Vegetation Mapping and Classification Study Plan
Eleven Sonoran Desert Network Parks

Updated: August 2008

INTRODUCTION

The Sonoran Desert Network (SODN) is engaged in planning a 5-year vegetation mapping and classification program for the following 11 parks in Arizona and southwestern New Mexico:

Casa Grande Ruins NM (CAGR)	**Gila Cliff Dwellings NM (GICL)**	**Tonto NM (TONT)**
Chiricahua NM (CHIR)	**Montezuma Castle NM (MOCA)**	**Tumacacori NHP (TUMA)**
Coronado N Mem (CORO)	**Organ Pipe Cactus NM (ORPI)**	**Tuzigoot NM (TUZI)**
Fort Bowie NHS (FOBO)	**Saguaro NP (SAGU)**	

This proposal identifies a general plan and resources required for completing vegetation maps and classification work for the 11 network parks. Most of the park units lie within the Sonoran Desert ecoregion, but five are allied with the Apache Highlands ecoregion (Tables 1 & 2). Park staff and Superintendents have identified contemporary, accurate vegetation maps as a high-priority information need for managing Sonoran Desert Network Parks. A recent informal poll of the network Board of Directors and Technical Committee indicated that park managers value vegetation maps on par with the biological inventory of vertebrates and vascular plants. However, only Tuzigoot NM has a relatively recent (mid-1990s) vegetation map that meets NPS service-wide standards. Published maps produced from the 1930s to the early 1990s exist for several of the other SODN parks, but these are of limited utility because they are outdated, too coarse in thematic resolution, classified in a way incompatible with National Vegetation Classification standards, or lack sufficient metadata or ecological documentation to clearly define the processes used to create them. Given their direct relevance to resource management, and the current lack of adequate vegetation maps for all but one SODN park, there is an evident need for the creation of new maps that meet the standards of the national USGS/BRD-NPS vegetation mapping program (http://biology.usgs.gov/npsveg/).

PROJECT OBJECTIVE

The objective of the proposed FY07-11 project is to map existing vegetation in Sonoran Desert Network parks at the Alliance or Association level, as defined by the National Vegetation Classification (NVC) system, as part of the ongoing, nationwide USGS-NPS vegetation mapping program. We expect that the less accessible areas of the larger parks (SAGU and ORPI) will be mapped at the coarser Alliance level, and more accessible areas in all parks will be mapped to Association. Our work will adhere to the standards of the national USGS-NPS vegetation mapping program, which incorporates the classification protocols of the US NVC system and is cognizant of and compliant with FGDC standards. The goal is to produce standards-compliant maps at 1:24,000 scale with a minimum mapping unit of 0.5 hectare and 80% thematic accuracy for each class mapped. This project will contribute to the completion of the SODN natural resource inventories, part of the servicewide mandate for inventory and monitoring established through the Natural Resource Challenge.

APPROACH

Our methodological approach to vegetation classification and mapping in SODN parks will be to adapt existing procedures being used by the national USGS-NPS vegetation mapping program, referenced at http://biology.usgs.gov/npsveg/ . The principal modifications we will make are to use high-resolution multispectral satellite imagery in lieu of aerial photography, and to emphasize collection of straight vegetation data in the field (particularly through numerous quick relevés), with a minimum of soil, topographic and other information collected at each sampling site. The methodology is, in effect,

time-honored field-based mapping substituting satellite imagery for aerial photos, rather than an approach that relies primarily on image classification with little field work. Classification of vegetation types will be based on published NVC-defined classes, legacy spatial and floristic data review, field reconnaissance, and field plot sampling for biostatistical analysis.

We will build on the experience gained through previous cooperative agreements with the UA Office of Arid Lands Studies/Arizona Remote Sensing Center which have focused on classification and mapping methods development at CORO, CHIR and, in FY06, FOBO. This work has fostered the evolution of what is now a fairly well-developed hierarchical, iterative and integrated approach to classification and mapping. It is hierarchical in the sense that we generally start with image-based vegetation Formations in a park and work toward field-based Alliances, but this path is blurred by the iterative and integrative aspects. Image processing and interpretation are iterated with field work for map drafting and refinement. Meanwhile, the process of identification and definition of Formations and Alliances to be mapped is integrated with their delineation on the map as it is created, because it is usually impractical (and always inefficient) to develop an exhaustive list of map classes *a priori*. Starting with Formation polygons sketched (if not floristically defined) through image interpretation, field crews verify, adjust and split these based on their observations of the relative abundance of dominant species present. Thus instead of field time being divided between separate classification and mapping phases, redundancy is avoided by integrating the two functions. The whole process is facilitated by use of mobile GPS-linked computers loaded with background imagery, tentative Formation polygons, and GIS software enabling field crews to edit and extend the draft map as they walk. It is also useful to have hardcopy image/map prints that can be sketched on and annotated in the field for later refinement of the digital map in the image processing lab. Again, the iteration of lab and field work is key.

