotsuga menziesii*) stands (Bosquet 1991, Penland 1987, Schwartz 1992, 1994, Shelz and Van Pelt 1990, and Spence 1994 and 1994a), and aspen (*Populus tremuloides*) stands (LeCavalier 1988 and Schelz and Van Pelt 1990). Data from the Spence 1997 study is catalogued under DS-SEUG-073.2.

There is also a large body of literature devoted to studies of cryptobiotic soils, primarily by Belnap and her colleagues (Anderson and Rushford 1976, Anderson et al 1982, Barr et al 1999, Belnap 1990, 1993, 1995, Belnap et al 1991, 1993, 1994, 1997a, 1997b, 2001a, Belnap and Gillette 1997, Belnap and Hill 1998, Campbell 1976, 1979, Davidson 1995, Davidson et al 1999, Harper and Belnap 2001, Johnston 1995, Kleiner et al 1977a, Lange et al 1996, 1998, Phillips and Belnap 1998, and Steppe et al 1996).

The blackbrush (*Coleogyne ramosissima*) has been an extensively studied plant in and around the park. From 1991-1993, Pendleton and his colleagues (Pendleton et al 1992, 1995, 1995a, Pendleton and Meyer 1994a, 1994b and Pendleton and Pendleton date unknown) began a series of long-term studies on blackbrush biology, establishing study sites across a large portion of the shrub's range. They examined blackbrush reproduction and recruitment through studies of factors influencing flowering and fruit set, pollination, seed germination, and seedling emergence, survival and growth rates. Other studies looked at population size and structure and community relationships. Seeds were collected from 30 locations from southeastern Nevada to eastern Utah. Seedling caches were examined for seedling emergence and survival studies. Fifteen long-term sites were used for studies of flowering, fruiting and community structure. Results of these studies indicated that blackbrush is wind-pollinated, and that moderate to heavy winter precipitation induces flowering. They found blackbrush to be a mast fruiting species with size of fruit crop a function of available stored resources, not simply precipitation history. Seed dormancy appears to be reduced by summer and fall rains and completely ends with winter chilling. Blackbrush has evolved ecotypes, at least for germination and establishment ecology, determined by a seedling experiment at Arches National Park and a site at Hurricane, Utah. Many seeds sprout from rodent caches with seedlings more likely to survive outside of a mature blackbrush stands, indicating that mature stands limit available resources. Finally, they found blackbrush rarely reestablishes after fire.

Meyer and Pendleton (date unknown) published their findings on blackbrush populations within Arches and Canyonlands National Parks, including flowering, seed production, seed dispersal, germination,

seedling emergence, and plant growth. The National Park Service (USDI 1988) has photographs showing seedling plots in a project to plant and grow blackbrush seedlings on newly constructed road shoulders in the Island in the Sky District of Canyonlands National Park. Hughes and Weglinski (1990) discussed the problems in reestablishing blackbrush in disturbed areas, with a two-year study evaluating the effectiveness of mound layering, stem cuttings, and rooted cuttings, with and without supplemental watering, as methods of propagation of blackbrush for use in revegetation in Canyonlands National Park.

Concern for the juniper populations in Canyonlands sparked a number of studies.
Weber and Nelson (1991, 1994 and 1994a) summarized an ongoing study of seven transects of Utah juniper (*Juniperus osterosperma*) in Natural Bridges National Monument to determine the cause of extensive foliar damage to these trees in southern Utah. After six months the authors concluded that the cause was not related to soil and plant factors and still unknown. Although the study was extended during the following season to include comparison sites in Canyonlands National Park, the cause was still not clearly identified. Increased moisture during the second season, however, coincided with a decrease in dying trees, which suggested some correlation with soil moisture and perhaps soil salinity.

In the proceedings from a symposium on wildland shrub and arid land restoration, Weber et al discussed juniper (*Juniperus osteosperma*) decline in Natural Bridges National Monument and Canyonlands National Park (Roundy et al 1995). Foliar damage on Utah juniper has been observed for several years from southeast Nevada across southern Utah and into southwest Colorado. Distal ends of branches become chlorotic and die, with damage moving up the branches. To examine the causes of damage, the authors created reference transects of 40 junipers each in Natural Bridges National Monument and Canyonlands National Park. They sampled and analyzed plant tissue and soils, and examined organisms on the trees. Diseases were not uncommon, but were not consistently associated with the twig tip die back. The decline did not correlate with any single soil element. Annual rainfall patterns did appear to correspond to the twig die-off. The authors suggested that the decline could be due to a combination of drought and temperature stress, which reduces water availability and increases the uptake of salts by the trees.

Lammers (1991) conducted a soil survey of the Canyonlands area including parts of Grand and San Juan counties for the USDA, Soil Conservation Service. The document consists of a general soil map including the Needles and Island in the Sky Districts of Canyonlands National Park. The region defined is divided into 57 areas, and a detailed soils map is provided for each. Different soil areas on the detailed maps are numbered, and described in detail in the accompanying report. Each description of individual soil types includes characteristics, example locations, permeability, human and wildlife uses of areas with this type of soil, general plant communities, suitability for rangeland seeding, and principal crops grown.

There are many studies concerning vegetation as habitat for birds and mammals in Canyonlands. Armstrong (1974) studied the vegetation composition and structure on the distribution of various species of wood rats (*Neotoma*) in the Needles District of Canyonlands, and also studied the microhabitat of 14 rodent species to determine what habitat descriptors apply to the rodent fauna (Armstong 1979). Johnson (1976) completed a M.S. degree on populations of small mammals on isolated buttes in Canyonlands National Park. He studied the mammal and plant populations on two isolated, island-like buttes (Jug and Junction Buttes) in Canyonlands National Park to determine species richness, density, niche space, and morphological characteristics in comparison to their mainland counterparts on the Island in the Sky mesa.

Hull (1984) completed a M.S. thesis on the seasonal nutrition of desert bighorn sheep in Canyonlands National Park, Utah. His analysis of nutrient content included dry matter, crude protein, in-vitro digestibility, cell wall content, phosphorus and calcium present in seasonal forages eaten by desert

bighorn in Canyonlands National Park. Robins and Journet (1992) studied the bird species present in the pinyon-juniper community in the Island in the Sky district of Canyonlands National Park. A report by Edwards et al (1993) concerned gap analysis, a theory relating the distribution of terrestrial vertebrate species to the synthesis of wildlife habitat data. Long-term data from Canyonlands were utilized to test this theory. Sweanor et al (1995) performed a bighorn sheep habitat assessment for the greater Canyonlands and Arches National Park area to identify patches of sheep habitat adequate to maintain a minimum viable population of 125 sheep.

There are a few studies that concern the effects of air pollution on the vegetation communities in the park. Sanchini (1983) established study sites at Canyonlands National Park and Glen Canyon National Recreation Area to determine air quality values associated with various plant species in order to provide baseline information for future sampling of plants with sulfur dioxide (SO2) injury.

Due to concerns about the potential impacts of sulfur dioxide and sulfates from various regional sources, Gladney et al (1993) analyzed total sulfur content in pinyon pine foliage and nearby soils as a baseline against which to assess sulfur accumulation in similar samples taken at a future date. Binkley et al (1997) summarized the key features of air quality and potential impacts of air pollution on plants and aquatic ecosystems in Canyonlands and eight other Class I air quality areas within the Colorado Plateau.

There have been several large studies devoted to ecological characterization and ecosystem processes. Van Pelt (1978) completed a M.S. thesis on woodland parks in southeastern Utah that included sites in Canyonlands. A book entitled Temperate Deserts and Semi-Deserts contains a chapter on the Southeastern Utah Galleta-three awn shrub steppe (West 1983). West describes the ecosystem type that occurs in the vicinity of the confluence of the Green and Colorado rivers in Canyonlands National Park as desert grassland with occasional shrubs on deep sandy soils, and also identifies the physical, biological, and human components of this ecosystem.

Cole (1998) submitted a research proposal on global change that would possibly involve collection of materials from Canyonlands National Park. Data on changes in the distribution of vegetation would be based on analysis of material from packrat middens, palynological data from lakes, rephotography of historical sites, and sampling of vegetation plots. These data would then be used to constrain computer models of past climates and their effects on vegetation. It is unknown if this study has been funded.

In a conference proceedings entitled, “Ecological characterization of the Canyon Country region: A basis for sustainable land management” Tuhy and Graham introduced the Canyon Country Science Committee, made up of agency and organizational scientists within the canyon country of southeastern Utah and westernmost Colorado (Hill et al 1998). The committee designed an ecological characterization study to acquire ecological information on the composition and functioning of the land in order to be able to manage it sustainably with the stresses of increased tourism and traditional uses. Phase one of the study will involve defining biophysical environments and modeling potential natural vegetation, within a pilot area of San Juan County, Utah, know as the Canyon Country Ecological Research Site. Later stages will involve defining landscape units, ranges of variability, and predictive modeling regarding vegetation and landscape changes.

Prompted by a closed-road controversy, a national team was brought in to evaluate how well the physical processes are functioning in a section of Salt Creek, Canyonlands National Park (Elmore et al 2001). They used a standardized assessment for proper functioning condition (PFC), which considered attributes of hydrology, vegetation, and erosion/deposition. PFC indicates a resilient state that reliably holds a riparian-wetland area to together during flooding events. The authors reviewed information and aerial

photos before visiting the site, and defined five reaches at Salt Creek, the middle three of which were involved in the study. The upstream of these three reaches has no roads, the middle reach has a road closed since 1998 and at the center of controversy, and the lower reach currently has an open 4WD road in it. The assessment team visited Salt Creek May 21-25, 2001, observed functional characteristics and completed checklists included in the report appendix.
Based on their analysis, they rated the lower reach as "functional - at risk with no apparent trend (recent years)", the middle reach as "functional - at risk with an upward trend," and the upper reach as PFC. They emphasize that PFC is a physical prerequisite to biological health, and that its assessment can complement but not replace biological monitoring. They advised Canyonlands National Park to include the entire wet portion of Salt Creek in any analysis for management and to remove vehicle use from Salt Creek if they choose PFC for the creek over easy access to Angel Arch.

Finally, a large portion of the literature for Canyonlands National Park concerns resource management. L. Loope (1974) compiled a descriptive report on the flora and fauna of the national parks of the southeast Utah desert canyonlands, with recommendations for management and planning to preserve these resources.

Kleiner et al (1977) studied the occurrence and soil characteristics of four major perennial grasses (Galleta, needle and thread, sand dropseed, Indian ricegrass) in a pristine grassland area of Canyonlands National Park, with a view to possibilities for improved future land use practices.
Paddock (1978) described a field study of three river bottom burn sites in and adjacent to Canyonlands National Park. The purpose of the study was to examine the effects of fire on river bottom vegetation, to compare vegetation re-growth on burn sites with existing vegetation to non-burn sites, and to note which vegetation returns to burn sites and which does not. Kitchell et al (1989) proposed to designate Virginia Park, in the Needles District of Canyonlands National Park, as a Research Natural Area to allow for management actions necessary to protect the area as well as to encourage research activities in this unique habitat type. The proposal is in response to increasing visitation in Canyonlands National Park, the need for an undisturbed Galleta grassland of the southeastern Utah shrub steppe, and the research history of this grassland.

The National Park Service (USDI 1993a) conducted an environmental assessment for backcountry management plan for Canyonlands National Park and the Orange Cliffs Unit of Glen Canyon National Recreation Area. It included various alternatives, with discussion of the environmental consequences of each. There are sections on vegetation, water, wilderness, wildlife and more.

Goldberg (1993) completed a M.S. thesis on the revegetation of a disturbed, semiarid grassland in Canyonlands National Park. The study site was in a section of the Needles District of Canyonlands National Park severely disturbed by road construction. The author investigated the effects of various soil treatments on *Stipa comata* seedling establishment and the relative colonization of vesicular-arbuscular mycorrhizae fungi (VAM) on Stipa.

Mitchell and Woodward (1993) conducted a study on the effects to aquatic and riparian organisms by humans in Arches National Parks and two other Colorado Plateau parks from 1990-1992. They studied small mammal, bird, plant, and aquatic organism distributions and patterns of abundance with respect to human travel systems in the parks and included management recommendations and sampling protocols for the future.

Rowlands (1994) produced a manual that presented a vegetation classification system developed for use in the Colorado Plateau park units, and addressed various concerns involved in planning and carrying out

a vegetative assessment. Appendices include information on field techniques, calibrating cover estimates and preparing herbarium specimens, as well as sample field forms. It is unclear if Colorado Plateau network parks are currently following these protocols.

In the proceedings of the second biennial conference on research in Colorado Plateau National Parks, Spence et al report on a new hierarchical and open-ended vegetation classification system which can be applied to any region of North America (van Riper et al 1995a). The levels in the hierarchy, from broad scale to fine scale, are biogeographic realm, floristic province, climate-elevation zone, plant formation, series, and association. A preliminary classification of the vegetation for the Colorado Plateau was presented at the series level. Thompson and Potochnik (1998) reported on the vegetation community of river terraces along the Colorado River in Cataract Canyon in CNP to provide a pre-dam analog for the Colorado River in Grand Canyon.

Threatened, Endangered or Sensitive Vegetation Studies

Heil (1979) published an account of three new species of Cactaceae from southeastern Utah. Descriptions included two species of fishhook cactus including the Canyonlands fishhook cactus *Sclerocactus contortus* Heil, found in Canyonlands National Park, and a hedgehog cactus (*Pediocactus*).

Anderson (1983) conducted a survey and compiled an inventory of rare plants from the Needles District of Canyonlands National Park. Rare plant surveys were also conducted in 1991-92 by Heil et al (1993) who documented the status and extent of a number of species, together with maps of population locations. While they did find a number of sensitive plant species, they did not find any federally listed threatened or endangered plants. As part of the survey, two permanent study plots were established for the sensitive species, Jane's globemallow (*Sphaeralcea janeae*) and monitored in 1991-92. All individuals were tagged with metal markers placed in the ground and buried, with their size and reproductive success recorded. These plots have not been re-visited since 1992.

Vanderbuilt (1990) compiled information on twenty-three sensitive plant species in the Southeast Utah Group. Floyd-Hanna (1993) detailed monitoring fieldwork on populations of the Arches biscuitroot (*Lomatium latilobium*) and Jane's globemallow (*Sphaeralcea janae*) in Arches and Canyonlands national parks. From 1999 through 2002 Schelz has maintained a list of sensitive species in the Southeast Utah Group (Schelz 2001d).

Invasive / Exotic Species Studies

Tamarisk (*Tamarix chinensis*), an exotic plant from Eurasia, has been the focus of much of the exotic plant control and monitoring work in Canyonlands National Park. Supported by the National Geographic Society, Graf (1976 and 1978) researched the impacts of tamarisk on channels and near-channel landforms along the Green River above its confluence with the Colorado River. The stretch of river included Labyrinth and Stillwater canyons, the lower half of which lies within Canyonlands National Park. Using historic photographs coupled with repeat photos and field measurements for reference distances, the author confirmed that sand bars and islands have stabilized and increased in size, and that the width between banks has been constricted an average of 27 percent by tamarisk growth. The constricted channel results in over the bank flooding at lower water levels. Tree-ring data revealed that some tamarisk were as old as 50 years, that climate change didn't play a significant role in the geomorphologic changes, and that large cottonwood trees pre-dated the tamarisk incursion of 50 years

ago. The author's calculations indicated that tamarisk in this stretch of river transpire approximately two percent of the total discharge of the Green River through Canyonlands and that tamarisk spread at an estimated rate of approximately 20 km/yr.

Brazell (1977) studied increasing tamarisk and decreasing willow populations on beaver abundance and distribution in Canyonlands. Collins and Belnap (1987) discussed control and mapping efforts of tamarisk in Horseshoe Canyon. Thomas et al (1987) described previous and current efforts to control tamarisk from Canyonlands and Arches National Parks and Natural Bridges National Monument, together with proposals for future efforts. Schelz (1988) wrote a report on tamarisk control in Horseshoe Canyon. He set up five permanent transects and took a number of photos to monitor vegetation change using a line-intersect method that ran perpendicular to the stream channel. The data from this work, however, has been lost. In a conference proceedings on tamarisk control in southwestern United States (Kunzmann et al 1989), Thomas and Kitchell summarized the tamarisk control efforts in Canyonlands and Arches National Parks and Natural Bridges National Monument.

W. Loope (1978) described the vegetation zones in Canyonlands National Park with a summary of locations and origins of disturbed sites; general observations about plant succession in arid areas, assessments of the revegetation potential of different plant types, and recommendations on how to proceed with revegetation efforts.

Graham and Hill (1998) surveyed parts of southern Utah, including areas in or near Canyonlands National Park, in the summer of 1997 to compare populations of grasshoppers in native grasslands with those in areas dominated by nonnative grass species. The surveys are part of a preliminary investigation into interactions between grasses, insect herbivores, and insectivores on the Colorado Plateau. Further information from this study is expected in the future, to provide assistance in management decisions for areas set aside to protect native species and natural communities. Little information is currently available regarding pressures on native perennial grasses from changes brought about by exotic species. Data from this study is catalogued under DS-SEUG-059.

Cheatgrass (*Bromus tectorum* L.) is another invasive plant that is well represented in the Canyonlands literature (Rawlings et al 1997, Miller et al 1999 and 2000). Hanson (1999) completed a Ph.D. dissertation on cheatgrass invasion in relation to phosphorus sources and availability in Canyonlands National Park, Utah. Miller (2000) also completed his Ph.D. dissertation on the effects of resource manipulations and soil characteristics on cheatgrass (*Bromus tectorum* L.) and bunchgrass (*Stipa hymenoides* R. & S.) in calcareous soils in Canyonlands National Park.

Budelier and Torrence, bio-technicians at Canyonlands National Parks, have both been involved with exotic plant mapping and control, Budelier from 1997 to 2000, and Torrence from 2001 to the present. Their mapping work is primarily GPS-based (Geographic Positioning System) and products can be found in the Geographic Information Systems (GIS) office at Canyonlands National Park. Their dataset is catalogued under DS-SEUG-046, DS-SEUG-049.1 and DS-SEUG-072.2.

A number of studies have looked at various control methods and soil-plant interactions of exotics in Canyonlands (Belnap et al 2001b, Evans and Belnap 1995, Gelbard 1999, Graham 1985, Loope et al 1988, and Sperry et al 1998, 1999, 2000). None of these studies have developed long-term monitoring plots.

Schelz and Budelier (2000) compiled a list of exotic plants in the Southeast Utah Group, including Canyonlands National Park. Schelz et al (2002) presently maintain the list.

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Data Sets

DS-SEUG-007.4 Frequency and cover of plant species and substrate on Long-Term Monitoring Program vegetation transects in SEUG parks

Canyonlands National Park - Vegetation

DS-SEUG-008.2	Riparian vegetation data, substrate data, and stream profiles, Arches and Canyonlands National Parks, 1998-present
DS-SEUG-011	Bunchgrass monitoring, Canyonlands National Park
DS-SEUG-023.1	Relict vegetation site descriptions, NPS units on the northern Colorado Plateau
DS-SEUG-024.1	Slides from permanent photo stations at relict vegetation sites on the northern Colorado Plateau
DS-SEUG-046	Records of revegetation projects and revegetation monitoring, Canyonlands National Park
DS-SEUG-049.1	Exotic plant control records, location data maps, Southeast Utah Group
DS-SEUG-058	Total vegetation volume in the Salt Creek riparian zone, Canyonlands National Park
DS-SEUG-059	Potential biological control of tamarisk: Investigation of interactions between Tamarix ramosissima and the grasshopper Schistocerca shoshone
DS-SEUG-065	Vegetation transects and mapping in Canyonlands National Park, 1972-1975.
DS-SEUG-072.2	Lake Mead Exotic Plant Management Team treatment records, 1997 - present
DS-SEUG-073.2	Hanging garden vegetation and water surveys, Arches and Canyonlands National Park, 1998

Capitol Reef National Park - Vegetation

General Plant Studies

Capitol Reef National Park lies in a portion of the Colorado Plateau that has been relatively poorly explored and studied botanically (Heil et al. 1993). Floristic studies conducted in the general region include the San Rafael Swell (Harris 1980), Henry Mountains (Stanton 1931, Everitt 1970, Neese 1981), Uinta Basin (Goodrich and Neese 1986), Natural Bridges National Monument (Welsh and Moore 1968), Arches National Park (Harrison et al. 1964), Canyonlands National Park (Loope 1977, Welsh 1970), and Glen Canyon National Recreation Area (Tuhy and MacMahon 1988). During the 1970s and 1980s, general surveys for vascular plants in Capitol Reef documented 759 species of plants (Heil et al. 1993). General observations by park staff during surveys and other resource management work in the 1990's added 46 plants bringing the current park total to 805 species (DS-CARE-00012).

There is very little general vegetation monitoring going on at the park. Because grazing was widespread throughout the park, several exclosures were established in the 1988 to study the effects on vegetation. Vegetation data in the exclosures was gathered only two or three times before cattle were removed from some allotments in the 1990s. No analysis or additional data gathering has occurred on these plots since that time. In the early 1960s numerous trend/utilization/photo plots were established by BLM on lands that were added to the park in 1969. The plots have been read every year by BLM or park staff and the data is used by BLM for their allotment management planning (DS-CARE-0019, DS-CARE-0020, DS-CARE-0021).

Threatened, Endangered, or Sensitive Plant Studies

There are a large number of listed, endemic, and/or rare plant species that occur on Capitol Reef. Early work on these species simply documented presence and was done in conjunction with general surveys discussed previously (Camp 1978, Heil et al. 1993). The first study specifically addressing rare plants was done to document their occurrence in grazing allotments and to evaluate the effect grazing has on the species (San Juan College 1994). Several new localities were discovered and anticdotal information was described on cattle trampling for three species. In 1996-97, the park received a two-year Canon grant to survey for rare plants in the heavily used headquarters area. Several new localities were found for the six species studied and numbers, habitat characteristics, and distributions were identified. For five of the species, monitoring plots were established to determine if visitors were impacting the species and to gather some basic life history information (Clark 1997, 1998b, Clark and Clark 1999, DS-CARE-0009). In 1997-98, BLM and the park funded a joint survey team to inventory Despain’s cactus and Winkler’s cactus, which occur on both agencies land (Clark 1998a, 1999a). A general life history plot was established for Winkler's cactus in 1995 and four monitoring plots for both species were established in 1999 on the park and BLM land to determine if grazing is effecting these species (DS-CARE-0009). Because Capitol Reef and surrounding BLM and FS lands have so many rare endemic plants, the agencies developed an Interagency Agreement in 1999 to hire and fund an interagency botany technician position. In 2000, the park received an NRPP-funded three-year project to survey the entire park for 31 of the rarest species known to occur at Capitol Reef. BLM, the two National Forests, Utah Native Plant Society, and the Capitol Reef Natural History Association added additional funds to support the project and expand the surveys to include adjacent habitats. By the end of FY02, survey and distribution work for these rare plants will be completed on all the agencies lands (DS-CARE-0010). Using this distribution information, monitoring protocols can be developed and plots can be established in appropriate locations.

Other relevant studies and sources of information

Endowments through the Center of Plant Conservation have been established for three species that occur on the park. Two endowments were established for cactus species by Capitol Reef through the Red Buttes Garden. This money will help fund genetic seed bank storage to prevent extinction of these species and to fund basic monitoring. An endowment for *Gilia caespitosa* helped fund basic life history and monitoring work through the Denver Botanic Garden (Dawson 1998). Utah Valley State College and Brigham Young University professors (Van Buren 1999, Van Buren and Harper 2000) are doing additional monitoring looking at life history of Maguire's daisy.

Vegetation Studies

The vegetation of CARE has been classified into 34 community types using plant assemblages identified from 344 sampling plots (Heil et al. 1993, DS-CARE-0023)). The types were crosswalked to the system developed by Brown, Lowe, and Pase (Romme et al. 1993). In 1997, park staff began mapping the vegetation types developed in these studies. This mapping effort has been folded into the NCPN vegetation mapping program and should be completed in about two years. In the 1980's, several Congressionally mandated projects began to study the effects of grazing on park resources. Barth and McCullough (1988) analyzed the effects of current and historic livestock grazing on riparian vegetation in CARE, and Welsh (1988) described the riparian vegetation along the Fremont River in the context of an assessment of a proposed water development upstream. Fisher et al. (1991) and Cole (1991) have reconstructed changes in grassland and woodland vegetation that occurred during the last several centuries. They found that major changes in species composition and abundance had occurred since the time grazing began in this area. Other vegetation research in CARE includes studies of the effects of soil microphytic crusts on erosion (West 1990, Williams et al. 1995) and of plant community dynamics in waterpockets (Haefner and Lindahl 1988, 1991; Lafrancois 1995, Baron et al. 1999).

Invasive or Exotic Plants

At least 78 of the 805 plant species in Capitol Reef National Park are exotic species and Wayne County classifies 13 plants as noxious weeds. Russian olive (*Eleagnus angustifolia*) and tamarisk (*Tamarix ramosissima*) are widespread tree species and are associated with virtually all of the riparian and wetland areas of the park. Cheatgrass (*Bromus tectorum*) and halogeton (*Halogeton glomerulus*) are found throughout the park but are especially prevalent in disturbed areas. Many exotics are associated with the Fruita Rural Historic District and are maintained as part of the historic pastures and orchards. Tree-of-heaven (*Ailanthus altissima*) is an ornamental plant present in the historic district but is actively being removed because of destructive impacts to historic resources.

Anecdotal information from long-time CARE employees describes removal of tree-of-heaven within the Fruita Valley in the mid 1970s. All but six large trees around a historic residence were removed. These trees served as a seed source for the subsequent reinfestation of the valley. The first written proposal to do exotic plant control in Capitol Reef was a May 1978 Environmental Assessment to do tamarisk control along the Fremont River. The project was not implemented due to lack of funds. In the mid 1980s, inventory and some control work was done for tamarisk and Russian olive on the Fremont River and Sulphur Creek (Henderson and Lichthardt 1985, Pistrang 1987, DS-CARE-0028). There were an estimated 800 trees and 1200 saplings of Russian olive in this area. Russian olive trees were removed from Sulphur Creek and much of the Fremont River in 1988-89 but little information is available about the success of the treatment. Three large trees in the housing area were left as ornamental and served as a source to reinfest Sulphur creek. Recent surveys by volunteers and staff within the Fremont River canyon document tamarisk and Russian olive cover values exceeding 27 and 8 percent respectively. Russian

olive tree numbers are increasing rapidly with numerous small trees throughout the canyon and are visually the dominant plant species in several areas.

Since 1996, control efforts have concentrated on removal of tree-of-heaven and on Russian olive in Sulphur Creek upstream of housing. In 1998, the Lake Mead Tamarisk Team spent one week at Capitol Reef removing tree-of-heaven and Russian olive in these areas. Subsequent efforts have been sporadic primarily using volunteers, but has prevented further expansion of these species in those locations. In addition, tamarisk was removed from Hall's Creek Narrows in 2000 and resprouts have been treated yearly.

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Cedar Breaks National Monument – Vegetation

General Plant Studies

There are two early ecological studies in the literature at Cedar Breaks National Monument. Siebert (1924) completed her M.S. thesis on an ecological study of the alpine zone of Cedar Breaks from the University of Chicago. Eardley and Viavant (1967) reported on the rates of denudation of the bristlecone pines (*Pinus aristata*) directly north of Cedar Breaks National Monument.

Jean (1990a) completed her M.S. thesis on the reproductive ecology and distribution of clonal subalpine tree-islands in Cedar Breaks National Monument, Utah. The thesis examined the community dynamics of the subalpine zone within Cedar Breaks National Monument, based on the distribution and reproductive ecology of spire-shaped sub-alpine fir (*Abies lasiocarpa clonal*) subalpine tree-islands. Jean also documented the site numbers, elevation, position, parent material/texture, habitat and comments related to endemic plant distributions, together with maps of the site areas (Jean 1990b). Sharpe et al (1990) published their pollen analysis from the North Point site, Cedar Breaks National Monument, Utah in Quaternary Geoarchaeology, Northern Arizona University.

Of all the taxonomic groups for which inventory and monitoring is needed at Cedar Breaks National Monument, the only group that approaches or meets the 90% level is vascular plants. Although adequate work on the presence or absence of plant species has been completed, additional work is needed on the relative abundance of species, especially as it relates to the inventory and monitoring of special concern and non-native species. Palmer (1980), a Southern Utah State College professor, compiled a checklist of the flowering plants in Cedar Breaks National Monument that was revised by Johnson and Palmer (1987) who also indicated general habitat and commonality. Malm (1987) compiled a detailed plant identification guide of the plants of Cedar Breaks with notes on identification, interpretation, illustrations and a glossary.

There are also two wildflower books published by the Zion-Bryce Natural History Association. Jepson and Allen (1958) compiled a checklist of wildflowers in a book entitled Wild Flowers of Zion and Bryce Canyon National Parks and Cedar Breaks National Monument. The book documents five life zones from low elevations near 3,600 feet to extremes over 11,300 feet: the Lower Sonoran Zone, the Upper Sonoran Zone, the Transition Zone, the Canadian Zone, and the Hudsonian Zone. Native plants typical of deserts, mesas and mountains grow within these extremes of elevation and include a wide variety of species. Of the three areas featured, Cedar Breaks National Monument contains the greatest variety, and frequently exhibits marvelous displays, depending on the amount of rainfall from year to year.
A book by Buchanan (1974) entitled, Living color: Wildflower communities of Bryce Canyon and Cedar Breaks, provides a checklist of the wildflowers in Cedar Breaks divided into low elevation, dry breaks, sagebrush communities, forest types, and subalpine communities.

Two studies from the Cedar Breaks literature concern lichens. Smith (1994) completed a M.S. thesis on the corticolous lichen flora of Cedar Breaks National Monument and surrounding areas on the Markagunt Plateau, Iron County, Utah. The thesis includes previous lichen studies and original lichen research from the west face of the Markagunt Plateau. Also included is a key to the lichen genera. St. Clair and Smith (1994) established an air quality baseline and lichen biomonitoring program at Cedar Breaks National Monument. The report details the following; identification of three reference sites within Cedar Breaks, collection, curation, and identification of lichen species, identification of 3-5 pollution-sensitive lichen species at each reference site,

and the determination of baseline thallus concentrations of twenty potential pollutant elements at each reference site.

The remaining literature concerns vegetation long-term monitoring. Shelz and Van Pelt (1990) established long-term photographic stations for monitoring community change in Cedar Breaks National Monument. Van Pelt et al (1991) reported on this multi-faceted study to locate, survey and photograph relict vegetation areas on the northern Colorado Plateau. They described the sites located within Cedar Breaks National Monument, Colorado National Monument, Black Canyon of the Gunnison National Park, Curecanti National Recreation Area, Mesa Verde National Park, and Dinosaur National Monument. A section for each relict site describes the geologic and physical setting, applies a comprehensive classification of Colorado Plateau vegetation types to the site, and includes a vascular plant species list. The report includes discussion of regional significance and suggestions for management and future surveys, and lists that Colorado Plateau vegetation types are included in the sites and which are not included. Detailed description of field methods for various aspects of the study, as well as descriptions and maps of locations are included.

Threatened, Endangered, and Sensitive Plant Species

A report by the Arizona Willow Interagency Technical Team (1995) contains a conservation agreement for the Arizona Willow (*Salix arizonica*) thought to be an endangered plant, which was recently discovered growing in and around Cedar Breaks National Monument. Voucher specimens were collected for all populations located within Cedar Breaks and adjacent Forest Service administered lands and deposited in the BYU herbarium. Field work for Arizona willow was completed by Atwood, Rodriguez and two graduate students as part of the baseline data for development of an Interagency Conservation Agreement and Strategy.

Roberts and Jean (1999) conducted a plant community study on rare and exotic species distribution and dynamics in Cedar Breaks National Monument. The report gives a comprehensive classification of the vegetation of Cedar Breaks National Monument, the habitat types and composition of the plant communities. The survey met the Level 1 standard (minimum level) at that time, and identified 269 vascular plant species within the Monument.

Welsh (date unknown) reported on the endangered and threatened plant species of the southern coal lands in Utah including a detailed listing of endangered plants and their habitats from Cedar Breaks National Monument.

Exotic and Invasive Plant Species

There is no literature concerning these species at this time.

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Colorado National Monument – Vegetation

General Plant Studies

Several studies and reports falling in the realm of general vegetation management concern microbial crusts, damage due to insect pests and the effects of bison in the Monument.
Grondin and Johansen (1993) published their findings on microbial spatial heterogeneity in microbiotic crusts in Colorado National Monument. Visually similar sites under Utah juniper canopy in Colorado National Monument were examined for the natural distribution patterns of the plants. The authors studied the floristics of the soil algal community in the pinyon-juniper community in order to estimate the algal heterogeneity within what one would consider, in the field, to be identical sites. Wheeler et al (1993) also studied the microbial spatial heterogeneity in microbiotic crusts in Colorado National Monument. Homogeneous sampling sites under Utah juniper canopy in Colorado National Monument were examined for the natural distribution patterns of the plants and for bacterial density and taxa composition. Samples from adjacent areas showed no more similarity to each other than did more widely separated samples.

Graham (1988) documented single-leaf ash tree (*Fraxinus anomala*) damage by the true bug *Tropidosteptes* sp. (Hemiptera: Miridae), and correlated the degree of damage with the nearness of trees to park roads.

From 1975-1977, Wasser (1977) conducted a study on the interrelations of bison and their canyon habitats to determine if bison induced any destructive impacts and how the nutrient status and the climate of Colorado National Monument affect the bison. Colorado National Monument has a report on the impact of bison on the vegetation in the Monument, together with approximately 100 color prints of plots in the range formerly grazed by bison (Author unknown 1984). It is unclear if this is part of a continuing study of the recovery of the vegetation in the area.
A project was initiated to support an evaluation of the grazing impacts, condition and recovery potential of the bison range on the Monument. In 1985, a vegetation map and database of 911 sites were completed with cover and density data collected for 317 sites. 233 strata were identified in 14 vegetation types. The data are catalogued under DS-COLM-0003.

Plant checklists were initiated in the early 1980's. The vascular flora record includes more than 66 families, 250 genera and 450 species, based on specimens in the Colorado National Monument herbarium and on the checklist developed in 1985 (Weber et al 1982). Campbell et al (1995) reported on the cacti of the Colorado National Monument. The list includes the mountain ball cactus (*Pediocactus simpsonii*), claret cup (*Echinocereus triglochidiatus*), spineless hedgehog (*Echinocereus triglochidiatus var. inermis*), Missouri pincushion (*Escobaria missouriensis*), porcupine prickly pear (*Opuntia erinacea var. ursina*), potato cactus (*Opuntia fragilis var. brachyarhtra*), purple-fruited prickly pear (*Opuntia phaecantha var. phaeacantha*), and starvation cactus (*Opuntia polycantha var. juniperina*). The report also includes descriptions of stems, spines, flowers, fruits, and habitat.

There have been several studies devoted to lichen inventory and monitoring in the Monument. Sanchini and Stein (1982) compiled a list of the lichens they collected at Colorado National Monument. The list is divided into those species that grow on pre-Cambrian gneiss and schists, species growing on bark and lichen species growing on soil or moss, together with a list of collection locations. A later study by Sanchini (1988) was conducted on the conditions of *Pinus edulis* trees and lichens on permanent biomonitoring plots at Colorado National Monument in 1986. The study was initiated out of concern for increasing levels of sodium dioxide and ozone in the Grand Valley near Colorado National Monument and Grand Junction, Colorado. The report documents the evaluation of air pollution injury and growth of marked individual plants.

St. Clair et al (1991) submitted a proposal to the National Park Service for establishment of an air quality baseline and a lichen biomonitoring program in Colorado National monument. It is unclear if this study was initiated. A Mesa State College study in the late 1990's was initiated by Ritter (date unknown) to determine if there are relationships between the distribution and size of specific lichen species, and the effects of auto emissions on these lichens as indicated by membrane permeability. Results of this study are unknown.

Finally, there are a few studies concerning vegetation long-term monitoring. Shelz and Van Pelt (1990) established long-term photographic stations for monitoring community change in Colorado National Monument. Van Pelt et al (1991) reported on this multi-faceted study to locate, survey and photograph relict vegetation areas on the northern Colorado Plateau. They described the sites located within Colorado National Monument, Black Canyon of the Gunnison National Park, Curecanti National Recreation Area, Mesa Verde National Park, and Dinosaur National Monument. A section for each relict site describes the geologic and physical setting, applies a comprehensive classification of Colorado Plateau vegetation types to the site, and includes a vascular plant species list. The report includes discussion of regional significance and suggestions for management and future surveys, and lists that Colorado Plateau vegetation types are included in the sites and which are not included. Detailed description of field methods for various aspects of the study, as well as descriptions and maps of locations are included.

Threatened, Endangered and Exotic Species

In a report to the Mesa County commissioners in Grand Junction, Colorado, Lyon et al (1996) presented their Natural Heritage Program inventory which lists 14 sensitive plant species for the Monument. Of these 14 species, at least two are in need of status surveys and monitoring Canyonlands, the wideleaf bisquitroot *(Lomatium latilobum*), G1/S1, and canyon bog orchid (*Platanthera sparsiflora* var. *ensifolia)* G4G5T3S2.

Hanna and Floyd-Hanna (2000) developed and tested a model to predict habitat for the wideleaf bisquitroot (*Lomatium latilobum*), a G1/S1 sensitive plant. The authors evaluated and GPS-documented populations *of Lomatium latilobum*, which is only known to be found at scattered locations in southeast Utah and western Colorado. They developed a GIS-based habitat model to predict unknown areas of potential habitat, and made field visits to these areas to test the model. Management recommendations are included.

Exotic and Invasive Plant Species

Richardson (1962) conducted a forestry study in the early 1960's to determine the then-current status of forest pests, tree reproduction, and forest composition. The data reported showed a need for close surveillance of porcupine concentrations, drought and tree breakage from heavy snowfall, which allow epidemics of disease or forest beetle attacks. Abbey (1985) reported on the ecological effects of vegetation manipulation and herbicides at Colorado National Monument, and also compiled a plant list.

Hamer (1986) reported on yellow sweet clover (*Trifolium procumbens*) in Colorado National Monument. The study investigated the changing of location by yellow sweet clover from year to year according to local growth conditions. Road maintenance procedures within Colorado National Monument may in some way contribute to the localized success of this plant, and further study of comparison areas may help in management. The report includes field observations of specific sites, recommendations for control measures, drawings of test plots, and marked maps sections.

Colorado National Monument – Vegetation

Larson (1990) studied the movement of the Canada thistle (*Cirsium arvense*), a roadside weed, into the drainage ditch along the main road through the park in order to assist in management decisions. The study indicated where the weed was most commonly found and what its environmental requirements are. The author describes the species, notes locations, and recommends the paving of roadside ditches as the best method for control. The report includes a marked topographical map showing concentrations of Canada thistle. A complete inventory of exotic species in the Monument has yet to be conducted, however the National Park Service (1995) conducted a tamarisk survey to track the extent of tamarisk population growth at Colorado National Monument. The Lake Meade tamarisk terminators treated all except about 15 kilometers (9 miles) of canyon habitat in 1997. Monument staff and volunteers have continued treatments and follow-ups each year. Pre-treatment maps are in the monument GIS. Additional follow-up treatments and documentation are needed. Russian knapweed (*Centaurea repens*) populations have been mapped and sprayed for several years and continue to need some follow-up.

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Colorado National Monument – Vegetation

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Data Sets

DS-COLM-0003 Colorado National Monument Vegetation Map and Database, 1985.

Curecanti National Recreation Area – Vegetation

General Plant Studies

A large portion of the vegetation literature for Curecanti National Recreation Area concerns management. There are a few historical studies, studies on the effects of Curecanti dams on vegetation resources, and classification and habitat studies.

Baker (1961) compiled a directory on the history, study techniques and locations of Colorado big game exclosures. Included is a section on the Blue Mesa Exclosure, as relating to deer and livestock. Vincent (1966) reported on the river habitat types along the Gunnison River with reference to both pre and post dam environments. Carr (1982) reported on the Red Creek fire of 1977 and the Bear Trap fire of 1974 and their effect on the ecology of those areas within Curecanti National Recreation Area.

Kugrens (1984) conducted phytoplankton studies at Blue Mesa Reservoir. Andrascik (date unknown) also examined phytoplankton samples and reported on possible algae problems in Blue Mesa Reservoir. Conclusions from this study are unknown. In 1986, the Park Service reported on their survey of reservoir benthic conditions including chlorophyll and secchi disk data; chlorophyll survey; benthic, phytoplankton and zooplankton survey; and airborne multispectral scanner data (National Park Service 1986).

Auble et al (1994) investigated demands on river water in arid regions and concluded that it was possible to cause substantial changes in riparian vegetation without changing mean annual flow, and also that riparian vegetation is especially sensitive to changes in minimum and maximum flows. In a Colorado State University report, Johnson et al (1995) provided detailed descriptions of Blue Mesa Reservoir operations and the ecological impacts on the biota, including fish, plants and microbes. Keller (1998) conducted a study on the phytoplankton taxa present in the reservoirs, their gross densities and relative abundance. He also reported trends in seasonal succession of the phytoplankton communities. Kittel et al (1999) produced a users guide to a classification of riparian wetland plan associations for the Colorado Natural Heritage Program at Colorado State University.

Rowlands (1994) produced a manual that presented a vegetation classification system developed for use in the Colorado Plateau park units, and addressed various concerns involved in planning and carrying out a vegetative assessment. Appendices include information on field techniques, calibrating cover estimates and preparing herbarium specimens, as well as sample field forms. It is unclear if Colorado Plateau network parks are currently following these protocols.
A joint report by the National Park Service and the Bureau of Land Management (1995) contains a bibliography covering published data pertaining to climate change, cultural resources, recreation, environmental documentation, ecology, geology, legislation, and water resources of the Gunnison River System.

Johnston and Huckaby (1999) classified the ecological types of the Upper Gunnison Basin from vegetation, soil and landform data collected from 1,666 points between 1982 and 1998.
Sewolt (1999) submitted a comprehensive report detailing the vegetation inventory for Gunnison Sage Grouse nesting/early brood-rearing habitat in and around the Curecanti boundary.
The Nature Conservancy is involved in an effort to classify international ecological communities and reported on the terrestrial vegetation of the western United States (Community Ecological Group 2000). The report divides all terrestrial ecosystems into forest, shrubland, woodland, dwarf-shrubland and herbaceous vegetation with their own subsequent alliances. Provided under each alliance type is concept, range, states/provinces, USFS ecoregion code and references.

There are five publications concerning plant species lists, which were generally produced during the 1960's. Einwater (1968) was the first to compile a checklist of the vascular plants found in Curecanti

National Recreation Area, followed by Woodbury et al (1962a, 1962b) who published their vegetation survey and ecological studies of the flora and fauna of the Curecanti Reservoir basins.
Engel (1980) conducted a floristic survey along the Gunnison River within the Riverway and Neversink areas, and Current (1984) compiled a checklist of the vascular plants in the vicinity of the Elk Creek Visitor's Center that included information on the plants found in native and cultivated areas. Finally, Ritz (1998) compiled a preliminary list of vascular plant taxa of Curecanti National Recreation Area.

The remaining literature is devoted to long-term monitoring studies, including the establishment of long-term photographic stations.
Van Pelt and Shelz (1991a) reported on this multi-faceted study to locate, survey and photograph relict vegetation areas on the northern Colorado Plateau. They described the sites located within Black Canyon of the Gunnison National Park, Curecanti National Recreation Area, Mesa Verde National Park, and Dinosaur National Monument. A section for each relict site describes the geologic and physical setting, applies a comprehensive classification of Colorado Plateau vegetation types to the site, and includes a vascular plant species list. The report includes discussion of regional significance and suggestions for management and future surveys, and lists that Colorado Plateau vegetation types are included in the sites and which are not included. Detailed description of field methods for various aspects of the study, as well as descriptions and maps of locations are included. Van Pelt and Schelz (1991b) reported on the community site descriptions and unit analysis for Black Canyon of the Gunnison and Curecanti. Overflights, topographic maps, and reconnaissance were used in assembling plant lists.

The National Park Service (1993a) initiated a monitoring program for narrowleaf cottonwood (*Populus angustifolia*) from 1993-1995, and also developed a report on long-term monitoring at Curecanti, including the inventorying of species, habitat characteristics, ecosystem processes, and community attributes and the establishment of a sampling program of ecosystem components(1993b).

The long-term vegetation-monitoring program was initiated to document and detect changes in the vegetation composition in Black Canyon National Park (National Park Service 1996). Data on species, frequency classes and cover classes were collected from 1996 through 1998 at five sites in the park: Morrow Point, Pine Creek, Cebolla, Cooper Ranch and Neversink. This monitoring effort is currently undergoing review to determine its suitability for meeting park needs. Data is catalogued under DS-CURE-0008. Another database, DS-CURE-0019, contains information taken from biomass studies at Cooper Ranch from 1992-1996.

Bradshaw and Beetch (2000) submitted an end of season report on the vegetation-mapping project at Curecanti. The report discusses the scope of the project, what has been completed thus far, and what remains to be accomplished.

Threatened, Endangered and Sensitive Species

There is no literature concerning these species at this time.

Exotics and Invasive Plant Species

May (1997) identified the noxious weed species of concern as identified by the State of Colorado, together with the species which will be targeted for management by both Black Canyon and Curecanti parks. Species that are considered state noxious weeds, but are not found on these NPS lands are noted. Mapping methodology using a GPS unit and a data logger is discussed. Thirteen mapped areas are documented. Protocols for other weed control practices such as mechanical, chemical and biological

controls are discussed. Other recommendations are presented, i.e., revegetation and the use of weed-free forages. An appendix contains vegetative descriptions of targeted species, and a disk with GPS data.

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Data Sets

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General Plant Studies

Dr. Alan Beetle, a range management professor at the University of Wyoming, and C. B. Marlow, an undergraduate assistant, conducted the first vegetation survey of Fossil Butte National Monument (Beetle and Marlow 1974). Their report contained a list of 81 species of plants belonging to 59 genera and 19 families, and a map of the distribution of 12 shrub-dominated plant communities that they identified.

In a subsequent report, Beetle (1975) identified poor grazing management practices and suggested how livestock could be better managed to reduce conflicts between livestock and visitors, and how grazing impacts, in particular, impacts on riparian vegetation, could be reduced.

In 1977, William Litzinger, a park seasonal ranger, collected and identified approximately 200 species of plants belonging to 137 genera, and 46 families (Litzinger 1977a); specimens Litzinger collected are reposited in the monument herbarium. Litzinger (1977b) also measured plant cover along two line transects. His stated purpose was to establish the baseline condition of the monument's vegetation before domestic livestock were excluded from the monument, however, it is doubtful the data accomplished Litzinger's stated purpose.

In the early 1980s, the National Park Service contracted Mountain West Environmental Services to conduct a grazing impact study on the monument (Dorn et al. 1984). During this study Dorn, a consulting botanist, and his team of investigators compiled a list of 347 plant species that they observed on the monument. They also generated a vegetation map of the monument showing the distribution of the different vegetation types.

The Mountain West Environmental Services' map differed from the map prepared by Beetle and Marlow (1974) in these respects: 1) smaller units of similar vegetation were illustrated (the vegetation was mapped in greater detail), 2) several shrub types were combined into a more inclusive mountain shrub type, 3) a grass-forb type was delineated, 4) a wet meadow type was delineated, 5) a saline type was delineated, and 6) a barren type was delineated. Dorn et al. also recognized an aquatic type and a disturbed type.

George Jones, with the Wyoming Natural Diversity Database (formerly part of the Nature Conservancy), field-checked Dorn's vegetation map, and certified it with minor modifications (Jones 1993, Marriott and Jones 1993). The digital version of this map, produced by the National Park Service GIS services in 1998, is the map currently used by monument personnel for management purposes. Jones also reported the presence of a previously undocumented plant species, *Carex rossii*.

From 1994 through 2002, Clayton Kyte, an NPS seasonal biotechnician and botanist, collected several hundred plant specimens, including approximately 120 previously undocumented species. When all of Kyte's specimens are reposited, the monument herbarium will contain more than 1000 specimens representing approximately 530 taxa, 68 families and 257 genera. The plant list for Fossil Butte National Monument may comprise 90% of the plants that occur on the monument; however, new species continue to be discovered. Kyte also compiled plant-related information from multiple sources into a centralized vegetation database (Kyte 2000a, DS-FOBU-0010

As part of the Chicken Creek restoration process, photo points along Chicken Chicken were established in 1985, and color slides have been taken at the photo points nearly every year since. The points were established to document the condition of the streambed and streamside vegetation, and to to document pre- and post-grazing vegetation conditions (DS-FOBU-0004).

In 2000, Walter Fertig, a botanist with the Wyoming National Diversity Database, examined the monument's herbarium collection and confirmed or corrected the identity of the specimens. After Fertig finished this work, he published a checklist of the monument's flora (Fertig 2000), which was based on both his specimen review and the research of others, specifically: Beetle and Marlow(1974), Dorn et al. (1984), Litzinger (1977a), Jones (1993), and Kyte (2000a). Fertig's checklist contains 505 taxa belonging to 67 families; since its release Kyte has collected an additional 25-30 taxa and added 1 new family to Fertig's list. The species Kyte collected since 2000 will require verification before they are added to the monument's official list of plants.

Threatened, Endangered, or Sensitive Plant Studies

In preparation for future development on Fossil Butte National Monument, Mountain West Environmental Services (1987) surveyed proposed development areas for threatened or endangered plants: none were found in these areas.

Tufted twinpod (*Physaria condesata*) occurs at various localities on Fossil Butte National Monument (Whisky Basin Consultants 1982); however, the extent and nature of its distribution has not been thoroughly documented. This plant is ranked G2 ("imperiled because of rarity or other factors making it vulnerable to extinction") by the Wyoming Natural Diversity Database. Kyte documented the twinpod population of a portion of Cundick Ridge (Kyte, 2000b).

Exotic or Invasive Plant Studies

Control of exotic plant species has been underway since the early 1990s. Currently, Canada thistle (*Cirsium arvense*), Musk Thistle (*Carduus nutans*), Spotted Knapweed (*Cenaturea maculosa*), Bull Thistle (*Cirsium vulgare*), Marsh Sow Thistle (*Sonchus uliginosus*), Houndstongue (*Cyglossum officinale*), Yellow Sweetclover (*Melilotus officinalis*), and Creeping Foxtail (*Alopecurus arundinaceus*) have been assigned the highest control priority. Diffuse Knapweed (*C. diffusa*), and Tamarisk (*Tamarix chinensis*) populations appear to have been eradicated with the removal of a few plants several years ago. Creeping Foxtail, uncontrolled prior to 2002, appears to be aggressively invading the monument's wetlands. Populations of the other high-priority exotic species scheduled for control are either declining or contained within the perimeters of preexisting stands. Records showing the number and kinds of weeds controlled, control methodologies, herbicide use, and time consumed by the weed control effort have been compiled, as has weed population data for specific locations (DS-FOBU-0001). A summary and evaluation of the weed control program was prepared by Kyte (2000).

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Data Sets

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DS-FOBU-0001	Comparative weed data.xls. 1/6/1996 -2002. (Excel; Office 2000). Originated by Kyte, Clayton; status: Active.
DS-FOBU-0004	Chicken Creek Erosion Series Photomonitoring. 6/1/1999 - present. (slides and prints organized in 3-ring binder). Originated by Banta, Andrew; status: Active.

Golden Spike National Historic Site - Vegetation

General Plant Studies

During the 1960s there were two photographic reports that lend some insight into historical vegetation communities. Appleman (1960), an historian from the NPS Washington Office, documented photographs of railroad right-of-ways from Blue Creek at the eastern end of the current site boundary, westwards. In a report on land appraisals, Solomon (1965) included approximately 15 original photographs of the Golden Spike area.

The earliest vascular plant species list was compiled in the mid-1970s (Hansen 1975), though a record of this is unavailable. Allen and Curto (1994) conducted a one-day floristic survey of Golden Spike in May, 1994. They reported on the survey areas, and submitted written narratives for each species with notes on form, relative frequency, and status (native vs. non-native). Allen worked with the Intermountain Herbarium at Utah State University; the other three members of the team worked with the Utah Native Plant Society. The species list generated from this study documents the occurrence of 121 vascular plant taxa annotated with habitat, location, and voucher information (Allen and Curto, 1995). A diagram accompanying the checklist compares the number of native perennials, introduced annuals and other vascular plant species in the list. Specimens from this project are deposited at the herbarium at Utah State in Logan.

A draft National Park Service Wildland Fire Management Plan was developed in (1998) to address the need for fires in the Golden Spike area, where fire suppression has increased the growth of big sagebrush, *Artemisia tridentata*. The draft plan discussed the use limitations of wild and prescribed fires, in terms of rates of spread, and the private lands that surround the park. The draft plan includes models of fire behavior based on different fuels, moisture levels and slopes. The National Park Service plan carried out a prescribed burn in mid-September 1999, after photos from 1869 showed much less shrub growth and more grass than at present. The purpose of the burn was to reduce hazardous fuels (especially sagebrush), improve public safety, and help maintain the cultural features of 1869, the time of the historic event to which the site is dedicated. An NPS Cultural Landscape Report (2000) provides an overall description of the site vegetation.

Powell (2000) wrote an issues paper on vegetation management at Golden Spike National Historic Site. Topics included the historic and current land use, sagebrush distribution, fire management plans, exotic species management plans and efforts to initiate a comprehensive plant inventory. It also contrasts the use of native versus non-native seeds for reseeding efforts following fires, and suggests that non-natives may be more appropriate for a linear-shaped park surrounded by private lands. In 2001, the National Park Service contracted the Department of Agriculture Research Station at Utah State University to prepare a vegetation management plan for the park.

Threatened, Endangered and Sensitive Plant Studies

Boyce (1980) submitted a report on the history, discovery and current status of the Passey onion (*Allium passeyi*) at Golden Spike National Historic Site. The report includes distribution information, description of habitat, sample count data, statistical analyses, and total population estimate calculations.

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Hovenweep National Monument – Vegetation

General Plant Studies

The earliest work with plants in the vicinity of Hovenweep National Monument can be attributed to the native peoples who have inhabited the area for the past 3000 years. They knew and used many of the local plants for sustenance, medicine, tool making, warmth and shelter. The presence of these indigenous people and their influence on the landscape probably had a major influence on the vegetation that exists today (Camilli and Winter 1975).

Botanical records of the general area by western science include work by Brandegee (1876), Eastwood (1896), and Rydberg (1911). Records of past botanical explorations at Hovenweep started with Richart in 1941 and Arnow in 1967 (citation pending). Richart (1941) published a small plant list of Hovenweep NM as a result of his work and Lois Arnow made some collections, which reside at the Garret Herbarium of the University of Utah.

During the 1970's, other researchers detailed the botanical resources at Hovenweep. The herbarium contains approximately 195 species from the monument based primarily on the collections of Schmidd (1973), Schmidt (citation pending), Redfield (citation pending), and Lipzinger (1974, 1974a and 1976a). Colyer, a biologist at Mesa Verde National Park, performed sporadic botanical fieldwork at Hovenweep from 1990-1995, and contributed approximately five specimens to the monument herbarium. The Colorado Native Plant Society (1998) produced a plant list from a two-day survey in 1998 though no collections were made. An unknown researcher helped compile a list for NPFlora, a National Park Service species list database, which contains approximately 308 species, many of which are unsubstantiated by any collections.

Mayes (1997) compiled a plant checklist using information from previous lists and reports and also produced an incomplete vegetation map of a couple of the archaeological units (Mayes 1997a). Schelz (2000, 2001) compiled a plant list based on all of the previous botanical work and collections, including three permanent long-term vegetation plots, and the floristic study he initiated in 2001.

There are various archeological reports that provide an excellent source of information on the vegetation of Hovenweep and the general area (Winter 1975, 1976, 1977, 1978, Weir 1976). Litzinger and Winter (1976, and date unknown) took part in the San Jose State University archeology studies coordinated by Winter and compiled a list of the plants of Hovenweep from Cajon Mesa. Litzinger, currently a professor at Prescott College, established permanent transects in Hovenweep as a part of his work. Schelz, the current Hovenweep biologist, is in the process of coordinating with Litzinger to obtain transect locations and baseline data.

In 1999, Schelz installed permanent vegetation transects at Hovenweep which have been monitored each year since (Schelz and Whitham 1999, Schelz and Moran 2002). The purpose of the study is to provide baseline vegetation information, and to document vegetation trends and natural vegetation variability in a variety of vegetation communities. Currently, four permanent vegetation plots representing different plant communities are monitored annually each spring. Each transect consists of 100 (0.5m x 0.5m) quadrats, usually arranged in two lines of 50 quadrats each. In each quadrat, frequency and percent cover are recorded in the field for each substrate type and each vascular plant species present. The data set (DS-SEUG-007.3) consists of raw data for individual quadrats. Each transect survey consists of a frequency record and cover record for each plant species and ground cover component present, on each of 100 quadrats. Hovenweep transects have plant diversities ranging from 24-30 plant species plus six to nine ground-cover components per transect.

