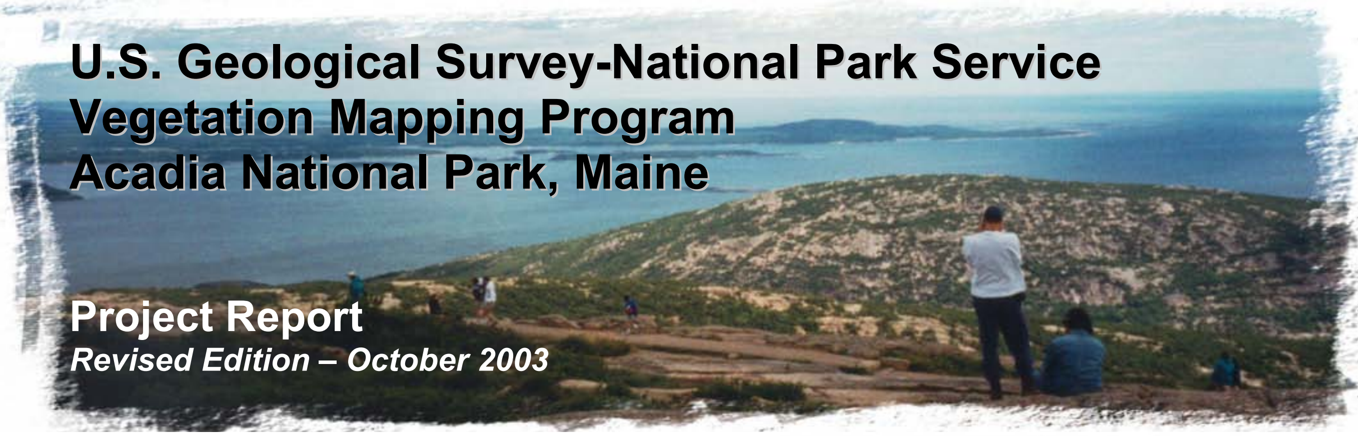
U.S. Geological Survey-National Park Service Vegetation Mapping Program Acadia National Park, Maine



Project Report

Revised Edition – October 2003

U.S. Geological Survey-National Park Service
Vegetation Mapping Program
Acadia National Park, Maine

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U.S. Geological Survey
Upper Midwest Environmental Sciences Center

and

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Brian Carlson tirelessly worked to convert field data into computer files accessible for analysis, and ensured attention to details. He also scanned slides and assisted with many tasks through the analysis phase of this project.
Sarah Evans converted the data into the proper format to match The Nature Conservancy (TNC) database and, along with Emily Pinkham, will be responsible for recording the presence of rare communities or selected examples of common communities into our Biological and Conservation Database. Emily also tracked the finances.
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by

Sara Lubinski, Kevin Hop, and Susan Gawler

Summary

The U.S. Geological Survey (USGS) is cooperating with the Inventory and Monitoring Program of the National Park Service (NPS) to classify, describe, and map vegetation for over 270 national park units. The USGS Upper Midwest Environmental Sciences Center (UMESC) in La Crosse, Wisconsin, The Nature Conservancy (TNC), and the NatureServe Eastern Regional Office, along with the Maine Natural Areas Program (MNAP), have completed mapping and classifying the existing vegetation in Acadia National Park (NP) and environs. The UMESC provided overall project coordination and compiled all project reports and data for distribution. The UMESC also organized the acquisition of aerial photographs; produced all digital spatial map coverages, including the interpretation of the aerial photographs and subsequent digital map automation; performed the accuracy assessment analysis of the vegetation map coverage; and prepared final project metadata and documentation discussing methods and results. TNC, NatureServe, and the MNAP provided ecological and vegetation support, vegetation field sampling (plot sampling and accuracy assessment), field data entry, and vegetation classification development (including association descriptions) based on the National Vegetation Classification System (NVCS). The USGS Center for Biological Informatics provided oversight to the project. Staff at Acadia NP contributed their botanical and ecological guidance, shared their management and research goals, and provided equipment support, housing, boat transportation, and personnel to help with field work.

The Federal Geographic Data Committee (FGDC) Vegetation Subcommittee has adopted the NVCS as the Federal standard for vegetation classification (FGDC 1997). The NVCS is used for describing the vegetation types and is the basis for mapping within the USGS-NPS Vegetation Mapping Program (VMP). It is an a priori classification that is continental in scope, and was chosen at the beginning of the program to ensure a balance between the needs of mapping local vegetation patterns within each park with the overall need to have consistency between parks. NatureServe and the Network of Natural Heritage Programs manage the NVCS, a system that emphasizes natural and existing vegetation.

Acadia NP was selected as one of several pilot parks to develop and refine the methodology and standards for the USGS-NPS Vegetation Mapping Program. The three basic components of this project are vegetation classification, vegetation mapping, and map accuracy assessment. Classifying and mapping the vegetation proceeded simultaneously as directed by the VMP, hoping to shorten the overall duration of

the project. Accuracy assessment followed classifying and mapping, and gives indication the shortcomings to classifying and mapping in a parallel method.

In Acadia NP, as in other national parks mapped for the VMP, extensive field sampling was conducted to understand the local expression of vegetation types of the park. Samples from 179 vegetation sampling plots were collected during 1997–99 field seasons throughout the project area and subsequently analyzed with previously collected plot data. Fifty-three natural/semi-natural vegetation communities (associations of the NVCS) are recognized and described in detail in this report.

The 53 vegetation communities are represented with 33 map classes. Fifty-eight map classes, including land use/land cover and park specific categories, were used to map Acadia NP and environs. Color infrared aerial photographs, collected in late May 1997 at a scale 1:15,840, were used for photointerpretation. Spring photography was chosen so fieldwork and mapping could begin that same year. Using spring photography limited the ability to map some NVCS vegetation types accurately. Photointerpretation data were manually transferred to orthophoto quadrangle maps (1:12,000-scale) and then digitally automated for use in geographic information systems (GIS).

The VMP standard for map accuracy of vegetation themes is 80%. Field data for accuracy assessment of the vegetation map were collected during the 1999 field season using a stratified random design based on map classes. Overall thematic map accuracy of the Acadia NP vegetation map is 80%; however, some individual map classes fell below the 80% accuracy requirement. Several factors contributed to low accuracy, of which the most critical were (1) map classes were developed before we had an understanding of corresponding vegetation types, resulting in confusing relations between the map classes and the vegetation associations; (2) not enough time in the field with the ecologists; (3) spring photography limited our ability to discern some vegetation types from others; and (4) Acadia NP abounds with compositionally heterogeneous communities with broad ecotones, and would be difficult to map regardless of the process. We provide several recommendations addressing these problems in the hope that future projects may proceed with greater efficiency and accuracy.

Products developed for the Acadia NP VMP include the following:

- This final project report, which includes methods, descriptions of vegetation types, vegetation key, map accuracy assessment results and contingency table, and map class description and visual guide
- Spatial database coverages of the vegetation map, observation points, vegetation field plots, accuracy assessment sites, flight line index, and other supportive GIS data
- Digital data files and hard copy data sheets of fieldwork including observation points, vegetation field plots, and accuracy assessment sites
- Aerial photographs of the project area (one transparency set and two contact print sets) and their corresponding interpreted overlays
- Hard copy flight line index of the project’s aerial photographs
- Representative ground photos of each vegetation community
- Graphics of all spatial database coverages, and map composition of the vegetation map
- Federal Geographic Data Committee compliant metadata to National Biological Information Infrastructure standards for all vegetation spatial database coverages and field work data
- CD-ROM containing reports, metadata, keys, classification lists, fieldwork data, spatial data, map composition, graphics, and ground photos

Introduction

Objective of the U.S. Geological Survey-National Park Service Vegetation Mapping Program

The USGS-NPS Vegetation Mapping Program (VMP) is a cooperative effort by the U.S. Geological Survey (USGS) and the National Park Service (NPS) to classify, describe, and map vegetation communities in more than 270 national park units across the United States. The goal of the VMP is to meet specific information needs identified by the NPS. The VMP, managed by the USGS Center for Biological Informatics in Denver, Colorado, is part of the NPS Inventory and Monitoring Program, a long-term effort to acquire the information needed by park managers in their efforts to maintain ecosystem integrity for all national park units that have a significant natural resource component. Vegetation maps and associated information support a wide variety of resource assessment, park management, and planning needs, and provide a structure for framing and answering critical scientific questions about vegetation communities and their relation to environmental processes across the landscape.

Program scientists have developed procedures to use existing data and to collect new data for classification, mapping, and accuracy assessment. Three major components essential to every mapping project are vegetation classification, vegetation mapping, and map accuracy assessment. Ecology and mapping teams work together to share knowledge and data and to resolve issues to carry out the procedures. Program products meet Federal Geographic Data Committee (FGDC) standards for vegetation classification and metadata and national standards for spatial accuracy and data transfer. Standards include a minimum mapping unit of 0.5 hectares (ha) and classification accuracy of 80% for each map class. Spatial data products include aerial photography, map classification, map classification and description key (<http://biology.usgs.gov/npsveg/overview.html>), spatial database of vegetation communities, hardcopy maps of vegetation communities, metadata for spatial databases, and complete accuracy assessment of the vegetation map. Vegetation information includes vegetation classification, dichotomous field key of vegetation classes, formal description of each vegetation class, ground photos of vegetation classes, and field data in database format.

Acadia National Park (NP) was selected as one of several pilot parks to develop and refine the methodology and standards of the Vegetation Mapping Program. Work in Acadia NP began in 1997. The major collaborators in this project have been The Nature Conservancy (TNC), NatureServe Eastern Regional Office ecological staff, Acadia NP Natural Resources staff, Maine Natural Areas Program (MNAP) ecological staff and contractors, and USGS Upper Midwest Environmental Sciences Center (UMESC) national park mapping staff.

The National Vegetation Classification System

The VMP uses the National Vegetation Classification System (NVCS) for mapping all parks. The NVCS was developed and implemented primarily by The Nature Conservancy (TNC) and NatureServe, and the network of Natural Heritage programs over the past 20 years (Grossman et al.1998). Additional support has come from Federal agencies, the Federal Geographic Data Committee (FGDC), and the Ecological Society of America. The NVCS has been adopted as the National Standard by the FGDC for vegetation mapping to ensure consistent classification of vegetation resources across regions. The use of a standardized national vegetation classification system and mapping protocol facilitate effective resource stewardship by ensuring compatibility and widespread use of the information throughout the NPS as well as by other Federal and state agencies.

The NVCS is a hierarchical system with physiognomic features at the highest levels of the hierarchy and floristic features at the lower levels. The physiognomic units have a broad geographic perspective and the floristic units have local and site-specific perspective (The Nature Conservancy and Environmental Systems Research Institute 1994a; Grossman et al. 1998).

The NVCS includes most existing vegetation, whether natural or cultural, but attention is focused on natural vegetation types. "Natural vegetation," as defined in The Nature Conservancy and Environmental Systems Research Institute (1994a), includes types that "occur spontaneously without regular management, maintenance, or planting and have a strong component of native species". "Cultural" vegetation includes planted/cultivated vegetation types such as orchards, pastures, and vineyards.

The physiognomic-floristic classification includes all upland terrestrial vegetation and all wetland vegetation with rooted vascular plants. The hierarchy has five physiognomic levels and two floristic levels (Table 1). The basic unit of the physiognomic portion of the classification is the "formation", a type defined by dominance of a given growth form in the uppermost stratum and characteristics of the environment (e.g., cold-deciduous alluvial forests). The physiognomic portion of the classification is based upon the United Nations Educational, Scientific, and Cultural Organization (UNESCO) world physiognomic classification of vegetation, which was modified to provide greater consistency at all hierarchical levels and to include additional types (Drake and Faber-Langendoen 1997).

Table 1. National Vegetation Classification System physiognomic-floristic hierarchy for terrestrial vegetation (from Grossman et al. 1998).

Level	Primary Basis For Classification	Example
Class	Growth form and structure of vegetation	Woodland
Subclass	Growth form characteristics (e.g., leaf phenology)	Deciduous woodland
Group	Leaf types, corresponding to climate	Cold-deciduous woodland
Subgroup	Relative human impact (natural/semi-natural or cultural)	Natural/semi-natural
Formation	Additional physiognomic and environmental factors, including hydrology	Temporarily flooded cold-deciduous woodland
Alliance	Dominant/diagnostic species of uppermost or dominant stratum	*Populus deltoides* temporarily flooded woodland alliance
Association	Additional dominant/diagnostic species from any strata	*Populus deltoides* - (*Salix amygdaloides*) / *Salix exigua* woodland

The floristic levels include alliances and associations. The alliance is a physiognomically uniform group of plant associations that share dominant or diagnostic species, usually found in the uppermost strata of the vegetation. For forested types, the alliance is roughly equivalent to the "cover type" of the Society of American Foresters. Alliances also include non-forested types.

The association is the finest level of the NVCS. The association is defined as "a plant community of definite floristic composition, uniform habitat conditions, and uniform physiognomy" (see Flahault and Schroter 1910 in Moravec 1993). Most schools of floristic classification have used this concept.

Ecological Setting of Acadia National Park

Acadia NP, the first national park to be established east of the Mississippi, is on the coast of Maine primarily in Hancock County (with outlying areas in adjacent Knox County) and encompasses almost 48,000 acres of granite-domed mountains, woodlands, lakes and ponds, and ocean shoreline. The park consists of a large portion of Mount Desert Island as well as some adjacent mainland and island tracts. Acadia consists of approximately 35,000 acres in fee (land held by government authority): 30,000 acres on Mount Desert Island, 3,000 acres on Isle au Haut, and 2,000 acres on Schoodic Peninsula (Patterson et al. 1983). Additional lands are held in conservation easements. With 3 million visitors per year, Acadia is one of the most heavily visited national parks (Figures 1 and 2). Lands donated between 1916 and 1929 form the core of the park, and smaller additions are still being made to its landholdings and easements. Mount Desert Island has an almost 300-year history of settlement, including extensive land clearing, and the peninsulas and other islands in Penobscot Bay have been likewise settled or at least used for pasture and/or timber for centuries.

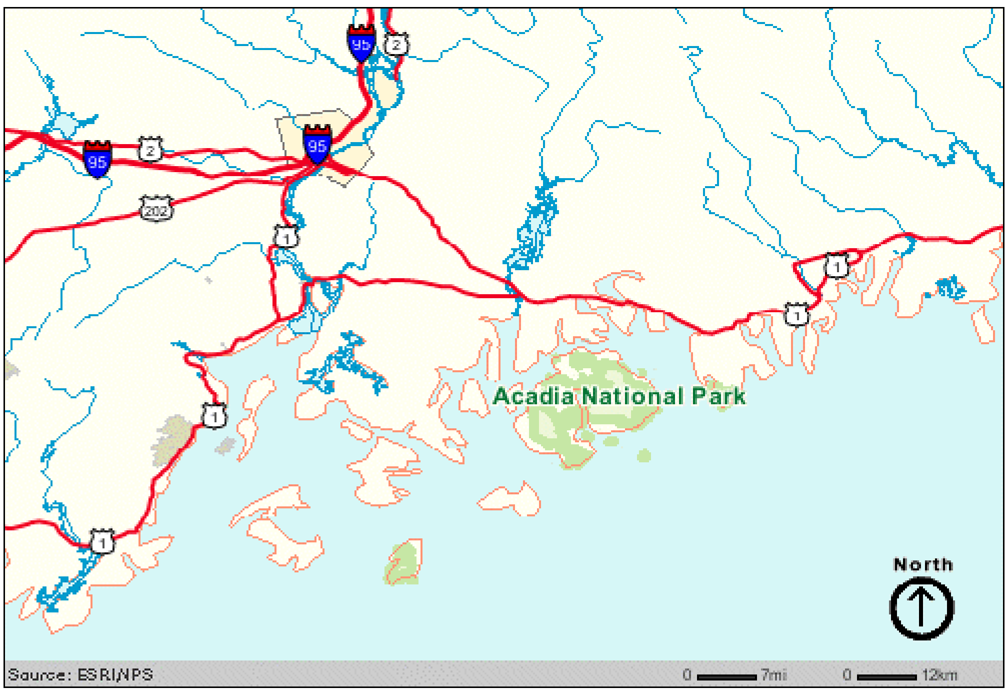

Figure 1. Acadia National Park with major highways marked on the mainland.

The lands within Acadia lie between 44º 12' and 44º 27' N latitude and between 68º 19' and 68º 27' W longitude. The maritime climate is cool and humid and fog is frequent, often lingering along the coast. At Bar Harbor, rain averages about 123 cm (49") annually, and snow about 1.5 m (5'); temperatures can range from -9º C (-16º F) in winter to 41º C (105º F) in summer, with a mean annual temperature (1940-1980) of 8º C (46º F; Patterson et al. 1983). The park lies at the western edge of the East Coastal biophysical region (McMahon 1990), which corresponds to the Maine Eastern Coastal subsection (in the Fundy Coastal and Interior section of the Laurentian Mixed Forest province) of the U.S. Forest Service ecoregion delineation (Keys et al. 1995).

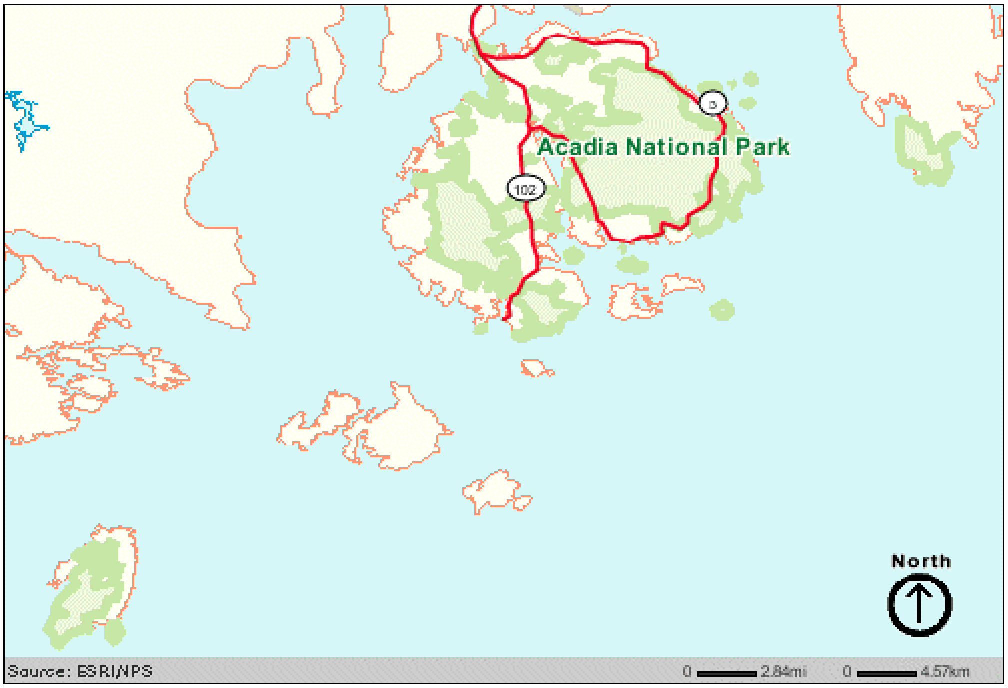

Figure 2. Acadia National Park with access and major roadways marked.

The landforms of Acadia NP are among the best-known features of the park and gave origin to the name Mount Desert Island (roughly, "Isle of the barren hills"). Glacial and post-glacial activity have left a series of north-south trending ridges separated by deep U-shaped valleys. (One of the valleys, Somes Sound, is the only fjord on the east coast of North America.) The ridges are rounded along their crests and extensive areas are treeless, standing out sharply above the predominant forest cover of the region. Areas of the park outside of Mount Desert Island have less rugged relief. Upland soils are mostly thin and granitic, with many areas of bedrock or talus where soil development is minimal at best. Wetlands are underlain by marine deposits or poorly drained tills and include both mineral soil and organic soil wetlands (Calhoun et al. 1994).

Acadia NP lies at the southern edge of Westveld's spruce-fir-northern hardwoods region (Westveld 1956). The vegetation reflects this transitional position with some areas more southern in character —pitch pine (*Pinus rigida*) woodlands, including areas of scrub oak on Acadia Mountain, at their northeastern range limit; or the *Ilex glabra* dominated fen on Isle au Haut reminiscent of Cape Cod and similar coastal plain areas. Other areas exhibit a boreal influence (headlands with *Rhodalia rosea* and *Iris setosa* or rocky woodlands with patchy cover of heaths and black spruce). Much of the undeveloped region is characterized by various expressions of spruce-fir forests or forests in transition toward spruce-fir forests. These have been described by Davis (1966) and Moore and Taylor (1927).

Fire is important to the Acadia NP vegetation. The famed 1947 fire (Figure 3) that burned most of the eastern side of Mount Desert Island is the most recent extensive fire, but evidence of past burns is present in trees and soils throughout the park (Patterson et al. 1983). Thus the present vegetation includes large areas of 50-year-old forest and woodland, as well as areas that have had a longer time since disturbance to develop. At Acadia, early- to mid-successional processes are superimposed on edaphic and topographic factors, all of which must be considered in dividing the vegetation into types and map classes.

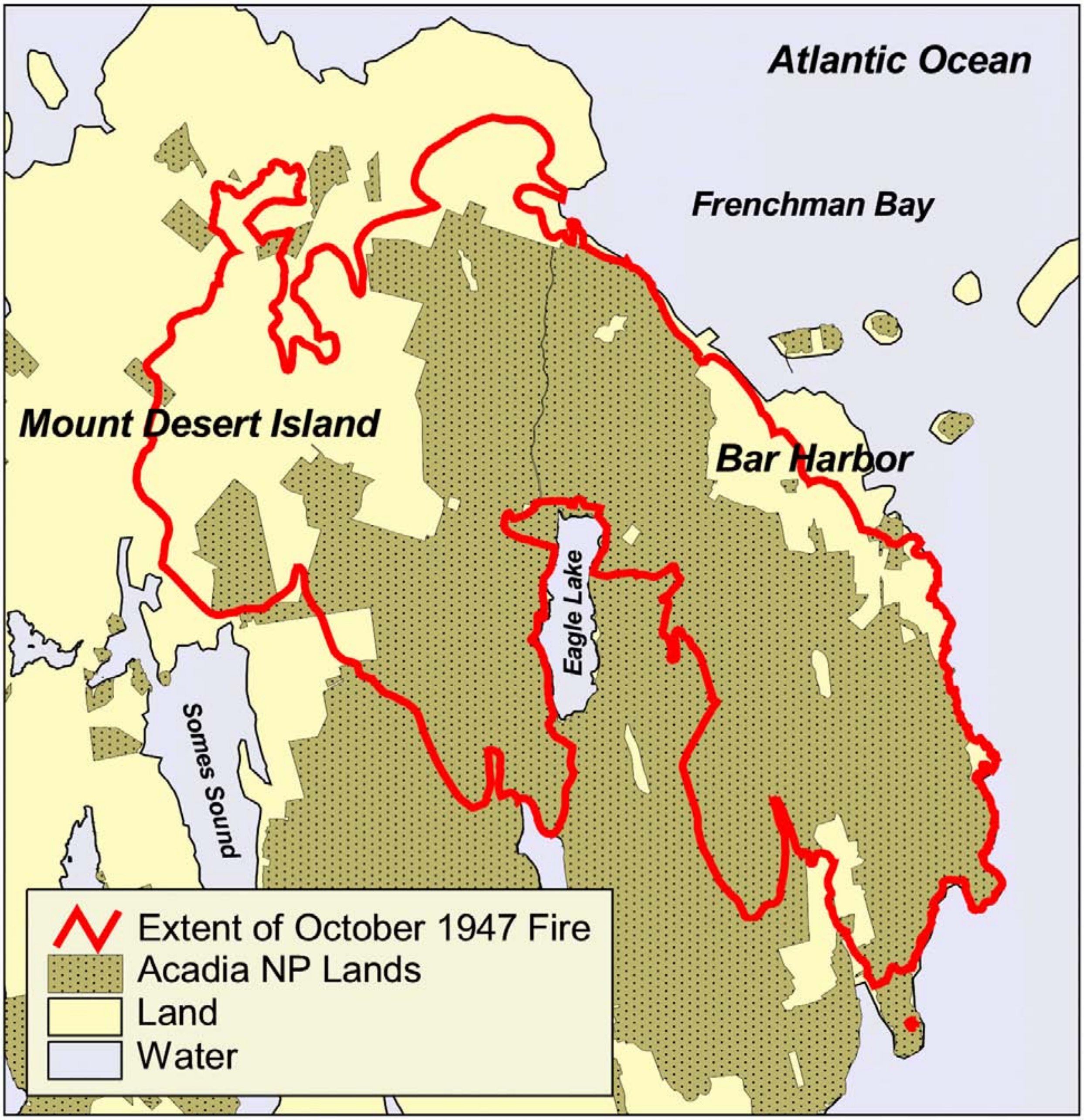

Figure 3. Mount Desert Island showing the extent of the October 1947 fire.

Previous Vegetation Studies

Acadia NP vegetation has long interested phytogeographers and ecologists, with published reports dating back over 100 years. The earliest publications are floras, notably those of Rand and Redfield (1894) and of Hill (1919). Hill (1923) subsequently went beyond the floristic approach to first describe the vegetation of the area, followed by Moore and Taylor's (1927) more extensive descriptions. These early descriptions reflect the prevailing Clementsian view of rather orderly vegetation development to a climax stage.

Kuchler (1956) mapped and described vegetation associations from the southeastern portion of Mount Desert Island (including areas that had burned in 1947) with dominant species and setting given for each. His work was instrumental in the earlier phases of this project, especially in developing the initial list of possible vegetation types for Acadia. Davis's monograph (1966 and references cited therein) on the spruce-fir forests of coastal Maine provides a useful picture of the predominant forests of the region, and remains a classic.

In the 1970s, Waggoner used aerial photos to map the vegetation of Mount Desert Island and developed a vegetation classification. Unfortunately, its utility was hampered by two factors: the emphasis on tree cover to the near exclusion of other layers, and the paucity of ground-truthing (on-site observation to verify and calibrate photointerpretation). Both are understandable, as this was the first attempt at a comprehensive map of the vegetation, and the scope of the task was perhaps not appreciated at the outset.

Recent vegetation work has focused on aspects of the park's flora or vegetation of particular interest. Patterson et al. (1983) spent many years studying fire regimes and fire-related vegetation on Acadia. Calhoun et al. (1994) mapped and described the wetlands of the region, using the U.S. Fish and Wildlife Service wetland classification methodology (Cowardin et al. 1979). Mittelhauser et al. (1996) studied the island flora, fauna, and forest composition. Aquatic plants have been inventoried throughout the park, although without detailed study of how the species are aggregated into vegetation types (Greene et al. 1997). These projects have provided useful compositional or ecological information on particular vegetation types described in this report.

The present report uses these previous works to inform the interpretation of our vegetation sampling, and in some cases, to provide information on types we did not sample. Resources allocated to this project were, however, insufficient to fully integrate the relevant pieces of these previous studies into this report and the type descriptions. Similarly, the geographic information system (GIS) based vegetation mapping presents an enticing opportunity for a more comprehensive analysis of vegetation patterns than in the past, but that was likewise not within the scope of this report.

Participants, Responsibilities, and Meeting Summary

The Acadia NP Vegetation Mapping Project is a cooperative effort among several agencies and organizations. The primary individuals and their roles are

USGS Center for Biological Informatics (CBI)
- Tom Owens - budgeting, program oversight (through December 2001)
- Karl Brown and Susan Stitt - budgeting, program oversight (beginning January 2001)

USGS Upper Midwest Environmental Sciences Center (UMESC)
- Kevin Hop - project management, map classification, quality control, and report writing and metadata
- Sara Lubinski - map classification, photointerpretation, accuracy assessment analysis, report writing
- Janis Boyd and Christine Calogero - digital spatial products

The National Park Service Inventory and Monitoring Program (NPS I&M)
Mike Story - budgeting, program oversight

Acadia National Park (ACAD)
David Manski - advisory re park management
Linda Gregory - botanist
Karen Anderson - advisory re digital spatial products

The Nature Conservancy, NatureServe and Maine Natural Areas Program (MNAP)
Jim Drake - project coordination
Mark Anderson and Lesley Sneddon - NVCS vegetation classification
Susan Gawler (MNAP) - vegetation sampling strategy, vegetation plots - vegetation data analysis, vegetation classification, primary field ecologist for UMESC mapping team
Jill Weber and Sally Rooney (contractors with MNAP) - vegetation plots and accuracy assessment data collection, and field assistants to UMESC mapping team.

The Acadia NP Vegetation Mapping Project formally began in March 1997 when personnel from Acadia NP, USGS CBI, USGS UMESC, TNC, and MNAP, in a planning (scoping) meeting at Acadia NP headquarters in Bar Harbor, Maine, organized the mapping project. Specific goals of the meeting were to review existing data, determine the mapping extent, discuss logistics and protocols, and assign tasks. Among the topics and tasks discussed were use of existing data, development of the classification and sampling strategy, data analysis, photointerpretation and digital map automation, determine extent of photography, and accuracy assessment process. Specific responsibilities and final products were assigned.

UMESC responsibilities and products:

- Facilitate project activities
- Perform field reconnaissance to learn photo signatures and local ecology, and to verify vegetation and land use/land cover appearances on the aerial photographs
- Develop map classes that link to the NVCS and other classification systems
- Assist TNC with information regarding the distribution and occurrence of vegetation types within the park
- Interpret and delineate vegetation and land use types using aerial photographs
- Transfer and automate interpreted information to produce a digital spatial database (in various formats) and hard copy vegetation maps
- Provide a photointerpretation mapping convention report and key
- Produce spatial coverages of all field data collection sites
- Provide accuracy assessment analysis and report results
- Provide a final report describing all aspects of the project
- Document FGDC compliant metadata for all vegetation data
- Provide a CD-ROM containing reports, metadata, keys, classification lists, fieldwork data, spatial data, map composition, graphics, and ground photos

TNC responsibilities and products:

- Develop a preliminary and final vegetation classification for the study area based on the NVCS
- Provide guidance to the photo interpreters regarding the ecology and floristic compositions of the vegetation types
- Design a sampling strategy to collect vegetation data
- Sample representative stands of the vegetation communities
- Provide vegetation descriptions and keys to vegetation communities

- Field test final classification, descriptions, and keys during accuracy assessment
- Collect accuracy assessment data
- Provide a PLOTS-generated database of vegetation field sample data and accuracy assessment field site data
- Provide documentation on field and analyses methodology and results

During the mapping project, ecologists and mappers held additional meetings and conducted fieldwork to collect the necessary information to classify the vegetation and interpret the aerial photographs. Table 2 summarizes these events.

Table 2. Summary of meetings and fieldwork for the Acadia National Park Vegetation Mapping Project.