The foregoing applies to the approach to be taken at each individual park. With respect to all 11 Network parks, a more or less sequential campaign will be implemented to make best use of two 2-person field crews taking into consideration elevation and seasonality. Crews will generally work at low elevations during the winter and high elevations during the summer, to minimize physiological stress and maximize the number of plant species identifiable during their active phenophase. A tentative project timeline is presented below. Field crews will work as closely as possible with the lab-based image analysts, and the analysts will spend considerable time in the field, so that there is a high level of functional integration.

As indicated in Tables 1 and 2, small parks will be mapped using a “census” approach, with field crews visiting essentially every Formation polygon tentatively identified in the imagery and making adjustments and splits on each one, to produce a map to the Association level for all of the park area. Large parks will be mapped using a sampling approach, with a selection of Formation polygons being visited and refined, and some park area mapped by extrapolation of this information. We anticipate that in this situation the Alliance level will be the finest thematic resolution achievable. Medium-sized parks may be mapped with a “hybrid” approach combining a census in uncomplicated, accessible areas and sampling in large, complex or less-accessible areas.

While the primary means of image analysis will be visual interpretation, we will use available enhancement techniques such as vegetation indices and principal components analysis to assist in breaking out identifiable vegetation types. Raster-based and GIS functions will assist in some tasks less well suited to human performance, such as objectively determining the percent canopy cover of trees and shrubs in a given polygon, which can determine the Formation type. In addition to established image processing techniques, we will apply the image segmentation algorithms of eCognition software to the task of vegetation mapping. Rather than operating on single pixels or limited, fixed windows, eCognition segments or classifies an image based on the information available in user-defined pixel neighborhoods. This provides a stronger ability to separate features from

background, and has been successful in such tasks as classifying urban *vs.* natural land cover. While we do not anticipate that eCognition will provide an automated means of classifying an image into a vegetation map, we expect it will contribute to the process by rapidly separating certain features, such as trees of a particular size or shape, which can be used with other information to build the vegetation map.

PROJECT COMPONENTS

The following is a description of the steps to be taken in executing the vegetation mapping and classification project. These components are presented as an itemized list for clarity, but this does not imply a strictly sequential implementation. Some steps may be pursued in parallel and some may be iteratively repeated, as discussed in the Approach above. These steps will be followed for each park mapped. With the expected two 2-person field crews employed, work may proceed on two different parks simultaneously, or both crews may be working on one park, as indicated in the tentative project timeline below.

1. Acquire and review existing data. For each park we will begin by reviewing available legacy data – existing vegetation maps, identified vegetation types (e.g., NVC or Brown, Lowe and Pase classes), and any spatial or plot-based floristic data. We will conduct basic reconnaissance and confer with park staff to evaluate plant species distribution patterns. From all this we will develop a tentative list of vegetation Formations and Alliances to be mapped. A primary tool facilitating this step is the Sonoran Desert Research and Monitoring Atlas, an I&M product that allows online search for NPS maps and documents. At an early stage in the project, we will establish an NPS web page to display interim products such as methodological SOPs, draft maps, etc., for park and public use. This web page will be frequently updated for maximum currency and usefulness.

2. Scoping at each park. Following Washington Service Office (WASO) guidelines, we will meet with park personnel in a forum for determining individual park needs that can potentially be filled by the products of this project. We will thus be able to tailor our products (to a degree) to meet particular park management needs. Scoping will also help us determine where we will map to Association and where to Alliance – e.g., riparian areas may be high priority for an Association map.

3. Acquire high-resolution multispectral satellite imagery. We will use commercially available 4-band (red, blue, green and near-infrared) satellite imagery as a basis for mapping, rather than aerial photography. Satellite imagery costs less (about $28 per km sq), is more convenient to use than numerous individual photos, and lends itself more readily to enhancement and analysis. Currently the preferred product is the “ortho-ready standard” bundle of 4 separate spectral bands collected at 2.4-m resolution plus panchromatic data collected at 0.6-m resolution by DigitalGlobe Inc.’s Quickbird satellite. This imagery will be orthorectified and pan-sharpened by the Arizona Remote Sensing Center (ARSC) before use. This project will make use of recent imagery that has already been collected for several parks (Tables 1 and 2).