Hovenweep National Monument – Vegetation

In 2001, Schelz (2001a) started the first year of a three-year floristic survey of Hovenweep National Monument. The objectives were to obtain a 90% complete inventory of plant species in Hovenweep, collect a specimen of any species absent from the Hovenweep herbarium, determine and map plant community types, and compile separate community types and species lists for each of the six archaeological units. Prior to fieldwork, Schelz examined all previous reports of botanical investigations and all specimens in the Hovenweep herbarium and mapped locations of collections to determine where most of the previous botanical work was performed. He then conducted a field survey of each of the six detached units that make up the Monument, with efforts most concentrated in areas not represented in the herbarium collections. The survey included walking over each section in every unit, recording each species encountered, and collecting at least one specimen of any species not already represented in the Hovenweep herbarium. Aerial photographs were used to guide the route of the surveys. The photos were also used in the field to delineate and map vegetation types. Separate plant lists of each unit and of each vegetation type were maintained. Schelz will process plant specimens to be stored in the Hovenweep herbarium, which is currently stored at the Southeast Utah Group Headquarters, in Moab, Utah. In 2001, a total of 73 new species were added to the plant list as a result of this project. Data for this survey is catalogued under DS-SEUG-055.

Various revegetation projects have occurred at Hovenweep National Monument. Budelier (DS-SEUG-048) summarized past efforts from files that include records of revegetation efforts, some of which were followed up with monitoring. The records include reports, native seed lists, slides and/or digital photographs, GPS data, and miscellaneous memos. Some seed lists include gathering and sowing information and success data. Files also include a 2001 table of qualitative success rates for germination and growth of native plant seeds, compiled from the SEUG revegetation monitoring lists and reports, and confirmed by literature review.

Because Hovenweep has only recently become a part of the Southeast Utah Group (late1998), revegetation records consist of only a single project, a plant salvage and revegetation plan associated with the building of the new Hovenweep Visitor Center. The purpose is to rehabilitate construction areas, roadsides and other disturbed areas using native vegetation, and to evaluate the success of revegetation efforts in order to apply lessons to future work.

Rowlands (1994) produced a manual that presented a vegetation classification system developed for use in the Colorado Plateau park units, and addressed various concerns involved in planning and carrying out a vegetative assessment. Appendices include information on field techniques, calibrating cover estimates and preparing herbarium specimens, as well as sample field forms. It is unclear if Colorado Plateau network parks are currently following these protocols.

Threatened, Endangered and Sensitive Plant Species

Colyer (1993) conducted approximately 20 threatened and endangered plant species releve surveys from 1993-1996. Only general locations are noted, with no permanent stakes, markers or photographs established. The Park has the completed data sheets, though no report. Schelz (2001a) has also surveyed for rare plants during the general inventory. No federally listed threatened, endangered, or sensitive plants have been found thus far.

Exotic and Invasive Plant Species

Litzinger and Winter (1976) and Enriquez (1983) discussed exotic vegetation in their reports but no active control was initiated. Tamarisk (*Tamarix chinensis*), an exotic plant from Eurasia, has been the focus of

much of the exotic plant control and monitoring work in Hovenweep National Monument. In the late 1990's, ranger Jim Dougan actively pursued tamarisk and eliminated most of it from the park. He did not map locations however and small patches remain (Schelz 2001a). Schelz and Budelier (2000) compiled a list of exotic plants in the Southeast Utah Group, including Hovenweep National Monument. Schelz et al (2002) presently maintains the list.

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Data Sets

DS-SEUG-007.3	Frequency and cover of plant species and substrate on Long-Term Monitoring Program vegetation transects in SEUG parks
DS-SEUG-048	Records of revegetation projects and revegetation monitoring, Hovenweep National Monument
DS-SEUG-055	Floristic survey of Hovenweep National Monument

Natural Bridges National Monument - Vegetation

General Plant Studies

The earliest plant collections in the Monument were made by B. F. Harrison of Brigham Young University beginning in 1933. In 1968, Welsh and Moore made numerous collections as part of an interpretive study of the Monument, and subsequently Welsh and Moore (1968) published "Plants of Natural Bridges National Monument" based on both their collections and the historic collections by Harrison. Their original list included 225 taxa, which is far short of a complete list. Several collecting trips were made in the late 1960s and early 1970s by Welsh, Higgins, and Atwood resulting in additional collections and additions to the species list. All subsequent plant lists are based on Welsh and Moore including Schelz (1999, 2000, 2001, 2002), Austin (1990), and Malm (1987). About 435 species are now listed as occurring in Natural Bridges National Monument and an extensive herbarium has been assembled at the headquarters of the Southeast Utah Group Headquarters in Moab, Utah.

Other botanical work at Natural Bridges National Monument includes rare plant surveys and vegetation mapping by Heil (1993) and Floyd-Hanna (1993), and demography work of Allphin (1992) and Allphin and Harper (1994). Allphin (1992) set up a long-term demographic study of the kachina daisy (*Erigeron kachinensis*) that she continues to monitor periodically, and Allphin and Harper (1994) wrote the definitive work on habitat requirements of the kachina daisy.

Hanging gardens are unique ecological communities within Natural Bridges National Monument. Welsh (1989) first looked at these in the 1980s and published a paper on the distribution of hanging gardens in Utah, which included some in Natural Bridges NM. He discussed the geomorphology and geography of the gardens, aspects of their diversity and distribution, and listed vascular plants and algae found. Fowler (1993, 1995) wrote extensively on the biogeography of hanging gardens on the Colorado Plateau, including some in Natural Bridges NM, and also proposed management recommendations (Fowler et al. 1995). May et al. (1994) studied the geologic and hydrologic features of the sandstone aquifers of the Colorado Plateau that provide the necessary conditions for hanging garden development. Stanton (1995) and van Riper et al. (1995) analyzed the biogeography of hanging gardens in the Colorado Plateau, including Natural Bridges. And May and Hill (1998) classified hanging gardens in parks of the Colorado Plateau.

In 1974, John Buckhouse, a graduate research assistant from Utah State University's Range Science Department, initiated a study to look at long-term vegetation trends in Natural Bridges and to compare these trends in an inaccessible, rarely-grazed area with those in an area that was heavily grazed in the early 1900s (Lyons et al. 1975, DS-SEUG-025). The purpose was to compare vegetation trends in an inaccessible, rarely grazed area with those in an area that was heavily grazed in the early 1900s. After the initial year, the focus shifted to long-term vegetation trends in general.

In 1987, three permanent vegetation transects were installed in Natural Bridges National Monument and these have been monitored each year since (Graham and Belnap 1989, 1990; USDI 1990, 1991, 1993); Schelz 1999, 2002). There are approximately 14 years of data on two of the transects (DS-SEUG-007.2). One transect was abandoned in 1998 because it was washed out due to its proximity to the creek in White Canyon. An additional transect was installed in 2002. Approximately 45 transect surveys were completed by summer of 2002. This project was initiated in order to is to provide baseline vegetation information, and to document vegetation trends and natural vegetation variability, in a variety of vegetation communities.

In 1989, as part of a cooperative agreement between the National Park Service, a study was undertaken to locate, survey, and photograph areas of pristine plant communities, located on buttes, mesas or canyons

generally remote and/or steep-sided enough to have prohibited access by cattle and human roads (Van Pelt et al. 1991). This study included sites in Natural Bridges, and includes nested frequency vegetation data and repeatable photography from permanent photo stations (DS-SEUG-023.3).

After park road realignment in 1993-1995, a roadside revegetation effort began on about six acres of disturbed ground in more than 60 sites. Construction areas, roadsides, and other disturbed areas were rehabilitated using native vegetation, and records evaluating the success of the project were maintained, including gathering and sowing information, qualitative success rates for germination and growth, slides and digital photographs (USDI 1994, DS-SEUG-053). A new revegetation protocol is being developed by current Vegetation Management Specialist Ian Torrence.

Declines and die-offs of Utah juniper in the monument were investigated by Weber and Nelson (1991, 1994), who established seven transects to determine the cause of extensive foliar damage to the trees. Increased moisture during the second year of studies coincided with a decrease in dying trees, suggesting some correlation with soil moisture and perhaps soil salinity. no pathogenic agents appeared to be responsible

Threatened, Endangered or Sensitive Plant Studies

Rare plant surveys were conducted in 1991-92 by Heil et al. (1993), the final report gives the status and extent of a number of species. . Habenaria zothecina, recognized as a new species in 1987, grows in damp alcoves as part of some hanging gardens in Natural Bridges National Monument Results of 1992 monitoring are presented in terms of age class structure, total count, herbivory, flowering phenology, pollination, and preliminary comparisons with related species. Management recommendations are primarily for monitoring at present (although future impacts may be greater), and a suggested protocol is included. A high-priority need in future research is to identify pollinators No federally-listed Threatened or Endangered plants were found but there were a number of sensitive species. Heil provided maps of population locations.

Work on the rare and sensitive kachina daisy (*Erigeron kachinensis)* began with Fagan (1984), who surveyed the monument for population locations (DS-SEUG-070). Belnap followed in 1988 with more surveys and the establishment of 4 permanent monitoring plots in order to establish baseline information for study of the population dynamics and ecological niche of this rare plant species (Belnap 1988, 1989).

In 1990, Loreen Allphin Woolstenhulme (Allphin and Harper 1994, 1997, Allphin et al. 1996, Allphin 1991, 1992, Woolstenhulme 1998a, 1998b) established long-term demographic monitoring plots in six populations of the kachina daisy at Natural Bridges National Monument. Monitoring was completed yearly from 1990 to 1997, except for 1995, and vegetative community data and soil samples were collected at each site (DS-SEUG-071). Reproductive success, mortality, disease, vegetation community, soil moisture content, and genetic drift between populations were studied.

In 1990, Vanderbuilt compiled information on 23 sensitive plant species in the Southeast Utah Group, and from 1999 through 2002 Schelz has maintained a list of sensitive species in the Southeast Utah Group (Schelz 1999, 2000, 2001, 2002),

Exotic / Invasive Species Studies

Tamarisk (*Tamarix chinensis*), an exotic plant from Eurasia, has been the focus of much of the exotic plant control and monitoring work in Natural Bridges National Monument. In 1977 Gilbert and

Hendrickx described a five-year effort to control tamarisk in the monument. Thomas et al. (1987) briefly describes earlier and present efforts to control and eliminate tamarisk. Kunzmann (1989) describes the work of a multi-park tamarisk control team which did some work at Natural Bridges National Monument. In the 1990s, ranger Jim Dougan actively pursued tamarisk and eliminated it from the park. He did not map locations however.

Budelier and Torrence, bio-technicians at Canyonlands National Parks, have both been involved with exotic plant mapping and control, Budelier from 1997 to 2000, and Torrence from 2001 to the present. Their mapping work is primarily GPS-based (global positioning system) and resulting information is maintained using Geographic Information Systems at Southeast Utah Group in Moab, Utah (DS-SEUG-49.3).

Schelz and Budelier (2000) compiled a list of Exotic plants in the Southeast Utah Group, including Natural Bridges National Monument. Schelz and Torrence (2002) presently maintain the list.

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Natural Bridges National Monument - Vegetation

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Pipe Spring National Monument – Vegetation

General Plant Studies

The first botanist to collect in or near Pipe Spring was A.O. Siler who collected the type of *Utahia sileri* (Welsh 1982). Siler made several collecting trips to the Kanab area and adjacent Mojave County, Arizona in the 1870s. It is very likely that he visited Pipe Spring for water and may have taken collections from the area. However, based on scant label data on his collections it is not possible to know for sure.

More recently, King (1977) compiled a list of the flora of Pipe Spring National Monument. While this is an incomplete list, 79 plants were identified to the generic level, with 71 of them identified to the species level. Alexander (1998) compiled the most recent and complete draft vegetation species list for Pipe Spring National Monument. The species list is approximately 70% complete with spring and fall plant species still needing collection and identification. Alexander also conducted a detailed literature review and ground survey while compiling a comprehensive plant species list for Pipe Spring National Monument. The species data he compiled includes scientific name, old scientific name (if appropriate), common name, plant family, growth form, whether native or introduced, and phenology during survey. The spreadsheets and documents associated with this study have organized the species lists by family and by plant community. The literature review is a thorough review of available knowledge of pre-settlement vegetation in the area. In 2001 he returned to collect numerous voucher specimens which are currently (10/12/01) being accessioned into the herbarium at the monument. His work is catalogued under DS-PISP-0001.

Two studies conducted in the 1970's concern livestock impacts on the vegetation at Pipe Spring National Monument. Clark (1975) reported on vegetation changes due to settler livestock grazing in the Moccasin terrace of northern Arizona. McCutchen (1976) conducted a general vegetative reconnaissance and photographic survey of the livestock pastures at Pipe Spring National Monument to determine resource damage, vegetative condition and trends.

Threatened, Endangered and Sensitive Species

There is no literature concerning these species at this time.

Exotic and Invasive Plant Species

There is no literature concerning these species at this time.

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Pipe Spring National Monument – Vegetation

Data Sets

DS-PISP-0001 Pipe Spring plant species data and literature review.

Timpanogos Cave National Monument - Vegetation

There have been several historical studies or plant surveys conducted in the cave. Hayward (1942) completed his Ph.D. dissertation on the biotic communities of Mt. Timpanogos and western Uinta Mountains, Utah. Douglas (1964) identified *Chrisophyta*, a yellow-brown alga present in the cave and observed unknown single celled blue-green algae that grew near the lights inside the caves.

Allred (1975) conducted a floristic study of Mt. Timpanogos as part of a master's graduate program. He compiled a comprehensive vascular plant list for Mt. Timpanogos, including information in the annotations regarding habitat, phenology, elevational range, and collector. He also described the topography, climate and vegetation zones of characteristic plants, together with a key to species. This list has been variously labeled as the list for Timpanogos NM (Allred 1974); however, the list is for the entire mountain area, not just the Monument (Allred 2000). Finally, St. Clair and Rushford (1976) published a diatom flora of the cavern system of Timpanogos Cave National Monument. They collected, identified and described twenty-six species, including eight species previously unknown from cave systems, four new records for the state of Utah, and claimed that their study "yielded the greatest diversity of cave diatoms thus far recorded from America".

Rowlands (1994) produced a manual that presented a vegetation classification system developed for use in the Colorado Plateau park units, and addressed various concerns involved in planning and carrying out a vegetative assessment. Appendices include information on field techniques, calibrating cover estimates and preparing herbarium specimens, as well as sample field forms. It is unclear if Colorado Plateau network parks are currently following these protocols.

PacifiCorp and Stillwater Environmental Services (2001) conducted a riparian corridor vegetation study on the American Fork River as a FERC requirement to relicense the American Fork Hydroelectric Project. The project evaluated of the potential effects of the proposed 4-cfs minimum flow on the riparian vegetation within the bypassed reach.

Atwood (2001)conducted a comprehensive inventory of vascular plants in the summer of 2001,and information was compiled on both existing collections made in the monument and new collections made by Atwood to fill specimen gaps. Information provided in this inventory includes Latin and common name, information on abundance, nativity, collection data, location, habitat, associated species, and elevation.

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Zion National Park - Vegetation

General Plant Studies

Checklists and Floras

Early Zion checklists and floras were developed by Woodbury (1929, 1933), Prenall (1937), Jepson and Allen (1958), Bradley (1973) and Kitchell (1977). More recently published field guides for the general public are *Plants of Zion National Park* (Nelson 1976) and the updated *Wildflowers of Zion National Park* (Welsh 1990). A valuable unpublished reference, *Plant Identification Guide – Zion National Park* (Malm 1993), contains a taxonomic key, complete plant descriptions, illustrations, and human uses on each vascular plant species specific to Zion. Other floras include the *Flora of Horse Ranch Mountain* (Palmer 1966), *Parunuweap Canyon Vegetation* (Harper 1992), *A Key to the Cactaceae of Zion National* Park (Walker 1939) and the *The Cacti of Zion National Park* (Trapp 1969) which contains numerous slides of each taxon. Welsh (1989a, 1995; DS-ZION-0003, DS-ZION-0011) compiled a comprehensive vascular pIant species list identifying endemic, disjunct, and non-native species. Specific studies in hanging gardens, seeps and springs have also contributed to our current knowledge of vascular plant species in the park (see section on hanging garden and spring communities). On a broader scale, Meyer (1976) completed a comprehensive *Annotated checklist of the vascular plants in Washington County* while Welsh (1982) compiled an annotated list of Utah plant types with an extensive bibliography of collectors and specimen deposition.

In summary, much work has been accomplished in documenting the park's flora. However, additional floristic inventory is needed in wetlands and remote or inaccessible areas at different times of the year. An example of this need was reflected in August 2000 when a new species of thistle was observed by a former Zion biotech in a remote hanging garden in the park. It is currently being described as *Cirsium joannii* by Drs. Welsh and Atwood at Brigham Young University (Welsh, pers. comm. 2002). Over 890 vascular plant species occur in Zion and are vouchered in the Zion herbarium and other herbaria (most significantly at Brigham Young University). Although Welsh annotated portions of the Zion herbarium in 1995, a comprehensive verification is needed (Welsh 1995).

Vegetation Communities

A general vegetation map with detailed analysis of Zion's vegetation communities was conducted by Dr. Kimball Harper and colleagues from 1988 to present (Harper 2001; Harper et al. 1988, 1990, 1994; Wiese and Harper 1993). Analyses are based on 289 permanently staked survey plots distributed throughout the park. Plant diversity, distribution and abundance are discussed along with the definition of 10 vegetation types. *Riparian Ecology in Zion National Park, Utah* (Harper et al. 1992) describes the park's riparian community and its unique value in an arid environment. In draft is a treatment on juniper-pinyon woodlands in the park discussing the environmental relationships and plant successional dynamics in these woodlands (Harper et al. 2001). The extensive number of citations listed above are mostly included in one bound document with accompanying data sheet folders stored in the Zion Resource Management Office (DS-ZION-0004). This volume of work provides great insight into plant community dynamics and composition in Zion.

In 1999, the Northern Colorado Plateau Network I&M Program and FirePro dollars funded a more detailed vegetation map and classification (with 110 mapping units) derived from photo interpretation of true color aerial photography (1:12,000 scale flown in June 1999), field sampling and accuracy assessment, and extensive GIS technology (DS-ZION-0022). The map will be completed by the end of calendar year 2002. Harper's work was incorporated into this work as much as possible.

A Biodiversity Monitoring Program (Kurth 1996; DS-ZION-0005) was initiated in 1996 and 1997. Thirty-three long-term vegetation monitoring plots were established in mostly ponderosa pine and

riparian communities. The methodology follows a modified version of the USDA Forest Service ECODATA vegetation monitoring protocol. The original intention of the plots were to relate these communities to fire and then broaden its scope in the future. Intended monitoring has not occurred except for recensusing 4 plots in 2001 to evaluate the feasibility of repeating and expanding the project. In 2001, challenges arose in relocating the plots from route descriptions and repeating the same transect lines since there were no photos taken nor permanent stakes to align the measuring tape (except for the base line). In addition, there were a disproportionate number of plots in ponderosa pine vs. the more common pinyon-juniper. We need assistance in evaluating how to incorporate this work in a meaningful way with future long-term ecological change monitoring. The limitations of this Biodiversity Monitoring Program were certainly the fault of inadequate time and funding.

Virgin River

Zion is planning to dechannelize a two-mile reach of the North Fork Virgin River to restore hydrologic function and riparian plant diversity. Monitoring of biotic and abiotic features will be necessary before and after deconstruction of levees and gabions. Steen (1999) used historic documents and photographs (particularly from CCC channelization work in the 1920s and 1930s) to assess changes in the floodplain forest ecology over time. This study helps explain the conditions we see today and documents what the river reach looked like in various stages of health and decline in the past. A report sponsored by the Grand Canyon Trust (2001) provides a geomorphic, hydrologic and ecological evaluation to determine the restoration potential of the Virgin River in Zion.

Hanging Garden and Spring Communities

Welsh and Toft (1981) summarized garden types and their seral stages of development on the Colorado Plateau, explaining the three basic types of gardens: alcove, terrace, and windowblind. They determined Zion Canyon gardens are mostly of the windowblind type, with smaller numbers of less-developed alcove gardens as compared to gardens along canyons of the Colorado River in southeast Utah. Malanson (1980, 1981) discussed habitat and plant distributions in hanging gardens of the Narrows and the effects of age, area, and location. Malanson and Kay (1980) studied flood frequency and the assemblage of dispersal types in hanging gardens of the Narrows. Welsh (1989a) published a summary paper on the distribution of Utah's hanging gardens.

Welsh (1989b) worked in collaboration with the NPS Water Resources Division to determine the relationship of total number and composition of plant species occurring in hanging gardens to water discharge, age and garden size. Welsh linked a reduced amount of water flow to a reduction of vascular plant species and ultimate loss of unique hanging garden resources. The results of this study provided scientific support towards a Federal Reserve Water Rights Claim adjudicated in November 2001.

An extended study of hanging gardens in Zion and six other NPS units on the Colorado Plateau was initiated in the early 1990s. The research focused on vascular plant community heterogeneity, species-area relationships, species occurrences patterns, level of endemism and bee diversity at Zion, Capitol Reef NP, Dinosaur NM, Glen Canyon NRA, and Natural Bridges NM (Fowler 1995, Fowler et al. 1995a). Geologic and hydrologic features of sandstone aquifers associated with these gardens were also explored (May et al. 1995). The overwhelming conclusion from this quantitative study confirmed the vital tie between the groundwater system and the existence of these rare and unique hanging gardens. Follow up management recommendations were made for areas of high human impact, establishment of Research Natural Areas, and future research and monitoring needs. Most notably is the need to reduce human trampling at Weeping Rock in Zion, control exotic plant species, and begin long-term monitoring (Fowler et. al 1995b). The Zion General Management Plan (2001) established a Hanging Garden Research

Zion National Park - Vegetation

Natural Area including five gardens: Grotto Spring, Weeping Rock, Sinawava, and two unnamed springs in Parunuweap Canyon.

Wong (1999) conducted a community analysis of hanging gardens on a local scale in Zion and on a regional scale of the Colorado Plateau. On a local scale, Wong found a distinction in species composition from the wet wall and the colluvial slope. On a regional scale, she verified a distinct geographic distribution of plant species between the eastern and western Colorado Plateau.

Meretsky (2002) is studying the short- and long-term variability in vegetation patterns at seeps and springs on the Colorado Plateau (DS-ZION-0024). Results will be useful to help assess habitat for rare invertebrates, assessing threats from exotic species, providing guidelines for restoration and mitigation of seep and spring sites, and for separating effects of changes in groundwater hydrology from natural variability. Established study sites are in Zion, Grand Canyon NP, and Glen Canyon NRA. In addition, Meretsky is collaborating with John Spence at Glen Canyon and L. E. Stevens to evaluate southwestern springs vegetation as it relates to biogeography, human impacts, and restoration (Meretsky et al. 2002).

Lindahl (1976) completed a biological survey of Grapevine Spring over three separate visits in July, August, and October 1976. Species lists of the flora and fauna (including snails and insects) were developed along with the identification of any rare or unique species. Lindahl notes the presence of tamarisk seedlings in North Creek, a drainage of Grapevine Spring.

Relict Communities

Van Pelt et al. (1991) examined relict communities (those areas not influenced by non-indigenous human activities) within Zion, Capitol Reef NP, Cedar Breaks NM, and Bryce Canyon NP, to foster their preservation, recognition, and appropriate use. In this study, Tuhy created a vascular plant species list for 6665 Mesa, Church Mesa, Greatheart Mesa, Hanging Canyon, Timber Top Mountain, and West Checkerboard Mesa in Zion. Access was almost entirely by helicopter. The report also provides recommendations on the suitability of each site as a relict area and its regional significance.

Fire Ecology and Effects

A survey by West and Loope (1977, 1979) found that fire was significant only at upper elevations within Zion. Madany and West (1980) developed a fire chronology for the last 480 years on Horse Pasture Plateau, a large plateau subjected to anthropogenic influences, and on Church Mesa, a small isolated and inaccessible mesa. Fire scar cross sections provided evidence of a sharp decline in fire frequency after 1881 on the Plateau, before this time large fires occurred nearly every three years. Fire frequency on the isolated relict mesas near Horse Pasture Plateau featured an interval of 69 years. The researchers discuss the role of indigenous use of fire, livestock grazing, and pioneer and Park Service suppression of fire. Their findings indicate the conversion of ponderosa pine savanna into forest cannot be attributed mainly to the absence of fire as widely believed, but the key factor in this conversion is livestock grazing (Madany and West 1981, 1983, 1984, Mason and West 1970).

Zion hosts a fire effects monitoring module that services Bryce Canyon NP, Golden Spike NHS, Mesa Verde NP, Great Basin NP, and Lake Mead NRA (Zion National Park 2002, DS-ZION-0020). The purpose of the program is to evaluate fire management actions and their effects on vegetation in a standardized way. Monitoring protocols follow the Western Region Fire Monitoring Handbook (1992) which records plant species composition, density, age and size class; fuel loading, burn severity, and photographic monitoring on prescribed fire burn units on a schedule of pre-, post 1 month, 1, 3, 5+ years.

Zion National Park - Vegetation

Threatened, Endangered, and Sensitive Plant Studies

Zion contains one federally-listed endangered plant species, the Shivwits milkvetch (*Astragalus eremiticus* var. *ampullarioides*). This species was listed in 2001 by the U.S. Fish and Wildlife Service because of its extremely limited range on the Chinle Formation and its rapidly vanishing habitat due to development (Federal Register Vol. 66, No. 189). At least 20 endemic and disjunct plant species are considered "sensitive" or of special concern in Zion. The sensitive species list, mostly plants specialized to sand or sandstone crevices, is guided by the work of Dr. Stanley Welsh.

Welsh et al. (1975) provided an extensive bibliography and checklist of endangered, threatened, extinct, endemic and rare vascular plants in Utah including Washington County. This paper was updated 10 years later (Welsh et al. 1985).

A preliminary survey of nine endemic plant species on category I and II lists to be considered for endangered and threatened status was conducted from October 8-21, 1982 (Mitchell and Fraser 1982) based on recommendations made by Dr. Welsh. The report includes basic descriptions, habitat, known distribution and illustrations. Other lists include: threatened and endangered plants and animals (Lewis 1978b) and a checklist of rare and endemic plant species including rare plant considerations near Zion (Tuhy 1990). The bulk of Zion's TES work was conducted by Welsh (1988, 1989; DS-ZION-0003) and colleagues between 1987 and 1989. The report includes a discussion on endemic and disjunct plant species, potential threats, and management recommendations. Hundreds of data sheets appear in the appendices. A GIS layer exists for plant locations.

Supported by the NPS Fire Program, rare plant surveys were conducted in prescribed burn units from 1998 - 2001 (Alexander et al. 1998, Stephens 1999, McDaniel 2000, 2001; DS-ZION-0006). Permanent line transects were established in 1999 by Stephens and in 2001 by McDaniel to monitor the effects of prescribed fire on sensitive plant species.

In 2002, Alexander and Hughes (2002a, 2002b) surveyed the sandstone canyons on the east side of the park and revisited hanging gardens recorded by Welsh (1989) in Zion Canyon. This work expanded the known distribution of sensitive plant species and documented the current condition of exotic species invasion in the hanging gardens.

Individual work on sensitive species include the following:

- An expansion of the known distribution of Zion tansy (*Sphaeromeria ruthiae*) in Zion (MacArther et. al 1989).
- Description of new endemic species in Zion (Baker 1938, Flowers 1949, Russell and Crosswhite 1963, Holmgren et. al 1976, Nesom 1976, Welsh 1986, Welsh 1998)
- Status report of Black spleenwort (*Asplenium adiantum-nigrum*) (Smith 1989)
- Status report of Shivwits milkvetch (*Astragalus eremiticus* var. *ampullarioides*) (Van Buren and Harper 1999)

Exotic or Invasive Plant Species

Over 100 non-native plant species occur in Zion. Nine of these species are of top management concern for control and eradication. Tamarisk (*Tamarix ramossisima*) and Russian olive (*Eleagnus angustifiolia*)

are the primary invasive species along riparian areas. In disturbed areas, Scotch thistle (*Onopordum acanthium*), bull thistle (*Cirsium vulgare*), and white top (*Cardaria draba*). Knapweed (*Centaurea* spp.) and yellow starthistle (*Centaurea solstitialis*) occur in small infestations but are of great potential threat.

Although Zion has been controlling exotic plant species for over a decade, documentation is scarce until 1997. Annual reports of control activities, distributions, and management recommendations are available from 1997 – 2001, with the exception of 1999 (Mason 1997, 1998, 1999, Poulsen 2000, 2001; DS-ZION-0001, DS-ZION-0021). Significant invasive species monitoring needs are control treatment efficacy, early detection monitoring, and risks of prescribed fire in escalating invasive weed problems.

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Arches National Park - Paleontological Resources

The first comprehensive paleontological resource inventory for Arches National Park was published by Santucci (2000). A formal paleontological resource scoping session was conducted at Arches National Park in May 2000. An inventory of paleontological resources associated with National Park Service caves, including Arches National Park, was published by Santucci et al (2001). For more detailed information on the geology and a stratigraphic section of Arches National Park see Doelling (2000), Lohman (1975), and Doelling (1985).

The oldest fossils known from the Arches National Park area occur in the Middle Pennsylvanian Paradox Formation. The Paradox is a marine unit composed largely of limestone that contains the remains of algae, corals, bryozoans, brachiopods, crinoids, and other marine fossils. During the Late Pennsylvanian, cyclic sediments of the Honaker Trail Formation were deposited and are exposed on the western boundary of the park. Melton (1972) reports the following fossils from the Honaker Trail Formation in the Moab area: fusilinids, corals, bryozoans, brachiopods, gastropods, bivalves, crinoids, echinoids, and a variety of marine trace fossils. In addition, Tidwell and others (1972) reported on a Calamites-like stem that was collected from the Honaker Trail Formation.

Fragmentary vertebrate remains occur in the Moenkopi and Chinle Formations in the Moab area. Just west of Arches National Park vertebrate bone, phytosaur teeth, and a large number of theropod tracks have been reported from within the Upper Triassic Chinle Formation (S. Duffy, verbal communication, 1999). An important new theropod track locality has been located in the Jurassic Wingate Formation within Arches National Park.

Dinosaur tracks have been reported from in and around Arches National Park since the 1940's. Paleontologist Roland Bird is reported to have visited some track sites in the Arches area. Two theropod tracks have been identified in the Lower Jurassic Kayenta Formation in the "Petrified Dunes" area of the Arches National Park (S. Duffy, verbal communication, 1999). Tiny theropod tracks and a single quadrupedal trackway are reported from the Entrada Sandstone on the perimeter of the park (Fran Barnes, written communication, 1999). A dinosaur megatracksite, consisting of thousands of theropod tracks, weaves in and out of Arches National Park boundary. The track producing layer was originally identified as the Moab Tongue of the Entrada Sandstone (Lockley, 1990, 1991; Duffy, 1993), but more recent interpretation places the tracks into the basal sandstone bed of the Summerville Formation (Fred Peterson, written communication, 2000). Additional dinosaur track localities occur in the Morrison and Cedar Mountain Formations just outside of Arches National Park (Engelmann and Hasiotis, 1999). Several iguanodontid tracks in the collections at the College of Eastern Utah have been collected from the Cedar Mountain Formation just north of Arches National Park.

The Upper Jurassic Morrison Formation is well exposed in and around Arches National Park. Petrified wood and a partial sauropod skeleton are reported from the Morrison within the park. Large petrified logs occur just west of the park at the contact between the base of the Morrison and the underlying Summerville. The Yellow Cat Flat area northeast of the park was administered as part of Arches National Park until 1971. The Lower Cretaceous Cedar Mountain Formation is capped by the Dakota Sandstone in the Yellow Cat Flat area. The area includes the Robert Gaston Quarry from which the first specimen of Utahraptor and the armored nodosaur Gastonia were collected along with other vertebrate remains referred to as the "Yellow Cat Fauna." Bodily (1969) reported on the most complete specimen of the nodosaur Smeropeltn from the Poison Strip Sandstone of the Cedar Mountain Formation. This specimen was found just west of Arches National Park in the Dalton Wells Quarry. Other specimens referred to as *Sauropelta* have been found along the north and west sides of the park (Carpenter et al, 1999). A variety of vertebrate tracks, including crocodilian, theropod, and “dromeosaurid-like” tracks and possible

pterosaur feeding traces, have been identified in the Cedar Mountain Formation from within and near Arches National Park (Lockley et al, 1999; J. Kirkland, verbal communication). Specimens of the cycadeoidales *Monanthesia* have been collected from the Cedar Mountain Formation near Arches National Park (Furniss and Tidwell, 1972).

The youngest Mesozoic unit in Arches National Park is the Upper Cretaceous Mancos Shale, which is exposed in thes southern portion of Salt Valley. A few marine invertebrate fossils, including bivalves, occur in the Mancos Shale in the park. Plesiosaur and mosasaur remains have been discovered in the Mancos Shale about 35 miles outside of Arches National Park.
During the 1950's, Arches Chief Ranger Lloyd Pierson discovered the remains of a Columbian mammoth in the park. A partial mandible was collected from the site and was determined to be from a juvenile. The specimen, nicknamed "Woody", may represent one of the youngest juvenile mammoths from the Colorado Plateau. The remains of a bighorn sheep (Ovis *canadensis)* and a bison *(Bison bison)* were found in rock shelters within Arches National Park (Mead et al, 1991). Packrat middens are common in the dry rock shelters and contain needles from Douglas fir *(Pseudotsvtga men-ziesii)* and Limber Pine *(Pines flexilis).* Radiocarbon dating of organic remains from the middens have yielded dates between 12,400 to 20,000 years B.P

Cooperative paleontology projects include the Morrison Extinct Ecosystem Project (early-mid 1990s), a joint National Park Service and United States Geological Survey project (Turner and Peterson, 1998). Arches Paleontological Survey was a cooperative effort between the National Park Service and the Utah Geological Survey (began May 2000 and is ongoing). Arches also worked with the National Park Service's Geologic Resources Division geologic resource inventory and paleontological resource inventory for Arches National Park (May 1999).

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Black Canyon of the Gunnison National Park - Paleontological Resources

The first comprehensive paleontological resource inventory for Black Canyon of the Gunnison National Park was published by Scott et al (2001). Hansen (1987) provides a comprehensive overview of the geology of Black Canyon of the Gunnison National Park. Hansen (1971) published a geologic map, which includes the national park. During 1999 and 2000, the National Park Service Geologic Resources Division produced a digital geologic map for the park, compiling maps by Hansen, at 1:24,000 scale.

The geologic setting of the park consists of a sequence of Precambrian rocks including arkosic sandstones, graywackes, and granite (Hansen, 1967). Renewed crustal movement in the area accompanied the intrusion of the Vernal Mesa and Curecanti plutons (Hansen, 1981). Most of the Paleozoic section in the park has been eroded away before or during the time of the Uncompahgre uplift. The only evidence of Paleozoic rocks in the canyon are diabase dikes dating to the Cambrian or Ordovician.

During the Jurassic, sediments accumulated on the older Precambrian rocks in the Black Canyon area. The Entrada, Wanakah, and Morrison formations preserve Jurassic paleoenvironments in the park, but these are poorly exposed within BLCA. Fiorillo (1996) reports on a Morrison Formation vertebrate locality within the boundaries of BLCA with the most significant fossil locality being a badly weathered sauropod bone impression found on the North Rim (Fiorillo, 2001, personal communication). One locality in the Salt Wash Member of the Morrison Formation, located just outside of the park, has yielded fragments of a theropod posterior caudal vertebra, a sauropod rib, and numerous other dinosaur bone fragments (Anonymous, 1990).
Overlying the Morrison Formation are the Cretaceous Burro Canyon Formation, Dakota Formation and Mancos Shale (Hansen, 1971). A few marine invertebrate fossils are known from the Mancos Shale in the park. A series of Tertiary volcanic eruptions covered the area with lava flows, breccias, and tuffaceous deposits including the West Elk Breccia.

Paleontology cooperative efforts include the Morrison Extinct Ecosystem Project (early-mid 1990s), a joint National Park Service and United States Geological Survey project (Turner and Peterson, 1998), and the National Park Service's Geologic Resources Division geologic resource inventory and paleontological resource inventory for Black Canyon of the Gunnison National Park (August 1998).

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Bryce Canyon National Park - Paleontological Resources

The first paleontological resource inventory for Utah National Parks was published by Santucci (2000). Bryce Canyon has need of a comprehensive paleontological resource inventory as a result of this preliminary effort. Bryce Canyon National Park lies along the eastern margin of the Paunsaugunt Plateau in south central Utah. The pink and white spires and cliffs have developed along an eroding fault escarpment within the early Tertiary Claron Formation. Underlying Upper Cretaceous rocks have produced a variety of paleontological resources from within and near Bryce Canyon National Park. For more information on the geology and a stratigraphic section of Bryce Canyon National Park, see Gregory (1951), Bowers (1990) and Davis and Pollock, (2000).

The Dakota Formation is the oldest exposed unit within Bryce Canyon National Park. A large collection of vertebrate fossils, including the remains of fish, sharks, rays, lizards, crocodiles, turtles, dinosaurs, and early marsupial mammals, occur in the fluvial facies of the Dakota Formation near the park (Jeff Eaton, written communication to Vince Santucci, 1999). The last North American fossil lungfish is known from the Dakota just east of the park, which documents the last gasp of a largely Jurassic freshwater fish fauna that dies out at the end of the Cenomanian (Kirkland, 1987). Locally, *in situ* stumps, large fragments of silicified and coalified wood, and palynomorphs (spores and pollen) have been found at the top of the Dakota Formation (May and Traverse, 1973 and Nichols, 1997). The remains of the bivalve (oyster) *Exogyra* sp. commonly occur at the top of the Dakota Formation (Gayle Pollock, written communication to Vince Santucci, 1999).

The Tropic Shale and its equivalents are some of the most fossiliferous Upper Cretaceous (Upper Cenomanian to Middle Turonian) marine units in North America. The Tropic Shale contains an abundance of marine invertebrates and the remains of a few marine vertebrates. The lower portion of the Tropic Shale contains the Late Cenomanian index fossil *Sciponoceras gracile ("Scip"* Zone) and the upper portion contains the middle Turonian index fossil *Collignoniceras woollgari* (Peterson and Waldrop, 1965). A small collection of invertebrate fossils has been recovered from within the park (Cobban et al, 1996). A few localized concentrations of fossil shark and ray teeth have been recovered from the upper portions of the Tropic Shale at nearby localities outside of the park.

The Straight Cliffs and Wahweap Formations contain significant terrestrial vertebrates (theropods and hadrosaurs). Eaton (1993, 1999) suggested that the faunas from the stratigraphically highest Cretaceous rocks of the plateau show affinities to the Kaiparowits Formation (Judithian Land-Mammal Age). Eaton and his colleagues are continuing their research on the Wahweap and possible Kaiparowits sediments in an effort to refine the biostratigraphy of the uppermost Cretaceous from the Paunsaugunt Plateau. The vertebrate fauna from Bryce Canyon includes fish, dinosaurs, crocodiles, lizards, turtles, mammals, and include a partial upper molar from a marsupial (Eaton, 1994, 1995, 1999; Eaton et al, 1993; Eaton et al, 1998; Eaton and Morrow, 1990; Munk, 1998). The Straight Cliffs Formation yielded assemblages of palynoflora and leaf impressions (Nichols 1997).

The Claron Formation (Late Paleocene to Early Eocene) is composed of limestone, mudstone, sandstone, and conglomerate beds that form the scenic landforms of Bryce Canyon National Park. The strata were deposited in lacustrine fluvial and overbank floodplain environments, but have been altered considerably by massive calcretization of many of the beds. A few invertebrate fossils and palynomorphs have been documented from this formation (Eaton et al, 1999b). A large number of invertebrate trace fossils were recently reported from the Claron Formation (Bown et al, 1997). The ichnofossils include hymenoptera nests, beetle burrows, and scorpion trails.

The Conglomerate of Boat Mesa, inferred to be Oligocene in age, overlies the Claron Formation. Permian invertebrates are preserved within chert pebbles from this conglomerate, indicating that Permian age rocks were at least a partial source of the clasts.

Quaternary alluvium was studied and the oldest alluvial section in the park is along Water Canyon, and contains records of the majority of the Holocene (+10,000 years). Paleontologic resources were collected and identified, including plant leaves, needles, seeds and twigs, and packrat midden samples (Agenbroad et al 1990).

Cooperative paleontology projects include a paleontological survey of Late Cretaceous sections, including the Kaiparowits Formation (Jeff Eaton, Weber State University in Ogden, Utah and curated by Paleontologists from the Utah Museum of Natural History in Salt Lake City, Utah), which began in 1988 and is ongoing. Also, the National Park Service's Geologic Resources Division held a scoping meeting on geologic resource inventory and paleontological resource inventory for Bryce Canyon National Park (July 1999), which brought attention to the importance of paleontologic resources at Bryce Canyon National Park.

Munk (1997, 1998) conducted a research project to determine if the Kaiparowits Formation (Upper Campanian) was present in Bryce Canyon National Park. The Kaiparowits Formation contains perhaps the best and most continuous record of Late Cretaceous terrestrial life in the world covering millions of years and is important in understanding the evolution of mammals and other terrestrial vertebrates. Previously known localities thought to represent the Kaiparowits Formation were resampled and a new locality was found in the Wahweap Formation (Lower Campanian) of Campbell Canyon in Bryce. The herptiles that were recovered from the Wahweap locality were compared to herptiles recovered from the stratigraphically highest Cretaceous beds of the Paunsaugunt Plateau. The presence of a Late Campanian salamander, *Habrosaurus*, suggests correlation of the uppermost beds to the Kaiparowits Formation.

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Data Set

DS-BRCA-0027 Paleontology of the Bryce Canyon National Park. 5/30/1982-present. Initiated by Dr. Jeffery Eaton. Status: Active.

Canyonlands National Park - Paleontological Resources

The first comprehensive paleontological resource inventory for Canyonlands National Park was published by Santucci (2000). For more information on the geology and a stratigraphic section of Canyonlands National Park, see Baars (2000), Lohman (1974), and Huntoon et al (1982).

The Honaker Trail Formation is a very fossiliferous Pennsylvanian limestone exposed in Canyonlands National Park. This unit contains rugose corals, bryozoans, brachiopods, gastropods, a few trilobites, and crinoids.

A fossil-rich locality within the Permian Cedar Mesa Sandstone is reported from the Indian Creek drainage just east of Canyonlands National Park (Stanesco and Campbell, 1989; Sumida et al, 1999). Cranial and vertebral remains of the pelycosaur reptile *Sphenacodon* and fragments identified as the temnospondyl amphibian *Eryops* were collected from within a petrified log jam. The logs at this locality have been identified as conifers and reach nearly a meter in diameter. This site was completely destroyed by vandalism in 1995 (Sumida et al, 1999). There may also be some tracks in the Permian Cedar Mesa Sandstone in the park that are accessible by river (A. Hunt, verbal communication, 1998).

A few poorly preserved steinkerns and gastropod impressions were reported from the Lower Triassic Sinbad Limestone Member of the Moenkopi Formation in Canyonlands National Park (Lucas, 1995). These specimens were first reported by McKnight (1940) and are dominated by the following taxa: the brachiopod *Lingula* sp., *Monotis thaynesiana*, unidentified viviparoid gastropods, and the ammonite *Meekoceras* sp.

The Upper Triassic Chinle Formation is well exposed in Canyonlands National Park and contains diverse faunal, floral, and ichnofossil assemblages. Vertebrate body fossils reported from the park include the remains of semionotid and turseodid fish, metoposaurs, phytosaurs, and the aetosaur *Stagonolepis* (Hasiotis, 1993; Lucas et al, 1997; Heckert et al, 1999;). Fresh water gastropods, bivalves, conchostrachans, and the earliest known crayfish also occur within this unit. An abundance of fossil plants occur in the Owl Rock Member of the Chinle including: *Neocalamites* sp. and *Pagiophyllum* sp.

Burrows produced by lungfish, crayfish, worms, and insects are common in the Chinle Formation in Canyonlands National Park (Hasiotis and Mitchell, 1989; Hasiotis, 1993, 1995). Hasiotis (1993) also reported a horseshoe crab resting trace from the park. A single well-preserved impression of a tridactyl dinosaur footprint *(Grallator* sp.) was found in the Rock Point Member of the Chinle Formation near Upheaval Dome (Hunt et al, 1993b; Lucas et al, 1995). Another Chinle tracksite contains impressions of a tetrapod with a four-toed manus and a five-toed pes. These tracks have blunt toes, lack claw impressions, and have been identified as *Brachychirotherium* sp. There are also two types of large five-toed tracks. One set is associated with an aetosaur-like reptile and the other is attributed to a dicynodont reptile (Santucci et al, 1998).

Fossil vertebrate tracks are also known from the upper part of the Kayenta Formation just below the overlying Navajo Sandstone in Canyonlands National Park (Lockley and Hunt, 1993; Santucci et al, 1998).

Canyonlands National Park - Paleontological Resources

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Capitol Reef National Park - Paleontological Resources

The first comprehensive paleontological resource inventory for Capitol Reef National Park was published by Santucci (2000). Santucci et al (1998) completed a detailed inventory of fossil vertebrate tracks in CARE. For more information on the geology and a stratigraphic section of Capitol Reef National Park, see Morris et al (2000), Gregory and Anderson (1939), Smith et al (1963), Davidson (1967), Billingsley et al (1987), and Collier (1987).

John C. Fremont traveled through the northern portion of the Capitol Reef area in 1853, during his fifth and final expedition through Utah prior to the Civil War. Fremont's party may have been the first Europeans to enter the area. G.K. Gilbert was probably the first geologist to visit the area which is now within Capitol Reef National Park. Fossil vertebrate tracks in the park received considerable attention by researchers after their discovery in 1945. A paleontological survey was conducted in 1994 along the GarKane Power Company's Right of Way through Capitol Reef National Park (Burres, 1994).

The Permian White Rim Sandstone (Cutler Group) which crops out locally within the park, is interpreted as a shoreface and coastal dune deposit in Capitol Reef National Park (Kamola and Chan, 1988). The marine trace fossils *Thalassinoides* and *Chondrites* are abundant in some parts of the cross-stratified sandstone facies. The Kaibab Limestone is a fossiliferous marine carbonate unit that interfingers with the White Rim Sandstone. The Kaibab Limestone contains fragmentary marine invertebrates including bryozoans, brachiopods, gastropods, bivalves, and crinoids.

The Triassic Sinbad Limestone Member of the Moenkopi Formation contains brachiopods, gastropods, bivalves, and ammonites. *Lingula* sp. is the only invertebrate fossil to be found outside of the Sinbad Limestone in the Moenkopi (Smith et al, 1963). Fossil vertebrate tracks were first reported from the Moenkopi in the Capitol Reef area by Charles Kelly in 1945. Paleontologist Charles Camp and Zion National Park naturalist Myrl Walker independently visited Capitol Reef in 1950 to survey for additional Moenkopi tracks after learning about Kelly's discovery. Peabody (1948, 1956) and Lammers (1964) published on the fossil vertebrate tracks, including *Chirotherium, Rotodactylus, Palaeophycus,* and *Diplidnites* from the Torrey Member of the Moenkopi Formation within Capitol Reef National Park. McAllister and Kirby (1998) reported on a variety of subaqueous reptile traces including: kick-off scours, z-traces, and buoyancy-size-mitigated, variably preserved traces.

In 1921, R.C. Moore, who was working with H.E. Gregory; collected some leaf impressions from the Upper Triassic Shinarump Formation in the Circle Cliffs area that is now within Capitol Reef National Park (Ash, 1975). These fossil plants were described by Berry (1927) and named *Zamites powelli.* Fossil plants were also collected in the Capitol Reef area by Roland Brown of the U.S. Geological Survey. Brown identified the fossil plants as *Palissya* sp., *Sphenozamites* sp., and an undetermined cycad leaf. The best preserved and most abundant stems of the fossil horsetail *Equisetites* occur in the Shinarump Member in the northern part of the park. *Phlebopteris, Cyneopteris, Cladophlebis, Pagiophyllum,* and *Araucarioxylon* are also known from this locality (Ash, 1975; 1993a). Leaves of a palmlike plant called *Sanmiguelia* cf. S. *lewisi* were reported from the Owl Rock Member of the Chinle Formation at Capitol Reef National Park (Ash, 1982). Petrified wood, leaf impressions, bivalves, vertebrate bones, coprolites and trace fossils, including a few tridactyl tracks, have also been found within the Chinle at the park.

Large algal mounds are reported from interdunal playa deposits within the Jurassic Navajo Sandstone in Capitol Reef National Park (Len Eisenberg, verbal communication, 1999). The algal mounds occur within carbonate lenses that have been tentatively interpreted as "Oasis deposits."

The Middle Jurassic Carmel Formation in central and southern Utah, including several localities in Capitol Reef National Park, contains a small but notable marine assemblage including *Ostrea* sp., *Trigonia* sp., *Camptonectes* sp. and the star-shaped columnals of the crinoid *Pentacrinus asteriscus*

(Imlay, 1964; Sohl, 1965). Jurassic dinosaur bones and petrified logs occur in the upper portion of the Salt Wash Member of the Morrison Formation in and near Capitol Reef National Park. Turtle and dinosaur remains are reported from the Lower Cretaceous Cedar Mountain Formation just north of the park (J. Kirkland, verbal communication, 1999).

The Cretaceous Dakota Sandstone is locally fossiliferous at Capitol Reef and contains a dense oyster shell reef composed of *Pycnodonte* sp. and *Exogyra (Costagyra) olisiponensis* Marine fossils, including bivalves, gastropods, ammonites, and shark's teeth, have been recovered from the Tununk Shale Member and the Blue Gate Member of the Mancos Shale in and around Capitol Reef National Park (W. Cobban, written communication, 2000).

The Flagstaff Limestone is a fossiliferous unit of Late Paleocene or Early Eocene age in the park. Charophytes, ostracods, bivalves, and gastropods indicate a freshwater origin for the carbonate unit (Smith et al, 1963).

Over two dozen packrat middens from Capitol Reef National Park have been studied in order to assess local vegetational changes from the Pleistocene to the Recent (Cole, 1992; Cole and Henderson, 1993). The oldest midden is dated to somewhat older than 39,000 years B.P. The remains of a Pleistocene mammoth were found on Boulder Mountain, west of Capitol Reef National Park.

Cooperative paleontology projects include the Morrison Extinct Ecosystem Project (early-mid 1990s), a joint National Park Service and United States Geological Survey project (Turner and Peterson, 1998). Also a paleontological assesment of trace fossils from the Triassic Moenkopi Formation (Deb Michelson, began 2000) is ongoinng. Also, the National Park Service's Geologic Resources Division conducted a geologic resource inventory and paleontological resource inventory for Capitol Reef National Park (September 1999).

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Cedar Breaks National Monument - Paleontological Resources

The first comprehensive review of paleontological resources for Cedar Breaks National Monument was published by Santucci (2000). An inventory of paleontological resources associated with National Park Service caves, including Cedar Breaks National Monument, was published by Santucci et al (2001). For more information on the geology and a stratigraphic section of Cedar Breaks National Monument see Hatfield et al (2000).

The only reports of paleontological resources from within or near Cedar Breaks National Monument include some marine invertebrates from the Jurassic Carmel Formation just west of the monument (Imlay, 1964) and freshwater gastropods from the early Tertiary Claron Formation. Eaton (written communication, 1999; Eaton et al, 1999a) reports on vertebrate fossils, including fish, turtles, and dinosaurs, from within the Straight Cliffs Formation in Cedar Canyon just west of the monument.

David Madsen and others (2002a) examined Quaternary bog deposits from two localities near Cedar Breaks National Monument. The remains of insects, plant macrofossils, and palynomorphs (spores and pollen) have been recovered. Radiocarbon dates from these deposits range from 17,000 B.P. to the Recent. Movement of vegetation communities in response to climate changes is recorded in the deposits. Thirteen fire events were recorded between bog stratum dated to ~5300 yr BP, indicating an occurrence of fire about every 330-410 years that did not change appreciably with the surrounding vegetation. An ash layer was also preserved in the peat deposit that originated at Mono Craters ~550 km to the west at about 14,000 yr BP (Madsen and others 2002b).

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Colorado National Monument - Paleontological Resources

The first comprehensive paleontological resource inventory for Colorado National Monument was published by Scott et al (2001).

COLM contains rocks dating from the Precambrian to the Cretaceous. Basement rock consists of Precambrian schist and gneiss. During the Paleozoic, the area was uplifted forming the Uncompahgre Highlands. Precambrian rocks are overlain by Mesozoic sedimentary units including, from oldest to youngest, the Chinle Formation, Wingate Sandstone and Kayenta Formation. The Triassic Chinle Formation is the oldest sedimentary formation in the COLM and unconformably overlies Precambrian crystalline rocks, reflecting a major unconformity. All of the sedimentary units in the park are Mesozoic. A theropod track site was discovered in the Chinle Formation in 1990 (A. Hunt, personal communication, 1999). The *Grallator*-like track site is located near the east entrance to the Monument.

Where the Kayenta has been removed; the Wingate Sandstone weathers into rounded domes and forms most of the named features within the Monument (Dubiel, 1992). The Entrada Sandstone of the Jurassic San Rafael Group is usually salmon colored and crossbedded: it is topped by the Wanakah. The Entrada Sandstone of Rattlesnake Canyon has been referred to as the second largest concentration of arches in the world and is of a different origin than the arches at Arches National Park. The Morrison Formation overlies the San Rafael Group and is fossiliferous. The Morrision Formation consists of the Tidwell, Salt Wash and the Brushy Basin Member (Turner and Fishman, 1991). The Jurassic section is topped by the Cretaceous Burro Canyon Formation and Dakota Sandstone.

In 1900, a famous dinosaur discovery was made in an area just outside of the current boundary of COLM. Elmer Riggs uncovered the forelimb of a sauropod dinosaur (*Camarasaurus grandis*) in the Brushy Basin Member of the Morrison Formation (Armstrong and Kihm, 1980). The site is marked today with an historic marker and is a local tourist stop known as Dinosaur Hill.

During 1977, an inventory of the Morrison Formation in COLM documented fourteen fossil localities (Callison, 1977). Fossils identified during the inventory included bivalves, gastropods, turtles, crocodilians, and dinosaurs, including an ischium of a dryosaur. Most of the specimens were found in the lower Salt Wash Member or Brushy Basin Member of the Morrison Formation. In 1985, many of these sites were resurveyed by George Engelmann yielding unionid bivalves, gastropods, and a sauropod caudal vertebra (Armstrong and Kihm, 1980). Engelmann and Fiorillo (2000) resurveyed these sites again in 1995 and reported several new sites. Only one of the original sites inventoried in 1977, specifically the site adjacent to the Black Ridge Trail, appears to have been vandalized (Engelmann, personal communication, 2000).
A historic newspaper clipping in the COLM files indicates that a mastodon tooth was found in 1965 in Thoroughfare Canyon. The tooth was reportedly discovered by Dr. Jack Roadifer, a local geologist. The whereabouts of the specimen are currently unknown.

Ichnofossils in COLM, all of which occur in the Chinle Formation, include *Scoyenia gracilis*, *Koupichnium nopsca* and *Camborygma* (Hasiotis, 1997), crayfish burrows, and plant roots (rhizoliths. Horseshoe crab traces were discovered in the lower units of the Tidwell Member of the Morrison Formation (Hasiotis et al., 1996), representing the first report of these traces from Jurassic rocks.

Previous cooperative palentology efforts include the Morrison Extinct Ecosystem Project (early-mid 1990s), a joint National Park Service and United States Geological Survey project (Turner and Peterson, 1998); the National Park Service's Geologic Resources Division geologic resource inventory and paleontological resource inventory for Colorado National Monument (June 1998); and the Colorado

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Curecanti National Recreation Area - Paleontological Resources

The first comprehensive paleontological resource inventory for Curecanti National Recreation Area was published by Scott et al (2001). The geologic setting is similar to that of the Black Canyon of the Gunnison. The park is recognized for having exposures of rocks that date to over 1.7 billion years in age, making these rocks among the oldest in western North America. (Fiorillo and Harris, 2000).

The Brushy Basin Member and the Salt Wash Member of the highly fossiliferous Upper Jurassic Morrison Formation are exposed at CURE. Trujillo (2000) prepared a detailed report documenting the paleontological field activities undertaken at the Dino Cove locality at CURE where the remains of two dinosaur taxa have been recovered from the Morrison Formation. The remains have been identified as a sauropod (cf. *Apatosaurus* sp.) and the theropod *Allosaurus* sp. (Fiorillo et al., 1995, 1996). There is a reptilian caudal vertebra in the park museum collection (Frank, personal communication, 2000). Conchostracans are very abundant in the Morrison at Curecanti, one location is Dino Cove (Fiorillo and May, 1996). There are several types of ichnofossils preserved within the Morrison Formation at CURE including crayfish burrows, termite nests, root casts and unionid clam burrows found near Red Creek (Fiorillo and Harris, 2000; Fiorillo, 1999; Fiorillo and McCarty, 1996). The invertebrate trace fossils predominantly occur in sandstone layers and suggest that during periods of non-deposition there were an abundance of small life forms (Fiorillo, 1999).