Meeting/Field Trip	Locations	Purpose/outcomes	Participants
Scoping Meeting March 25-26, 1997	Acadia National Park Headquarters, Bar Harbor, Maine	Informed the park staff about the Vegetation Mapping Program. Learned about the park's management and science issues and concerns. Learned about existing data. Developed a preliminary schedule with assigned tasks. Started a process to define possible cooperation with neighbors. Defined a project boundary.	K. Anderson, M. Anderson, M. Blaney, T. Curtis, F. D'Erchia, S. Gawler, L. Gregory, K. Hop, D. Jones, D. Manski, T. Owens, N. Shaw, P. Super, G. Waggoner
Gradsect June 9-11, 1997	UMESC	GIS analysis using environmental data layers to determine biophysical diversity on MDI. Results used to plan vegetation sampling.	M. Bower, K. Hop, S. Gawler, L. Gregory, S. Lubinski, T. Owens
Field trip July 29-August 4, 1997	Schoodic Peninsula, Mount Desert Island, Isle au Haut	Confirmed existence of the vegetation types based on provisional community list, correlate the photo signatures with the appropriate vegetation types, and understand photo interpretation limitations. Forty-four vegetation types were visited.	M. Anderson, S. Gawler, L. Gregory, K. Hop, S. Lubinski, S. Rooney, J. Weber
September 1997	Mount Desert Island, Isle au Haut, Schoodic Peninsula	Continued correlation of photo signatures to appropriate vegetation types, verify earlier interpretation	S. Gawler, L. Gregory, K. Hop, S. Lubinski, S. Rooney, J. Weber
Field seasons 1997 and 1998	Acadia NP	Collected vegetation plot data for vegetation classification	S. Rooney, J. Weber
Spring 1998	UMESC	Reviewed and revised map classes to better align with vegetation types	M. Anderson, S. Gawler, K. Hop, S. Lubinski
June 22-July 2, 1998	Mount Desert Island, Bartlett Island	Continued correlation of photo signatures to appropriate vegetation types, verify earlier interpretation	S. Gawler, L. Gregory, S. Lubinski, S. Rooney, J. Weber
Field season 1999	Acadia NP	Finished collection of vegetation plot data and performed an accuracy assessment	S. Rooney, J. Weber

Methods

Aerial Photography Acquisition

Scoping meeting participants agreed to acquire aerial photography during spring 1997 so fieldwork and mapping could get underway the following summer and fall seasons. The UMESC and U.S. Army Corp of Engineers contracted with Aero-Metric, Inc. (Sheboygan, Wisconsin) to fly the photography mission and photos were collected May 27 and 28, 1997 (Figure 4, photo not to scale). An extended area was included in the photo mission to cover possible future easements. The photographs were 9 x 9-inch dia-positive transparencies from color infrared (CIR) film, collected with a 30% side lap (overlap between each flight line) and a 60% forward lap along each flight line to assure full area coverage and stereo viewing capability. Photo acquisition was at 7,920 feet above ground level with a lens focal length of 6 inches to obtain a scale of 1:15,840 (negative scale of 1 inch = 1,320 feet, or 4 inches = 1 mile). We collected 1,179 photos across 28 initial flight lines covering all park fee and easement lands and extended environs. An additional 37 photos were collected (a total of 1,216 photos) across 4 flight lines re-flown over the mountainous areas of Mount Desert Island to adjust the photo scale of the high mountain terrain. Two sets of contact prints were made from the original photo transparency film (one set for field sampling and one for mapping). The photo acquisition was successful in collecting all park fee and easement lands with extended environs (Figure 5). Two hundred thirty-nine aerial photographs were interpreted and used to produce the vegetation spatial database coverage for the Project.

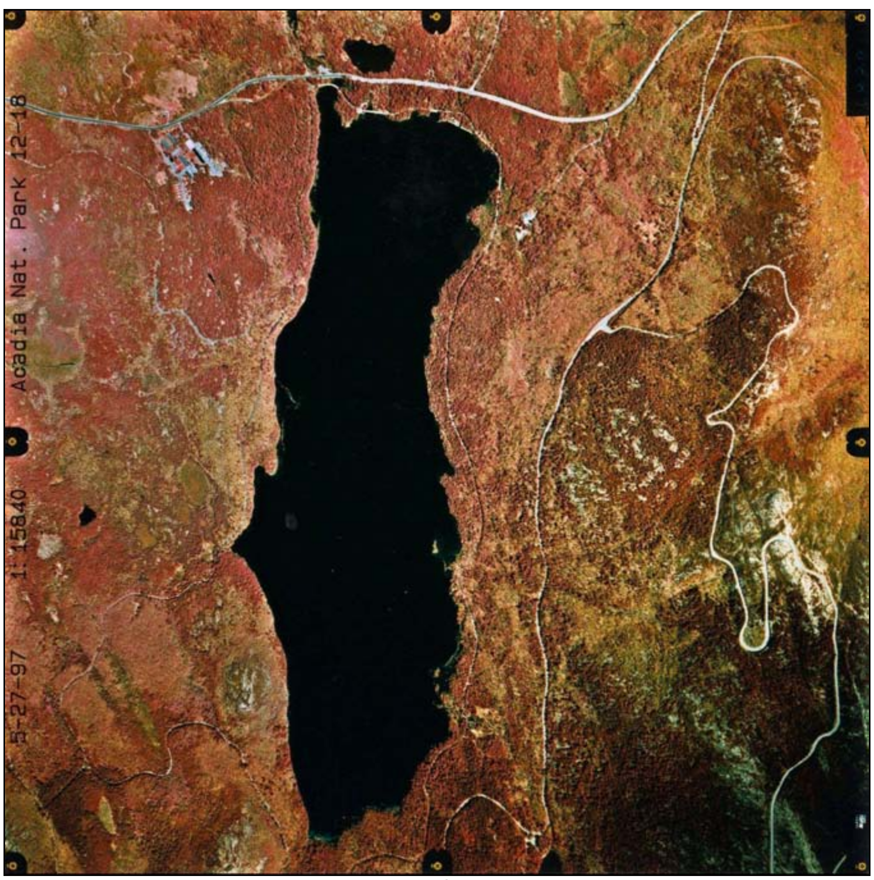

Figure 4. An aerial photograph collected for the Acadia National Park Vegetation Mapping Project.

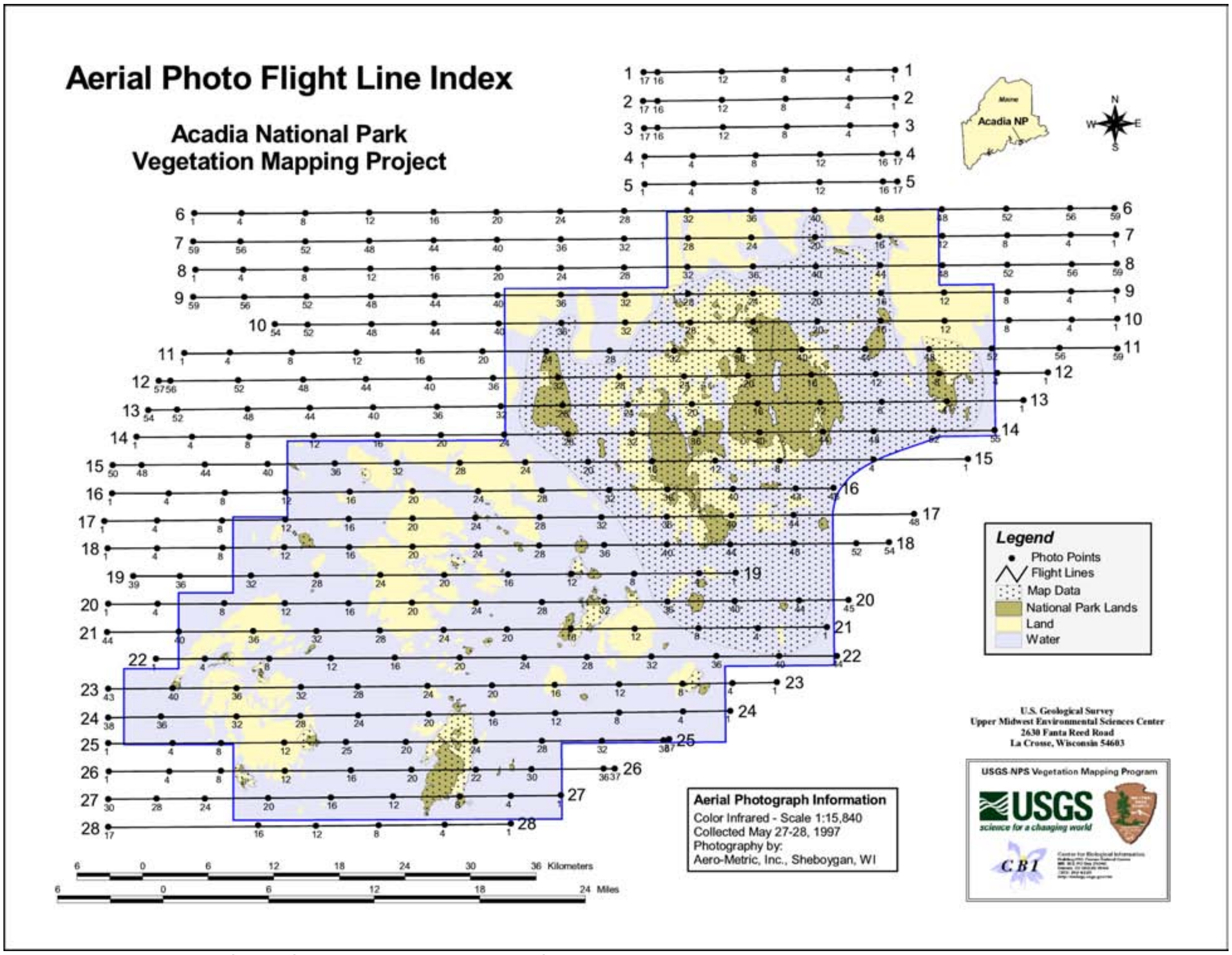

Figure 5. Flight lines flown for aerial photography of Acadia National Park and extended environs.

Fieldwork for Vegetation Classification Development

Vegetation samples were collected for subsequent analysis for defining and describing vegetation communities. Fieldwork planning to develop a strategy for vegetation sampling efforts at Acadia NP consisted of (1) developing a draft list of vegetation community elements for Acadia, (2) conducting a gradsect (gradient directed transect sampling) analysis of Mount Desert Island (MDI) to examine environmental gradients and help focus field efforts, and (3) a field reconnaissance visit (see online glossary of terms <http://biology.usgs.gov/npsveg/glossary.html>). Once a sound strategy was in place, vegetation sampling followed and strategy was adjusted as necessary.

Draft List of Vegetation Community Types

A draft list of 56 vegetation community elements (with cross-references between state and national names) was produced by ecologists from MNAP, TNC, and Acadia NP based on existing community records for MDI available at MNAP, an analysis of the 1956 Kuchler map and descriptions, and additional information and personal knowledge. We used the draft list of vegetation types primarily to grasp and understand the vegetation expressions at Acadia NP, providing a springboard to fieldwork planning and vegetation definitions. We also used environmental, topographic, and geologic information to develop a list of 23 landforms and cross-referenced each draft type to the landforms with which it was associated. Stratified by two additional factors, coastal-inland and 1947 fire - no fire, this list of landforms provided a conceptual model to which we could compare the results of the gradsect analysis.

Gradient Directed Transect (Gradsect) Sampling Analysis

Gradsect analysis took place at the UMESC on June 9-11, 1997. Gradsect analysis, a GIS technique, uses computerized data layers for a particular area, in our case MDI, to determine areas of greater and lesser biophysical diversity. The basic idea is that areas of higher physical diversity should be areas of higher vegetational diversity, and that focusing limited field time for sampling on these areas increases efficiency when one is trying to sample as many vegetation types as possible.

The utility of the results naturally depends on which variables are chosen. We reviewed the 20 available data layers and settled on five to use as variables (Table 3). We divided each variable into a number of classes. Because of computational and display limitations, we attempted to minimize the number of classes for each variable without losing too much information.

Table 3. Variables used in gradient directed transect sampling analysis.

Fire 1947	Soil Type	Elevation	Slope	Geology
no	not available	0 – 200' (0-60 m): lowland	<25% (0-15°): flat	undefined
yes	muck	201 – 600' (61-182 m): low hills	26-100% (15 – 45°): moderate	beach
	silt loam	601-1000' (183-303 m): medium hills	>100% (>45°): steep	salt marsh
	sandy loam	>1000' (>304 m): higher summits		talus
	very stony sandy loam			freshwater wetland
	loamy sand			exposed bedrock
	fine sandy loam			water
	very stony fine sandy loam			coarse emerged marine sediments
	bouldery complex			fine emerged marine sediments
	outcrop complex			undifferentiated emerged marine sediments
				glacial stream sediments
				end moraine
				till

Each cell of the MDI grid (cell size 70 m) was assessed for each variable, resulting in 224 unique combinations, here called biophysical units (BPU). Focal diversity (F) of each cell was calculated as the number of BPUs within a radius of five cells; values ranged up to 23. Areas of high physical diversity are thus areas with high F values. Two sets of gradsect maps resulted: plotting areas with $F \geq 10$ and plotting areas with $F \geq 15$. The 1979 vegetation type was overlaid to generally characterize the areas.

The maps were used with F ≥ 15 to translate the gradsect results into directions for field effort. This selected approximately 20 areas within the MDI portion of the park as areas of high focal diversity. We then used the BPU information accompanying the maps to determine which BPUs were not included within the selected areas, identifying conditions that should be sampled to assure representative coverage. These included saltmarsh; exposed bedrock on medium to high hills; near-coastal areas (emerged marine sediments); talus; and low, flat areas with muck or silt loam soils and without fire.

The areas highlighted by the gradsect analysis did not cover all of the characteristic ecological features of the MDI portion of Acadia. Had we restricted our field efforts to the gradsect-identified areas, we would have missed the bald summits of Acadia that, perhaps more than any other feature, characterize the park; we would have missed important wetlands, including saltmarshes; and we would have missed some interesting near-coastal areas that also support regionally characteristic vegetation. When gradsect is used as a screening tool, it also is essential to determine the conditions not included in the areas selected and adjust the field effort accordingly.

Field Reconnaissance

Reconnaissance in late July and early August 1997 allowed us to refine our efforts. We visited several dozen areas within the park to

- Refine the working vegetation classification system,
- Identify photo signatures for different communities,
- Check the gradsect-identified areas and determine where to sample, and
- Review the sampling protocol with the field ecologists.

Field Sampling

We sampled 179 areas, 63 in 1997, 107 in 1998, and 9 in 1999 during field data collection for accuracy assessment (Figure 6). Methods were derived from those in Section 5 of the Field Methods for Vegetation Mapping manual (The Nature Conservancy and Environmental Systems Research Institute 1994b). For Acadia NP, the plot sampling design was modified to make sampling congruent with other natural community sampling efforts in Maine while still compatible with the standards specified for this project (Table 4). The major difference was that rather than one large plot for a sample, we used four smaller subplots and nested subplots within those for the different vegetation layers. This we found to lessen plot location bias, incorporated more of the within-community variability, and reduced observer bias in cover estimates.

The initial step for a sample (hereafter referred to as a “plot” even though it consists of four subplots) is locating the center of the sampling area. This is the point at which the GPS reading is taken and from which the subplots radiate (Figure 7). For communities not dominated by trees, the layout is the same, with the largest subplot corresponding to the tallest layer. In a shrub swamp, for example, four 25-m^2 subplots with nested herb plots would be the sample. In a peatland community dominated by dwarf shrubs and herbs, the sample would be 16 1-m^2 subplots, 4 in each of the cardinal directions from the plot center point. Additional specifications are that, where possible, the outer edges of the subplots be at least 30 m from the edge of the community polygon; but in communities wherein the shape does not allow placing the four subplots in the cardinal directions, subplots may be placed four-in-line.

Recording of percent cover for each species also differs somewhat from the method recommended in the manual. For the tree layer, all diameters (dbh, diameter at breast height) are recorded by species, allowing calculation of basal area values. Relative dominance (RD) is calculated for each species as the percentage of the total basal area made up of that species. Percent cover of each species is derived as the relative dominance of a species times the total cover of the canopy.

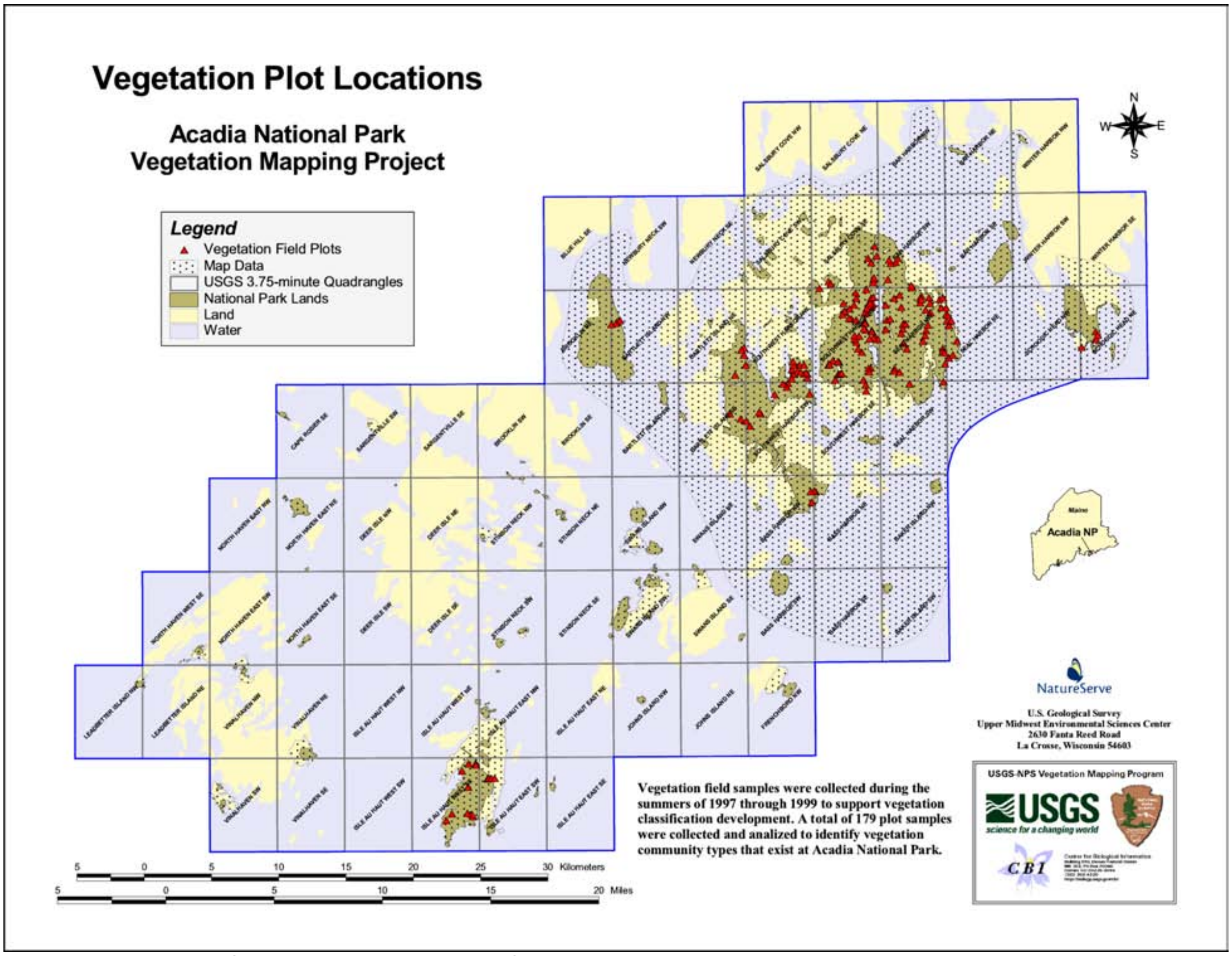

Figure 6. Locations of vegetation plots sampled for the Acadia National Park Vegetation Mapping Project.

Table 4. Vegetation data layers collected with each sample plot.

Layer	Description
Tree	woody stems ≥ 10 cm dbh (diameter at breast height)
Sapling / tall shrub	woody stems < 10 cm dbh and > 3 m tall
Shrub	all woody plants 1 – 3 m tall
Herb	all vascular plants < 1 m tall (segregating woody plants from herbs)
Bryoid	bryophytes and lichens on the ground

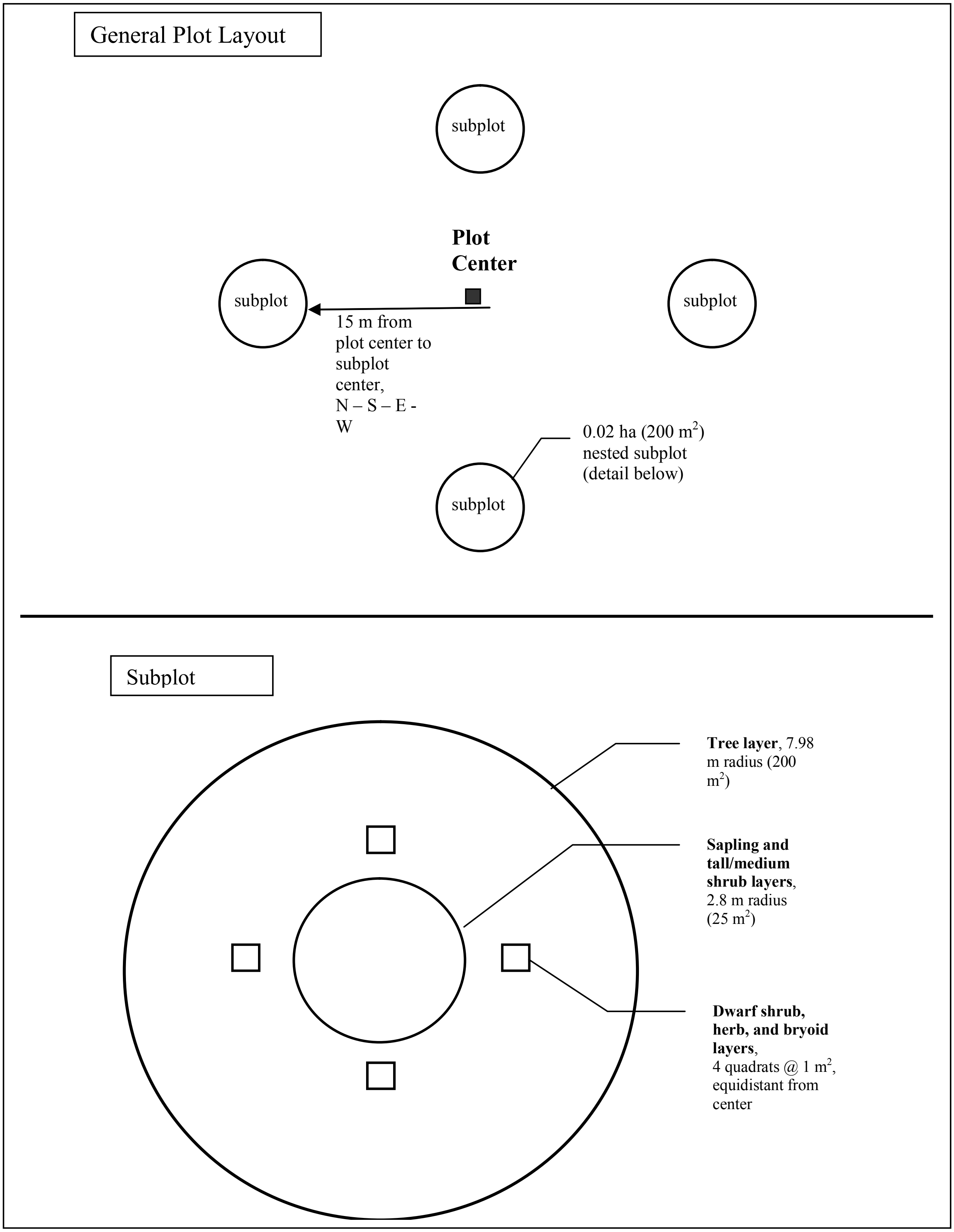

Figure 7. Plot sampling layout for the Acadia National Park.Vegetation Mapping Project. Plots without a tree canopy used the same design, but without the 200 m^2 outer subplot.

Within each layer below the tree layer, cover class midpoint is recorded in each subplot for each species (Table 5). After trying various cover estimations and permutations of classes, we settled on a 7-point cover scale with which our field crews were accustomed, similar to the Braun-Blanquet scale but omitting sociability.

Table 5. Cover class 7-point scale.

Percent cover	Cover class midpoint
<2	1
2–5	3
6–12	9
13–24	19
25–49	37
50–74	63
75–100	87

Subplot cover midpoints are averaged for the whole plot. Four values are averaged for tree, sapling, and shrub layers and 16 for herb and bryoid layers. Zeros are included for subplots wherein the species is absent. The species average can be used as a cover value on other scales (e.g., it can be entered as the nearest class midpoint on the 12-point scale in the mapping manual. Environmental data were collected in the vicinity of the overall plot center (the GPS point), following the methods given in the manual.

Vegetation Data Analysis for Vegetation Classification Development

Vegetation field sampling data were entered into a modified version of The PLOTS Database (The Nature Conservancy 1997) at the Maine Natural Areas Program, which (after checking the data for accuracy) was used to produce plot vegetation summaries and associated environmental information. Along with the 179 samples collected specifically for this project were 38 additional samples collected in 1995 as part of the Maine Ecological Reserves inventory (which followed a congruent data collection method) for a total of 216 complete plots. Tree layer information was available for an additional 33 plots sampled by Mittelhauser et al. (1994); these data were not used in the ordinations but were helpful in developing the descriptions.

Percent cover data for each plot were exported as matrices (species by samples) for multivariate analysis in PC-ORD 4.0 (McCune and Mefford 1999). MS Excel was used as an intermediate tool to prepare the matrices for compatibility with PC-ORD.

To analyze vegetation patterns and classify types, we used Detrended Correspondence Analysis (DCA), Two-Way Indicator Species Analysis (TWINSPAN), and Indicator Species Analysis (ISA) within PC-ORD. An ordination technique, DCA arranges samples along derived axes according to compositional similarity. A divisive polythetic technique, TWINSPAN classifies samples and species, using a similar algorithm to that for DCA. The ISA identifies indicator species for user-defined groups of samples (in this case vegetation types) by calculating an indicator value based on a species' abundance and frequency in each of several defined groups, then using a Monte Carlo test to determine those that are significantly allied with one group as opposed to randomly distributed. Further references for all techniques can be found in the PC-ORD documentation (McCune and Mefford 1999).

Data for each plot were relativized so that the cover values for the plot totaled 1 (relativization by the maximum by sample); this removed variation due to differences in total amount of vegetation among plots and resulted in clearer ordinations.

Different matrices were used for different subsets of the data, such as all upland forests and woodlands, all non-forested non-tidal wetlands, all tidal wetlands, etc. Progressive analyses, looking at a larger matrix for general patterns and then deriving submatrices for more detailed analyses, allowed the identification of larger and smaller groups of community types. For each samples-by-species matrix, a secondary matrix (samples by associated variables) contained additional information for interpreting the ordinations. These secondary variables included environmental measures such as slope, aspect, elevation, topographic position, hydrologic regime, soil texture and drainage, latitude, and longitude, as well as summary variables such as the total coverage of each vegetation layer in the sample, the relative importance of dwarf shrubs versus herbs, and the percent of conifer versus deciduous trees in the canopy.

Defining vegetation types was an iterative process with the following steps:

- Overlay DCA ordinations with vegetation type as assigned in the field;
- Use those to look for gross patterns, environmental gradients, and to look for possibly misassigned samples;
- Recode samples' vegetation type where needed and re-plot the DCA;
- Run TWINSPAN and plot results onto the DCA ordination to see how the major TWINSPAN breaks correspond to the evolving vegetation type differences;
- Further refine type assignments, and split data set for further ordinations, based on TWINSPAN distinctions and on review of compositional similarities of closely plotted samples;
- Run DCA on smaller data sets to try for better discrimination among the messy types, and use TWINSPAN to look for indicators;
- Recode samples' vegetation type as appropriate; and
- Re-run DCA and TWINSPAN with final vegetation type assignments and apply ISA.

A single technique such as TWINSPAN can give useful results when dealing with a relatively small group of vegetation types to classify and where reasonably comprehensive data are available. With a project of this scale, however, dealing with all vegetation types within the park, and with far fewer than the 10 samples per type average recommended in the manual, multiple techniques are combined to identify vegetation types. The vegetation types derived do not necessarily perfectly match those that TWINSPAN would produce from the data at hand. Instead, ordination and classification results are used to identify important gradients or factors in the data, which are then used to develop diagnostics for different vegetation types. Once types have thus been refined, DCA can be re-run to show the relations and overlaps between vegetation types, and ISA can be used to determine which species are most diagnostic for particular types.

Whereas vegetation types were being developed and refined from the sample data, reference to the NVCS (Anderson et al. 1998) had to be maintained. The required consultations with TNC regional ecologists to (1) determine if an existing NVCS type fit the Acadia type; (2) if no existing NVCS type matched, whether it made sense to refine an existing type or to create a new type; and (3) if a new type was indicated, to name and describe that type.

Mapping the Vegetation of Acadia National Park

The process of vegetation mapping involved four integrated primary steps, (1) field reconnaissance, (2) map classification, (3) photointerpretation, and (4) digital map automation.

Field Reconnaissance

Field reconnaissance helped us relate vegetative photo signatures (appearances of vegetation on the aerial photographs) to vegetation on the ground and become familiar with the local ecology, which is important when we apply ecological concepts to our photointerpretation mapping. This field effort required visiting numerous sites in the field to learn, test, and verify photo signatures. We collected 46 observation points (Figure 8) to verify vegetation communities and to document the relations between field and aerial photo perspectives. Ground coordinates were collected with Rockwell Precision Lightweight Global Positioning System Receiver (PLGR) GPS units. Formal data sheets were used to document the field participants, location information (including GPS coordinates), aerial photo relations (including photo signature), ground survey of plants, classification, and general observations and discussions about the site (Appendix A: Example of Observation Field Reconnaissance Form).

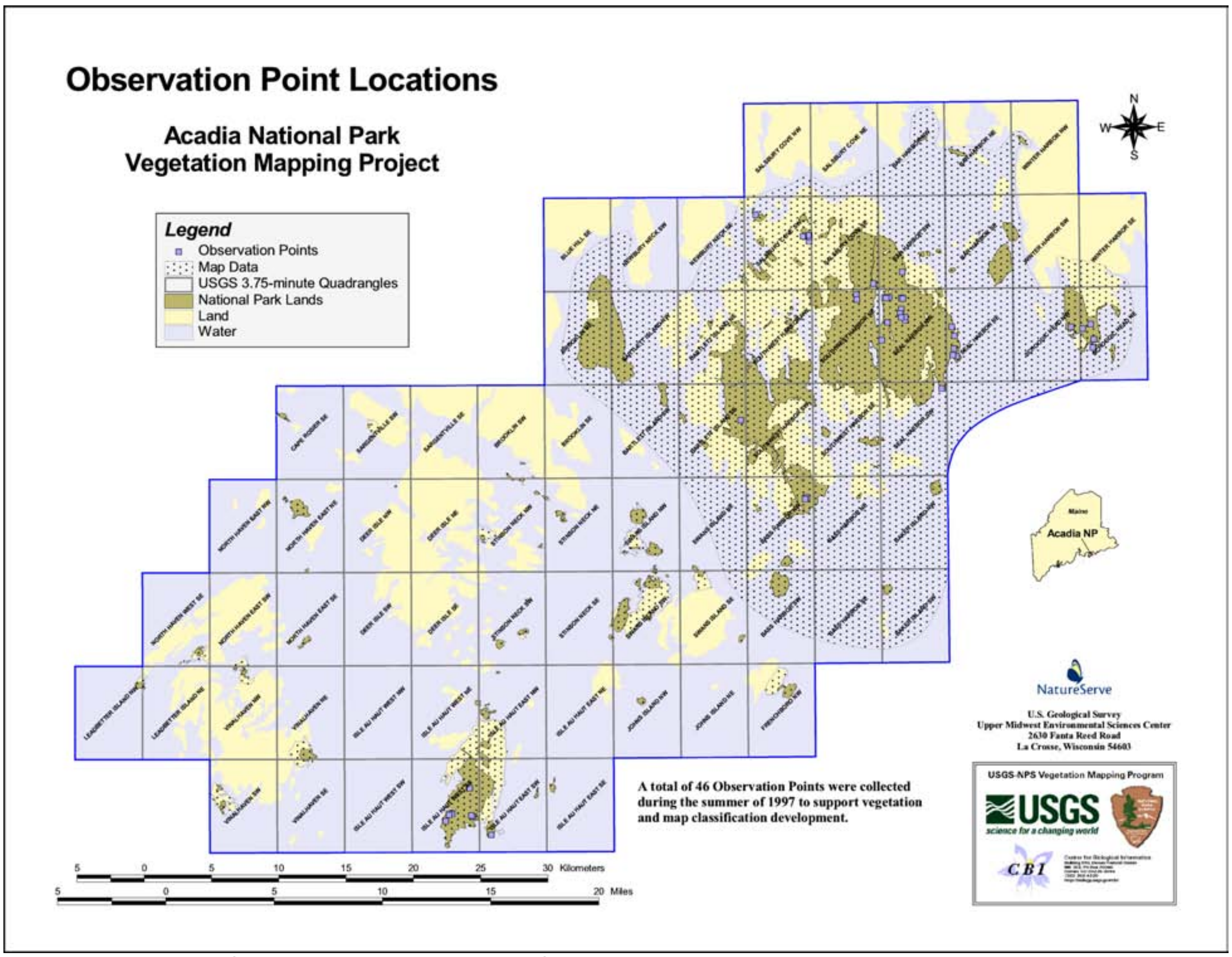

Figure 8. Locations of observation points collected for the Acadia National Park Vegetation Mapping Project.