4. Project planning/coordination meetings. A number of meetings are needed to launch the vegetation mapping project and for coordination throughout the multi-year implementation period. Training-type meetings will be held for alignment of the activities of image processors and field technicians. Planning meetings will be held with parks and cooperators. Additional coordination meetings will be scheduled over the course of the project as needed.

5. Preliminary image-interpretation/ecology reconnaissance trips. Project ecologists, field crews and image interpreters will participate in reconnaissance field trips to each park unit to gain familiarity with vegetation and project conditions. Image interpreters need to develop a basic understanding of vegetation distribution patterns as a basis for conducting their work. Ecologists need to gain a similar foundation to plan for field sampling and classification work. A joint field trip with image interpreters and ecologists provides an opportunity to address classification and training issues in the field.

6. Perform image processing tests. We will conduct two types of image processing tests which, if successful, will aid in mapping. The first is automated image segmentation using eCognition software. As mentioned, this may not produce a full-fledged vegetation map by itself, but should make separation of some vegetation types easier. In particular, it may be a fast and objective way to separate vegetation Formations. We will try this technique first on a portion of CHIR, then expand its use if successful. The second type of test we will conduct is to analyze multitemporal imagery for its effectiveness in aiding separation of vegetation types on the basis of their phenological characteristics. We expect that tree and shrub savannas, and certain functional types such as oaks vs. evergreen pinyon-juniper, may show up more clearly by looking at different seasons. We will apply this technique first to CORO because of its functional type diversity and because we already have two images of this park to use. We will acquire a third image at a complementary season for the analysis.

7. Draft preliminary Formations map. A preliminary map of vegetation Formations will be created through image enhancement and interpretation, informed by the study of existing vegetation data and field reconnaissance. Image segmentation with eCognition may be used, along with more established techniques such as spectral classification and texture analysis. Based on previous experience, we anticipate that differences in soil background, topographic illumination and other factors will lead to some spurious “Formation” polygons being digitized, but these can be rectified later through field work. The intent of this step is to delineate all homogeneous and distinct polygons that may be related to vegetation structure.

8. Develop field campaign strategy. In concert with park personnel and project leaders, the field crew(s) assigned to a particular park will outline a logistical plan for accomplishing the field work for mapping. Ideally, the field crews will work 10 days on and 4 days off to minimize driving overhead. At this stage, planning will be done primarily for direct mapping observations as described in Step 7 below, including relevé data collection. For most parks, planning for modular plots and accuracy assessment data collection will be done at a later stage. As a tool for rapid yet objective assessment, an abbreviated set of relevant plant data – floristics, relative abundance and structure – will be collected at a large number of relevés (California Native Plant Society Vegetation Committee 2003). Relevés will be distributed in a non-random, overdispersed pattern throughout the park to capture the range of vegetation patterns present. In contrast to the NVC approach in which "regions of transitional nature are avoided", we intend to concentrate especially on transitions, as these are critical to drawing vegetation polygons in the right places. Relevé data will help establish the vegetation alliances to be mapped, and will be used directly to aid in the creation of Alliance and Association polygons from the draft Formations map.

9. Map Alliances in the field. This is the central task of mapping and will account for the majority of project time and effort. Starting with the draft Formations map, field crews will visit the preliminary polygons, adjust their boundaries as needed, and refine them into Alliances based on observations of the relative abundance of dominant species. Field crews will have the background imagery and the draft Formations map loaded onto GPS-linked mobile computers and will also carry hardcopy prints at two or more zoom levels. While it will be possible to edit

the digital Formations map on the computer and thus map Alliances in “real time”, our experience has shown that it is more effective to sketch on and annotate the hardcopy prints in the field, and transfer the information to the digital files each evening, or back in the image processing lab later. Each new Alliance or Association will be described according to NVC criteria as it is mapped, and relevé data may be taken at this time. More intensive modular plot data will be taken later, and more formal type descriptions written, when the range of variability of each vegetation class is clear. We will make use of low-cost “EcoFlights” (http://www.ecoflight.info/ or http://www.lighthawk.org/) to acquire oblique photography over remote areas in the large parks, to help in mapping these areas, and to post on the public website.