The first collection of Pleistocene (Rancholabrean) vertebrate remains from western Colorado come from Haystack Cave, located just outside of the CURE boundary. Specimens include remains identified as cf. *Miracinonyx trumani*, *Equus* sp. and *Phenacomys intermedius* (Emslie, 1986; Jefferson, personal communication, 2001).

Previous cooperative efforts include the Morrison Extinct Ecosystem Project (early-mid 1990s), a joint National Park Service and United States Geological Survey project (Turner and Peterson, 1998); and the National Park Service's Geologic Resources Division geologic resource inventory and paleontological resource inventory for Curecanti National Recreation Area (August 1998).

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Dinosaur National Monument - Paleontological Resources

The first comprehensive paleontological resource inventory for Dinosaur National Monument was published by Santucci (2000), and followed by Scott et al (2001).

Although the dinosaur-producing Morrison Formation has been the principal focus at DINO, the geologic record extends from the Precambrian through the Cretaceous. There has been such extensive paleontological study of DINO that more than 300 references are in existence (National Park Service, 2002). For more information on the geology of DINO, see Gregson and Chure (2000), Untermann and Untermann (1954, 1969), Hansen et al. (1983), and Hansen (1996).

The oldest sedimentary rocks within DINO are in the Precambrian Uinta Mountain Group. Hansen (1996) reported on fossilized algal globules *Chuaria* sp. from the Uinta Mountain Group near Manila, Utah, about 70 miles north of the Monument. Thus there is a potential for these fossils in the Monument.

The Upper Cambrian Lodore Formation consists of variegated, glauconitic shales and sandstones that contain marine invertebrates and trace fossils. Brachiopods, gastropods, and trilobites have been identified from the Lodore Formation in DINO (Herr, 1979; Herr et al., 1982; Hansen, 1996).

Corals, brachiopods, gastropods, and echinoderms are preserved, but rare, in the Lower Mississippian Madison Limestone (Hansen et al., 1983). Upper Mississippian brachiopods, fish, and coal beds are present in the Doughnut Formation (Hansen et al., 1983). The Lower Pennsylvanian Round Valley Limestone contains bryozoans, brachiopods, mollusks, and echinoderms (Hansen et al., 1983). Sponge spicules, corals, brachiopods, echinoid spines, crinoids, foraminifera, and conodonts are common in the marine facies of the Middle Pennsylvanian Morgan Formation (Driese, 1982).
The Permian Park City Formation (equivalent to the Phosphoria Formation farther north) consists of limestone, sandstone, and some chert layers. Marine invertebrates including brachiopods, bivalves, cephalopods, gastropods, and other invertebrates have been found in this unit (Hansen et al., 1983).

Peabody (1948) studied some unusual reptile tracks in the Lower Triassic Moenkopi Formation in the vicinity of DINO. These include some swimming traces now in the collections of the Utah Field House Museum of Natural History in Vernal, Utah. *Scoyenia* traces have been reported from the Moenkopi at DINO (Lockley et al., 1990).

In the 1960's an important vertebrate tracksite was discovered just northeast of DINO. Today over two dozen tracksites have been identified within the Monument. Numerous tracksites have been discovered in the Upper Triassic Popo Agie and Chinle Formations. Fossil tracks are diverse and include those identified from dinosaurs, mammal-like reptiles, phytosaurs, aetosaurs, lepidosaurs, trilophosaurs, and tanystropheids (Lockley et al., 1990, 1992a, 1992b, 1992c; Hunt et al., 1993). Among these is a swimming trackway of *Gwyneddichnium* that shows webbing between the toes. In addition, there are examples of both walking and swimming types of these tracks. Horseshoe crab-like tracks and petrified wood are documented from the Chinle Formation at DINO.

Tridactyl theropod tracks and a rich *Otozoum* tracksite are known from the Lower Jurassic Glen Canyon Sandstone, which is equivalent to the Glen Canyon Group farther south and the Nugget Sandstone farther west and north (Lockley et al., 1992a; Santucci et al., 1998). The Middle Jurassic Carmel Formation is a shallow marine deposit that locally contains gypsiferous beds. Bivalves, gastropods, echinoderms, and a few rare tridactyl vertebrate tracks have been reported from the Carmel Formation near DINO.

Chure (1993) reported on three plesiosaur specimens that may have been collected from the Redwater Member of the Stump Formation (Middle to Upper Jurassic) near the western boundary of DINO.

Belemnites, ammonites, gastropods, and bivalves occur in the Middle Jurassic Curtis Member of the Stump Formation in the DINO area.

The Upper Jurassic Morrison Formation is widely recognized as one of the most prolific dinosaur-bearing units in the world. In addition to dinosaurs, the Morrison Formation has produced important collections of Jurassic mammals and other vertebrates (Chure and Engelmann, 1989). The Morrison Formation at DINO contains four members including, from oldest to youngest, the Windy Hill, Tidwell, Salt Wash, and Brushy Basin Members (Turner and Peterson, 1999).

Utah's first theropod dinosaur (also recognized as the second dinosaur discovered in Utah) was found in 1870 near what is today DINO (Marsh, 1871; Bilbey and Hall, 1999). Earl Douglass made his famous discovery of the dinosaur bonebed in 1909. Under Douglass' direction the Carnegie Museum worked the site until 1922. During 1923, the U.S. National Museum (Smithsonian Institution) paleontologists collected a specimen of *Diplodocus,* which was mounted for display in that museum. In 1924, the University of Utah collected a skeleton of *Allosaurus* from the quarry. Holland (1912, 1915, 1916, and 1924) and Gilmore (1924, 1925a, 1925b, 1926, 1932, 1936a, and 1936b) published extensively on the dinosaur discoveries from DINO.

Theodore White was hired as the Monument's first paleontologist in 1953. White focused his attention on the preparation of the *in situ* bone-bearing layer and talking with the public about the world of dinosaurs. He hired and trained two maintenance men, Tobe Wilkins and Jim Adams, to expose in relief the bones on the Carnegie Quarry cliff face. White published both scientific and popular articles about the fossils at DINO (White, 1958, 1964). White liked to call himself the "Chief Ramrod of the Hammers and Chisels" until his retirement in 1973 (Ann Elder, written communication, 1999). Russ King, Dan Chure, Ann Elder, and Scott Madsen have recently worked as staff paleontologists at DINO (Chure, 1987, 1992; Chure and McIntosh, 1990). Elder (1999) provides an historical overview of the Carnegie Quarry at DINO.

Between 1989 and 1992, George Engelmann conducted a comprehensive paleontological survey of the Morrison Formation at DINO (Engelmann, 1992). More than 270 fossil sites were recorded during the survey. Most of the sites were dinosaur bone localities, but sites containing plant remains, invertebrates, and small vertebrates were also reported.

A number of new dinosaurs have been collected in recent years from DINO. In 1990, the first large carnivorous theropod dinosaur was collected from the Salt Wash Member of the Morrison Formation (Chure and Madsen, 1993; Chure et al., 1993). Chure (1994) reported on the oldest known troodontid dinosaur that was recovered from the Monument. A partial skeleton of a hatchling dinosaur, identified as *Camptosaurus*, was discovered at the Monument in 1991 (Chure et al., 1992) and represents the only hatchling of this genus known in the fossil record.

Chure et al (1989) reported on non-mammalian vertebrates collected from the Brushy Basin Member of the Morrison in DINO. Evans and Chure (1999) reported on lizards from the Morrison Formation that were collected in the Monument. The remains of the turtle *Glyptops* sp. and the crocodile *Goniopholis* sp. have been collected from the Monument. Several tiny frog skeletons and many isolated frog bones have been collected from a Brushy Basin microvertebrate locality in DINO. These amphibian remains represent at least four different species of frogs including *Comobatrachus* sp., *Eobatrachus* sp., and a new pipoid anuran (Henrici, 1992, 1993, 1998).

Engelmann et al (1989) reported on microvertebrates, including mammals that have been collected from quarries in DINO. The quarries are in the Brushy Basin Member of the Morrison and have yielded hundreds of isolated teeth and a few partial jaws. The skull of a new multituberculate, *Glirodon grandis,* was also found at the Monument (Engelmann and Callison, 1999). Other mammals identified include a triconodont, a symmetrodont, at least two species of dryolestids, and a paurodontid.

Yen and Reeside (1950) described freshwater mollusks from the Morrison Formation. Sohn and Peck (1963) identified the ostracode *Theriosynoecum wyomingense* as a guide fossil to the Salt Wash Member of the Morrison Formation.

Ash (1993, 1994) reported on an unusual leaf *Czechanowskia* sp. from the Brushy Basin Member of the Morrison Formation in the Monument. This plant is considered by some as an indicator of humid paleoclimates, but, the discovery of this plant in deposits of an alkaline-saline lake farther south brings this interpretation into question (Turner and Fishman, 1991). A gingko leaf locality occurs in the middle of the Brushy Basin Member . Tidwell (1990) reported on a plant locality in Orchid Draw in the western part of DINO. A palynological (fossil pollen) assessment of the Morrison Formation, including several sites within the Monument, was conducted by Litwin et al (1998).

Recent evidence shows that dermestid beetle larvae (Coleoptera: Dermestidae) borings are preserved in dinosaur bones collected from the Carnegie Quarry (Hasiotis, et al., 1999). These trace fossils suggest subaerial exposure of the dinosaur carcasses prior to burial and represent the earliest evidence of dermestids in the paleontological record.

Recent work in the Lower Cretaceous Cedar Mountain Formation has produced some spectacular fossil specimens. One site in particular, a river-deposited bonebed, has yielded a nearly complete articulated sauropod skull, elements of a second disarticulated sauropod skull, numerous sauropod post-cranial elements, and a few isolated theropod bones. Though only a preliminary analysis of these fossils has been completed, the cranial materials appear to be some of the most complete Cretaceous sauropod specimens found in North America (A. Elder, written communication, 1999).

The Dakota Formation of Late Early or Early Late Cretaceous age consists of shoreface and terrestrial strata deposited along the western margin of the western interior seaway. Petrified wood and fragmentary invertebrate remains have been found in the Dakota. Fish scales and bones are locally abundant in the Upper Cretaceous Mowry Shale, while bivalves, ammonites, and shark teeth are also known from this unit within DINO. The Upper Cretaceous Frontier Formation contains bivalves, gastropods, ammonites, petrified wood, and some thin coal beds. The Mancos Shale is not well exposed in the Monument, but locally this unit is very fossiliferous and preserves a high diversity of marine invertebrates. Ammonites are reported from the Mancos Shale at Ashley Creek and Brush Creek near the Monument (Kennedy and Cobban, 1991).
Sharpe (1991) reported on the Quaternary and Holocene flora in DINO that was collected to assess vegetational changes.

Previous cooperative efforts include the Morrison Extinct Ecosystem Project (early-mid 1990s), a joint National Park Service and United States Geological Survey project (Turner and Peterson, 1998); and the National Park Service's Geologic Resources Division geologic resource inventory and paleontological resource inventory for Dinosaur National Monument (September 1998).

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Fossil Butte National Monument - Paleontological Resources

Fossil Butte National Monument and surrounding areas are extensively studied for the fossils contained in the Green River Formation (National Park Service, 2002). This Formation represents an Eocene lake deposit and has preserved outstanding fossil fish and a host of other lake-dwelling organisms. The Eocene Wasatch Formation is the terrestrial component to this lake system and has produced various fossils including reptiles and early mammals. For more information on the geology see Rubey et al (1975).

Clupea humulis, later renamed *Knightia eocaena*, was the first fossil fish to be described in the Green River Formation deposits by Joseph Leidy (Ambrose, 1996). As a result of the early fish discoveries, scientists in the Geologic and Geographic Survey of the Territories investigated the Fossil Butte area. Albert Charles Peale conducted the first geological and paleontological survey of Fossil Butte in 1879. In 1884, Edward Drinker Cope published a comprehensive report of all the Tertiary vertebrates found during this survey (Cope, 1884). In this extensive volume, Cope names and describes a number of fossil fish from Fossil Butte. Due to growing interest in the exceptional perservation of fossil fish, the Fossil Butte area attracted many amateur commercial collectors, including Lee Craig and David Haddenham at the turn of the century.

Fossil insects, algae reefs, stromatolites, oolites, and plants of the Green River Formation were studied by W.H. Bradley in the 1920s (Bradley, 1924, 1925). The fossil bat *Icaronycteris index*, described by Glenn Jepsen (1966, 1970) was one of the oldest fossil bats ever found and contributed to the understanding of bat evolution. Coprolites of Fossil Lake were described in a short paper by Paul Edwards (1976). Storrs Olson (1977) described a frigate bird *Limnofregata azygosternon* from the Green River Formation.

Paul Buchheim has conducted extensive research in the Green River Formation since the 1970s and continues his study with the permission of the National Park Service. Buchheim has examined the lake's sediment laminations, size, shape, depth, geochemistry, salinity, and depositional environment which has greatly enhanced the understanding of the ancient ecosystem (Buchheim, 1981).

Lance Grande has also spent many years studying the fossil fish of the Green River Formation. He has contributed to our knowledge of the origin of modern fishes by comparing the anatomy of the fossil fishes to the anatomy of modern fishes. A comprehensive review of his work has been published (Grande, 1984).

The Wasatch Formation at Fossil Butte has received attention due to rich fossil mammal deposits. Cope's field workers collected fossil mammal material from the Wasatch, which Cope later described. Princeton University also sent expeditions out in 1939 and 1940 to collect fossil mammals.

Nelson studied fossil rodents from the Wasatch Formation (in what was formally called the Fowkes Formation), and the site was located in the south portion of Fossil Basin, 5 miles NW of Evanston (Nelson, 1974). Along with rodents, fossil primates have been discovered at the same location and formation (Nelson, 1977). A comprehensive study of the trace fossils at Fossil Butte was conducted by Zonneveld et al (2000). Paleontological inventory efforts of the Wasatch Formation are continuing with direct support from the National Park Service.

Cooperative paleontology projects include the National Park Service's Geologic Resources Division geologic resource inventory and paleontological resource inventory for Fossil Butte National Monument (May 2002).

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Golden Spike National Historic Site - Paleontological Resources

The first comprehensive paleontological resource inventory for Golden Spike National Historic Site was published by Santucci (2000).

Late Paleozoic miogeoclinal rocks are exposed in uplifted areas in and around Golden Spike National Historic Site. The Pennsylvanian-Permian Oquirrh Formation is exposed in the nearby Promontory Mountains. The basal limestone member consists of coarse bioclastic beds that contain fusulinids, horn corals, bryozoans, brachiopods, gastropods, and crinoids that have been reported to be Early to Middle Pennsylvanian in age (Miller et al, 1991).

A fossilized mandible from an extinct marmot, *Paenemarmota* cf. P. *sawrockensis,* was collected from an early Pliocene colluvium locality near Golden Spike (Nelson and Miller, 1990).

Fine-grained lacustrine deposits associated with the Late Pleistocene Lake Bonneville Alloformation contain pockets of ostracods, bivalves, and gastropods (Don Currey, verbal communication, 1999).

Cooperative paleontology projects include the National Park Service's Geologic Resources Division geologic resource inventory and paleontological resource inventory for Golden Spike National Historic Site (June 1999).

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Hovenweep National Monument - Paleontological Resources

The first comprehensive paleontological resource inventory for Hovenweep National Monument was published by Santucci (2000) and followed by Scott et al (2001).

Sedimentary rocks exposed in the monument include the Upper Jurassic Morrison Formation, the Lower Cretaceous Burro Canyon Formation, and the Upper Cretaceous Dakota Sandstone. The only report of paleontological resources from the monument is an unidentified bone found by a Utah Geological Survey geologist (Martha Hayden, written communication, 1999). Although there are not many reports of fossils from within the monument, judging from their known presence nearby, invertebrate fossils most likely are present in Hovenweep National Monument.

Cooperative projects include the National Park Service's Geologic Resources Division geologic resource inventory and paleontological resource inventory for Hovenweep National Monument (September 2000).

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Natural Bridges National Monument - Paleontological Resources

The first comprehensive paleontological resource inventory for Natural Bridges National Monument was published by Santucci (2000). An inventory of paleontological resources associated with National Park Service caves, including Natural Bridges National Monument, was published by Santucci et al (2001).

The natural bridges are formed in the Permian Cedar Mesa Sandstone, which is the oldest geologic unit exposed in the monument. Stratigraphically, the rocks near the monument range from Permian to Jurassic in age. Although a paleontological survey has not been undertaken at the monument, a few isolated fossils have been reported. For more information on the geology and a stratigraphic section of Natural Bridges National Monument see Huntoon et al (2000).

The Permian Cutler Formation in southeastern Utah was originally divided into five members (Baker and Reeside, 1929). More recent work by Condon (1997) recognized the Cutler as a Group in southeastern Utah and identified the following subdivisions in and near Natural Bridges: lower Cutler beds, Halgaito Formation, Cedar Mesa Sandstone, and Organ Rock Formation. The Cedar Mesa Sandstone is primarily a light-colored, cross-bedded sandstone unit that locally contains pink arkosic sandstone and mudstone beds as well as scarce grey-green limestone lenses. The unit has been interpreted as largely eolian in origin because of the abundant cross-bedded sandstone. However minute fragments of marine invertebrate fossils locally occur within the sandstone. Baars (1975) suggested that the fossils indicate a marine origin of the beds whereas Stanesco and Campbell (1989) concluded that the marine fossils were transported into the eolian sands by wind. Duffy (1998) reported on in situ fossilized plant roots or rhizoliths preserved in the Cedar Mesa Sandstone at Natural Bridges National Monument. Poorly preserved horizontal and vertical burrows are also preserved in the fine-grained, green-gray, interdunal sandstone beds (Jackie Huntoon, written communication, 1999).

The Upper Triassic Chinle Formation is exposed near the monument and some isolated petrified wood specimens have been reported from this formation (S. Duffy, verbal communication, 1999). Dubiel (1983, 1987) reported ostracods, conchostracans, unionid bivalves, and various trace fossils from the Chinle Formation nearby in White Canyon.

A large, flat-floored dry rock shelter in the Cedar Mesa Sandstone contains a wealth of indurated late Pleistocene (Rancholabrean) packrat middens and a 100-cm stratigraphic profile that contains skeletal and plant remains. Dung pellets from the shelter were radiocarbon dated and range in age between 39,000 to 9660 years B.P. (Mead and Agenbroad, 1992; Mead et al, 1993b). Two metapodials, identified as those belonging to the extinct mountain goat *Oreamnos harringtoni*, were recovered from the shelter and represent the oldest dated remains of this mountain goat. Plant microfossils indicate that Engelmann spruce (*Picea engelmannii*), limber pine (*Pinus flexilis*), and Douglas fir (*Pseudotsuga menziesii*) grew nearby during the late Pleistocene, whereas a riparian willow (*Salix* sp.) and cottonwood (*Populus* sp.) is now present in the bottom of the canyon and a pinyon-juniper (*Pinus edulis-Juniperus osteosperma*) community now predominates higher up on the canyon walls and in the benchlands above the canyon (Mead et al, 1987).

A cooperative paleontology project is the National Park Service's Geologic Resources Division geologic resource inventory and paleontological resource inventory for Natural Bridges National Monument (May 1999).

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Pipe Springs National Monument- Paleontological Resources

A comprehensive paleontological resource inventory has not been conducted at Pipe Spring National Monument, however significant trace fossils have been identified. Santucci et al (1998) completed a detailed inventory of these fossil vertebrate tracks.

The stratigraphic units within the Monument are primarily Mesozoic in age and are noted to be fossiliferous in other park service areas. These units are Lower Jurassic Navajo Sandstone, Jurassic Kayenta Formation, and Triassic Chinle Formation. The Navajo Sandstone has produced a dinosaur trackway in PISP.

R.J. Cuffey was the first to thoroughly investigate the tracks at PISP in 1995 (Cuffey et. al, 1998). Three tracks, two side by side and a third out in front, are preserved in the orange-red, quartz sandstone 2 meters above the base of the Navajo Sandstone. The shallow depressions make identification of the ichnofossils difficult. However, several species of the Early Jurassic *Eubrontes* have been suggested, including: *E. approximatus, E. divaricatus, E. giganteus, E. platypus,* or *E. tuberatus*. The ichnogenus *Eubrontes* is the fossilized track of a large bipedal carnivorous theropod dinosaur, presumably a carnosaur or megalosaurid (Cuffey et. al, 1998).

Cooperative paleontology projects include the National Park Service's Geologic Resources Division geologic resource inventory and paleontological resource inventory for Pipe Spring National Monument (June 2001).

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Timpanogos Cave National Monument - Paleontological Resources

The first comprehensive paleontological resource inventory for Timpanogos Cave National Monument was published by Santucci (2000). An inventory of paleontological resources associated with National Park Service caves, including Timpanogos Cave National Monument, was published by Santucci et al (2001). For more information on the geology and a stratigraphic section of Timpanogos Cave National Monument see Mayo et al (2000), Baker and Crittenden (1961), and White and Van Gundv (1974).

The oldest fossils in the monument are trace fossils found within the Precambrian Mutual Formation. Invertebrate fossils are preserved in the Cambrian Maxfield Limestone, Ophir Shale, and the Devonian/ Mississippian Fitchville Formation. Walcott reported Early and Middle Cambrian trilobites (*Olenellus*) from the Ophir Shale. Worm burrows and brachiopods also occur within the Ophir (Baker and Crittenden, 1961). The limestone caves in the national monument are developed in the Mississippian Deseret Formation. A variety of fossilized marine invertebrates, including syringoporoid corals and brachiopods, have been found in the formation.

Packrat middens have been found at several localities within the national monument including the Timpanogos Cave System and Hidden Cave Mine. In 1939, Tom Walker found mammal bones in a rockshelter known as the Grotto, which was known to be the den for a mountain lion until 1880. Bones were collected from packrat nests found in the Organ Pipe Room of Hansen Cave. During 1998, George (1999) initiated an assessment of packrat middens from three cave areas within Timpanogos Cave National Monument. Eleven species of mammals were collected and identified from the middens. A partial bison skeleton was found in the gravels at the mouth of Swinging Bridge Canyon in the monument (Rod Horrocks, written communication, 1999).

Cooperative paleontology projects include the National Park Service's Geologic Resources Division geologic resource inventory and paleontological resource inventory for Timpanogos Cave National Monument (May 1999).

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Zion National Park - Paleontological Resources

The first comprehensive paleontological resource inventory for Zion National Park was published by Santucci (2000). For more information on the geology and a stratigraphic section of Zion National Park see Biek et al (2000), Gregory (1939, 1945, 1950), and Hamilton (1978, 1984).

Several important expeditions by Europeans came into or near Zion Canyon during the 18th and 19th centuries. The earliest description of the area is in the diaries of the Dominguez-Escalante Expedition of 1776. The federal government initiated scientific surveys into southwestern Utah during 1853, some of which passed into and near Zion Canyon. Some of the more notable surveys were led by George Wheeler and John Wesley Powell. These two surveys mapped and interpreted the geographic and geologic features in a region that covered more than 50,000 square miles.

The Wheeler Survey, also referred to as the U.S. Geographic Surveys West of the One Hundredth Meridian, was a series of military and scientific expeditions undertaken by the U.S. Army. The survey was led by Captain George M. Wheeler. Although field surveys were conducted in 1869 and 1871, Wheeler did not receive funding to organize a regional scientific survey until 1872. The Wheeler Survey continued field work until 1879. Geologists G.K. Gilbert and Edwin E. Howell joined the Wheeler Survey and were involved in geologic field work in Zion Canyon and the surrounding area during 1872. The results of the survey, including descriptions of the geology and paleontology, were published in a series of volumes by the U.S. government.

The following quote is found within the Wheeler Geographic Report (1886) in reference to southwestern Utah. "Clambering along the cliff, and while securing a large haul of fossils, the crisp edge of coal crops was noticed, and prospecting which a 12-foot vein of dense bituminous coal, having both above and below a bed of shale 15 to 18 inches thick, was found, with petrified wood strewn in many directions. Fossils were found in sandstones..."

John Wesley Powell followed the Virgin River Valley northward into Zion Canyon during 1871 (Powell, 1875). Powell did not focus much attention on the geology until he employed Howell in 1874 and Gilbert and Dutton in 1875. William Henry Holmes produced several outstanding line drawings of the area that are well known for their geological and topographical accuracy as well as their artistic beauty.

The rocks exposed in and around Zion National Park range from Permian through Cretaceous in age. During this interval, the Zion area was repeatedly covered by marine transgressions from seaways that lay largely to the west, north, or east. The oldest unit exposed in Zion National Park is the Lower Permian Toroweap Formation. The Kaibab Limestone of Late Early Permian age is a marine limestone unit, overlying the Toroweap, exposed in two small areas in the northwest corner of the park along the escarpment produced by the Hurricane fault. Brachiopods, bryozoans, corals, crinoids, and sea urchins have been recovered in the Zion area (McKee, 1952) although fossil preservation generally is poor.

The Moenkopi Formation (Early to Middle Triassic) represents both shallow marine and nearshore terrestrial environments in and near the Zion region. Fossilized marine bivalves, snails, and ammonites *(Meekoceras* sp.*)* are known from the formation. A few pieces of fossil wood and bone have been found in this unit. The Virgin Limestone Member contains fossilized asteroid starfish and abundant internal molds of mollusks. This unit is well exposed in the northwest and southwest corners of the park. The terrestrial component of the Moenkopi Formation increases upsection, reflecting gradual transgressions and regressions of the early Triassic sea.

The Chinle Formation (Late Triassic) includes petrified wood that was originally transported by streams from the east and southeast. The logs are found in the basal Shinarump Conglomerate Member and has

been identified as *Araucarioxylon* sp. and *Woodworthia* sp. Fossilized bones from the labyrinthodont *Metoposaurus* sp. have been collected from freshwater mudstone beds near Cougar Mountain.

The Lower Jurassic Moenave Formation includes, from oldest to youngest, the Dinosaur Canyon, Whitmore Point, and Springdale Sandstone Members. The Dinosaur Canyon Member consists of red mudstone, siltstone, and some sandstone deposited in mudflat, fluvial, and overbank environments. The Whitemore Point Member is a gray mudstone and shale unit deposited primarily in lacustrine environments. Palynomorphs (pollen and spores) recovered from this member are especially important as they provided the most reliable dating of this formation. The Springdale Sandstone Member is composed largely of red sandstone deposited by high energy streams that originated in a highland source region in the ancestral Rockies of western Colorado. Pond and stream deposits from the Moenave Formation contain the remains of the fish Semiorlottcs *kanabensis* (Hesse, 1935; Day, 1967). Fossil vertebrate tracks have been found in both the Whitmore Point and Springdale Members of the Moenave (Smith and Santucci, 1999).

The Lower Jurassic Kayenta Formation in the Zion region consists primarily of siltstone and sandstone deposited in sabkhas (a very flat landform where tides or groundwater at the surface traps windblown grains) downwind (south) of extensive eolian dune deposits that are included in the Navajo Sandstone. This unit contains several thin limestone beds that preserve fossil trails of aquatic snails or worms. The first vertebrate tracks reported from Zion National Park were tridactyl dinosaur prints in the Kayenta (Stokes and Bruhn, 1960). Additional vertebrate tracksites were discovered in the Kayenta during a paleontological survey in Zion during 1998 and 1999 (Santucci et al, 1998; Smith and Santucci, 1999).

Although the Navajo Sandstone is one of the most easily recognized units in the southwest, the unit appears to be largely devoid of body fossils in Zion National Park, although a few tridactyl dinosaur footprints have been found along the trail to Observation Point (Fred Peterson, written communication, 2000). The large-scale cross-bedding that is so pronounced in the park reflects stratification produced in windblown sand deposits. In an unpublished report found in the Zion National Park files, John Bradbury claims that during 1962 poorly preserved fossil wood was found within a shale lens of the Navajo Formation.

The Middle Jurassic Carmel Formation includes several light tan to gray limestone beds that contain marine fossils, including crinoids, pectens, oysters, and other bivalves (Gregory and Williams, 1947). The crinoids are identified as *Isocrinus* sp. An oolitic limestone bed containing algal balls, bivalves, and gastropods is present along Wildcat Canyon Trail.

A small exposure of the Cretaceous Dakota Sandstone is exposed in the northwest corner of the park on top of Horse Ranch Mountain. The formation contains a basal conglomerate overlain by a series of sandstone and mudstone beds, some of which contain freshwater bivalves and plant impressions. A few undescribed vertebrate fossils are reported from the Dakota just east of Zion National Park (Eaton, written communication, 1999; Kirkland, written communication, 1999).

The remains of a plesiosaur were excavated from the Upper Cretaceous Tropic Shale near the eastern boundary of Zion National Park (Gillette et al, 1999).

A large artiodactyl track and a bird track resembling those of herons were collected from Quaternary lacustrine deposits in the Coalpits Wash area (Santucci and others, 1998). The remains of a bison *(Bison antiquus)* were collected in the park many years ago (Wayne Hamilton, verbal communication, 1998).

Hevly (1979) analyzed pollen and spore samples taken from Quaternary lacustrine sediments in Zion National Park.

Cooperative paleontology projects include the National Park Service's Geologic Resources Division geologic resource inventory and paleontological resource inventory for Zion National Park (April 1999), and the Zion Paleontological Survey project between the National Park Service and the Utah Geological Survey (Santucci, Smith, and Kirkland, began 1998 and is ongoing).

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DS-SEUG-004 Chicken Creek Erosion Series Photomonitoring

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Arches National Park - Climate

Arches National Park has been a participant in the National Weather Service Cooperative Observer Program (NWS COOP) since 1980 (see http://www.nws.noaa.gov/om/coop/index.htm for information on this program). Maximum temperature, minimum temperature, and total precipitation for the previous 24 hours are recorded daily at approximately 7 a.m. from instruments housed in a station located near park headquarters. Monthly data summaries are sent to the National Weather Service. Long-term monthly climate summaries are available on-line from the Western Regional Climate Center (http://www.wrcc.dri.edu/climsum.html). Daily data are available for a fee. Since 1990, NWS COOP data also have been archived by park staff (DS-SEUG-001).

In addition to the NWS COOP data, hourly meteorological data were collected by an automated station associated with air-quality monitoring at Arches National Park from May 1987 until July 1992 (DS-SEUG-041.1). These data are available via an on-line query of the National Park Service Air Quality Network Database (see http://www2.nature.nps.gov/ard/gas/netdata1.htm).

Climatological data for Arches, Canyonlands, Capitol Reef, and Natural Bridges and the surrounding region were summarized in a report by Davis (1974).

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Davis, Denis. 1974. Regional resources basic inventory- climatology: Arches National Park, Canyonlands National Park, Capitol Reef national Park, Natural Bridges National Monument and surrounding region. 45 p.

Data Sets

DS-SEUG-001

Daily weather data for Arches National Park, September 1990-present. 9/1/1990 - . (MS Excel spreadsheets; hard-copy monthly data sheets). Originated by Moore, Lynda; status: Active.

DS-SEUG-041.1

Arches National Park air quality: Meterological data. 5/1/1987 - 7/7/1992. (database). Originated by ; status: Inactive.

Black Canyon of the Gunnison National Park - Climate

Ongoing climate monitoring at Black Canyon of the Gunnison National Park is restricted to a single automated RAWS station (Remote Area Weather Station) established in 1997 on the south rim of the park. This station collects hourly observations of average and peak wind speeds, average and peak wind directions, air temperature, total precipitation, relative humidity, and fuel temperature. Data for the past 24-36 hours are available on-line at http://raws.boi.noaa.gov/obs2/CO_BLACK_CANYON.html (also accessible via the Grand Junction National Weather Service website, http://www.crh.noaa.gov/gjt/). Archived data are available on-line from the Western Regional Climate Center at http://www.wrcc.dri.edu/wraws/.

Recent studies have addressed potential effects of climate change on aspects of the Gunnison River system. August et al. (1992) used data from 16 databases to examine the sensitivity of water supply to climate change in several western river basins, including that of the Gunnison River. Elliott and Parker (1992a,b) evaluated potential effects of climate change on fluvial geomorphic processes in the Gunnison River gorge.

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Bryce Canyon National Park - Climate

Bryce Canyon National Park has been a participant in the National Weather Service Cooperative Observer Program (NWS COOP) since 1959 (see http://www.nws.noaa.gov/om/coop/index.htm for information on this program). Maximum temperature, minimum temperature, and total precipitation for the previous 24 hours are recorded daily at approximately 7 a.m. from instruments housed in a station located near park headquarters. Monthly data summaries are sent the National Weather Service. Long-term monthly climate summaries are available on-line from the Western Regional Climate Center (http://www.wrcc.dri.edu/climsum.html). Daily data are available for a fee.

In addition to the NWS COOP station, two automated RAWS (Remote Area Weather Stations) stations are located in Bryce Canyon National Park and managed by park fire-management staff. These are the HQ RAWS, located near park headquarters (established 2002), and the Agua Canyon RAWS, located at the south end of the park (established 1990). These stations collect hourly observations of average and peak wind speeds, average and peak wind directions, air temperature, total precipitation, relative humidity, dewpoint, fuel temperature, and 10-hour fuel moisture (ranked 1-5). Real-time data for the previous 24-36 hours are available on-line from the NWS at http://www.wrh.noaa.gov/saltlake/fire/raws/. Archived data are available on-line from the Western Regional Climate Center at http://www.wrcc.dri.edu/wraws/.

Changes in climate are recorded in forest fire scars, tree rings, and precipitation measurement. The pine and fir chronologies are found to differ (Grow 1999, Verville 2001), and by comparing the sensitivity of the two species to summer precipitation, it is hoped their relative value as recorders (of past changes in the seasonal distribution of precipitation will be discovered by upcoming research. Fire incidence and tree rings document individual trees responses to climate, fire and fire response (Mast 1994).

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Verville, Julia. 2001. Investigator Annual Report: Summer precipitation and humidity dynamics recorded in tree rings. 2 pages.

Data Sets

DS-BRCA-0029 Climate Change Observations. 01/01/1959 – present. (paper files, web-based data NWS, excel spreadsheet for dendrochronology samples). Initiated by BRCA Resource Management Staff. Status: active.

Canyonlands National Park - Climate

Canyonlands National Park has participated in the National Weather Service Cooperative Observer Program (NWS COOP) by collecting daily weather records at three separate stations since 1965 (see http://www.nws.noaa.gov/om/coop/index.htm for information on this program). One station is located in the Needles District ("The Needle"), one in the Island in the Sky District ("The Neck"), and one just outside the Maze District ("Hans Flat"). Maximum temperature, minimum temperature, and total precipitation for the previous 24 hours are recorded daily at approximately 7 a.m. from instruments housed at each of these stations. Monthly data summaries are sent to the National Weather Service. Long-term monthly climate summaries are available on-line from the Western Regional Climate Center (http://www.wrcc.dri.edu/climsum.html). Daily data are available for a fee. Since 1987, NWS COOP data also have been archived by park staff (DS-SEUG-004, DS-SEUG-005, and DS-SEUG-006).

In addition to the NWS COOP data, meteorological data are collected by several automated stations located within or near the park. One of these is located near the visitor center at the Island in the Sky District and is associated with air-quality monitoring that has been conducted there since 1986. The station records hourly average wind speed, wind direction, incoming solar radiation, relative humidity, and total precipitation (DS-SEUG-041.2). Data collected after 12/31/94 are available on-line from the Environmental Protection Agency at http://www.epa.gov/castnet/metdata.html. Data on this site are posted and updated yearly.

Two automated stations associated with the U.S. Geological Survey Southwest Climate Impacts Project (see http://climchange.cr.usgs.gov/info/sw/index.html) are located in the Needles District, and two accompanying stations are located on lands managed by the Bureau of Land Management and The Nature Conservancy within a few miles of the Needles District. These stations record hourly average and peak wind speeds, wind direction, incoming and outgoing radiation, relative humidity, air temperature, precipitation, and soil moisture. Data are used in integrated ecological studies of soil erosion, climate variability, vegetation change, desert soils, and ecosystem function in the Canyonlands area. Site descriptions and archived meteorological are available on-line at http://climchange.cr.usgs.gov/info/sw/clim-met/.

Two climate-related studies have been conducted at Canyonlands. Climatological data for Arches, Canyonlands, Capitol Reef, and Natural Bridges and the surrounding region were summarized in a report by Davis (1974). Schwartz (1994) used dendrochronological methods to study Holocene climatic fluctuations and develop a 600-year climate record for the park.

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Data Sets

Canyonlands National Park - Climate

DS-SEUG-004 Daily weather data for The Neck, Island in the Sky District, Canyonlands NP, January 1987-present. 1/1/1987 - . (MS Excel spreadsheets; hard-copy monthly data sheets). Originated by Tanner, Karla; status: Active.

DS-SEUG-005 Daily weather data for Hans Flat, near the Maze District of Canyonlands NP, April 1987-present. 4/1/1987 - . (MS Excel spreadsheets; hard-copy monthly data sheets). Originated by Beyer, Cynthia;

DS-SEUG-006 Daily weather data for the Needles District of Canyonlands NP, February 1987-present. 2/1/1987 - . (MS Excel spreadsheets; hard-copy monthly data sheets). Originated by Habig, Dan; status: Active.

DS-SEUG-041.2 Canyonlands National Park air quality: Meterological data. 7/1/1992 - . (database). Originated by ; status: Active.

Capitol Reef National Park - Climate

Capitol Reef National Park has been a participant in the National Weather Service Cooperative Observer Program (NWS COOP) since 1967 (see http://www.nws.noaa.gov/om/coop/index.htm for information on this program). Maximum temperature, minimum temperature, and total precipitation for the previous 24 hours are recorded daily at approximately 7 a.m. from instruments housed in a station located near park headquarters. Monthly data summaries are sent to the National Weather Service. Long-term monthly climate summaries are available on-line from the Western Regional Climate Center (http://www.wrcc.dri.edu/climsum.html). Daily data are available for a fee.

In addition to the NWS COOP data, a variety of climate data and reports has been assembled and filed by park staff since 1948 (DS-CARE-0029). Davis (1974) summarized climatological data for Capitol Reef, Arches, Canyonlands, Natural Bridges, and the surrounding region.

References

Davis, Denis. 1974. Regional resources basic inventory- climatology: Arches National Park, Canyonlands National Park, Capitol Reef national Park, Natural Bridges National Monument and surrounding region. 45 p.

Data Sets

DS-CARE-0029 Climate data for Capitol Reef National Park. 1/1/1948 - . (Paper sheets, summaries, graphs, and reports in appx. six file folders.). Originated by Capitol Reef National Park; status: Inactive.

Cedar Breaks National Monument - Climate

Cedar Breaks National Monument intermittently participated in the National Weather Service Cooperative Observer Program (NWS COOP) from 1948 until 1970 (see http://www.nws.noaa.gov/om/coop/index.htm for information on this program). During that period, maximum temperature, minimum temperature, and total precipitation were recorded on a daily basis. Long-term monthly climate summaries derived from this data set are available on-line from the Western Regional Climate Center (http://www.wrcc.dri.edu/climsum.html). Daily data are available for a fee. Currently, the nearest NWS COOP station to Cedar Breaks National Monument is the Blowhard Mountain radar site, located approximately one mile south of the Monument. Daily data have been collected at this station since 1964. Summaries of the Blowhard Mountain data set are available on-line at http://www.wrcc.dri.edu/climsum.html.

Colorado National Monument - Climate

Colorado National Monument has participated in the National Weather Service Cooperative Observer Program (NWS COOP) since 1948 (see http://www.nws.noaa.gov/om/coop/index.htm for information on this program). Maximum temperature, minimum temperature, and total precipitation for the previous 24 hours are recorded daily at approximately 7 a.m. from instruments housed in a station located near park headquarters. Monthly data summaries are sent to the National Weather Service. Long-term monthly climate summaries are available on-line from the Western Regional Climate Center (http://www.wrcc.dri.edu/climsum.html). Daily data are available for a fee. Between 1983 and 1991, Monument staff also archived these data in an electronic format (DS-COLM-002).

Only one climate-related study is recorded in the bibliographic database for Colorado National Monument. Spry (1989) studied the effects of bedrock composition on sediment particle sizes carried by runoff from the same storm event in two different drainage basins in the Monument. The maximum probable runoff for 1989 and 1985 storm events was calculated based on rainfall records and compared to the runoff from the greatest rainfall of 1978, a year with flooding in one of the canyons.

References

Spry, Linda. 1989. Bedrock influence on basin morphometry and basin response to brief precipitation events. Geomorphology term project. 50 p.

Data Sets

DS-COLM-002	Meteorological Data, Colorado National Monument, 1983-1991.. (Excel spreadsheet). Originated by ; status: Inactive.

Curecanti National Recreation Area - Climate

Curecanti National Recreation Area has participated in the National Weather Service Cooperative Observer Program (NWS COOP) since 1967 (see http://www.nws.noaa.gov/om/coop/index.htm for information on this program). Maximum temperature, minimum temperature, and total precipitation for the previous 24 hours are recorded daily at approximately 7 a.m. from instruments housed in a station located near the recreation-area headquarters. Monthly data summaries are sent to the National Weather Service. Long-term monthly climate summaries are available on-line from the Western Regional Climate Center (http://www.wrcc.dri.edu/climsum.html, station name "Blue Mesa Lake"). Daily data are available for a fee.

Two climate-related studies are recorded in the bibliographic database for Curecanti. Burgi (1989) conducted a 6-year study of winter ice jams on Blue Mesa Reservoir, the Taylor Park Reservoir, and the Gunnison River Reach in relation to climatological conditions. Elliott and Parker (1992) evaluated potential effects of climate change on fluvial geomorphic processes in the Gunnison River gorge.

References

Burgi, Phil H. 1979. Winter Ice Jams on the Gunnison River. REC-ERC-79-4. United States Department of the Interior. Denver, CO. 29 p.

Elliott, John G. and Parker, Randolph S. 1992. Potential climate-change effects on bed-material entertainment, the Gunnison Gorge, Colorado. 28th Annual Conference and Symposia; American Water Resources Association. 9 p.

Dinosaur National Monument - Climate

Dinosaur National Monument maintains two long-term monitoring stations in conjunction with the National Weather Service Cooperative Observer Program (NWS COOP, see http://www.nws.noaa.gov/om/coop/index.htm for information on this program). Daily maximum temperature, minimum temperature, and total precipitation are recorded at stations located near the Quarry ("Dinosaur NM Quarry Area," established 1958) and Monument headquarters ("Dinosaur Natl Monument," established 1965). Monthly data summaries are sent to the National Weather Service. Long-term monthly climate summaries are available on-line from the Western Regional Climate Center (http://www.wrcc.dri.edu/climsum.html). Daily data are available for a fee. Monument staff have maintained a file of meteorological data collected at the headquarters station since 1964 (DS-DINO-023).

Two fire-weather monitoring stations were initiated at the Monument in 1965 (one at the Quarry and one at Monument headquarters). During the wildfire season (May through September) from 1965 until mid-season 2002 when they were discontinued, daily maximum temperature and relative humidity, minimum temperature and relative humidity, average wind speed and direction, total precipitation, precipitation duration, and 10-hour fuel moisture were recorded at these stations. Data were used to calculate daily fire danger ratings. Monument staff retained paper copies of data sheets (DS-DINO-037), but data also may exist in an electronic database at the National Information Technology Center in Kansas City. Inquiries have been made regarding the accessibility of Dinosaur National Monument's long-term fire-weather data.

Two automated RAWS stations (Remote Area Weather Stations) also are located in the Monument. The Ladore station (operated by BLM) was established in 1989, and the Success station was established in 1990. These stations collect hourly observations of average and peak wind speeds, average and peak wind directions, air temperature, total precipitation, relative humidity, and fuel temperature. Data are transferred hourly to the National Interagency Fire Center in Boise via satellite. Data for the past 24-36 hours are available at http://raws.boi.noaa.gov/obs2/CO_Ladore.html and http://raws.boi.noaa.gov/obs2/CO_DINOSAUR_NM_SUCCESS.html (also accessible via the Grand Junction National Weather Service website, http://www.crh.noaa.gov/gjt/). Archived data are available on-line from the Western Regional Climate Center at http://www.wrcc.dri.edu/wraws/.

Data Sets

DS-DINO-023	NOAA Weather. 1/1/1964 - present. (Tables). Status: Active.
DS-DINO-037	Daily weather readings for fire risk assessment, Dinosaur NM Quarry and Headquarters, 1965 - present. (manual notes, national database). Status: Active.

Fossil Butte National Monument - Climate

Fossil Butte National Monument has participated in the National Weather Service Cooperative Observer Program (NWS COOP) since 1990 (see http://www.nws.noaa.gov/om/coop/index.htm for information on this program). Maximum temperature, minimum temperature, and total precipitation are recorded daily (DS-FOBU-2001-0). Monthly data summaries are sent to the National Weather Service. Long-term monthly climate summaries are available on-line from the Western Regional Climate Center (http://www.wrcc.dri.edu/climsum.html). Daily data are available for a fee.

Data Sets

DS-FOBU-2001-0 Weather data. 7/1/1990 - . (Nat. Weather Service form WS-B-91). Originated by Banta, Andrew; status: Active.

Golden Spike National Historic Site - Climate

Golden Spike National Historic Site does not participate in the National Weather Service Cooperative Observer Program (NWS COOP), although NWS COOP data were collected at Promontory, Utah, from 1981 until 1984 (see http://www.nws.noaa.gov/om/coop/index.htm for information on this program). Currently, the nearest NWS COOP station is found 25 miles east of Golden Spike at Corinne, Utah, where climate data have been collected since 1871. At Corinne, maximum temperature, minimum temperature, and total precipitation are recorded on a daily basis. Summaries of the Promontory and Corinne data sets are available on-line from the Western Regional Climate Center (http://www.wrcc.dri.edu/climsum.html). Daily data are available for a fee.

Hovenweep National Monument - Climate

Hovenweep National Monument has participated in the National Weather Service Cooperative Observer Program (NWS COOP) since 1955 (see http://www.nws.noaa.gov/om/coop/index.htm for information on this program). Maximum temperature, minimum temperature, and total precipitation are recorded daily. Monthly data summaries are sent to the National Weather Service. Long-term monthly climate summaries are available on-line from the Western Regional Climate Center (http://www.wrcc.dri.edu/climsum.html). Daily data are available for a fee. Since 1999, Monument staff have maintained electronic and hard-copy versions of this long-term data set (DS-SEUG-002).

Data Sets

DS-SEUG-002	Daily weather data for Hovenweep National Monument, March 1999-present. 3/1/1999 - . (MS Excel spreadsheets; hard-copy monthly data sheets). Originated by Huebner, Jim; status: Active.

Natural Bridges National Monument - Climate

Natural Bridges National Monument has participated in the National Weather Service Cooperative Observer Program (NWS COOP) since 1965 (see http://www.nws.noaa.gov/om/coop/index.htm for information on this program). Maximum temperature, minimum temperature, and total precipitation for the previous 24 hours are recorded daily at approximately 7 a.m. from instruments housed in a station located near Monument headquarters. Monthly data summaries are sent to the National Weather Service. Long-term monthly climate summaries are available on-line from the Western Regional Climate Center (http://www.wrcc.dri.edu/climsum.html). Daily data are available for a fee. Since 1988, electronic and hard-copy records of NWS COOP data have been maintained by park staff (DS-SEUG-003).

Two climate-related studies are documented in the bibliographic database for Natural Bridges. Davis (1974) summarized climatological data for Natural Bridges, Arches, Canyonlands, Capitol Reef and the surrounding region. West (1978) used pollen analyses to study effects of climate and human activities on vegetation changes in the Cedar Mesa area between the prehistoric period of early human settlement and the early 1970s. He concluded that no major climate changes had occurred in the area since the prehistoric period, and that human activities were the major drivers of vegetation changes during the period of study.

References

Davis, Denis. 1974. Regional resources basic inventory- climatology: Arches National Park, Canyonlands National Park, Capitol Reef national Park, Natural Bridges National Monument and surrounding region. 45 p.

West, Gerald James. 1978. Recent palynology of the Cedar Mesa area, Utah. PhD dissertation in Anthropology, University of California at Davis. Davis CA. 175 p.

Data Sets

DS-SEUG-003 Daily weather data for Natural Bridges National Monument, January 1988-present. 1/2/1988 - . (MS Excel spreadsheets; hard-copy monthly data sheets). Originated by Nickel, Chris; status: Active.

Pipe Spring National Monument - Climate

Pipe Spring National Monument has participated in the National Weather Service Cooperative Observer Program (NWS COOP) since 1963 (see http://www.nws.noaa.gov/om/coop/index.htm for information on this program). Maximum temperature, minimum temperature, and total precipitation are recorded daily, and monthly data summaries are sent to the National Weather Service. Summaries of this long-term data set are available on-line from the Western Regional Climate Center (http://www.wrcc.dri.edu/climsum.html). Daily data are available for a fee.

Timpanogos Cave National Monument - Climate

Timpanogos Cave National Monument has participated in the National Weather Service Cooperative Observer Program (NWS COOP) since 1948 (see http://www.nws.noaa.gov/om/coop/index.htm for information on this program). Maximum temperature, minimum temperature, and total precipitation are recorded daily, and monthly data summaries are sent to the National Weather Service. Summaries of this long-term data set are available on-line from the Western Regional Climate Center (http://www.wrcc.dri.edu/climsum.html). Daily data are available for a fee.

Zion National Park - Climate

Zion National Park has participated in the National Weather Service Cooperative Observer Program (NWS COOP) since 1948 (see http://www.nws.noaa.gov/om/coop/index.htm for information on this program). Maximum temperature, minimum temperature, and total precipitation are recorded daily, and monthly data summaries are sent to the National Weather Service. Summaries of this long-term data set are available on-line from the Western Regional Climate Center (http://www.wrcc.dri.edu/climsum.html). Daily data are available for a fee.

Two automated RAWS stations (Remote Area Weather Stations) also are located in the Park. The Lava Point station was established in 1995, and the Zion Canyon station was established in 2002 (anticipated Aug-Sep). These stations collect hourly observations of average and peak wind speeds, average and peak wind directions, average air temperature and relative humidity, dewpoint, total precipitation, fuel temperature, and 10-hour fuel moisture. Data are transferred hourly to the National Interagency Fire Center in Boise via satellite. Data for the past 24-36 hours are available on-line at http://www.wrh.noaa.gov/Saltlake/fire/raws/raws/SouthernRAWS.htm (also accessible via NWS Salt Lake City website http://www.wrh.noaa.gov/Saltlake/). Archived data available on-line from the Western Regional Climate Center at http://www.wrcc.dri.edu/wraws/.

The sole climate-related study included in the bibliographic database for Zion National Park is that of Balling (1992) who conducted a preliminary analysis of historical climate patterns in the upper Virgin River Basin.

References

Balling, Robert C., Jr. 1992. Analysis of historical climate patterns in the upper Virgin River Basin of Utah (preliminary description of assembled climate data). 13 p.

Arches National Park - Air Quality

Arches National Park is designated as a "Class I" area under provisions of the 1977 Clean Air Act Amendments (Binkley et al. 1997). Federal land managers are required to protect air quality related values in Class I areas, including visibility, soils, surface waters, plants, animals, historic and geologic features, night sky, and other resources affected by air quality (Binkley et al. 1997).

Historic air-quality monitoring data are available for Arches, but air quality is not currently monitored in the Park. From 1978 to 1985, panoramic photographs were taken daily from a location at the southwest corner of the Park to document visibility conditions in relation to the Atlas uranium mill south of the Park. The complete dataset consists of approximately 6350 photographic slides (DS-SEUG-054). Monitoring associated with the IMPROVE program (Interagency Monitoring of Protected Visual Environments, http://vista.cira.colostate.edu/improve/) was conducted from 1986 until 1992. As part of this program, visibility was monitored photographically with a 35-mm camera between 1986 and 1991, and concentrations of fine and coarse airborne particles were monitored by air samplers between 1988 and 1992 (DS-SEUG-043). Results of pollutant and meteorological monitoring conducted in 1991 are summarized in an NPS report (National Park Service, Air Quality Division 1992). Standard visual range (the greatest distance that a large black object can be seen against the horizon) was monitored at Arches from summer 1986 until spring 1987. Ozone was monitored in Arches from 1987 until 1992; SO_2 was monitored from 1988 until 1992. Miller et al. (2000) summarized ozone monitoring conducted in National Parks between 1992 and 1997, including Arches. Ozone and meteorological data for Arches are available on-line from the NPS Air Quality Monitoring Database at http://www2.nature.nps.gov/ard/gas/netdata1.htm.

A variety of studies and reports related to air quality are available for Arches. Belnap (1990) studied effects of airborne pollutants on soil and rock lichens of several Colorado Plateau parks, including Arches. This work also was summarized in a subsequent report (Belnap et al. 1991). Gladney et al. (1993) sampled waters of pothole ecosystems in several southwestern parks (including Arches) to assess water quality sensitivity to airborne pollutants. Binkley et al. (1997) provided an excellent summary and synthesis of air-quality conditions in Class I parks and monuments of the Colorado Plateau through 1996. Maniero (2001) summarized extant air quality monitoring for parks of the Northern Colorado Plateau Network and made recommendations regarding priorities for supplemental monitoring. She noted that current monitoring conducted at the Island in the Sky District of Canyonlands National Park (wet deposition, dry deposition, IMPROVE visibility, and ozone) is applicable to Arches National Park. For information on these monitoring efforts, see the air-quality monitoring narrative for Canyonlands National Park.

References

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Belnap, Jayne, Mangis, Deborah, Baron, Jill and Stolte, Kenneth. 1991. Sensitivity of desert cryptogams to air pollutants: soil crusts and rock lichens. Acid Rain and Air Pollution in Desert Park Areas. United States Department of Interior, National Park Service. Page(s) 112-119. 129 p.

Binkley, Dan, Giardina, Christian, Dockersmith, Ingrid, Morse, Dee, Scruggs, Mark and Tonnessen, Kathy. 1997. Status of air quality and related values in class I national parks and monuments of the Colorado Plateau. Air Resources Division, National Park Service, USDI. Denver, CO. 307 pages.

Gladney, Ernest S., Graham, Tim, Ferenbaugh, Roger W., Bell, Michael G., Burns, Colleen and Morgan, Janet D. 1993. Chemical analysis of selected pothole water sources in southwestern national parks, monuments, and recreation areas. LA-12605-MS. Los Alamos National Laboratory. Los Alamos, NM. 55 pages.

Miller, Debra, Flores, Miguel, Joseph, David and Ray, John D. 2000. Statistical summary of ozone measurements in the national park system, 1992-1997. Air Resources Division, Research and Monitoring Branch. Denver, CO. 385 pages.

Maniero, T. 2001. Air quality monitoring considerations for the Northern Colorado Plateau Network. NPS Air Resources Division, Denver. 6 pp. plus appendices.

National Park Service, Air Quality Division. 1992. Arches National Park, 1991 gaseous pollutant and meteorological monitoring annual data summary. Technical Report NPS/NRAQD/NRTR-92/65. National Park Service. Denver, CO. 180 pages.

Data Sets

DS-SEUG-043 Arches National Park air quality: IMPROVE visibility data. 7/1/1982 - 5/31/1992. (database). Originated by [unknown] ; status: Inactive.

DS-SEUG-054 Visual air quality photographic monitoring on the southern edge of Arches National Park. 10/4/1978 - 4/10/1985. (photographic slides). Originated by [unknown]; status: Historic.

Black Canyon of the Gunnison National Park - Air Quality

Black Canyon of the Gunnison National Park is designated as a "Class I" area under provisions of the 1977 Clean Air Act Amendments (Binkley et al. 1997). Federal land managers are required to protect air quality related values in Class I areas, including visibility, soils, surface waters, plants, animals, historic and geologic features, and other resources affected by air quality (Binkley et al. 1997).

Limited air quality monitoring has occurred at Black Canyon. Visibility monitoring was conducted from 1985 until 1993. Methods included photographic monitoring with a 35-mm camera (1985-1993; Air Resource Specialists, Inc. and Environmental Consultants 1994) and standard visual-range estimates (1985-1991). Passive ozone monitoring has been conducted during summer at Black Canyon since 1994.