Besides collecting formal reconnaissance data, we “ground-truthed” additional sites, documenting our discoveries on photo sleeves covering the print CIR photos and in field notebooks (Figure 9). Our field notes included dominant species (or the vegetation type, if known), tree heights, and other information that would help us link the photo signature to an appropriate map class. With the Acadia NP extensive trails and carriage roads, hiking was the primary mode of travel. However, some “ground-truthing” was done during frequent vehicle stops along roadsides with good vistas. Bicycles were another handy mode of travel on the carriage roads, with stops and short hikes to view signatures of interest. The park service also provided ferry service to Isle au Haut and Long Island, where we hiked to habitats of interest. The first reconnaissance trip was in June 1997, with two more trips in September 1997 and June 1998. During the last trip, we took some of the preliminary interpretation to validate in the field.

Figure 9. Field botanists and photointerpreters “ground-truthing” in Acadia National Park.

During our reconnaissance, we became familiar with the vegetation and local ecology, especially on days when we were accompanied by the ecologists. We discussed the structural, floristic, and habitat characteristics of the vegetation encountered in the field, and compared them to their appearances on the photos. We referred to the preliminary list of vegetation types, providing us some concept of their global (regional) characterization (local descriptions were developed after the mapping). Through this process, we built an understanding of how to map the vegetation types (or anticipated types). Two ecologists from TNC and NPS accompanied us on a few days of the fieldwork and were instrumental in helping us understand the vegetation patterns we encountered and their relations to the NVCS.

Map Classification

Following the initial reconnaissance trip, we began to define map classes (units that represent vegetation types or other ground features) based on further inspection of the aerial photographs. Using stereoscopes, we viewed photo signature characteristics to determine their relations to a list of vegetation types validated in the field. As determined from the initial scoping (planning) meeting, our fieldwork and photointerpretation mapping was to proceed simultaneously with vegetation sampling and subsequent analysis. We had to develop a map classification prior to having a complete understanding of the vegetation types. We relied on NVCS concepts and a draft list of vegetation communities as the basis for mapping vegetation of Acadia NP and environs.

During the early stages of photointerpretation, new questions surfaced regarding the map classes and we soon discovered that we could not always determine where to draw boundary lines between vegetation types. Thus, we organized a meeting at the UMESC with the mappers and ecologists in spring 1998 to help both parties understand the relations between photo signatures and vegetation types (Figure 10). This meeting was very helpful for all of us; the classifiers were able to better understand the challenges of applying the classification and the mappers were able to better understand how to interpret the vegetation types on the aerial photos. However, a final vegetation classification, key, and descriptions of each NVCS vegetation association were not available until after the mapping was completed.

Figure 10. Mappers and ecologists examine aerial photographs to understand vegetation appearance.

In addition to developing map classes to reflect NVCS types, we also developed map classes to represent other general land cover situations, such as urban areas and non-vegetated bodies of water. For these map classes, we used a combination of the USGS land use/land cover classification (Anderson et al. 1976) and some project-derived map classes.

Photointerpretation

Preparation of the aerial photographs for interpretation generally follows procedures of Owens and Hop (1995). We placed clear acetate overlays onto each aerial photograph transparency that would be used for mapping. We registered each overlay to the photos by demarking the fiducials and photo identification information. We viewed the aerial photo transparencies for interpretation using light tables and Bausch and Lomb Zoom 240 stereoscopes over a Richards MIM2 light table (Figure 11). We paired up each transparency photo with the adjacent photo so we could view the images 3-dimensionally. Only the middle portion of each photograph was used for photointerpretation to minimize edge distortion. We delineated feature polygons and scribed their corresponding map class codes onto the acetate overlays using Rapidograph ink pens.

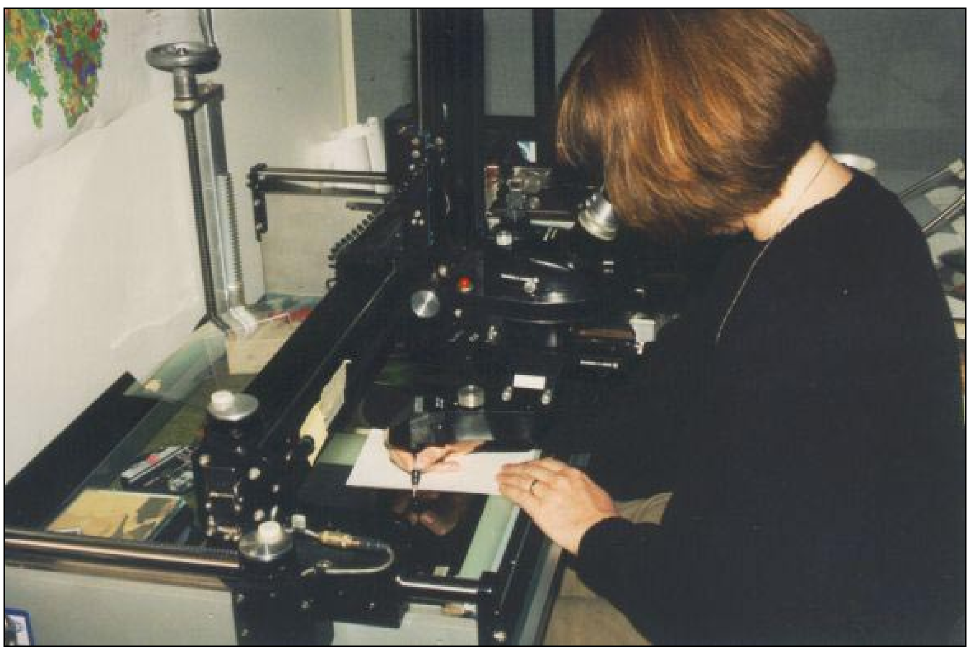

Figure 11. Bausch and Lomb Zoom 240 stereoscope over a Richards MIM2 light table.

We delineated larger polygons first, with smaller polygons following, down to a minimum size of 0.5 ha (with the exception of small islands within wetlands and ocean, which were mapped to a minimum size of 0.1 ha). We applied standard photo signature characteristics, including texture, color, pattern, and position in the landscape to guide our polygon delineation placement. In addition to photo signature characteristics, knowledge of the environmental distribution of the types helped us to identify vegetation types and properly place polygon boundaries. For each polygon, the appropriate map class code and physiognomic modifier codes (Table 6) were applied.

Table 6. Physiognomic modifiers assigned to polygons during photointerpretation.

Catagory	Modifier	Meaning
Coverage density	1	Closed Canopy/Continuous (60-100% cover)
	2	Open Canopy/Discontinuous (25-60% cover)
	3	Dispersed-Sparse Canopy (10-25% cover)
Coverage pattern	A	Evenly Dispersed
	B	Clumped/Bunched
	C	Gradational/Transitional
	D	Regularly Alternating
Height	1	30-50 meters (98-162 feet)
	2	20-30 meters (65-98 feet)
	3	12-20 meters (40-65 feet)
	4	5-12 meters (16-40 feet)
	5	0.5-5 meters (1.5-16 feet)
	6	<0.5 meters (<1.5 feet)

Digital Map Automation

To geo-reference the photo interpreted data, we used Bausch and Lomb zoom transfer scopes to manually transfer the polygons onto drafting film over base maps (Figures 12–13). The transfer process removes much of the aerial photograph's inherent distortion and ties the interpreted data to real-world coordinates so it can be digitally automated. Sixty-five USGS 3.75-minute digital orthophoto quadrangles (DOQ) were used to plot hard copy (film acetate) orthophoto base maps at a scale of 1:12,000 (Figure 14). The polygons were manually transferred to overlays that were registered to the base maps. Map class attributes and appropriate physiognomic modifiers were added to a second overlay. The overlays were subsequently rechecked for accuracy. Each overlay of transferred data was scanned using a large format sheet fed scanner with a resolution of 400 dots per inch (Figure 15). The resulting Tagged Image File Format (TIFF) images were then converted to a grid format using ArcInfo (Version 7.2.1 Patch 2, Environmental Systems Research Institute, Redlands, California). The grid data was projected to Universal Transverse Mercator (UTM), Zone 19 with datum in North American Datum of 1983 (NAD83). Each individual grid was transformed to a geo-referenced boundary coverage to digitally reference the data to real-world coordinates. In ArcTools, the ArcScan utility was used to trace the referenced polygon data creating an ArcInfo coverage. Each individual coverage was then edited for errors, assigned attributes to polygons, checked against the hand-transferred overlays for line and attribute errors, and then joined to create a seamless coverage of the vegetation map.

We originally produced the map attribute table in spreadsheet format (dBASE IV) with the items listed in Table 7. The attribute table contains numerous items that, when linked to the coverage, offers a set of information for each polygon. We converted the dBASE IV table to an ArcInfo table using ArcInfo (Version 8.0.2, Environmental Systems Research Institute, Redlands, California). We then merged the table with the spatial database coverage. In addition to the items listed in Table 7, ArcInfo default items are also included in the final map coverage (e.g., perimeter, area, and polygon identification numbers). ArcInfo was used to produce the ArcInfo Export and Spatial Data Transfer Standard files of the map coverage.

Figure 12. Transferring photointerpreted data to base maps using a zoom transfer scope.

Figure 13. Closeup of zoom transfer mapping process.

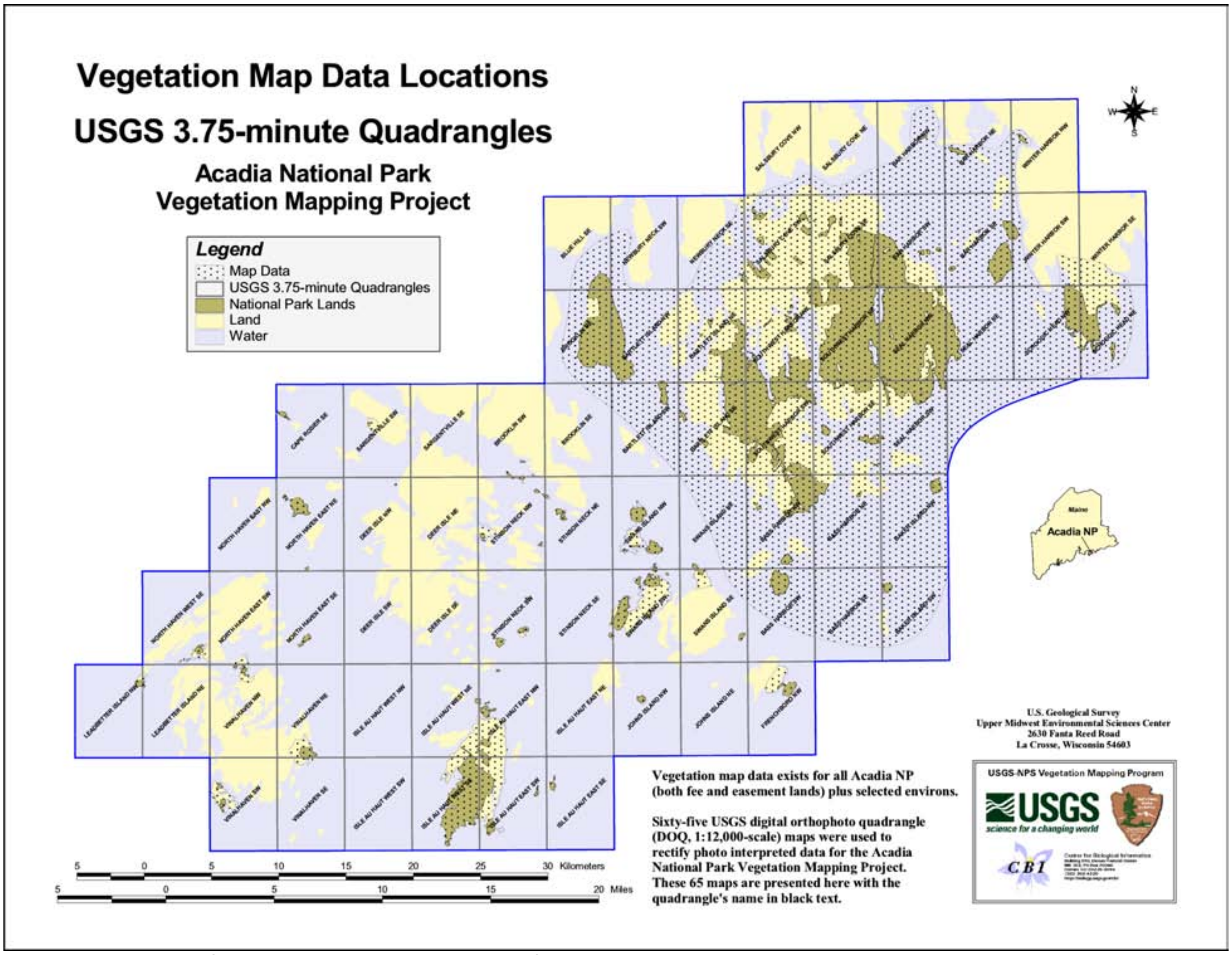

Figure 14. Extent of the vegetation map coverage for the Acadia National Park Vegetation Mapping Project.

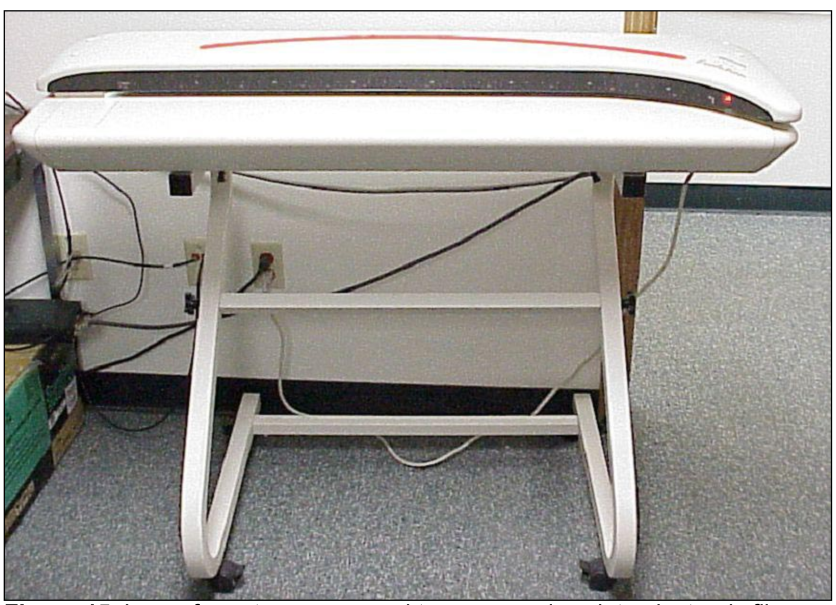
Figure 15. Large format scanner used to scan overlays into electronic files.

Table 7. Items included in the vegetation map coverage's attribute database table.

Code	Definition
MAP_CODE	Map Class Code - project derived
MAP_DESC	Map Class Description Name - project derived
MAP_ATT	Map Class Code with all applicable Physiognomic Modifier codes
DENS_MOD	Physiognomic Modifier - Coverage Density (all vegetation map classes)
PTRN_MOD	Physiognomic Modifier - Coverage Pattern (all vegetation map classes)
HT_MOD	Physiognomic Modifier - Height (woody terrestrial vegetation map classes)
PHYS_HYDR	Physiognomic - Hydrologic Category - Maine Natural Areas Program
MAINE_CLSF	Maine Natural Community Classification - Maine Natural Areas Program
ECO_SYSTEM	U.S. Terrestrial Ecological System Classification (name & code) - NatureServe
ASSN_SNAME	National Vegetation Classification System Association (scientific name) - NatureServe
ASSN_TNAME	NVCS Association (translated common name) - NatureServe
ASSN_CNAME	NVCS Association (synonym name) - NatureServe
ASSN_CEGL	Community Element Global Code (Elcode link to Association) - NatureServe
NVCS_CODE	NVCS Code (to Alliance level) - FGDC
CLASS	NVCS Formation Class (code & name) - FGDC
SUBCLASS	NVCS Formation Subclass (code & name) - FGDC
GROUP	NVCS Formation Group (code & name) - FGDC
SUBGROUP	NVCS Formation Subgroup (code & name) - FGDC
FORMATION	NVCS Formation (code & name) - FGDC
ALL_SNAME	NVCS Alliance Name (code & scientific name) - NatureServe
ALL_TNAME	NVCS Alliance Name (translated common name) - NatureServe
LUC_II	Land Use and Land Cover Classification System (code & name) - USGS

Accuracy Assessment

Purpose

The accuracy assessment estimates thematic errors in the data, providing users the information needed to assess data suitability for a particular application. At the same time, data producers are able to learn more about the nature of errors in the data. Thus, there are actually two views to an accuracy assessment: users' accuracy", which is the probability that an accuracy assessment point has been mapped correctly (also referred to as errors of commission) and "producers' accuracy," which checks to see if the map actually represents what was found on the ground (also referred to as errors of omission). With users' accuracy, the number of correctly classified samples of a map class is divided by the total number of field samples that were classified in that map class. The emphasis here is on the reliability of the map, or how well the map represents what is really on the ground. With producers' accuracy, the number of correctly classified samples of a map class is divided by the total number of field samples of that map class. The emphasis here is on the probability that the ground field samples have been correctly classified. Both users' and producers' accuracy can be obtained from the same set of data using different analyses. Errors occur when map classes are not the same as the classes observed in the field. A major assumption of accuracy assessment is that the process of mapping and the process of the assessment (i.e., the application of the classification system) are identical, so that a false error is not detected because of procedural differences.

Results of the accuracy assessment are presented in an error or misclassification matrix (also referred to as a contingency or confusion matrix). The accuracy numbers are interpreted as the probability of encountering a particular map class when visiting a particular spot, or point, not a particular polygon. Accuracy requirements for the project specify 80% overall (the proportion of correctly assessed sites) accuracy for each vegetation map class.

Sampling Design

The objectives of collecting samples for the accuracy assessment is to obtain a measure of the probability with which a particular location has been assigned its correct vegetation class. We used a stratified random sampling approach that covered most park fee areas (and some easement areas). For logistical reasons, we did not include in our sampling approach the numerous smaller islands within Penobscot Bay that encompass many of the Park's easement lands (discussed later in more detail). Because of access constraints, we did not include in the design areas mapped outside the park. Maximum and minimum number of samples per map class theme followed program recommendations (The Nature Conservancy et al. 1994), as suggested in the following scenarios:

Scenario A: The class is abundant. It covers more than 50 ha of the total area and consists of at least 30 polygons. In this case, the recommended sample size is 30.

Scenario B: The class is relatively abundant. It covers more than 50 ha of the total area but consists of fewer than 30 polygons. In this case, the recommended sample size is 20. The rationale for reducing the sample size for this type of class is that sample sites are more difficult to find because of the lower frequency of the class.

Scenario C: The class is relatively rare. It covers less than 50 ha of the total area but consists of more than 30 polygons. In this case, the recommended sample size is 20. The rationale for reducing the sample size is that the class occupies a small area. At the same time, however, the class consists of a considerable number of distinct polygons that are possibly widely distributed. The number of samples therefore remains relatively high because of the high frequency of the class.

Scenario D: The class is rare. It has more than 5 but fewer than 30 polygons and covers less than 50 ha of the area. In this case, the recommended number of samples is 5. The rationale for reducing the sample size is that the class consists of small polygons and the frequency of the polygons is low. Specifying more than 5 sample sites will therefore probably result in multiple sample sites within the same (small) polygon. Collecting 5 sample sites will allow an accuracy estimate to be computed, although it will not be very precise.

Scenario E: The class is very rare. It has fewer than 5 polygons and occupies less than 50 ha of the total area. In this case, it is recommended that the existence of the class be confirmed by a visit to each sample site. The rationale for the recommendation is that with fewer than 5 sample sites (assuming 1 site per polygon), no estimate of level of confidence can be established for the sample (the existence of the class can only be confirmed through field checking).

The recommendations above take into account both the statistical and operational aspects of sampling. The accuracy estimate associated with rare classes cannot be stated with the same level of confidence as that associated with classes that are more abundant. For example, with a sample size of 5, the level of error in the estimate is closer to 25% at a 90% confidence level, as opposed to 10% with a sample size of 27. This has implications for our ability to accept a given point estimate as meeting accuracy requirements. Whether or not a given accuracy estimate is accepted as meeting requirements depends on the width of the confidence interval associated with the point estimate and the outcome of a hypothesis test that determines if a given point estimate is equivalent to or exceeds requirements.

We randomly stratified all accuracy assessment site locations across the vegetation map data that are within lands that could be accessed by the field crew. We determined accessible lands for accuracy assessment by park ownership and ease of access. We determined that all Acadia NP lands on Mount Desert Island, Schoodic Peninsula, Isle au Haut, and Long Island were accessible. In contrast, we determined that the numerous small islands in the ocean (most under Park easement) were too remote and difficult to access, requiring considerable more time and logistical maintenance. In consolation, these islands express vegetation communities that are quite extensive throughout the areas we determined accessible (e.g., maritime spruce-fir forest). We had determined areas for accuracy assessment early on in the mapping process, which allowed us to prioritize our mapping efforts for the accuracy assessment field season.

While we had completed our initial photointerpretation process prior to the field season, our subsequent digital mapping of the interpreted data extended into the field season. As we continued with our digital mapping, focusing on the areas for accuracy assessment, we provided the field crew locations (GPS coordinates and maps) in segments as we continued our mapping. We separated the park accessible lands into four major segments (phases), sending site location data to the field crew shortly after we completed them. These four phases are as follows:

- Phase I covered the western third of Mound Desert Island
- Phase II covered the Schoodic Peninsula, Isle au Haut, and Long Island
- Phase III covered the eastern third of Mound Desert Island
- Phase IV covered the central third of Mound Desert Island

As the field season continued, our digital mapping of the assessment area concluded. We were able to provide the field crew all site locations in time for successful data collection during the 1999 field season.

We had determined number of samples needed per map class (taking in account all phase areas) prior to the site selection process. We extrapolated the number of sample sites needed per phase area by analyzing area reports of map phase areas already complete coupled with the photo interpreter's knowledge of map class distribution for the phase areas that we were digitally mapping at the time. Based on these results, we distributed each map theme's number of samples across each of the four phase areas. Three times the number of sites needed was randomly generated using a software program. We did this for two reasons. One is that, in our experience, PLGR units often express up to 10 m in reading errors, particularly in dense conifer forests (a signature for Acadia NP). By eliminating random generated GPS coordinates that fall near polygon boundaries, we anticipated fewer GPS field collected coordinates displace into neighboring polygons. The second reason was to reduce any other accessibility issues that our pre-processing of access areas did not address. An example of this is a remote site distanced far from other sites or access points (e.g., roads, trails) requiring high investment of time, energy, and logistical planning to access. After reducing the over-selection back to the designated number of sites per theme (map class), we had selected 728 sites.

To prepare the field team with locating assessment sites, we plotted 1:12,000-scale orthophoto quadrangle hardcopy maps (from USGS 3.75-minute digital orthophoto quadrangle images) showing locations of the accuracy assessment sites, the unlabelled polygon boundaries of the vegetation map, and the park boundary. We sent Acadia NP staff the field site coordinates (projection in UTM, Zone 19, and datum in NAD83), which they in turn uploaded into a PLGR GPS unit. We also provided the field crew with written instructions for general navigational and data collection methods and with data sheets.

Data Collection Methods

The accuracy assessment team used the PLGR GPS unit to navigate to each site. They also used the hard copy orthophoto maps showing the accuracy assessment site, along with the Project's aerial photographs, to navigate around environmental barriers (e.g., lakes, ponds, deep marshes). Once the sampling site was reached, they evaluated the plant community within a 0.5-hectare radius (the minimum mapping unit or MMU) using the key to vegetation types (see Appendix B: Dichotomous Keys to the Vegetation Communities at Acadia National Park). They also assigned a provisional vegetation community name to the site and recorded the field GPS coordinate location, dominant species, environmental data, and pertinent comments (see Appendix C: Example of an Accuracy Assessment Form for a sample data sheet). If the area was not homogeneous (containing more than one vegetation association), the other associations were also listed on the data sheet. The field team collected data for 724 sites using this method (Figure 16), nearly all of the 728 selected sites (an outstanding achievement).

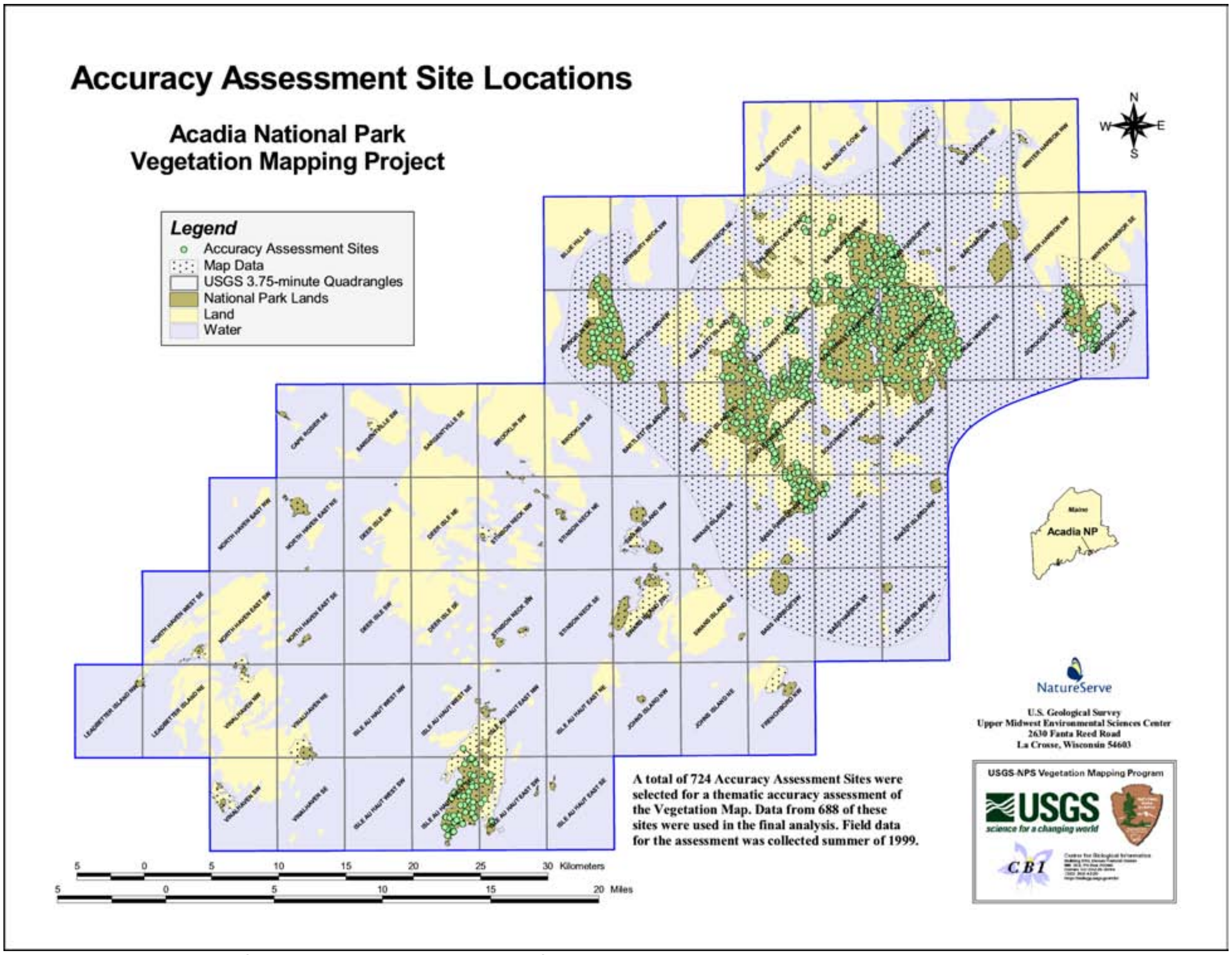

Figure 16. Locations of assessment sites sampled for the Acadia National Park Vegetation Mapping Project.

Data Analysis

The accuracy assessment data were entered into the PLOTS database (The Nature Conservancy 1997) and subsequently reviewed for data entry errors. The analysis of the map accuracy using the field data includes the following steps:

- Initial regrouping of vegetation types and map classes to make a 1:1 relation
- Initial comparison analysis of field and map data
- Initial review of all disagreements and making data adjustments as necessary
- Further classification adjustments and comparison analysis of field and map data
- Final output of results into a contingency matrix

Initial Classification Relations

Although some map classes and vegetation communities (associations) have a 1:1 relation to each other, some do not. Some map classes represent two or more vegetation types. In contrast, some vegetation types are represented with more than one map class (e.g., to map variations of a community, subtype). More on this is discussed in the Results and Discussion, Map Classification section. To properly compare the map class data with the field assessed vegetation types, we regrouped map classes and vegetation communities such that a 1:1 relation exists.

Initial Comparison Analysis

With the 1:1 relations between the two classifications in place, we intersected the field point data with the map polygon data. This allowed us to compare each field accuracy assessment call to the corresponding polygon map class code. PROC FREQ (SAS 1996) was used to compare and tabulate the total number of field assessment sites and map polygons that were in agreement.

Initial Review of Disagreements

All mismatches (disagreements) were subsequently reviewed to see if there were any "false errors." A false error is defined as a mismatch between the map polygon and an accuracy assessment call if caused by any of the following: (1) error in GPS field coordinate, (2) map agreement to an alternate field call, (3) misapplied field call (e.g., from misapplication of the vegetation key), or (4) field site assessment area smaller than the polygon minimum mapping unit (MMU). This review process involved looking at every polygon and its corresponding accuracy assessment site on the photos. We used both the accuracy assessment site and the vegetation map coverages in ArcView GIS to help us locate the sites on each photo. The field data sheet was usually reviewed to gain a fuller context of the ground data. From this process, disagreements that were deemed "false errors" were corrected, resulting in either a match or a true error.

> (1) Spatial GPS coordinate errors occur when the field collected GPS coordinate has slight inaccuracies in geo-positional placement, moving the coordinate just inside an adjacent polygon and acquiring a map class different from that intended for the actual area assessed in the field. Through our sampling design (selecting sites more than 10 m from polygon edges), we were able to reduce these errors. There are limitations to the design approach, however, especially with narrow corridor shaped polygons. For sites determined to have spatial GPS field coordinate displacement, we adjusted accordingly for the analysis to reflect the intended polygon's map class. (We left the accuracy assessment database intact, preserving the actual field coordinate locations.)
>
> Some GPS coordinate errors are due merely to incorrect database entry. We assessed these types of errors by reviewing the field data sheets, complimented with accessing the original selected site coordinates using GIS (as an additional measure to assertain proper site coordinate lcation). Some coordinates could not be successfully recovered and thus dropped from the analysis. Of those that could be recovered, the accuracy assessment database was updated to reflect the correction.
>
> (2) Alternate vegetation communities were often recorded on the field data sheets when the site being assessed was not clear between closely related vegetation types. With these alternate calls entered into the database in a secondary field, they were not included with the comparison analysis (only the primary or initial field call was used). Upon manual review of the field data sheets, if the alternate vegetation community matched the vegetation map, the assessment was adjusted to give the map the benefit, an approach approved by the VMP. (In future, comparing the map data to both the primary field call and all subsequent alternate calls using computerized automation techniques might expedite the review process and reduce the tedious manual approach taken. However, this did encourage us to look deeper into vegetation community concepts, understand how they relate to other closely related types, or understand how those relations correspond to the vegetation map.)
>
> (3) In some instances, the analysis team might question the field assessment call based on the final vegetation key and final community descriptions. During 1999, the vegetation key was in draft, and in one sense, being tested with the accuracy assessment. Vegetation community

descriptions of Acadia NP had not yet been written as the vegetation analyses was not yet complete. In these cases, vegetation classifiers reviewed the data sheets. We updated our analysis tables to reflect any changes in the classified community type in preparation for the second comparison analysis (the project's vegetation database was updated, too).

(4) The area of which some sites are assessed in the field might fall below the MMU for mapping (termed as an inclusion). We discovered instances where, after reviewing the aerial photographs, the site was found to be an inclusion to the surrounding vegetation type. Certain vegetative features can be quite apparent from each other while viewing the aerial photographs (e.g., sparse vegetation on rock outcrop versus dense stand of conifer trees), allowing easy assessment in the lab of site inclusions. In these cases, the map again was given the benefit.

Additional Classification Adjustments and Comparison Analysis

As a side benefit to the in depth review of all disagreements between the accuracy assessment sites and the vegetation map, we began to notice consistent diverging patterns between the map and field assessment data. At this point, we began adjusting the map through a series of "global" changes, digitally changing the classification in the map (that is, globally changing the classification of entire groups of like-classified map polygons) to better align with the final version of vegetation classification (final version of the classification was completed prior to final accuracy assessment). For example, we combined selected wetland forested map classes into one group to account for several conceptual differences between the vegetation classification and the map classes. Another example, we collapsed two alder map classes into one.