10. Collect and analyze modular plot data, prepare vegetation type descriptions. When the vegetation map is nearing completion, locations for modular plots will be selected and data will be collected for statistical analysis. Following USGS-NPS guidelines, we will establish a set of "stratified random ... community-based plots placed in areas of homogeneous vegetation which are determined to be representative of [each] vegetation type." These will be modular plots in groups of 10x10-m modules as described by Peet et al. (1998) to adequately sample over a range of scales. Plot data will finalize, validate and document the mapped vegetation classes, with a view toward submission of data and new candidate classes to the ESA VegBank and NatureServe NVC systems. Type descriptions will include information on environmental characteristics, dominant species, and vegetation structure as well as the placement of each vegetation type in the NVC hierarchy.

11. Conduct Accuracy Assessment. A statistically valid number of stratified (by vegetation class area) random sample points will be selected and visited to assess the accuracy of the map. Small-area classes may be oversampled. At each sample point the field crew will be asked to integrate the vegetation in a “virtual relevé” of at least 0.5 hectare and record a vegetation Alliance or Association name. During the course of Alliance/Association definition and mapping, pictorial and written "keys" will be developed for each class. These will be used to train and assist field crews in map accuracy assessment. The determination of which alliance is present will be based on species identification and ocular estimation of relative abundance within the virtual relevé, with reference to the defining alliance keys. Ocular estimates of cover in the sampling radius will be made with the aid of the satellite imagery displayed on a mobile computer. To the extent possible, we will have parks or sections of parks assessed by a field crew other than the one that mapped the area, to avoid bias or the perception that the accuracy assessment is trivial. The target thematic accuracy is 80% or better per class. In the event that one or more alliances is mapped with less than 80% accuracy, reasons for the confusion will be investigated and the map will be corrected as necessary. Additional accuracy assessment will then be done in and around the corrected areas.

12. Finalize vegetation map and GIS database. Any mapping errors that become evident through accuracy assessment will be corrected, and map polygons and their attributes will be finalized. Coordinates for relevés and modular plots will be organized digitally for reference. Metadata will be generated for each map. We will load all of our final maps, plot data, etc. on the Sonoran Desert Research and Monitoring Atlas for park and public use.

Table 1. Units of the Sonoran Desert Network within the Sonoran Desert Ecoregion (Bailey 1998) and recently collected high-resolution imagery available to NPS (either NPS owned or added to license). IKONOS and Quickbird products are 4-band commercial satellite data with 1-m^2 and 0.6 m^2 panchromatic pixel resolution, respectively. See text for description of the three mapping approaches and the field crews.

Unit	*Size (ha)*	*Sensor*	*Date(s) Acquired*	*Comments*	*Existing Map*[1]	*Field Crew*	*Mapping Schedule*		
							Approach	*Start*	*End*
Tuzigoot NM (TUZI)	324	Quickbird	12/2003	TUZI + large buffer	ESRI 1996 (NVC)	NPS	Correct existing map	7/2011	10/2011
Casa Grande Ruins NM (CAGR)	191	Quickbird	2/2008	8km x 8km tile including CAGR + large buffer	Reichhardt 1992 (BLP)	NPS	Census	11/2007	10/2008
Saguaro NP – Tucson Mtn. District (SAGU-TMD)	~11,667	Quickbird	9/2007	Imagery collected using network and WASO funding	No	NPS	Hybrid	11/2008	10/2011
Montezuma Castle NM (MOCA)	347	Quickbird	12/2003-1/2004	Both Castle (MOCA) and Well (MOWE) units + large buffer along Verde River	Ruffner & Johnson 1990 (BLP)	NPS	Census	10/2009	10/2010
Tonto NM (TONT)	452	Airphotos	2005	1-ft^2 digital airphotos collected by TONT and Tonto NF	Jenkins et al. 1995 (BLP)	NPS	Census	11/2008	2/2009
		Quickbird	7/2008	Quickbird collected due to intervening disturbances					
Organ Pipe Cactus NM (ORPI)	133,882	Quickbird	11/2003	7km strip along U.S./Mexico border	Warren et al. 1981 (BLP)	NPS & SI	Sample-based	3/2010	10/2011
		IKONOS	Various in 2005, 2007	ORPI + 1km buffer; archived imagery purchased by DoD					
Saguaro NP – Rincon Mtn. District (SAGU-RMD)	~22,334	Airphotos	2004	1-ft^2. digital Airphotos	Roseberry & Dole (1937)	NPS	Sample-based	7/2008	1/2011
		Quickbird	9/2007	Imagery collected using network and WASO funding					

[1]With the exception of Tuzigoot NM, existing maps do not meet the NPS National Vegetation Mapping Standards. "BLP" = Brown, Lowe, Pase (1979), "NVC" = National Vegetation Classification System

Table 2. Units of the Sonoran Desert Network within the Apache Highlands and Southern Rocky Mountain Ecoregions (Bailey 1998), and recently collected high-resolution imagery available to NPS (either NPS owned or added to license). IKONOS and Quickbird products are 4-band commercial satellite data with 1-m^2 and 0.6 m^2 panchromatic pixel resolution, respectively. See text for description of the three mapping approaches and the field crews.