Two recent air-quality synthesis reports are pertinent to Black Canyon. Binkley et al. (1997) provided an excellent summary and synthesis of air-quality conditions in Class I parks and monuments of the Colorado Plateau through 1996, including Black Canyon. Maniero (2001) summarized extant air quality monitoring for parks of the Northern Colorado Plateau Network and made recommendations regarding priorities for supplemental monitoring. She noted that permanent, continuous ozone monitoring may be established at Black Canyon in FY2003 (Maniero 2001). She also identified the nearest air quality monitoring stations that collect data relevant to Black Canyon. Wet deposition monitoring stations associated with the NADP/NTN program (National Atmospheric Deposition Program/National Trends Network, http://nadp.sws.uiuc.edu/) are located at Gothic (70 km northeast of Black Canyon, Site No. CO10) and Molas Pass, Colorado (80 km south of Black Canyon, Site No.CO96). Dry deposition also is monitored at Gothic (Site No. GTH161) in association with the CASTNet program (Clean Air Status and Trends Network, http://www.epa.gov/castnet/). The nearest IMPROVE visibility monitoring station (Interagency Monitoring of Protected Visual Environments, http://vista.cira.colostate.edu/improve/) is located in the Weminuche Wilderness Area (100 km south of Black Canyon, Site No. WEMI1). Continuous ozone monitoring occurs at Mesa Verde National Park, 130 km southwest of Black Canyon. Ozone and associated meteorological data for Mesa Verde are available on-line from the NPS Air Quality Monitoring Database at http://www2.nature.nps.gov/ard/gas/netdata1.htm.

References

Air Resource Specialists, Inc. and Environmental Consultants. 1994. Permenent photographic archive and data summaries for Black Canyon of the Gunnison National Monument Colorado 1986-1993. Bureau of Land Management-Service Center. Denver, CO. 60? p.;2 3 1/2 computer discs; 71 color slides.

Binkley, Dan, Giardina, Christian, Dockersmith, Ingrid, Morse, Dee, Scruggs, Mark and Tonnessen, Kathy. 1997. Status of air quality and related values in class I national parks and monuments of the Colorado Plateau. Air Resources Division, National Park Service, USDI. Denver, CO. 307 pages.

Maniero, T. 2001. Air quality monitoring considerations for the Northern Colorado Plateau Network. NPS Air Resources Division, Denver. 6 pp. plus appendices.

Bryce Canyon National Park - Air Quality

Bryce Canyon National Park is designated as a "Class I" area under provisions of the 1977 Clean Air Act Amendments (Binkley et al. 1997). Federal land managers are required to protect air quality related values in Class I areas, including visibility, soils, surface waters, plants, animals, historic and geologic features, and other resources affected by air quality (Binkley et al. 1997).

Numerous air-quality parameters have been monitored at Bryce Canyon since 1984. Visibility has been monitored photographically with a 35-mm camera since 1984. This monitoring effort remains ongoing as an element of the IMPROVE program (Interagency Monitoring of Protected Visual Environments, http://vista.cira.colostate.edu/improve/) (Air Resource Specialist, Inc. 1997). Visibility was monitored by standard visual range estimates at three separate locations from 1978 until 1991. Also in conjunction with the IMPROVE program, concentrations of fine and coarse airborne particles have been monitored by air samplers since 1988 (DS-BRCA-0004). Passive ozone monitoring has been conducted for five months during summer since 1995 (DS-BRCA-0005). SO_2 was monitored from 1988 until 1992. Since 1985, wet deposition has been monitored at Bryce Canyon in association with the NADP/NTN program (National Atmospheric Deposition Program/National Trends Network, http://nadp.sws.uiuc.edu/).

Two recent air-quality synthesis reports are pertinent to Bryce Canyon. Binkley et al. (1997) provided an excellent summary and synthesis of air-quality conditions in Class I parks and monuments of the Colorado Plateau through 1996, including Bryce Canyon. Maniero (2001) summarized extant air quality monitoring for parks of the Northern Colorado Plateau Network and made recommendations regarding priorities for supplemental monitoring. She also identified the nearest air quality monitoring stations that collect data relevant to Bryce Canyon. Dry deposition is monitored at Grand Canyon National Park (170 km south of Bryce Canyon, Site No. GRC474) and Canyonlands National Park (215 km northeast of Bryce Canyon, Site No. CAN407) in association with the CASTNet program (Clean Air Status and Trends Network, http://www.epa.gov/castnet/). Continuous ozone monitoring is scheduled for initiation at Zion National Park (90 km southwest of Bryce Canyon) in during fall 2002. Currently, Grand Canyon National Park is the nearest station that monitors ozone continuously. Ozone and accompanying meteorological data for Grand Canyon are available on-line from the NPS Air Quality Monitoring Database at http://www2.nature.nps.gov/ard/gas/netdata1.htm.

Two additional studies related to air quality occur in the bibliographic database for Bryce Canyon. Belnap (1990) studied effects of airborne pollutants on soil and rock lichens of several Colorado Plateau parks, including Bryce Canyon. Kalkstein et al. (1990) evaluated effects of air quality on winter visibility at the Park.

References

Air Resource Specialist, Inc. 1997. Bryce Canyon Air Quality Summary. 13 p.

Belnap, Jayne. 1990. Effects of air pollutants on cold-desert cyanobacterial-lichen crusts and rock lichens: chlorophyll degradation, electrolyte leakage and nitrogenase activity. National Park Service, Canyonlands National Park. Moab, UT. 6 p.

Binkley, Dan, Giardina, Christian, Dockersmith, Ingrid, Morse, Dee, Scruggs, Mark and Tonnessen, Kathy. 1997. Status of air quality and related values in class I national parks and monuments of the Colorado Plateau. Air Resources Division, National Park Service, USDI. Denver, CO. 307 pages.

Kalkstein, L. S., Skindlov, J. A., Sutherland, J. L. and Mathai, C. V. 1990. A synoptic evaluation of winter scenes air quality data. AWMA/EPA International Specialty Conference on Visibility and Fine Particles. pages 518-526.

Maniero, T. 2001. Air quality monitoring considerations for the Northern Colorado Plateau Network. NPS Air Resources Division, Denver. 6 pp. plus appendices.

Data Sets

DS-BRCA-0004 IMPROVE Network air particulate and visibility monitoring data. 1/1/1988 - present. (Downloadable ASCII files from IMPROVE website). Originated by IMPROVE Monitoring Network; status: Active.

DS-BRCA-0005 Ozone passive sampling data. 1/1/1995 - present. (Unsure of database format used by Originator.). Originated by NPS Air Resources Division; status: Active.

Canyonlands National Park - Air Quality

Canyonlands National Park is designated as a "Class I" area under provisions of the 1977 Clean Air Act Amendments (Binkley et al. 1997). Federal land managers are required to protect air quality related values in Class I areas, including visibility, soils, surface waters, plants, animals, historic and geologic features, and other resources affected by air quality (Binkley et al. 1997).

Visibility Monitoring

Visibility monitoring has been conducted at Canyonlands National Park since 1978. Standard visual range estimates were used to monitor visibility at two separate locations at the Island in the Sky District (ISKY) from 1978 until 1987. This technique also was used at the Hans Flat Ranger Station west of the Maze District for two years from spring 1979 until spring 1981. Photographic visibility monitoring with a 35-mm camera was conducted at the Island in the Sky District from 1982 until 1995 as an element of the IMPROVE program (Interagency Monitoring of Protected Visual Environments, http://vista.cira.colostate.edu/improve/). Also in conjunction with the IMPROVE program at ISKY, concentrations of fine and coarse airborne particles have been monitored by air samplers since 1988, and light extinction (a visibility parameter) has been monitored with a transmissometer since 1987 (DS-SEUG-042). Malm (1991) summarized IMPROVE particulate data collected at ISKY from spring 1988 through spring 1990. Particulate data and sampling techniques associated with IMPROVE monitoring at ISKY have been analyzed and discussed by Lewis, Eatough and colleagues (Lewis and Eatough 1990; Lewis et al. 1991a,b; Lewis 1992; Eatough et al. 1993; Eatough et al. 1996a,b,c). Much of this work was oriented towards the identification of emissions sources responsible for visibility reductions at Canyonlands.

In addition to the IMPROVE program, several other visibility studies have been conducted. Cahill et al. (1979) used particulate and visual-range data from Canyonlands and Zion National Park to assess regional episodes of decreased visibility. Pitchford et al. (1980) sampled aerosols in remote areas of southern Utah, including Canyonlands, to establish baseline conditions prior to the projected development of energy resources in the region. Baseline air-quality studies also were conducted in Davis Canyon adjacent to Canyonlands National Park as part of an environmental assessment for a proposed nuclear waste storage facility (Bechtel National, Inc. 1985). The feasibility of using inert tracers to identify emission sources responsible for visibility reductions at Canyonlands, Glen Canyon National Recreation Area, and Grand Canyon National Park was investigated in the WHITEX study (Winter Haze Intensive Tracer Experiment; Malm et al. 1989). Markowski (1992) critically reviewed the WHITEX study and found it to be flawed.

Ozone and Sulfur Dioxide Monitoring

Ozone has been monitored continuously at ISKY since 1992 (DS-SEUG-040). Ozone and associated meteorological data for Canyonlands are available on-line from the NPS Air Quality Monitoring Database at http://www2.nature.nps.gov/ard/gas/netdata1.htm. Several technical reports have summarized ozone and meteorological monitoring at ISKY (National Park Service, Air Resource Division 1993, 1994, 1995; Miller et al. 2000). Sulfur dioxide (SO_2) was monitored at ISKY from 1988 until 1995.

Wet and Dry Deposition Monitoring

Since 1997, wet deposition has been monitored at Canyonlands in association with the NADP/NTN program (National Atmospheric Deposition Program/National Trends Network, http://nadp.sws.uiuc.edu/). Dry deposition has been monitored in association with the CASTNet program (Clean Air Status and Trends Network, http://www.epa.gov/castnet/) since 1995 (DS-SEUG-039). As

part of the PRIMENet program (Park Research and Intensive Monitoring of Ecosystems Network, http://www2.nature.nps.gov/ard/prime/index.htm), ultraviolet radiation (UV-B) has been monitored at Island in the Sky since 1997 (DS-SEUG-077). Data and graphs are available on-line from the National Ultraviolet Monitoring Center at http://oz.physast.uga.edu/.

Ecosystem Effects Monitoring

Investigations concerning effects of air pollutants on ecosystem components and processes have been limited relative to direct monitoring of air-quality conditions and pollutants. Belnap and colleagues (Belnap 1990, Belnap et al. 1991) studied effects of airborne pollutants on physiological parameters of soil and rock lichens. Sulfur concentrations in soils and foliage of pinyon pine (*Pinus edulis*) were documented by Gladney et al. (1993) to provide baseline data for future assessments of pollutant accumulations. In a set of experimental studies, Belnap et al. (2002) investigated effects of UV-B augmentation, nitrogen deposition, and altered precipitation patterns on physiological performance of biological soil crusts, nitrogen and phosphorus cycling, and physiological performance of vascular plant communities at Canyonlands.

Synthesis Reports

Two recent air-quality synthesis reports are pertinent to Canyonlands. Binkley et al. (1997) provided an excellent summary and synthesis of air-quality conditions in Class I parks and monuments of the Colorado Plateau through 1996. Maniero (2001) summarized extant air quality monitoring for parks of the Northern Colorado Plateau Network and made recommendations regarding priorities for supplemental monitoring.

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Data Sets

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DS-SEUG-040	Canyonlands National Park air quality: Ozone monitoring data. 7/1/1992 - present. (database). Status: Active.
DS-SEUG-042	Canyonlands National Park air quality: IMPROVE visibility data. 7/2/1982 - present. (database). Status: Active.
DS-SEUG-077	Ultraviolet radiation: monitoring current levels and conducting effects research in Canyonlands National Park. 1/1/1999 - present. Status: Active.

Capitol Reef National Park - Air Quality

Capitol Reef National Park is designated as a "Class I" area under provisions of the 1977 Clean Air Act Amendments (Binkley et al. 1997). Federal land managers are required to protect air quality related values in Class I areas, including visibility, soils, surface waters, plants, animals, historic and geologic features, and other resources affected by air quality (Binkley et al. 1997).

Aspects of air quality have been monitored at Capitol Reef since 1978. Visibility was monitored by standard visual range estimates from 1978 to 1987 at three locations in the Park, although only one location was monitored at any given time. Subsets of the visual range data collected at Capitol Reef were summarized in reports by Malm et al. (1981) and Air Quality Specialists, Inc. (1986). From 1983 to 1991, visibility was monitored photographically with a 35-mm camera at two separate locations in the Park. As with visual range estimates, photographic monitoring was conducted only at one site at any given time. Passive ozone monitoring has been conducted for five months during summer since 1995 (DS-CARE-0008). In conjunction with the IMPROVE program (Interagency Monitoring of Protected Visual Environments, http://vista.cira.colostate.edu/improve/), concentrations of fine and coarse airborne particles have been monitored by air samplers since March 2000 (DS-CARE-0007).

Two recent air-quality synthesis reports are pertinent to Capitol Reef. Binkley et al. (1997) provided an excellent summary and synthesis of air-quality conditions in Class I parks and monuments of the Colorado Plateau through 1996. Maniero (2001) summarized extant air quality monitoring for parks of the Northern Colorado Plateau Network and made recommendations regarding priorities for supplemental monitoring. She also identified the nearest air quality monitoring stations that collect data relevant to Capitol Reef. Wet deposition monitoring stations associated with the NADP/NTN program (National Atmospheric Deposition Program/National Trends Network, http://nadp.sws.uiuc.edu/) are located at Bryce Canyon National Park (90 km southwest of Capitol Reef, Site No. UT99) and Canyonlands National Park (115 km east of Capitol Reef, Site No.UT09). Dry deposition also is monitored at Canyonlands (Site No. CAN407) in association with the CASTNet program (Clean Air Status and Trends Network, http://www.epa.gov/castnet/). Canyonlands also monitors ozone continuously. Ozone and associated meteorological data for Canyonlands are available on-line from the NPS Air Quality Monitoring Database at http://www2.nature.nps.gov/ard/gas/netdata1.htm.

Three additional citations related to air quality occur in the bibliographic database for Capitol Reef. Summer visibility was monitored photographically in 1982 by Sutherland (1982). Belnap (1990) studied effects of airborne pollutants on soil and rock lichens of several Colorado Plateau parks, including Capitol Reef. St. Clair (1991) proposed establishment of a lichen biomonitoring program for Capitol Reef to document long-term changes in air-quality conditions reflected by sensitive lichen taxa.

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Data Sets

DS-CARE-0007 IMPROVE Network air particulate and visibility monitoring data. 4/1/2000 - present. (Downloadable ASCII files from IMPROVE website). Originated by IMPROVE Monitoring Network; status: Active.

DS-CARE-0008 Ozone passive sampling data. 5/1/1995 - present. (Unsure of database format used by Originator.) Originated by NPS Air Resources Division; status: Active.

Cedar Breaks National Monument - Air Quality

Minimal air-quality monitoring has occurred at Cedar Breaks National Monument. St. Clair and Smith (1994) established a biomonitoring program at the Monument to document long-term changes in air-quality conditions reflected by sensitive lichen taxa.

Maniero (2001) summarized extant air quality monitoring for parks of the Northern Colorado Plateau Network and made recommendations regarding priorities for supplemental monitoring. She also identified the nearest air quality monitoring stations that collect data relevant to Cedar Breaks. Wet deposition is monitored in association with the NADP/NTN program (National Atmospheric Deposition Program/National Trends Network, http://nadp.sws.uiuc.edu/) at Bryce Canyon National Park (65 km east of Cedar Breaks, Site No. UT99). Dry deposition is monitored at Grand Canyon National Park (180 km south of Cedar Breaks, Site No. GRC474) and Great Basin National Park (180 km northwest of Cedar Breaks, Site No. GRB411) in association with the CASTNet program (Clean Air Status and Trends Network, http://www.epa.gov/castnet/). Grand Canyon National Park and Great Basin National Park also monitor ozone continuously. Ozone and associated meteorological data for these stations are available from the NPS Air Quality Monitoring Database at http://www2.nature.nps.gov/ard/gas/netdata1.htm. Continuous ozone monitoring was scheduled for initiation at Zion National Park (45 km south of Cedar Breaks) in FY2002. The nearest IMPROVE visibility monitoring stations (Interagency Monitoring of Protected Visual Environments, http://vista.cira.colostate.edu/improve/) are located in Zion National Park and Bryce Canyon National Park.

References

Maniero, T. 2001. Air quality monitoring considerations for the Northern Colorado Plateau Network. NPS Air Resources Division, Denver. 6 pp. plus appendices.

St. Clair, Larry L. and Smith, Del William. 1994. Establishment of a lichen biomonitoring program and air quality baseline at Cedar Breaks National Monument, Utah. 54 p.

Colorado National Monument - Air Quality

Historic air-quality monitoring data are available for Colorado National Monument, but air quality is not currently monitored in the Monument. Visibility was monitored photographically with a 35-mm camera from 1981 until 1991. Visibility also was monitored by standard visual range from 1980 to 1982 and again from 1984 until 1987. Ozone and SO_2 both were monitored at the Monument from 1984 until 1992 (AeroVironment, Inc. 1989, Christiano 1989; DS-COLM-007). Permanent biomonitoring plots were established by Sanchini (Sanchini et al. 1982, Sanchini 1988) to evaluate effects of ozone and SO_2 on sensitive lichen taxa and pinyon pine (*Pinus edulis*).

Maniero (2001) summarized extant air quality monitoring for parks of the Northern Colorado Plateau Network and made recommendations regarding priorities for supplemental monitoring. She also identified the nearest air quality monitoring stations that collect data relevant to Colorado National Monument. Wet deposition is monitored in association with the NADP/NTN program (National Atmospheric Deposition Program/National Trends Network, http://nadp.sws.uiuc.edu/) at Sunlight Peak, Colorado (110 km northeast of the Monument, Site No. CO92) and Canyonlands National Park (130 km southwest, Site No. UT09). Dry deposition also is monitored at Canyonlands (Site No. CAN407) in association with the CASTNet program (Clean Air Status and Trends Network, http://www.epa.gov/castnet/). Canyonlands also monitors ozone continuously. Ozone and associated meteorological data for Canyonlands are available from the NPS Air Quality Monitoring Database at http://www2.nature.nps.gov/ard/gas/netdata1.htm. The nearest IMPROVE visibility monitoring station (Interagency Monitoring of Protected Visual Environments, http://vista.cira.colostate.edu/improve/) also is located at Canyonlands.

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Data Sets

DS-COLM-007 Air quality data, Colorado National Monument. 5/24/1978 - 12/31/1992. (xls, wk1 and exe files). Originated by Resource Management staff; status: Inactive.

Curecanti National Recreation Area - Air Quality

No air quality monitoring has occurred at Curecanti NRA. Maniero (2001) summarized extant air quality monitoring for parks of the Northern Colorado Plateau Network, and she identified the nearest air quality monitoring stations that collect data relevant to Curecanti. Wet deposition monitoring stations associated with the NADP/NTN program (National Atmospheric Deposition Program/National Trends Network, http://nadp.sws.uiuc.edu/) are located at Gothic (60 km northeast of Curecanti, Site No. CO10) and Molas Pass, Colorado (70 km south of Curecanti, Site No.CO96). Dry deposition also is monitored at Gothic (Site No. GTH161) in association with the CASTNet program (Clean Air Status and Trends Network, http://www.epa.gov/castnet/). The nearest IMPROVE visibility monitoring station (Interagency Monitoring of Protected Visual Environments, http://vista.cira.colostate.edu/improve/) is located in the Weminuche Wilderness Area (90 km south of Curecanti, Site No. WEMI1). Continuous ozone monitoring occurs at Mesa Verde National Park, 140 km southwest of Curecanti. Ozone and associated meteorological data for Mesa Verde are available on-line from the NPS Air Quality Monitoring Database at http://www2.nature.nps.gov/ard/gas/netdata1.htm. Permanent, continuous ozone monitoring may be established at Black Canyon of the Gunnison National Park near Curecanti in FY2003.

References

Maniero, T. 2001. Air quality monitoring considerations for the Northern Colorado Plateau Network. NPS Air Resources Division, Denver. 6 pp. plus appendices.

Dinosaur National Monument - Air Quality

Historic air-quality data are available for Dinosaur National Monument, but current monitoring is minimal. Visibility was monitored photographically with a 35-mm camera from 1979 until 1981 and again from 1985 until 1991. Slides are maintained in a folder at the Monument (Dinosaur National Monument 1985). Visibility also was monitored by standard visual range from 1979 to 1981 and again from 1984 until 1987 (DS-DINO-005). Visual range data collected from winter 1984 through spring 1985 were summarized by Air Resource Specialists, Inc. (1985). Fine and coarse airborne particulates were monitored by air samplers from 1982 until 1985 (DS-DINO-004). St. Clair and colleagues (St. Clair 1996, St. Clair et al. 2000) recently established a biomonitoring program at the Monument to document long-term changes in air-quality conditions reflected by sensitive lichen taxa.

Maniero (2001) summarized extant air quality monitoring for parks of the Northern Colorado Plateau Network and made recommendations regarding priorities for supplemental monitoring. She also identified the nearest air quality monitoring stations that collect data relevant to Dinosaur National Monument. Wet deposition is monitored in association with the NADP/NTN program (National Atmospheric Deposition Program/National Trends Network, http://nadp.sws.uiuc.edu/) at Sand Spring, Colorado (80 km east of Dinosaur, Site No. CO15). Dry deposition is monitored at Canyonlands National Park (240 km southwest of Dinosaur, Site No. CAN407) in association with the CASTNet program (Clean Air Status and Trends Network, http://www.epa.gov/castnet/). Canyonlands also maintains the nearest continuous monitor. Ozone and associated meteorological data for Canyonlands are available from the NPS Air Quality Monitoring Database at http://www2.nature.nps.gov/ard/gas/netdata1.htm. The nearest IMPROVE visibility monitoring stations (Interagency Monitoring of Protected Visual Environments, http://vista.cira.colostate.edu/improve/) is located in the Mount Zirkel Wilderness Area (150 km east of Dinosaur). Given the distance to existing monitoring stations, Maniero (2001) noted that IMPROVE visibility monitoring and continuous ozone monitoring should be considered for Dinosaur National Monument.

References

Air Resource Specialists, Inc. 1985. Visibility data summary report for Dinosaur National Monument: Winter 1984 - Spring 1985. Contract No. CX-0001-3-0057. Air Resource Specialists, Inc.. Fort Collins, Colorado. 17 p.

Dinosaur National Monument. 1985. Air quality log sheets. 250 p.

Maniero, T. 2001. Air quality monitoring considerations for the Northern Colorado Plateau Network. NPS Air Resources Division, Denver. 6 pp. plus appendices.

St. Clair, Larry L. 1996. Air quality. Echoes: official guide to Dinosaur National Monument. 13 p.

St. Clair, Larry, St. Clair, Samuel and Newberry, Clayton C. 2000. Establishment of a lichen biomonitoring program and air quality baseline for Dinosaur National Monument. Brigham Young University. Provo, UT. 60 pages.

Data Sets

DS-DINO-004 Particulate Monitoring and Data Analysis. 6/1/1982 - 2/1/1985. (Bound report). Originated by National Park Service; status: Inactive.

Dinosaur National Monument - Air Quality

DS-DINO-005 Visibility Data for Dinosaur National Monument, Winter 1984-Spring 1985. 1/1/1984 - 4/1/1985. (Spiral bound report). Originated by Air Resource Specialists; status: Inactive.

Fossil Butte National Monument - Air Quality

No air quality monitoring has occurred at Fossil Butte National Monument. Maniero (2001) summarized extant air quality monitoring for parks of the Northern Colorado Plateau Network, and she identified the nearest air quality monitoring stations that collect data relevant to Fossil Butte. Wet deposition monitoring stations associated with the NADP/NTN program (National Atmospheric Deposition Program/National Trends Network, http://nadp.sws.uiuc.edu/) are located at Murphy Ridge, Utah (60 km southwest of Fossil Butte, Site No. UT08) and Pinedale, Wyoming (130 km northeast of Fossil Butte, Site No.WY06). Dry deposition also is monitored at Pinedale (Site No. PND165) in association with the CASTNet program (Clean Air Status and Trends Network, http://www.epa.gov/castnet/). The nearest IMPROVE visibility monitoring station (Interagency Monitoring of Protected Visual Environments, http://vista.cira.colostate.edu/improve/) is located in the Bridger Wilderness Area, Wyoming (150 km northeast of Fossil Butte, Site No. BRID1). Several continuous ozone monitoring stations are located in Logan, Utah, 90 km west of Fossil Butte.

References

Maniero, T. 2001. Air quality monitoring considerations for the Northern Colorado Plateau Network. NPS Air Resources Division, Denver. 6 pp. plus appendices.

Golden Spike National Historic Site - Air Quality

No air quality monitoring has occurred at Golden Spike NHS. Maniero (2001) summarized extant air quality monitoring for parks of the Northern Colorado Plateau Network, and she identified the nearest air quality monitoring stations that collect data relevant to Golden Spike. Wet deposition is monitored at Logan, Utah (65 km northeast of Golden Spike, Site No. UT01) in association with the NADP/NTN program (National Atmospheric Deposition Program/National Trends Network, http://nadp.sws.uiuc.edu/). Dry deposition is monitored at Pinedale, Wyoming (240 km east of Golden Spike, Site No. PND165) in association with the CASTNet program (Clean Air Status and Trends Network, http://www.epa.gov/castnet/). The nearest IMPROVE visibility monitoring station (Interagency Monitoring of Protected Visual Environments, http://vista.cira.colostate.edu/improve/) is located in at Craters of the Moon National Monument, Idaho (160 km northwest of Golden Spike, Site No. CRMO1). Ozone is continuously monitored in Brigham City, Utah, 50 km east of Golden Spike.

References

Maniero, T. 2001. Air quality monitoring considerations for the Northern Colorado Plateau Network. NPS Air Resources Division, Denver. 6 pp. plus appendices.

Hovenweep National Monument - Air Quality

No air quality monitoring has occurred at Hovenweep National Monument. Maniero (2001) summarized extant air quality monitoring for parks of the Northern Colorado Plateau Network, and she identified the nearest air quality monitoring stations that collect data relevant to Hovenweep. Wet and dry deposition are monitored at Mesa Verde National Park (40 km southeast of Hovenweep) in association with the NADP/NTN program (National Atmospheric Deposition Program/National Trends Network, http://nadp.sws.uiuc.edu/) and the CASTNet program (Clean Air Status and Trends Network, http://www.epa.gov/castnet/), respectively. The nearest IMPROVE visibility monitoring station (Interagency Monitoring of Protected Visual Environments, http://vista.cira.colostate.edu/improve/) also is located in at Mesa Verde. Mesa Verde also continuously monitors ozone. Ozone and associated meteorological data for Mesa Verde are available on-line from the NPS Air Quality Monitoring Database at http://www2.nature.nps.gov/ard/gas/netdata1.htm.

References

Maniero, T. 2001. Air quality monitoring considerations for the Northern Colorado Plateau Network. NPS Air Resources Division, Denver. 6 pp. plus appendices.

Natural Bridges National Monument - Air Quality

Minimal air quality monitoring has occurred at Natural Bridges National Monument. Some air-quality information for Natural Bridges exists in NPS files (National Park Service, Southeast Utah Group 1982), but the content of this information currently is unclear. Belnap (1990) studied effects of airborne pollutants on soil and rock lichens of several Colorado Plateau parks and monuments, including Natural Bridges. Maniero (2001) summarized extant air quality monitoring for parks of the Northern Colorado Plateau Network, and she identified the nearest air quality monitoring stations that collect data relevant to Natural Bridges. Wet and dry deposition are monitored at Canyonlands National Park (90 km north of Natural Bridges) in association with the NADP/NTN program (National Atmospheric Deposition Program/National Trends Network, http://nadp.sws.uiuc.edu/) and the CASTNet program (Clean Air Status and Trends Network, http://www.epa.gov/castnet/), respectively. The nearest IMPROVE visibility monitoring station (Interagency Monitoring of Protected Visual Environments, http://vista.cira.colostate.edu/improve/) also is located in at Canyonlands. Canyonlands also continuously monitors ozone. Ozone and associated meteorological data for Canyonlands are available on-line from the NPS Air Quality Monitoring Database at http://www2.nature.nps.gov/ard/gas/netdata1.htm.

References

Belnap, Jayne. 1990. Effects of air pollutants on cold-desert cyanobacterial-lichen crusts and rock lichens: chlorophyll degradation, electrolyte leakage and nitrogenase activity. Canyonland National Park. Moab, UT. 6 p.

Maniero, T. 2001. Air quality monitoring considerations for the Northern Colorado Plateau Network. NPS Air Resources Division, Denver. 6 pp. plus appendices.

National Park Service, Southeast Utah Group. 1982. Air quality monitoring [Arches National Park, Canyonlands National Park, Natural Bridges National Monument].

Pipe Spring National Monument - Air Quality

No air quality monitoring has occurred at Pipe Spring National Monument. Maniero (2001) summarized extant air quality monitoring for parks of the Northern Colorado Plateau Network, and she identified the nearest air quality monitoring stations that collect data relevant to Pipe Spring. Wet deposition is monitored at Bryce Canyon National Park (115 km northeast of Pipe Spring, Site No. UT99) and Grand Canyon National Park (120 km southeast of Pipe Spring, Site No. AZ03) in association with the NADP/NTN program (National Atmospheric Deposition Program/National Trends Network, http://nadp.sws.uiuc.edu/). Grand Canyon (Site No. GRC474) also monitors dry deposition in conjunction with the CASTNet program (Clean Air Status and Trends Network, http://www.epa.gov/castnet/). The nearest IMPROVE visibility monitoring station (Interagency Monitoring of Protected Visual Environments, http://vista.cira.colostate.edu/improve/) is located at Zion National Park (45 km northwest of Pipe Spring). Currently, the nearest continuous ozone monitoring station is at Grand Canyon. Ozone and associated meteorological data for Grand Canyon are available from the NPS Air Quality Monitoring Database at http://www2.nature.nps.gov/ard/gas/netdata1.htm. Continuous ozone monitoring is scheduled for initiation at Zion National Park in fall 2002.

References

Maniero, T. 2001. Air quality monitoring considerations for the Northern Colorado Plateau Network. NPS Air Resources Division, Denver. 6 pp. plus appendices.

Timpanogos Cave National Monument - Air Quality

No air quality monitoring has occurred at Timpanogos Cave National Monument. Maniero (2001) summarized extant air quality monitoring for parks of the Northern Colorado Plateau Network, and she identified the nearest air quality monitoring stations that collect data relevant to Timpanogos Cave. Wet deposition is monitored at Murphy Ridge, Utah (115 km northeast of Timpanogos Cave, Site No. UT08) and Logan, Utah (140 km north of Timpanogos Cave, Site No. UT01) in association with the NADP/NTN program (National Atmospheric Deposition Program/National Trends Network, http://nadp.sws.uiuc.edu/). Great Basin National Park (270 km southwest, Site No. GRB411) and Canyonlands National Park (280 km southeast, Site No. CAN407) are the nearest stations that monitor dry deposition in association with the CASTNet program (Clean Air Status and Trends Network, http://www.epa.gov/castnet/). The nearest IMPROVE visibility monitoring station (Interagency Monitoring of Protected Visual Environments, http://vista.cira.colostate.edu/improve/) is located at Capitol Reef National Park (230 km south of Timpanogos Cave). Currently, the nearest continuous ozone monitoring station is at Provo, Utah.

An air quality station was established for the U.S. Forest Service in the monument from 1995-2001 and was serviced by monument staff; resource management staff are currently trying to locate the resulting data.

References

Maniero, T. 2001. Air quality monitoring considerations for the Northern Colorado Plateau Network. NPS Air Resources Division, Denver. 6 pp. plus appendices.

Zion National Park - Air Quality

Zion National Park is designated as a "Class I" area under provisions of the 1977 Clean Air Act Amendments (Binkley et al. 1997). Federal land managers are required to protect air quality related values in Class I areas, including visibility, soils, surface waters, plants, animals, historic and geologic features, and other resources affected by air quality (Binkley et al. 1997).

Aspects of air quality have been monitored at Zion National Park since 1985. From 1985 until 1991, visibility was monitored photographically with a 35-mm camera. Visibility also was monitored by standard visual range for one month in 1985 and for 16 months in 1986 and 1987. In conjunction with the IMPROVE program (Interagency Monitoring of Protected Visual Environments, http://vista.cira.colostate.edu/improve/), concentrations of fine and coarse airborne particles have been monitored by air samplers since March 2000 (DS- ZION-0013). Passive ozone monitoring has been conducted for five months during summer since 1995 (DS- ZION-0014). A permanent, continuous ozone monitor is scheduled for installation at Zion during fall 2002.

Two recent air-quality synthesis reports are pertinent to Zion. Binkley et al. (1997) provided an excellent summary and synthesis of air-quality conditions in Class I parks and monuments of the Colorado Plateau through 1996. Maniero (2001) summarized extant air quality monitoring for parks of the Northern Colorado Plateau Network and made recommendations regarding priorities for supplemental monitoring. She also identified the nearest air quality monitoring stations that collect data relevant to Zion. Since 1985, wet deposition has been monitored at Bryce Canyon National Park (80 km northeast of Zion, Site No. UT99) in association with the NADP/NTN program (National Atmospheric Deposition Program/National Trends Network, http://nadp.sws.uiuc.edu/). Grand Canyon National Park (160 km southeast of Zion, Site No. GRC474) and Great Basin National Park (160 km northwest of Zion, Site No. GRB411) are the nearest stations that monitor dry deposition in association with the CASTNet program (Clean Air Status and Trends Network, http://www.epa.gov/castnet/). Currently, Grand Canyon National Park and Great Basin National Park also are the nearest stations that monitor ozone continuously. Ozone and accompanying meteorological data for these stations are available on-line from the NPS Air Quality Monitoring Database at http://www2.nature.nps.gov/ard/gas/netdata1.htm.

Three additional air-quality citations are in the bibliographic database for Zion. A preliminary assessment of Class I air quality related values is found in a Zion National Park report (1978). Flocchini et al. (1981) published a study of airborne particulates pertinent to Zion. Johnson and Frank (1993) studied the effects of pollutants on roadside vegetation in the Park.

References

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Flocchini, Robert G., Cahill, Thomas A., Ashbaugh, Lowell L. and Eldred, Robert A. 1981. Seasonal behavior of particulate matter at three rural Utah sites. Atmospheric Environment. Volume: 15. Page(s) 315-320.

Johnson, Mike and Williams, C. Frank. 1993. Roadside vegetation pollution study. 1 file folder; 150? p.

Maniero, T. 2001. Air quality monitoring considerations for the Northern Colorado Plateau Network. NPS Air Resources Division, Denver. 6 pp. plus appendices.

Zion National Park. 1978. Preliminary national assessment of class I related values: Visibility report. National Park Service, Rocky Mountain Region. Zion National Park, CO. 25 p.

Data Sets

DS-ZION-0013 IMPROVE Network air particulate and visibility monitoring data. 3/2000 - present. (Downloadable ASCII files from IMPROVE website). Originated by IMPROVE Monitoring Network; status: Active.

DS-ZION-0014 Ozone passive sampling data. 1995-present. (Unsure of database format used by Originator.). Originated by NPS Air Resources Division; status: Active.

Arches National Park - Water Quality and Water Quantity

Springs, seeps, and streams within Arches provide a vital source of water for wildlife, aquatic organisms, vegetation, and visitors. Many scientific studies, drinking water investigations, flood plain studies, management plans, and monitoring efforts focus on water resources at Arches.

General studies and reviews discussing water resources include a Canyonlands National Park, Arches National Park, and Natural Bridges National Monument Water Resources Scoping Report (Berghoff and Vana-Miller 1997), which calls on the park to develop a Water Resources Management Plan. This effort resulted in one such plan (Cudlip et al. 1999), which defined park issues for both Arches and Canyonlands and developed a series of project statements. The project statements range from assessing springs and seeps for aquatic flora to evaluating the structure and function of the Colorado River Corridors Ecosystem.

Providing drinking water to visitors and park personnel required hydrogeological studies. Price (1959), Arnow (1963), and Sumsion (1971) summarized attempts to locate potable water sources at three different areas including the headquarters, Devil's Garden, and the Willow Flats area. Other hydrology studies include those of Arneson (1987) and Reed (1990) regarding hydraulics and flood plains. The later study determined that the unnamed wash in Moab Canyon is subject to hazardous flood flows, and suggested preparation of plans to remove or protect facilities.

Water quality monitoring efforts are summarized in Long and Smith (1996), Berghoff and Vana-Miller (1997) and Cudlip et al. (1999). They were also evaluated and documented in NPS (1994), which evaluated past efforts at monitoring water in the Southeast Utah Group of parks. In addition, in 1983 a water quality monitoring program for springs, seeps, and streams in the SEUG parks was initiated and this program is still underway (DS-SEUG-009). Currently, a Hydrolab is used to measure temperature, pH, dissolved oxygen and conductivity; water is also collected and analyzed for a suite of chemicals, nutrients and metals. Fecal coliform analysis is done in house; the other samples are analyzed at the Utah Department of Environmental Quality Water Laboratory. Analysis results are available via the web on STORET, a national database maintained by the Environmental Protection Agency (EPA); paper copies are also stored at the Southeast Utah Group Resource Management office. Macroinvertebrates are also analyzed at water collection sites every four months during the year water samples are collected. Threats that might cause degradation of water quality include oil and gas development and recreational development along park borders, trespass livestock use; internal park development and recreational use (including roads), as well as yet unforeseen sources.

Specific scientific investigations relating to aquatic ecosystems include information on fish, invertebrates, potholes, hanging gardens, and water quality and quantity in Arches. Conner and Kepner (1983) commented that water quality of samples taken from Arches generally met state standards. Mithchell and Woodward (1993) report on the effects of human activities on riparian and aquatic organisms.

A series of studies was conducted on potential acidification of potholes. They include Gladney et al. (1993), Graham et al. (1991), and Graham (1992). The former introduced the concept that brief showers can create a more acidic solution in potholes, thus producing an untenable environment for aquatic organisms. The latter two studies found that potholes and aquatic areas in high elevation deserts may be especially vulnerable to damage from accumulation of acid pollutants. The authors investigated pothole ecology and artificially acidified potholes to three pH levels.

Hanging gardens are unique ecosystems relegated to desert environments where an aquifer is underlain by an aquitard. Rare and endemic species are found at these sites. Van Riper and others (1995) described results of field work studying 75 hanging gardens. Fowler et al. (1995) surveyed the level of endemism among vascular plant taxa in Arches. Laity and Malin (1985) provided a description of sapping processes leading to hanging garden development on the Colorado Plateau, and May et al. (1995) described the geomorphology of hanging gardens in Arches.

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Data Sets

DS-SEUG-009 Water quality monitoring program for springs, seeps, and streams in the SEUG parks, 1983-present. (MS Excel spreadsheets; MS Word documents; hard-copy data sheets and analysis reports; photos). Originated by Schelz, Charlie; status: Active.

Black Canyon of the Gunnison National Park - Water Quality and Water Quantity

The Gunnison River is the main feature of this park and as a result of its associated federal water, the concern and interest of many researchers and managers has been sparked. Since the waters in this section of the Gunnison River are low-level release waters from the Aspinall Unit of the Colorado River Storage Project (i.e., Blue Mesa, Morrow Point, and Crystal Reservoirs), they are noted to be of high quality. Additionally, the Gunnison at this point has been studied in terms of impacts as a result of damming. This literature search notes those investigations in the above categories and includes other studies specific to fisheries and other topics.

A bibliography of water-related studies for the Upper Colorado River Basin was completed in 1995 (Bauch and Apodoca, 1995). This is tremendous resource which annotates many of the studies. The Gunnison River in this park is referenced numerous times.

The following studies addressed the response of sediment and vegetation to various hydrologic regimes. These studies prefaced the proposed quantification of the Black Canyon of the Gunnison River water right. Auble et al. (1991), Auble et al. (1994), Friedman and Auble (1999), Elliot and Hammack (1999), and Elliot and Hammack (2000). Diaz et al. (1996) assessed the changes in streamflow characteristics of the Gunnison River as a result of diversions to the Gunnison Tunnel and from the Aspinall Unit.

The Upper Colorado River Basin was selected as one of the 36 National Water Quality Assessment sites (NAWQA), and the Gunnison River below the Gunnison Tunnel located in the Black Canyon of the Gunnison River National Park served as one of the basic fixed sites. In general the water is of good quality. Numerous reports from the U.S. Geological Survey point to this assessment. They include: Deacon and Stephens (1996), Deacon and Mize (1997), Spahr and Wynn (1997), Stephens and Deacon (1997), Spahr and Boulger (1997), Bauch and Spahr (1998), Bauch and Spahr (2000), Spahr et al. (2000), and Gurdak et al. (2002). Most of the water quality, quantity and biota collection occurred during a period from 1996 through 1998.

Many studies relate to the alteration of a river from damming. Two researchers, Stanford and Ward, addressed this alteration; their papers discussed the response of discontinuities in the distribution of invertebrate species (Stanford and Ward, 1989; Hauer et al. 1989). Others incorporate findings regarding ecosystem stability and effects on the phisicochemistry of the river (Stanford and Ward, 1981; Standford, 1989). Restoration of dammed rivers was reviewed by Stanford et al. (1996). Standford et al. (1991) discuss the hyporheic zone of the Black Canyon with regards to presence of zoobenthos and the effects of regulation of the river on its biodiversity and natural environmental biodiversity.

Studies relating to the fishery in the Gunnison River and the four endangered fish species include: Wiltzius (1976, 1978), McAda et al. (1990), Burdick (1995), and Osmundson et al. (1995).

Two assessments review a proposed AB Lateral diversion on the Gunnison River (U.S. Bureau of Reclamation (1989, 1990). Other studies on file with the park include a reconnaissance of vegetation along the Black Canyon of the Gunnison River (Lichvar, 1987). Lastly, water quality monitoring protocols were developed in Malick and Cudlip, (1995).

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Bryce Canyon National Park - Water Quality and Water Quantity

Bryce Canyon National Park developed a water resources management plan in 1982 (National Park Service, 1982), but has followed that with two recent project statements. One calls for another water resources management plan (Bryce Canyon National Park 1996) to call attention to issues regarding livestock impacts, lack of monitoring on springs, and questions regarding water quality of culinary supplies. A second project statement calls for rehabilitation of spring areas impacted by hikers and livestock (Bryce Canyon National Park 1996).

In general, the water resources literature available for Bryce Canyon covers five topics: ground water and culinary sources; water quality of springs; bacterial assessments; macroinvertebrate studies; and coal studies.

Czarnowski (1991) provided a broad overview on springs, surface waters, and aquifers in the Bryce Canyon area. Development of culinary sources for Tropic and other communities were discussed by Austin (1974), Canyonlands Engineering, Inc. (1974), and John Call Engineering, Inc. (1987a, 1987b). Other general ground water appraisals were presented in Carpenter and others (1967), Freethey (1988), Goode (1964, 1966, 1970), Heilweil et al. (1992), Marine (1958, 1963), and Thiros and Brothers (1993). Martin (1998) developed the ground water source protection plan for the park.

Those who have studied water quality of springs in Bryce Canyon include Mundorff (1971), Ott (1996), Doremus and Kreamer (1999), and the National Park Service (1999). Doremus and Kreamer (1999) found high sulfate levels in some of the springs' waters.

In 1996 the park initiated a baseline water quality inventory and analysis project, in response to the pressures of increased visitor numbers. Selected seeps and springs were recorded and tested by Ott in 1996, and data continued to be collected through 2001. Information is stored both on-site at the park and in STORET (DS-BRCA-0021).

Bacterial levels in 16 springs around the park were measured by Nakashima (1981). The Utah Department of Public Health (1981) reported on bacterial levels of fecal coliforms and fecal streptococci at 16 camp site and trail springs in the park. Dorr and Weiss (1994) conducted an aquatic macroinvertebrate survey of the upper Paria River basin in Bryce Canyon National Park.

Lastly, numerous studies regarding the geology, geohydrology and hydrology of areas near Bryce Canyon are discussed with regards to coal extraction, particularly the Alton project. These include the following: Bingham (1987), Camp Dresser & McKee, Inc. (1987), David Keath Todd Consulting Engineering and others (1987), Doelling and Graham (1972), Grasser (1987), Plantz (1984), Price and Plantz (1987), and Sandberg (1979).

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Data Sets

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DS-BRCA-0033	Research of Bryce Canyon National Park Water Rights. 4/1/91 – 7/30/2001. (MS Word 97 documents, paper files). Initiated by BRCA resource management staff, status: Inactive.

Canyonlands National Park – Water Quality and Water Quantity

Berhoff and Vana-Miller (1997) developed a water resources scoping report for Canyonlands National Park and other Southeast Utah Group parks as a precursor to the Arches National Park and Canyonlands National Park Water Resources Management Plan (Cudlip et al. 1999). Both of these documents describe the nature of the water resources at Canyonlands and discuss some of the pertinent issues including culinary water sources, water of seeps and springs, riparian habitat of creeks and washes, and the Green and Colorado river systems. The latter document proceeds to develop project statements regarding the issues. Prior to either of these Kitchell (1987) discussed water resource issues at both Arches National Park and Canyonlands National Park.

The Water Resource Division (National Park Service 1983) conducted an inventory of the water resources at Canyonlands. Later the National Park Service (1993) assessed their long-term monitoring program and proposed future monitoring in areas of perceived threats. The Southeast Utah Group documented water sampling techniques again (2001). The park (Canyonlands National Park 1995) provided information on backcountry use and camping. The backcountry management plan discusses campsite management and regulations on stock animals, use of camp sites, and water use.

The desert environment drives parks to conduct many studies regarding ground water and culinary sources. The most important works regarding this topic are: Huntoon (1977), Huntoon (1979), Richter (1980), and Sumsion (1972). Other investigators also centered on ground water, culinary sources, and water rights were Cznarnowski (1989) and Osmund (1965).

Water quality studies by Ecosystems Research Institute (1984) centered on impacts to water resources from a proposed nuclear waste facility. Lieberman et al. (1989) provide a broad brush overview of trends in streamflows and dissolved solids in the Upper Colorado River Basin. Spence (1997) proposed a study to characterize water quality and biota of a couple of isolated springs along the Colorado River in the park, and the park developed its on water quality monitoring plan (National Park Service, 1994). Long and Smith (1996) summarized water quality data since 1983 for the Southeast Utah Group parks focussing on springs and seeps.

Abandoned mines are an issue from not only from a radiological standpoint, but also a water quality basis. Burghardt (1988) addressed the health and safety issues including water quality at eight mines.

Macroinvertebrates were the focus of several studies at Canyonlands. These include Conner and Kepner (1983), Mithchell and Woodward (1993), Wolz and Shiozawa (1995). The former found few aquatic organisms associated with springs in Arches and Canyonlands. The latter found 521 individuals in 37 taxa in several drainages. In 2001, Schelz (2001) reports on the long-term monitoring program in Salt Creek in Canyonlands. Macroinvertebrates are also analyzed at water collection sites every four months during the year water samples are collected.

Lamarra (1981) studied waste disposal techniques used by commercial rafters in Canyonlands and identified the impact of user density. Another series of special investigations studied acidification of potholes (Graham, 1991, 1992), and hanging gardens (van Riper et al. 1995; May et al. 1995; Fowler et al. 1995.)

In 1983 a water quality monitoring program for springs, seeps, and streams in the SEUG parks was initiated and this program is still underway. Currently, water monitoring is conducted twelve times a year every third year. A Hydrolab is used to measure temperature, pH, dissolved oxygen and conductivity; water is also collected and analyzed for a suite of chemicals, nutrients and metals. Fecal coliform analysis is done in house; the other samples are analyzed at the Utah Department of Environmental Quality Water

Laboratory. Analysis results are available via the web on STORET, a national database maintained by the Environmental Protection Agency (EPA); paper copies are stored at the Southeast Utah Group Resource Management office. Threats that might cause degradation of water quality include oil and gas development and recreational development along park borders, trespass livestock use; internal park development and recreational use (including roads), as well as yet unforeseen sources.

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Capitol Reef National Park - Water Quality and Water Quantity

Capitol Reef National Park has numerous folders of data and reports regarding grazing and its impacts on water resources, water quality, and tinaja studies. Authors are not attributed to much of this data; most likely they were generated by park staff. These can be invaluable sources of background information that would serve for a water resources management plan. The park also has two project statements - one for development of a water resources management plan (Capitol Reef National Park 1999a) and the other for Halls Creek watershed evaluation (Capitol Reef National Park 1999b).

Water resources of the park have been assessed by both the park and private entities. They include Christiana (1989), Christiana et al. (1991), and Kehrer (1986). The National Park Service (1991) developed a water resources management plan for Capitol Reef National Park. This document relates aspects of park water resources and a means to continue assessment of those resources.

The Fremont River has been the source of potable drinking water for the park for many years; however, several investigations were completed to assess sources of culinary water at headquarters and in other parts of the park. Bjorklund (1969) investigated ground water sources in the upper Fremont River. Huntoon (1978) identified best sources of ground water in three areas of the park. The earliest reviews come from Marine (1962).

Efforts towards assessing the water quality of the Fremont River, springs, seeps and tinajas comprise many works. One of the earlier works by Envirosphere (1981) described a program to assess water quality with the intent of assuring protection of the water resources. A water quality study in the Fremont River and surrounding watershed monitored temperature, turbidity, fecal coliform, and conductivity (Capitol Reef National Park, 1990). The following year Borthwick and Henderson (1991) proposed a monitoring program for the Fremont River watershed. The proposal was implemented for several years and resulted in reports such as National Park Service (1994) and Berghoff (1995a). Since this time the river has been listed as a State 303(d) water for phosphorus, dissolved oxygen, and total dissolved solids. Millenium Science and Engineering (2001) provide total maximum daily loads for the Fremont River. Particular interest in the park small pools and tinajas are expressed through specific studies on these systems. Haefner and Lindahl (1988, 1991) described the mechanisms of community organization in rock pool habitats and the effects of livestock grazing on these systems. Lafrancois (1994, 1995, 1996) studied the ecology of desert rock pools in the park. He documented more macroinvertebrate species than in studies past. Baron et al. (1998) also reviewed the chemical and biological characteristics of desert rock pools in the park. They found that neither flooding, or drying, nor the presence or absence of surrounding vegetation had a great effect on the chemical composition. In order to better-understand tinajas in the park, biological and physical parameters of tinajas and associated wetlands were measured by park staff from autumn of 1993 to spring of 1994. Data collected included sampling location, date, time, water depth, volume, faunal species, water pH, conductance, chemical composition, and other parameters (DS-CARE-0024). Berghoff (1995b) conducted survey of tinaja wetlands in the Waterpocket fold and found over 400 sites.

Several investigators including the State of Utah have assessed macroinvertebrate populations in water sources at the park. Early investigators Woodbury and Musser (1963) established stations to examine different aquatic environments. Reichert et al. (1977) document the initiation of an aquatic invertebrate monitoring program in 1977. Bauman (1989) established 10 macroinvertebrate sampling sites along the Fremont River and collected data in 1988 and 1989, in order to help evaluate the potential effects on macroinvertebrates from aaproposed reservoir construction project (DS-CARE-032). Ten macroinvertebrate sampling sites were established along the Fremont River from Bicknell Bottoms downstream to near the east boundary of Capitol Reef National Park (CARE). Six of these sampling stations were upstream of CARE and the other four were within CARE boundaries. Samples were

collected from each station on three dates, one date each in Autumn (October 1988), spring (March 1989), and summer (June 1989). listed macroinvertebrates for the Fremont River. The Forest Service (1991) studied three stations in 1988 for macroinvertebrates. They found taxa typically associated with systems high in sediment. Magnum (1993) reviewed samples taken and results for macroinvertebrates in the Fremont River. Other efforts include MacDonald's (1992) work in Pleasant and Sulphur creeks, Winget's (1975) very early work on the Fremont, Brammer (1998) on Pleasant Creek, and Kirby and McAllister's(2000) work in Pleasant and Sulphur creeks and the Fremont River are surveys of those systems invertebrate populations.

Fish populations were studied in response to a proposed hydropower plant on the Fremont River (Hardy, 1989). The author noted that the loss of stream habitat would be offset by the improvement of water quality downstream. Murdock et al. (1987) organized information regarding flow conditions in the lower Fremont River. Chemical reclamation projects conducted upstream from the park caused Hepworth et al. (1993) to survey fish populations in the Fremont River. And in 2000 and 2001, data were collected from the Fremont River to assess benthic species composition, identify food use of fish species, and to characterize river habitats and identify stream characteristics. In particular, the stream characteristic data was collected at 48 sampling sites along the Fremont River, including date, time, observer, stream flow, stream width, estimate of pool/riffle ratio, bank shape, bank substrate, riparian vegetation, and UTM location of sampling site (DS-CARE-0006).
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Livestock grazing has occurred in the park and so too many studies relating to its impacts on natural resources are in the park. One report (Barth and McCullough, 1988) documents these impacts by comparing Pleasant Creek and Oak Creek, where Oak Creek had been more heavily grazed than the other. A flood plain study of the Fremont River was completed by Berghoff (1995c). Additionally a drinking water source protection plan was developed by Martin (1998).

Lastly, Frye (1998) details the administrative history of the park while relating some of the natural resource issues in the park.

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Capitol Reef National Park - Water Quality and Water Quantity

Data Sets

DS-CARE-0024	Tinaja survey data: 1993 and 1994. 10/12/1993 - 5/26/1994. (MS Access97 (converted from Dbase); associated paper files.). Originated by Capitol Reef National Park; status: Inactive.
DS-CARE-0006	Fremont river study site database. 6/27/2000 - 7/11/2001. (MS Access97; paper field forms with map sketches; digital study site photographs). Originated by Schwarzbach, Amy; status: Inactive.
DS-CARE-0032	Macroinvertebrate fauna of the Fremont River. 10/1/1988 - 6/30/1989. (Tables in a report) Originated by Baumann, Richard W.; status: Inactive.

Cedar Breaks National Monument - Water Quality and Water Quantity

Investigation of the water resources, particularly water quality, at Cedar Breaks National Monument is limited. Few if any significant water quality threats exist, since the springs in the area are at the watershed upper edge along a ridgeline, generally upslope from impacts. Of concern is the development of potable water for park personnel and visitors. This has been the focus of most water studies in the park.

Early on, Dunn (1941) studied the water supply for the park, and Gates (1961) investigated the park's spring water resources. Sumsion (1967, 1971) reviewed the water sources for the park and later focused on discharge at Sunset View Spring at the monument. Lastly, Bingham Engineering (1993) included the monument in an evaluation of water supply and demand for Cedar City, UT.

Studies pertaining to ground and surface waters and impacts thereof include Heilweil and others (1992) who reviewed water level declines as related to water withdrawal in southwestern Utah. Price and Plantz (1978) monitored the hydrology of selected streams in coal fields in central and southern Utah.

The Utah Division of Water Resources and Department of Natural Resources (1994) are only entities that document the fisheries and water-related wildlife of the park. Lastly, the Resource Management Plan (1992) for Cedar Breaks National Monument develops several project statements including those for water resources inventory.

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Colorado National Monument - Water Quality and Water Quantity

Water specialists at a meeting coordinated by Nancy Driver with the U.S. Geological Survey – NAWQA program (Rosenlieb 1994) noted that the basin-wide issues for the Colorado River were: effects of 1) mining, 2) agriculture, 3) urbanization, 4) natural geology, and 5) water diversion. With regards to Colorado National Monument, the issues of agriculture, development and natural geology are particularly important. As such several studies review the flood potential of intermittent and streams in or near the monument (Corps of Engineers 1976, Spry 1989). Also the monument documented erosion control efforts in National Park Service (1951).

With any park, development of water resources for visitors and park personnel is important. Maxwell (1940) is a water supply study particularly for the monument. Lohman's (1965) explores artesians for the Grand Junction area. The monument also has a map for noting location of springs and developed water sources (Colorado National Monument 1938), and a monument folder holds a listing of spring locations, flows, and water rights (Colorado National Monument no date).

The Fruita waterline runs through the park and Colorado National Monument (1999) reviews the leaks, breaks and other features of a poorly maintained line. This pipeline is further discussed in Benton (1977). As of this date, the waterline through the monument is not in use and new impacts that result from leaks are not an issue. Artificial habitats and the promotion of exotic vegetation associated with previous leaks in the waterline remain to be dealt with.

The Colorado River, which can receive intermittent waters from Colorado National Monument, remains the focus of the U.S. Geological Survey – NAWQA program. Two sites on the river near Grand Junction document salinity and pesticide levels. These are reviewed in Bauch (1998, 2000). Within the park boundaries, Butler (2001) surveyed water quality at approximately 10 springs and 2 surface sites. This is one of the few documented water quality surveys for the park. Other surveys have been ancillary to water quality studies including assessments for bighorn sheep introduction (Colorado National Monument, 1976; Armstrong, 1988). Lastly, numerous studies regarding the endangered fishes in the Gunnison and Colorado rivers are available, yet are not pertinent to the park in that the Colorado River does not flow through the park. Regardless, water quality and flow from the park water resources may influence immediate stretches of the Colorado during storm events. These issues are not necessarily reviewed in the endangered fishes reports.

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Curecanti National Recreation Area - Water Quality and Water Quantity

Curecanti, a water-based national recreation area, has a large database and literature set for their water resources. The General Management Plan (National Park Service, 1997) indicates that the waters of the recreation area are important and directs their management. Two earlier documents, the water resource scoping report and management plan, (Curecanti National Recreation Area and Water Resources Division, 1995; Cudlip et al., 1996) dealt directly with water resources and specific issues such as the water quality monitoring program and its progression, fisheries, wetlands and watershed analysis, water rights and upstream impacts. Bibliographies for Curecanti waters and the surrounding watershed are contained in National Park Service (1995) and U.S. Geological Survey (1995).