Also, from the detailed review, we recognized additional map classes that merely represent an expression (or, in part) of vegetation types. We wanted these expressions preserved in the vegetation map database, while at the same time combine the subtype mapping for the accuracy assessment. To do so, we combined those map classes only for this analysis, leaving the map classes intact in the spatial database. For example, with our analysis we combined the conifer dominant spruce - fir forest map class with that of the mixed conifer-deciduous expression (two map classes representing different expressions of the same vegetation types).

Of the 724 accuracy assessment sites originally collected, we dropped 36 from the analyses. 17 were due to irresolvable GPS errors. The other 19 were due to a disjointed map class that had to be eliminated (19 cases). We discovered at this time that our defining concepts for this map class were incompatible with its counterpart in the vegetation classification (we reinterpreted areas originally mapped with this class to other various other valid map classes). We considered another 72 sites to be inclusions and corrected these to reflect the surrounding area that was of mappable size (adjusted for this analysis only and not in the Project's accuracy assessment database). A total of 688 accuracy assessment sites were used for the final analysis.

With each "false" discrepancy now reflecting proper assignments (whether now a match, or remains a disagreement), and revisions made to the vegetation map to better reflect the vegetation classification, we once performed a comparison analysis of the field data and vegetation map data, once again using PROQ FREQ (SAS 1996).

Contingency Table

We transferred the final set of numbers generated from this last analysis into a contingency table (matrix), where we calculated user and producer accuracy percentages for each map class (theme). The matrix shows both the frequency of agreement and the placement (and frequency thereof) of disagreements.

Results and Discussion

Vegetation Classification

Our initial provisional list of 56 types was augmented, winnowed, and reshuffled into the 53 vegetation types here recognized and described for Acadia National Park.

- 10 upland forest types
- 13 upland woodland types
- 2 wetland forest types
- 3 wetland woodland types
- 6 non-forested upland types
- 6 shrub or dwarf shrub wetland types
- 13 herbaceous wetland types

Results of the vegetation data analyses along with ordination diagrams are presented in Appendix D: Ordination Diagrams and Results of the Vegetation Data Analysis. Table 8 provides a listing of the 53 vegetation associations identified and described at the Acadia NP vegetation mapping project.

Table 8. National Vegetation Classification System associations (vegetation communities) recognized at Acadia National Park.

NVCS Vegetation Community Name (NatureServe Association)	NVCS Common Community Name (NatureServe Association)	NatureServe CEGL Code	NVCS Code
Upland Forest Types			
Pinus strobus - Tsuga canadensis - Picea rubens Forest	Eastern Hemlock - White Pine - Red Spruce	CEGL006324	I.A.8.N.b.13
Pinus strobus - Pinus resinosa / Cornus canadensis Forest	Red Pine - White Pine Forest	CEGL006253	I.A.8.N.b.14
Picea rubens - Picea glauca Forest	Maritime Spruce - Fir Forest	CEGL006151	I.A.8.N.c.15
Acer saccharum - Betula alleghaniensis - Fagus grandifolia / Viburnum lantanoides Forest	Northern Hardwood Forest	CEGL006252	I.B.2.N.a.4
Quercus rubra - Acer rubrum - Betula spp. *- Pinus strobus* Forest	Successional Oak - Pine Forest	CEGL006506	I.B.2.N.a.39
Picea rubens - Betula alleghaniensis / Dryopteris campyloptera Forest	Red Spruce - Hardwoods Forest	CEGL006267	I.C.3.N.a.4
Picea rubens - Abies balsamea - Betula spp. *- Acer rubrum* Forest	Successional Spruce - Fir Forest	CEGL006505	I.C.3.N.a.4
Pinus strobus - Quercus (rubra, velutina) - Fagus grandifolia Forest	White Pine - Oak Forest	CEGL006293	I.C.3.N.a.21
Tsuga canadensis - (Betula alleghaniensis) - Picea rubens / Cornus canadensis Forest	Hemlock - Hardwood Forest	CEGL006129	I.C.3.N.a.32
Acer saccharum - Pinus strobus / Acer pensylvanicum Forest	Sugar Maple - White Pine Forest	CEGL005005	I.C.3.N.a.300
Upland Woodland Types			
Pinus banksiana / Kalmia angustifolia - Vaccinium spp. Woodland	Jack Pine Heath Barren	CEGL006041	II.A.4.N.a.9
Pinus rigida / Vaccinium spp. *- Gaylussacia baccata* Woodland	Pitch Pine / Blueberry spp. - Huckleberry Woodland	CEGL005046	II.A.4.N.a.26

NVCS Vegetation Community Name (NatureServe Association)	NVCS Common Community Name (NatureServe Association)	NatureServe CEGL Code	NVCS Code
Pinus rigida / Photinia melanocarpa / Deschampsia flexuosa - Schizachyrium scoparium Woodland	Pitch Pine Rocky Summit	CEGL006116	II.A.4.N.a.26
Pinus rigida / Corema conradii Woodland	Coastal Pitch Pine Outcrop Woodland	CEGL006154	II.A.4.N.a.26
Thuja occidentalis / Gaylussacia baccata - Vaccinium angustifolium Woodland	White-cedar Woodland	CEGL006411	II.A.4.N.b.1
Thuja occidentalis - Fraxinus pennsylvanica / Acer pensylvanicum Woodland	Cedar Seepage Slope	CEGL006508	II.A.4.N.b.1
Picea rubens / Vaccinium angustifolium - Sibbaldiopsis tridentata Woodland	Spruce - Fir Rocky Summit	CEGL006053	II.A.4.N.b.3
Picea rubens / Ribes glandulosum Woodland	Red Spruce Talus Slope Woodland	CEGL006250	II.A.4.N.b.3
Picea mariana / Kalmia angustifolia Woodland	Black Spruce / Heath Rocky Woodland	CEGL006292	II.A.4.N.b.400
Populus (tremuloides, grandidentata) - Betula (populifolia, papyrifera) Woodland	Early Successional Woodland/Forest	CEGL006303	II.B.2.N.a.10
Quercus rubra - (Quercus prinus) / Vaccinium spp. / *Deschampsia flexuosa* Woodland	Central Appalachian High-Elevation Red Oak Woodland, Northern Variant	CEGL006134	II.B.2.N.a.24
Betula alleghaniensis - Quercus rubra / Polypodium virginianum Woodland	Red Oak Talus Slope Woodland	CEGL006320	II.B.2.N.a.24
(Pinus strobus, Quercus rubra) / Danthonia spicata Acid Bedrock Wooded Herbaceous Vegetation	White Pine - Oak Acid Bedrock Glade	CEGL005101	V.A.5.N.e.8
Wetland Forest Types			
Acer rubrum - Fraxinus spp. */ Nemopanthus mucronatus - Vaccinium corymbosum* Forest	Northern Hardwood Seepage Swamp	CEGL006220	I.B.2.N.e.1
Picea rubens - Acer rubrum / Nemopanthus mucronatus Forest	Red Maple - Conifer Acidic Swamp	CEGL006198	I.C.3.N.d.10
Wetland Woodland Types			
Thuja occidentalis - Abies balsamea / Ledum groenlandicum / Carex trisperma Woodland	Northern White-cedar Wooded Fen	CEGL006507	II.A.4.N.f.11
Picea mariana / (Vaccinium corymbosum, Gaylussacia baccata) / Sphagnum sp. Woodland	Black Spruce Woodland Bog	CEGL006098	II.A.4.N.f.13
Acer rubrum / Alnus incana - Ilex verticillata / Osmunda regalis Woodland	Red Maple Swamp Woodland	CEGL006395	II.B.2.N.e.1
Non-forested Upland Types			
Morella pensylvanica - Empetrum nigrum Dwarf-shrubland	Crowberry - Bayberry Maritime Shrubland	CEGL006510	IV.A.1.N.b.7
Vaccinium angustifolium - Sorbus americana / Sibbaldiopsis tridentata Dwarf-shrubland	Blueberry Granite Barrens	CEGL005094	IV.B.2.N.a.1
Ammophila breviligulata - Lathyrus japonicus Herbaceous Vegetation	Northern Beachgrass Dune	CEGL006274	V.A.5.N.c.2
Polypodium (virginianum, appalachianum) / Lichen spp. Nonvascular Vegetation	Northern Lichen Talus Barrens	CEGL006534	VI.B.1.N.c.300
Solidago sempervirens - (Rhodiola rosea) - Juniperus horizontalis Sparse Vegetation	Northern Maritime Rocky Headlands	CEGL006529	VII.A.2.N.a.4

NVCS Vegetation Community Name (NatureServe Association)	NVCS Common Community Name (NatureServe Association)	NatureServe CEGL Code	NVCS Code
Cakile edentula ssp. *edentula - Mertensia maritima* Sparse Vegetation	Sea-rocket - Oysterleaf Sparse Vegetation	CEGL006106	VII.C.2.N.a.2
Shrub or Swarf Shrub Wetland Types			
Alnus incana - Cornus sericea / Clematis virginiana Shrubland	Alluvial Alder Thicket	CEGL006062	III.B.2.N.d.9
Alnus incana ssp. *rugosa - Nemopanthus mucronatus / Sphagnum* spp. Shrubland	Northern Peatland Shrub Swamp	CEGL006158	III.B.2.N.e.9
Myrica gale - Spiraea alba - Chamaedaphne calyculata Shrubland	Sweetgale Mixed Shrub Swamp	CEGL006512	III.B.2.N.g.9
Kalmia angustifolia - Chamaedaphne calyculata - (Picea mariana) / Cladina spp. Dwarf-shrubland	Northern Dwarf-shrub Bog	CEGL006225	IV.A.1.N.g.1
Chamaedaphne calyculata / Eriophorum virginicum / Sphagnum rubellum Dwarf-shrubland	Leatherleaf Acidic Fen	CEGL006513	IV.A.1.N.g.1
Empetrum nigrum - Gaylussacia dumosa - Rubus chamaemorus / Sphagnum spp. Dwarf-shrubland	Maritime Crowberry Bog	CEGL006248	IV.A.1.N.g.4
Herbaceous Wetland Types			
Trichophorum caespitosum - Gaylussacia dumosa / Sphagnum (fuscum, rubellum, magellanicum) Herbaceous Vegetation	Maritime Peatland Sedge Lawn	CEGL006260	V.A.5.N.h.1
Carex stricta - Carex vesicaria Seasonally Flooded Herbaceous Vegetation	Eastern Tussock Sedge Meadow	CEGL006412	V.A.5.N.k.36
Calamagrostis canadensis - Scirpus spp. *- Dulichium arundinaceum* Herbaceous Vegetation	Seasonally Flooded Mixed Graminoid Meadow	CEGL006519	V.A.5.N.k.39
Schoenoplectus (tabernaemontani, acutus) Eastern Herbaceous Vegetation	Bulrush Deepwater Marsh	CEGL006275	V.A.5.N.l.16
Eriocaulon aquaticum - Lobelia dortmanna Herbaceous Vegetation	Seven-angle Pipewort - Dortmann's Cardinal-flower Herbaceous Vegetation	CEGL006346	V.A.5.N.l.2
Juncus militaris Herbaceous Vegetation	Bayonet Rush Herbaceous Vegetation	CEGL006345	V.A.5.N.l.3
Typha (angustifolia, latifolia) - (Schoenoplectus spp.) Eastern Herbaceous Vegetation	Eastern Cattail Marsh	CEGL006153	V.A.5.N.l.9
Carex (lasiocarpa, utriculata, canescens) Herbaceous Vegetation	Slender Sedge Fen	CEGL006521	V.A.5.N.m.7
Spartina patens - Distichlis spicata - (Juncus gerardii) Herbaceous Vegetation	Spartina High Salt Marsh	CEGL006006	V.A.5.N.n.11
Typha angustifolia - Hibiscus moscheutos Herbaceous Vegetation	Brackish Tidal Marsh, Cattail Variant	CEGL004201	V.A.5.N.n.2
Carex (oligosperma, exilis) - Chamaedaphne calyculata Shrub Herbaceous Vegetation	Few-seeded Sedge - Leatherleaf Fen	CEGL006524	V.A.7.N.o.3
Vallisneria americana - Potamogeton perfoliatus Herbaceous Vegetation	Open Water Marsh with Mixed Submergents/Emergents	CEGL006196	V.C.2.N.a.17
Nuphar lutea ssp. *advena - Nymphaea odorata* Herbaceous Vegetation	Water Lily Aquatic Wetland	CEGL002386	V.C.2.N.a.102

Map Classification

Map classes that represent nautral/semi-natural vegetation types of the NVCS reflect the vegetation classification as close as possible based on what we knew at the time of mapping (which was before the vegetation classification was developed) and what we learned through the accuracy assessment (which was after the vegetation classification was developed). Our original list of map classes was rearranged several times before we began the photointerpretation, and several adjustments to the map classification and mapping concepts were made as we proceeded with the mapping process.

We made our largest adjustment to the map classification during the accuracy assessment when we proceeded with an in depth review of field assessment sites and map data discrepancies. As discussed earlier, it was then we realized some consistent divergence between the map and vegetation classifications. (It was our conclusion that this was because of (1) mapping before the vegetation classification was developed and (2) using spring photography that hindered the interpretability of deciduous tree components and of herbaceous wetlands. For more discussion on this, see the Recommendations section of this report.) At this point, we combined several map classes to better align with the vegetation classification based on final vegetation community descriptions and results of the accuracy assessment.

We finalized the map classification with 33 map classes representing NVCS natural/semi-natural vegetation associations (NatureServe 2003) that we identified at Acadia NP with this mapping project (Appendix E: Vegetation Classification Matrix show the relations between vegetation map classes and NVCS vegetation communities). Including land use/land cover features and some park specific features, 57 map classes (58 including the class for no map data) were developed for the Acadia NP Vegetation Mapping Project (Table 9; Map Classification for Acadia Nationial Park Vegetation Mapping Project). Table 10 shows the number of map classes broken out by general categories.

Table 9. Map Classification for the Acadia National Park Vegetation Mapping Project.

MAP CLASS CODE	MAP CLASS NAME
Forest - Conifer - Upland	
SF	Spruce - Fir Forest (conifer phase)
WPC	White Pine - Mixed Conifer Forest
WRP	Red Pine - White Pine Forest
Forest - Deciduous - Upland	
MDF	Beech - Birch - Maple Forest
Forest - Mixed - Upland	
OPF	Oak - Pine Forest
SFM	Spruce - Fir Forest (mixed phase)
WPM	White Pine - Hardwood Forest
Woodland - Conifer - Upland	
MCW	Mixed Conifer Woodland
WCW	White Cedar Woodland
JPW	Jack Pine Woodland
PPB	Pitch Pine - Heath Barren

MAP CLASS CODE	MAP CLASS NAME
PPC	Pitch Pine - Corema Woodland
PPW	Pitch Pine Woodland
Woodland - Deciduous - Upland	
ABF	Aspen - Birch Woodland/Forest Complex (forest phase)
ABW	Aspen - Birch Woodland/Forest Complex (woodland phase)
ABS	Aspen - Birch Woodland/Forest Complex (shrubland phase)
ROW	Red Oak Woodland
Woodland - Mixed - Upland	
MW	Mixed Conifer - Deciduous Woodland
Forest - Deciduous - Wetland	
MAS	Red Maple - Hardwood Swamp
Woodland - Conifer - Wetland	
CSW	Conifer Swamp Woodland (spruce-mixed phase)
WCS	Conifer Swamp Woodland (white cedar phase)
Dwarf Shrubland - Evergreen - Upland	
CB	Crowberry - Bayberry Headland
Dwarf Shrubland - Deciduous - Upland	
BBSS	Blueberry Bald - Summit Shrubland Complex
Graminoid - Upland	
AM	Dune Grassland
Sparse Vascular - Upland	
SVH	Open Headland - Beach Strand
SVT	Sparsely Vegetated Talus
Shrubland - Deciduous - Wetland	
ASP	Alder Shrubland
SG	Sweetgale Mixed Shrub Fen
Dwarf Shrubland - Evergreen - Wetland	
DSB	Dwarf Shrub Bog
FX	Fen Complex
Graminoid - Wetland	
TG	Tidal Marsh
SMG	Graminoid Shallow Marsh
Forb - Wetland	
OWM	Open Water - Deep Marsh Complex
Tidal Zone	
TZ	Tidal Algal Zone

MAP CLASS CODE	MAP CLASS NAME
TB	Tidal Beach
TM	Tidal Mud Flat
Small Island with Vegetation	
SIT	Small Island with Trees
SIS	Small Island with Shrubs
SIG	Small Island with Grass
SIR	Small Island with Rock
Cultural Vegetation	
EPL	Evergreen Plantation
SMD	Mixed Deciduous Shrubland
MGF	Mixed Grass - Forb
PGCH	Perennial Grass Crops
PGCS	Perennial Grass Crops with Sparse Shrubs
Non-vegetated Water	
WBP	Beaver Pond (non-vegetated)
WNP	Natural Pond (non-vegetated)
WST	Stream (non-vegetated)
WLK	Lake (non-vegetated)
WO	Ocean - Bay - Estuary (non-vegetated)
Land Use	
UR	Residential
UC	Commercial and Services
UT	Transportation and Roads
UM	Mixed Urban or Built-up Land
UBL	Other Urban or Built-up Land
ARB	Other Agricultural Land
BLQ	Strip Mines, Quarries, and Gravel Pits
No Data	
ND	No Data

Table 10. Number of map classes by general category.

# Map classes	General category
33	Natural/Semi-natural Vegetation (NVCS association types)
3	Beach and Tidal Zone (NVCS natural/semi-natural vegetation alliance and formation types)
4	Small Island with Vegetation (small islands 0.1 ha > 0.5 ha, project-derived)
5	Cultural Vegetation (e.g., idle field, plantation, NVCS planted/cultivated types)
5	Non-vegetated Water (e.g., ocean, lake, river, pond, Anderson et al. 1976 and project-derived)
7	Land Use (developed land, Anderson et al. 1976)
1	No Data (defines areas not mapped with project, project-derived)

It is preferred that each vegetation type is mapped with its own unique map class. However, due to limitations inherent in using aerial photographs to identify floristic vegetation components, this is not always possible. Yet, some map classes do relate to vegetation associations on a 1:1 relation. For example, map class White Pine – Red Pine Forest (WPC) ties directly to the Red Pine - White Pine Forest association type. A polygon correctly mapped as WPC will always and only represent this association.

Many map classes represent more than one association. For example, the map class Mixed Conifer Woodland (MCW) includes 4 associations: Cedar Seepage Slope, Spruce - Fir Rocky Summit, Red Spruce Talus Slope Woodland, and Black Spruce / Heath Rocky Woodland. A polygon correctly mapped as MCW will represents one or more of these associations. Although we originally tried to map 3 of these associations separately, we discovered through the accuracy assessment process that we were not successful, mainly due to photo limitations. Black spruce, red spruce, and cedar were not always distinctive from one another, or they occurred together in mixed stands and we were just not able to consistently determine which species dominated the individual stands. We combined other original map classes for similar reasons.

Some of the map classes “share” associations. In other words, an association may be included in more than one map class. The sharing is due, in part, to the fact that not all associations always appear visible as separate entities on the photos. The aerial photographs limit our ability to map different vegetation types as seen and understood by the ecologists. For example, the association Cedar Seepage Slope occurs in the map class MCW and in the map class WCW because we could not consistently recognize cedar on the photographs when occurring on talus, nor could we see the seepage characteristic.

Another example of a map class that shares associations with other map classes is the Fen Complex (FX), which includes a suite of non-forested wetland types that either were not distinctive on the spring photography or occurred in patterns too small to practically delineate. The timing of the photo mission was too early in the season to capture many of the unique signature characteristics of wetland vegetation, and often these wetland types intermingle or grade together. The Fen Complex map class includes associations that were also mapped under other map classes in the wetland shrubland, dwarf-shrubland, and graminoid groups. These other map classes were used when we could clearly see the dominant vegetation in a pattern large enough to map.

Some of the map classes represent the same association. ABF is the forest phase of the Aspen - Birch Woodland/Forest Complex, ABW is the woodland phase, and ABS is the shrubland phase. These map classes were originally thought to be distinctive vegetation types from one another because their physiognomy is different. However, the vegetation classifiers identified all three as being compositionally similar enough to regard as one vegetation community having different structures. MW, the Mixed Conifer - Deciduous Woodland also includes the Aspen - Birch Woodland/Forest Complex.

The difficulty in having compatible map classes with the vegetation classification is an artifact of the process combined with the challenges of mapping highly transitional vegetation with spring photography. As mentioned previously, vegetation classification work proceeded simultaneously with mapping, and we created map classes before having a complete understanding of the vegetation types and their variability. Although classifiers and mappers recognized that species assemblages change more or less gradually along environmental and geographical gradients, ecotones — especially broad ones between two distinctive types — are problematic in determining where to draw the line. As stated earlier in this report, "Acadia is characterized by a full suite of forest-to-woodland gradations, and it is not always obvious to which class a particular type should be assigned… Many types exhibit both forest and woodland characters: variable canopy closure, and sometimes but not always a well-developed understory." Thus, our attempts at creating map classes that were strongly linked to the ecology prior to knowing the ecology limited our success in mapping the vegetation communities non-ambiguously. As a result, some map classes share associations, and some associations share map classes. Indeed, once vegetation data analysis was completed and the vegetation descriptions written, we realized that many types are not distinctive from a photointerpretation perspective because of their inherent ecological variability. For specific details about each map class and detailed relations to the NVCS, see Appendix F: Map Class Descriptions and Visual Guide.

Non-vegetated map classes represent land use and land cover features not included within the NVCS, such as populated areas, roads, agricultural lands, quarries, and open water bodies that are <10% vegetated. To map these features, a land use and land cover classification system developed by Anderson et al. (1976) was used (to Level II). A few map classes were developed to represent some park specific situations such as small islands that are less than the minimum mapping unit of 0.5 ha but greater than 0.1 ha.

Vegetation Map Summary

Table 11 is an area report of the Acadia NP Vegetation Map. We mapped 96,693 ha (246,347 acres) mapped of Acadia NP and environs. Of this total, 34,174 ha (84,446 acres), or 35%, are NVCS natural/semi-natural vegetated map classes sampled by this mapping project. Other natural/semi-natural vegetation types that were not sampled (e.g., tidal zone communities), small islands with vegetation, and cultural vegetation together make up another 5% of the coverage (4,801 ha, or 11,864 acres). The remaining map classes are non-vegetated land use/land cover (e.g., residential lands, open water). Open water, especially the Ocean-Bay-Estuary and map classes, dominate these non-vegetated classes (over 90% of non-vegetated map classes). Of the total map coverage, 52,872 ha (130,650 acres) is non-vegetated ocean, bays, and estuaries (53% of coverage).

The Spruce - Fir Forests (SF and SFM, conifer and mixed phases) together are found the most extensive vegetated map classes. Indeed, these forests cover over 60% of natural vegetated classes and over half of all vegetated classes. They also have the greatest number of polygons and the largest average area per polygon.

Among the natural vegetated classes, the rarest types both in area and number of polygons are the Dune Grassland (AM), the Pitch Pine variants Pitch Pine - Heath Barren and Pitch Pine - Corema Woodland (PPB and PPC), and the Crowberry - Bayberry Headlands (CB).

Table 11. Area report of the vegetation map coverage, Acadia National Park Vegetetation Mapping Project.

Map code	Map class name	Polygons	Area hectares	Average area hectares
Forest - Conifer - Upland				
SF	Spruce - Fir Forest (conifer phase)	933	12,865	14
WPC	White Pine - Mixed Conifer Forest	111	545	5
WRP	Red Pine - White Pine Forest	9	17	2
	SubTotals	*1,053*	*13,426*	*13*
Forest - Deciduous - Upland				
MDF	Beech - Birch - Maple Forest	54	382	7
	SubTotals	*54*	*382*	*7*
Forest - Mixed - Upland				
OPF	Oak - Pine Forest	48	497	10
SFM	Spruce - Fir Forest (mixed phase)	686	8,371	12
WPM	White Pine - Hardwood Forest	191	1,787	9
	SubTotals	*925*	*10,656*	*12*
Woodland - Conifer - Upland				
MCW	Mixed Conifer Woodland	663	2,327	4
WCW	White Cedar Woodland	8	163	20
JPW	Jack Pine Woodland	40	84	2
PPB	Pitch Pine - Heath Barren	3	9	3
PPC	Pitch Pine - Corema Woodland	1	5	5
PPW	Pitch Pine Woodland	47	380	8
	SubTotals	*762*	*2,968*	*4*
Woodland - Deciduous - Upland				
ABF	Aspen - Birch Woodland/Forest Complex (forest phase)	172	1,184	7
ABW	Aspen - Birch Woodland/Forest Complex (woodland phase)	25	219	9
ABS	Aspen - Birch Woodland/Forest Complex (shrubland phase)	8	105	13
ROW	Red Oak Woodland	62	549	9
	SubTotals	*267*	*2,057*	*8*
Woodland - Mixed - Upland				
MW	Mixed Conifer - Deciduous Woodland	243	1,497	6
	SubTotals	*243*	*1,497*	*6*
Forest - Deciduous - Wetland				
MAS	Red Maple - Hardwood Swamp	80	142	2
	SubTotals	*80*	*142*	*2*
Woodland - Conifer - Wetland				
CSW	Conifer Swamp Woodland (spruce-mixed phase)	322	781	2

Map code	Map class name	Polygons	Area hectares	Average area hectares
WCS	Conifer Swamp Woodland (white cedar phase)	98	134	1
	SubTotals	*420*	*915*	*2*
Dwarf Shrubland - Evergreen - Upland				
CB	Crowberry - Bayberry Headland	4	14	4
	SubTotals	*4*	*14*	*4*
Dwarf Shrubland - Deciduous - Upland				
BBSS	Blueberry Bald - Summit Shrubland Complex	129	375	3
	SubTotals	*129*	*375*	*3*
Graminoid - Upland				
AM	Dune Grassland	1	1	1
	SubTotals	*1*	*1*	*1*
Sparse Vascular - Upland				
SVH	Open Headland - Beach Strand	255	372	1
SVT	Sparsely Vegetated Talus	12	11	1
	SubTotals	*267*	*383*	*1*
Shrubland - Deciduous - Wetland				
ASP	Alder Shrubland	146	162	1
SG	Sweetgale Mixed Shrub Fen	87	134	2
	SubTotals	*233*	*297*	*1*
Dwarf Shrubland - Evergreen - Wetland				
DSB	Dwarf Shrub Bog	6	93	15
FX	Fen Complex	169	476	3
	SubTotals	*175*	*569*	*3*
Graminoid - Wetland				
TG	Tidal Marsh	75	179	2
SMG	Graminoid Shallow Marsh	123	183	1
	SubTotals	*198*	*362*	*2*
Forb - Wetland				
OWM	Open Water - Deep Marsh Complex	71	131	2
	SubTotals	*71*	*131*	*2*
	Project Natural Vegetation Community Totals	***4,882***	***34,174***	***7***
Tidal Zone				
TZ	Tidal Algal Zone	411	2,744	7
TB	Tidal Beach	1	2	2
TM	Tidal Mud Flat	96	453	5
	SubTotals	*508*	*3,198*	*6*

Map code	Map class name	Polygons	Area hectares	Average area hectares
Small Island with Vegetation (map units of 0.1 - 0.5 ha)				
SIT	Small Island with Trees	54	10.0	0.2
SIS	Small Island with Shrubs	4	0.6	0.1
SIG	Small Island with Grass	4	0.7	0.2
SIR	Small Island with Rock	22	4.7	0.2
	SubTotals	*84*	*16.0*	*0.2*
Cultural Vegetation				
EPL	Evergeen Plantation	5	8	2
SMD	Mixed Deciduous Shrubland	251	726	3
MGF	Mixed Grass - Forb	208	369	2
PGCH	Perennial Grass Crops	166	481	3
PGCS	Perennial Grass Crops with Sparse Shrubs	3	4	1
	SubTotals	*633*	*1,587*	*3*
	All Vegetation Map Classes Totals	***6,107***	***38,976***	***6***
Non-vegetated Water				
WBP	Beaver Pond (non-vegetated)	4	3	1
WNP	Natural Pond (non-vegetated)	20	127	6
WST	Stream (non-vegetated)	1	0	0
WLK	Lake (non-vegetated)	9	930	103
WO	Ocean - Bay - Estuary (non-vegetated)	11	52,872	4,807
	SubTotals	*45*	*53,932*	*1,198*
Land Use				
UR	Residential	592	1,788	3
UC	Commercial and Services	82	384	5
UT	Transportation and Roads	29	123	4
UM	Mixed Urban or Built-up Land	71	1,027	14
UBL	Other Urban or Built-up Land	16	99	6
ARB	Other Agricultural Land	96	148	2
BLQ	Strip Mines, Quarries, and Gravel Pits	82	216	3
	SubTotals	*968*	*3,785*	*4*
	MAP DATA GRAND TOTALS	***7,120***	***96,693***	***14***
No Data				
ND	No Data	2	158,245	79,125
	SubTotals	*2*	*158,245*	*79,122*
	Map Data & No Data Totals	***7,122***	***254,938***	***36***

Accuracy Assessment

Of the 724 accuracy assessment sites originally collected, we dropped 36 from the analyses (for reasons discussed earlier in the Accuracy Assessment Methods section). A total of 688 accuracy assessment sites were used for the final analysis. Our initial run of the analysis revealed an overall accuracy of 73%, well below the acceptable program standard of 80% accuracy. Overall accuracy improved to 80% with subsequent analyses once the adjustments were made to better aligning map and vegetation classification concept (Discussed in detail in the Accuracy Assessment Methods section of this report). A Kappa index was applied to the overall 80% to adjust for chance agreements, resulting in an index of 79%.

The accuracy assessment contingency matrix can be found in Appendix G: Accuracy Assessment Contigency Table. The matrix is an array of numbers set out in rows and columns which reveal the number of polygons assigned to a particular vegetation association(s) relative to the actual vegetation association as verified on the ground. The columns represent the vegetation associations, and the rows represent the map class codes. The accuracies of each map class are described along with the users' accuracy reflecting errors of inclusion (commission errors) and producers' accuracy reflecting errors of exclusion (omission errors) present in the mapping. To reiterate what was written in the Methods section of this report, with users' accuracy, the number of correctly classified samples of a map class is divided by the total number of field samples that were classified in that map class. The emphasis here is on the *reliability* of the map, or how well the map represents what is really on the ground. With producers' accuracy, the number of correctly classified samples of a map class is divided by the total number of field samples of that map class. The emphasis here is on the *probability* that the ground field samples have been correctly classified. Confidence intervals are also given. The width of the confidence interval is affected by the sample size used to derive the point estimate. An example of how to use the matrix follows: map class White Pine – Red Pine Forest (WPC) has a producers' accuracy of 83%, meaning that 83% of the accuracy assessment points were also found to be classified as WPC. Users' accuracy is 79%, meaning that 79% of the polygons classified as WPC in the data can be expected to be WPC when visited on the ground.

Errors in the mapping occurred for a variety of reasons, and we attempted to group these reasons into 4 broad categories. Although some errors could be placed in more than one category, we nevertheless found that a quick estimate of the percent error by category provided a better understanding of the mapping problems.

About 20% of the errors were related to disagreements of percent canopy cover. The photo interpreter sees canopy crowns from above at a relatively small scale and large area, and the field crew has a relatively narrow view looking up from the ground. These different perspectives frequently lead to different estimates of percent cover, which in turn leads to different conclusions on determining the vegetation type. Canopy cover disagreements occurred most often when the actual cover of a site was closest to the percent that determines one vegetation type from another, such as conifer versus a deciduous type, or between the relative proportions of species present. For example, the difference between two closely related types, White Pine - Mixed Conifer Forest (WPC) and White Pine - Hardwood Forest relies on the estimate of the relative canopy of the deciduous tree species. When judging percent canopy cover, it is difficult to say which perspective provides the most accurate cover estimates. Regardless, this is a difficult problem to eliminate because major breaks within the classification are based on percent cover.

Approximately 25% of the errors were due to mapping mistakes. The majority of these errors were related to unmapped stands of minimum map unit size (0.5 ha). These unmapped areas were ecologically similar to the surrounding polygon's vegetation, but still should have been mapped in accordance to standard minimum map unit. Other mistakes included drawing polygon boundaries that disagreed with the ground calls so that a small portion of a polygon where an assessment point fell should have been mapped with the adjacent polygon. Another type of error occurred when a polygon was mapped as a single association when it should have been mapped using one of the complex map classes. For example, some polygons were mapped as the Sweet Gale Mixed Shrub Fen, and the accuracy assessment team found other associations present within the same polygon.