Water Quality Data

A relatively large amount of water quality data is available for the Upper Gunnison Basin including Curecanti: some are park-based and others were initiated by other agencies or academic institutions. Tributaries to Blue Mesa received early scrutiny prior to and just after impoundment (Wiltzius, 1965, 1966, 1967, 1971, 1974, 1976). These studies focused on fisheries and water quality measurements including temperature, pH, conductivity, dissolved oxygen, alkalinity, hardness, turbidity, and various ions. Reed (1968) anticipated certain limnological developments in light of reservoir completion on the Gunnison River. He suggested that nutrient leaching and an availability of major ions after impoundment would create a productive reservoir.

Boettcher (1971) evaluated water quality and supply at six planned or existing recreation sites at Curecanti. The Colorado Department of Health (1975) discussed baseline water quality and potential problem sites within the upper Gunnison River drainage. Colburn (1981) studied levels of trace elements in aquatic insects in Gunnison area tributaries including the East River, Slate River, Oh-Be-Joyful Creek, Coal Creek, and the Gunnison River. Richards and Ferchau (1978) and Apley (1981) summarized chemical, physical, and biological data for Cebolla Creek, a main tributary to Blue Mesa Reservoir. Rumberg et al. (1978) noted that waters in the upper Gunnison Basin including tributaries to Curecanti were generally of high quality. Effects of the Aspinall Unit impoundments on the physico-chemistry and biology of the downstream environment were discussed by Stanford and Ward (1983). In addition, Standford and Ward (1989), Hauer et. al. (1989), and Ward and Stanford (1990, 1991) noted faunal discontinuities resulting from damming upper and middle reaches of the Gunnison River.

Metals, inorganics, organic hydrocarbons, and radionuclide data were reported in a documents by Aaronson (1982a, 1982b). Only manganese exceeded U.S. Environmental Protection Agency criteria (1976) in Cimarron Creek. Fish tissue analyses (Kunkle et al., 1983; U.S. Fish and Wildlife Service, 1987) found metals not to be at levels harmful to humans.

Summaries of biological, chemical, and physical data on Blue Mesa Reservoirs and tributaries to Curecanti NRA are presented by Bio-Environs (1985), National Park Service (1986), Hickman (1987), and Cudlip et al. (1987). Long et al. (1995) summarized 13 years of water quality monitoring activities at Curecanti.

Fisheries and Benthos

A summary of fisheries and benthic studies in the Gunnison River were presented by Nehring and Anderson (1983). Wiltzius (1971, 1974) focused on post-impoundment investigations of fish populations after initial stocking. Middleton's (1969) research entailed studies on catostomid fishes in Blue Mesa Reservoir and associated tributaries. Wiltzius (1976) prepared a report on the historical influences of irrigation diversions and reservoirs on temperature and fish distribution in the Gunnison River. Wiltzius and Smith (1976) chronicled harvest trends and migration of salmonids in the Aspinall Unit. Weiler (1985) conducted a trend analysis on rainbow trout and kokanee salmon versus catch per angler. McAda

and Kaeding (1990) describe the effects of dam construction on the fishery of the Gunnison River as it relates to endangered fish species. Johnson (1994) outlines in a annual project report a study that elucidates impacts to the productivity of plankton and the quality of the fishery in Blue Mesa Reservoir from reservoir re-operations. Van Buren and Burkhard (1991) completed a Kokanee study in Blue Mesa, and Walsh (1995) noted the economic benefits of stocking the reservoir. Gowan and Fausch (1996) discussed the feasibility of establishing new populations of Colorado River cutthroat trout in streams draining into Curecanti, while Duff (1996) discussed the distribution, status, and habitat management implications of this trout.

Trophic Status of Blue Mesa Reservoir

A preliminary report on Blue Mesa Reservoir noted the waters were mesotrophic, and that they ranked sixth in overall trophic quality for Colorado's lakes and reservoirs (U.S. Environmental Protection Agency, 1976). Blue Mesa Reservoir's water quality was surveyed as part of a selected lakes and reservoir study; Sapinero Basin was sampled and determined to be oligotrophic (Britton and Wentz, 1980). Blackwell and Boland (1979) included Landsat imagery and principal components technique to determine trophic status of Blue Mesa Reservoir. Additional multispectral scanner information was obtained in 1983 (Verdin, 1984), and correlated to actual water samples. Water variability patterns were recognized and reported. Bauch and Malick (1999) investigated the 25 year trophic status of Blue Mesa Reservoir and also looked at the overall loading of nutrients into the Aspinall Unit.

Water Quality Monitoring

At least five major park-based efforts in monitoring the water resources at Curecanti NRA have occurred. The first included an early period of sampling pre- and post-impoundment (Wiltzius, 1965, 1966). In 1982, Roger Andrascik, Resource Management Specialist, and Don Hickman, Park Ranger, initiated a water quality monitoring program(1982-1985) In 1987, Wayne Valentine, Resource Management Specialist, reactivated the water quality monitoring program in Blue Mesa Reservoir. A threats- based sampling program from 1993 –2000 maintained many of the earlier sampling sites on the reservoirs and streams (Malick and Cudlip, 1997). The park houses several datasets including those for quality control, periphyton, reservoir, profiles, and water quality from 1944 to 2001 (DS-CURE-0010, DS-CURE-0022, DS-CURE-0014, DS-CURE-0013, DS-CURE-0021).

Beginning in 2001, the focus of the water quality monitoring program changed. Curecanti is seeking Outstanding Natural Resource Waters classification (anti-degradation designation) for selected tributaries in the park. Curecanti also wants the State to re-classify certain streams from Aquatic Life 2, Recreation 2, Use Protected (based on no data) to the higher level Aquatic Life Cold 1 class, to be based on the high quality data that the park is collecting. The Colorado State Water Quality Commission agreed to this proposal in its 2000 rule making hearing. The park is working closely with the U.S. Geological Survey to ensure clean sampling techniques.

Special Studies

Particular problems stemming from ice jams in the Gunnison River above Blue Mesa Reservoir resulted in Burghi (1979) and Morrison-Knudsen Engineers, Inc.(1985). In 1993, the Gunnison avulsed (changed channels) above Blue Mesa; the park requested a study to assess the rates and causes of avulsion (Wohl and Hammack, 1995).

U.S. Geological Survey and NAWQA

The U.S. Geological Survey has been very active in the Upper Colorado River Basin with the National Water Quality Assessment Program (NAWQA) since 1995. Their network of sites on the Colorado and Gunnison rivers and tributaries addressed the differences of two major physiographic provinces (Southern

Rocky Mountain, Colorado Plateau) and different land uses such as agricultural, urban, and historic mining. Their investigations range from an overview of the Upper Colorado Basin to trace elements to nutrient levels. They include: Deacon and Stephens, 1996; Deacon and Stephens, 1998; Deacon et al., 1999; Spahr and Deacon, 1998; Spahr and Deacon, 1999; Spahr and Wynn, 1997; Spahr et al., 2000a; and Spahr et al., 2000b. A water quality summary paper includes a most recent assessment of past data (Gurdak et al., 2002).

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Curecanti National Recreation Area - Water Quality and Water Quantity

Data sets

DS-CURE-0001	Reservoir Elevation Levels. 1/1/1967 - present. (Microsoft Access). Originated by [Unknown]; status: Active.
DS-CURE-0010	Curecanti Reservoir Profiles. 1/1/1994 - 1/1/2001. (Microsoft Access). Originated by Myron Chase; status: Active.
DS-CURE-0011	Phytoplankton data from Curecanti reservoirs. [no dates]. (Microsoft Access). Originated by Myron Chase; status: Inactive.
DS-CURE-0012	Phytoplankton data (unprocessed) from Curecanti reservoirs. [no dates]. (Microsoft Access). Originated by Myron Chase; status: Inactive.
DS-CURE-0014	Periphyton: qualitative analysis. 1/1/1997 - 1/1/1998. (Microsoft Access). Originated by Myron Chase; status: Inactive
DS-CURE-0022	Curecanti Water Quality Duplicate Samples. 1/1/1983 - 1/1/2000. (Microsoft Access). Originated by Myron Chase; status: Active.

Dinosaur National Monument - Water Quality and Water Quantity

Many water resource studies pertaining to Dinosaur National Monument relate to endangered fish investigations and impacts from Flaming Gorge Reservoir on the Green River. Few studies discuss macroinvertebrates or water quality. However, the park's resource management plan (National Park Service, 1991) did analyze and prioritize needs, and establish actions for managing the endangered fishes, wetland and riparian vegetation, the Yampa and Green rivers, water rights, and other water resources. Other park assessments (National Park Service, 1980) determined that the Green and Yampa rivers were eligible for the National Wild and Scenic Rivers System.

In general, investigations or studies in or near the park include the following topics: water availability, river ecology, flow dynamics, wetland studies, water quality, endangered fishes, dam impacts, and macroinvertebrate surveys.

Sumsion (1976) appraised the water resources for Dinosaur National Monument in light of expansion of facilities and the localized occurrence of potable water. Related to park water resources and visitor needs, Collins (1992) conducted an environmental sanitation survey on the facilities at Dinosaur. Water availability in the Yampa River near Maybell, CO and Deerlodge Park within Dinosaur were characterized by the Colorado Water Conservation Board (1995).

Hagen and Banks (1962) conducted an early review of the Green River's ecology and limnology within Dinosaur. Another ecological characterization of the Green River in Dinosaur was conducted by Neuhold and Annear (1981). This study also includes work on the Yampa River, and anticipates changes in the river systems as a result of proposed water development.

An early review of Yampa River hydrology was conducted by Steele and others (1977) in 1948. Elliot and others (1984) reviewed sediment transport in the lower section of the Yampa River. Potter (1983) reviewed the relationship between fluctuating water levels and vegetation along the Green and Yampa rivers in Dinosaur. O'Brien (1983, 1984) investigated river dynamics, and hydraulic and sediment transport. Sediment sampling continued in studies conducted from 1997 to 2000 (2002, results from park questionnaire). Instream flow needs were reviewed by the Water Resources Field Support Laboratory (Flug and others, 1983). They noted that instream flow needs are based on preservation of physical stream characteristics needed to maintain habitat for endangered fishes. Cluer (1999) applied Doppler techniques to large-river studies.

Wetland studies relate to specific projects, in particular restoration of the Hog Canyon riparian area (Martin and Wagner, 1992; Dinosaur National Monument, 1993). The riparian system at Deerlodge Park served as one of the study sites for a functional assessment of reference wetlands in Colorado (Cooper and others, 1998).

Water quality studies are few, but include O'Brien (1984) and Larson (1989). The former studied temperature on the Green and Yampa rivers to determine impacts to temperature relating to water diversion. Larson monitored temperatures on the Green River at two sites within the park. Monitoring of temperature continued through 2000 (2002, results from park questionnaire). Two other studies in the area of Dinosaur include Department of Interior (1983) and Wentz and Steele (no date). Foster and others (2000) characterized seeps and springs within the monument. Ninety-four water sources were identified. Lastly, the U.S. Geological Survey (Chafin, 2002) completed a study of apparent increasing pH levels on the Yampa River. Chafin found that much of the increase in pH in the Yampa River near Maybell between 1950-74 and 1975-99 was due to bacterial oxidation of organic matter in sample containers during shipping.

Endangered fishes investigations are numerous, and therefore only a few are referred to here. Holden (1975, 1980) described the distribution, abundance, and life history of fish in the Upper Colorado Basin, and also developed a relationship between flows in the Yampa River, and the success of rare fish in the Green River. McNatt and Skates (1981) initiated a cooperative fish survey in Dinosaur. Miller and others (1982) conducted a study of the Yampa River to determine the habitat preferences, abundance, and distribution of fishes. Seethaler and others (1979) provided an early summary of the endangered and threatened fishes in the Yampa and Green rivers in the park.

Archer and others (1986) expanded information on the distribution and movement of the adult Colorado pikeminnow. The Biological Sub-committee (1984) depicted the distribution, concentration, and spawning areas of the Colorado pikeminnow, humpback chub, and razorback sucker. The Colorado River Recovery Implementation Committee (1990, 1996) defined water acquistions for the endangered fishes, and the other clarifies the recovery action plan. Irving and Burdick (1995) completed a reconnaissance and prioritization of existing and potential bottomlands for endangered fishes recovery. Jones (1985) evaluated the reproductive success of the Colorado pikeminnow in the Green River. Karp (1989) reviewed the requirements and life history of the humpback chub in the Yampa and Green rivers within the park. Modde (1996) discussed the environmental setting of the endangered fishes. Spawning locations on the Yampa River in Dinosaur were determined by Mussetter and Harvey (1994). Nesler (1995) described the interactions between introduced game fishes and endangered fished in the Yampa. Rose and Hann (1989) provided a summary of fish habitat modeling on the Yampa River.

Stanford (1993) provided recommendations for instream flow needs for the endangered fishes. Other streamflow needs are discussed by Tyus and Karp (1988, 1991). Other references to the fish include Hoover and Langlois (1977), U.S. Fish and Wildlife Service (1984, 1993), Valdez (1995), Vanicek (1969), National Park Service (1984) and Wick (1982).

Impacts from proposed dams and, or the Flaming Gorge reservoir are related in Adams (1983), Hlohowskyj and Hayse (1994), Holden and Crist (1981), LaGory and van Lonkhuyzen (1994), U.S. Department of Energy (1995), Williams and others (1994), Woodbury (1963), and Yin (1994).

A special report relating to a rotenone release below Flaming Gorge Dam was completed by Kittams (1962). Unanticipated fish kills occurred within the park. Another special investigation includes a review of hanging gardens in Dinosaur (van Riper and others, 1995) and other Northern Colorado Plateau parks.

Lastly, macroinvertebrate studies include Carlson and others (1979, 1994), field notes (Dinosaur National Monument, 1962, 1985), and Collins and Shiozawa (2001). The latter investigated the effects of exclusion with backwater invertebrates in the Green River. They found that densities of various taxa changed when predators were excluded.

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Data Sets

DS-DINO-008	The park has one data set for water resources: Data set: Water Quality: Inventory and characterization of upland water resources in Dinosaur National Monument. 6/1/97-98.

Fossil Butte National Monument - Water Quality and Water Quantity

The water resources of Fossil Butte National Monument comprise of these features: seeps and springs, small streams supplied by seeps and springs, beaver ponds, ephemeral slump ponds, and ephemeral streams which convey precipitation runoff and water from spring snowmelt. Small volumes of water (generally 25 gallons per minute or less) flow from perennial springs located in sections 11, 13, 14, 23, 24, 25, 26, and 36 of Township 22 North, Range 118 West. The Green River Formation serves as the recharge area for most of the perennial springs and seeps on the monument. Since the recharge area is rather small (approximately 1300 acres), some of the springs stop flowing during periods of drought.

Presently, small intermittent streams, and springs supply water to active and inactive beaver ponds that contain water throughout the year in sections 13, 14, 23, and 24. Depressions formed by land slumping are common, especially in sections 24, 25, and sections 5 and 6 of Township 21 North, Range 117 West. These depressions generally only hold water for short periods of time following precipitation events and following snowmelt, but some slump depressions contain water throughout much of the year because they receive water from nearby seeps or small springs. Beaver, slump ponds, and springs are important because the serve as watering areas for the parks wildlife, and breeding areas for amphibians, beaver, and a few shorebirds and other waterfowl.

Assessments of water resources for Fossil Butte National Monument were first documented by Huntoon (1978) and then later in a letter (Ashley 1978). The Natural Resource Management Plan for the monument (Author unknown 1985) indicates a concern regarding livestock management, water resource management, and erosion control. In a technical assistance request Andrew Banta, the monuments chief ranger, recommended that the restoration of Chicken Creek occur and that the monument's erosion problem be assessed (Banta, 1995). The request also recommended that water resources management plan be developed.

Twice, a questionnaire pertaining to threats in the park revealed that erosion was a concern in the park (author unknown 1980, 1987). Glatter (1993) provided a restoration plan that used a holistic watershed approach to the restoration of Chicken Creek. Kyte and Santucci (1997) and Kyte (1998, 1999) documented the implementation of portions of this plan (Kyte, 1997, 1998, 1999).

The discussions regarding the development of the monument's springs are recorded in memos (Fossil Butte National Monument, no date) and environmental assessments (National Park Service 1989, Author unknown 1979). Lastly, a Section 6 compliance statement reviews the potential threats to cultural and biological material associated with development of Cundick Springs (Author unknown 1977).

The U.S. Geological Survey analyzed water samples from the park (1977) and the only known baseline water quality study completed for the park was performed by the Water Resources Division of the National Park Service (Tucker 1998). Kyte monitored the depth to alluvial groundwater along Chicken Creek in shallow, small-diameter wells from 1995 to 2000 and prepared a summary report of his monitoring data (Kyte, 2000).

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Golden Spike National Historic Site - Water Quality and Water Quantity

With the exception of Blue Creek, there are no water bodies, springs, or seeps in Golden Spike National Historic Site. Some research has been conducted on water resources within the site: Bolke and Price (1972) conducted a reconnaissance of the Blue Creek Valley area, and determined that the principal chemical types of water in the area are calcium magnesium chloride and sodium chloride. Hermance and Mekeel (1981) investigated the hydrology of the park, and Hood (1971, 1972) covered a broader area including Hansel Valley, Northern Rosel Flat, and the Promontory mountains in his hydrological reconnaissance.

Well construction at Golden Spike National Monument was documented by Price (1968). Martin (1999) developed a drinking water source protection plan for the park. The State of Utah and the Federal Government signed a water rights agreement on January 16, 2002. The United States acquired Water Right No. 13-2131 for use of water at Golden Spike National Historic Site, which provided that the maximum annual diversion shall not exceed eight acre feet.

The only water quality study available is one completed by the National Park Service (2000). This study found that at Blue Creek sampling sites outside of the park, 13 groups of parameters exceeded EPA water quality criteria. These included such parameters as dissolved oxygen, pH, chloride, cadmium, copper, chloride, sulfate, fluoride, arsenic, lead, nickel, and fecal-indicatior concentrations. Some of these exceedances may be due to natural factors or sampling error. The report states that in general the water resources, especially in Blue Creek appear to have been significantly impacted by natural and human activities.

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Hovenweep National Monument - Water Quality and Water Quantity

Five significant water resources are identified for this park. Presently, three sites are sampled for water quality by park personnel from the Southeast Utah Group parks, as part of a water quality monitoring program for springs, seeps, and streams in the SEUG parks (DS-SEUG-009). Currently, water monitoring is conducted twelve times a year every third year. A Hydrolab is used to measure temperature, pH, dissolved oxygen and conductivity; water is also collected and analyzed for a suite of chemicals, nutrients and metals. Fecal coliform analysis is done in house; the other samples are analyzed at the Utah Department of Environmental Quality Water Laboratory. Analysis results are available via the web on STORET, a national database maintained by the Environmental Protection Agency (EPA); paper copies are also stored at the Southeast Utah Group Resource Management office. Macroinvertebrates are also analyzed every four months during the year water samples are collected. Threats that might cause degradation of water quality include oil and gas development and recreational development along park borders, trespass livestock use; internal park development and recreational use (including roads), as well as yet unforeseen sources.

A baseline water quality study was completed for the monument (National Park Service, 2000). Other water quality work include Colorado State University (1994). One water resource data set is available for the park (DS-SEUG-009.4). And the Natural Resource Management Plan (Trick, 1982) for the monument develops project statements for water quality and quantity monitoring.

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Data Sets

DS-SEUG-009 Water quality monitoring program for springs, seeps, and streams in the SEUG parks, 1983-present. (MS Excel spreadsheets; MS Word documents; hard-copy data sheets and analysis reports; photos). Originated by Schelz, Charlie; status: Active.

Berghoff and Vana-Miller (1997) discuss water resource issues in 3 park units of southeastern Utah including Natural Bridges. Efforts to monitor the water quality at the park continue in coordination with other Southeast Utah Group parks. As a means of assessing the monitoring program initiated in 1983, the Resource Division of Southeast Utah Group (1994) summarized their efforts. Long and Smith (1996) completed water quality analysis for this same group of parks which included Natural Bridges.

Huntoon (1977), in his effort to determine the feasibility of developing water sources in southeastern Utah, found that the Cedar Mesa sandstone was the best ground-water source at Natural Bridges. The park (author unknown, 1978, 1980) in environmental assessments identify four potential sources of water supply to address increased visitor use and park personnel numbers.

Special studies in the park include those on acidification of rock pools (Graham, 1991; Graham et al. 1992), studies of hanging gardens (May et al. 1995; Fowler et al. 1995; van Riper et al. 1995), and macroinvertebrates (Mitchell and Woodward 1993). Woodward-Clyde Consultants (1979) lists springs within the park. Kitchell (1987), in early documentation, outlines the need for complete and better understanding of the park's water resources and the issues that affect water resources. These concerns have been partly addressed through the water quality monitoring program for springs, seeps, and streams in the SEUG parks (DS-SEUG-009). Currently, water monitoring is conducted twelve times a year every third year. A Hydrolab is used to measure temperature, pH, dissolved oxygen and conductivity; water is also collected and analyzed for a suite of chemicals, nutrients and metals. Fecal coliform analysis is done in house; the other samples are analyzed at the Utah Department of Environmental Quality Water Laboratory. Analysis results are available via the web on STORET, a national database maintained by the Environmental Protection Agency (EPA); paper copies are stored at the Southeast Utah Group Resource Management office. Macroinvertebrates are also analyzed every four months during the year water samples are collected. Threats that might cause degradation of water quality include oil and gas development and recreational development along park borders, trespass livestock use; internal park development and recreational use (including roads), as well as yet unforeseen sources.

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Pipe Spring National Monument - Water Quality and Water Quantity

The most important resource at Pipe Spring National Monument is water, and as a result investigations regarding general geohydrology, chemistry, water table declines, and management are abundant for a park unit of 40 acres. A call for protection of the springs began in 1933 (Rose 1933) with a report from the assistant superintendent regarding water resources and administrative problems at the monument. Geerdes (1970) later discussed the ownership of water at the monument. The monument superintendent (Pipe Spring National Monument 1990) relayed information to help protect the water resources of Pipe Spring related to a hazardous waste incinerator being located close to the monument. The Monument's Resource Management Plan (National Park Service 1993) proposes to conduct a hydrological study of Pipe Springs National Monument.

General hydrological studies of Pipe Spring include the Bureau of Indian Affairs' (1976) study of the Kaibab Indian Reservation, the U.S. Geological Survey review (1979) regarding wells and springs in the Kanab area, and Truini's (1986) geohydrologic review of the Pipe Spring National Monument area. The most extensive study (Bills et al. 2000) reveals that recharge to the aquifer supporting Pipe Spring is 240,000 acre-ft per year and discharge is approximately 400,000 acre-ft per year; however, ground water from areas outside the study area contributes to this discharge as well. The water generally has less than 500 mg/L of total dissolved solids and is a calcium, magnesium, and bicarbonate type.

With regards to monitoring Dewitz (1991) developed a plan to monitor coliform bacteria in the Pipe Spring system. Inglis (1997) monitored and analyzed spring flows at the monument and the University of Arizona (2000) analyzed water samples for oxygen and deuterium.

Since 1976, the NPS has observed a decline of about 50 percent in discharge from springs at the monument, with the combined spring discharges decreasing about 2 (gal/min)/yr (Truini, 1999; Barrett and Williams, 1986). Inglis (1989, 1990) determined whether water pumping caused the decline of spring flows. After discharge from Spring Room and Main Springs ceased in June 1999, Sharrow (1999) tested the addition and removal of water from main spring and spring room, demonstrating that these features are hydologically connected in the subsurface.

Heilweil and others (1992) simulated ground-water flow and water-level declines that could be caused by proposed withdrawals in the Navajo Sandstone of southwestern Utah and northwestern Arizona. Development of the springs also has been a park concern. The National Park Service (1982) developed a concept plan for the Pipe Spring residential and maintenance areas, and Rust Engineering Company conducted a preliminary study for development of water resources on the Kaibab Indian Reservation. Finally, MaGavock (1974) provides results of test drilling in Pipe Spring National Monument.

The U.S. Geological Survey (2002) is currently conducting geologic mapping of the Pipes Spring vicinity and seismic investigations to improve the scientific basis for understanding the hydrology of the Springs.

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Timpanogos Cave National Monument - Water Quality and Water Quantity

Timpanogos Cave National Monument cave system contains three water bodies, which have been investigated by park personnel and outside sources. Mayo et al. (2000) recently discussed the geology and hydrology of Timpanogos Cave. Park personnel (Jensen 1990) indicated that water dripping in the caves responds to spring runoff and snowmelt. Eisenberg (no date) developed a park information sheet that discusses stream sediments in the cave water bodies.

Special studies have included a study of the diatoms in Timpanogos Cave (St. Clair and Rushforth 1976). They found diatoms throughout the cave system, and the diatoms were distributed according to moisture and natural openings. Twenty-six species were identified and described, including eight not previously collected from caves and four new records for the state of Utah. A baseline water quality assessment was completed by the Water Resource Division (National Park Service 1999). Tranel et al. (1991) investigated cave hydrogeology and hydrogeochemistry (DS-TICA-0002).

A very short section of the American Fork (0.7 mile) flows through the monument; however, the flow is partially diverted to an hydroelectric pipeline that routes water around the monument. Martin and Jackson (1999) suggest a minimum 10 cfs flow as opposed to the present 4 cfs flow that results from diversion of water to an hydroelectric pipeline.

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Zion National Park - Water Quality and Water Quantity

Numerous water resources-related studies have occurred in and near Zion National Park. Water resource topics researched or investigated include: water management; water quality; water supply and quantity; general aquatic biota; impacts to water resources; fish, hanging gardens; and management plans. Zion National Park has developed a Resource Management Plan (National Park Service, 1994) which addresses a number of these issues and provides project statements for water resources in the park.

The Five County Association of Governments (1977, 1977, 1989) completed a water quality assessment of the Virgin River Basin, a 208 plan, and a management plan for southwestern Utah. Gunnell (1984) produced a water quality report that includes information on aquatic organisms in Zion. Jones (1988) provided a map of over 200 springs in Zion, and Maddox et al. (1977) completed a water resource inventory (quality and quantity) in the eastern part of Zion. Trace elements of springs in Zion were examined by Yelken (1996). The Water Resources Division of the National Park Service (National Park Service, 1998) completed a review of the park's water quality. As a cooperative effort, the Dixie National Forest (2001) provides an overview of sampling sites, objectives and parameters.

Other water quality studies include those of Peterson (1991), who modeled stream temperatures in the park, Sandberg et al. (1985) who examined the surface water quality in the Virgin River Basin. Lastly, the Department of Environmental Quality (1998) provided a Utah water quality assessment to Congress.

Bacterial and chemical inputs to Zion National Park were studied by Maddox et al. (1997), and most recently Sharrow (2001) summarized bacterial levels in streams sampled around the park (DS-ZION-007). Work is continuing with Dr. Samandpour at the University of Washington to use DNA techniques to distinguish among sources of bacterial contamination.

Water supply investigations include those in and outside of the park. Gates (1964) examined the supply of water at the Taylor Creek entrance and found it not to be a feasible source. Sumsion (1971) measured spring discharge in Zion. Covering the Virgin River Basin, a study by Soil Conservation Service and the Utah Department of Natural Resources (1990) summarized water resources.

Lindahl (1976) surveyed the fauna and flora of the Grapevine Spring in the park. Workman (1980, 1983) studied riparian resources with its associated biota and water quality. Boyle et al. (1993) completed an inventory of the aquatic resources of the Virgin River in the park.

In special studies focused on the impacts to water resources, Stromberg and Patten (1994) looked at the response of riparian systems to water withdrawals from the Virgin River. Shakarjian et al. (1997) studied the effects of trampling by river recreationists on zoobenthos in the North Fork of the Virgin River. Cordy et al. (1993) reviewed the potential hydrological effects of mining the L. C. Holding coal-lease tract and adjacent areas in southwestern Utah.

Specific fish studies include Addley and Hardy (1993) who discussed the distribution and status of the Virgin spinedace, and Deacon et al. (1991), who developed a habitat preference analysis for this species. Cross (1985) reviewed the distribution of fish in the Virgin River, and Gregory and Deacon (1994) examined the effects of human-induced changes on fish in the Virgin River.

Zion National Park supports excellent examples of hanging gardens, which often support rare and endemic species, and, as such, serve as sites for research. Malanson and Kay (1980) explained the distribution of plant species relating to flood frequency in gardens. Welsh and Toft (1980) and Welsh (1989) discussed the distribution and biotic communities of hanging gardens. Van Riper et al. (1995)

described results of fieldwork studying 75 hanging gardens. Fowler et al. (1995) surveyed the level of endemism among vascular plant taxa in Zion. Laity and Malin (1985) provided a description of sapping processes leading to hanging garden development on the Colorado Plateau, and May et al. (1995) described the geomorphology of hanging gardens in Arches. Kimball and Christensen (1993) examined the presence of ground water at hanging gardens and the extent to which water withdrawals affect the gardens.

In response to rapid growth in the Virgin River Basin, the Washington County Water Conservancy District et al. (1999) developed a coordinated management plan for the watershed. Stevens and Hansen (19917) investigated the controlled releases of water from Kolob Reservoir, which is the only reservoir of size upstream of the park and its waters are on the State 303(d) list.

References

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Data Sets

DS-ZION-0007	Zion bacterial water quality data. 6/1/2000 – 12/31/2001. (MS Access database with 7 data tables.) Originated by Sharrow, Dave; status: Inactive.

Arches National Park - Soundscape

In 1987, legislation was passed that directed the NPS to monitor and assess the impacts of aircraft overflights in national parks. In the late 1980s and early 1990s, NPS monitored sound levels in six parks in the northern Colorado Plateau, including Arches (Ernenwein 1992, Grasser and Moss 1992).

In 1994 and 1995 digital audio tapes (DAT) were made for several hours; these recordings could be analyzed for some audibility data, or used in comparison with current conditions (Gadula and Gudorf). Fifteen-minute dBA metrics are also available for the 1994-1995 study. All information is stored at NPS offices in Denver, and future analysis is planned by the NPS Natural Sounds Resource Division in Ft. Collins (Ambrose pers. comm.).

In a project begun in 2002, two permanent sound monitoring stations (1/3 octave band data) were established: one in a pinon-juniper community; the other, in Salt Valley, in a blackbrush community (DS-SEUG-052). Additionally, two movable stations will be set up for ten days each season at different locations in the park. Sound data collected will be evaluated and analyzed by the Natural Sounds Resource Division, and will be used in developing an air tour policy and a future soundscape management plan for the park.

References

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Gadula, E., and M. Gudorf. 1998. Southeast Utah Group Sound Monitoring Program, 1994-1996, Final Report. Unpublished report to Southeast Utah Group, National Park Service, Moab, UT.

Grasser, M. A., and K. Moss. 1992. The sounds of silence. Sound & Vibration, Noise and Vibration Control, February 1992, Volume 26, Number 2. Pp. 24-26.

Data Sets

DS-SEUG-052 Acoustic monitoring data, Arches National Park. 2/1/2002 - present. (database). Originated by S. Ambrose; status: Active.

Black Canyon of the Gunnison National Park - Soundscape

Only one study on sound is currently known for Black Canyon of the Gunnison. In 1995 dBA and 1/3 octave band data was collected for a one-month period (Foch 1995). Results or analysis of these results are not known.

References

Foch, J. 1995. Helicopter Tour Flight Noise in Black Canyon of the Gunnison National Monument, 10/31/1995.

Bryce Canyon National Park - Soundscape

Only limited audibility data is available from the early 1980s and early 1990s. The earliest sound monitoring efforts in Bryce Canyon National Park began in 1980, when the U.S. Environmental Protection Agency was requested by the Park Service to conduct sound monitoring in reponse to the proposed development of the Alton coal field directly south of the park (Foch and Oliver 1980, Foch 1980). This was part of an overall assessment on the effects of surface coal mining on unique and significant public lands.

Foch further addressed the protection of quiet in pristine areas using Bryce Canyon as the focus of his discussion (Foch 1992).

Park staff conducted noise monitoring surveys during the summer of 1995 at five sites, using the 15-second LEQ method. Approximately 40 hours of data was collected on noise levels from aircraft and other mechanical sources, and natural or background noise was also monitored (Foster and Bryant 1995, DS-BRCA-0009).

In 1997 the FAA conduted a study on visitors' responses to noise as part of gathering information on the National Parks Overflight Rule (FAA 1997). The resulting report was the basis for the park purchasing sound monitoring equipment and collecting additional data. In a 2000 study, park visitors were again interviewed to learn if aircraft overflights affected their enjoyment of park tranquility and solitude. Most responses from the 56 visitors interviewed indicated a negative impact from aircraft overflights (Blackham and Britten 2000); however, these results are subjective.

In 2002 a new effort was begun to collect daily (1/3 octave band) digital ambient and intrusive (non-natural) recordings at two locations in the park. Data are sent off-site to NPS offices in Ft. Collins, CO, for initial interpretation and analysis. Project end date is currently indefinite; no references or data sets are yet available for this study. In addition, Rossman (2002) is developing a soundscape management plan for the park.

References

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Foch, James D., Jr. and Oliver, Geoff S. 1980. Technical report on sound levels in Bryce Canyon National Park and the noise impact of the proposed Alton coal mine. Noise Technical Assistance Center-University of Colorado. Boulder, CO. 137 pages.

Bryce Canyon National Park - Soundscape

Foster, Dan A. and Bryant, Richard M. 1995. Preliminary results of noise monitoring in 1995 in Bryce Canyon National Park, Utah. Bryce Canyon Nationa Park. 9 p.

Rossman, Robert. 2002. Soundscape management objectives for Bryce Canyon National Park. Bryce Canyon National Park. 1 p.

Data Sets

DS-BRCA-0009	Preliminary Results of Noise Monitoring in 1995 in Bryce Canyon NP. (summer, 1995). (paper files, handwritten observation pages, GIS shapefiles, *.WAV files). Originated by Dan Foster and Richard Bryant; status: Inactive.

Canyonlands National Park - Soundscape

The earliest sound monitoring conducted in Canyonlands occurred in the mid-1980s, when an assessment was conducted of potential noise impacts associated with a proposed nuclear waste repository adjacent to the park (BBN 1983, 1985). In 1987, legislation was passed that directed the NPS to monitor and assess the impacts of aircraft overflights in national parks, and in the late 1980s early 1990s, the NPS monitored sound levels in several parks in the northern Colorado Plateau, including Canyonlands (Ernenwein 1992). In addition, digital audio tapes (DAT) were made in 1994-1995 and some fifteen-minute dBA metrics were also collected: these recordings could be analyzed for some audibility data or used in comparison with current conditions (Gudorf and Gadula 1998).

In 2002 a study was begun collecting continuous 1-second dBA data and digital recordings in the Needles district. This projuect was primarily test acoustic monitors' ability to collect biological data (in this case, bird vocalizations). Information is provided to the NPS Soundscape Program office in Ft. Collins for analysis and interpretation; no publication or data set has yet been completed for this project.

References

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Capitol Reef National Park - Soundscape

The only sound monitoring project known for Capitol Reef was conducted in the early 1990s. The physiological responses of wildlife to aircraft, including supersonic flights, were studied in relation to a U.S. Air Force proposal to conduct low-level training flights within two miles of the north park boundary. It is unknown if any associated audibility or sound level metrics data is available from this work.

References

Workman, Gar W., Bunch, Thomas D., Neilson, La Dawn S., Rawlings, Elizabeth M. et al. 1992. Sonic boom/animal disturbance studies on pronghorn antelope, Rocky Mountain elk, and bighorn sheep. Contract number: F42650-87-C-0349. 268 p.

Colorado National Monument - Soundscape

Sound monitoring was conducted at Colorado National Monument from 1990-1992, in order to quantitatively define ambient sound levels as the basis for protecting parks from anthropogenic noise sources (DS-COLM-0004). Monitors were installed at three locations, with dBA metric data recorded on paper rolls. Meteorological data was also gathered to aid in interpretation. Some raw data is housed at the park; interpreted data from the NPS Denver regional office.

Grasser and Moss(1992) looked at representative sound levels in a number of national parks, including Colorado National Monument, and reviewed sound level data collection procedures are reviewed.

And in 1994, in response to the Regional Director of Rocky Mountain Region's request for information on the aircraft overflight issue, the monument studied aircraft noise and visitor experience, concluding that in order to preserve the resource of natural quiet, airspace restrictions over a major part of the monument would be needed (Colorado National Monument 1994).

References

Colorado National Monument. 1994. Aircraft overflight problems associated with resource protection and visitor experience at Colorado National Monument. 5 p.

Grasser, Mary Ann, Colorado National Monument and Moss, Kerry. 1992. The sounds of silence. Sound and Vibration. Sound Monitoring Study. Volume: 26, Issue: 2. Page(s) 24-26. 1 folders.

Data Sets

DS-COLM-0004 Ambient Sound Monitoring Study, Colorado National Monument, 1990-1992. (Lotus spreadsheets (as zip files); paper rolls from recorder). Originated by Resource Management Staff; status: Legacy.

Dinosaur National Monument - Soundscape

Several sound monitoring studies have been conducted at Dinosaur National Monument. In 1989 a monitoring site was established at West Cactus Flat (DS-DINO-003); in 1990 at Harper's Corner (DS-DINO-003.1); and in 1991 at a site near the Dinosuar Quarry (dataset pending). The main objective was to document the ambient sound levels in the monument and establish baseline data. A Digital Acoustics Model DA 607P noise monitor were used consecutively at all three sites. The Harper's Corner site was selected as the seasonal visitor use area, West Cactus Flat as representative of a backcountry area, and The Dinosaur Quarry site as representative of an area with year-long activity. The Harpers Corner and Dinosaur Quarry sites were 200-400m from paved roads. Monitors measured dBA metrics data hourly, with quarterly data, monthly graphs, and an interval chart for each month produced (Collaboration in Science and Technology 1989, 1990).

Ambient sound levels were found to be very low at all three monitoring sites. L90 is the sound level exceeded 90% of the time and is often used to represent the baseline or ambient sound level.

Collaboration in Science and Technology (1990) reports the L90 hourly sound levels at West Cactus Flat for average days in the 10 months of monitoring ranged from 16 dBA during the evening for a month when the equipment noise floor was 13 dBA (October) to 30 dBA during the day for a month when the noise floor was 23 dBA (May). Spikes in recorded sound levels may have been associated with passage of weather fronts and elk bugling. Hourly L90 octave band sound pressure levels were made during a period of low wind; those levels were somewhat limited by the equipment floor noise but recorded levels below 15 dB for the 125-8000 Hz octave bands,

Collaboration in Science and Technology (1990) reports the L90 sound levels at Harpers Corner were often below the 21-22 dBA noise floor of the equipment during winter and spring seasons. On a few days the L90 was as high as 34 dBA; these may have been associated with weather fronts passing through the area. Hourly L90 octave band sound pressure levels were made during a period of low wind; those levels were also limited by the equipment floor noise but recorded levels below 12 dB for the 63 to8000 Hz octave bands.

Additional measurement sites were located in the monument in the early 1990s, and results were summarized by Bommer and Bruce (1992) and also addressed by Grasser and Moss (1992).

References

Bommer, Arno S. and Bruce, Robert D. 1992. Long-term ambient sound monitoring in national parks. S V Sound and Vibration. Volume: 26, Issue: 2. Page(s) 16-18.

Collaboration in Science and Technology Inc. 1989. Sound monitoring data, 1989-1990: West Cactus Flat, Dinosaur National Monument. 50 p.

Collaboration in Science and Technology Inc. and National Park Service, Mining and Minerals Branch. 1990. Monitoring results at Harpers Corner site, Dinosaur National Monument (8.0). Ambient sound monitoring program for Colorado Plateau parks. National Park Service Contract No. CX-1200-8-PO63, CSTI Report No. 128, CSTI Job No. 5026. 150 p.

Grasser, Mary Ann, and Moss, Kerry. 1992. The sounds of silence. Sound and Vibration. Sound Monitoring Study. Volume: 26, Issue: 2. Page(s) 24-26. 1 folders.

Dinosaur National Monument - Soundscape

Data Sets

DS-DINO-003.1	Ambient Sound Monitoring - Harper's Corner. 1/1/1990 - 2/2/1991. (Folder). Originated by National Park Service; status: Inactive.
DS-DINO-003	Ambient Sound Monitoring - West Cactus Flat. 5/1/1989 - 4/1/1990. (Folder). Originated by National Park Service; status: Inactive.
DS-DINO-[pending]	Ambient Sound Monitoring – Dinosaur Quarry. Ca. 1991-1992

Fossil Butte National Monument - Soundscape

Sound monitoring was conducted from the fall of 1991 through 1993 at Fossil Butte National Monument, to establish baseline of ambient sound levels for the monument (Grasser 1993). The location of the raw data, extent of data collected, and any resulting analysis, is currently not known.

References

Grasser, Mary Ann. 1993. Sound monitoring at Fossil Butte National Monument. [Unpublished report.] Fossil Butte National Monument, Kemmer, WY. 1 p.

Natural Bridges National Monument - Soundscape

No sound monitoring projects are currently underway at Natural Bridges. Digital audio tape recordings were made for several hours in 1994 and 1995 (Gadula and Gudorf 1998); these recordings could potentially be analyzed for audibility data.

References

Gadula, E., and M. Gudorf. 1998. Southeast Utah Group Sound Monitoring Program, 1994-1996, Final Report. Unpublished report to NPS. Moab, UT.

Zion National Park - Soundscape

In 1987, legislation was passed that directed the NPS and Federal Aviation Administration (FAA) to monitor, assess, and reduce the impacts of aircraft overflights in national parks. In the late 1980s and early 1990s, NPS monitored sound levels in six parks in the northern Colorado Plateau, including Zion (Ernenwein 1992). Measurements were taken in 1995 (Harris Miller Miller and Hanson 1998a) and 1998 (Harris Miller Miller and Hanson 1998b). In 2000, the National Parks Air Tour Management Act was passed, further directing FAA and NPS to jointly manage air tour operations over NPS lands and establish monitoring programs as necessary.

To further characterize the soundscape in Zion for air tour and overflight management, several additional sound inventories were undertaken. Observer logs, DAT recordings, and 1/3 octave band recordings were collected in 2000-2001 and summarized by Wyle (2002). The Wyle Labs study included seasonal measurements for 21 days each in spring, summer, and fall at 12 sites and a continuous, year-long monitor at one site. For the winter season, similar data was collected by park staff at 6 of the 12 sites still accessible without snow cover (Ambrose 2001a). Using data from the continuous monitoring site, Foch (2002) developed an automated system to detect high-flying jet aircraft. In the fall of 2001, Ambrose (2001b) collected audibility recordings at 2 of the 12 sites used in the Wyle Labs study, and found that man-made noise could be heard for greater than 50% of the time, 90% of which was attributable to aircraft.

References

Ambrose, S. 2001a. ZION Winter 2001 Acoustic Measurements. Unpublished memorandum. Zion National Park. 5pp.

Ambrose, S. 2001b. Acoustic monitoring in Zion National Park, Fall 2001. Unpublished memorandum. Zion National Park. 17pp.

Ernenwein, R. L. 1992. A study to define the effects of aircraft overflights on parks and wilderness areas. Sound & Vibration, Noise and Vibration Control, February 1992, Volume 26, Number 2. Pp. 6-8.

Foch, J. D. 2002. The natural soundscape and jet noise in Zion National Park. Unpublished report, Zion RM&R files. 10pp.

Harris Miller Miller and Hanson (HMMH). 1998a. Summary of Noise Monitoring Results – Zion, Rocky Mountain National Parks. Unpublished memorandum. HMMH Project No. 295270.02

Harris Miller Miller and Hanson (HMMH). 1998b. Zion NP Measurements, Task Order No. 2, Sound Monitoring Results - October 1998 Field Work. Unpublished memorandum. HMMH Job 295860.02.

Wyle Laboratories. 2002. Draft Report: The Soundscape in ZION.

Arches National Park - Night Sky

A proposal to measure night sky light levels in Arches National Park has been funded and will proceed during 2003-2004 (Schelz 2001). The primary objective of this program is to develop protocols and gather baseline data on night sky light levels at the four units of the Southeast Utah Group, including Arches National Park.

This project will result in the development of a Night Sky Long-Term Monitoring Plan and a report that will be a template for future reports. The "Night Sky Long-Term Monitoring Plan" will outline all protocols, database management, and analysis to be performed at each monitoring site. It will also clearly specify night sky monitoring needs and objectives. And will provide a clear understanding of how the monitoring program will support management information needs. This plan will identify site-specific current resource impacts and address future concerns and problem areas. It will set monitoring management standards for resource conditions and will identify and assign priorities to areas of greatest concern.

An annual report will be developed in November, 2003 and will be based on protocols established in the Night Sky Long-Term Monitoring Plan. This report will include all monitoring sites at all four units of the Southeast Utah Group (Schelz 2001). Initial measurements of baseline night sky levels at Arches began in April, 2002, and will be followed by long-term monitoring of light levels (DS-SEUG-056) at specific locations within the park. A quarter-sky CCD (charged coupled device) high-resolution camera and a robotic arm, all controlled by a laptop computer with program, take precise sky brightness measurements. Initial methodology will be guided by the NPS Night Sky Initiative Committee headed by Chad Moore, a physical scientist at Pinnacles National Monument (Moore 2000).

References

Moore, Chad. 2000. Night Sky Brightness, Limiting Magnitude Visual Estimation. Report developed by the National park Service and the International Night-Sky Association. Pinnacles National Monument, Paicines, CA. 50 pp.

Schelz, Charles. 2001. Night sky monitoring in the Southeast Utah Group, Canyonlands and Arches National Parks, Natural Bridges and Hovenweep National Monuments. A funded proposal of work to be completed during 2003-2004. 8 pp.

Data Sets

DS-SEUG-056 Night sky light monitoring in the Southeast Utah Group national parks. 4/1/2002 - present. (data collected electronically; final format being determined). Originated by Schelz, Charles; status: New.

Canyonlands National Park - Night Sky

Night sky light levels in Canyonlands National Park were first modeled and estimated by Yocke and Lundberg (1985) in the early 1980's. This work was part of the planning process of a proposal to locate a nuclear waste repository site adjacent to the Needles District of Canyonlands National Park.

Currently, a proposal to measure night sky light levels in Canyonlands National Park has been funded and will proceed during 2003-2004 (Schelz 2001). The primary objective of this program is to develop protocols and gather baseline data on night sky light levels at the four units of the Southeast Utah Group, including Canyonlands National Park.

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References

Moore, Chad. 2000. Night Sky Brightness, Limiting Magnitude Visual Estimation. Report developed by the National park Service and the International Night-Sky Association. Pinnacles National Monument, Paicines, CA. 50 pp.

Schelz, Charles. 2001. Night sky monitoring in the Southeast Utah Group, Canyonlands and Arches National Parks, Natural Bridges and Hovenweep National Monuments. A funded proposal of work to be completed during 2003-2004. 8 pp.

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Yocke, M., H. Hogo, and G.W. Lundberg. 1985. Impacts of Four Proposed Waste Facilities on the Night Sky in Canyonlands National Park. Systems Applications, Inc., San Rafael, CA (SYSAPP-85/002).

Data Sets

DS-SEUG-05 Night sky light monitoring in the Southeast Utah Group national parks. 4/1/2002 - present. (data collected electronically; final format being determined). Originated by Schelz, Charlie; status: New.

Hovenweep National Monument - Night Sky

A proposal to measure night sky light levels in Hovenweep National Monument has been funded and will proceed during 2003-2004 (Schelz 2001). The primary objective of this program is to develop protocols and gather baseline data on night sky light levels at the four units of the Southeast Utah Group, including Hovenweep National Monument.

This project will result in the development of a Night Sky Long-Term Monitoring Plan and a report that will be a template for future reports. The "Night Sky Long-Term Monitoring Plan" will outline all protocols, database management, and analysis to be performed at each monitoring site. It will also clearly specify night sky monitoring needs and objectives. And will provide a clear understanding of how the monitoring program will support management information needs. This plan will identify site-specific current resource impacts and address future concerns and problem areas. It will set monitoring management standards for resource conditions and will identify and assign priorities to areas of greatest concern.

An annual report will be developed in November, 2003 and will be based on protocols established in the Night Sky Long-Term Monitoring Plan. This report will include all monitoring sites at all four units of the Southeast Utah Group (Schelz 2001). A quarter-sky CCD (charged coupled device) high-resolution camera and a robotic arm, all controlled by a laptop computer with program, take precise sky brightness measurements. Initial methodology will be guided by the NPS Night Sky Initiative Committee headed by Chad Moore, a physical scientist at Pinnacles National Monument (Moore 2000).

References

Moore, Chad. 2000. Night Sky Brightness, Limiting Magnitude Visual Estimation. Report developed by the National park Service and the International Night-Sky Association. Pinnacles National Monument, Paicines, CA. 50 pp.

Schelz, Charles. 2001. Night sky monitoring in the Southeast Utah Group, Canyonlands and Arches National Parks, Natural Bridges and Hovenweep National Monuments. A funded proposal of work to be completed during 2003-2004. 8 pp.

Data Sets

DS-SEUG-056 Night sky light monitoring in the Southeast Utah Group national parks. 4/1/2002 - present. (data collected electronically; final format being determined). Originated by Schelz, Charlie; status: New.

Natural Bridges National Monument - Night Sky

A proposal to measure night sky light levels in Natural Bridges National Monument has been funded and will proceed during 2003-2004 (Schelz 2001). The primary objective of this program is to develop protocols and gather baseline data on night sky light levels at the four units of the Southeast Utah Group, including Natural Bridges National Monument.

This project will result in the development of a Night Sky Long-Term Monitoring Plan and a report that will be a template for future reports. The "Night Sky Long-Term Monitoring Plan" will outline all protocols, database management, and analysis to be performed at each monitoring site. It will also clearly specify night sky monitoring needs and objectives. And will provide a clear understanding of how the monitoring program will support management information needs. This plan will identify site-specific current resource impacts and address future concerns and problem areas. It will set monitoring management standards for resource conditions and will identify and assign priorities to areas of greatest concern.

An annual report will be developed in November, 2003 and will be based on protocols established in the Night Sky Long-Term Monitoring Plan. This report will include all monitoring sites at all four units of the Southeast Utah Group (Schelz 2001). A quarter-sky CCD (charged coupled device) high-resolution camera and a robotic arm, all controlled by a laptop computer with program, take precise sky brightness measurements. Initial methodology will be guided by the NPS Night Sky Initiative Committee headed by Chad Moore, a physical scientist at Pinnacles National Monument (Moore 2000).

References

Moore, Chad. 2000. Night Sky Brightness, Limiting Magnitude Visual Estimation. Report developed by the National park Service and the International Night-Sky Association. Pinnacles National Monument, Paicines, CA. 50 pp.

Schelz, Charles. 2001. Night sky monitoring in the Southeast Utah Group, Canyonlands and Arches National Parks, Natural Bridges and Hovenweep National Monuments. A funded proposal of work to be completed during 2003-2004. 8 pp.

Data Sets

DS-SEUG-056 Night sky light monitoring in the Southeast Utah Group national parks. 4/1/2002 - present. (data collected electronically; final format being determined). Originated by Schelz, Charlie; status: New.

VOLUME 2, PART IV

Summary of Monitoring Programs and Projects of Interest to the Northern Colorado Plateau Network Inventory & Monitoring Program

Northern Colorado Plateau Network staff have developed an Excel table to track natural resource monitoring programs and projects conducted by other divisions, agencies or organizations.

Key information fields we are compiling in this effort include:

- resource category

Aquatics - General	Paleontological
Amphibians	Air Quality
Birds	Earth Sciences
Fish	Nightsky
Invertebrates	Soundscape
Mammals	Landscape
Reptiles	Climate
Herpetofauna - general	Water Quality
Plants	Water Quantity
Plants - Invasives	Regional Research, Monitoring, and Database Programs
Ecosystems	

- project title
- project description: goals, general methods, general geographic extent
- aim (e.g., monitoring, inventory, assessment, database)
- lead agency
- partner agencies involved
- start and end dates
- geographic location (e.g., county, state, drainage, mountain range)
- project documentation (reports, publications or websites that document the project)
- principal contact name, agency, phone, email
- comments

The following pages contain a representation of work completed to date on assembling this information. This project in ongoing, and data will continue to be assembled through all phases of plan development.

PART IV Index **Page**

Air Quality	IV-1
Aquatics - General	IV-1
Birds	IV-2
Climate	IV-5
Earth Sciences	IV-6
Fish	IV-6
Invertebrates	IV-7
Landscape	IV-8
Mammals	IV-8
Plants	IV-9
Regional Research, Monitoring, and Database Programs	IV-10
Reptiles and Amphibians	IV-12
Water Quality	IV-13
Water Quantity	IV-14

Summary of monitoring programs and projects of interest to the Northern Colorado Plateau Network Inventory and Monitoring Program

Air Quality

National Atmospheric Deposition Program/National Trends Network (NADP/NTN). State Agricultural Experiment Station at University of Illinois (with USGS, USDA, others). Project Dates: 1978 - ongoing.

The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) monitors precipitation at a nationwide network of sites. Several groups cooperate to maintain the network, including the State Agricultural Experiment Stations, U.S. Geological Survey, U.S. Department of Agriculture, and numerous other governmental and private entities. Data is collected on the chemistry of precipitation for monitoring of geographical and temporal long-term trends. Weekly precipitation samples are collected and then analyzed for hydrogen (acidity as pH), sulfate, nitrate, ammonium, chloride, and base cations, at the Central Analytical Laboratory. All of the NPS units in the Northern Colorado Plateau Network have an NADP/NTN wet deposition monitor on-site or within 115 km (about 70 miles).

Contact: Van C. Bowersox, Coordinator. Illinois State Water Survey. 217-333-7873, nadp@sws.uiuc.edu.

Aquatics - General

U.S. Environmental Protection Agency (US EPA), Environmental Monitoring and Assessment Program (EMAP) Surface Waters - Western Pilot Study. US EPA (with collaborators). Project Dates: 2000 - 2005.

The Western Pilot is the Surface Waters component of the U.S. Environmental Protection Agency's (EPA) Western Geographic Study through the Environmental Monitoring and Assessment Program (EMAP). Its objective is to develop monitoring tools to estimate ecological condition of surface waters across a large geographic area of the Western U.S.. Its goal is to answer questions about the importance of stressors and the extent of their effects on ecological condition of wadeable streams. Methodology of the project includes sampling of water chemistry, stream discharge, periphyton, sediment, benthic macroinvertebrates, fish, and physical habitat characteristics. Primary candidate sampling sites are spread throughout the northern Colorado Plateau.

Contact: David Peck. US EPA. 541-754-4426, peck.david@epa.gov.

Birds

Institute for Bird Populations, Monitoring Avian Productivity and Survivorship Program (MAPS). Institute for Bird Populations (with USGS, UDWR, CDOW, The Nature Conservancy, BLM, and others). Project Dates: 1989 - ongoing.

The Institute for Bird Populations at Point Reyes Station, California, is a non-profit corporation focused on research and monitoring of avian populations at a global scale. In 1989, the Institute initiated the MAPS program to monitor avian productivity and survivorship at constant-effort mist net trapping and banding stations across the United States. Currently, data from over 500 MAPS stations have contributed to productivity indices and improving understandings of population trends, ranges and habitat of various species.

MAPS stations can be run by any agency or organization which follows the standard protocols used by the IBP, and which contributes their data to the national MAPS database. In Utah, 8 MAPS stations are run by the Utah Division of Wildlife Resources, Partners in Flight Program, in addition to 10 others in the state. Colorado has 3 MAPS stations. Wyoming has 6 MAPS stations.

Contact: Sara Martin, MAPS Biologist;Utah MAPS stations: Jim Parrish, Utah Partners in Flight Coordinator. UDWR. Parrish: 801-538-4788 Martin: 415-663-1436, JimParrish@utah.gov.

National Audubon Society, Christmas Bird Count. National Audubon Society (with Cornell Lab of Ornithology). Project Dates: 1900 - ongoing.

The National Audubon Society's Christmas Bird Count (CBC) is an annual 15-mile diameter circle Area Search for birds, conducted on one day in the winter by volunteers. Results from the CBC achieve the primary objective of monitoring the status and distribution of bird populations across the Western Hemisphere. The Count has been conducted since 1900, and results are available from a national website sponsored by the National Audubon Society and the Cornell Lab of Ornithology. Counts are conducted in several places on the Colorado Plateau, including 17 sites in Utah, 37 sites in Colorado, and 18 sites in Wyoming.

Contact: Geoffrey S. LeBaron, Director of the Count. National Audubon Society. 413-268-9372, glebaron@audubon.org.

North American Breeding Bird Survey. USGS (with USFS, NPS, etc.). Project Dates: ongoing.

Begun in 1966, the North American Breeding Bird Survey (BBS) was first administrated by the US Fish and Wildlife Service, and is currently being administered by the U.S. Geological Survey, Patuxent Wildlife Research Center. The survey is conducted once in June across North America, at over 3500 routes. Routes are 24.5 miles long, with observers stopping every 0.5 miles to record all birds seen and heard during a 3-minute point count. Analysis of the data results in continent-scale abundance maps, and trend information on individual species and groups such as neotropical migrants. Breeding Bird Survey routes are located in and around several Northern Colorado Plateau Network NPS units.

Contact: [pending]

Rocky Mountain Bird Observatory (RMBO), Monitoring Colorado's Birds (MCB). RMBO (with CDOW, NPS, USDA - FS, BLM,). Project Dates: 2000 - ongoing.

Monitoring Colorado's Birds (MCB) is a multi-agency monitoring program coordinated by the Rocky Mountain Bird Observatory (RMBO) to detect trends in breeding birds which regularly occur in Colorado. Funding and fieldwork are contributed mainly by The Colorado Division of Wildlife, but also by the Bureau of Land Management, the United States Forest Service, and the National Park Service, with each agency responsible for the dominant habitats - of 17 total habitat types identified for Colorado- on the lands they manage. The goal of MCB is to focus on species for which Colorado is an important breeding area, and which are not currently being monitored under other programs. Generally this means that game and special status species will not receive specific attention. Methods are primarily transect-based, using distance sampling, although some species will require specialized techniques. These specialized techniques are described under the "Special Monitoring Projects" component of the MCB program.

Contact: Tony Leukering, Monitoring Director. RMBO. 303-659-4348, monitoring@cbobirds.org.

U.S. Fish and Wildlife Service (USFWS), Region 6 Peregrine Falcon Working Team. USFWS (with NPS, state agencies, other federal agencies). Project Dates: ongoing.

The USFWS Mountain Prairie Region (R6) encompasses the northern Colorado Plateau. Peregrine falcon monitoring in this region is overseen by the Regional Peregrine Falcon Working team, which is composed of the regional peregrine falcon recovery coordinator, Rob Hazlewood, and state biologists. Currently, most states or federal agencies with nesting peregrine falcons are doing some form of monitoring, including the states of Utah, Wyoming, and Colorado. The USFWS expects to publish its National Peregrine Falcon Monitoring Plan in the fall of 2002, which will lay the framework for long-term monitoring of the peregrine falcon. The USFWS intends for the national Plan to become the standard for monitoring in the region. The USFWS is very interested in NPS contribution to and collaboration with this upcoming Plan.

Contact: Rob Hazlewood, Region 6 Peregrine Falcon Recovery Coordinator. USFWS. 406-449-5225, rob_hazlewood@fws.gov.

U.S. Geological Survey (USGS), Breeding Biology Research & Monitoring Database (BBIRD). USGS (with Montana Cooperative Wildlife Research Unit). Project Dates: 1987 - ongoing.

A component of the USGS Global Change Research Program, the Breeding Biology Research and Monitoring Database (BBIRD) is a national program that uses standardized protocols to study bird nest success and nesting habitat requirements. Study sites consist of nest-finding plots, a minimum of 4 ha in size, which are intensively surveyed throughout the breeding season. Study sites often match unaltered with altered plots to examine how land use affects the ability of habitats to support source or sink populations of birds. Participants contribute their data to the national BBIRD database, which can then be used to identify large-scale patterns and trends. BBIRD sites on the northern Colorado Plateau do not appear to be common.

Contact: Dr. Thomas E. Martin, Director. University of Montana. 406-243-5312, rdb@selway.umt.edu.

Utah Division of Wildlife Resources (UDWR), Non-Game Avian Program. UDWR. Project Dates: ongoing.

The Utah Division of Wildlife Resources operates a Non-Game Avian Program, coordinated by Frank Howe. The program involves various research, inventory, and monitoring projects throughout the state. Species associated with current projects include the bald eagle, golden eagle, peregrine falcon, ferruginous hawk, northern goshawk, black swift, Southwest willow flycatcher, and the yellow-billed cuckoo. The state is actively looking to collaborate with other agencies in avian monitoring programs.

Contact: Frank Howe, Non-Game Avian Program Coordinator. UDWR. 801-538-4764, FrankHowe@utah.gov.

Utah Division of Wildlife Resources (UDWR), Upland Game Species Program. UDWR Project Dates: ongoing.

The Utah Division of Wildlife Resources operates an Upland Game Species Program, mostly but not entirely focused on birds, coordinated by Dean Mitchell. The program involves various research, inventory, and monitoring projects throughout the state. The Division collects annually, or has on file, population data for the following species: pheasant, mourning dove, band-tailed pigeon, greater sage grouse, Gunnison sage grouse, ruffed grouse, blue grouse, California quail, turkey, white-tailed ptarmigan, cottontail rabbit, snowshoe hare. In addition, UDWR maintains comprehensive GIS distribution and habitat data for each of these species.

Contact: Dean Mitchell, Upland Game Species Coordinator. UDWR. 801-538-4786, DeanMitchell@utah.gov.

Utah Division of Wildlife Resources, Partners in Flight Program. UDWR/UT PIF (with NPS). Project Dates: ongoing.

Partners in Flight began in 1989 as a national effort to document and reverse apparent declines in neotropical migratory birds. Partners in Flight (PIF) is now international in scope, with PIF Mexico and PIF Canada. The Utah PIF coordinator, Jim Parrish, works for the Utah Division of Wildlife Resources, and coordinates several projects with the state agency. These projects include 10+ years of monitoring for a state-wide Riparian Bird Study, monitoring programs focused on birds of shrubsteppe and pinyon-juniper habitat, running 8 MAPS (Monitoring Avian Productivity and Survivorship) mist net stations throughout the State, and producing a multi-species Avian Conservation Strategy for Utah.

Contact: Jim Parrish, Utah Partners in Flight Program Coordinator. UDWR. 801-538-4788, JimParrish@utah.gov.

Climate

National Oceanic and Atmospheric Administration (NOAA), United States Climate Reference Network. NOAA (with Western Regional Climate Center (Desert Research Institute)). Project Dates: being developed now (2002).

The Climate Reference Network is a network of climate stations being established, with the help of the Western Regional Climate Center, as part of a NOAA initiative. The goal of this project is to monitor long-term precipitation and temperature observations to couple with past observations in order to investigate present and future climate change. If fully implemented, the network will have established about 250 stations nationwide, including one in Capital Reef National Park.

Contact: John Jensen, Program Manager. NOAA. 828-271-4475, John.A.Jensen@noaa.gov.

U.S. Geological Survey (USGS), Earth Surface Dynamics Program, Southwest Climate Impacts Project. USGS (with agencies, universities, and non-governmental cooperators). Project Dates: ongoing.

The Southwest Climate Impacts Project investigates how climate and human activities affect geologic processes (weathering, erosion, deposition) that change the landscape. The project involves the use of remotely placed CLIM-MET meteorological stations which function for long periods of time, usually long enough to support a parent project which monitors surficial processes. This project is part of the USGS Earth Surface Dynamics Program, which is one of several areas of research the USGS leads as part of its participation in the larger U.S. Global Change Research Program. CLIM-MET stations currently exist in and around the area of Canyonlands National Park.

Contact: Rich Reynolds. USGS. 303-236-1303, rreynolds@usgs.gov.

U.S. Geological Survey (USGS), Interactions of Cattle Grazing and Climate Change on Semi-arid Ecosystem Function: Rainout Shelter Experiments and Climate Data. USGS (with BLM; NOAA; USDA; Oregon State Univ.; Colorado State Univ.). Project Dates: 2000 - ongoing.

The Interactions of Cattle Grazing and Climate Change on Semi-arid Ecosystem Function project aims to predict effects of changing global climates in combination with various grazing practices and soil types on the semiarid Great Basin and Colorado Plateau rangelands. Data from precipitation shift (rainout shelter) experiments and information collected from agencies on grazing practices and climate will be inputted into their CENTURY model to predict how these factors affect ecosystem processes. Study areas will be located in semi-arid, non-forested, upland portions of the Intermountain West, on federally-managed lands. This study also has an invertebrate component.

Contact: David Pyke, Rangeland Ecologist. USGS. 541-750-7335, david_a_pyke@usgs.gov.

Earth Sciences

Interpreting Indicators of Rangeland Health: Land Health Assessments. (with USGS, USDA - ARS, BLM, NRCS). Project Dates:

A collaboration among the U.S. Geological Survey, the USDA Agricultural Research Station, the Bureau of Land Management, and the NRCS, the Interpreting Indicators of Rangeland Health program is designed to provide a quick, qualitative assessment of rangeland health based on the functional status of 17 indicator variables. These indicators reflect three resource attributes of rangelands: soil stability, hydrologic function, and biotic integrity. The program is not a quantitative monitoring technique, but is designed to identify areas of concern which would then need further quantitative assessment and/or monitoring.

Contact: David Pyke,Rangeland Ecologist. USGS. 541-750-7334, david_a_pyke@usgs.gov.

Fish

Colorado Division of Wildlife (CDOW), Sport and Native Fish Monitoring Programs. CDOW (with). Project Dates: ongoing.

The Colorado Division of Wildlife monitors native fish informally, such as the Colorado River Cutthroat Trout (State Species of Concern), as well as sport fish in the Gunnison River. Standard protocols, including electrofishing, are used.

Contact: Sherman Hebein -sport fishTom Nestler, Fisheries Biologist, native fish. CDOW. Nestler: 970-472-4384, sherman.hebein@state.co.us.

U.S. Fish and Wildlife Service (USFWS), Upper Colorado River Endangered Fish Recovery Program. USFWS (with TNC; US BOR; Env. Defense; Western Area Power Admin.; UT Water Users Assoc.; States of CO, WY, AND UT; WY Water Dev. Assoc.; CO River Energy Distributors Assoc.). Project Dates: 1988 - ongoing.

The Recovery Program for Endangered Fish of the Upper Colorado River Basin is a partnership of public and private organizations whose goal is recovering the endangered Colorado pikeminnow, razorback sucker, humpback chub and bonytail in the Colorado river system, while providing for new water development. Intended to be a 15 year program, it was officially established in 1988, after publication of the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin by the U.S. FWS in 1987. It is directed by the USFWS in partnership with many other program participants. Its methods include habitat management and development, stocking native fish, monitoring long-term population trends in native and non-native fish species as well as studying competition between them. This program is an umbrella for many different ongoing projects, within and outside of NPS units, throughout the Colorado and Green River systems. Each project has a unique number and produces annual reports.

Contact: Debbie Felker, Program Information and Education Coordinator. USFWS. 303-969-7322 ext 227, debbie_felker@fws.gov.

Invertebrates

Inventory of Kanab Ambersnail Distribution Along Streams in Southwestern Utah. BLM (with Indiana University). Project Dates: 1999 - 2000.

The BLM contracted with Indiana University to conduct Kanab ambersnail surveys in two different areas: the Kanab Canyon in the Kanab BLM district, and in Grand Staircase - Escalante National Monument. Other areas were incidentally surveyed during the project, including the Virgin and Sevier rivers in southern Utah.

Contact: Dr. Vicky Meretsky. Indiana University. 812-855-5971, meretsky@indiana.edu.

Utah State University, Bee Biology and Systematics Laboratory, Biodiversity and Conservation of Native Bees in North America. USDA - ARS (with USGS). Project Dates: 2000 - ongoing.

The Biodiversity and Conservation of Native Bees in North America project involves three different collaborative efforts with other agencies and organizations. One of these efforts is a four year study of the native bees of Grand Staircase-Escalante National Monument. This study aims to identify diversity patterns across the Monument and to understand the factors which predict these patterns. Although it is an inventory, it will also create a baseline for future monitoring efforts. Protocols have been developed and assessed to see which could be used in a standardized way.

Contact: Terry Griswold, Research Entomologist. USU/USDA-ARS Bee Biology and Systematics Laboratory (BBSL). 435-797-2526, tgris@biology.usu.edu.

Utah State University, National Aquatic Monitoring Center. USU (with BLM, USDA Forest Service). Project Dates: ongoing

The Utah State University, National Aquatic Monitoring Center, otherwise known as the "Bug Lab", is a collaborative effort of the Bureau of Land Management, USDA Forest Service, and Utah State University. The Center conducts projects throughout Utah and the Western United States, involving research, monitoring, and development of bioassessment techniques for evaluating water quality using biota rather than chemical concentrations. It is currently involved in a cooperative project with the Grand Staircase - Escalante National Monument to determine the occurrence of aquatic invertebrates in the Monument, as well as to evaluate long term changes in aquatic ecosystems of the Monument.

Contact: Dr. Mark Vinson, Aquatic Ecologist. Utah State University, Logan. 435-797-2038, buglab@cc.usu.edu.

Landscape

U.S. Geological Survey (USGS), Landscape-scale Assessment of Native and Exotic Plant Diversity and Microbiotic Crusts in the Grand Staircase-Escalante National Monument. USGS (with NREL, GSENM). Project Dates: 1999 - ongoing.

The U.S. Geological Survey (USGS), in cooperation with the Natural Resource Ecology Laboratory (NREL), and Grand Staircase - Escalante National Monument (GSENM) staff, will be providing the BLM with scientific data from the Landscape-scale Assessment project to assist the BLM with their management objectives for GSENM. As stated in the project website, the project will address, "(1) Identifying hot spots of native plant diversity and rare/unique habitats; (2) Determining areas where cryptobiotic crusts and plant communities are particularly sensitive to disturbance; (3) Detecting the loss of native plant diversity caused by exotic plants; and (4) Developing a science-based long-term monitoring plan for vegetation and soil resources." Methods include using a multi-phase, multi-scale approach, in addition to remotely sensed data, field sampling and predictive models.

Contact: Dr. Thomas J. Stohlgren, Research Ecologist. USGS - MESC at CSU Ft Collins. 970-491-1980, toms@nrel.colostate.edu.

Mammals

U.S. Geological Survey (USGS), Bat Population Status in the United States and Territories. USGS. Project Dates: 1995 - 2002.

The USGS Bat Population Status project is intended to synthesize bat information from states, conservation organizations, and Interior Department land managers which will then support hypothesis testing, developing monitoring protocols, and a summary of conservation needs. The initial phase of the project involved the creation of a Bat Population Database. This database will then be used for hypothesis testing, statistical analysis, and in the design of potential long-term monitoring programs.

Contact: Tom O'Shea, Wildlife Research Biologist. USGS MESC; Univ. of New Mexico. O'Shea: 970-226-9397, tom_oshea@usgs.gov;.

Utah Division of Wildlife Resources (UDWR), Big Game Program and Once in a Lifetime Program. UDWR. Project Dates: ongoing.

The UDWR Wildlife Section is organized into six different programs: Mammals, Once in a Lifetime, Upland Game, Waterfowl, Nongame Avian, and Big Game. Two of these programs monitor ungulates in the state of Utah. The "Big Game Program" monitors mule deer, elk, and pronghorn antelopes. The "Once in a Lifetime Program" monitors rocky mountain goats, desert bighorn sheep, rocky mountain bighorn sheep, bison and moose.

Contact: Steve Cranney, Big Game Program Coordinator. UDWR. 801-538-4780, stevecranney@utah.gov.

Utah Division of Wildlife Resources (UDWR), Mammals Program. UDWR (with USFWS, USDA FS, USU, BLM, SUU, Department of Oil, Gas and Mining). Project Dates: ongoing.

The UDWR Mammals Program conducts inventory and monitoring of bats, rodents, carnivores, and lagomorphs, many of whom fall under the Sensitive Species branch of this program . Special status species such as the Utah prairie dog and the black-footed ferret have been intensively monitored for years, in cooperation with other agencies such as the USFWS. Other species with minimal monitoring or plans to begin monitoring include the jackrabbit, pygmy rabbit, pika, black bear, mountain lion, lynx, marten, wolverine, fisher, kit fox, swift fox, kangaroo rat, Gunnison prairie dog, white-tailed prairie dog, and bats. The UDWR is currently the lead agency in a cooperative effort to monitor Utah bats, primarily in abandoned mines.

Contact: Craig McLaughlin, Mammals Program Coordinator. UDWR. 801-538-4758, craigmclaughlin@utah.gov.

Plants

USDA Forest Service, Forest Health Monitoring (FHM) Program. USDA - FS Project Dates: ongoing.

USDA Forest Service, Forest Health Monitoring is a component of the national Forest Inventory and Analysis program. Forest Health Monitoring is designed to determine status, changes, and trends in indicators of forest condition on an annual basis. Its focus is on forest health issues that affect ecosystem sustainability. Intensive data are collected from a subset of plots already established by the FIA program. These data, identified as indicators of forest health, collect information about vegetation diversity, soils, lichens, downed woody debris, and tree crowns. They provide the basis for developing analytical approaches to addressing forest health issues. On the northern Colorado Plateau, FHM is a component of the Interior West Forestry Inventory and Analysis Program (IWFIA), based at the Rocky Mountain Research Station, Ogden Forestry Sciences Lab.

Contact: Michael J. Wilson, Program Manager. USDA - FS - RMRS. 801-625-5388, .

USDA Forest Service, Forest Inventory and Analysis Program (FIA). USDA - FS. Project Dates: 1930 - ongoing.

FIA is a national USDA Forest Service program which has been continuously providing a census of landscape level information about forestry resources since 1930. The FIA program inventories all forested lands, including federal, private and state lands. Forest Inventory and Analysis on the northern Colorado Plateau (UT, WY, CO, AZ) is conducted by the Interior West branch of the national program, at the USDA Rocky Mountain Research Station, Ogden Forestry Sciences Laboratory. Although plot locations are confidential to protect land ownership information, access to the data is available through the National Forest Inventory and Analysis Geospatial Data Service Center, which can be accessed on the internet at: http://www.fs.fed.us/ne/fia/spatial/index_ss.html.

FIA data is collected in 3 Phases, the third phase of which comprises the Forest Health Monitoring Program. Phase I data are collected at a coarse scale to make broad land cover classifications. Phase II data are collected at a fine scale on randomly selected plots located at the intersections of a 5000 m X 5000m grid. Phase II data collection requires a large data collection effort in the field and includes

tree mensuration information, forest typing and habitat typing. Together, Phase I and Phase III plots measure over 120 variables. Phase III intensive data collection, done on a subset of Phase II plots, is aimed towards indicators of forest health including vegetation diversity, soils, lichens, downed woody debris and tree crowns.

FIA data collection was historically done every several years, or "periodically". The program is in the process of changing the frequency of data collection to an annual, nationally consistent effort. This annual effort is currently happening in 3 of the Interior West region states: CO, UT, AZ.

Contact: Michael J. Wilson, Program Manager. USDA - FS - RMRS. 801-625-5388,

Regional Research, Monitoring, and Database Programs

Canyon Country Ecosystems Research Site (CCERS). USGS (with NPS, USDA - FS, TNC, Utah State University, U. of Utah, College of S. Utah, College of Santa Fe, Denver U., BYU, EPA, NRCS,USFWS, Canyonlands Field Institute, San Juan County). Project Dates: still being established.

Currently being established by a collection of federal agencies, local governments and regional universities, the Canyon Country Ecosystems Research Site (CCERS) will focus on promoting long term ecological research, monitoring, and assessment of the region. One of its primary objectives is collaboration between scientists and managers. Research themes of CCERS include Elevational Gradients, Land use/Disturbance Gradients, Shifting Climatic Regimes, Substrate Gradients, and Exotic Invasive Plants. The program is currently inactive until further funding is available.

Contact: Jayne Belnap, Research Ecologist. USGS Canyonlands Field Station. 435-719-2333, jayne_belnap@usgs.gov.

Colorado Natural Heritage Program. Colorado NHP. Project Dates: 1979 - ongoing.

The Colorado Natural Heritage Program is one of 86 primary data centers throughout the United States, Canada, Latin America, and the Caribbean countries, which uses the Natural Heritage Methodology for ranking and preserving species and communities. Its database collates and interprets scientific information on three elements: species, subspecies and significant natural communities. This allows the program to rank relative degree of imperilment of these elements, rank populations or occurrences of each according to their level of health or quality, and delineate and rank potential conservation areas. In Colorado, the Natural Heritage Program does more inventory than monitoring, such as the Small Mammal Atlas project for the state, and rare plant and weed inventory and mapping on the west slope of the Rocky Mountains.

Contact: Boyce Drummond, Director. Colorado State School of Natural Resources, CSU. 970-491-1150, heritage@lamar.colostate.edu (general CNHP); boyce@lamar.colostate.edu (director).

Southwestern Museum of Biology, Curation of Biological Survey Collection. USGS (with University of New Mexico). Project Dates: 1920s - ongoing.

In 1994, United States Geological Survey (USGS) scientific collections of western vertebrates were moved from Fort Collins, CO, to Albuquerque, NM, where they joined a larger collection at the Museum of Southwestern Biology. This project creates and maintains electronic databases and curates the USGS collections, which consist of amphibians and reptiles, fishes, birds and mammals, mostly from the Rocky Mountains and Intermountain West. The collection is rich in bats and rodents, and a general research emphasis has been to document mammal species from public lands in the West.

Contact: Cindy Ramotnik, Museum Specialist (Zoology). USGS Arid Lands Field Station - UNM. 505-277-5369, ramotnik@unm.edu.

U.S. Geological Survey (USGS), Grand Canyon Monitoring and Research Center. USGS (with BIA, BOR, USFWS, NPS, Western Area Power Administration, Colorado River Basin States, Native American Tribes, Colorado River Energy Development Assoc., recreational users, environmental organizations). Project Dates: 1996 - ongoing.

The USGS Grand Canyon Monitoring and Research Center is a cornerstone of the Glen Canyon Dam Adaptive Management Program, which was established in 1996. Research and monitoring assess the effect of Dam operations on downstream biological resources. Research efforts focus on: aquatic food base, native and non-native fish populations, vegetation change in riparian zones, TES studies including the Kanab ambersnail and humpback chub, avian monitoring of riparian species and the Southwest willow flycatcher.

Contact: Steve Gloss. USGS. 928-556-7069, sgloss@usgs.gov.

Utah Natural Heritage Program, Utah Conservation Data Center. UDWR - UNHP. Project Dates: ongoing.

The Utah Natural Heritage Program is one of 86 primary data centers throughout the United States, Canada, Latin America, and the Caribbean countries, which uses the Natural Heritage Methodology for ranking and preserving species and communities. Its database collates and interprets scientific information on three elements: species, subspecies and significant natural communities. This allows the program to rank relative degree of imperilment of these elements, rank populations or occurrences of each according to their level of health or quality, and delineate and rank potential conservation areas. The Natural Heritage network enables scientists to monitor the status of species and natural communities from a state, national, and global perspective.

Contact: Mike Canning, UNHP Coordinator. UDWR-UNHP. 801-538-4716, mikecanning@utah.gov.

Reptiles and Amphibians

U.S. Department of Agriculture, Forest Service (USDA FS), Fishlake National Forest, Inventory of Amphibians. USDA - FS (with UDWR). Project Dates: 2000 - ongoing.

The Fishlake National Forest and the Utah Division of Wildlife Resources cooperatively surveyed several areas of the forest for amphibians in 2000. These surveys were more focused on inventory rather than monitoring, and some were incidental to fisheries work. Species surveyed include the tiger salamander, boreal toad, and leopard frog.

Contact: Frank Fay, Forest Planner. USDA - FS (Fishlake NF). 435-896-1097, ffay@fs.fed.us.

U.S. Geological Survey (USGS), Amphibian Research and Monitoring Initiative (ARMI). USGS (with NPS, FWS, BLM). Project Dates: 2000 - ongoing.

In response to growing awareness of amphibian declines and malformations, the USGS Amphibian Research and Monitoring Initiative program was initiated by the United States Congress in 2000 to monitor trends in amphibian populations on Department of Interior (DOI) lands, and to research the cause of amphibian declines. While intensive monitoring will be focused on DOI lands, ARMI will also provide a framework for incorporating amphibian monitoring data by other agencies outside of DOI lands. Partnerships with other DOI agencies include a nationwide survey by the Fish and Wildlife Service on 48 National Wildlife Refuges in 31 states for contaminants that may induce malformations in amphibians.

The Northern Colorado Plateau is divided between the Pacific NW ARMI Region (including Utah) and the Rocky Mountain ARMI Region (including Colorado). For the Northern Colorado Plateau area of Utah and Western Colorado, the only ARMI project is focused in Canyonlands National Park.

Contact: Mike Adams, Wildlife Biologist. USGS FRESC in Corvallis. 541-758-8857, Michael_adams@usgs.gov.

Utah Division of Wildlife Resources (UDWR), Amphibian Inventory and Monitoring. UDWR (with USFS (boreal toad)). Project Dates: ongoing.

The Utah Division of Wildlife Resources conducts some general amphibian inventories and some specific monitoring of special status amphibians in the state. The Division began leading a boreal toad monitoring project in southwestern Utah in cooperation with the United States Forest Service in 1994, and a Columbia spotted frog monitoring program in central and western Utah in 1994. Both projects are ongoing in 2002. In 1999, the Division began an ongoing inventory for amphibians in the Virgin River Basin.

Contact: Matthew Anderson. UDWR. 801-538-4756, MatthewAnderson@utah.gov.

Herptile Atlas for Colorado. CDOW (with Private consulting firm: Camp, Dresser, & McKee). Project Dates: 2002 - ongoing.

The Colorado Division of Wildlife is developing an Amphibian and Reptile Atlas for Colorado through the private contractor, Camp, Dresser & McKee. The intent is to collect inventory data which will eventually lead to a volunteer-based monitoring program. Three specific components of the project are 1) to populate a database from existing sources, 2) identify resources for and set up parts of a monitoring program to continually update the database, and 3) to make the atlas available to the public from a website.

Contact: Gary Skiba, Wildlife Manager. CDOW. 303-291-7466, gary.skiba@state.co.us.

U.S. Geological Survey (USGS) Inventory, Monitoring, and Research Database for Reptiles. USGS (with PARC). Project Dates: ongoing.

The USGS reptile database project originally aimed to collect information about reptile inventory, monitoring, and research projects on U.S. Department of Interior lands. It has expanded its scope to include all federal lands, as well as to include amphibian data. As of September, 2002, it is only partially complete, due to a lack of funding. It is currently being worked on by David Scott at the Savannah River Ecological Lab, USGS. The database is intended to complement database work under the Amphibian Initiative, and will eventually become part of the PARC (Partners in Amphibian and Reptile Conservation) website and the USGS website.

Contact: David Scott. USGS - SREL. 803-725-5747, .

Water Quality

U.S. Geological Survey (USGS), National Water Quality Assessment Program (NAWQA) - Upper Colorado River Basin Unit. USGS. Project Dates: 1994 - 1998.

Initiated in 1994 and completed in 1998, the Upper Colorado NAWQA includes the 178,000 sq mi drainage basin of the Colorado River from its headwaters to the Colorado-Utah State line. The study was divided between the Southern Rocky Mountain and the Colorado Plateau Physiographic provinces. The major use of water is irrigation, but transmountain diversions provide water to more than a million people in the eastern part of Colorado. Impacts mining, urbanization, and agriculture were addressed at an array of sites. Some sites, those within park units, served as reference sites associated with little impacts. A suite of water quality parameters were measured including temperature, pH, dissolved oxygen, specific conductance, major cations and anions, metals, suspended sediment, bed sediment and fish tissue samples, and discharge. Park sites include those near or within CURE and BLCA.

Contact: Paul Von Guerard. USGS. 970-245-5257x14, pbvongue@usgs.gov.

Utah Department of Environmental Quality, Division of Water Quality, Water Quality Assessment. UDEQ, Division of Water Quality (with NPS, other agencies). Project Dates: variable - present.

The Utah Department of Environmental Quality, Division of Water Quality monitors the state's waters to ensure that quality meets state standards. The focus is on larger streams and rivers, and generally does not include seeps, springs or hanging gardens unless particular springs have a drinking water or salinity issue. A cooperative effort between the National Parks (particularly the Southeast Utah Group) and the state includes training, technical advise, and assistance. Interpretation is done by the state, and sample collection is done by the Parks.

Contact: Richard Denton, Arnie Hultquist. Utah DEQ. 801-538-6055, rdenton@deq.state.ut.us.

Water Quantity

U.S. Geological Survey (USGS), National Streamgaging Program (NSP). USGS (with Federal, state, and local agencies).Project Dates: variable - ongoing.

The USGS has been collecting streamflow information since 1887. Their National Streamgaging Program, which partners with many agencies, monitors flows on major and minor streams at nearly 7,000 stations throughout the United States. Several stations are located in the area of the northern Colorado Plateau. Streamflow-gaging stations provide data that can be used for planning and operating water resources projects, flood warning, reservoir operations, and long term background information about changes in streamflow in response to climate and land use change.

Contact: Mike Norris. USGS , mnorris@usgs.gov.

VOLUME 2, PART V

Summary of Geospatial Data Catalogued by the Northern Colorado Plateau Network

The following table, a subset of the GIS Inventory Database (Appendix G), provides a summary of geospatial data that has been catalogued by the Northern Colorado Plateau Network. The information is organized by spatial extent and includes each park unit within the network, along with several groupings that encompass multiple park units (e.g., Black Canyon of the Gunnison NP and Curecanti NRA, network-wide data, the Southeast Utah Group). Records are further organized by broad category, and by data theme. This table does not include many statewide, regional, or national base cartographic data sets that are not specific to the network.

The network's geospatial data is far from complete, and because of lack of documentation, some of the data sets catalogued here may not be usable. The process of obtaining, verifying, and documenting network geospatial will be an ongoing process.

Explanation of Columns
"Spatial Extent" indicates the geographic area the dataset encompasses. "Category" allows us to group data based on broad subject; "Theme" provides additional subcategories. The "Description" column is typically a brief indication of the dataset content, often with additional comments. The column "12 Basic" indicates whether the data theme is one of the '12 Basic Inventory Datasets' identified by the NPS Inventory and Monitoring Program (Table 3). "NCPN Essential" indicates if the Northern Colorado Plateau Network considers the data theme to be a high priority (Table 4). "Quality" is a general asssessment of the dataset, based on associated attributes, documentation, scale, and overall consistency. And "Status" allows us to track the development of the data set: many are complete, others are incomplete or in progress. Those with no value in this column indicate specific data gaps that we are trying to fill.

Part V Index - Spatial Extent **Page**

Arches NP (ARCH)	V - 1
Black Canyon of the Gunnison NP (BLCA)	V - 4
Black Canyon NP *and* Curecanti NRA	V - 5
Bryce Canyon NP (BRCA)	V - 7
Canyonlands NP (CANY)	V - 9
Capitol Reef NP (CARE)	V - 13
Cedar Breaks NM (CEBR)	V - 15
Colorado NM (COLM)	V - 16
Curecanti NRA (CURE)	V - 18
Dinosaur NM (DINO)	V - 20

Part V Index - Spatial Extent **Page**

Fossil Butte NM (FOBU)	V - 22
Golden Spike NHP (GOSP)	V - 24
Hovenweep NM (HOVE)	V - 25
Natural Bridges NM (NABR)	V - 28
Northern Colorado Plateau Network (NCPN)	V - 30
Pipe Spring NM (PISP)	V - 35
Southeast Utah Group (SEUG) -- includes ARCH, CANY, HOVE, and NABR	V - 36
Timpanogos Cave NM (TICA)	V - 38
Zion NP (ZION)	V - 39

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
Arches National Park							
ARCH	Base Carto	Boundaries	arches, lost srng, wsa	No	No	Unknown	Complete
ARCH	Base Carto	Boundaries	intensive/non-int. use zones; ARCH & surroundings	No	No	Unknown	Complete
ARCH	Base Carto	Boundaries	Zones	No	No	Good to Fair	Complete
ARCH	Base Carto	Boundaries	8 zones: Salt Valley, Devils Garden, Salt Wash, Klondike bluffs, Courthouse Wash, Petrified Dunes, Willow Flats, Salt Wash	No	No	Excellent	Complete
ARCH	Base Carto	Boundaries	Most current boundary file, also in various projections.	Yes	No	Excellent	Complete
ARCH	Base Carto	Boundaries	Historic bndry from 1971	No	No	Excellent	Complete
ARCH	Base Carto	Boundaries	Historic bndry from 1969	No	No	Excellent	Complete
ARCH	Base Carto	Boundaries	Historic bndry from 1960	No	No	Excellent	Complete
ARCH	Base Carto	Boundaries	Historic bndry from 1929	No	No	Excellent	Complete
ARCH	Base Carto	Boundaries	Historic bndry from 1938	No	No	Excellent	Complete
ARCH	Base Carto	DEM	DEM for ARCH	Yes	No	Excellent	Complete
ARCH	Base Carto	DEM	wider area beyond ARCH	No	Yes	Excellent	Complete
ARCH	Base Carto	DEM	Hillshade of ARCH	No	No	Excellent	Complete
ARCH	Base Carto	DEM	30m DEM of ARCH area	Yes	No	Excellent	Complete
ARCH	Base Carto	DEM	10m DEM of ARCH area	No	Yes	Excellent	Complete
ARCH	Base Carto	DOQQ	Few around road & Delicate	No	Yes	Excellent	Incomplete
ARCH	Base Carto	DOQQ	Assorted B&W DOQQ's for ARCH in jpeg format.	Yes	No	Excellent	Complete
ARCH	Base Carto	DRG	Uncollared mosaic of 1:24k DRG's	Yes	No	Excellent	Complete
ARCH	Base Carto	DRG	Decollared mosaic	Yes	No	Excellent	Complete
ARCH	Base Carto	DRG	Uncollared mosaic of ARCH DRG's	Yes	No	Excellent	Complete
ARCH	Base Carto	DRG	Index of ARCH 1:24k topos	No	No	Excellent	Complete
ARCH	Base Carto	Hydro	Blue lines - various files	Yes	No	Good to Fair	Complete
ARCH	Base Carto	Hydro	tinajas	No	Yes	Excellent	Incomplete
ARCH	Base Carto	Hydro	Seeps and Springs	No	Yes	Excellent	Unknown
ARCH	Base Carto	Ownership	Land Inholdings	No	Yes	Unknown	Incomplete
ARCH	Base Carto	Ownership	State land within ARCH	No	No	Unknown	Complete
ARCH	Base Carto	Topography	15m topographic contour cover of wide area around ARCH	No	Yes	Excellent	Complete
ARCH	Base Carto	Topography	Contours of Windows area; also as shapefile.	No	Yes	Excellent	Complete
ARCH	Base Carto	Topography	contours for ARCH	No	Yes	Excellent	Complete
ARCH	Natural Resources	Fire	Durango fire extent	No	Yes	Good to Fair	Complete
ARCH	Natural Resources	Fire	GPS'd fire boundary	No	Yes	Excellent	Complete
ARCH	Natural Resources	Geology	Geology map of ARCH, updated '01.	Yes	No	Excellent	Unknown
ARCH	Natural Resources	Mines	Mine sites and visibility coverage	No	No	Excellent	Complete
ARCH	Natural Resources	Plants, TES	purple sage areas, collected Apr-Jul 1999	No	Yes		Work in progress
ARCH	Natural Resources	Plants, TES	2 polys	No	Yes	Unknown	Complete
ARCH	Natural Resources	Plants, TES	polys of purplesage areas	No	Yes	Unknown	Complete
ARCH	Natural Resources	Plants, TES	zones of lomatium	No	Yes	Excellent	Complete
ARCH	Natural Resources	Soils	SSURGO Soils coverage	Yes	No	Good to Fair	Unknown
ARCH	Natural Resources	Vegetation, general		Yes	No		Work in progress
ARCH	Natural Resources	Vegetation, general	veg map	Yes	No	Poor	Complete
ARCH	Natural Resources	Vertebrates, TES	82 raptor nesting sites; see also arches_nest-sites.shp. Reviewed.	No	Yes	Excellent	Work in progress
ARCH	Natural Resources	Weather data	Climate monitoring stations.	No	Yes		Incomplete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
ARCH	Park Infrastructure	Buildings	buildings; buildings2 has one additional bldg	No	Yes	Excellent	Complete
ARCH	Park Infrastructure	Buildings	12 polys of buildings at ARCH	No	Yes	Excellent	Complete
ARCH	Park Infrastructure	Buildings	Buildings in ARCH	No	Yes	Good to Fair	Complete
ARCH	Park Infrastructure	Campsites	some attributed with "Backcountry vehicle campsite"	No	Yes	Good to Fair	Complete
ARCH	Park Infrastructure	Fences	fences	No	Yes	Unknown	Incomplete
ARCH	Park Infrastructure	Fences	Existing and proposed fences	No	No		Complete
ARCH	Park Infrastructure	Parking Lots	GPS'd parking area	No	Yes	Excellent	Complete
ARCH	Park Infrastructure	Parking Lots	new and existing parking lot	No	Yes	Excellent	Complete
ARCH	Park Infrastructure	Parking lots	Paved entrance area to ARCH	No	Yes	Good to Fair	Complete
ARCH	Park Infrastructure	Pullouts	198 points; comments, purpose, recommendations. Also as shapefile.	No	Yes	Excellent	Complete
ARCH	Park Infrastructure	Roads	Trails and roads, some GPS'd. GPS dates are 12/5/2000 and 4/20/2000.	Yes	No	Excellent	Complete
ARCH	Park Infrastructure	Roads	Contours of roads;also as shapefile.	No	Yes	Excellent	Complete
ARCH	Park Infrastructure	Roads	also as shapefile	Yes	No	Good to Fair	Complete
ARCH	Park Infrastructure	Roads	GPS'd	Yes	No	Excellent	Complete
ARCH	Park Infrastructure	Roads	polygon coverage	Yes	No	Unknown	Complete
ARCH	Park Infrastructure	Roads	GPS'd roads	Yes	No	Excellent	Complete
ARCH	Park Infrastructure	Roads	roads, trails; all gps'd, no date (0198?)	Yes	No	Good to Fair	Complete
ARCH	Park Infrastructure	Roads	Roads and trails, attributed with names, GPS'd	Yes	No	Excellent	Complete
ARCH	Park Infrastructure	Signs	Milemarkers along main ARCH roads; also as shapefile.	No	No	Excellent	Complete
ARCH	Park Infrastructure	Signs	21 points; all of windows-signs, plus others	No	No	Excellent	Complete
ARCH	Park Infrastructure	Signs	12 regulatory trail signs	No	No	Good to Fair	Work in progress
ARCH	Park Infrastructure	Signs	road signs; attributed with class, type, and message	No	No	Excellent	Work in progress
ARCH	Park Infrastructure	Signs	Attributed with sign messages; GPS'd	No	No	Excellent	Work in progress
ARCH	Park Infrastructure	Trails	attributes include surface type, name, disabled access	No	Yes	Excellent	Complete
ARCH	Park Infrastructure	Trails	also as shapefile	No	Yes	Excellent	Complete
ARCH	Park Infrastructure	Utilities	7 tower locations	No	No	Good to Fair	Complete
ARCH	Park Infrastructure	Utilities	ends of culvert	No	No	Excellent	Complete
ARCH	Park Infrastructure	Utilities	shutoff valves	No	Yes	Excellent	Complete
ARCH	Park Infrastructure	Utilities	telephone box locations	No	Yes	Excellent	Complete
ARCH	Park Infrastructure	Utilities	misc points	No	No	Excellent	Complete
ARCH	Park Infrastructure	Utilities	misc pts	No	No	Excellent	Complete
ARCH	Park Infrastructure	Utilities	misc point locations	No	No	Excellent	Complete
ARCH	Park Infrastructure	Utilities	gas line	No	Yes	Excellent	Complete
ARCH	Park Infrastructure	Utilities	meter locations	No	Yes	Excellent	Complete
ARCH	Park Infrastructure	Utilities	phone line	No	Yes	Excellent	Complete
ARCH	Park Infrastructure	Utilities	phoneline, fiber optic	No	Yes	Excellent	Complete
ARCH	Park Infrastructure	Utilities	sidewalk, block path	No	Yes	Excellent	Complete
ARCH	Park Infrastructure	Utilities	communication lines	No	Yes	Excellent	Complete
ARCH	Park Infrastructure	Utilities	visibility of towers, wide area beyond ARCH	No	No	Good to Fair	Complete
ARCH	Park Infrastructure	Utilities	Monuments, brass cap and aluminum	No	No	Unknown	Complete
ARCH	Park Infrastructure	Utilities	utilities	No	No	Excellent	Complete
ARCH	Park Infrastructure	Utilities	empty data set	No	Yes	Unknown	Incomplete
ARCH	Park Infrastructure	Utilities	blm, nps, proposed addition	No	Yes	Unknown	Complete
ARCH	Park Infrastructure	Utilities	visibility of towers, ARCH only	No	No	Good to Fair	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
ARCH	Park Infrastructure	Wilderness	ARCH wilderness/non-wilderness areas.	No	Yes	Good to Fair	Complete
ARCH	Park Infrastructure	Wilderness	ARCH wilderness/non-wilderness areas. Attributed with name, unit_name. Similar to but different from the final and final_map covers.	No	Yes	Excellent	Complete
ARCH	Park Specific	Archaeology	GPS'd; 1 line	No	No	Excellent	Complete
ARCH	Park Specific	Archaeology	11 points	No	No	Excellent	Complete
ARCH	Park Specific	Archaeology	9 sites, just outside of west bndry of ARCH	No	No	Excellent	Complete
ARCH	Park Specific	Archaeology	Just outside of west bndry of ARCH	No	No	Excellent	Complete
ARCH	Park Specific	Archaeology	3 points	No	No	Unknown	Unknown
ARCH	Park Specific	Archaeology	Various covers; pt, line, poly; unknown use	No	No	Unknown	Unknown
ARCH	Park Specific	Archaeology	"scatter lithic"	No	No	Unknown	Complete
ARCH	Park Specific	Archaeology		No	No	Unknown	Complete
ARCH	Park Specific	Archaeology	61 pts; various dino traces	No	No	Excellent	Complete
ARCH	Park Specific	Archaeology	8 pts	No	No	Excellent	Complete
ARCH	Park Specific	Arches	Locations of the arches w/in Arches. Needs to be updated; there are now > 2000 arches recorded, but only 1374 in this file.	No	No	Good to Fair	Incomplete
ARCH	Resource/Stressor Monitoring	Monitoring, air quality	Air quality monitoring location	No	Yes		Incomplete
ARCH	Resource/Stressor Monitoring	Monitoring, sound	Bitmap of Arcview project showing location of sound monitoring stations	No	Yes	Excellent	Complete
ARCH	Resource/Stressor Monitoring	Monitoring, sound	2 sound monitoring locations, unknown date	Yes	Yes	Excellent	Complete
ARCH	Resource/Stressor Monitoring	Monitoring, vegetation	2 points; veg transect	No	Yes	Excellent	Complete
ARCH	Resource/Stressor Monitoring	Monitoring, vegetation	Veg transect?	No	Yes	Good to Fair	Complete
ARCH	Resource/Stressor Monitoring	Monitoring, vegetation	Corner coordinates of veg transects in burned area (Durango fire)	Yes	Yes	Poor	Complete
ARCH	Resource/Stressor Monitoring	Monitoring, vegetation	Durango fire vegetation monitoring sites; corners GPS'd	Yes	Yes	Excellent	Complete
ARCH	Resource/Stressor Monitoring	Monitoring, water quality	Monitoring station	No	Yes		
ARCH	Resource/Stressor Monitoring	Monitoring, water quality	2 sites, monitoring locations	Yes	No	Excellent	Complete
ARCH	Resource/Stressor Monitoring	Monitoring, water quality	2 pts, monitoring locations	Yes	No	Excellent	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
Black Canyon of the Gunnison National Park							
BLCA	Base Carto	Boundaries	BLCA boundary, Zone 13	Yes	No	Excellent	Complete
BLCA	Base Carto	DEM	10 meter DEM	No	Yes		
BLCA	Base Carto	DEM	30m DEM of BLCA/CURE area	Yes	No	Excellent	Complete
BLCA	Base Carto	DEM	30m DEM clipped to BLCA bndry	Yes	No	Excellent	Complete
BLCA	Base Carto	DEM	30m DEM of BLCA and wider area	Yes	No	Excellent	Complete
BLCA	Base Carto	DOQQ	DOQQ	Yes	No	Excellent	Complete
BLCA	Base Carto	DRG	Uncollared DRG mosaic of BLCA area	No	No	Excellent	Complete
BLCA	Base Carto	DRG	Zone 13; index to topos of BLCA area	No	No	Excellent	Complete
BLCA	Base Carto	Hydro	Misc. Hydro - tinajas, ponds etc.	No	Yes		
BLCA	Base Carto	Hydro	GPSed ditches on south rim only.	No	No	Excellent	Complete
BLCA	Base Carto	Hydro	WRD data, 2 layers.	Yes	No	Good to Fair	Complete
BLCA	Base Carto	Hydro		No	No	Unknown	Complete
BLCA	Base Carto	Ownership	BLCA easements.	No	No	Good to Fair	Complete
BLCA	Miscellaneous	Misc	GPSed gate data.	No	No	Excellent	Work in progress
BLCA	Miscellaneous	Misc	Cattleguard data.	No	No	Excellent	Work in progress
BLCA	Miscellaneous	Misc	Survey monuments & boundary markers, incomplete.	No	No	Excellent	Incomplete
BLCA	Natural Resources	Fire	Fire history	No	Yes		
BLCA	Natural Resources	Plants, TES	TES plant locations	No	Yes		
BLCA	Natural Resources	Vertebrates, general	4 GPSed reptile array sites ~1997/98.	No	Yes	Excellent	Complete
BLCA	Natural Resources	Vertebrates, TES		No	Yes		
BLCA	Natural Resources	Weather data	Climate monitoring stations	Yes	No		
BLCA	Park Infrastructure	Pullouts	Pullouts	No	Yes		
BLCA	Park Infrastructure	Roads	2 WRD layers	Yes	No	Good to Fair	Complete
BLCA	Park Infrastructure	Utilities	GPSed manhole locations.	No	Yes	Excellent	Incomplete
BLCA	Park Infrastructure	Utilities	4 propane tank locations, incomplete	No	Yes	Excellent	Incomplete
BLCA	Park Infrastructure	Wilderness	Digitized in GRASS from 1:44,409-scale paper map	No	Yes	Excellent	Complete
BLCA	Park Infrastructure	Wilderness	NP wilderness boundary of designated wilderness.	No	Yes	Excellent	Complete
BLCA	Resource/Stressor Monitoring	Monitoring, air quality	GPSed location of ozone monitoring site.	Yes	No	Excellent	Complete
BLCA	Resource/Stressor Monitoring	Monitoring, sound	Sound monitoring location	No	Yes		
BLCA	Resource/Stressor Monitoring	Monitoring, vegetation	Long term monitoring sites	No	Yes	Good to Fair	Work in progress
BLCA	Resource/Stressor Monitoring	Monitoring, vertebrates	Long term monitoring sites	No	Yes	Good to Fair	Work in progress
BLCA	Resource/Stressor Monitoring	Monitoring, water quality	WRD data	Yes	No	Good to Fair	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
Black Canyon of the Gunnison National Park and Curecanti National Recreation Area							
BLCA/ CURE	Base Carto	Hydro	Seeps & Springs/ Wetland files - various.	No	Yes	Unknown	Complete
BLCA/ CURE	Base Carto	Hydro	DLG streams, WRD Data	No	Yes	Poor	Complete
BLCA/ CURE	Base Carto	Ownership	General land status for CURE & BLCA.	No	Yes	Unknown	Complete
BLCA/ CURE	Base Carto	Ownership	Gunnison County Parcel Data	No	Yes	Good to Fair	Complete
BLCA/ CURE	Base Carto	Ownership	Montrose County Parcel Data.	No	Yes	Good to Fair	Complete
BLCA/ CURE	Base Carto	Topography	60' contours	No	Yes	Good to Fair	Complete
BLCA/ CURE	Miscellaneous	Misc	Misc. GPSed points - stairs, benches, trailheads.	No	No	Excellent	Work in progress
BLCA/ CURE	Miscellaneous	Misc	GPSed road culverts.	No	No	Excellent	Complete
BLCA/ CURE	Miscellaneous	Misc	GPSed trail culverts.	No	No	Excellent	Incomplete
BLCA/ CURE	Miscellaneous	Misc	Picnic areas in BLCA & CURE.	No	Yes	Excellent	Complete
BLCA/ CURE	Miscellaneous	Misc	GPSed BLCA & CURE overlooks, 1997/99.	No	Yes	Unknown	Complete
BLCA/ CURE	Natural Resources	Geology	Several coverages - geology, faults, folds, attitudes	Yes	No	Unknown	Complete
BLCA/ CURE	Natural Resources	Grazing	Grazing allotments.	No	No	Good to Fair	Complete
BLCA/ CURE	Natural Resources	Plants, exotic/invasive	GPSed Spotted knapweed data, 1999+2000.	No	Yes	Excellent	Complete
BLCA/ CURE	Natural Resources	Plants, exotic/invasive	GPSed Russian Knapweed data, 1999+2000.	No	Yes	Excellent	Complete
BLCA/ CURE	Natural Resources	Plants, exotic/invasive	Houndstongue, per. Pepperweed, mullein, & common burdock weed data, 1999+2000.	No	Yes	Excellent	Complete
BLCA/ CURE	Natural Resources	Plants, exotic/invasive	GPSed Bull Thistle data, 1999+2000 data.	No	Yes	Excellent	Complete
BLCA/ CURE	Natural Resources	Plants, exotic/invasive	GPSed Canada Thistle data, 1999+2000.	No	Yes	Excellent	Complete
BLCA/ CURE	Natural Resources	Plants, exotic/invasive	Survey areas of exotic plants.	No	Yes	Excellent	Complete
BLCA/ CURE	Natural Resources	Plants, exotic/invasive	Musk Thistle GPSed data, 1999+2000.	No	Yes	Excellent	Complete
BLCA/ CURE	Natural Resources	Soils	Incomplete	Yes	No	Poor	Incomplete
BLCA/ CURE	Natural Resources	Soils	Obtained from BLM - Gunnison Office.	Yes	No	Poor	Incomplete
BLCA/ CURE	Natural Resources	Vegetation, general	Several different files. Some GPSed, some on-screen digitized.	Yes	No	Unknown	Work in progress
BLCA/ CURE	Natural Resources	Vertebrates, general	Deer, elk, & bighorn data sets from CDOW.	No	Yes	Unknown	Complete
BLCA/ CURE	Park Infrastructure	Bridges	GPSed Foot Bridges.	No	No	Excellent	Incomplete
BLCA/ CURE	Park Infrastructure	Buildings	GPSed permanent structures, not all buildings included.	No	Yes	Excellent	Work in progress
BLCA/ CURE	Park Infrastructure	Buildings	Visitor Centers (BLCA & CURE). Visitor center = WRD data	No	Yes	Excellent	Complete
BLCA/ CURE	Park Infrastructure	Buildings	GPSed restroom data.	No	Yes	Excellent	Work in progress
BLCA/ CURE	Park Infrastructure	Campsites	Campgrounds for BLCA & CURE. Campground = WRD data	No	Yes	Good to Fair	Complete
BLCA/ CURE	Park Infrastructure	Fences	Not complete coverage of all fences.	No	Yes	Unknown	Work in progress

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
BLCA/ CURE	Park Infrastructure	Parking lots	GPSed data.	No	Yes	Excellent	Work in progress
BLCA/ CURE	Park Infrastructure	Roads	Roads (all types) in/around BLCA & CURE.	Yes	No	Excellent	Complete
BLCA/ CURE	Park Infrastructure	Roads	100K DLG combined	Yes	No	Unknown	Complete
BLCA/ CURE	Park Infrastructure	Signs	GPSed signs - interpretive, directional and informational.	No	No	Excellent	Work in progress
BLCA/ CURE	Park Infrastructure	Trails	GPSed trail in BLCA & CURE. Trail = WRD data.	No	Yes	Excellent	Complete
BLCA/ CURE	Park Infrastructure	Utilities	GPSed 1995/99 well data, incomplete	No	No	Excellent	Incomplete
BLCA/ CURE	Park Infrastructure	Utilities	Electric transformers, telephone splice boxes, wateline drain, water storage/fountain/shutoff, pumphouses GPSed data.	No	Yes	Excellent	Incomplete
BLCA/ CURE	Park Specific	Archaeology	Sites and surveys, GPSed at various dates.	No	No	Excellent	Complete
BLCA/ CURE	Resource/Stressor Monitoring	Monitoring, vegetation	Vegetation sample sites - various coverages, on-going project.	No	Yes	Excellent	Complete
BLCA/ CURE	Resource/Stressor Monitoring	Monitoring, vegetation	GPSed site locations, from 94-95	Yes	Yes	Excellent	Complete
BLCA/ CURE	Resource/Stressor Monitoring	Monitoring, vegetation	Veg. Plots from <1994. GPSed sites.	No	Yes	Unknown	Complete
BLCA/ CURE	Resource/Stressor Monitoring	Monitoring, vertebrates	GPSed bird site locations for LTMP, ~1994/95.	No	Yes	Excellent	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
Bryce Canyon National Park							
BRCA	Base Carto	Boundaries	BRCA boundary, also as shapefile	Yes	No	Excellent	Complete
BRCA	Base Carto	DEM	10m DEM of BRCA and wider area	No	Yes	Excellent	Complete
BRCA	Base Carto	DEM	10m DEM clipped to BRCA bndry	No	Yes	Excellent	Complete
BRCA	Base Carto	DOQQ	Color DOQQs	No	Yes		Work in progress
BRCA	Base Carto	DRG	Index to USGS 24k topos of BRCA area	No	No	Excellent	Complete
BRCA	Base Carto	DRG	Uncollared mosaic of 1:100k topos	No	No	Excellent	Complete
BRCA	Base Carto	DRG	Uncollared mosaic of 1:24k topos	Yes	No	Excellent	Complete
BRCA	Base Carto	Hydro	Lakes & Reservoirs	Yes	No		Not applicable
BRCA	Base Carto	Hydro	small-scale hydro	No	No	Unknown	Complete
BRCA	Base Carto	Hydro	Rivers & Streams, from WRD	No	Yes		Not applicable
BRCA	Base Carto	Hydro	Misc. Hydro - tinajas, ponds etc	No	Yes		Incomplete
BRCA	Base Carto	Hydro	Seeps/Springs	No	Yes	Good to Fair	Work in progress
BRCA	Base Carto	Ownership	Land inholdings	No	Yes		Incomplete
BRCA	Base Carto	Topography	Contours	No	Yes		
BRCA	Miscellaneous	Misc	Random points generated for 2001 I&M survey crews	No	No	Excellent	Complete
BRCA	Natural Resources	Fire	Yovimpa 95 & 1983-94	No	Yes	Good to Fair	Complete
BRCA	Natural Resources	Geology	Geology map	Yes	No	Excellent	
BRCA	Natural Resources	Grazing	"Driveways" through park need to be mapped	No	Yes	Unknown	Incomplete
BRCA	Natural Resources	Plants, exotic/invasive	Mueller 2000, digital & paper	No	Yes	Unknown	Unknown
BRCA	Natural Resources	Plants, TES	No data is georeference-able, need to GPS	No	Yes		Work in progress
BRCA	Natural Resources	Soils	15 meter data, not reliable	Yes	No	Poor	
BRCA	Natural Resources	Vegetation, general	Vegetation map	Yes	No	Unknown	Work in progress
BRCA	Natural Resources	Vegetation, general	Combined habitat/community types and fuel types.	Yes	No	Excellent	Complete
BRCA	Natural Resources	Vegetation, general	Fuel model for BRCA - Dave Roberts data.	Yes	No	Excellent	Complete
BRCA	Natural Resources	Vegetation, general	Community types	Yes	No	Excellent	Complete
BRCA	Natural Resources	Vegetation, general	Ideal mapping boundary for 2001 I&M veg mapping proposal	No	No	Excellent	Complete
BRCA	Natural Resources	Vegetation, general	Minimum mapping boundary for 2001 I&M veg mapping proposal	No	No	Excellent	Complete
BRCA	Natural Resources	Vegetation, general	Habitat types according to Daubenmier	Yes	No	Excellent	Complete
BRCA	Natural Resources	Vegetation, general	Historical Data	Yes	No	Excellent	Complete
BRCA	Natural Resources	Vertebrates, TES		No	Yes	Unknown	Unknown
BRCA	Natural Resources	Weather data	Climate monitoring stations	Yes	No		Incomplete
BRCA	Park Infrastructure	Buildings	BRCA buildings	No	Yes		Incomplete
BRCA	Park Infrastructure	Campsites	sort of contained in brca_rds file - campground circles labeled	No	Yes	Poor	Incomplete
BRCA	Park Infrastructure	Fences	fences	No	Yes		Work in progress
BRCA	Park Infrastructure	Parking lots	New construction '02	No	Yes		Work in progress