More than 35% of the errors were related to photo limitations. In hindsight, the use of spring photography likely increased the error rate. Many deciduous types had little or no canopy at the time of photography, affecting our ability to discriminate within forest, woodland, and shrub alliances (e.g., birch-red maple and red oak woodlands) and in our ability to determine percent cover and tree height. Distinguishing vegetation types on the photographs is dependent on relative coverage, so where underdeveloped canopies existed, the interpreter needed to extrapolate to an expected full canopy. For example, oak trees in many places were lacking canopies so that the ground cover was easily viewed rather than the forest or woodland strata. We often attempted to extrapolate the percent canopy cover to later in the growing season, assuming we would be more successful identifying the vegetation type correctly. Unfortunately, we still had difficulty in mapping some stands; especially determining the percent canopy cover of deciduous trees to evergreens in mixed stands. Wetland vegetation types (e.g., tall-saturated grasslands, hydromorphic vegetation) were not discernable on the photos because it was too early in the growing season. Neither were other wetland types clearly expressed on the photos, confusing interpretation between several types. Cattails, bulrushes, and other emergent species were barely starting their seasonal growth, thus the photography revealed only the previous years' dead stalks. In addition, water lilies and submersed aquatic species such as pondweeds had not reached the surface of ponds and thus were not picked up on the photographs.

Other errors were simply problems inherent with the scale of the photography such as determining one species from one another. For example, short red maple trees in a wetland were confused with the alder signature. Jack pine and pitch pine had similar signatures, and we mapped these based on limited knowledge of their distributions. Cedar was especially difficult to tell from other conifers in most situations, but especially on angled slopes, in shadowed areas, and when mixed with other conifer species.

Some errors (~20%) were conceptual differences between map classes and vegetation associations. Conceptual differences occurred because the map classes were developed before the vegetation classification was completed, and although we adjusted many of the map classes to better fit the classification, we were still not able to reach complete compatibility. Several of the vegetation associations are highly variable in terms of their canopy closure and species composition and "stretch" beyond our map class definitions and beyond conventions of the USNVC hierarchy. We didn't anticipate some of the variability when we created the map classes. Thus, some of the map classes use narrower cover classes to separate physiognomic groups (e.g., shrub versus woodland) that are not consistent with the ecological perspectives. Appendix F: Map Class Descriptions and Visual Guide, presents results of the accuracy assessment for each map class, includes the percent of polygons mapped in agreement with the accuracy assessment calls, and report the types of errors.

Recommendations for Future Projects

Acadia NP was one of the earlier parks to be mapped under USGS-NPS Vegetation Mapping Program, and great care went into designing this initial effort. As with any complex task, however, we learned some important lessons with this project. We offer our perspective and several suggestions we believe will benefit the program as it continues its complex task at efficiently (time and funds) and accurately documenting the vegetation patterns of the National Parks.

Sequential rather than parallel timing of products

In this effort, classifying and mapping of the vegetation proceeded on parallel rather than sequential tracks and vegetation types were redefined several times as the learning process proceeded. Ongoing mapping efforts lost efficiency, therefore, as effort needed to be directed toward ensuring maps created under earlier classification schemes where brought into compliance with the newest classification approach. From a mapping perspective, greatest accuracy and cost-effectiveness would result from developing the vegetation types from the vegetation samples prior to mapping. Whereas the goal is to shorten the overall duration of the project, we suggest it would be more efficient to stack different parks rather than to stack the steps of the process for a single park. We believe it would be better to have the mappers and ecologists work together on reconnaissance and the draft classification, but allow mapping itself to wait until the vegetation samples have been analyzed. This philosophy is partially reflected in the updated VMP documentation that regards the entire process as iterative between classifiers and mappers, yet puts an emphasis on classifying first with mappers lending support, then mapping with classifiers lending support.

Careful selection of the timing of aerial photography

Spring 1997 aerial photography was decided upon at the initial scoping meeting (March 1997) with the hope of jump-starting the mapping effort into the present year and, optimistically, expediting the entire mapping process. Unfortunately, we found the selection of spring photography lengthened the mapping process and adversely affected mapping accuracy for several major vegetation types.

At the time of the photography flight, not all the vegetation had reached peak biomass and some had not yet begun. This greatly affected our ability to interpret percent canopy cover or species composition. Deciduous forest types, for example, became difficult to distinguish from each other. The contrast between deciduous and conifer species also was limited and misinterpretation of vegetation communities easily occurred. One of Acadia's prominent management concerns involves wetlands, which, at the time of photography, were not fully expressed in terms of photo signatures. The timing of the photo mission, therefore, should be carefully considered in relation to the objectives of the project and management issues.

Better planning to ensure adequate field time and information exchange between ecologists and mappers

We believe the time mappers, classification staff, and managers are together in the field is one of the most critical steps towards creating a successful relation of meaningful map classes to vegetation types. Certainly, scheduling such time with such a diverse and busy group is difficult. However, we feel our initial time together in the field for the Acadia NP product was insufficient in duration. Consequently, time in the field was inadequate to discover and learn the vegetation types and discuss how they best be mapped.

More vegetation samples for classification development

Whereas the sampling protocol (The Nature Conservancy and Environmental Systems Research Institute 1994b) calls for an average of 10 plots per vegetation type, funding limited us to an average <4 plots per type. This sample size was sufficient for many plant types, but it was inadequate for variable ones. Since at the start of a mapping effort, the exact nature of variability is unknown, we believe it best to come as close to the recommended allocation of effort (10 plots) as is financially feasible. Alternatively, if historical data exist to generally define variability of types, sample allocation may perhaps be reduced or more effectively allocated.

Incorporate accuracy assessment data into vegetation descriptions

Much potentially useful vegetation data was collected through the accuracy assessment process. We believe such data can be valuable in refining the vegetation descriptions for especially variable types for which we had few initial samples (see previous paragraph).

Incorporate data into Biological and Conservation Database for statewide and larger perspective

The USGS-NPS Vegetation Mapping Program is an exceptional source of new information on the presence of rare or exemplary communities. We strongly support entering data from such projects into the Natural Heritage Program's Biological and Conservation Database (e.g., Maine Natural Areas Program). Not only does this make the information available within the NatureServe and Natural Heritage Network standard data formats, but it also allows a statewide perspective on their presence, which is essential in conservation planning. Unfortunately our initial scoping and budgeting did not acknowledge this need and we were able to only partially complete this task.

Implement enhanced protocols and training for accuracy assessment

Accuracy assessment is a lengthy, expensive, and necessary part of the mapping project. In this project, accuracy assessment was problematic because a large portion of the errors was "false" errors. (A false error is a mismatch between a polygon and an accuracy assessment call if the disagreement was caused by either a GPS error or an inclusion error.) "False" errors, if included in the accuracy assessment, would have resulted in accuracy below 70%. Many false errors could be avoided through better training of field crews. In addition, the point selection process could include "cost surfacing," saving time from having to manually eliminate inaccessible points. To ensure a smooth process and more accurate data, therefore, we suggest standardized field training methods be developed and implemented for the program. Standardization, we also suggest, should include an Arc Macro Language (AML) or other GIS application for site selection, field training methods, and data analysis.

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Appendix A

Example of an Observation Field Reconnaissance Form

National Park Mapping

Site ID # 6 National Park ACAD
Prepared By KEVIN DHOP Agency ____ Date: 7-30-97
Other Field Personnel/Agency: 1) SARA ROGERS 2) SUE GAWLER
3) MARIA TRINH 4) JILL WEBER 5) SAL ROONY

1. Location:
USGS 7.5' Quadrangle SEAL HARBOR
Township N/A Range N/A Section N/A
GPS Location (UTM): Easting 560500 Northing 4913165
GPS Zone 19 GPS Type PLGR+96
Brief description of site relative to identifiable points on topographic map
JUST DOWN THE SLOPE WEST OF CORNER OF CADILAC SUMMIT ROAD & PARK LOOP ROAD
Attach photocopy of field site from 7.5' quadrangle.

2. Aerial Photography:
Photo # 12-17 Date 5-22-97 Type CIR PRINT Scale 1:15,840
Brief description of photo signature LIGHT-PALE FLUFFY PINK & GREEN TREES W ROUND TOPPED CANOPY
Attach photocopy of aerial photo.

3. Ground Survey:
Description of Site (overstory-understory, upland/wetland, etc...)
DECIDUOUS FOREST ON WEST FACE SLOPE W LITTLE UNDERSTORY DEVELOPMENT
Dominant Plants: 1) BEECH 2) ____
3) ____ 4) ____ 5) ____
Common Plants: 1) SUGAR MAPLE 2) YELLOW BIRCH
3) ____ 4) ____ 5) ____
Less Common Plants: 1) ASPEN 2) HEMLOCK
3) STRIPED MAPLE 4) ____ 5) ____
Ground Photo Data: Roll # 1 Exp# 5 Direction E
Exp# ____ Direction ____ Exp# ____ Direction ____
Exp# ____ Direction ____ Exp# ____ Direction ____

4. Classification:
Initial Attribute: MAPLE-BIRCH-BEECH DECIDUOUS NORTHERN HARDWOOD FOREST (MDF)
Modifier Information:
% Closure 100% Composition EVENLY DISPERSED Tree Height 50-60'
Final Attribute: ~~BEACH – BIRCH – MAPLE FOREST (MDF)~~ (CEGL006252) KDH 1-27-2003

5. Discussions/Other Observations:
Photo Interpretation SOME VARIATIONS IN SIGNATURE THROUGHOUT THIS DECIDUOUS FOREST. MAY BE DUE TO PURER AREAS OF BEECH.
Other ____

Figure A-1. Reconnaissance field data sheet for photointerpretation mapping.

Appendix B

Dichotomous Keys to the Vegetation Communities at Acadia National Park

This is a key to vegetation community types (associations) of the National Vegetation Classification System that have been identified at Acadia National Park as a result of this mapping project. This key is a working document. Because it is based on limited samples for many types, it may not work as well for variations that did not appear in the samples.

Conventions:

- The layers are as defined in the plot sampling (see Methods). For example, "canopy" refers to the cover of trees over 10 cm dbh, and "subcanopy" to smaller trees over 3 m tall.
- The cutoff used for shrub versus dwarf shrub is about 1 m, but is not meant to be constrained to that exactly. Use your judgment in the field.
- Relative Dominance (RD) is the proportion of the total canopy occupied by a species. If *Picea rubens*'s cover value is 30%, in a setting in which the canopy cover totals 60%, *Picea rubens*'s relative dominance is 50%. This concept is used repeatedly in this key.
- Types that occur in the Park, but for which we have no samples, are marked with an asterisk.

Which Key To Use:

1. Trees forming ≥ 20% canopy, or if less (rarely), then canopy and subcanopy (everything > 3 m tall) total ≥ 30% cover: forests and woodlands 2
1. Tree canopy ≤ 10%, or if slightly more, then canopy and subcanopy together total < 30% (these layers usually total < 10%): non-forested vegetation 3

2. UPLAND: soils not saturated throughout season, *Sphagnum* < 10% of ground surface. Exception: sometimes in ledgy types such as Black Spruce / Heath Rocky Woodland, the "soil" is thin peat pockets over bedrock, and usually saturated; these are treated as uplands .... **UPLAND FOREST AND WOODLAND KEY**
2. WETLAND: soils saturated throughout season and/or *Spahgnum* covering > 10% of ground surface (see note *re* exceptions in other half of couplet); usually basins or streamsides .... **WETLAND FOREST AND WOODLAND KEY**

3. UPLAND: soils not saturated throughout season, *Sphagnum* < 10% of ground surface. Exception: sometimes in ledgy types such as Blueberry Granite Barrens, the "soil" is thin peat pockets over bedrock, and usually saturated; these are treated as uplands .... **UPLAND NON-FORESTED VEGETATION KEY**
3. WETLAND: soils saturated throughout season and/or *Spahgnum* covering > 10% of ground surface (see note regarding exceptions in other half of couplet); usually basins or streamsides .... **WETLAND NON-FORESTED VEGETATION KEY**

Upland Forest and Woodland Vegetation Key

1. Conifer forests and woodlands: deciduous trees < 20-25% RD 2
1. Deciduous forests and woodlands: coniferous trees < 20-25% RD 17
1. Mixed forests and woodlands: both conifers and deciduous spp > 25% RD 22

Conifer forests and woodlands: general

1. Conifer forests: tree cover usually > 65%, lower layers generally more sparse than canopy; area lacks a well-developed low shrub layer of *Vaccinium angustifolium, Gaylussacia baccata, Kalmia angustifolia*, and/or *Photinia melanocarpa*; substrate various, but often mineral soil, usually not a thin organic layer over bedrock 2
1. Conifer woodlands: tree cover usually < 65%, as low as 20% (but occasionally to ~80%), trees more-or-less open grown; low shrub layer of *Vaccinium angustifolium, Gaylussacia baccata, Kalmia angustifolia*, and/or *Photinia melanocarpa* prominent (>15% cover), or sometimes *Pteridium aquilinum* prominent (> 7% cover) instead; ground cover may feature fruticose lichens; substrate bedrock, with a thin layer of mostly organic soil material typically < 15 cm deep.......... 8

Conifer forests

2. *Tsuga canadensis* the dominant conifer 3
2. Other conifer species dominant 4

3. Hardwoods typically including *Acer rubrum, Acer saccharum*, and/or *Fraxinus pennsylvanica* present, *Pinus strobus* usually very minor (type is usually mixed but some examples are heavy to hemlock and will key here) .... **Hemlock - Hardwood Forest (CEGL006129)**
3. Hardwoods, other than *Quercus rubra* and *Betula*, absent or very sparse; *Pinus strobus* more abundant .... **Eastern Hemlock - White Pine - Red Spruce (CEGL006324)**

4. *Thuja occidentalis* the dominant conifer 5
4. Other conifer species dominant 6

5. Somewhat open forest (canopy closure often < 65%), with *Thuja* generally at least twice as dominant as other conifers; *Fraxinus pennsylvanica* often present; heath shrubs lacking or very minor; seepage at soil surface .... **Cedar Seepage Slope (CEGL006508)**
5. *Thuja* mixed with other conifers (*Pinus* and/or *Picea*), canopy closure more complete, and soils not seepy 6

6. *Pinus resinosa* ≥ 40% RD .... **Red Pine - White Pine Forest (CEGL006253)**
6. *Pinus resinosa* absent or < 40% RD 7

7. *Pinus strobus* ≥ 25% RD, may be mixed with *Tsuga canadensis* or *Thuja occidentalis* (occasionally *Pinus resinosa* replaces some of the *P. strobus*) .... **Eastern Hemlock - White Pine - Red Spruce (CEGL006324)**
7. *Picea rubens*, *P. glauca* and/or *Abies balsamea* dominant; *Pinus strobus* < 25% RD .... **Maritime Spruce - Fir Forest (CEGL006151)**

Conifer woodlands

8. *Thuja occidentalis* the dominant tree species, usually twice as abundant as any other tree species .... **White-cedar Woodland (CEGL006411)**
8. Other species dominate tree layer... 9

9. Mixture of conifer species all < 50% RD; or woodlands dominated by *Pinus strobus* or *Picea rubens* (or, rarely*, Pinus resinosa*) 10
9. Pitch pine, jack pine, or black spruce woodlands: ≥ 60% RD of a single conifer species (other than *Pinus strobus* or *Picea rubens*).. 11

10. Woodland dominated by *Picea rubens* (> 60% RD).. .... **Spruce - Fir Rocky Summit (CEGL006053)**
10. Woodland dominated by *Pinus strobus, P. resinosa* (only occasionally), or mixture of conifers .... **Spruce - Fir Rocky Summit (CEGL006053)**

11. *Pinus rigida* dominates... 12
11. Another conifer dominates 14

12. Pitch pine woodlands on ledge, trees often stunted.. 13
12. Pitch pine woodlands, or tending towards closed forest, on sandy soil, trees taller; known in Acadia NP only from Long Island .... **Pitch Pine / Blueberry spp. - Huckleberry Woodland (CEGL005046)**

13. Understory features *Corema conradii*, with heaths and lichens.. ....**Coastal Pitch Pine Outcrop Woodland (CEGL006154)**
13. Understory typical heath shrubs, lichens, etc., without *Corema* .... **Pitch Pine Rocky Summit (CEGL006116)**

14. *Pinus banksiana* dominates ....**Jack Pine Heath Barren (CEGL006041)**
14. *Picea* sp. dominates.. 15

15. *Picea rubens* dominates.. 16
15. *Picea mariana* dominates........................ **Black Spruce / Heath Rocky Woodland (CEGL006292)**

16. Woodlands on bedrock .... **Spruce - Fir Rocky Summit (CEGL006053)**
16. Woodlands on talus; trees may be more sparse.. ....**Red Spruce Talus Slope Woodland (CEGL006250)**

Deciduous forests and woodlands

17. Northern hardwood species (*Fagus grandifolia, Betula alleghaniensis*, &/or *Acer saccharum or A. rubrum)* dominate.. 18
17. Oak, birch, and/or aspen, rather than northern hardwood species, dominate 19

18. Forest (> 65% canopy), soil more or less well developed; *Fagus grandifolia, Betula alleghaniensis*, &/or *Acer saccharum or A. rubrum* total > 50% RD; occasionally one of those replaced by *Fraxinus pennsylvanica*; conifers may be up to 25% RD, usually much < 20%; *Quercus rubra*, if present, < 30% RD ....**Northern Hardwood Forest (CEGL006252)**
18. Woodland (< 60% canopy); *Betula alleghaniensis* dominant or at least co-dominant; on talus, soil very limited.. **Red Oak Talus Slope Woodland (CEGL006320)**

19. *Quercus rubra* dominant 20
19. *Betula* spp. (other than *alleghaniensis*) and/or *Populus* spp. dominant 21

20. Woodland: Canopy < 50%; on bedrock, or glacial till soils..
.. **Central Appalachian High-Elevation Red Oak Woodland, Northern Variant (CEGL006134)**
20. .... Forest: Canopy ≥ 60%; on soil, not bedrock
.... **Successional Oak - Pine Forest (CEGL006506)**

21. Canopy ≥ 60%, with subcanopy/tall shrub cover less than canopy cover, creating a forest character; *Populus grandidentata* often dominant, sometimes with *Quercus rubra* subdominant, *Betula populifolia* typically absent or unimportant..
.... **Early Successional Woodland/Forest (CEGL006303)**
21. Canopy cover ≤ 50%, with subcanopy/tall shrub cover usually greater than canopy cover; *Populus tremuloides, Betula populifolia, B. papyrifera*, and/or *B. caerulea* most commonly dominant, although some examples are dominated by sapling-size *Betula alleghaniensis* ....
.... **Early Successional Woodland/Forest (CEGL006303)**

Mixed forests and woodlands

22. *Thuja occidentalis* dominant (usually a conifer type, can be mixed) ....
.... **Cedar Seepage Slope (CEGL006508)**
22. *Thuja occidentalis* not dominant 23

23. *Tsuga canadensis* the dominant conifer and usually the dominant tree, growing with *Quercus rubra* and northern hardwood species .... **Hemlock - Hardwood Forest (CEGL006129)**
23. *Pinus*, *Picea*, or *Abies* sp. the dominant conifer... 24

24. Woodlands: trees with "woodland" form and canopy cover typically < 50%, may be up to 60%; heath shrubs > 15% (except on talus), often > 25%.. 25
24. Forests: canopy cover ≥60%, trees taller, more forest-like; heath shrubs < 15% 28

25. Talus woodland with *Picea rubens* the dominant conifer ....
.... **Red Spruce Talus Slope Woodland (CEGL006250)**
25. Woodlands not on talus 26

26. *Quercus rubra* the dominant deciduous species, with *Pinus strobus* or *Picea rubens* the most common canopy conifers... **White Pine - Oak Acid Bedrock Glade (CEGL005101)**
26. *Quercus rubra* not the most common deciduous species, most commonly it is a heterogeneous mix of *Acer rubrum*, *Betula* spp., *Populus* spp., etc 27

27. Mixed woodland with more than 50% of the canopy plus subcanopy coniferous ....
.... **Spruce - Fir Rocky Summit (CEGL006053)**
27. Mixed woodland with more than 50% of the canopy plus subcanopy deciduous................................
.... **Early Successional Woodland/Forest (CEGL006303)**

28. *Quercus rubra* the dominant deciduous species, with *Pinus strobus* or *Picea rubens* the most common canopy conifers.. **White Pine - Oak Forest (CEGL006293)**
28. *Quercus rubra* not the most common deciduous species, most commonly it is *Acer rubrum*, and sometimes *Betula papyrifera, Betula alleghaniensis*, or (rarely) *Populus grandidentata* 29

29. *Pinus strobus* the most abundant canopy conifer, ≥25% RD 30
29. *Pinus strobus* < 25% RD, typically *Picea rubens* (or, less commonly, another conifer) is more dominant 31

30. Deciduous component is more northern hardwood species (*Acer saccharum, Betula alleghaniensis, Fagus grandifolia*) than early successional species (*Betula papyrifera, B. populifolia, Acer rubrum, Populus* spp.) .... **Sugar Maple - White Pine Forest (CEGL005005)**
30. Deciduous component is more early successional species than northern hardwood species .... **Successional Oak - Pine Forest (CEGL006506)**

31. *Acer rubrum, Betula papyrifera*, or *Populus grandidentata* the most common deciduous species, northern hardwood species very minor (totaling << 20% RD); conifer component typically features *Picea rubens* mixed with varying amounts of *Abies balsamea, Picea glauca, Thuja occidentalis*, and/or *Pinus strobus* .... **Successional Spruce - Fir Forest (CEGL006505)**
31. *Betula alleghaniensis* the most common deciduous species, usually ≥ 20% RD (occasionally *Acer rubrum* will be common *but Betula alleghaniensis, Acer saccharum*, *Fagus grandifolia*, and *Fraxinus pennsylvanica* combined will exceed *Acer rubrum*); conifer component typically less diverse, featuring *Picea rubens*, sometimes with *Thuja occidentalis* .... **Red Spruce - Hardwoods Forest (CEGL006267)**

Wetland Forest and Woodland Vegetation Key

1. Wetland forest (canopy may grade towards woodland) in drainages or on gentle slopes with mineral soil rather than peat substrate; *Sphagnum* often present on ground surface but generally < 20% cover; canopy deciduous to mixed, *Acer rubrum* and/or *Fraxinus* prominent...2
1. Canopy closure and composition various; substrate is peat, with *Spahgnum* often > 25% of ground surface; not on slopes 3

2. Canopy deciduous (conifers < 25% RD), *Fraxinus* spp. (*pennsylvanica* or *americana)* plus *Betula alleghaniensis* more abundant than *Acer rubrum*...
....**Northern Hardwood Seepage Swamp (CEGL006220)**
2. Canopy mixed, or if occasionally with < 25% conifer RD, then conifers (usually *Picea* and *Abies*) well-represented in subcanopy and shrub layers (>15% cover); *Acer rubrum* the dominant deciduous tree, mixed with *Picea rubens*, *Abies balsamea*, and sometimes *Thuja* ....
.... **Red Maple - Conifer Acidic Swamp (CEGL006198)**

3. Conifers make up > 75% RD of canopy and subcanopy..4
3. Tree layer mixed (both conifers and deciduous > 25% RD) or deciduous..7

4. *Picea mariana* and/or *Larix laricina* the dominant conifer..5
4. *Thuja occidentalis* the dominant conifer 6

5. ≥ 50% canopy; heath shrubs usually < 10% (up to 15%); *Larix, Acer rubrum*, and/or *Thuja* totalling > 30% RD (rarely less) ....**Black Spruce Woodland Bog (CEGL006098)**
5. ≤ 40% canopy; heath shrubs > 25% ....**Black Spruce Woodland Bog (CEGL006098)**

6. More closed-forest character, with canopy > 50% (*Thuja* may be strongly dominant or mixed with other conifers); heath shrubs ≤ 10%; *Carex trisperma* characteristically a dominant sedge ....
.... **Northern White-cedar Wooded Fen (CEGL006507)**
6. Bog woodland character, canopy ≤ 40%, heath shrubs > 20%, *Carex trisperma* absent or very minor (*Carex stricta* dominant in the one sample) ....
.... **Northern White-cedar Wooded Fen (CEGL006507)**

7. Canopy at least 60% *Picea mariana* and/or *Larix laricina* (slightly mixed) ....
....**Black Spruce Woodland Bog (CEGL006098)**
7. Canopy at least half *Acer rubrum*...8

8. *Acer rubrum* dominates canopy, conifers < 25% RD...
....**Red Maple Swamp Woodland (CEGL006395)**
8. *Acer rubrum* mixed with *Picea mariana* (≥ 25% RD) ....
....**Red Maple Swamp Woodland (mixed variant, CEGL006395)**

Upland Non-Forested Vegetation Types Key

1. Herbaceous or dwarf shrub – herbaceous (occasionally sparse) vegetation at the immediate coast (tree islands may be present in rocky headland communities) 2

1. Shrub/herb occasionally sparse) vegetation on summits and rocky upper slopes; scattered stunted *Picea rubens* and *Quercus rubra* may be present (< 15% cover overall) 5

2. Dune and tidal-edge vegetation on sand, dominated by *Ammophila breviligulata*; limited extent in Acadia NP..**Northern Beachgrass Dune (CEGL006274)**

2. Graminoids not dominant; near-shore vegetation in patches on bedrock or cobble........................... 3

3. Vegetation sparse (< 25%, often < 10%).. 4

3. Vegetation forming nearly continuous cover (or at least there is more vegetated surface than bare rock surface); *Empetrum* mats may be extensive; *Myrica pensylvanica* characteristic .... **Crowberry - Bayberry Maritime Shrubland (CEGL006510)**

4. Vegetation forming scattered patches in rock crevices; *Solidago sempervirens, Sedum rosea, Plantago maritima, Euphrasia randii,* etc. are typical .... **Northern Maritime Rocky Headlands (CEGL006529)**

4. Vegetation on loose cobble near and above the high tide line; *Cakile edentula* and *Lathyrus japonicus* characteristic..................................... **Sea-rocket - Oysterleaf Sparse Vegetation (CEGL006106)***

5. Vegetation sparse (< 25%, often < 10% cover), on talus .... **Northern Lichen Talus Barrens (CEGL006534)***

5. Vegetation with higher cover (usually) and not on talus... 6

6. Vegetation forming patches across bare rock; mosaics of dwarf (< 0.5 m tall) *Vaccinium angustifolium* patches and somewhat taller *Gaylussacia baccata* patches, heath species dominate the shrub vegetation; shrubs > 1 m tall absent in the *Vaccinium angustifolium* patches, up to 25% cover in the taller vegetation patches; *Kalmia angustifolia, Sibbaldiopsis tridentata,* and *Deschampsia flexuosa* characteristic associated species..................... **Blueberry Granite Barrens (CEGL005094)**

6. Vegetation more uniformly shrubby, shrubs > 1 m tall form > 25% cover, often > 50% cover; non-heath shrubs exceed heath shrubs in total shrub cover... 7

7. Summit shrublands with shrub layer characterized by some combination of *Viburnum nudum, Nemopanthus mucronata*, and *Ilex verticillata*; Betula spp. and/or *Sorbus americana* often present, but not dominant; shrub layer (1-3 m) usually < 50% cover... .... **Blueberry Granite Barrens (CEGL005094)**

7. Shrublands of upper ridges and sometimes summits with *Betula* spp. strongly dominating the shrub layer (1-3 m), that layer usually forming > 50% cover; *Picea rubens* an associate in some locations; other shrubs typical of the Blueberry Granite Barrens type may be present but at much lower abundance.. **Early Successional Woodland/Forest (CEGL006303)**

Wetland Non-Forested Vegetation Types Key

1. Tidal marshes 2
1. Non-tidal marshes and wetlands...3

2. Brackish tidal marshes with mixed tall sedges and often with *Typha angustifolia* .... **Brackish Tidal Marsh, Cattail Variant (CEGL004201)***
2. Saltmarshes: vegetation varies, but *Spartina alterniflora* usually present if not a major component; dominants include *Carex paleacea, Juncus gerardi*, etc. .... **Spartina High Salt Marsh (CEGL006006)**

3. Saturated or only seasonally flooded wetlands and marshes, with persistent emergent vegetation....4
3. Open-water marshes, permanently (or, rarely semipermanently) ...flooded, vegetation not persistent over winter...**see below**

- Floating-leaved vegetation with *Nuphar lutea* a characteristic species .... **Water Lily Aquatic Wetland (CEGL002386)***
- Seasonally emergent tall rushes (*Scirpus validus*, etc.) dominate ....**Bulrush Deepwater Marsh (CEGL006275)***
- Submerged vegetation dominated by *Vallisneria* and *Potamogeton* spp...................................... .... **Open Water Marsh with Mixed Submergents/Emergents (CEGL006196)***
- Submerged vegetation in shallow waters, rosette plants dominate, typical species *Eriocaulon aquaticum* and *Lobelia dortmanna* .... **Seven-angle Pipewort - Dortmann's Cardinal-flower Herbaceous Vegetation (CEGL006346)***

4. Seasonally flooded wetlands and marshes, without *Sphagnum* peat base; *Sphagnum* ground cover < 50%; *Alnus* spp., *Calamagrostis canadensis, Carex stricta, Juncus* spp. and/or *Scirpus*-types (excluding *Trichophorum*) dominant; *Myrica gale*, if present, is less abundant than alders 5
4. *Sphagnum* peatlands, with dwarf shrubs or graminoids dominant; *Sphagnum* > 50% cover, or, if *Sphagnum* cover < 50% then heath shrubs (occasionally *Empetrum*) or *Myrica gale* (sometimes with *Spiraea* spp.) are the dominant <u>shrubs</u> (regardless of whether the overall vegetation is dwarf-shrub-dominated or graminoid-dominated)..10

5. Alder wetlands; shrubs over 1 m tall > 35% cover, usually > 50%; *Alnus* spp. dominate.................6
5. Graminoid-dominated, shrubs over 1 m tall sparse < 25%, usually < 10% (SMG)............................7

6. Alder wetlands along streamsides or in narrow valleys ....**Alluvial Alder Thicket (CEGL006062)**
6. Basin wetlands dominated by *Alnus* spp., often forming a zone near the perimeter of a peatland; *Nemopanthus* often present ....**Northern Peatland Shrub Swamp (CEGL006158)**

7. *Typha latifolia* dominant ....**Eastern Cattail Marsh (CEGL006153)**
7. Other graminoids dominant...8

8. *Carex stricta* or *Juncus militaris* dominant 9
8. *Carex stricta or Juncus militaris* not dominant, although may be present; *Calamagrostis canadensis* characteristic, sometimes dominant; other graminoids such as *Scirpus cyperinus, Dulichium arundinaceum* occur as part of the mixture and may exceed cover of *Calamagrostis*......................... .... **Seasonally Flooded Mixed Graminoid Meadow (CEGL006519)**

9. Tussocks of *Carex stricta* dominate; wetland often flooded or at least saturated to surface through season .... **Eastern Tussock Sedge Meadow (CEGL006412)**
9. *Juncus militaris* dominates at least central portion; dense shrubs (e.g., *Ilex verticillata*) typical around perimeter; seasonally flooded drawdown wetlands whose ground surface may be dry by late summer ....**Bayonet Rush Herbaceous Vegetation (CEGL006345)**

10. Total coverage by *Myrica gale* and *Spiraea* spp exceeds total coverage by heath shrubs; vegetation usually strongly shrub-dominated .... **Sweetgale Mixed Shrub Swamp (CEGL006512)**
10. Total coverage by heath shrubs exceeds total coverage by *Myrica* and *Spiraea*; vegetation may be shrub-, herb-, or bryophyte-dominated..11

11. Fens: minerotrophic peatlands with or without drainage 12
11. Bogs: ombrotrophic peatlands, vegetation surface raised; fen vegetation may occur around perimeter but most of peatland is raised 13

12. Fens along streams or in peatlands with drainage into and out of the peatland ....**see vegetation key following**
12. Fens in closed drainages (small outlet drainage may be present, but no inlet stream), often with transitional fen-bog vegetation ....**see vegetation key following**

13. Coastal bogs with central plateau featuring *Trichophorum cespitosum* "lawn" community; Big Heath the only known example in Acadia NP ....**see vegetation key following**
13. Coastal or inland bogs with vegetation dominated by dwarf heath shrubs, graminoids patchy and often sparse and *Trichophorum cespitosum* absent or infrequent...................**see vegetation key following**

Vegetation-type Key for Bog and Fen Types

a. *Carex lasiocarpa* dominates, with other tall sedges such as *Carex utriculata* characteristic; heath shrubs may be present but are typically minor; fen community, usually in open fen ....**Slender Sedge Fen (CEGL006521)**
a. Other sedges or dwarf shrubs dominate, or vascular vegetation sparse; fens or bogs.........................b

b. Graminoid cover exceeds dwarf shrub cover c
b. Dwarf shrub cover exceeds graminoid cover ....d

c. *Trichophorum cespitosum* the dominant graminoid species; lawn community of coastal raised bogs, known from Acadia NP only at Big Heath........... **Maritime Peatland Sedge Lawn (CEGL006260)**
c. Other sedges more abundant than *Tricophorum cespitosum*, *Carex oligosperma* and/or *C. exilis* characteristic; *Chamaedaphne* a characteristic shrub... ....**Few-seeded Sedge - Leatherleaf Fen (CEGL006524)**

d. Heath shrub cover > 60% <u>or</u> *Gaylussacia dumosa* and *Empetrum nigrum* present; *Chamaedaphne* usually less common than other heath shrubs; ombrotrophic.. e
d. Heath shrub cover < 50% <u>and</u> *Gaylussacia dumosa* and *Empetrum nigrum* absent; *Chamaedaphne* often the most common heath shrub; basically minerotrophic.. ....**Leatherleaf Acidic Fen (CEGL006513)**

NOTE: the Few-seeded Sedge - Leatherleaf Fen and Leatherleaf Acidic Fen vegetation communities are very closely related and hard to tease apart in the samples and ordinations. But in Maine peatland work and in regional reviews, there's a clear concept of how they're separated (supposedly the proportion of sedges/shrubs, with moderate to high cover of *Carex exilis* the classic feature for Few-seeded Sedge - Leatherleaf Fen).

e. *Gaylussacia dumosa* the most abundant shrub, or at least dominates extensive patches; *Empetrum nigrum* almost always present though not necessarily at high cover; graminoid cover may be relatively high (often > 25%) .... **Maritime Crowberry Bog (CEGL006248)**

e. Other heath species, typically *Kalmia angustifolia* and/or *Rhododendron canadense*, more abundant than *Gaylussacia dumosa*; graminoid cover typically low (< 10%) **Northern Dwarf-shrub Bog (CEGL006225)**

Appendix C

Example of an Accuracy Assessment Form

USGS-NPS Vegetation Mapping Program 333

ACCURACY ASSESSMENT FORM
ACADIA NATIONAL PARK, 1999 [redacted]

Plot #: WP 381 1327	**Park code:** ***ACAD***
Date: 99-08-19	**Observers:** ***SCR JEW*** DR COB
Datum: NAD 83	**Accuracy:** 4.2
UTM Zone: ***19***	
UTM Easting 5 6 0 . 9 3 0	**UTM Northing** 4 . 9 1 4 . 8 9 1
Offset from pt. Easting: ±0 **m**	**Offset from pt. Northing:** +1 **m**

SETTING

Topography:	Slope = ~35, +22%. Transitional rocky shrubland between bald & forest. Bedrock outcrops + surface deposits (not huge erratics though)
Elevation: 126 (m) OR ft	**Aspect** 240°
Soil texture: gravelly sand. **Soil depth:** 30 cm	**Stoniness:** small stones (1.5cm) **Drainage:** ex. well
Setting comments:	Huge charcoal chunks. Soil full of charcoal.

STRUCTURE & COMPOSITION

stratum	Major Species Present	% evergreen:decid 0 : 100	% Cover of Layer	Cover Patchy or ~Uniform?
TREE	Bet pop		<5	P
SAPLING	Bet pap Bet pop Ame sp.		40	~U
SHRUB (1-3 m)	Bet pop.		50	U
DWARF SHRUB	Vac ang Die lon Ame sp. Ace rub		30	U
HERB	Dan spi*, Sol rand, Pte aqu. Ory asp		10-15	~U
BRYOID	Pol pil, Cla syl Cla sp.		10	P

Indicator spp: ——— **Rare spp:** ———

VEGETATION TYPE and MAP UNIT

Veg. Type Code: ABW	**Map Unit Code:** SB
Alternate Veg Type: ABW	**Alternate Map Unit:** MDW
Veg Type #2 w/in 50 m of Pt.: ABW	**Veg. Type #3 w/in 50 m of Pt.:** BBSS

Rationale for Classification: Keys well. Downslope (i.e. Veg type #2 w/in 50m) = more ABW/ABF This is SB.

Comments:

Figure C-1. Accuracy assessment field data form.

Appendix D

Ordination Diagrams and Results of the Vegetation Data Analysis

The following discussions and diagrams provide a detailed explanation of the analysis performed on vegetation sample data collected at Acadia National Park (NP; see Data Analysis section in Methods section). The purpose of the analysis is to elucidate vegetation patterns and vegetation types. The data from these analyses are built upon vegetation sampled at Acadia NP.

The results of the analyses are shown as ordination diagrams in Figures D-1–D-12, which may be unfamiliar to some readers. The diagrams plot samples according to their compositional similarity: samples close to each other are similar and those father apart less so. The data are first and second axis ordination scores for the samples. These axes reflect compositional gradients related to environmental factors; however, they are not direct scales of certain factors. Ordination diagrams are useful in two major ways. First, they give a graphical picture of the relations among groups of samples. Groups may be classes (forest, woodland, shrubland [e.g., Figure D-1]), hydrologic group (upland, wetland, etc. [e.g., Figure D-4]), or vegetation types (e.g., Figures D-5–D-8 and D-10–D-12). Second, one can overlay or correlate values of environmental factors to deduce influential environmental gradients (See Figure 7 in Field Sampling of Methods for example). If hydrologic regime shows a relation to the first axis, for example (Figure D-3), it is a more important determinant in vegetation composition than if it shows a relation only to the second or third axis, or none at all.

Preliminary Analyses

Vegetation was analyzed first with reference to physiognomic class and hydrologic regime. To see how vegetation differences corresponded to physiognomic class, we ran Detrended Correspondence Analysis (DCA) on forests, woodlands, and shrublands together. Wetland shrublands were strongly different from all other samples and the ordination was re-run without them. The two major gradients were forests and woodlands on the first axis (with considerable overlap), and uplands to wetlands on the second axis (Figures D-1 and D-2). The upland shrublands separated from the woodlands to some degree on the third axis, but it is apparent that physiognomic differences between woodlands and shrublands in Acadia do not translate into strong compositional differences. TWINSPAN of this same data set echoed these two gradients.

Looking at forests only, certain types, the “easy” ones, fell out clearly. Of the 12 forest types with more than one sample, six showed reasonably good separation in the ordination and the other six formed a largely undifferentiated mass in the center. Forest types that separated well included two wetland types, the closed expression of the Black Spruce Woodland Bog (CEGL006098) and the closed-canopy expression of the Northern White-cedar Wooded Fen (CEGL006507), and four upland types: Hemlock - Hardwood Forest (CEGL006129), Red Pine - White Pine Forest (CEGL006253), Northern Hardwood Forest (CEGL006252), and White Pine - Oak Forest (CEGL006293). The messy types, Sugar Maple - White Pine Forest (CEGL005005), Eastern Hemlock - White Pine - Red Spruce (CEGL006324), Maritime Spruce - Fir Forest (CEGL006151), Successional Spruce - Fir Forest (CEGL006505), Red Spruce - Hardwoods Forest (CEGL006267), and Red Maple - Conifer Acidic (CEGL006198), are those that are characterized by red spruce, balsam fir, and/or red maple. The wide ecological amplitudes of these three species can obscure differentiation of community types.

Woodland samples paralleled the forest samples. Detrended Correspondence Analysis separated half the types well, with the other half initially failing to separate. The first axis separated the boggy woodland types, Red Maple Swamp Woodland (CEGL006395) and Black Spruce Woodland Bog (CEGL006098), from the remainder. The second axis reflected a conifer to deciduous gradient. (It was also significantly correlated with introduced species, but only because of high values in one sample, a rather spurious relation). The third axis provided little additional information beyond separating out those woodlands with a strong white cedar component.

Woodland types that separated easily were those dominated by pitch pine or jack pine, black spruce or red maple bog woodlands, and white cedar woodlands. Those that remained, reflecting an indistinct identity within the full data set, were those with red spruce, red oak, or with both conifers and deciduous trees making up at least 25%. Within this group, the red spruce woodlands were at one end of the gradient and the mixed deciduous woodlands at the other end.

Samples dominated by dwarf shrubs or herbs segregated first by hydrology and saltwater influence. Salt marshes, dune, and beach vegetation pulled out strongly on the first axis (Figure D-3). Once those were removed, the strongest gradient remained the upland – wetland split, with class (shrub, dwarf shrub, herb) showing gradations but no clear separations between the three physiognomic types (Figure D-4).

Based on these preliminary analyses, the complete data set was divided into the following subsets for further refining the vegetation types:

- Upland forests and woodlands
- Wetland forests and woodlands
- Non-forested uplands
- Non-forested wetlands

Wetland shrublands were included in the non-forested data sets; upland shrublands were included in both forested and non-forested sets (because of overlap with both types), and then pulled out entirely. In some cases, we extracted smaller data sets to look at particular types.

By analyzing these smaller sets with better resolution, we assessed how the rough assignment of vegetation type, usually done in the field, corresponded to actual compositional differences. Our concept of vegetation types was evolving based on both field observations and photointerpretation, and these analyses were useful for identifying gross vegetational patterns and highlighting where the characteristics on which we discriminated vegetation types were not sufficiently refined to result in consistent assignment.

Dendrograms constructed from the TWINSPAN analyses, ordination diagrams coded by field vegetation type, and the summaries of each sample point provided the material for two important, and iterative, steps: determining which samples did not classify well or were misclassified, and determining what suite of structural characters and dominant species were most useful in segregating the vegetation types.

We then assigned each sample to a vegetation type based on these revised diagnostics, and re-ran DCA. These ordinations show the relations and overlap of the vegetation types as best as we can distinguish them with the available data. Indicator Species Analyses identified species that might be diagnostic in discriminating between closely related types.

All species found during the sampling effort are listed in Appendix H: Plant Species List of Acadia National Park.

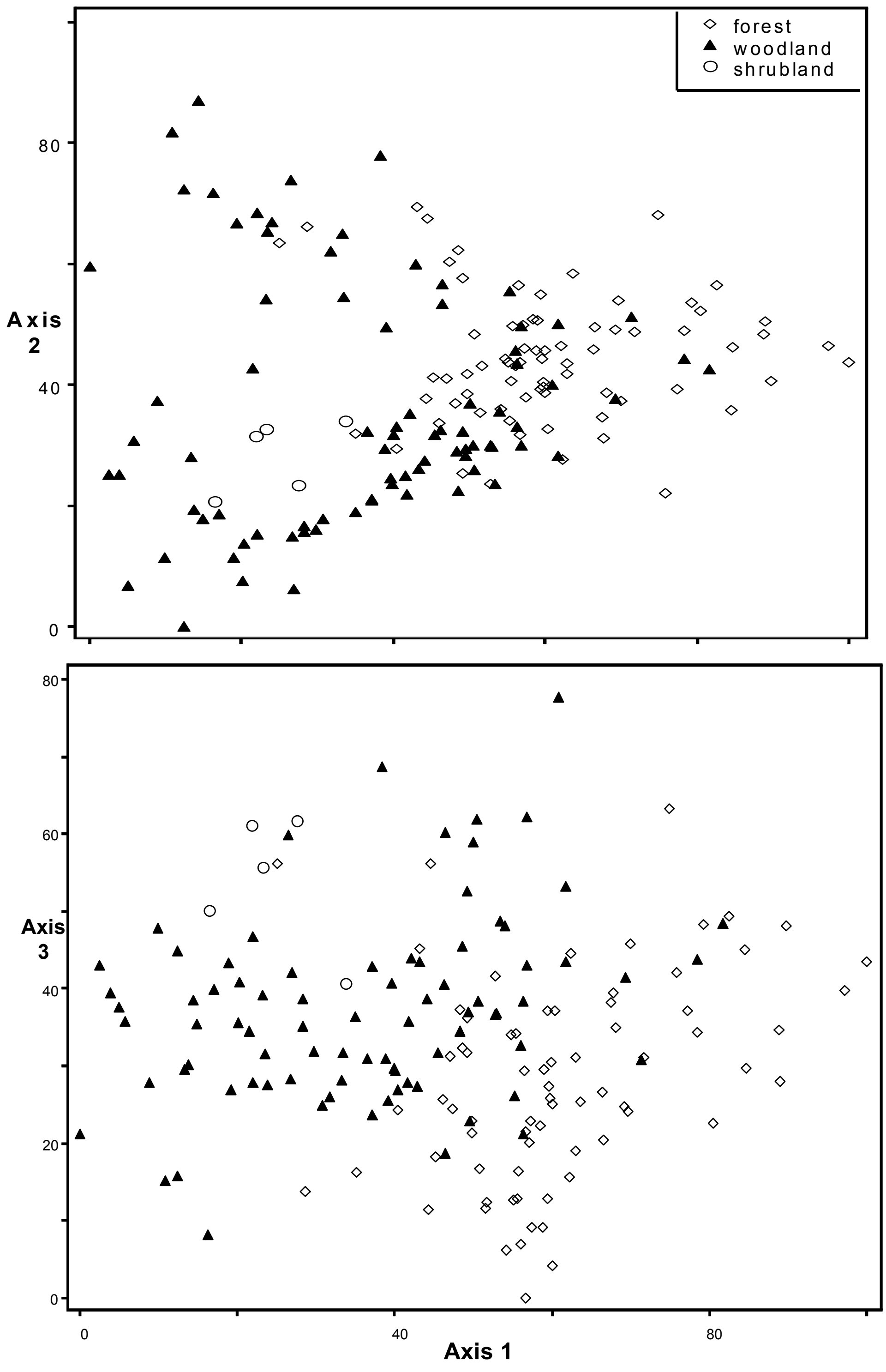

Figure D-1. Detrended Correspondence Analysis ordination of all forests, woodlands, and upland shrublands, by vegetation class. The first axis is plotted against the second axis (top figure) and the third axis (bottom figure). These axes accounted for 38% of the variance in the data. Axes are scaled to percent of the maximum score on axis 1.

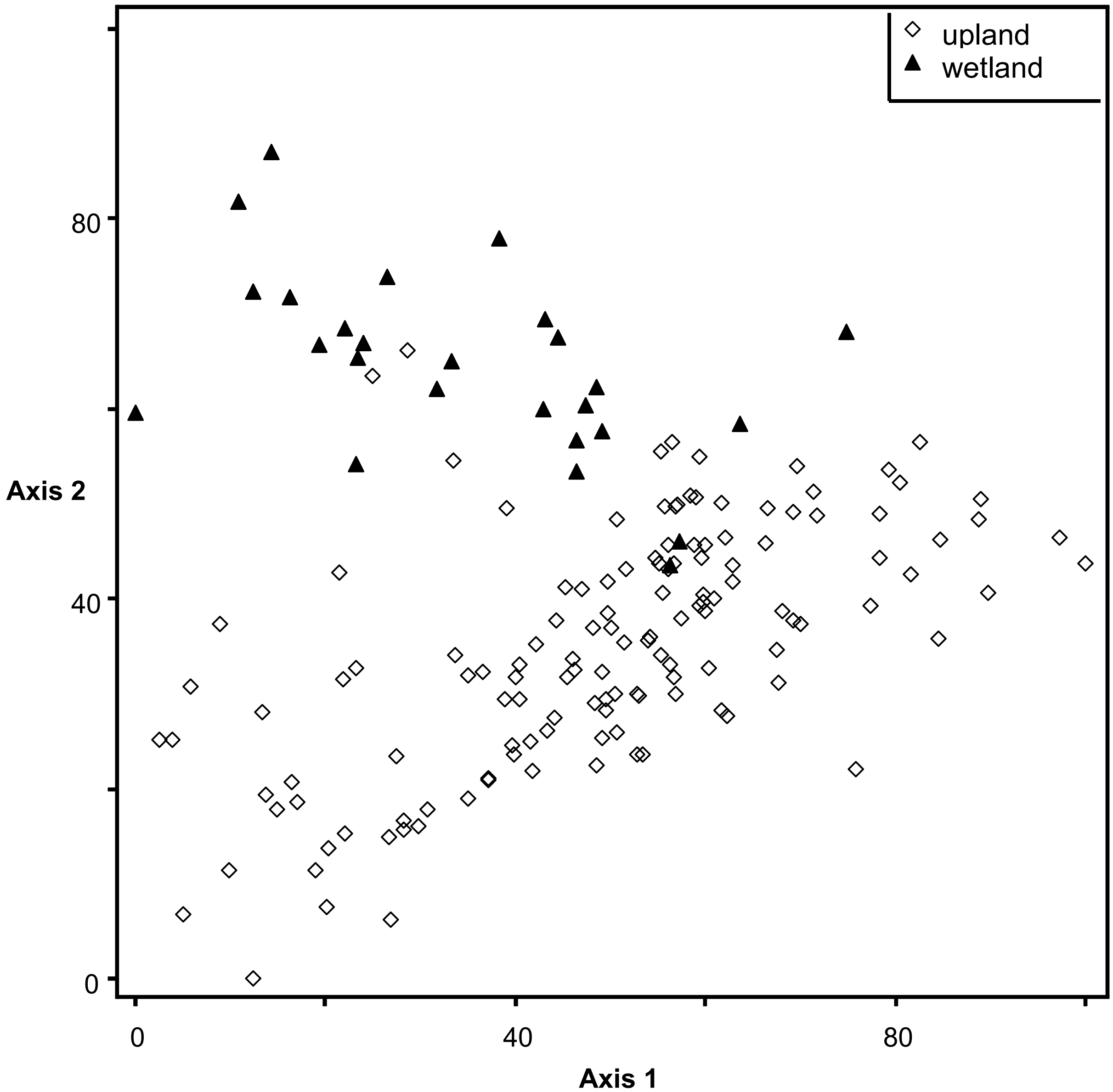

Figure D-2. Detrended Correspondence Analysis ordination of all forests, woodlands, and upland shrublands, plotted by hydrologic regime. Note the strong separation of wetland samples on the second axis. Axes are scaled to percent of the maximum score on axis 1.

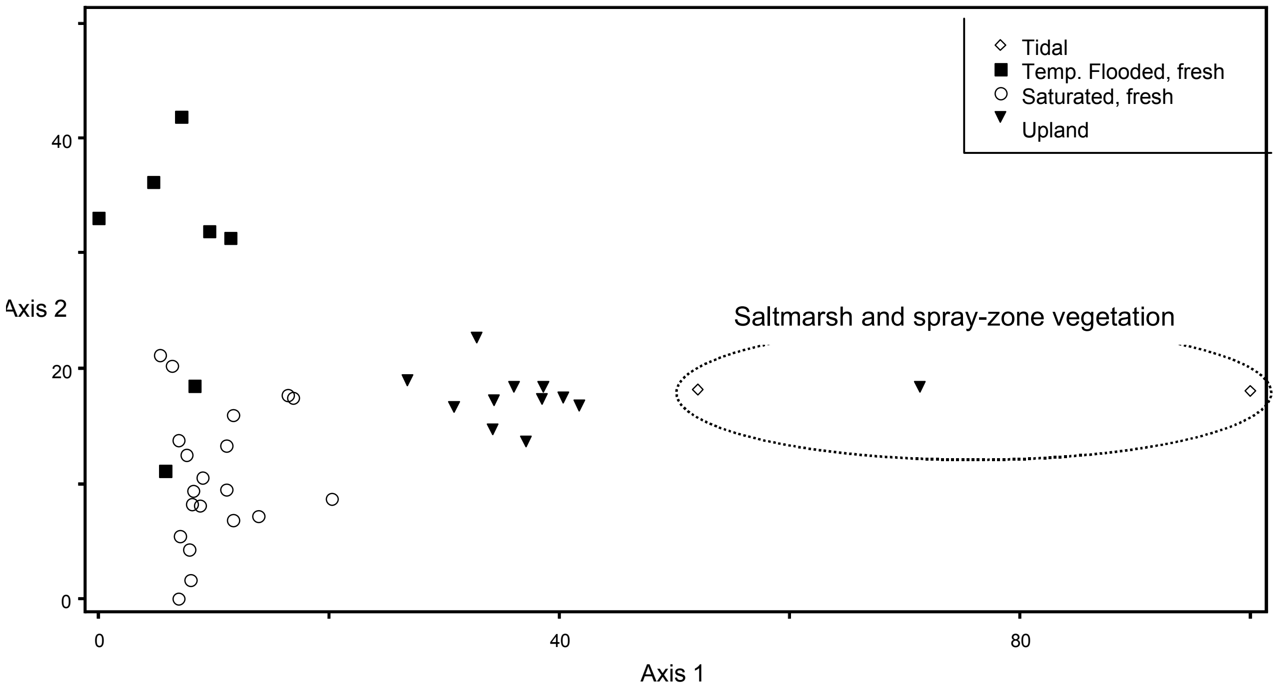

Figure D-3. Non-forested vegetation showing the strong influence of salt-spray vegetation types (removed for subsequent analysis). Axes are scaled to percent of the maximum score on axis 1.

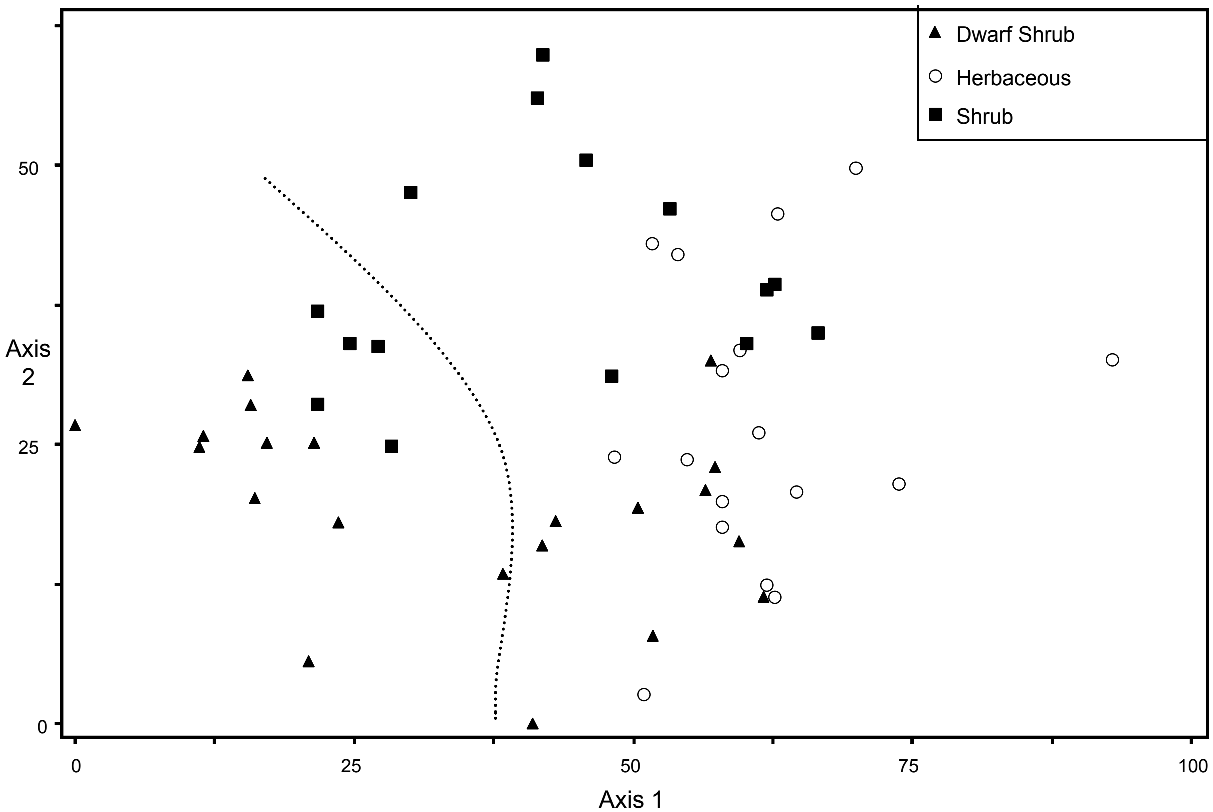

Figure D-4. Non-forested vegetation by physiognomic class. Note upland to wetland gradient on Axis 1: points to the left of the dashed line are upland. Axes are scaled to percent of the maximum score. R2 for the first three axes = .382. Axes are scaled to percent of the maximum score on axis 1.

Upland Forests and Woodlands

Twenty-three types of upland forests and woodlands are defined for Acadia. Analysis of the 133 samples showed the primary gradient (first axis) to be a forest-woodland transition (Figure D-6), with an element of nutrient status. Northern hardwood forests are at the left end of the axis, followed by spruce/fir and oak forests, then by oak, spruce or mixed pine woodlands, then by the most nutrient poor pitch pine / jack pine / black spruce woodlands (see Figures D-7 and D-8). Superimposed on the forest-to-woodland gradient is a deciduous-to-coniferous gradient, with deciduous forests and woodlands in the upper left quadrant of the ordination diagram, grading to coniferous samples in the lower right (Figure D-6).

The environmental and vegetation summary variables' correlations with the DCA axes mirrored forest-to-woodland and deciduous-to-coniferous gradients. First axis scores were positively correlated with the percent of conifer cover in the canopy and with the total cover of dwarf shrubs, herbs, and bryoids (i.e., cover of the lower layers increases as one moves from forest to woodland). The axis was negatively correlated with the total canopy percent, total basal area, number of canopy species, and number of herbaceous species. The second axis was positively correlated with both cover and richness of herbs and dwarf shrubs, and negatively correlated with canopy conifer percentage, basal area, canopy closure, and bryoid cover.

TWINSPAN of these data showed a clear separation (1st split; Figures D-7 and D-8) into forests and oak woodlands versus spruce/pine woodlands, with the spruce/pine woodlands characterized by *Kalmia angustifolia*, *Vaccinium angustifolium*, and *Gaylussacia baccata*. A few types in the middle of the ordination diagram, Early Successional Woodland/Forest (CEGL006303), White Pine - Oak Acid Bedrock Glade (CEGL005101), White-cedar Woodland (CEGL006411), Eastern Hemlock - White Pine - Red Spruce (CEGL006324), and Red Pine - White Pine Forest (CEGL006253), were divided by this first split. (A characteristic of TWINSPAN is that groups in the middle—the area of least definition-- can get split "artificially" in an early iteration.) In the case of the woodland types, Early Successional Woodland/Forest (CEGL006303) and White Pine - Oak Acid Bedrock Glade (CEGL005101), the split relates to their rather broad amplitude in canopy closure and overall character: both can range from almost-closed-canopy forests to quite open woodlands, with associated understory variation. In the case of the white pine forest types, Red Pine - White Pine Forest (CEGL006253) and Eastern Hemlock - White Pine - Red Spruce (CEGL006324), and the White-cedar Woodland (CEGL006411) type, the same forest-woodland gradation may be a factor, but these are also types that are not well represented in Acadia and thus with few samples (N=3 for each).

The first TWINSPAN split also reveals how the forest-to-woodland distinction relates both to canopy closure and the development of understory vegetation. When samples dominated by red spruce were assigned to forest or woodland type based only on the canopy closure, the "woodland" (< 70% canopy) samples were divided by the first TWINSPAN split; but when the < 70% canopy samples without the heath shrub layer were put back with the Maritime Spruce - Fir Forest (CEGL006151) type, the split was clean (Figure D-7). This supports the field observations that whether an area is best typed as "forest" or "woodland" depends both on the dwarf shrub and herb layer development as well as canopy closure.

The difficulties in separating some forests and woodlands vegetationally are consistent with difficulties in separating them during photointerpretation. Acadia is characterized by a full suite of forest-to-woodland gradations, and it is not always obvious to which class a particular type should be assigned. For example, Cedar Seepage Slope (CEGL006508) and White-cedar Woodland (CEGL006411) types exhibit both forest and woodland characters: variable canopy closure, and sometimes but not always a well-developed understory; and the DCA showed them to have the greatest overlap with the forested types of any woodland types (Figure D-8). Similarly, two of the three samples for the Red Pine - White Pine Forest

(CEGL006253) type appear on the "woodland" side of the ordination diagram, and this forest type does have characters intermediate between forest and woodland.

TWINSPAN produced four major groups of forest types, plotted onto the DCA diagram in Figure D-7. Group "A", with the largest number of samples, are the spruce-fir forests. The three major components of this group are the Maritime Spruce - Fir Forest (CEGL006151) type and two variants of it. The Successional Spruce - Fir Forest (CEGL006505) type is an earlier successional version of the Maritime Spruce - Fir Forest (CEGL006151) type, and is common in the portion of the park that burned in 1947. The Eastern Hemlock - White Pine - Red Spruce (CEGL006324) type is similar to the spruce-fir stands but with a white pine supercanopy component. Group "B" are samples intermediate between heavily coniferous spruce-fir and heavily deciduous northern hardwoods. This includes the Red Spruce - Hardwoods Forest (CEGL006267) type, two of the three samples of the Hemlock - Hardwood Forest (CEGL006129) type, and those of the Northern Hardwood Forest (CEGL006252) type that have 5-20% of the canopy made up of spruce and/or fir. Group "C" is primarily beech-birch-maple forests without spruce and fir, but also includes the third sample of the Hemlock - Hardwood Forest (CEGL006129) type. Group "D", the "oak" group, has the largest range of variation of the four groups, and includes both forests and deciduous-to-mixed woodlands. Types that fall here are most of the Early Successional Woodland/Forest (CEGL006303) type and all of the red oak types: White Pine - Oak Forest (CEGL006293), Successional Oak - Pine Forest (CEGL006506), Central Appalachian High-Elevation Red Oak Woodland, Northern Variant (CEGL006134), and White Pine - Oak Acid Bedrock Glade (CEGL005101).

On the other side of the first TWINSPAN division, four groups of conifer woodlands can be identified (Figure D-8). Group "A", Jack Pine Heath Barren (CEGL006041) type and most of the CEGL006041 (CEGL006292) type are those in the most low-nutrient and cool microclimate habitats, Acadia's closest approach to boreal conditions. The other groups are more temperate in character. Group "B" are woodlands mostly featuring red spruce, including the Spruce - Fir Rocky Summit (CEGL006053) type, the Red Spruce Talus Slope Woodland (CEGL006250), two of the three samples of Red Pine - White Pine Forest (CEGL006253) type, and the two samples of the Pitch Pine / Blueberry spp. - Huckleberry Woodland (CEGL005046) type. Groups "C" and "D" are characterized by pitch pine. The wide amplitude of pitch pine woodlands on the first axis, resulting in this split into two groups, reflects the extensive development of this type in Acadia. Pitch pine woodlands range from those more closely allied with oak-pine woodlands (Group "C") to those in more extreme habitats that show similarities to the black spruce or jack pine types. The one sample of the Coastal Pitch Pine Outcrop Woodland (CEGL006154) type, a type known from only one location in Acadia, is at the extreme right end of the pitch pine woodland range of variation, and occurs on a foggy and cool headland on the immediate coast. (Pitch pine - Corema woodlands elsewhere in the state occur in more temperate settings as well, and are not considered vegetationally distinct from straight pitch pine woodlands in the state classification.)

A description of each upland forest and woodland type is given in Appendix I: Vegetation Descriptions of this report.