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
BRCA	Park Infrastructure	Pullouts	Pullouts	No	Yes		
BRCA	Park Infrastructure	Roads	GPSed (G3) roads from Kelly - as Polys	Yes	No	Excellent	Unknown
BRCA	Park Infrastructure	Roads	roads within park only	Yes	No	Good to Fair	Complete
BRCA	Park Infrastructure	Trails	Trails - attributed from park map	No	Yes	Good to Fair	Complete
BRCA	Park Infrastructure	Utilities	various files - power, gas, water, sewer, & electric lines & hydrants	No	Yes	Unknown	Complete
BRCA	Park Infrastructure	Wilderness	Source = Ft. Collins, Water Resource Div. Modifying boundaries in 2003.	No	Yes	Excellent	Complete
BRCA	Resource/Stressor Monitoring	Monitoring, air quality	Paper map, Air quality monitoring location	Yes	No	Unknown	Incomplete
BRCA	Resource/Stressor Monitoring	Monitoring, water quality	Data from WRD, other ? Data at BRCA	Yes	No	Good to Fair	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
Canyonlands National Park							
CANY	Base Carto	Boundaries	photo index	No	No	Excellent	Complete
CANY	Base Carto	Boundaries	Dugout ranch outline, parcels	No	No	Excellent	Complete
CANY	Base Carto	Boundaries	Proposed expansion for CANY bndry	No	No	Excellent	Complete
CANY	Base Carto	Boundaries	CANY boundary	Yes	No	Excellent	Complete
CANY	Base Carto	Boundaries	Counties in CANY?	No	No	Excellent	Complete
CANY	Base Carto	Boundaries	Districts in CANY, duplicate	No	No	Excellent	Complete
CANY	Base Carto	Boundaries	Districts + Orange Cliffs	No	No	Excellent	Complete
CANY	Base Carto	Boundaries	various expansion outlines	No	No	Unknown	Complete
CANY	Base Carto	Boundaries	CANY boundary, duplicate	Yes	No		Complete
CANY	Base Carto	Boundaries	Boundary of CANY plus orange cliffs	No	No	Excellent	Complete
CANY	Base Carto	DEM	10m DEM of CANY	No	Yes	Excellent	Complete
CANY	Base Carto	DEM	10m hillshade	No	Yes	Excellent	Complete
CANY	Base Carto	DEM	aspect of SE CANY corner (topography)	No	No	Excellent	Complete
CANY	Base Carto	DEM	DEM of SE corner of CANY	No	No	Excellent	Complete
CANY	Base Carto	DEM	DEM of SE corner of CANY 16 bit unsigned int	No	No	Excellent	Complete
CANY	Base Carto	DEM	10m DEM of Salt Creek	No	Yes	Excellent	Complete
CANY	Base Carto	DEM	Aspect of CANY	No	No	Excellent	Complete
CANY	Base Carto	DEM	10m slope cover of Salt Creek	No	No	Excellent	Complete
CANY	Base Carto	DEM	southern half of CANY	No	No	Excellent	Complete
CANY	Base Carto	DOQQ	Assorted DOQQ's for CANY in jpeg format.	Yes	No	Excellent	Complete
CANY	Base Carto	DOQQ	DOQQ	No	Yes		Work in progress
CANY	Base Carto	DRG	Decollared mosaic	Yes	No	Excellent	Complete
CANY	Base Carto	DRG	covers CANY and a bit to the southwest	Yes	No	Excellent	Complete
CANY	Base Carto	DRG	Uncollared DRG of SE corner of CANY	No	No	Excellent	Complete
CANY	Base Carto	DRG	Uncollared mosaic of DRGs	Yes	No	Excellent	Complete
CANY	Base Carto	DRG	Uncollared mosaic of 1:24k DRGs of CANY	Yes	No	Excellent	Complete
CANY	Base Carto	Hydro	Misc - Tinajas, ponds etc	No	Yes	Unknown	Incomplete
CANY	Base Carto	Hydro	5 pts; source: DLG	No	Yes	Poor	Complete
CANY	Base Carto	Hydro	southeast corner; source: DLG	Yes	No	Good to Fair	Complete
CANY	Base Carto	Hydro	rivers, CO and Green. Digitized from topo sheet.	Yes	No	Good to Fair	Complete
CANY	Base Carto	Hydro	SE corner; source: DLG Streams/washes (?)	Yes	No	Good to Fair	Complete
CANY	Base Carto	Hydro	seeps in CANY, ARCH, labeled	No	Yes	Good to Fair	Incomplete
CANY	Base Carto	Hydro	8 pts; wells	No	No	Unknown	Complete
CANY	Base Carto	Hydro	line rivers	No	Yes	Excellent	Complete
CANY	Base Carto	Hydro	Polygon rivers	No	Yes	Excellent	Complete
CANY	Base Carto	Hydro	Lakes & reservoirs	Yes	No	Unknown	Incomplete
CANY	Base Carto	Hydro	213 pts; seeps	No	Yes	Good to Fair	Work in progress
CANY	Base Carto	Ownership	Land inholdings	No	Yes		
CANY	Base Carto	Ownership	Land inholdings within park boundary	No	Yes	Unknown	Incomplete
CANY	Base Carto	Ownership	Research Natural Areas, designated and proposed (as of 1999).	No	Yes	Good to Fair	Complete
CANY	Base Carto	PLSS	TRS map, Salt Creek area	No	No	Excellent	Complete
CANY	Base Carto	Topography	20m contour map; covers ARCH as well	No	Yes	Excellent	Complete
CANY	Miscellaneous	Misc	Belnap data [to be verified]	No	No	Unknown	Unknown

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
CANY	Miscellaneous	Misc	section corner, monument, abandoned well	No	No	Excellent	Complete
CANY	Miscellaneous	Misc	propane tanks, construction site, diesel pump, gas pump	No	Yes	Excellent	Complete
CANY	Natural Resources	Fire	Extent of "Birthday Fire" near Salt Creek	No	Yes	Excellent	Complete
CANY	Natural Resources	Fire	GPS'd fire location; includes acreage	No	Yes	Excellent	Complete
CANY	Natural Resources	Fire	Southern pt in Birthday fire extent, GPS'd	No	Yes	Excellent	Complete
CANY	Natural Resources	Fire	NE pt in Birthday fire extent, GPS'd	No	Yes	Excellent	Complete
CANY	Natural Resources	Fire	extent of fire; same as fireextent.shp, w/o acreage, GPS'd	No	Yes	Excellent	Complete
CANY	Natural Resources	Geology	geology	Yes	No	Unknown	Incomplete
CANY	Natural Resources	Mines	Lathrop mine?	No	No	Unknown	Complete
CANY	Natural Resources	Plants, exotic/invasive	attributed with "heavy", "medium", or "light".	No	Yes	Unknown	Complete
CANY	Natural Resources	Plants, exotic/invasive	11 polys, attributed with "heavy", "medium", or "light". .	No	Yes	Unknown	Complete
CANY	Natural Resources	Plants, TES	TES species	No	Yes	Unknown	Incomplete
CANY	Natural Resources	Soils	Outlines of soil areas?	Yes	No	Poor	Complete
CANY	Natural Resources	Vegetation, general	Veg map of CANY. Not well regarded.	Yes	No	Poor	Complete
CANY	Natural Resources	Vertebrates, TES	43 polygons. Unknown significance.	No	Yes	Unknown	Complete
CANY	Natural Resources	Vertebrates, TES	2 sighting points	No	Yes	Good to Fair	Complete
CANY	Natural Resources	Vertebrates, TES	sightings in the maze; very well attributed Dates in the 80's	No	Yes	Excellent	Work in progress
CANY	Natural Resources	Vertebrates, TES	15 pts, all in cany, from division of wildlife resources	No	Yes	Unknown	Unknown
CANY	Natural Resources	Vertebrates, TES	309 pts; all in cany, from division of wildlife resources	No	Yes	Unknown	Unknown
CANY	Natural Resources	Vertebrates, TES	25 pts	No	Yes	Good to Fair	Work in progress
CANY	Natural Resources	Vertebrates, TES	PACs (Protected Activity Centers)	No	Yes	Excellent	Complete
CANY	Park Infrastructure	Buildings	Buildings in the Maze district	No	Yes	Excellent	Complete
CANY	Park Infrastructure	Buildings	Buildings in the Isky district	No	Yes	Excellent	Complete
CANY	Park Infrastructure	Buildings		No	Yes	Excellent	Complete
CANY	Park Infrastructure	Buildings	3 towers: weather, radio, section corner	No	Yes	Excellent	Complete
CANY	Park Infrastructure	Buildings	buildings in Needles	No	Yes	Excellent	Complete
CANY	Park Infrastructure	Buildings	CANY powerhouse	No	Yes	Unknown	Complete
CANY	Park Infrastructure	Buildings	CANY structures	No	Yes	Unknown	Complete
CANY	Park Infrastructure	Buildings	CANY mobile residences	No	Yes	Excellent	Complete
CANY	Park Infrastructure	Buildings	CANY rest rooms	No	Yes	Excellent	Complete
CANY	Park Infrastructure	Buildings	CANY visitor center	No	Yes	Unknown	Complete
CANY	Park Infrastructure	Buildings	CANY maintenance structures	No	Yes	Excellent	Complete
CANY	Park Infrastructure	Campsites	river campsites, incl greenriver ones	No	Yes	Unknown	Complete
CANY	Park Infrastructure	Campsites	21 campsites	No	Yes	Unknown	Complete
CANY	Park Infrastructure	Campsites	frontcountry, backcountry campsites	No	Yes	Unknown	Complete
CANY	Park Infrastructure	Campsites	2 sites, unknown	No	Yes	Unknown	Complete
CANY	Park Infrastructure	Campsites	10 river (?) campsites	No	Yes	Unknown	Complete
CANY	Park Infrastructure	Campsites	river campsites	No	Yes	Unknown	Complete
CANY	Park Infrastructure	Campsites	lg campsite	No	Yes	Unknown	Complete
CANY	Park Infrastructure	Fences	fences	No	Yes	Unknown	Incomplete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
CANY	Park Infrastructure	Parking lots	Paved areas, with attributes. Coverage made up of 2 other covers: 'Paved' and 'Paved2'	No	Yes	Good to Fair	Complete
CANY	Park Infrastructure	Parking lots	pavement	No	Yes	Excellent	Complete
CANY	Park Infrastructure	Parking lots	pavement	No	Yes	Excellent	Complete
CANY	Park Infrastructure	Pullouts	Pullouts	No	Yes	Unknown	Incomplete
CANY	Park Infrastructure	Roads	Roads and trails, some GPS'd	Yes	No	Excellent	Complete
CANY	Park Infrastructure	Roads	Roads and trails in the Isky district	No	No	Excellent	Complete
CANY	Park Infrastructure	Roads	Paved roads in CANY, collected late 1998 early 1999	Yes	No	Excellent	Complete
CANY	Park Infrastructure	Signs	subset of 'signs'; all those collected on 7/24	No	No	Excellent	Complete
CANY	Park Infrastructure	Signs	subset of signs; all those collected on 7/22	No	No	Excellent	Complete
CANY	Park Infrastructure	Signs	142 points; directional/informational	No	No	Excellent	Work in progress
CANY	Park Infrastructure	Signs	187 points; road, trails, other; same pts as isky	No	No	Excellent	Complete
CANY	Park Infrastructure	Signs	185 signs; directional, informational, regulatory. GPS'd by Gdula	No	No	Excellent	Complete
CANY	Park Infrastructure	Trails	GPSed trails	No	Yes	Excellent	Work in progress
CANY	Park Infrastructure	Utilities	3 locations, all in CANY	No	No	Good to Fair	Complete
CANY	Park Infrastructure	Utilities	junctions	No	Yes	Excellent	Complete
CANY	Park Infrastructure	Utilities	nps phone jct box	No	Yes	Excellent	Complete
CANY	Park Infrastructure	Utilities	phone line	No	Yes	Excellent	Complete
CANY	Park Infrastructure	Utilities	phone line	No	Yes	Excellent	Complete
CANY	Park Infrastructure	Utilities	gas line	No	Yes	Excellent	Complete
CANY	Park Infrastructure	Utilities	phone lines	No	Yes	Excellent	Complete
CANY	Park Infrastructure	Utilities	phone lines; looks more complete than phone orr	No	Yes	Unknown	Complete
CANY	Park Infrastructure	Utilities	underground power line	No	Yes	Excellent	Complete
CANY	Park Infrastructure	Utilities	junctions	No	No	Unknown	Complete
CANY	Park Infrastructure	Utilities	landfill poly	No	No	Excellent	Complete
CANY	Park Infrastructure	Utilities	gas line	No	Yes	Excellent	Complete
CANY	Park Infrastructure	Utilities	mess of lines	No	Yes	Unknown	Complete
CANY	Park Infrastructure	Utilities	meter locations	No	Yes	Excellent	Complete
CANY	Park Infrastructure	Wilderness	Wilderness, non-wilderness, or potential wilderness.	No	Yes	Excellent	Complete
CANY	Park Infrastructure	Wilderness	Big Spring area (I assume).	No	Yes	Unknown	Complete
CANY	Park Infrastructure	Wilderness	All variations of each other. Not sure which is the most accurate or up-to-date.	No	Yes	Unknown	Complete
CANY	Park Infrastructure	Wilderness	All variations of each other. Not sure which is the final version. All attributed with wilderness, potential wilderness, or non-wilderness.	No	Yes	Unknown	Complete
CANY	Park Specific	Archaeology	1 pt	No	No	Excellent	Complete
CANY	Park Specific	Archaeology	lithic scatter site	No	No	Excellent	Complete
CANY	Park Specific	Archaeology	4 pts	No	No	Unknown	Complete
CANY	Park Specific	Archaeology	33 pts	No	No	Unknown	Unknown
CANY	Park Specific	Archaeology	1330 points	No	No	Unknown	Unknown
CANY	Park Specific	Archaeology	"Packrat Palace" as attribute	No	No	Unknown	Unknown
CANY	Park Specific	Archaeology	large sites on mesas, buttes	No	No	Unknown	Unknown
CANY	Resource/Stressor Monitoring	Monitoring, air quality	Air quality monitoring location	No	Yes	Unknown	Incomplete
CANY	Resource/Stressor Monitoring	Monitoring, climate/weather	Climate Monitoring stations	Yes	No	Unknown	Incomplete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
CANY	Resource/Stressor Monitoring	Monitoring, other	Crust plots (soils)	No	Yes	Excellent	Complete
CANY	Resource/Stressor Monitoring	Monitoring, vegetation	48 points; extremely well attributed	No	Yes	Unknown	Unknown
CANY	Resource/Stressor Monitoring	Monitoring, vegetation	Salt Creek veg transect; associated transect line file is sc13line.shp	No	Yes	Excellent	Complete
CANY	Resource/Stressor Monitoring	Monitoring, vegetation	Salt Creek veg transect pts; associated transect file is sc03line.shp	No	Yes	Excellent	Complete
CANY	Resource/Stressor Monitoring	Monitoring, vegetation	Salt Creek veg transect pts; associated transect file is sc01line.shp. Associated jpegs: saltcreek-transect01-photo saltcreek-transect01-topo	No	Yes	Excellent	Complete
CANY	Resource/Stressor Monitoring	Monitoring, vegetation	Salt Creek veg transect Associated point file: sc03pts	No	No	Excellent	Complete
CANY	Resource/Stressor Monitoring	Monitoring, vegetation	Salt Creek veg transect	No	Yes	Excellent	Complete
CANY	Resource/Stressor Monitoring	Monitoring, vegetation	Horse Cyn riparian area; transect	No	Yes	Excellent	Complete
CANY	Resource/Stressor Monitoring	Monitoring, vegetation	Horse Cny riparian area; CANY and ARCH;2 pts marking beginning and end of transect	No	Yes	Excellent	Complete
CANY	Resource/Stressor Monitoring	Monitoring, vegetation	Consolidated file of multiple monitoring files	No	Yes	Excellent	Complete
CANY	Resource/Stressor Monitoring	Monitoring, vegetation	Transect of survey points.Associated point file: sc01pts	No	Yes	Unknown	Complete
CANY	Resource/Stressor Monitoring	Monitoring, water quality	Salt Creek water quality	Yes	Yes	Excellent	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
Capitol Reef National Park							
CARE	Base Carto	Boundaries	CARE boundary, also as shapefile.	Yes	No	Excellent	Complete
CARE	Base Carto	Boundaries	14 shapefiles of the CARE boundary shown in each of the 1:24k topos. Used for I&M survey (bats) avproject.	No	No	Excellent	Complete
CARE	Base Carto	DEM	10m DEM clipped to CARE boundary	No	Yes	Excellent	Complete
CARE	Base Carto	DOQQ	Associated DOQQs: q3325-26, q3425-26, q3525-27, q3626-27, q3726-28, q3828	Yes	No	Excellent	Complete
CARE	Base Carto	DOQQ	Color DOQQs	No	Yes		Work in progress
CARE	Base Carto	DRG	Index of 1:24k topos for CARE	No	No	Excellent	Complete
CARE	Base Carto	DRG	Decollared mosaic of CARE 1:100k DRGs	Yes	No	Excellent	Complete
CARE	Base Carto	DRG	Individual DRGs for CARE; those prefaced with 'o' are collared; complete coverage of CARE	Yes	No	Excellent	Complete
CARE	Base Carto	DRG	Individual DRGs for CARE; those prefaced with 'pq' are decollared	Yes	No	Excellent	Complete
CARE	Base Carto	Hydro	Tinajas, both as points and lines with lines indicating drainage.	No	Yes	Excellent	Unknown
CARE	Base Carto	Hydro	small-scale hydro	No	No	Unknown	Complete
CARE	Base Carto	Hydro	Seeps & Springs	No	Yes		
CARE	Base Carto	Hydro	DLGs	Yes	No	Poor	Complete
CARE	Base Carto	Hydro	DLGs	Yes	No	Poor	Complete
CARE	Base Carto	Ownership	Land inholdings	No	Yes		
CARE	Base Carto	Topography	Contours	No	Yes		Incomplete
CARE	Natural Resources	Fire	Fire history etc	No	Yes		
CARE	Natural Resources	Geology	2 files, one goes slightly outside park boundary. Also as grids.	Yes	No	Good to Fair	Complete
CARE	Natural Resources	Geology	Quaternary & bedrock geology, strike & dip, fractures for fruita quad.	Yes	No	Good to Fair	Complete
CARE	Natural Resources	Geology	2 files, one goes slightly outside park boundary.	Yes	No	Good to Fair	Complete
CARE	Natural Resources	Grazing	Many files - cattleguards, stock, range conditions, historic, fence etc.	No	Yes	Good to Fair	Complete
CARE	Natural Resources	Plants, exotic/invasive	GPSed data	No	Yes	Excellent	Complete
CARE	Natural Resources	Plants, exotic/invasive	GPSed data	No	Yes	Excellent	Complete
CARE	Natural Resources	Plants, exotic/invasive	GPSed data	No	Yes	Excellent	Complete
CARE	Natural Resources	Plants, exotic/invasive	GPSed data	No	Yes	Excellent	Complete
CARE	Natural Resources	Soils	Well attributed. Uncertain where coverage orginated (ssurgo, statsgo or other?)	Yes	No	Good to Fair	Complete
CARE	Natural Resources	Vegetation, general	Vegetation map, type and name attributes. Origin unknown.	Yes	nny	Unknown	Complete
CARE	Natural Resources	Weather data	Climate monitoring stations	Yes	No		
CARE	Park Infrastructure	Buildings	GPSed features, appears to be a coverage of historic features as it does not include VC.	No	Yes	Good to Fair	Complete
CARE	Park Infrastructure	Campsites	3 campgrounds	No	Yes	Good to Fair	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
CARE	Park Infrastructure	Fences	Named fences (segments?)	No	Yes	Good to Fair	Complete
CARE	Park Infrastructure	Parking lots	parking lots	No	Yes		
CARE	Park Infrastructure	Pullouts	GPSed - Comment field seems to have name of overlook.	No	Yes	Excellent	Complete
CARE	Park Infrastructure	Roads	Some roads (in park) GPSed.	Yes	No	Excellent	Complete
CARE	Park Infrastructure	Trails	Named	No	Yes	Excellent	Complete
CARE	Park Infrastructure	Utilities		No	Yes		
CARE	Park Infrastructure	Wilderness	Divides (nearly) entire park into wilderness. Two files - wilderness99 & potentail wilderness (smaller).	No	Yes	Unknown	Complete
CARE	Resource/Stressor Monitoring	Monitoring, air quality	Air quality monitoring location	Yes	No		
CARE	Resource/Stressor Monitoring	Monitoring, sound	Sound monitoring location	No	Yes		
CARE	Resource/Stressor Monitoring	Monitoring, vegetation	Digitized from 15' quads. Missing points on at least one quad.	Yes	No	Good to Fair	Incomplete
CARE	Resource/Stressor Monitoring	Monitoring, water quality	From WRD dataset	Yes	No	Good to Fair	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
Cedar Breaks National Monument							
CEBR	Base Carto	Boundaries	Boundary of CEBR	Yes	No	Excellent	Complete
CEBR	Base Carto	DEM	30m DEM containing CEBR and wider area	Yes	No	Excellent	Complete
CEBR	Base Carto	DEM	30m DEM clipped to CEBR bndry	Yes	No	Excellent	Complete
CEBR	Base Carto	DOQQ	DOQQ	Yes	No	Excellent	Complete
CEBR	Base Carto	DOQQ	Color DOQQs	No	No		Work in progress
CEBR	Base Carto	DRG	Index of the 4 topos on or adjacent to CEBR	No	No	Excellent	Complete
CEBR	Base Carto	DRG	Decollared, individual DRGs	Yes	No	Excellent	Complete
CEBR	Base Carto	DRG	Index of CEBR's 2 1:24k topos	No	No	Excellent	Complete
CEBR	Base Carto	Hydro	Part of water resources dataset.	Yes	No	Good to Fair	Complete
CEBR	Base Carto	Hydro	Misc. hydro - tinajas, ponds, etc.	No	Yes		
CEBR	Base Carto	Hydro	Springs in CEBR area, one in park	No	Yes	Good to Fair	Complete
CEBR	Base Carto	Ownership	PLSS	No	No	Excellent	Complete
CEBR	Base Carto	Topography	Contours	No	Yes		
CEBR	Miscellaneous	Misc	Shapefile of random points created for I&M 2001 survey crews	No	No	Excellent	Complete
CEBR	Natural Resources	Fire	Fire history	No	Yes		
CEBR	Natural Resources	Geology	geology	Yes	No		
CEBR	Natural Resources	Plants, exotic/invasive		No	Yes		
CEBR	Natural Resources	Plants, TES		No	Yes		
CEBR	Natural Resources	Soils		Yes	No		
CEBR	Natural Resources	Vegetation, general	Vegetation map	Yes	No		Work in progress
CEBR	Natural Resources	Vertebrates, TES		No	Yes		
CEBR	Natural Resources	Weather data	Climate monitoring stations	Yes	No		
CEBR	Park Infrastructure	Buildings	Permanent structures ie, VC	No	Yes		
CEBR	Park Infrastructure	Campsites	campsites	No	Yes	Good to Fair	Complete
CEBR	Park Infrastructure	Fences	Fences	No	Yes		
CEBR	Park Infrastructure	Parking lots	parking lots	No	Yes		
CEBR	Park Infrastructure	Pullouts	Pullouts	No	Yes		
CEBR	Park Infrastructure	Roads	Roads	No	Yes	Good to Fair	Complete
CEBR	Park Infrastructure	Roads	CEBR area highways	No	Yes	Excellent	Complete
CEBR	Park Infrastructure	Roads	Roads in CEBR area.	Yes	No	Good to Fair	Complete
CEBR	Park Infrastructure	Trails	Trails in CEBR, from water resources	No	Yes		Complete
CEBR	Park Infrastructure	Utilities		No	Yes		
CEBR	Park Infrastructure	Wilderness	Wilderness designations	No	Yes		
CEBR	Resource/Stressor Monitoring	Monitoring, air quality	Air quality monitoring location	Yes	No		
CEBR	Resource/Stressor Monitoring	Monitoring, sound	Sound monitoring location	No	Yes		
CEBR	Resource/Stressor Monitoring	Monitoring, water quality	Included in water resource division GIS layers from internet.	No	Yes	Unknown	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
Colorado National Monument							
COLM	Base Carto	Boundaries	Boundary of Grand Junction, CO; also in NAD83 folder	No	No	Excellent	Complete
COLM	Base Carto	Boundaries	Boundary of Fruita, CO; also in NAD83 folder	No	No	Excellent	Complete
COLM	Base Carto	Boundaries	Same file also in NAD83	Yes	No	Excellent	Complete
COLM	Base Carto	DEM	10 meter DEMs	No	Yes		
COLM	Base Carto	DEM	30m DEM of COLM and wider area	Yes	No	Excellent	Complete
COLM	Base Carto	DOQQ	DOQQs	Yes	No	Excellent	Complete
COLM	Base Carto	DOQQ	Color DOQQs	No	Yes		
COLM	Base Carto	DRG	Uncollared mosaic of COLM 100k DRGs	Yes	No	Excellent	Complete
COLM	Base Carto	DRG	Uncollared DRG mosaic of COLM area; 5x5 square topos. See also 3x3 topo mosaic for smaller area	Yes	No	Excellent	Complete
COLM	Base Carto	DRG	Index to COLM's 1:24k topos, 5x5 square region	No	No	Excellent	Complete
COLM	Base Carto	DRG	Uncollared DRG mosaic of COLM area; 3x3 square topos. See also 5x5 topo mosaic for wider area	Yes	No	Excellent	Complete
COLM	Base Carto	DRG	Index to COLM's 1:24k topos, 3x3 square. File also as shapefile.	No	No	Excellent	Complete
COLM	Base Carto	Hydro	small-scale base hydro	No	Yes	Unknown	Complete
COLM	Base Carto	Hydro	CO river in COLM area	No	No	Unknown	Complete
COLM	Base Carto	Hydro	Misc. hydro - tinajas, ponds, etc.	No	Yes		
COLM	Base Carto	Hydro	Seeps & Springs	No	Yes		
COLM	Base Carto	Hydro	From WRD data.	Yes	No	Good to Fair	Complete
COLM	Base Carto	Hydro	also in NAD83 folder	No	No	Excellent	Complete
COLM	Base Carto	Topography	Contours	No	Yes		
COLM	Miscellaneous	Misc	GPSed? Various items in COLM - trashcans, tunnels etc.	No	No	Excellent	Complete
COLM	Natural Resources	Fire	Various files, 2 of fires, one of burn plan (polygon)	No	Yes	Excellent	Complete
COLM	Natural Resources	Geology	Various covers from the USGS geologic inventory of COLM and adjacent areas. See README.txt in this folder for more info.	Yes	No	Excellent	Complete
COLM	Natural Resources	Plants, exotic/invasive	COLM map of tamarisk locations	No	Yes	Excellent	Complete
COLM	Natural Resources	Plants, TES		No	Yes		
COLM	Natural Resources	Soils	Assorted files associated with colm_soils. The README.txt states that the files are in zone 13; this is true only for files outside of the NAD27 or NAD83 folders	Yes	No	Poor	Complete
COLM	Natural Resources	Vegetation, general	COLM veg map, missing metadata. Load the associated legend file (colm_veg.avl) to tag the veg polys. Also in NAD83.	Yes	No	Unknown	Complete
COLM	Natural Resources	Vegetation, general	Digitized by Dave Price at COLM July 2001; boundary for I&M 2001 veg mapping project proposal	No	No	Excellent	Complete
COLM	Natural Resources	Vertebrates, TES		No	Yes		
COLM	Natural Resources	Weather data	Climate monitoring stations	No	Yes		

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
COLM	Park Infrastructure	Buildings	Buildings from various sources	No	Yes	Good to Fair	Complete
COLM	Park Infrastructure	Campsites	From WRD data	No	Yes	Good to Fair	Complete
COLM	Park Infrastructure	Fences	GPSed with Swat Team using Pro XRs	No	Yes	Excellent	Complete
COLM	Park Infrastructure	Parking lots	parking lots	No	Yes		
COLM	Park Infrastructure	Pullouts	Pullouts	No	Yes		
COLM	Park Infrastructure	Roads	Roads and trails; also in NAD83 folder	No	No	Excellent	Complete
COLM	Park Infrastructure	Roads	also in NAD83 folder, has associated .lyr file	Yes	No	Excellent	Complete
COLM	Park Infrastructure	Trails	Jones Canyon trail; also in NAD83 folder	No	No	Unknown	Complete
COLM	Park Infrastructure	Utilities	GPSed with Swat Team.	No	Yes	Excellent	Complete
COLM	Park Infrastructure	Wilderness	On screen digitized from .jpg - 1971 wilderness boundary, only wilderness boundary supposrted by an EIS.	No	Yes	Poor	Complete
COLM	Park Infrastructure	Wilderness	Wilderness coverage from IMR office (Ifer).	No	Yes	Excellent	Complete
COLM	Park Infrastructure	Wilderness	On screen digitized from .jpg - 1984 proposed/recommended … wilderness boundary.	No	Yes	Poor	Complete
COLM	Resource/Stressor Monitoring	Monitoring, air quality	Air quality monitoring location	Yes	No		
COLM	Resource/Stressor Monitoring	Monitoring, sound	Sound monitoring location	No	Yes		
COLM	Resource/Stressor Monitoring	Monitoring, vegetation	COLM veg map plot locations. Desperately in need of metadata. Also in NAD83.	Yes	No	Unknown	Complete
COLM	Resource/Stressor Monitoring	Monitoring, water quality	From WRD data.	Yes	No	Good to Fair	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
Curecanti National Recreation Area							
CURE	Base Carto	Boundaries	Zone 13 CURE boundary	Yes	No	Excellent	Complete
CURE	Base Carto	Boundaries	Assorted files used to show the extent of the CURE boundary on the underlying topos. Useful for 1 project.	No	No	Unknown	Complete
CURE	Base Carto	Boundaries	Updated boundary coverage in 2001.	Yes	No	Excellent	Complete
CURE	Base Carto	DEM	30m DEM of CURE and wider area. Zone 13	Yes	No	Excellent	Complete
CURE	Base Carto	DEM	30m DEM clipped to CURE boundary. UTM Zone 13	Yes	No	Excellent	Complete
CURE	Base Carto	DEM	10 meter DEMs	No	Yes		
CURE	Base Carto	DOQQ	Color DOQQs	No	Yes		Work in progress
CURE	Base Carto	DRG	Individual DRGs, with collars, of CURE	Yes	No	Excellent	Complete
CURE	Base Carto	DRG	Uncollared mosaic of 1:24k DRGs of CURE	Yes	No	Excellent	Complete
CURE	Base Carto	DRG	UTM Zone 13. Index to 1:24k topos of the CURE area.	No	No	Excellent	Complete
CURE	Base Carto	DRG	Index to 1:24k DRGs of CURE	No	No	Excellent	Complete
CURE	Base Carto	Hydro	Curecanti Reservoir - BLCA WRD data	Yes	No	Excellent	Complete
CURE	Base Carto	Hydro	Reservoirs in CURE, updated 2001.	Yes	No	Excellent	Complete
CURE	Base Carto	Hydro	Seeps & springs - WRD data	No	Yes	Good to Fair	Complete
CURE	Base Carto	Hydro	Misc. hydro -- tinajas, ponds, etc	No	Yes		Incomplete
CURE	Base Carto	Hydro	small-scale hydro	No	No	Unknown	Complete
CURE	Base Carto	Ownership	Land inholdings	No	Yes		
CURE	Base Carto	Transportation	Cimarron trains.	Yes	No	Excellent	Work in progress
CURE	Miscellaneous	Misc	Reservoir no wake zones.	No	No	Excellent	Complete
CURE	Miscellaneous	Misc	GPSed markers & boundary.	No	No	Excellent	Incomplete
CURE	Miscellaneous	Misc	Boat ramps in CURE.	No	No	Excellent	Complete
CURE	Miscellaneous	Misc	CURE boat docks.	No	No	Excellent	Complete
CURE	Miscellaneous	Misc	RV sewage dump sites.	No	Yes	Excellent	Work in progress
CURE	Miscellaneous	Misc	Random survey points located in specific topo quads	No	No	Excellent	Complete
CURE	Miscellaneous	Misc	Hazards in reservoir.	No	No	Excellent	Complete
CURE	Miscellaneous	Misc	100 random points generated as potential sampling locations for I&M survey crews, summer2001. Also as coverage.	No	No	Excellent	Complete
CURE	Natural Resources	Fire	Fire history	No	Yes		
CURE	Natural Resources	Paleo	Various paleo sites, GPSed at various dates.	No	No	Excellent	Complete
CURE	Natural Resources	Plants, exotic/invasive	GPSed Dalmation toadflax data.	No	Yes	Excellent	Complete
CURE	Natural Resources	Plants, exotic/invasive	GPSed Hoary Cress data.	No	Yes	Excellent	Complete
CURE	Natural Resources	Plants, exotic/invasive	GPSed Yellow Toadflax data.	No	Yes	Excellent	Complete
CURE	Natural Resources	Plants, exotic/invasive	GPSed Black Hebane data.	No	Yes	Excellent	Complete
CURE	Natural Resources	Plants, TES		No	Yes		
CURE	Natural Resources	Vegetation, general	Vegetation map	Yes	No		Work in progress

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
CURE	Natural Resources	Vertebrates, TES	Prairie dog data, but no relevant attribute information.	No	Yes	Poor	Complete
CURE	Natural Resources	Vertebrates, TES	Heron Rookeries, GPSed ~1994	No	Yes	Excellent	Complete
CURE	Natural Resources	Weather data	Climate monitoring stations	Yes	No		
CURE	Park Infrastructure	Bridges	Curecanti bridges	No	No	Excellent	Incomplete
CURE	Park Infrastructure	Campsites	Backcountry camping areas.	No	Yes	Excellent	Complete
CURE	Park Infrastructure	Pullouts	CURE pullouts.	No	Yes	Excellent	Complete
CURE	Park Infrastructure	Trails	GPSed trailheads.	No	No	Excellent	Work in progress
CURE	Park Infrastructure	Utilities	Elk Creek Sewage ponds.	No	Yes	Excellent	Complete
CURE	Park Infrastructure	Wilderness		No	Yes		
CURE	Resource/Stressor Monitoring	Monitoring, air quality	Air quality monitoring location	Yes	No		
CURE	Resource/Stressor Monitoring	Monitoring, sound	Sound monitoring location	No	Yes		
CURE	Resource/Stressor Monitoring	Monitoring, vegetation	Long term monitoring sites	No	Yes	Good to Fair	Work in progress
CURE	Resource/Stressor Monitoring	Monitoring, vertebrates	Long term monitoring sites	No	Yes	Good to Fair	Work in progress
CURE	Resource/Stressor Monitoring	Monitoring, water quality	WRD data	Yes	No	Good to Fair	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
Dinosaur National Monument							
DINO	Base Carto	Boundaries	DINO boundary	Yes	No	Excellent	Complete
DINO	Base Carto	DEM	Not clipped to boundary. Clipped grid = dino_30bnd.	Yes	No	Excellent	Complete
DINO	Base Carto	DEM	10 meter DEM coverage of DINO area, missing 2 quads	No	Yes	Excellent	Incomplete
DINO	Base Carto	DEM	10m DEM coverage clipped to boundary, missing 2 quads.	No	Yes	Excellent	Incomplete
DINO	Base Carto	DEM	4 30m DEMs covering area where 10 meters don't (2 on road section, 2 northern end of park). Also coverage clipped to boundary (miss30_bnd).	No	No	Excellent	Complete
DINO	Base Carto	DOQQ	DOQQ	No	Yes		Work in progress
DINO	Base Carto	DRG	Mosaic of all DINO DRGs, both UT & CO.	Yes	No	Excellent	Complete
DINO	Base Carto	Hydro	DLG based	No	Yes	Poor	Complete
DINO	Base Carto	Hydro	Lakes & reservoirs	Yes	No		
DINO	Base Carto	Hydro	DLG based	No	Yes	Poor	Complete
DINO	Base Carto	Hydro	Misc. hydro - tinajas, ponds, etc.	No	Yes		
DINO	Base Carto	Hydro	Seeps & springs & wells from NPS	No	Yes	Excellent	Complete
DINO	Base Carto	Hydro	DLG based	No	Yes	Poor	Complete
DINO	Base Carto	Ownership	Land inholdings (possibly in dino_wild coverage)	No	Yes		
DINO	Base Carto	Topography	Contours	No	Yes		
DINO	Natural Resources	Fire	This is a folder of (to date) 5 shapefiles containing various fire boundaries and acreages.	No	Yes	Good to Fair	Complete
DINO	Natural Resources	Geology	Fault lines in most of Dinosaur.	Yes	No	Excellent	Complete
DINO	Natural Resources	Geology	Folds (?) for Dinosaur.	Yes	No	Excellent	Complete
DINO	Natural Resources	Geology	Paleontological sites (?) around Dinosaur.	No	No	Excellent	Complete
DINO	Natural Resources	Geology	Strikes, dips, anticlines, etc. with directions within Dinosaur.	Yes	No	Excellent	Complete
DINO	Natural Resources	Geology	Geology coverage	Yes	No	Excellent	Complete
DINO	Natural Resources	Grazing	Grazing allotments in DINO, with name attributes.	No	No	Good to Fair	Complete
DINO	Natural Resources	Plants, exotic/invasive	Weed locations	No	Yes		Work in progress
DINO	Natural Resources	Plants, TES	Points digitized (in AV) from 1:24K quad maps of rare plants.	No	Yes	Excellent	Complete
DINO	Natural Resources	Plants, TES	Polygonal areas digitized from 1:24k quad maps of rare plants in Dino.	No	Yes	Excellent	Work in progress
DINO	Natural Resources	Soils	Soil data from NRCS soils survey from 7-10 years ago.	Yes	No	Excellent	Complete
DINO	Natural Resources	Vegetation, general		Yes	No		Work in progress
DINO	Natural Resources	Vertebrates, TES		No	Yes		
DINO	Natural Resources	Weather data	Climate monitoring stations	Yes	No		
DINO	Park Infrastructure	Buildings	DINO bldgs.	No	Yes		
DINO	Park Infrastructure	Campsites	DINO campsites	No	Yes		
DINO	Park Infrastructure	Fences	Fences	No	Yes		
DINO	Park Infrastructure	Parking lots	parking lots	No	Yes		
DINO	Park Infrastructure	Pullouts	Pullouts	No	Yes		
DINO	Park Infrastructure	Roads	1999 roads and trails	Yes	No	Good to Fair	Complete
DINO	Park Infrastructure	Roads	DLG based	Yes	No	Poor	Complete
DINO	Park Infrastructure	Trails	trails	No	Yes		
DINO	Park Infrastructure	Utilities	DLG based	No	Yes	Poor	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
DINO	Park Infrastructure	Wilderness	Appears to have inholdings for park as well as wilderness designations.	No	Yes	Excellent	Complete
DINO	Resource/Stressor Monitoring	Monitoring, air quality	Air quality monitoring location	Yes	No		
DINO	Resource/Stressor Monitoring	Monitoring, sound	Sound monitoring location	No	Yes		
DINO	Resource/Stressor Monitoring	Monitoring, water quality	Monitoring station	Yes	No		

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
Fossil Butte National Monument							
FOBU	Base Carto	Boundaries	DOBU boundary. Also in NAD83 projection.	Yes	No	Excellent	Complete
FOBU	Base Carto	DEM	30m DEM clipped to FOBU boundary. Fobu_dem = FOBU & wider area.	Yes	No	Excellent	Complete
FOBU	Base Carto	DEM	10m DEM of FOBU clipped to bnd. Fobu_10mdems = FOBU & wider area	No	Yes	Excellent	Complete
FOBU	Base Carto	DOQQ	Color DOQQs	No	Yes		
FOBU	Base Carto	DOQQ	DOQQ	Yes	No	Excellent	Complete
FOBU	Base Carto	DOQQ	DOQQ	Yes	No	Excellent	Complete
FOBU	Base Carto	DOQQ	DOQQ	Yes	No	Excellent	Complete
FOBU	Base Carto	DOQQ	DOQQ	Yes	No	Excellent	Complete
FOBU	Base Carto	DRG	Index to FOBU 1:24k topos	No	No	Excellent	Complete
FOBU	Base Carto	DRG	Individual, collared 1:24k DRGs for FOBU	Yes	No	Excellent	Complete
FOBU	Base Carto	Hydro	small-scale base hydro	No	No	Unknown	Complete
FOBU	Base Carto	Hydro	Misc. hydro -- tinajas, ponds, etc.	No	Yes	Good to Fair	Complete
FOBU	Base Carto	Hydro	WRD data	Yes	No	Good to Fair	Complete
FOBU	Base Carto	Hydro	Lakes & reservoirs	Yes	No		
FOBU	Base Carto	Hydro	WRD data - Chicken Creek water shed.	No	No	Unknown	Complete
FOBU	Base Carto	Hydro	Seeps & springs.From nps web site. Spring = WRD data	No	Yes	Good to Fair	Work in progress
FOBU	Base Carto	Ownership	Land inholdings	No	Yes		
FOBU	Base Carto	Topography	20-ft contours	No	Yes	Excellent	Complete
FOBU	Natural Resources	Fire	Fire history	No	Yes		
FOBU	Natural Resources	Geology	fold lines	Yes	No	Unknown	Complete
FOBU	Natural Resources	Geology	geological units, Kemmerer quad	Yes	No	Unknown	Complete
FOBU	Natural Resources	Geology	fault lines	Yes	No	Unknown	Complete
FOBU	Natural Resources	Geology	geological units, Evanston Quad	Yes	No	Unknown	Complete
FOBU	Natural Resources	Geology	limestone bed lines	Yes	No	Unknown	Complete
FOBU	Natural Resources	Plants, exotic/invasive	Weed locations as polys, points, & historic weed locations as polys & points. Unfinished, Clay is still GPSing.	No	Yes	Excellent	Work in progress
FOBU	Natural Resources	Plants, TES		No	Yes		
FOBU	Natural Resources	Plants, TES	23 pts. Heritage data. Multiple attributes	No	Yes	Unknown	Complete
FOBU	Natural Resources	Plants, TES	7 pts. Heritage data. Multiple attributes	No	Yes	Unknown	Complete
FOBU	Natural Resources	Soils		Yes	No	Unknown	Complete
FOBU	Natural Resources	Vegetation, general	Veg map. Clay & regional office working on this map.	Yes	No	Good to Fair	Complete
FOBU	Natural Resources	Vertebrates, TES	7 pts. Heritage data. Multiple attributes	No	Yes	Unknown	Complete
FOBU	Natural Resources	Vertebrates, TES	23 pts. Heritage data. Multiple attributes	No	Yes	Unknown	Complete
FOBU	Natural Resources	Weather data	Climate monitoring stations - WRD data	Yes	No	Good to Fair	Complete
FOBU	Park Infrastructure	Buildings	WRD data New layer GPSed by SWAT team?	No	Yes	Good to Fair	Complete
FOBU	Park Infrastructure	Fences	GPSed by Swat team June '02. Fence surrounding park.	No	Yes	Excellent	Complete
FOBU	Park Infrastructure	Parking lots	All parking lots were GPSed by SwAT team June '02	No	Yes	Excellent	Complete
FOBU	Park Infrastructure	Pullouts	GPSed by SWAT team?	No	Yes	Excellent	Unknown

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
FOBU	Park Infrastructure	Roads	derived from DLGs. K620All roads were GPSed by Swat team,	Yes	No	Unknown	Complete
FOBU	Park Infrastructure	Trails	trail - WRD data All trails were GPSed by SWAT team June '02	No	Yes	Good to Fair	Complete
FOBU	Park Infrastructure	Utilities	GPSed by SWAT team June '02. Various utilities.	No	Yes	Excellent	Complete
FOBU	Park Infrastructure	Wilderness		No	Yes		
FOBU	Resource/Stressor Monitoring	Monitoring, air quality	Air quality monitoring location	Yes	No		
FOBU	Resource/Stressor Monitoring	Monitoring, sound	Sound monitoring location	No	Yes		
FOBU	Resource/Stressor Monitoring	Monitoring, water quality	WRD data	Yes	No	Good to Fair	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
Golden Spike National Historic Site							
GOSP	Base Carto	Boundaries	GOSP boundary. Also as shapefile.	Yes	No	Excellent	Complete
GOSP	Base Carto	DEM	30m DEM of GOSP and area. Go_30d_bnd = clipped to boundary.	Yes	No	Excellent	Complete
GOSP	Base Carto	DEM	Two quads of GOSP with 10m DEM coverage. Go_10d_bnd = clipped to GOSP bnd.	No	Yes	Excellent	Incomplete
GOSP	Base Carto	DOQQ	DOQQ	Yes	No	Excellent	Complete
GOSP	Base Carto	DOQQ	Color DOQQs	No	Yes		
GOSP	Base Carto	DRG	Index to the 1:24k topos in GOSP	No	No	Excellent	Complete
GOSP	Base Carto	DRG	Individual decollared DRGs for GOSP.	Yes	No	Poor	Incomplete
GOSP	Base Carto	Hydro	base hydro	Yes	No	Good to Fair	Complete
GOSP	Base Carto	Hydro	DLG based, from agrc.	No	Yes	Good to Fair	Complete
GOSP	Base Carto	Hydro	Rivers & streams, small scale	No	Yes		
GOSP	Base Carto	Hydro	Misc. hydro - tinajas, ponds, etc.	No	Yes		
GOSP	Base Carto	Topography	topography	No	Yes		
GOSP	Miscellaneous	Misc	30 random points generated for I&M survey crews, summer 2001. Also as shapefile: gosp_randompts30	No	No	Excellent	Complete
GOSP	Natural Resources	Fire	Fire History	No	Yes		
GOSP	Natural Resources	Geology	geology	Yes	No		
GOSP	Natural Resources	Plants, exotic/invasive		No	Yes		
GOSP	Natural Resources	Plants, TES		No	Yes		
GOSP	Natural Resources	Soils	Western half of Box Elder county soils. ut602_a is coverage of soils.	Yes	No	Excellent	Complete
GOSP	Natural Resources	Soils		Yes	No		
GOSP	Natural Resources	Vegetation, general		Yes	No		
GOSP	Natural Resources	Vertebrates, TES		No	Yes		
GOSP	Natural Resources	Weather data	Climate monitoring stations	Yes	No		
GOSP	Park Infrastructure	Buildings	GOSP structures	No	Yes		
GOSP	Park Infrastructure	Fences	fences	No	Yes		
GOSP	Park Infrastructure	Parking lots	parking lots	No	Yes		
GOSP	Park Infrastructure	Pullouts	Pullouts	No	Yes		
GOSP	Park Infrastructure	Roads	Roads	Yes	No	Good to Fair	Complete
GOSP	Park Infrastructure	Trails	trails	No	Yes		
GOSP	Park Infrastructure	Utilities		No	Yes		
GOSP	Park Infrastructure	Wilderness		No	Yes		
GOSP	Resource/Stressor Monitoring	Monitoring, air quality	Air quality monitoring location	Yes	No		
GOSP	Resource/Stressor Monitoring	Monitoring, sound	Sound monitoring location	No	Yes		
GOSP	Resource/Stressor Monitoring	Monitoring, water quality	Monitoring station	Yes	No		