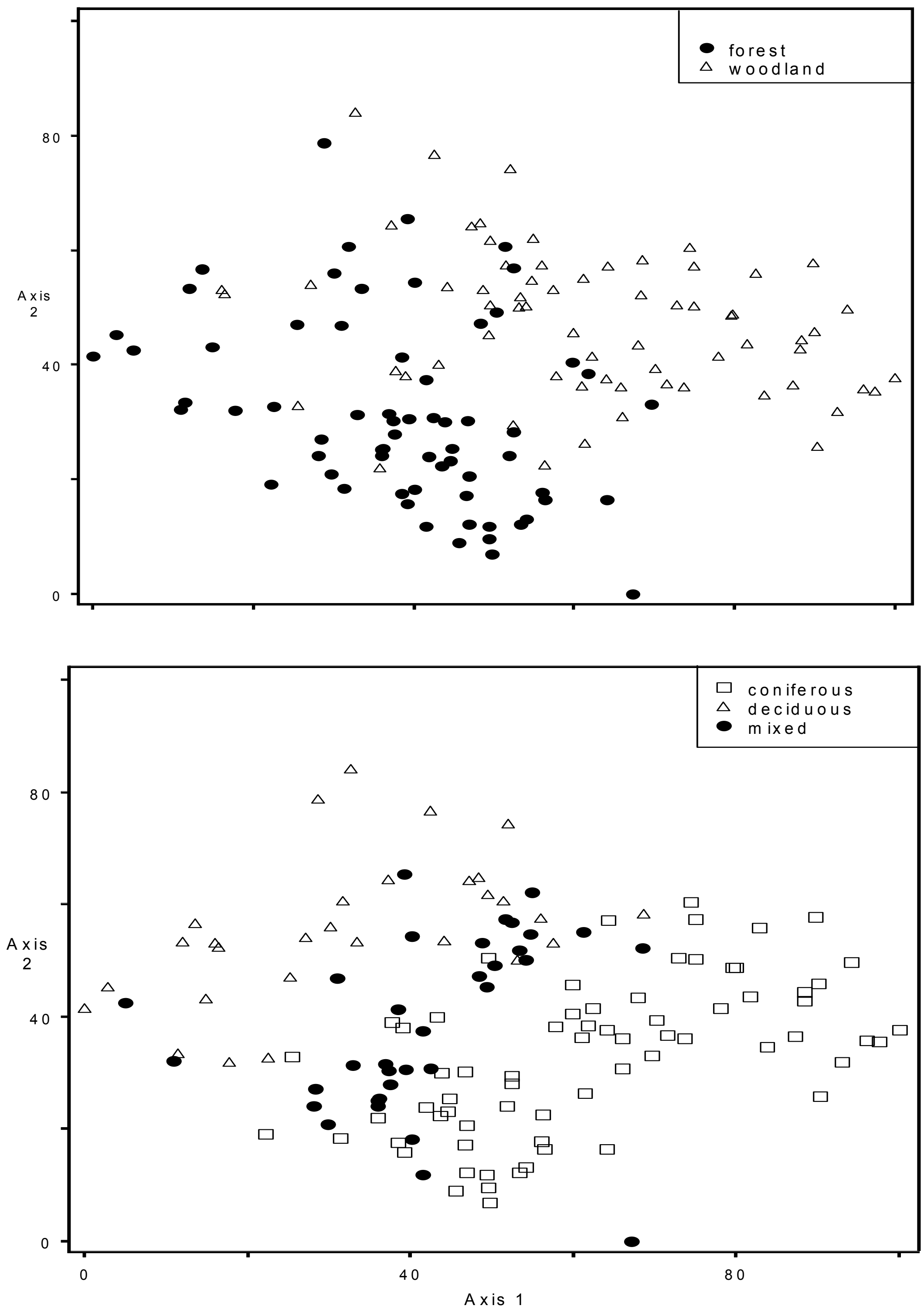

Figure D-6. Upland forests and woodlands by class and subclass, showing gradients on both axes from forest to woodland and from deciduous to coniferous. Axes are scaled to the percent of the maximum score on axis 1.

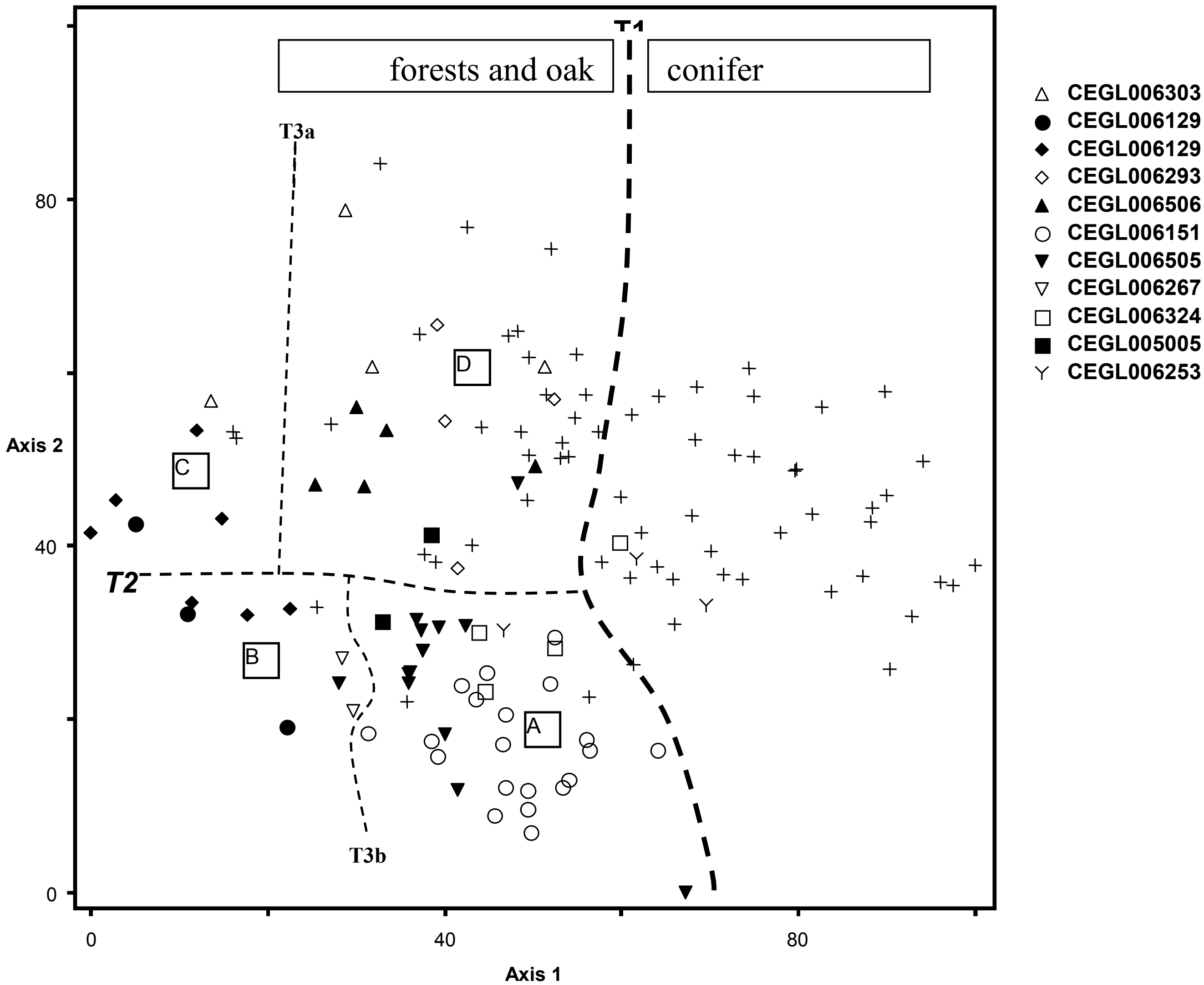

Figure D-7. Detrended Correspondence Analysis ordination of upland forest and woodland samples, coded by forest type. Twinspan divisions are shown as heavier to lighter lines; "T1" refers to the first Twinspan division, etc. (Divisions on the "conifer woodland" side of the first division are shown in Figure D-11.) Woodland types are included for reference and marked with a cross; Figure D-11 shows those by type. Boxed letters A-D refer to groups discussed in the text. Axes are scaled to percent of the maximum score on axis 1.

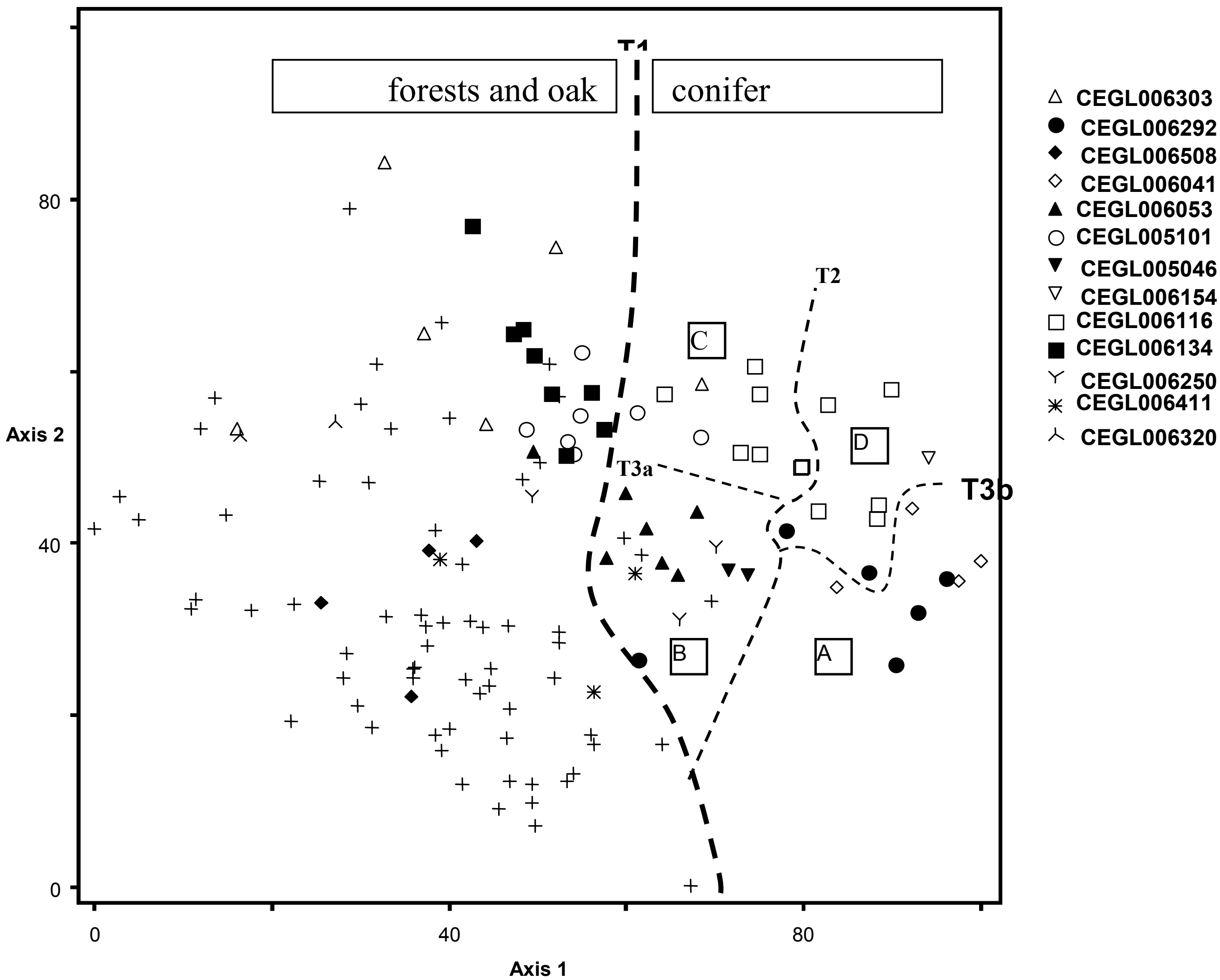

Figure D-8. Detrended Correspondence Analysis ordination of upland forest and woodland samples, coded by woodland type. Twinspan divisions are shown as heavier to lighter lines; "T1" refers to the first Twinspan division, etc. (Divisions on the "forest" side of the first division are shown in Figure D-10.) Forest samples are marked with a cross. Boxed letters A-D refer to groups discussed in the text. Axes are scaled to percent of the maximum score on axis 1.

Wetland Forests and Woodlands

Five types of wetland forests and woodlands were differentiated, with one type, the Red Maple Swamp Woodland (CEGL006395), subdivided into a deciduous phase and a mixed phase. Detrended Correspondence Analysis ordination of the 26 samples revealed a first axis gradient related to nutrient availability and substrate (Figure D-9): boggy samples at the left end, and mineral soil wetlands with few bryophytes and somewhat higher pH at the right. The second axis showed a strong coniferous to deciduous gradient. The species plot of these data placed the heath shrubs conspicuously in the lower left corner (boggy samples), corresponding with the most acidic and nutrient poor conditions where black spruce dominates.

Figure D-9 demonstrates the continuous gradation from one type to another; intermediates among types, especially the peatland types Black Spruce Woodland Bog (CEGL006098), Northern White-cedar Wooded Fen (CEGL006507), and Red Maple Swamp Woodland (CEGL006395), are common. Northern white cedar, in particular, displays the wide amplitude seen also in the upland samples. Northern white cedar wetlands range from those closely allied with black spruce bog woodlands, to typical cedar fens, to those in a more minerotrophic setting with red spruce.

Woodlands dominated by red maple are mapped as only one type but separated in both DCA and TWINSPAN analyses. Those with strong dominance of red maple tend to be in higher nutrient conditions and may be on either shallow peat or mineral soil. On the islands, the red maple woodlands have a strong black spruce component (technically mixed), and a more nutrient-limited character. In analyses of statewide vegetation patterns, red maple woodland fens likewise grade from all deciduous canopies to those mixed with black spruce or larch, although red maple is always the most abundant tree. Red maple wetlands on mineral soils are a different type statewide; the closest ally in Acadia are the Red Maple - Conifer Acidic Swamp (CEGL006198) type along fairly small drainages.

A description of each wetland forest and woodland type is given in Appendix I: Vegetation Descriptions of this report.

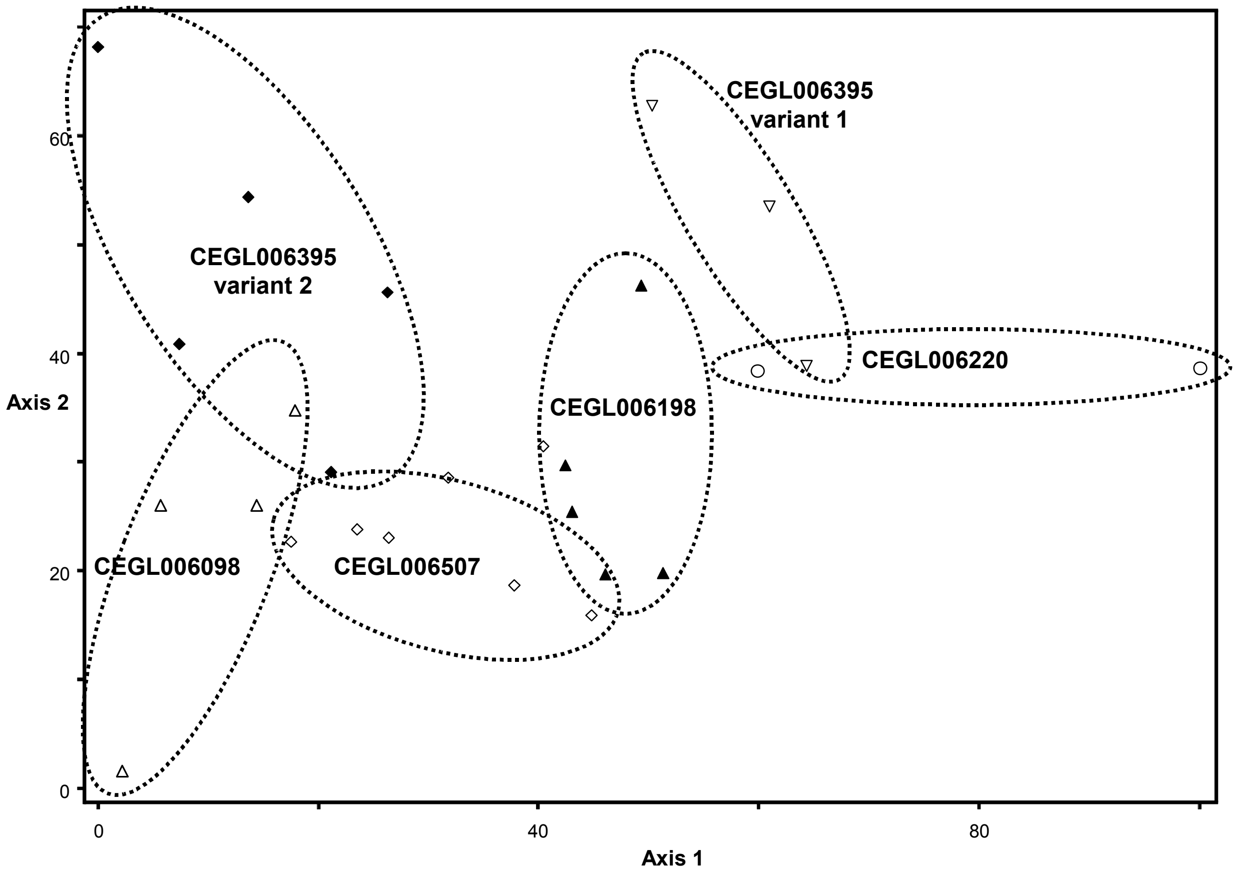

Figure D-9. Detrended Correspondence Analysis ordination of wetland forests and woodland samples, coded by vegetation type. Note that one of the CEGL006507 (Northern White-cedar Wooded Fen) samples falls into the CEGL006198 (Red Maple - Conifer Acidic Swamp) oval rather than the CEGL006507 oval. CEGL006395 variant 1 is the deciduous phase of CEGL006395 (Red Maple Swamp Woodland); CEGL006395 variant 2 is the mixed phase (see text). R2 for the first three axes = .625. Axes are scaled to the percent of the maximum score on axis 1.

Non-forested Uplands

Whereas Acadia is known for its bald summits, non-forested uplands are generally scarce in heavily forested Maine. Six non-forested upland vegetation types were distinguished for Acadia. Detrended Correspondence Analysis ordination of the samples showed the types to divide up fairly neatly, albeit with too few samples for most of the types (Figure D-10). In some cases the low sample numbers are due to natural scarcity of these types in Acadia.

Near the immediate shore, Northern Beachgrass Dune (CEGL006274) and Northern Maritime Rocky Headlands (CEGL006529) are distinctive as herbaceous-dominated types whose composition reflects the constant exposure to salt. The only dune grassland documented in Acadia is at Sand Beach, and this shows the typical dune grassland composition of Ammophila breviligulata dominance. Northern Maritime Rocky Headlands (CEGL006529) is a distinctive coastal type in which the sparse vegetation includes species with floristic alliances to subarctic coastal environments: Rhodalia rosea, Iris setosa var. canadensis, etc. This vegetation extends east from Acadia along the Maine and Canadian Maritime coastline, but Acadia represents its westernmost extent.

Most of the upland vegetation samples fall into the summit complex vegetation (lower left corner of Figure D-10), where the shrub form of the Early Successional Woodland/Forest (CEGL006303) grades into mixed summit shrublands and sparsely vegetated areas of blueberry and three-toothed cinquefoil (together typed as Blueberry Granite Barrens (CEGL005094), but variable). This complex of vegetation includes areas of low sparse vegetation with blueberry, herbs, and lichens, areas of taller (>1 m) non-heath shrubs with scattered spruce, and intermediate areas with huckleberry and other heaths (0.5 – 1 m tall) dotted with low spruce. These three subtypes often form mosaics on summits with extensive open areas.

The remaining open upland type, Crowberry - Bayberry Maritime Shrubland (CEGL006510), combines characteristics of dwarf shrubland vegetation with those of spray-zone vegetation. Like the open summit vegetation, it has a strong dwarf shrub component and features three-toothed cinquefoil, but the prominence of Myrica pensylvanica reveals its near-coastal location. Like the Northern Maritime Rocky Headlands (CEGL006529) type, this is typical of extreme coastal environments from Mount Desert Island east into the Canadian maritimes.

A description of each upland non-forested type is given in Appendix I: Vegetation Descriptions of this report.

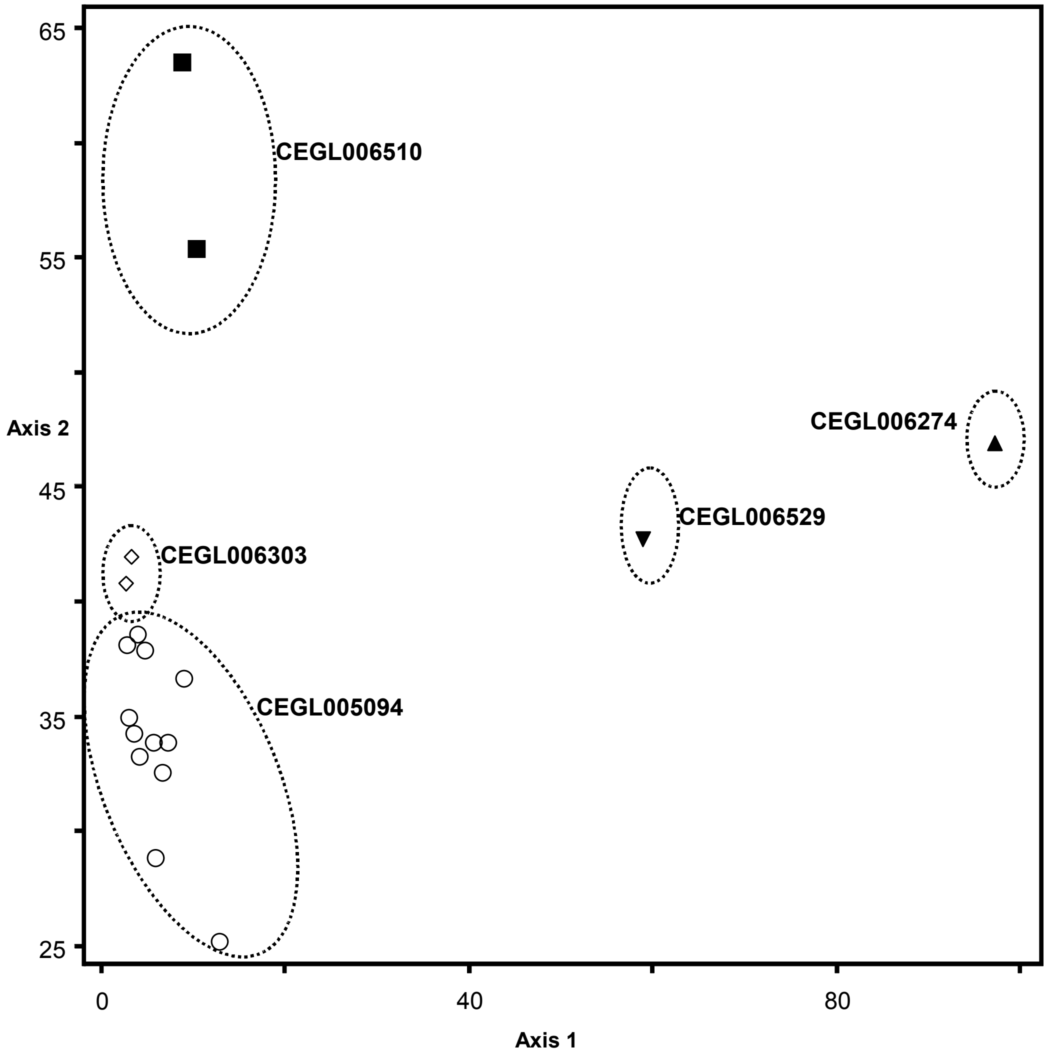

Figure D-10. Upland non-forested vegetation types. The CEGL006303 (Early Successional Woodland/Forest) samples are the two shrubland samples of that physiognomically variable type. Two types, CEGL006106 (Sea-rocket - Oysterleaf Sparse Vegetation) and CEGL006534 (Northern Lichen Talus Barrens had no samples. Axes are scaled to percent of the maximum score on axis 1. R2 for the first three axes = .877.

Non-forested Wetlands

Non-forested wetlands in Acadia include a full array of peatland to marsh to open water wetlands, from freshwater to brackish and saline marshes. Open water marshes (i.e., those that lack persistent emergent vegetation, and these appear as open water on the May aerial photos, but support aquatic plant associations during the growing season) were not sampled; saltmarshes and brackish habitats were minimally sampled (N=2). Of the 19 vegetation types distinguished, we had samples for 13 of those (N=39); however, 9 of those 13 types had 3 or fewer samples. In some cases, this was due to natural scarcity (e.g., Bayonet Rush Herbaceous Vegetation [CEGL006345] type); in others, to lack of sufficient sampling effort (e.g., saline and brackish marshes). The two saltmarsh samples were omitted from the DCA because their marked differences from freshwater wetlands obscured the variation in the latter.

DCA of the 37 non-forested freshwater wetland samples revealed a gradient on the first axis running from dwarf-shrub dominated ombrotrophic peatlands through mineral soil graminoid-shrub marshes, to tall shrub alder wetlands, reflecting elements of nutrient availability, hydrologic regime, and substrate type (Figure D-11). The second axis was dominated by the strongly different Juncus militaris drawdown wetlands, clearly different from all of the other graminoid shallow marsh types (at least based on the two samples of this naturally scarce type).

The mineral-soil wetland samples segregated reasonably well into vegetation types, except for the two alder-dominated shrub wetland types, the Northern Peatland Shrub Swamp (CEGL006158) and the Alluvial Alder Thicket (CEGL006062), which were vegetationally indistinguishable with the 5 samples analyzed. Certain vegetation types are intermediate between clearly mineral-soil wetlands and clearly peatlands. The Eastern Tussock Sedge Meadow (CEGL006412) and the Sweetgale Mixed Shrub Swamp (CEGL006512) types can occur on either organic substrates, or on mineral substrates with a relatively thin organic layer on top. These transitional types fall in the middle of the first ordination axis.

Differences among the various bog and fen (organic soil) vegetation types were expressed on the third axis, after the more dramatic vegetation differences accounted for on the first two axes. The two apparent major gradients here are from ombrotrophy to minerotrophy on the first axis, and from graminoid dominance to dwarf-shrub dominance on the third axis (Figure D-12). The two types with the strongest affinity to near-coastal environments, the Maritime Crowberry Bog (CEGL006248) and the Maritime Peatland Sedge Lawn (CEGL006260), appear at the left side of the ordination diagram, with the other low-nutrient type, Northern Dwarf-shrub Bog (CEGL006225), at the top of the diagram. With more samples, one would likely see overlaps between these types as are seen between the other types in Figure D-12. The four fen vegetation types, Few-seeded Sedge - Leatherleaf Fen (CEGL006524), Leatherleaf Acidic Fen (CEGL006513), Slender Sedge Fen (CEGL006521), and Sweetgale Mixed Shrub Swamp (CEGL006512), show overlap as expected, but all but Slender Sedge Fen (CEGL006521) at least show sufficient separation to support the differences between the concepts for each type. The three Slender Sedge Fen (CEGL006521) samples span the gradient from Few-seeded Sedge - Leatherleaf Fen (CEGL006524) to Sweetgale Mixed Shrub Swamp (CEGL006512) types; however, the Slender Sedge Fen (CEGL006521) type is not well represented in Acadia, and analyses of samples statewide indicate that this is indeed a reasonably well-defined type (Anderson and Davis 1997, Gawler 1998).

A description of each non-forested wetland type is given in Appendix I: Vegetation Descriptions of this report.

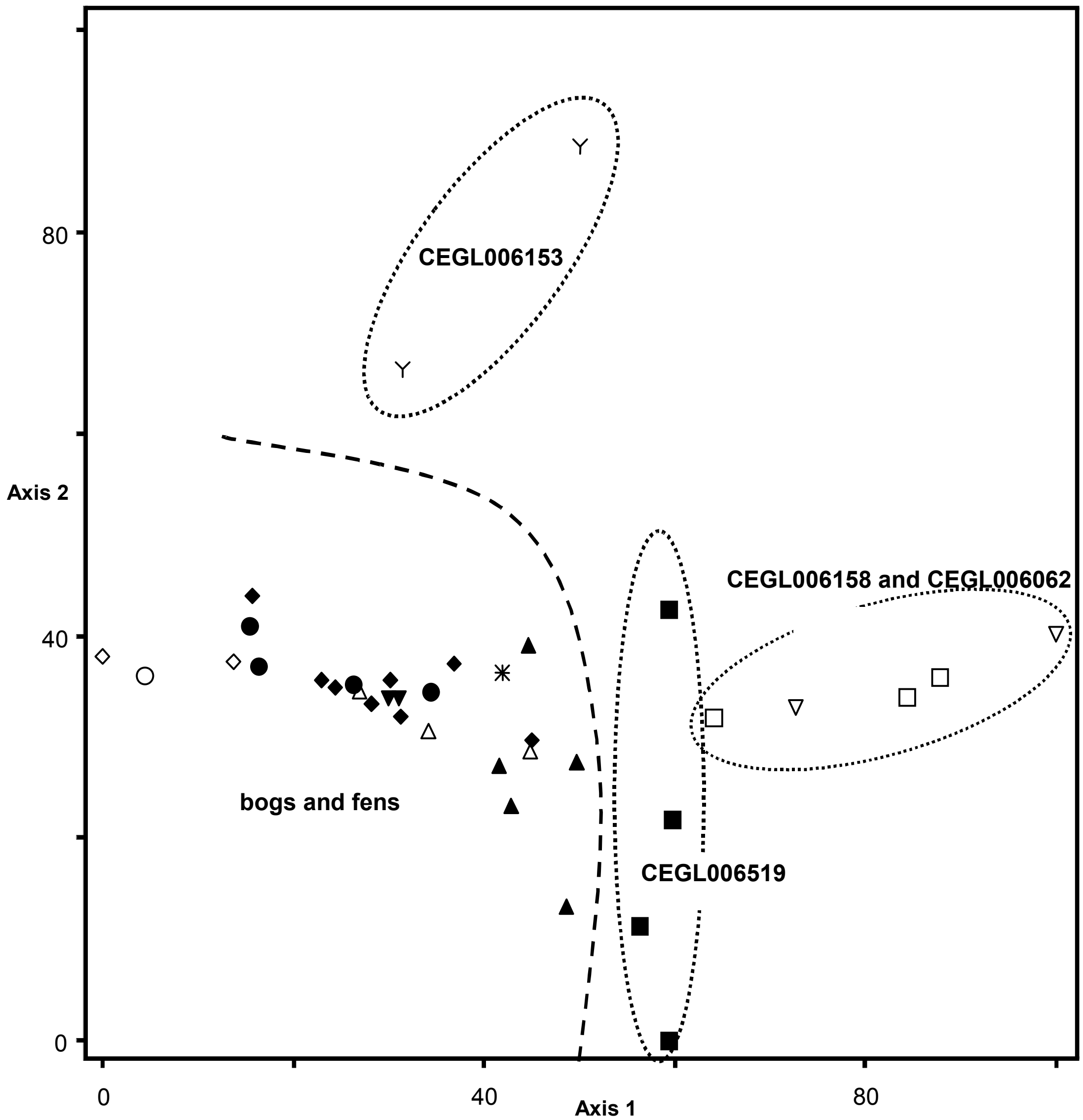

Figure D-11. Non-forested wetland vegetation, excluding saltmarshes: general patterns, with different symbols for different vegetation types. Dashed line separates bogs and fens from mineral-soil wetlands, which are labeled by type. See Figure D-12 for better resolution of bog and fen types. Axes are scaled to percent of the maximum score on axis 1. R2 for the first three axes = .504.

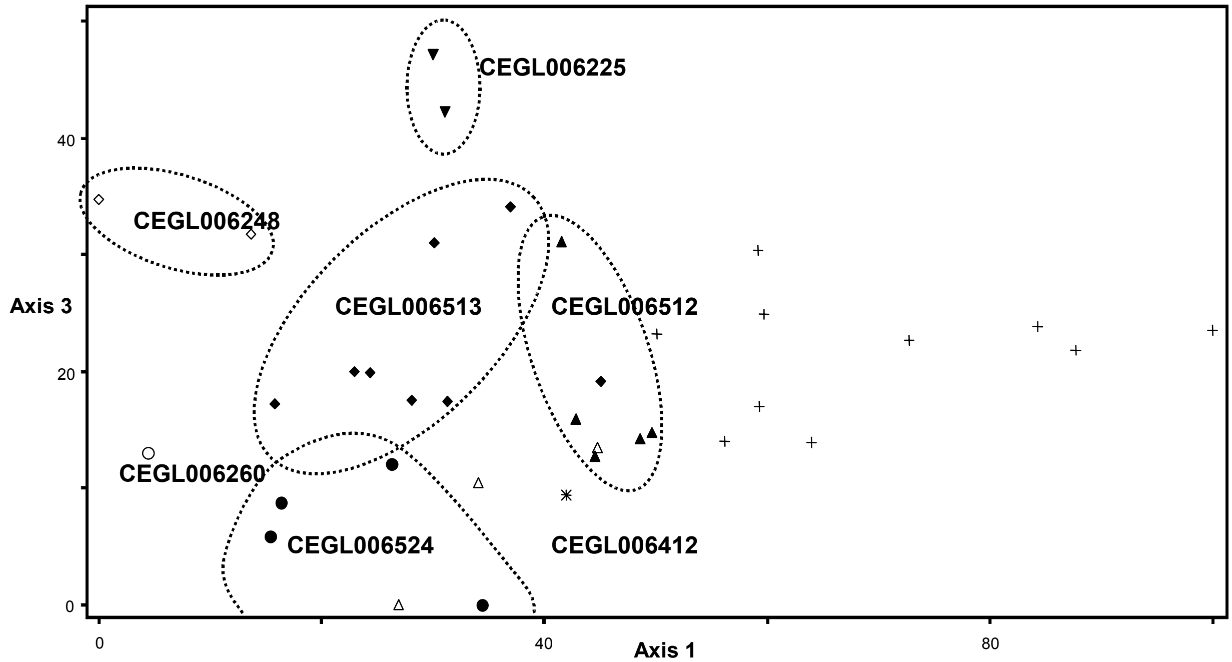

Figure D-12. Axes 1 and 3 of non-forested wetland vegetation ordination (see Figure D-11), showing bog and fen vegetation patterns. Symbols represent different vegetation types, labeled. "+" are mineral-soil wetland samples; see Figure D-11 for those vegetation types. Open triangles are the three CEGL006521 (Slender Sedge Fen) vegetation samples that overlap with CEGL006524 (Few-seeded Sedge - Leatherleaf Fen)and CEGL006512 (Sweetgale Mixed Shrub Swamp)types; also note one CEGL006513 (Leatherleaf Acidic Fen)sample in the CEGL006512 (Sweetgale Mixed Shrub Swamp)oval. CEGL006260 (Maritime Peatland Sedge Lawn) and CEGL006412 (Eastern Tussock Sedge Meadow) types had only one sample each. Axes are scaled to percent of the maximum score on axis 1.

Appendix E

Vegetation Classification Matrix

(National Vegetation Classification System Vegetation Communities – Vegetation Map Classes)

How to use the Vegetation Classification Matrix

In the electronic version, the classification matrix is a separate spreadsheet. The matrix is designed to show the relations between the National Vegetation Classification System association types (vegetation communities) as per NatureServe (2003) and the map classes used in the Acadia National Park vegetation mapping project. The associations are listed in rows and the map class codes are listed in columns. A key to the map class codes is listed to the right of the matrix.

Blue squares signified with an “x” indicate a match or link between associations and map classes. In most instances, there is one blue square where a map class links to an association, signifying a one-to-one relation between a given map class and its corresponding vegetation association.

Some map classes have more than one blue square in their columns. This means that map classes sometimes include more than one association. For example, map class White Pine - Mixed Conifer Forest (WPC) includes two associations: the Eastern Hemlock - White Pine - Red Spruce Forest and the Hemlock - Hardwood Forest associations.

Likewise, some associations have more than one blue square in their rows. This means that some associations are mapped in more than one map class. For example, the Eastern Cattail Marsh association is mapped with two map classes: the Graminoid Shallow Marsh (SMG) and the Open Water - Deep Marsh Complex (OWM).

The numbers at the left of each row (listing the vegetation association) signify the frequency of shared occurances of the vegetation type with other map classes. Likewise, the numbers at the top of each column (listing the map class) signify the frequency of shared occurances of map class of that column with other vegetation types.

A key to map class names is on the right side of the matrix table.

Appendix F

Map Class Description and Visual Guide
(separate document)

Appendix G

Accuracy Assessment Contingency Matrix

Using the Accuracy Assessment Contingency Matrix

In the electronic version, the accuracy assessment matrix is a separate spreadsheet. The accuracy assessment contingency matrix is an array of numbers set out in rows and columns which reveal the number of polygons assigned to a particular vegetation type(s) relative to the actual vegetation type as verified on the ground. The columns represent National Vegetation Classification System (NVCS) associations (vegetation community) as per NatureServe (2003) listed by their Community Global Element (CEGL), and the rows represent the map classes (listed by their map class codes). The accuracies of each map class are described as both producers' accuracy with errors of inclusion (commission errors), and users' accuracy with errors of exclusion (omission errors) present in the mapping.

A key to the names of map class codes and vegetation association CEGL codes are listed below the matrix table.

Appendix H

Plant Species List of Acadia National Park

More than 400 plant species were identified and documented in 179 vegetation samples collected for the Acadia National Park Vegetation Mapping Project. Plant species, along with other sample data, were entered into the PLOTS Database System (The Nature Conservancy 1997) to produce the Project's vegetation database. The following list of plant species was generated from the vegetation database. The list is not intended to be comprehensive of every species in the Park. Plant species are organized alphabetically within plant families. Nomenclature follows the PLANTS database (U.S. Department of Agriculture 1996).

Table H-1. Plant species list of Acadia National Park summarized by family.

Family	Scientific Name	Common Name
Aceraceae	*Acer pensylvanicum* L.	striped maple
	Acer rubrum L.	red maple
	Acer saccharum Marsh.	sugar maple
	Acer spicatum Lam.	mountain maple
Adelanthaceae	*Odontoschisma* (Dum.) Dum.	odontoschisma
Alismataceae	*Sagittaria latifolia* Willd.	broadleaf arrowhead
Amblystegiaceae	Drepanocladus *(C. Müll.) G. Roth*	drepanocladus moss
Anacardiaceae	Rhus hirta *(L.) Sudworth*	staghorn sumac
	Toxicodendron radicans ssp. radicans (L.) Kuntze	eastern poison ivy
Apiaceae	*Angelica atropurpurea* L.	purplestem angelica
	Ligusticum scoticum L.	Scottish licoriceroot
Apocynaceae	*Apocynum androsaemifolium* L.	spreading dogbane
Aquifoliaceae	*Ilex glabra* (L.) Gray	inkberry
	Ilex verticillata (L.) Gray	common winterberry
	Nemopanthus mucronatus (L.) Loes.	catberry
Araceae	*Arisaema triphyllum* (L.) Schott	Jack in the pulpit
	Symplocarpus foetidus (L.) Salisb. ex Nutt.	skunk cabbage
Araliaceae	*Aralia nudicaulis* L.	wild sarsaparilla
Asteraceae	*Achillea millefolium* L.	common yarrow
	Aster cordifolius L.	common blue wood aster
	Aster L.	aster
	Aster lateriflorus (L.) Britt.	calico aster
	Aster macrophyllus L.	bigleaf aster
	Aster puniceus L.	purplestem aster
	Aster X blakei (Porter) House (pro sp.)	Blake's aster
	Bidens connata Muhl. ex Willd.	purplestem beggarticks
	Bidens L.	beggartick
	Doellingeria umbellata (P. Mill.) Nees	
	Euthamia graminifolia (L.) Nutt.	flattop goldentop
	Hieracium canadense Michx.	Canadian hawkweed

Family	Scientific Name	Common Name
	Hieracium L.	hawkweed
	Hieracium paniculatum L.	Allegheny hawkweed
	Hieracium pilosella L.	mouseear hawkweed
	Oclemena acuminata (Michx.) Greene	
	Oclemena nemoralis (Ait.) Greene	
	Prenanthes alba L.	white rattlesnakeroot
	Prenanthes trifoliolata (Cass.) Fern.	gall of the earth
	Solidago bicolor L.	white goldenrod
	Solidago L.	goldenrod
	Solidago puberula Nutt.	downy goldenrod
	Solidago rugosa P. Mill.	wrinkleleaf goldenrod
	Solidago sempervirens L.	seaside goldenrod
	Solidago simplex ssp. randii (Porter) Ringius	Rand's goldenrod
	Solidago uliginosa Nutt.	bog goldenrod
	Solidago uliginosa var. linoides (Torr. & Gray) Fern.	bog goldenrod
Aulacomniaceae	*Aulacomnium palustre* (Hedw.) Schwaegr.	aulacomnium moss
	Aulacomnium Schwaegr.	aulacomnium moss
Balsaminaceae	*Impatiens capensis* Meerb.	jewelweed
	Bartramia pomiformis Hedw.	bartramia moss
Berberidaceae	*Berberis thunbergii* DC.	Japanese barberry
Betulaceae	*Alnus incana* (L.) Moench	mountain alder
	Alnus serrulata (Ait.) Willd.	hazel alder
	Alnus viridis ssp. crispa (Ait.) Turrill	American green alder
	Betula alleghaniensis Britt.	yellow birch
	Betula L.	birch
	Betula papyrifera Marsh.	paper birch
	Betula papyrifera var. cordifolia (Regel) Fern.	mountain paper birch
	Betula populifolia Marsh.	gray birch
	Betula X caerulea Blanch. (pro sp.)	birch
	Betula X sargentii *Dugle*	Sargent's birch
	Corylus cornuta Marsh.	beaked hazelnut
	Ostrya virginiana (P. Mill.) K. Koch	eastern hophornbeam
Blechnaceae	*Woodwardia virginica* (L.) Sm.	Virginia chainfern
Brachytheciaceae	*Brachythecium* Schimp. in B.S.G.	brachythecium moss
Bryaceae	*Bryum argenteum* Hedw.	silvergreen bryum moss
	Bryum Hedw.	bryum moss
	Pohlia Hedw.	pohlia moss
Campanulaceae	*Campanula rotundifolia* L.	bluebell bellflower
Caprifoliaceae	*Diervilla lonicera* P. Mill.	northern bush honeysuckle
	Linnaea borealis L.	twinflower
	Lonicera canadensis Bartr. ex Marsh.	American fly honeysuckle
	Lonicera villosa (Michx.) J.A. Schultes	mountain fly honeysuckle
	Viburnum acerifolium L.	mapleleaf viburnum
	Viburnum lantanoides Michx.	hobblebush
	Viburnum lentago L.	nannyberry
	Viburnum nudum var. cassinoides (L.) Torr. & Gray	possumhaw
Caryophyllaceae	*Cerastium arvense* L.	field chickweed

Family	Scientific Name	Common Name
	Minuartia glabra (Michx.) Mattf.	Appalachian stitchwort
	Minuartia groenlandica (Retz.) Ostenf.	Greenland stitchwort
	Sagina nodosa ssp. nodosa (L.) Fenzl	knotted pearlwort
Cephaloziellaceae	*Cephaloziella* (Spruce) Steph.	cephaloziella
Chenopodiaceae	*Atriplex patula* L.	spear saltbush
Cistaceae	*Lechea intermedia* Leggett ex Britt.	largepod pinweed
Cladoniaceae	*Cladina* (Nyl.) Nyl.	reindeer lichen
	Cladina arbuscula (Wallr.) Hale & Culb.	reindeer lichen
	Cladina rangiferina (L.) Nyl.	greygreen reindeer lichen
	Cladina stellaris (Opiz) Brodo	star reindeer lichen
	Cladonia cristatella Tuck.	cup lichen
	Cladonia P. Browne	cup lichen
	Cladonia pyxidata (L.) Hoffm.	cup lichen
Clusiaceae	*Hypericum boreale* (Britt.) Bickn.	northern St. Johnswort
	Hypericum gentianoides (L.) B.S.P.	orangegrass
	Triadenum fraseri (Spach) Gleason	Fraser's marsh St. Johnswort
Conocephalaceae	*Conocephalum* Wigg.	conocephalum
Convolvulaceae	*Calystegia sepium* (L.) R. Br.	hedge false bindweed
Cornaceae	*Cornus canadensis* L.	bunchberry dogwood
Crassulaceae	*Sedum rosea* (L.) Scop.	roseroot stonecrop
Cupressaceae	*Juniperus communis* L.	common juniper
	Juniperus horizontalis Moench	creeping juniper
	Thuja occidentalis L.	eastern arborvitae
Cyperaceae	*Carex arctata* Boott ex Hook.	drooping woodland sedge
	Carex atlantica ssp. atlantica Bailey	Atlantic sedge
	Carex atlantica ssp. capillacea (Bailey) Reznicek	prickly bog sedge
	Carex brunnescens (Pers.) Poir.	brownish sedge
	Carex canescens L.	silvery sedge
	Carex communis Bailey	fibrousroot sedge
	Carex debilis Michx.	white edge sedge
	Carex echinata Murr.	prickley sedge
	Carex exilis Dewey	coastal sedge
	Carex folliculata L.	northern long sedge
	Carex gracillima Schwein.	graceful sedge
	Carex gynandra Schwein.	nodding sedge
	Carex gynocrates Wormsk. ex Drej.	northern bog sedge
	Carex hormathodes Fern.	marsh straw sedge
	Carex intumescens Rudge	greater bladder sedge
	Carex L.	sedge
	Carex lacustris Willd.	hairy sedge
	Carex lasiocarpa Ehrh.	woollyfruit sedge
	Carex laxiflora Lam.	broad looseflower sedge
	Carex leptalea Wahlenb.	bristlystalked sedge
	Carex leptonervia (Fern.) Fern.	nerveless woodland sedge
	Carex lucorum Willd. ex Link	Blue Ridge sedge
	Carex lurida Wahlenb.	shallow sedge
	Carex magellanica ssp. irrigua (Wahlenb.) Hulten	boreal bog sedge

Family	Scientific Name	Common Name
	Carex magellanica ssp. magellanica Lam.	little sedge
	Carex nigra (L.) Reichard	smooth black sedge
	Carex novae-angliae Schwein.	New England sedge
	Carex oligosperma Michx.	fewseed sedge
	Carex ovalis Goodenough	sedge
	Carex paleacea Schreb. ex Wahlenb.	chaffy sedge
	Carex pallescens L.	pale sedge
	Carex pedunculata Muhl. ex Willd.	longstalk sedge
	Carex projecta Mackenzie	necklace sedge
	Carex rosea Schkuhr ex Willd.	rosy sedge
	Carex rugosperma Mackenzie	parachute sedge
	Carex scabrata Schwein	eastern rough sedge
	Carex scoparia Schkuhr ex Willd.	broom sedge
	Carex stricta Lam.	uptight sedge
	Carex tonsa (Fern.) Bickn.	shaved sedge
	Carex tribuloides Wahlenb.	blunt broom sedge
	Carex trisperma Dewey	threeseeded sedge
	Carex utriculata Boott	Northwest Territory sedge
	Carex wiegandii Mackenzie	Wiegand's sedge
	Dulichium arundinaceum (L.) Britt.	threeway sedge
	Eleocharis acicularis (L.) Roemer & J.A. Schultes	needle spikerush
	Eleocharis obtusa (Willd.) J.A. Schultes	blunt spikesedge
	Eriophorum angustifolium Honckeny	tall cottongrass
	Eriophorum tenellum Nutt.	fewnerved cottongrass
	Eriophorum vaginatum var. spissum (Fern.) Boivin	tussock cottongrass
	Eriophorum virginicum L.	tawny cottongrass
	Rhynchospora alba (L.) Vahl	whitebeaked rush
	Scirpus atrocinctus Fern.	blackgirdle bulrush
	Scirpus cyperinus (L.) Kunth	woolgrass
	Trichophorum cespitosum (L.) Hartman	
Dennstaedtiaceae	*Dennstaedtia punctilobula* (Michx.) T. Moore	eastern hayscented fern
	Pteridium aquilinum (L.) Kuhn	western brackenfern
Dicranaceae	*Dicranella* (C. M□ll.) Schimp.	dicranella moss
	Dicranum flagellare Hedw.	dicranum moss
	Dicranum fulvum Hook.	dicranum moss
	Dicranum fuscescens Turn.	dicranum moss
	Dicranum Hedw.	dicranum moss
	Dicranum polysetum Sw.	dicranum moss
	Dicranum scoparium Hedw.	dicranum moss
	Dicranum undulatum Brid.	undulate dicranum moss
	Paraleucobryum (Lindb.) Loeske	paraleucobryum moss
	Paraleucobryum longifolium (Hedw.) Loeske	longleaf paraleucobryum moss
Droseraceae	*Drosera intermedia* Hayne	spoonleaf sundew
	Drosera rotundifolia L.	roundleaf sundew
Dryopteridaceae	*Athyrium filix-femina* (L.) Roth	common ladyfern
	Dryopteris carthusiana (Vill.) H.P. Fuchs	spinulose woodfern
	Dryopteris cristata (L.) Gray	crested woodfern

Family	Scientific Name	Common Name
	Dryopteris intermedia (Muhl. ex Willd.) Gray	intermediate woodfern
	Dryopteris marginalis (L.) Gray	marginal woodfern
	Gymnocarpium dryopteris (L.) Newman	western oakfern
	Onoclea sensibilis L.	sensitive fern
	Polystichum acrostichoides (Michx.) Schott	Christmas fern
Empetraceae	*Corema conradii* (Torr.) Torr. ex Loud.	broom crowberry
	Empetrum nigrum L.	black crowberry
Equisetaceae	*Equisetum sylvaticum* L.	woodland horsetail
Ericaceae	*Andromeda polifolia* L.	bog rosemary
	Chamaedaphne calyculata (L.) Moench	leatherleaf
	Epigaea repens L.	trailing arbutus
	Gaultheria hispidula (L.) Muhl. ex Bigelow	creeping snowberry
	Gaultheria procumbens L.	eastern teaberry
	Gaylussacia baccata (Wangenh.) K. Koch	black huckleberry
	Gaylussacia dumosa (Andr.) Torr. & Gray	dwarf huckleberry
	Kalmia angustifolia L.	sheep laurel
	Kalmia polifolia Wangenh.	bog laurel
	Ledum groenlandicum Oeder	bog Labradortea
	Rhododendron canadense (L.) Torr.	rhodora
	Vaccinium angustifolium Ait.	lowbush blueberry
	Vaccinium boreale Hall & Aalders	northern blueberry
	Vaccinium corymbosum L.	highbush blueberry
	Vaccinium macrocarpon Ait.	cranberry
	Vaccinium myrtilloides Michx.	velvetleaf huckleberry
	Vaccinium oxycoccos L.	small cranberry
	Vaccinium vitis-idaea L.	lingonberry
Fabaceae	*Lathyrus japonicus* Willd.	sea peavine
	Trifolium L.	clover
Fagaceae	*Fagus grandifolia* Ehrh.	American beech
	Quercus ilicifolia Wangenh.	bear oak
	Quercus L.	oak
	Quercus rubra L.	northern red oak
Fissidentaceae	*Fissidens* Hedw.	fissidens moss
Fontinalaceae	*Fontinalis* Hedw.	fontinalis moss
Gentianaceae	*Bartonia paniculata* (Michx.) Muhl.	twining screwstem
Grimmiaceae	*Grimmia* Hedw.	grimmia dry rock moss
Grossulariaceae	*Ribes triste* Pallas	red currant
Haloragaceae	*Proserpinaca pectinata* Lam.	combleaf mermaidweed
Hamamelidaceae	*Hamamelis virginiana* L.	American witchhazel
Hylocomiaceae	*Hylocomium* Schimp. in B.S.G.	hylocomium feather moss
	Hylocomium splendens (Hedw.) Schimp. in B.S.G.	splendid feather moss
	Pleurozium schreberi (Brid.) Mitt.	Schreber's big red stem moss
	Rhytidiadelphus triquetrus (Hedw.) Warnst.	rough goose neck moss
Hypnaceae	*Callicladium haldanianum* (Grev.) Crum	callicladium moss
	Hypnum Hedw.	hypnum moss
	Hypnum imponens Hedw.	hypnum moss
	Ptilium crista-castrensis (Hedw.) De Not.	knights plume moss

Family	Scientific Name	Common Name
Iridaceae	*Iris setosa var. canadensis* M. Foster ex B.L. Robins. & Fern.	Canada beachhead iris
	Iris versicolor L.	harlequin blueflag
	Sisyrinchium montanum Greene	mountain blueeyed grass
Jubulaceae	Frullania *Raddi*	frullania
Juncaceae	*Juncus balticus* Willd.	Baltic rush
	Juncus brevicaudatus (Engelm.) Fern.	narrowpanicle rush
	Juncus bufonius L.	toad rush
	Juncus canadensis J. Gay ex Laharpe	Canadian rush
	Juncus effusus L.	common rush
	Juncus filiformis L.	thread rush
	Juncus gerardii Loisel.	saltmeadow rush
	Juncus militaris Bigelow	bayonet rush
	Juncus pelocarpus E. Mey.	brownfruit rush
	Luzula DC.	woodrush
	Luzula luzuloides (Lam.) Dandy & Wilmott	oakforest woodrush
Juncaginaceae	*Triglochin maritimum* L.	seaside arrowgrass
Lamiaceae	*Lycopus americanus* Muhl. ex W. Bart.	American waterhorehound
	Lycopus L.	waterhorehound
	Lycopus uniflorus Michx.	northern bugleweed
	Lycopus virginicus L.	Virginia waterhorehound
	Prunella vulgaris L.	common selfheal
	Scutellaria galericulata L.	marsh skullcap
Lentibulariaceae	*Utricularia cornuta* Michx.	horned bladderwort
	Utricularia purpurea Walt.	eastern purple bladderwort
Lepidoziaceae	*Bazzania trilobata* (L.) S. Gray	threelobed bazzania
Leucobryaceae	*Leucobryum glaucum* (Hedw.) □ngstr. in Fries	leucobryum moss
	Leucobryum Hampe	leucobryum moss
Liliaceae	*Clintonia borealis* (Ait.) Raf.	yellow bluebeadlily
	Maianthemum canadense Desf.	Canada beadruby
	Maianthemum trifolium (L.) Sloboda	threeleaf false Solomon's seal
	Medeola virginiana L.	Indian cucumberroot
	Trillium erectum L.	red trillium
	Trillium undulatum Willd.	painted trillium
	Uvularia sessilifolia L.	sessileleaf bellwort
Lycopodiaceae	*Huperzia appalachiana* Beitel & Mickel	
	Lycopodium annotinum L.	stiff clubmoss
	Lycopodium dendroideum Michx.	tree groundpine
	Lycopodium L.	clubmoss
	Lycopodium obscurum L.	rare clubmoss
Mniaceae	*Mnium* Hedw.	mnium calcareous moss
Monotropaceae	*Monotropa uniflora* L.	Indianpipe
Myricaceae	*Comptonia peregrina* (L.) Coult.	sweet fern
	Morella pensylvanica (Mirbel) Kartesz, comb. nov. ined.	
	Myrica gale L.	sweetgale
Oleaceae	*Fraxinus americana* L.	white ash
	Fraxinus pennsylvanica Marsh.	green ash
Onagraceae	*Epilobium leptophyllum* Raf.	bog willowherb

Family	Scientific Name	Common Name
Orchidaceae	*Arethusa bulbosa* L.	dragon's mouth
	Calopogon tuberosus (L.) B.S.P.	tuberous grasspink
	Cypripedium acaule Ait.	pink lady's slipper
	Goodyera pubescens (Willd.) R. Br. ex Ait. f.	downy rattlesnake plantain
	Goodyera repens (L.) R. Br. ex Ait. f.	lesser rattlesnake plantain
	Malaxis unifolia Michx.	green addersmouth orchid
	Platanthera L.C. Rich.	bog orchid
	Pogonia ophioglossoides (L.) Ker-Gawl.	snakemouth orchid
Orobanchaceae	*Epifagus virginiana* (L.) W. Bart.	beechdrops
Osmundaceae	*Osmunda cinnamomea* L.	cinnamon fern
	Osmunda claytoniana L.	interrupted fern
	Osmunda regalis L.	royal fern
Oxalidaceae	*Oxalis montana* Raf.	mountain woodsorrel
	Oxalis stricta L.	common yellow oxalis
Parmeliaceae	*Cetraria islandica* (L.) Ach.	island cetraria lichen
	Parmelia Ach.	shield lichen
Pelliaceae	*Pellia* Raddi	pellia
Pinaceae	*Abies balsamea* (L.) P. Mill.	balsam fir
	Larix laricina (Du Roi) K. Koch	tamarack
	Picea glauca (Moench) Voss	white spruce
	Picea mariana (P. Mill.) B.S.P.	black spruce
	Picea rubens Sarg.	red spruce
	Pinus banksiana Lamb.	jack pine
	Pinus resinosa Soland.	red pine
	Pinus rigida P. Mill.	pitch pine
	Pinus strobus L.	eastern white pine
	Tsuga canadensis (L.) Carr.	eastern hemlock
Plantaginaceae	*Plantago maritima var. juncoides* (Lam.) Gray	goose tongue
Plumbaginaceae	*Limonium carolinianum* (Walt.) Britt.	Carolina sealavender
Poaceae	*Agrostis gigantea* Roth	redtop
	Agrostis hyemalis (Walt.) B.S.P.	winter bentgrass
	Agrostis L.	bentgrass
	Agrostis scabra Willd.	rough bentgrass
	Agrostis stolonifera L.	creeping bentgrass
	Ammophila breviligulata Fern.	American beachgrass
	Anthoxanthum odoratum L.	sweet vernalgrass
	Brachyelytrum septentrionale (Babel) G. Tucker	northern shorthusk
	Calamagrostis canadensis (Michx.) Beauv.	bluejoint
	Danthonia spicata (L.) Beauv. ex Roemer & J.A. Schultes	poverty danthonia
	Deschampsia flexuosa (L.) Trin.	wavy hairgrass
	Dichanthelium (A.S. Hitchc. & Chase) Gould	rosette grass
	Distichlis spicata (L.) Greene	inland saltgrass
	Festuca L.	fescue
	Festuca ovina L.	sheep fescue
	Festuca rubra L.	red fescue
	Glyceria borealis (Nash) Batchelder	northern mannagrass
	Glyceria canadensis (Michx.) Trin.	rattlesnake mannagrass

Family	Scientific Name	Common Name
	Glyceria grandis S. Wats.	American mannagrass
	Glyceria melicaria (Michx.) F.T. Hubbard	melic mannagrass
	Glyceria obtusa (Muhl.) Trin.	Atlantic mannagrass
	Glyceria R. Br.	mannagrass
	Glyceria striata (Lam.) A.S. Hitchc.	fowl mannagrass
	Leersia oryzoides (L.) Sw.	rice cutgrass
	Muhlenbergia glomerata (Willd.) Trin.	spiked muhly
	Muhlenbergia Schreb.	muhly
	Muhlenbergia uniflora (Muhl.) Fern.	bog muhly
	Oryzopsis asperifolia Michx.	roughleaf ricegrass
	Oryzopsis Michx.	ricegrass
	Panicum L.	panicum
	Spartina alterniflora Loisel.	smooth cordgrass
Polygonaceae	*Polygonum achoreum* Blake	leathery knotweed
	Polygonum sagittatum L.	arrowleaf tearthumb
	Rumex orbiculatus Gray	greater water dock
Polypodiaceae	*Polypodium virginianum* L.	rock polypody
	Atrichum P. Beauv.	atrichum moss
	Atrichum undulatum (Hedw.) P. Beauv.	undulate atrichum moss
	Polytrichum commune Hedw.	polytrichum moss
	Polytrichum Hedw.	polytrichum moss
	Polytrichum juniperinum Hedw.	juniper polytrichum moss
	Polytrichum piliferum Hedw.	polytrichum moss
	Polytrichum strictum Brid.	polytrichum moss
Pontederiaceae	*Pontederia cordata* L.	pickerelweed
Potamogetonaceae	*Potamogeton* L.	pondweed
Primulaceae	*Glaux maritima* L.	sea milkwort
	Lysimachia quadrifolia L.	whorled yellow loosestrife
	Lysimachia terrestris (L.) B.S.P.	earth loosestrife
	Trientalis borealis Raf.	American starflower
	Ptilidium Nees	ptilidium
Pyrolaceae	*Orthilia secunda* (L.) House	sidebells wintergreen
	Pyrola americana Sweet	American wintergreen
	Pyrola elliptica Nutt.	waxflower shinleaf
Ranunculaceae	*Anemone virginiana* L.	tall thimbleweed
	Clematis virginiana L.	devil's darning needles
	Coptis trifolia (L.) Salisb.	threeleaf goldthread
	Ranunculus acris L.	tall buttercup
	Ranunculus L.	buttercup
	Thalictrum pubescens Pursh	king of the meadow
Rhamnaceae	*Frangula alnus* P. Mill.	buckthorn
Rhizocarpaceae	*Rhizocarpon geographicum* (L.) DC.	world map lichen
Rosaceae	*Amelanchier arborea* (Michx. f.) Fern.	common serviceberry
	Amelanchier canadensis (L.) Medik.	Canadian serviceberry
	Amelanchier laevis Wieg.	Allegheny serviceberry
	Amelanchier Medik.	serviceberry
	Amelanchier stolonifera Wieg.	running serviceberry

Family	Scientific Name	Common Name
	Aronia melanocarpa (Michx.) Ell.	black chokeberry
	Comarum palustre L.	purple marshlocks
	Dalibarda repens L.	robin runaway
	Fragaria virginiana Duchesne	Virginia strawberry
	Physocarpus opulifolius (L.) Maxim.	common ninebark
	Potentilla simplex Michx.	common cinquefoil
	Prunus pensylvanica L. f.	pin cherry
	Prunus virginiana L.	common chokecherry
	Rosa carolina L.	Carolina rose
	Rosa L.	rose
	Rosa nitida Willd.	shining rose
	Rosa rugosa Thunb.	rugosa rose
	Rosa virginiana P. Mill.	Virginia rose
	Rubus allegheniensis Porter	Allegheny blackberry
	Rubus flagellaris Willd.	northern dewberry
	Rubus hispidus L.	bristly dewberry
	Rubus idaeus L.	American red raspberry
	Rubus L.	blackberry
	Rubus pubescens Raf.	dwarf red blackberry
	Sibbaldiopsis tridentata (Ait.) Rydb.	shrubby fivefingers
	Sorbus americana Marsh.	American mountainash
	Spiraea alba Du Roi	white meadowsweet
	Spiraea tomentosa L.	steeplebush
Rubiaceae	*Galium asprellum* Michx.	rough bedstraw
	Galium L.	bedstraw
	Galium labradoricum (Wieg.) Wieg.	northern bog bedstraw
	Mitchella repens L.	partridgeberry
Salicaceae	*Populus grandidentata* Michx.	bigtooth aspen
	Populus tremuloides Michx.	quaking aspen
	Salix L.	willow
	Salix sericea Marsh.	silky willow
Sarraceniaceae	*Sarracenia purpurea* L.	purple pitcherplant
Scapaniaceae	*Scapania* (Dum.) Dum.	scapania
Scrophulariaceae	*Euphrasia randii* B.L. Robins.	small eyebright
	Melampyrum lineare Desr.	narrowleaf cowwheat
	Veronica officinalis L.	common gypsyweed
Sparganiaceae	*Sparganium americanum* Nutt.	American burreed
	Sparganium L.	burreed
Sphagnaceae	*Sphagnum angustifolium* (C. Jens. ex Russ.) C. Jens. in Tolf	sphagnum
	Sphagnum capillifolium (Ehrh.) Hedw.	sphagnum
	Sphagnum compactum DC. in Lam. & DC.	low sphagnum
	Sphagnum cuspidatum Ehrh. ex Hoffm.	toothed sphagnum
	Sphagnum fimbriatum Wils. in Wils. & Hook. f. in Hook. f.	sphagnum
	Sphagnum flavicomans (Card.) Warnst.	sphagnum
	Sphagnum fuscum (Schimp.) Klinggr.	sphagnum
	Sphagnum girgensohnii Russ.	Girgensohn's sphagnum
	Sphagnum L.	sphagnum

Family	Scientific Name	Common Name
	Sphagnum magellanicum Brid.	Magellan's sphagnum
	Sphagnum majus (Russ.) C. Jens.	sphagnum
	Sphagnum palustre L.	prairie sphagnum
	Sphagnum papillosum Lindb.	papillose sphagnum
	Sphagnum pylaesii Brid.	Pylaes' sphagnum
	Sphagnum recurvum P. Beauv.	recurved sphagnum
	Sphagnum rubellum Wils.	sphagnum
	Sphagnum russowii Warnst.	Russow's sphagnum
	Sphagnum squarrosum Crome	sphagnum
	Sphagnum subsecundum Nees in Sturm	sphagnum
	Sphagnum tenellum (Brid.) Bory	sphagnum
	Sphagnum wulfianum Girg.	Wulf's sphagnum
Thelypteridaceae	*Phegopteris connectilis* (Michx.) Watt	long beechfern
	Thelypteris noveboracensis (L.) Nieuwl.	New York fern
	Thelypteris palustris Schott	eastern marsh fern
Thuidiaceae	*Thuidium delicatulum* (Hedw.) Schimp. in B.S.G.	delicate thuidium moss
Umbilicariaceae	*Umbilicaria* Hoffm.	navel lichen
Violaceae	*Viola cucullata* Ait.	marsh blue violet
	Viola L.	violet
Xyridaceae	*Xyris difformis* Chapman	bog yelloweyed grass

Appendix I

Vegetation Community Descriptions of Acadia National Park
(separate document)