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
Hovenweep National Monument							
HOVE	Base Carto	Boundaries	Boundary	Yes	No	Excellent	Complete
HOVE	Base Carto	DEM	Index to 10m DEMs	No	No	Excellent	Complete
HOVE	Base Carto	DOQQ	color DOQQs	No	Yes	Unknown	Incomplete
HOVE	Base Carto	DOQQ	B&W DOQ in jpeg format	Yes	No	Excellent	Complete
HOVE	Base Carto	DOQQ	B&W DOQ in jpeg format	Yes	No	Excellent	Complete
HOVE	Base Carto	DOQQ	B&W DOQ in jpeg format	Yes	No	Excellent	Complete
HOVE	Base Carto	DOQQ	B&W DOQQ in jpeg format	Yes	No	Excellent	Complete
HOVE	Base Carto	DOQQ	B&W DOQ in jpeg format	Yes	No	Excellent	Complete
HOVE	Base Carto	DOQQ	B&W DOQ in jpeg format	Yes	No	Excellent	Complete
HOVE	Base Carto	DRG	Collared topo in TIF format.	Yes	No	Excellent	Complete
HOVE	Base Carto	DRG	Collared topo in TIF format.	Yes	No	Excellent	Complete
HOVE	Base Carto	DRG	Collared topo in TIF format.	Yes	No	Excellent	Complete
HOVE	Base Carto	DRG	Collared DRG in TIF format	Yes	No	Excellent	Complete
HOVE	Base Carto	DRG	Index to HOVE 1:24k topos	No	No	Excellent	Complete
HOVE	Base Carto	DRG	Collared topo in TIF format.	Yes	No	Excellent	Complete
HOVE	Base Carto	DRG	Decollared mosaic	Yes	No	Excellent	Complete
HOVE	Base Carto	DRG	Collared topo in TIF format.	Yes	No	Excellent	Complete
HOVE	Base Carto	Hydro	basic hydro	No	Yes	Unknown	Incomplete
HOVE	Base Carto	Hydro	1 spring	No	Yes	Excellent	Complete
HOVE	Base Carto	Hydro	Seeps and Springs	No	Yes	Unknown	Incomplete
HOVE	Base Carto	Hydro	Springs, 1 point	No	Yes	Excellent	Complete
HOVE	Base Carto	Hydro	Tinajas & ponds -- etc. hydro features	No	Yes	Unknown	Incomplete
HOVE	Base Carto	Topography	1 ft (?) contours; also in shapefile	No	Yes	Excellent	Complete
HOVE	Miscellaneous	Misc	leach field site	No	No	Excellent	Complete
HOVE	Natural Resources	Fire	fire history	No	Yes	Unknown	Incomplete
HOVE	Natural Resources	Geology	boulders; also as coverage Also in NAD83 folder See README.txt in ../squaretower/	Yes	No	Unknown	Complete
HOVE	Natural Resources	Plants, exotic/invasive		No	Yes	Unknown	Incomplete
HOVE	Natural Resources	Plants, TES		No	Yes	Unknown	Incomplete
HOVE	Natural Resources	Soils		Yes	No	Unknown	Incomplete
HOVE	Natural Resources	Vegetation, general		Yes	No	Unknown	Incomplete
HOVE	Natural Resources	Vertebrates, TES		No	Yes	Unknown	Incomplete
HOVE	Park Infrastructure	Buildings	Date sometime in 1999; all buildings	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Buildings	new VC; also road and parking lot	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Campsites	Campsites, picnic tables, grills, benches, cattle guards, survey markers, gates, other Date sometime in 1999	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Fences	Also as coverage; Also in NAD83 folder See README.txt in ../squaretower/	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Fences	Fence corners; GPS'd	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Fences	Unknown	No	No	Unknown	Complete
HOVE	Park Infrastructure	Fences	1 polygon, fence area	No	Yes	Unknown	Complete
HOVE	Park Infrastructure	Fences	Goodman Point trail; attributed, GPS'd	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Fences	Gates: "Hiker's gate", "Vehicle gate"; GPS'd	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Fences	2 pts; hiker's gate, vehicle gate	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Parking lots	1 poly	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Roads	roads as polys	Yes	No	Excellent	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
HOVE	Park Infrastructure	Roads	Roads IN HOVE; mostly GPS'd	Yes	No	Excellent	Complete
HOVE	Park Infrastructure	Roads	Surrounding area roads, pieced out of state road coverages. Some attributing may be incorrect.	No	Yes	Good to Fair	Work in progress
HOVE	Park Infrastructure	Signs	signs	No	No	Excellent	Complete
HOVE	Park Infrastructure	Signs	Signs, warning, informational, other	No	No	Excellent	Complete
HOVE	Park Infrastructure	Signs	Informational, regulatory, warning, and other signs. Attributed with sign message. Date sometime in 1999	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Trails	trails, also suspected social trails	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Trails	trail from VC to sites	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Utilities	Culverts	No	No	Excellent	Complete
HOVE	Park Infrastructure	Utilities	Valves	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Utilities	Misc points: spigot, propane tanks, hydrants, etc.	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Utilities	Driveway, water tank	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Utilities	culverts, walkways	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Utilities	17 powerpoles	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Utilities	Sewer manhole points	No	Yes	Good to Fair	Complete
HOVE	Park Infrastructure	Utilities	Gas, electric, pezzo (?!) meters	No	Yes	Good to Fair	Complete
HOVE	Park Infrastructure	Utilities	Sewer manhole covers Date sometime in 1999	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Utilities	Electric, gas, pezzo, and other meter locations. Date sometime in 1999	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Utilities	Power pole locations Date sometime in 1999	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Utilities	Air relief, water stem, shut off Date sometime in 1999	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Utilities	Fire hydrants, elec outlets, weather stations, propane tanks, spigot, flagpole, gas tank, culvert, wires, hosebox, clean out.	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Utilities	5 polygons; driveways, water tanks	No	No	Excellent	Complete
HOVE	Park Infrastructure	Utilities	Walkways, culverts	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Utilities	valve locations	No	Yes	Unknown	Complete
HOVE	Park Infrastructure	Utilities	sewer lines	No	Yes	Unknown	Complete
HOVE	Park Infrastructure	Utilities	electric lines	No	Yes	Unknown	Complete
HOVE	Park Infrastructure	Utilities	water	No	Yes	Unknown	Complete
HOVE	Park Infrastructure	Utilities	phone line	No	Yes	Unknown	Complete
HOVE	Park Infrastructure	Utilities	sites of garden, buildings,..	No	No	Excellent	Complete
HOVE	Park Infrastructure	Utilities	section markers, water valves. Also GPS'd in 10/99	No	Yes	Excellent	Complete
HOVE	Park Infrastructure	Wilderness	In and around HOVE	No	Yes	Unknown	Incomplete
HOVE	Park Specific	Archaeology	outline of ruin sites?	No	No	Excellent	Complete
HOVE	Park Specific	Archaeology	Ruin sites	No	No	Excellent	Complete
HOVE	Park Specific	Archaeology	56 pts	No	No	Unknown	Complete
HOVE	Park Specific	Archaeology	8 GPS'd polys	No	No	Unknown	Complete
HOVE	Park Specific	Archaeology	archaeological sites, attributed with condition, site type, reference	No	No	Excellent	Complete
HOVE	Park Specific	Archaeology	Well attributed	No	No	Excellent	Complete
HOVE	Park Specific	Archaeology	63 pts; Archaeological sites	No	No	Excellent	Complete
HOVE	Park Specific	Archaeology	waterlines, and road to berm	No	Yes	Excellent	Complete
HOVE	Park Specific	Archaeology	5 pts	No	No	Excellent	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
HOVE	Park Specific	Archaeology	sites, no attributes	No	No	Unknown	Complete
HOVE	Park Specific	Archaeology	gps'd berm	No	Yes	Unknown	Unknown
HOVE	Resource/Stressor Monitoring	Monitoring, air quality	Air quality monitoring location	Yes	No	Unknown	Incomplete
HOVE	Resource/Stressor Monitoring	Monitoring, climate/weather	Air quality monitoring location	Yes	No	Unknown	Incomplete
HOVE	Resource/Stressor Monitoring	Monitoring, sound	Sound monitoring location	No	Yes	Unknown	Incomplete
HOVE	Resource/Stressor Monitoring	Monitoring, water quality	monitoring station	No	Yes	Unknown	Incomplete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
Natural Bridges National Monument							
NABR	Base Carto	Boundaries	Current boundary	Yes	No	Excellent	Complete
NABR	Base Carto	Boundaries	Historical Boundary	No	No	Excellent	Complete
NABR	Base Carto	Boundaries	historical boundaries	No	No	Excellent	Complete
NABR	Base Carto	DEM	looks just like 30m	Yes	No	Excellent	Complete
NABR	Base Carto	DOQQ	Color DOQQs	No	Yes	Unknown	Incomplete
NABR	Base Carto	DOQQ	Assorted DOQQ's of NABR in jpeg format	Yes	No	Excellent	Complete
NABR	Base Carto	DRG	Uncollared mosaic of 1:24k DRGs	Yes	No	Excellent	Complete
NABR	Base Carto	DRG	Decollared mosaic	Yes	No	Excellent	Complete
NABR	Base Carto	DRG	Uncollared mosaic of 1:24k topos	Yes	No	Excellent	Complete
NABR	Base Carto	Hydro	Lakes & Reservoirs	Yes	No	Unknown	Incomplete
NABR	Base Carto	Hydro	seeps, springs	No	Yes	Excellent	Complete
NABR	Base Carto	Hydro	Misc. - Tinajas & ponds etc	No	Yes	Unknown	Incomplete
NABR	Base Carto	Hydro	streams in/around NABR	No	Yes	Good to Fair	Complete
NABR	Base Carto	Ownership	Land inholdings withing park boundary	No	Yes	Unknown	Incomplete
NABR	Base Carto	Topography	contours, 15m	No	Yes	Excellent	Complete
NABR	Base Carto	Topography	15m contour coverage of NABR	No	Yes	Excellent	Complete
NABR	Natural Resources	Fire	fire (need details)	No	Yes	Unknown	Incomplete
NABR	Natural Resources	Geology	Geology map, completed 4 years ago.	Yes	No	Excellent	Complete
NABR	Natural Resources	Geology	3 pts; strike and dip of bedding	Yes	No	Excellent	Complete
NABR	Natural Resources	Geology	5 geology formation types	Yes	No	Excellent	Complete
NABR	Natural Resources	Geology	geology of NABR	Yes	No	Excellent	Complete
NABR	Natural Resources	Geology	line bisecting NABR; w/ associated jpg?	Yes	No	Excellent	Complete
NABR	Natural Resources	Geology	outlines of known locations and map boundaries	Yes	No	Excellent	Complete
NABR	Natural Resources	Plants, exotic/invasive	178 pts.	No	Yes	Unknown	Complete
NABR	Natural Resources	Plants, exotic/invasive	184 pts.	No	Yes	Unknown	Complete
NABR	Natural Resources	Plants, exotic/invasive	362 points; 1996	No	Yes	Unknown	Complete
NABR	Natural Resources	Plants, TES		No	Yes	Unknown	Incomplete
NABR	Natural Resources	Soils		Yes	No	Unknown	Incomplete
NABR	Natural Resources	Vegetation, general	Veg map, 5 classes.	Yes	No	Good to Fair	Complete
NABR	Natural Resources	Vegetation, general	polys of habitat type	Yes	No	Unknown	Complete
NABR	Natural Resources	Vertebrates, TES		No	Yes		
NABR	Park Infrastructure	Bridges	Locations of 3 bridges in NABR	No	No	Excellent	Complete
NABR	Park Infrastructure	Bridges	Locations of 3 bridges in NABR	No	No	Excellent	Complete
NABR	Park Infrastructure	Bridges	Locations of 3 bridges in NABR	No	No	Excellent	Complete
NABR	Park Infrastructure	Bridges	Locations of 3 bridges in NABR	No	No	Excellent	Complete
NABR	Park Infrastructure	Buildings	buildings at NABR; all pretty much the same	No	Yes	Excellent	Complete
NABR	Park Infrastructure	Fences	fences	No	Yes	Unknown	Incomplete
NABR	Park Infrastructure	Parking lots	parking lots	No	Yes	Unknown	Incomplete
NABR	Park Infrastructure	Pullouts	Pullouts	No	Yes	Unknown	Incomplete
NABR	Park Infrastructure	Roads	roads	Yes	No	Excellent	Complete
NABR	Park Infrastructure	Roads	roads, includes sidewalks	Yes	No	Excellent	Complete
NABR	Park Infrastructure	Utilities	natural gas pipeline?	No	Yes	Unknown	Complete
NABR	Park Infrastructure	Utilities	pipeline of some kind	No	Yes	Unknown	Complete
NABR	Park Infrastructure	Utilities	Manhole points	No	Yes	Unknown	Complete
NABR	Park Infrastructure	Utilities	sewerlines	No	Yes	Unknown	Complete
NABR	Park Infrastructure	Utilities	no idea	No	No	Unknown	Complete
NABR	Park Infrastructure	Utilities	waterlines	No	Yes	Unknown	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
NABR	Park Infrastructure	Wilderness	Wilderness boundaries	No	Yes	Unknown	Incomplete
NABR	Park Specific	Archaeology	142 pts; date ?; type ("masonry", "lithic scatter", "feature site"…)	No	No	Unknown	Complete
NABR	Park Specific	Archaeology	Jul 2000; site_type ("rock art," "isolated feature", "habitation")	No	No	Unknown	Complete
NABR	Park Specific	Archaeology	May-Jun 1997; no desc	No	No	Unknown	Complete
NABR	Park Specific	Archaeology	May-Jul 1997; type desc ("stone," "ceramic," "flaked stone")	No	No	Unknown	Complete
NABR	Resource/Stressor Monitoring	Monitoring, air quality	Air quality monitoring location	No	Yes	Unknown	Incomplete
NABR	Resource/Stressor Monitoring	Monitoring, climate/weather	Climate Monitoring station	No	Yes	Unknown	Incomplete
NABR	Resource/Stressor Monitoring	Monitoring, water quality	Monitoring station	No	Yes	Unknown	Incomplete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
Northern Colorado Plateau Network							
NCPN	Base Carto	Boundaries	Boundaries of the 4 states that comprise the NCPN parks	No	No	Excellent	Complete
NCPN	Base Carto	Boundaries	Boundaries of the 16 parks in the NCPN	No	No	Excellent	Complete
NCPN	Base Carto	Boundaries	States of the NCPN (AZ, UT, CO, WY), in various projections	No	No	Excellent	Complete
NCPN	Base Carto	Boundaries	ARCH, CANY, NABR, COLM	Yes	No	Excellent	Complete
NCPN	Base Carto	Boundaries	Boundary of Grand Staircase Escalante Nat'l Monument (from WRD data).	No	No	Excellent	Complete
NCPN	Base Carto	Boundaries	All NCPN parks in zone 13	No	No	Excellent	Complete
NCPN	Base Carto	Boundaries	ARCH, CANY, GCNRA, COLM, NABR	Yes	No	Excellent	Complete
NCPN	Base Carto	Boundaries	CANY, GLCA	No	No	Excellent	Complete
NCPN	Base Carto	Boundaries	public land survey? SE Utah	No	No	Unknown	Complete
NCPN	Base Carto	Boundaries	Boundaries of the 4 corner states	No	No	Good to Fair	Complete
NCPN	Base Carto	Boundaries	All NCPN parks in zone 12, also shapefile & various projections.	Yes	No	Excellent	Complete
NCPN	Base Carto	Boundaries	Glan Canyon NRA	No	No	Excellent	Complete
NCPN	Base Carto	Boundaries	Part of Glen Canyon NRA	No	No	Excellent	Complete
NCPN	Base Carto	Boundaries	AZ, UT, CO, NM	No	No	Excellent	Complete
NCPN	Base Carto	Boundaries	Parks of the NCPN in Lambert Azimuthal	No	No	Excellent	Complete
NCPN	Base Carto	DLG	covers wide areas around SEUG	No	No	Unknown	Complete
NCPN	Base Carto	DRG	Index of USGS topo map coverage (1:24k) for NCPN area. Also coverage.	No	No	Excellent	Complete
NCPN	Base Carto	DRG	Assorted DRGS from AZ, NM, CO, UT	No	No	Excellent	Complete
NCPN	Base Carto	DRG	Index of USGS topo map coverage in UTM zone13	No	No	Excellent	Complete
NCPN	Base Carto	Hydro	Data from Atlas, named segments.	Yes	No	Good to Fair	Complete
NCPN	Base Carto	Hydro	Data from Atlas, named lakes.	Yes	No	Good to Fair	Complete
NCPN	Base Carto	Hydro	Major rivers, also Lake Powell	Yes	No	Unknown	Complete
NCPN	Base Carto	Hydro	GLCA lake, also CO, Green Rivers	Yes	No	Good to Fair	Complete
NCPN	Base Carto	Ownership	clipped; BLM land around cany	No	Yes		Complete
NCPN	Base Carto	Ownership	Administration/Ownership/Land Status. .e00 file	No	No	Unknown	Complete
NCPN	Base Carto	Ownership	Administration/Ownership/Land Status	No	No		Complete
NCPN	Base Carto	Ownership	Administration/Ownership/Land Status. .e00 file	No	No		Complete
NCPN	Base Carto	Ownership	land ownership?	No	Yes	Excellent	Complete
NCPN	Base Carto	Ownership	Administration/Ownership/Land Status .e00 file	No	No	Unknown	Complete
NCPN	Base Carto	Ownership	Escalante land ownership	No	No	Excellent	Complete
NCPN	Base Carto	Ownership	Clipped land ownership	No	No	Excellent	Complete
NCPN	Base Carto	Ownership	Land ownership	No	No		Complete
NCPN	Base Carto	PLSS	township, range, section map	No	No	Excellent	Complete
NCPN	Natural Resources	Soils	Utah Digital general soil association map developed by the National Cooperative Soil Survey.	Yes	No	Good to Fair	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
NCPN	Natural Resources	Vertebrates, general	This coverage contains mammal data from 2001 for CARE, CEBR, PISP, GOSP, TICA, FOBU, BLCA & CURE.	No	Yes	Good to Fair	Work in progress
NCPN	Natural Resources	Vertebrates, general	GPS locations from NCPN Herps survey, CEBR, BRCA, ZION and CARE. Fifth dataset download from Garmin 12cx unit. Raw data located in ../raw/ directory.	No	Yes	Good to Fair	Complete
NCPN	Natural Resources	Vertebrates, general	GPS locations from NCPN Herps survey, ZION and CARE. Third dataset downloaded from Garmin 12cx unit. Raw data located in ../raw/ directory.	No	Yes	Good to Fair	Complete
NCPN	Natural Resources	Vertebrates, general	GPS locations from NCPN Herps survey, ZION, BRCA, GOSP and FOBU. Second dataset downloaded from Garmin 12cx unit. Raw data located in ../raw/ directory.	No	Yes	Good to Fair	Complete
NCPN	Natural Resources	Vertebrates, general	GPS locations from NCPN Herps survey, GOSP and FOBU. Second dataset downloaded from Garmin 12cx unit. Raw data located in ../raw/ directory.	No	Yes	Good to Fair	Complete
NCPN	Natural Resources	Vertebrates, general	GPS locations from NCPN Herps survey, CARE. Third dataset downloaded from Garmin 3+ unit. Raw data located in ../raw/ directory.	No	Yes	Good to Fair	Complete
NCPN	Natural Resources	Vertebrates, general	GPS locations from NCPN Herps survey, GOSP, FOBU, CEBR, BRCA, ZION and CARE. Fifth dataset download from Garmin 3+ unit. Raw data located in ../raw/ directory.	No	Yes	Good to Fair	Complete
NCPN	Natural Resources	Vertebrates, general	GPS locations from NCPN Herps survey, BRCA and CARE. Fourth dataset download from Garmin 3+ unit. Raw data located in ../raw/ directory.	No	Yes	Good to Fair	Complete
NCPN	Natural Resources	Vertebrates, general	GPS locations from NCPN Herps survey, primarily ZION. First dataset downloaded from Garmin 3+ unit. Raw data located in ../raw/ directory.	No	Yes	Good to Fair	Complete
NCPN	Natural Resources	Vertebrates, general	GPS locations from NCPN Herps survey, CEBR and CARE. Fourth dataset download from Garmin 12cx unit. Raw data located in ../raw/ directory.	No	Yes	Good to Fair	Complete
NCPN	Natural Resources	Vertebrates, general	GPS locations from NCPN Herps survey (ZION). First dataset downloaded from Garmin 12cx unit. Raw data located in ../raw/ directory.	No	Yes	Good to Fair	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
NCPN	Natural Resources	Vertebrates, general	GPS locations from NCPN Herps survey, CEBR, BRCA, ZION, TICA, and CARE. Sixth dataset download from Garmin 12cx unit. Raw data located in ../raw/ directory	No	Yes	Good to Fair	Complete
NCPN	Natural Resources	Vertebrates, general	from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, general	flightlines; chasing raptors, from division of wildlife resources, helicopter survey data.	No	Yes	Excellent	Complete
NCPN	Natural Resources	Vertebrates, general	from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, general	from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, general	from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, general	from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, general	GPSed point locations from inventory crew for ARCH, BRCA, CANY, CARE, CEBR, COLM, FOBU, GOSP, HOVE, NABR, PISP, TICA, ZION	No	Yes	Good to Fair	Complete
NCPN	Natural Resources	Vertebrates, general	Coverage of herps in NCPN. See associated legend in /ncpn/avlegends/herps_legend.avl	No	Yes	Good to Fair	Complete
NCPN	Natural Resources	Vertebrates, TES	29 pts, from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	28 pts, from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	detailed database of locations, species. From division of wildlife resources, helicopter survey data.	No	Yes	Excellent	Work in progress
NCPN	Natural Resources	Vertebrates, TES	from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	55 sites, from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	38 pts, 13 other fish .shp files.	No	Yes	Unknown	Work in progress
NCPN	Natural Resources	Vertebrates, TES	buffer around owl, from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	4 pts	No	Yes	Unknown	Complete
NCPN	Natural Resources	Vertebrates, TES	30 pts	No	Yes	Unknown	Complete
NCPN	Natural Resources	Vertebrates, TES	from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	22 pts, from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	6 pts	No	No	Unknown	Complete
NCPN	Natural Resources	Vertebrates, TES	mostly around CARE, from division of wildlife resources	No	Yes	Unknown	Unknown

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
NCPN	Natural Resources	Vertebrates, TES	9 pts, some in CARE, from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	73 pt locations, from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	22 pts	No	Yes	Unknown	Complete
NCPN	Natural Resources	Vertebrates, TES	20 pts	No	Yes	Unknown	Complete
NCPN	Natural Resources	Vertebrates, TES	4 pts	No	Yes	Unknown	Complete
NCPN	Natural Resources	Vertebrates, TES	41 pts	No	Yes	Unknown	Complete
NCPN	Natural Resources	Vertebrates, TES	3 pts	No	Yes	Unknown	Complete
NCPN	Natural Resources	Vertebrates, TES	4 polys, from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	580 pts, from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	no data, from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	no data, from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	no data, from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	Adjacent to CARE, from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	24 pts, all in cany, from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	no data, from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	8pts, from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	no data, from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	1 pts	No	Yes	Unknown	Complete
NCPN	Natural Resources	Vertebrates, TES	1 poly, from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	7 pts	No	Yes	Unknown	Complete
NCPN	Natural Resources	Vertebrates, TES	13 pts	No	Yes	Unknown	Complete
NCPN	Natural Resources	Vertebrates, TES	67 pts	No	Yes	Unknown	Complete
NCPN	Natural Resources	Vertebrates, TES	1 pt, from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	1 pt, from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	from division of wildlife resources	No	Yes	Unknown	Unknown
NCPN	Natural Resources	Vertebrates, TES	Federal and state-listed TES and otherwise rare species point localities in Utah parks	No	Yes	Excellent	Complete
NCPN	Park Infrastructure	Roads	Roads for AZ, UT, CO, NM - fairly coarse resolution	No	No	Poor	Complete
NCPN	Park Infrastructure	Roads	Fairly coarse resolution; probably only major roads	Yes	No	Poor	Complete
NCPN	Park Infrastructure	wilderness	No clue. Wilderness areas of some sort. Cryptic attributes.	No	Yes	Unknown	Complete
NCPN	Park Infrastructure	wilderness	Wilderness areas spanning wide area, uncertain rationale. Attributed with 'data', (name, apparently) and 'acres'.	No	Yes	Unknown	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
NCPN	Park Infrastructure	wilderness	Not sure what the criterion is. Same as Hr1500, but that coverage has calculated acres.	No	Yes	Unknown	Complete
NCPN	Resource/Stressor Monitoring	Monitoring, water quality	Data from CSU (Aug. 02). Compiled from various sources. Points cover all NCPN parks plus adjacent lands except COLM.	Yes	No	Unknown	Work in progress

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
Pipe Spring National Monument							
PISP	Base Carto	Boundaries	Also as shapefile, and in NAD83 folder	Yes	No	Excellent	Complete
PISP	Base Carto	DEM	10m DEM of PISP and wider area. Pi_10d_bnd = clipped to boundary	No	Yes	Excellent	Complete
PISP	Base Carto	DOQQ	B & W	Yes	No	Excellent	Complete
PISP	Base Carto	DOQQ	Color DOQQs	No	Yes		
PISP	Base Carto	DRG	Uncollared mosaic of DRGs of PISP and MUCH wider area	Yes	No	Excellent	Complete
PISP	Base Carto	DRG	4 DRGs around PISP	No	No	Excellent	Complete
PISP	Base Carto	DRG	1 DRG boundary that includes PISP	No	No	Excellent	Complete
PISP	Base Carto	Hydro	small-scale hydro	No	No	Unknown	Complete
PISP	Base Carto	Hydro	From WRD data.	Yes	No	Good to Fair	Complete
PISP	Base Carto	Hydro	Misc. Hydro - tinajas, ponds, etc.	No	Yes		
PISP	Base Carto	Hydro	From WRD data.	No	Yes	Good to Fair	Complete
PISP	Base Carto	Topography	Contours	No	Yes		
PISP	Natural Resources	Fire	fire (need details)	No	Yes		
PISP	Natural Resources	Geology	geology	Yes	No		
PISP	Natural Resources	Plants, exotic/invasive		No	Yes		
PISP	Natural Resources	Plants, TES		No	Yes		
PISP	Natural Resources	Soils		Yes	No		
PISP	Natural Resources	Vegetation, general		Yes	No		
PISP	Natural Resources	Vertebrates, TES		No	Yes		
PISP	Natural Resources	Weather data	Climate monitoring stations	Yes	No		
PISP	Park Infrastructure	Buildings	PISP buildings	No	Yes		
PISP	Park Infrastructure	Fences	fences	No	Yes		
PISP	Park Infrastructure	Parking lots	parking lots	No	Yes		
PISP	Park Infrastructure	Pullouts	Pullouts	No	Yes		
PISP	Park Infrastructure	Roads	From WRD data.	Yes	No	Good to Fair	Complete
PISP	Park Infrastructure	Roads	From WRD data	No	Yes	Good to Fair	Complete
PISP	Park Infrastructure	Roads	From WRD data	No	Yes	Good to Fair	Complete
PISP	Park Infrastructure	Trails	trails	No	Yes		
PISP	Park Infrastructure	Utilities		No	Yes		
PISP	Park Infrastructure	Wilderness		No	Yes		
PISP	Resource/Stressor Monitoring	Monitoring, air quality	Air quality monitoring location	Yes	No		
PISP	Resource/Stressor Monitoring	Monitoring, sound	Sound monitoring location	No	Yes		
PISP	Resource/Stressor Monitoring	Monitoring, water quality	From WRD data.	No	Yes	Good to Fair	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
Southeast Utah Group (Arches, Canyonlands, Hovenweep, Natural Bridges)							
SEUG	Base Carto	Boundaries	Index of 9 counties around SEUG parks	No	No	Excellent	Complete
SEUG	Base Carto	Boundaries	Counties around SEUG	No	No	Excellent	Complete
SEUG	Base Carto	Boundaries	Boundaries of the SEUG parks	Yes	No	Excellent	Complete
SEUG	Base Carto	DEM	Index to 10m DEMs; ARCH, northern half of CANY	No	No	Excellent	Complete
SEUG	Base Carto	DEM	DEM for both ARCH and CANY	No	Yes	Excellent	Complete
SEUG	Base Carto	DEM	ARCH, CANY, and NABR	Yes	No	Excellent	Complete
SEUG	Base Carto	DEM	10m DEM mosaic that covers ARCH, CANY	No	Yes	Excellent	Complete
SEUG	Base Carto	DEM	Index to 10m DEMs West of CANY	No	No	Excellent	Complete
SEUG	Base Carto	DEM	Hillshade for ARCH, CANY, and NABR	No	No	Excellent	Complete
SEUG	Base Carto	DEM	Hillshade for both ARCH and CANY	No	No	Excellent	Complete
SEUG	Base Carto	DLG	dlg clipped to smaller area around SEUG	No	No	Unknown	Complete
SEUG	Base Carto	DOQQ	Index to CANY doqq's	No	No	Excellent	Complete
SEUG	Base Carto	DRG	Index of 1:250k topos around SEUG parks	No	No	Excellent	Complete
SEUG	Base Carto	DRG	Index of 1:100 topos around SEUG parks	No	No	Excellent	Complete
SEUG	Base Carto	DRG	Index for USGS 1:24k topos for SEUG area	No	No	Excellent	Complete
SEUG	Base Carto	DRG	Index to 100k topos	No	No	Excellent	Complete
SEUG	Base Carto	DRG	Index to 250k topos	No	No	Excellent	Complete
SEUG	Base Carto	Hydro	458 pts.; wide area around SEUG, incl CARE	No	Yes	Good to Fair	Complete
SEUG	Base Carto	Hydro	watershed areas (HUCs), 5th & 6th level. 7 tiles.	No	No	Excellent	Complete
SEUG	Base Carto	Hydro	river through CANY, s of ARCH	No	Yes	Excellent	Complete
SEUG	Base Carto	Hydro	soil data	No	No	Poor	Complete
SEUG	Base Carto	Hydro	same as river_only, w/ land, extends further N	No	No	Good to Fair	Complete
SEUG	Base Carto	Hydro	Includes washes/dry channels? Off of DLG's	Yes	No	Good to Fair	Complete
SEUG	Base Carto	Hydro	CO and Green Rivers; includes land islands as features	No	Yes	Excellent	Complete
SEUG	Base Carto	Ownership	Land ownership around SEUG parks	No	Yes	Excellent	Complete
SEUG	Base Carto	Ownership	Moab area Administration/Ownership/Land Status .e00 file	No	No	Unknown	Complete
SEUG	Base Carto	Ownership	La Sal area Administration/Ownership/Land Status. .e00 file	No	No	Unknown	Complete
SEUG	Base Carto	Topography	contours, different than 90contour20	No	Yes	Good to Fair	Complete
SEUG	Base Carto	Topography	covers ARCH, CANY	No	Yes	Good to Fair	Complete
SEUG	Base Carto	Topography	Contours; also as shapefile.	No	Yes	Excellent	Complete
SEUG	Base Carto	Topography	Contours; also as shapefile.	No	Yes	Excellent	Complete
SEUG	Base Carto	Topography	20m contours; covers CANY, ARCH	No	Yes	Excellent	Complete
SEUG	Natural Resources	Mines	oil and mineral leases	No	No	Unknown	Complete
SEUG	Natural Resources	Plants, exotic/invasive	246 pts.	No	Yes	Unknown	Complete
SEUG	Natural Resources	Soils	soils, Grand County area.	Yes	No	Unknown	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
SEUG	Natural Resources	Vertebrates, general	1 polygon betw ARCH and CANY, attributed with "high use"	No	Yes	Unknown	Work in progress
SEUG	Natural Resources	Vertebrates, general	hab/non habitat	No	Yes	Good to Fair	Work in progress
SEUG	Natural Resources	Vertebrates, general	ranges w/in ARCH, CANY ('water', 'arches', '7 Mile Cyn', 'Isky/Potash', 'Needles/Lockhart Basin', 'Maze')	No	Yes	Good to Fair	Complete
SEUG	Natural Resources	Vertebrates, general	coded as 1 or 0; also as grid	No	Yes	Good to Fair	Work in progress
SEUG	Natural Resources	Vertebrates, general	coded as 1 or 0; also as grid	No	Yes	Good to Fair	Work in progress
SEUG	Natural Resources	Vertebrates, TES	Mexican Spotted Owl	No	Yes	Excellent	Complete
SEUG	Natural Resources	Vertebrates, TES	hab/non-habitat in ARCH, CANY	No	Yes	Good to Fair	Work in progress
SEUG	Natural Resources	Vertebrates, TES	432 pts, sightings in ARCH and CANY	No	Yes	Good to Fair	Work in progress
SEUG	Natural Resources	Vertebrates, TES	covers ARCH and CANY; coded 1 or 0	No	Yes	Good to Fair	Work in progress
SEUG	Park Infrastructure	Buildings	headquarters	No	No	Unknown	Complete
SEUG	Park Infrastructure	Roads	Potash Road	No	No	Excellent	Complete
SEUG	Park Infrastructure	Roads	Roads	No	No	Excellent	Complete
SEUG	Park Infrastructure	Roads	Hiking, paved, 4wd	No	No	Good to Fair	Complete
SEUG	Park Infrastructure	Roads	Roads off DLG's	No	No	Good to Fair	Complete
SEUG	Park Infrastructure	Utilities	7 towers with height and offset values	No	No	Excellent	Complete
SEUG	Park Infrastructure	Utilities	mostly ARCH, some CANY; coded 0,1	No	No	Good to Fair	Complete
SEUG	Park Infrastructure	Utilities	Antenna (base/repeater) locations, ARCH and CANY	No	No	Good to Fair	Complete
SEUG	Park Infrastructure	wilderness	Proposed wsa. South as far as NABR, east of CANY and ARCH.	No	Yes	Unknown	Complete
SEUG	Park Infrastructure	wilderness	BLM wilderness areas ? Attributed with 'data', 'blm-id', 'blm-name'. Same as aowsa, but no acres calculated	No	Yes	Unknown	Complete
SEUG	Park Infrastructure	wilderness	BLM wilderness areas ? Attributed with 'name', 'region', 'agency', 'blm-id'. Much blockier than aowsa; probably 1:500k scale..	No	Yes	Unknown	Complete
SEUG	Park Infrastructure	wilderness	BLM wilderness areas ? Attributed with 'data', 'blm-id', 'blm-name', 'acres'.	No	Yes	Unknown	Complete
SEUG	Park Infrastructure	wilderness	Aopw1 includes labeled attributes; otherwise very similar, and I'm not sure what the geographical differences mean.	No	Yes	Unknown	Complete
SEUG	Resource/Stressor Monitoring	Monitoring, vertebrates	GPS'd April - June, 2000; unknown use	No	No	Excellent	Complete
SEUG	Resource/Stressor Monitoring	Monitoring, vertebrates	GPS'd May-June, 2000 CANY and HOVE coverage	No	No	Excellent	Complete
SEUG, CARE	Park Infrastructure	wilderness	Attributed w/ name, division. Awpw2 includes more area but has no labeled attributes	No	Yes	Unknown	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
Timpanogos Cave National Monument							
TICA	Base Carto	Boundaries	Also as shapefile, and in NAD83 folder	Yes	No	Excellent	Complete
TICA	Base Carto	DEM	30m DEM of TICA and wider area. Ti_30d_bnd = clipped to boundary	Yes	No	Excellent	Complete
TICA	Base Carto	DEM	10 meter DEM	No	Yes		Incomplete
TICA	Base Carto	DOQQ	color DOQQs	No	Yes		
TICA	Base Carto	DRG	uncollared DRG of TICA. Also collared DRG--q1521.tif	Yes	No	Excellent	Complete
TICA	Base Carto	Hydro	Misc. hydro - tinajas, ponds, etc.	No	Yes		
TICA	Base Carto	Hydro	From WRD - named stream segments	Yes	No	Good to Fair	Complete
TICA	Base Carto	Hydro	From WRD.	No	Yes	Excellent	Complete
TICA	Base Carto	Hydro	From WRD, appears to be dams and gaging stations around park.	No	No	Good to Fair	Complete
TICA	Base Carto	Hydro	small-scale hydro	No	No	Unknown	Complete
TICA	Base Carto	Hydro	From NPS website - section of Am. Fork Creek thru park as poly	No	Yes	Excellent	Complete
TICA	Base Carto	Topography	10 foot contours	No	Yes	Excellent	Complete
TICA	Miscellaneous	Misc	30 random points generated for I&M survey crews, summer 2001	No	No	Excellent	Complete
TICA	Natural Resources	Fire	fire (need details)	No	Yes		
TICA	Natural Resources	Geology	geology	Yes	No		
TICA	Natural Resources	Plants, exotic/invasive	weed locations	No	Yes		
TICA	Natural Resources	Plants, TES		No	Yes		
TICA	Natural Resources	Soils		Yes	No		
TICA	Natural Resources	Vegetation, general		Yes	No		
TICA	Natural Resources	Vertebrates, TES		No	Yes		
TICA	Natural Resources	Weather data	Climate monitoring stations	Yes	No		
TICA	Park Infrastructure	Buildings	From WRD data.	No	Yes	Good to Fair	Complete
TICA	Park Infrastructure	Fences	Fences	No	Yes		
TICA	Park Infrastructure	Parking lots	parking lots	No	Yes		
TICA	Park Infrastructure	Pullouts	Pullouts	No	Yes		
TICA	Park Infrastructure	Roads	From WRD data.	Yes	No	Excellent	Complete
TICA	Park Infrastructure	Trails	2 files, one from NPS website, one from WRD data	No	Yes	Excellent	Complete
TICA	Park Infrastructure	Utilities	utilities	No	Yes		
TICA	Park Infrastructure	Wilderness		No	Yes		
TICA	Resource/Stressor Monitoring	Monitoring, air quality	Air quality monitoring location	Yes	No		
TICA	Resource/Stressor Monitoring	Monitoring, sound	Sound monitoring location	No	Yes		
TICA	Resource/Stressor Monitoring	Monitoring, water quality	Monitoring station from WRD data.	No	Yes	Good to Fair	Complete

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
Zion National Park							
ZION	Base Carto	Boundaries	Also as shapefile, and in NAD83 folder	Yes	No	Excellent	Complete
ZION	Base Carto	Boundaries	RNA boundaries	No	Yes	Excellent	Complete
ZION	Base Carto	DEM	30m DEM, clipped to ZION	Yes	No	Excellent	Complete
ZION	Base Carto	DEM	10m DEM of ZION and area zion_10mdem = clipped to boundary	No	Yes	Excellent	Complete
ZION	Base Carto	DOQQ	Color DOQQs	No	Yes	Excellent	Complete
ZION	Base Carto	DRG	Index to 1:24k topos	No	No	Excellent	Complete
ZION	Base Carto	Hydro	HUC level 5. NWI data.	No	Yes	Excellent	Complete
ZION	Base Carto	Hydro	small-scale base hydro	No	No	Unknown	Complete
ZION	Base Carto	Hydro	Virgin River	No	Yes	Excellent	Complete
ZION	Base Carto	Hydro	Perennial streams	No	Yes	Excellent	Complete
ZION	Base Carto	Hydro	seeps & springs	No	Yes	Excellent	Complete
ZION	Base Carto	Hydro	water courses	No	Yes	Excellent	Complete
ZION	Base Carto	Hydro	HUC level 5, NWI data.	No	Yes	Excellent	Complete
ZION	Base Carto	Hydro	intermittent streams	No	Yes	Excellent	Complete
ZION	Base Carto	Hydro	Hydro; also in NAD83	No	Yes	Excellent	Complete
ZION	Base Carto	Ownership	ownership	No	Yes	Excellent	Complete
ZION	Base Carto	Ownership	public accessiblity	No	Yes	Excellent	Complete
ZION	Base Carto	Topography	Also in NAD83	No	Yes	Excellent	Complete
ZION	Base Carto	Topography	Contours	No	Yes		
ZION	Base Carto	Water bodies		Yes	No	Excellent	Complete
ZION	Base Carto	Water bodies		Yes	No	Excellent	Complete
ZION	Base Carto	Water bodies		Yes	No	Excellent	Complete
ZION	Miscellaneous	Misc	GPSed BLM Survey monuments	No	No	Excellent	Complete
ZION	Miscellaneous	Misc	Random points generated for I&M survey crews, summer 2001	No	No	Excellent	Complete
ZION	Miscellaneous	Misc	climbing areas	No	No	Excellent	Complete
ZION	Natural Resources	Fire	-unplanned fires greater than 10 acres.	No	Yes	Excellent	Complete
ZION	Natural Resources	Fire	unplanned fire ignitions	No	Yes	Good to Fair	Complete
ZION	Natural Resources	Fire	GPSed.	No	No	Excellent	Complete
ZION	Natural Resources	Geology	surficial geology	Yes	No	Excellent	Complete
ZION	Natural Resources	Plants, exotic/invasive	weed locations	No	Yes		
ZION	Natural Resources	Plants, TES		No	Yes		
ZION	Natural Resources	Soils	Third order soil survey data from NRCS.	Yes	No	Unknown	Complete
ZION	Natural Resources	Soils	cryptobiotic soils	Yes	No	Unknown	Complete
ZION	Natural Resources	Vegetation, general	Veg map	Yes	No	Good to Fair	Complete
ZION	Natural Resources	Vegetation, general	New vegetation map.	Yes	No	Excellent	Complete
ZION	Natural Resources	Vegetation, general	-thematic accuracy of 65.7%. Coverage developed from 1978 analog orthophotos.	Yes	No	Unknown	Complete
ZION	Natural Resources	Vertebrates, TES		No	Yes	Excellent	Complete
ZION	Natural Resources	Vertebrates, TES		No	Yes	Excellent	Complete
ZION	Natural Resources	Vertebrates, TES		No	Yes	Excellent	Complete
ZION	Natural Resources	Vertebrates, TES		No	Yes	Excellent	Complete
ZION	Natural Resources	Vertebrates, TES		No	Yes	Excellent	Complete
ZION	Natural Resources	Vertebrates, TES	GPSed data.	No	Yes	Excellent	Complete
ZION	Natural Resources	Vertebrates, TES		No	Yes	Excellent	Complete
ZION	Natural Resources	Vertebrates, TES	GPSed data.	No	Yes	Excellent	Complete
ZION	Natural Resources	Vertebrates, TES		No	Yes	Excellent	Complete
ZION	Natural Resources	Weather data	Climate monitoring stations	Yes	No		

Spatial Extent	Category	Theme	General Description	12 Basic?	NCPN Essential?	Quality	Status
ZION	Park Infrastructure	Buildings		No	Yes		
ZION	Park Infrastructure	Campsites	Back country campsites in Kolob Canyon.	No	Yes	Excellent	Complete
ZION	Park Infrastructure	Fences	Fences	No	Yes		
ZION	Park Infrastructure	Parking lots	parking lots	No	Yes		
ZION	Park Infrastructure	Pullouts	Pullouts	No	Yes		
ZION	Park Infrastructure	Roads	Roads from DOQs in ZION	Yes	No	Excellent	Complete
ZION	Park Infrastructure	Roads	paved roads in ZION	Yes	No	Excellent	Complete
ZION	Park Infrastructure	Roads	dirt roads in ZION	Yes	No	Excellent	Complete
ZION	Park Infrastructure	Roads	paved roads	Yes	No	Excellent	Complete
ZION	Park Infrastructure	Trails	trails	No	Yes		
ZION	Park Infrastructure	Utilities	power lines	No	Yes	Excellent	Complete
ZION	Park Infrastructure	Wilderness		No	Yes		
ZION	Resource/Stressor Monitoring	Monitoring, air quality	Air quality monitoring location	Yes	No		
ZION	Resource/Stressor Monitoring	Monitoring, sound	Sound monitoring location	No	Yes		
ZION	Resource/Stressor Monitoring	Monitoring, water quality	Monitoring station	Yes	No		

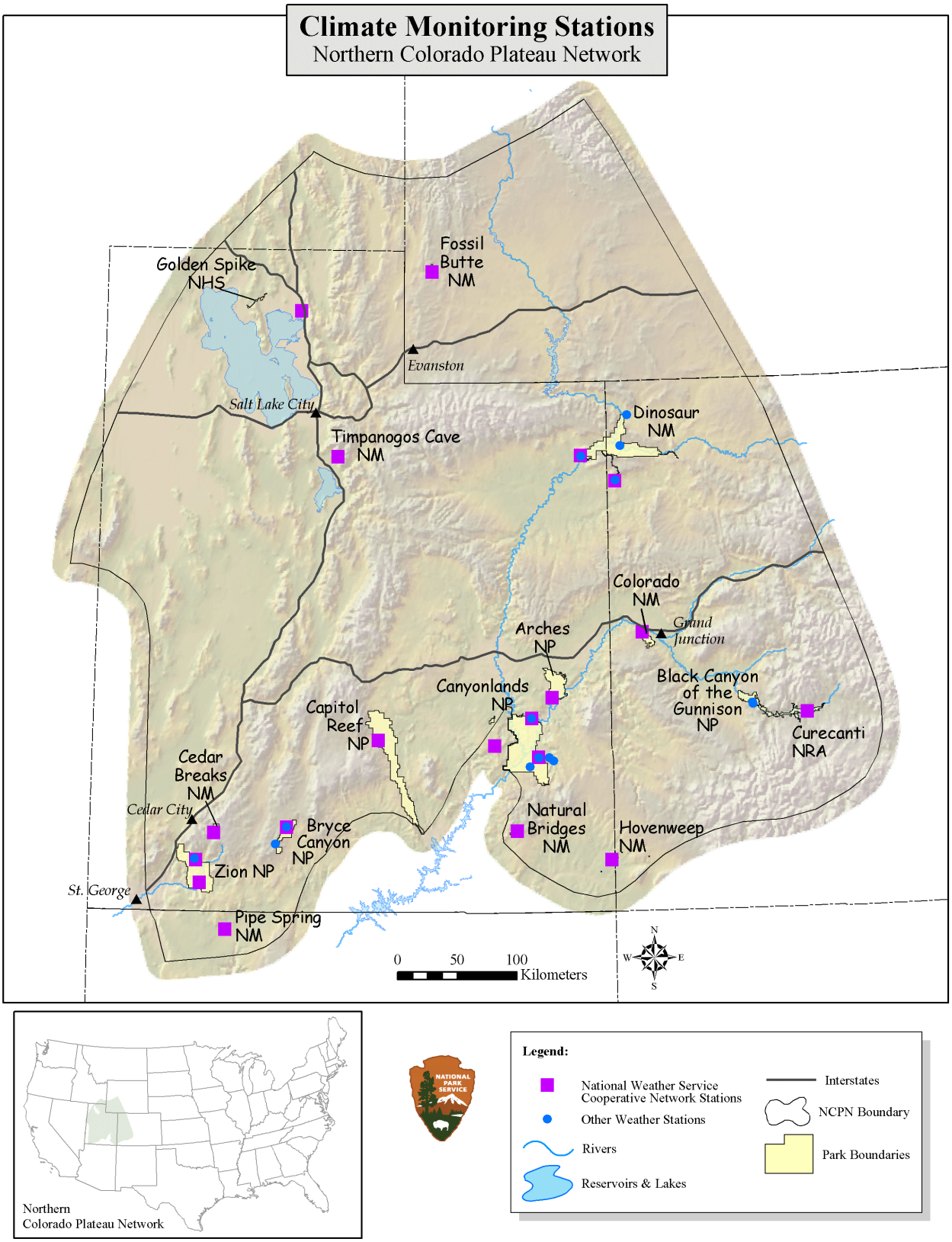
VOLUME 2, PART VI

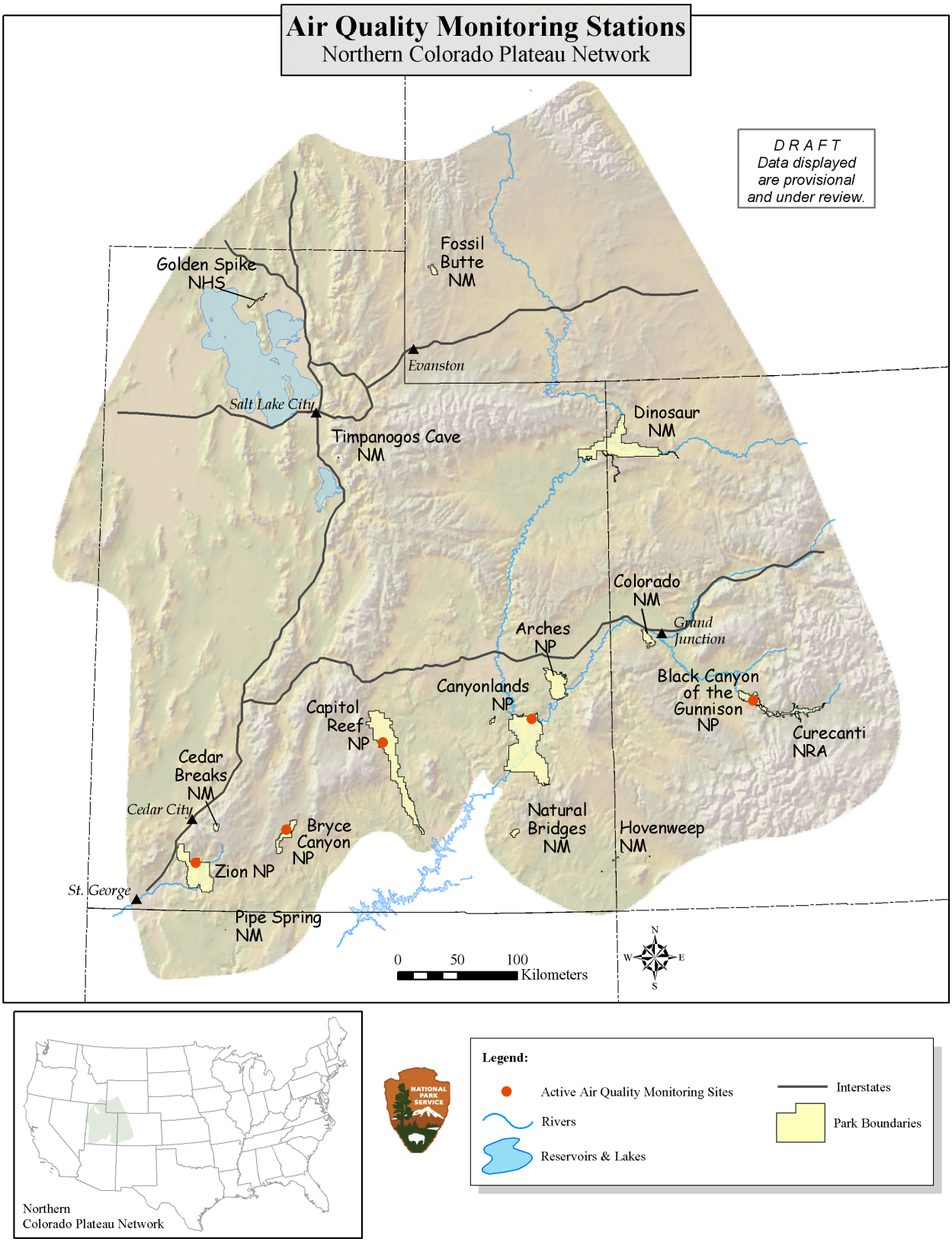
Sample Maps of Active Monitoring Locations in Northern Colorado Plateau Network Parks

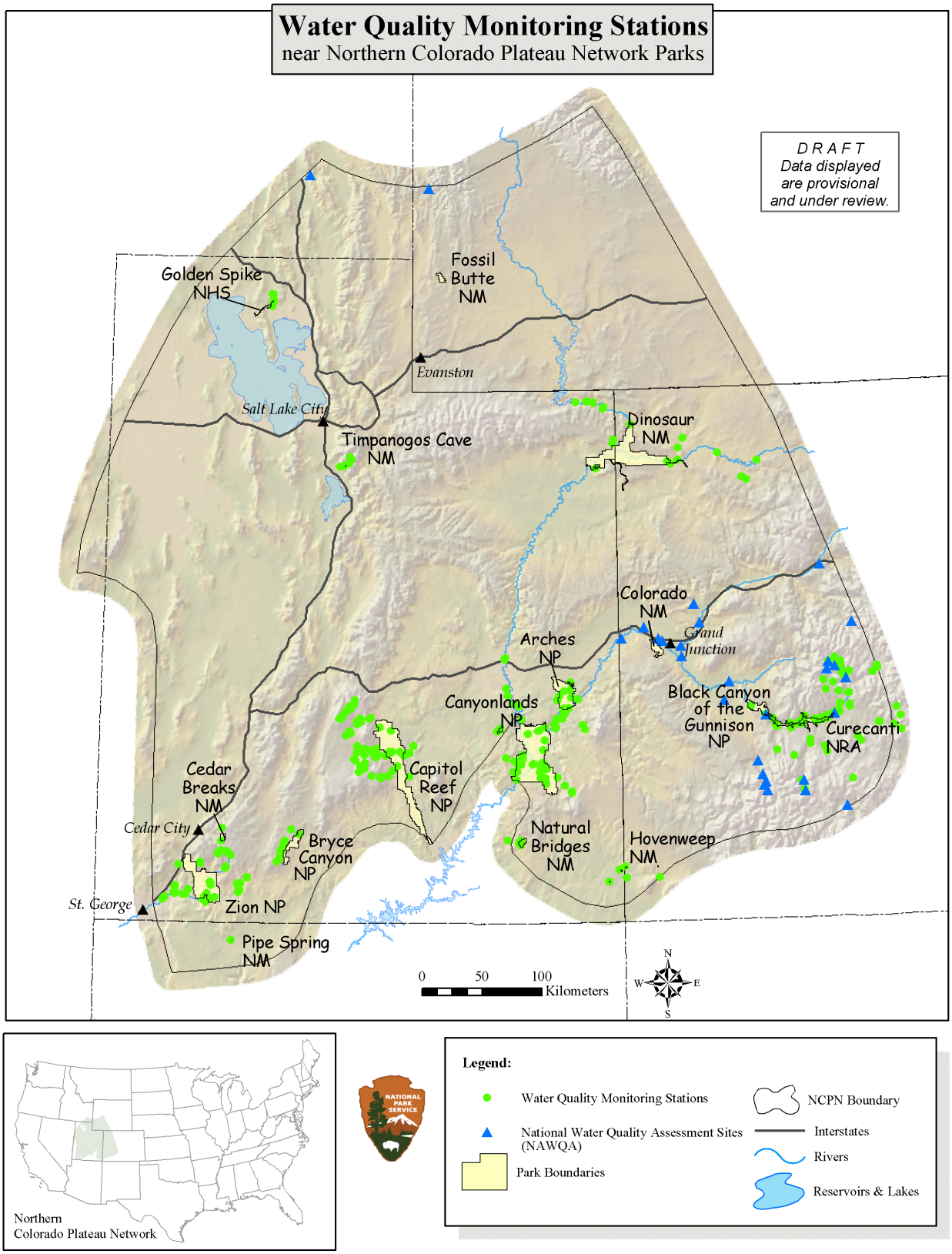
The following maps are examples of georeferenced monitoring locations in NCPN parks. The network will emphasize verifying and georeferencing additional locations in the upcoming year, and will link spatial files with corresponding tabular records in the Dataset Catalog.

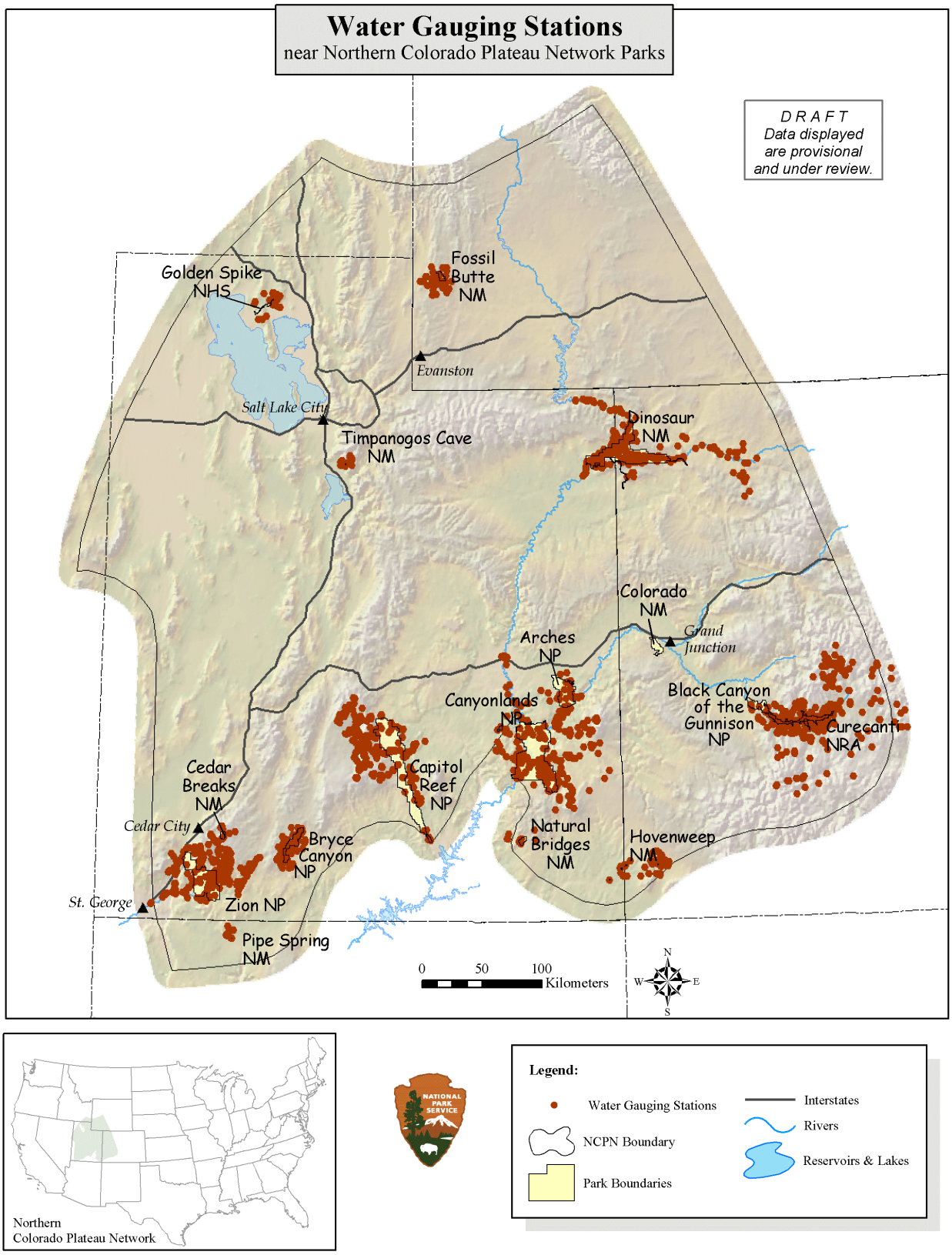
Part VI. Index **Page**

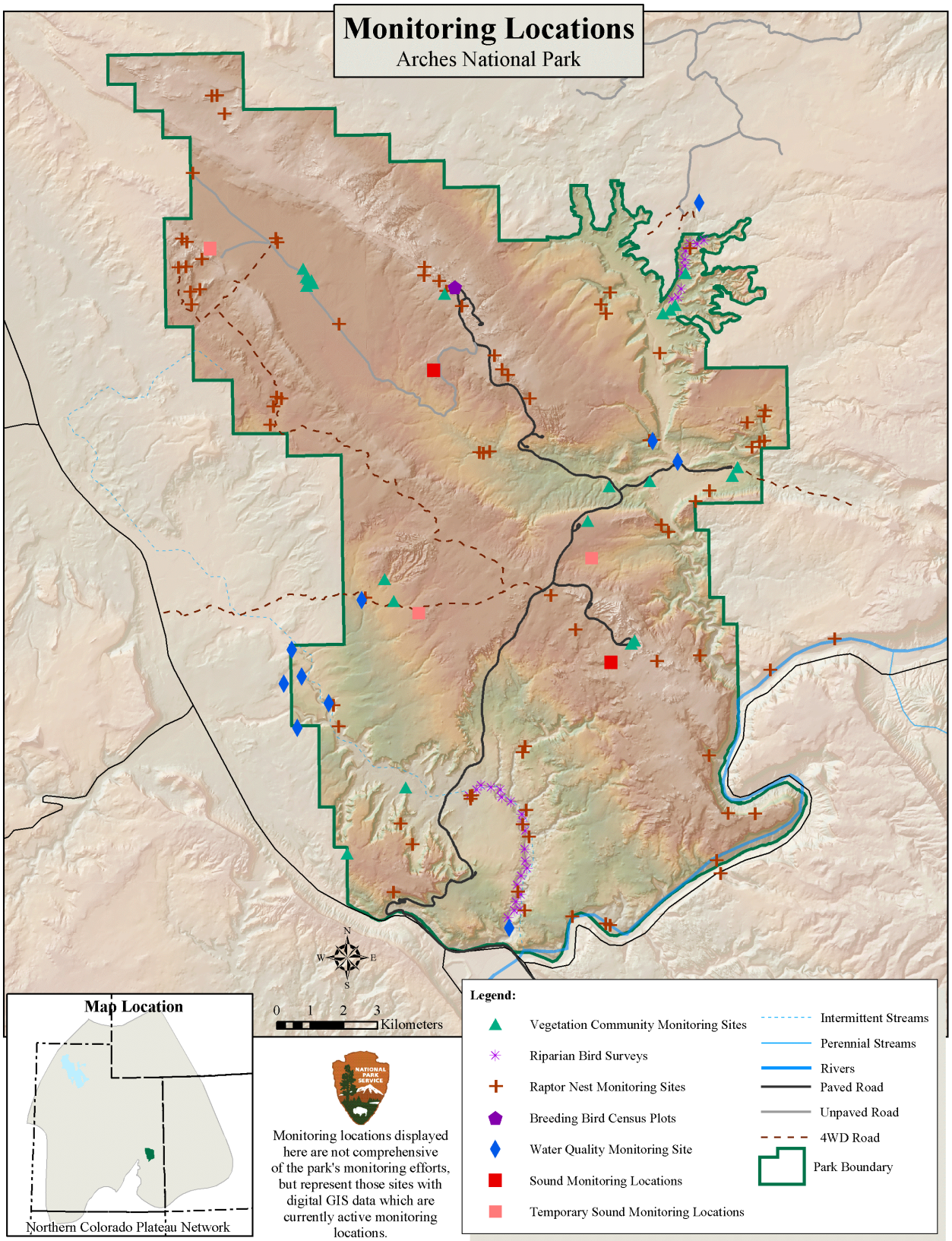
Climate Monitoring Stations in the Vicinity of Northern Colorado Plateau Parks	VI - 1
Air Quality Monitoring Stations Located in Northern Colorado Plateau Network Parks	VI - 2
Water Quality Monitoring Stations Located in or near Northern Colorado Plateau Network Parks	VI - 3
Water Gauging Stations Located in or near Northern Colorado Plateau Network Parks	VI - 4
Locations of Active Natural Resource Monitoring Projects in Arches National Park	VI - 5


Climate Monitoring Stations
Northern Colorado Plateau Network
Golden Spike NHS
Fossil Butte NM
Evanston
Salt Lake City
Timpanogos Cave NM
Dinosaur NM
Colorado NM
Grand Junction
Arches NP
Canyonlands NP
Black Canyon of the Gunnison NP
Curecanti NRA
Capitol Reef NP
Cedar Breaks NM
Cedar City
Bryce Canyon NP
Zion NP
St. George
Natural Bridges NM
Hovenweep NM
Pipe Spring NM
0 50 100 Kilometers
N
W
E
S
Northern Colorado Plateau Network
NATIONAL PARK SERVICE
Legend:
National Weather Service Cooperative Network Stations
Other Weather Stations
Rivers
Reservoirs & Lakes
Interstates
NCPN Boundary
Park Boundaries


Air Quality Monitoring Stations
Northern Colorado Plateau Network
DRAFT
Data displayed are provisional and under review.
Golden Spike NHS
Fossil Butte NM
Evanston
Salt Lake City
Timpanogos Cave NM
Dinosaur NM
Colorado NM
Grand Junction
Arches NP
Canyonlands NP
Black Canyon of the Gunnison NP
Curecanti NRA
Capitol Reef NP
Cedar Breaks NM
Cedar City
Bryce Canyon NP
Zion NP
St. George
Natural Bridges NM
Hovenweep NM
Pipe Spring NM
0 50 100 Kilometers
N
W
E
S
Northern Colorado Plateau Network
NATIONAL PARK SERVICE
Legend:
Active Air Quality Monitoring Sites
Rivers
Reservoirs & Lakes
Interstates
Park Boundaries


Water Quality Monitoring Stations
near Northern Colorado Plateau Network Parks
DRAFT
Data displayed are provisional and under review.
Golden Spike NHS
Fossil Butte NM
Evanston
Salt Lake City
Timpanogos Cave NM
Dinosaur NM
Colorado NM
Grand Junction
Arches NP
Canyonlands NP
Black Canyon of the Gunnison NP
Curecanti NRA
Capitol Reef NP
Cedar Breaks NM
Cedar City
Bryce Canyon NP
Natural Bridges NM
Hovenweep NM
St. George
Zion NP
Pipe Spring NM
0 50 100 Kilometers
N
W
E
S
Northern Colorado Plateau Network
Legend:
Water Quality Monitoring Stations
National Water Quality Assessment Sites (NAWQA)
Park Boundaries
NCPN Boundary
Interstates
Rivers
Reservoirs & Lakes


Water Gauging Stations
near Northern Colorado Plateau Network Parks
DRAFT
Data displayed are provisional and under review.
Golden Spike NHS
Fossil Butte NM
Evanston
Salt Lake City
Timpanogos Cave NM
Dinosaur NM
Colorado NM
Grand Junction
Arches NP
Canyonlands NP
Black Canyon of the Gunnison NP
Curecanti NRA
Capitol Reef NP
Cedar Breaks NM
Cedar City
Bryce Canyon NP
Natural Bridges NM
Hovenweep NM
St. George
Zion NP
Pipe Spring NM
0 50 100 Kilometers
N
W
E
S
Northern Colorado Plateau Network
Legend:
Water Gauging Stations
NCPN Boundary
Park Boundaries
Interstates
Rivers
Reservoirs & Lakes


Monitoring Locations
Arches National Park
N
W
E
S
0 1 2 3
Kilometers
Map Location
Northern Colorado Plateau Network
Monitoring locations displayed here are not comprehensive of the park's monitoring efforts, but represent those sites with digital GIS data which are currently active monitoring locations.
Legend:
Vegetation Community Monitoring Sites
Riparian Bird Surveys
Raptor Nest Monitoring Sites
Breeding Bird Census Plots
Water Quality Monitoring Site
Sound Monitoring Locations
Temporary Sound Monitoring Locations
Intermittent Streams
Perennial Streams
Rivers
Paved Road
Unpaved Road
4WD Road
Park Boundary