Unit	*Size (ha)*	*Sensor*	*Date(s) Acquired*	*Comments*	*Existing Map*[1]	*Field Crew*	*Mapping Schedule*		
							Approach	*Start*	*End*
Fort Bowie NHS (FOBO)	404	Quickbird	4/2005, 2008	CHIR + FOBO with 1km buffer	Warren et al. 1992 (BLP)	SI	Census	8/2007	10/2008
Tumacacori NHP (TUMA)	144	Quickbird	8/2006	All three units + lg. buffer to be purchased by network & partner	No	SI	Census	11/2007	10/2008
Gila Cliff Dwellings NM (GICL)	216	Quickbird	**FY09**	Gila Cliff Dwellings NM (GICL)	No	SI	Census	8/2009	10/2010
Coronado NM (CORO)	1,923	IKONOS	3/2002	CORO + 700 m buffer	Ruffner & Johnson 1991; Drake et al. 2003 (NVC)	SI	Hybrid	6/2008	10/2009
		Quickbird	10/2003	CORO + 9km extent into Sonora; 2 km buffer					
Chiricahua NM (CHIR)	4,852	IKONOS	4/2001	CHIR + 500m buffer	Roseberry & Dole (1939); Kunzmann et al. 1996 (BLP); Drake et al. 2006 (NVC)	SI	Sample-based	6/2007	5/2009
		Quickbird	4/2005, 2008	CHIR + FOBO with 1km buffer					

[1]None of the existing maps meet the NPS National Vegetation Mapping Standards. "BLP" = Brown, Lowe, Pase (1979).

BUDGET, STAFFING AND CONTRACTING

Personnel and resources committed to the project will reflect a balance of UA, USGS and NPS involvement. The NPS Key Official will be Andy Hubbard, SODN Inventory and Monitoring Program Coordinator, and the University Principal Investigator will be Sam Drake, Assistant Research Scientist at the Arizona Remote Sensing Center (ARSC), within the Office of Arid Lands Studies. Dr. Hubbard will supervise one GS-11 project manager and 2 term GS-5 field technicians. The I&M program will provide one vehicle, travel expenses and GPS-linked mobile computer hardware and software. Dr. Drake will supervise 2 graduate Research Associates working on the project through ARSC, and 2 field technicians hired as temporary Classified Staff through the University. Dr. Marsh will provide senior faculty backstopping, financial administration and contingent participation as necessary. One vehicle will be purchased for project use as a UA vehicle, since non-NPS employees are prohibited from driving NPS vehicles. Dr. Kathryn Thomas (USGS) will serve as a project advisor for the duration of the program, providing insights on the overall approach and product development. In addition to these dedicated resources, we anticipate occasionally employing the services of a consulting botanist (Meg Quinn). Proposed costs are detailed in the Budget tables below.

Budget – Summary.

	SODN Parks:	To CESU partners:	To SODN:	SODN Direct $$:	Total WASO:
FY2007	CAGR, CHIR, TUMA	$177,122	$36,578	$57,530 + $35,000 grant from NPS-OIA	$213,700 (actual; $326,190 requested)
FY2008	FOBO*, CHIR*, SAGU (RMD), CORO, TONT	$256,481	$166,041	$60,454	$422,522 (actual)
FY2009	CHIR, CORO, TONT, SAGU (RMD and TMD)	$202,999	$160,376	$60,454	$363,375 (requested)
FY2010	MOCA ,GICL, SAGU (RMD), ORPI	$209,645	$160,376	$60,454	$370,021 (requested)
FY2011	ORPI, SAGU, TUZI	$215,277	$160,376	$60,454	$375,653 (requested)

$1,745,271 for ~0.5 million acres = $3.49/acre, vegetation maps and vegetation classification for Sonoran Desert and Apache Highlands Ecoregions.

*** Funding shortfall in FY07 delayed completion of FOBO and CHIR until FY08 (FOBO), and early FY09 (CHIR). Funding shortfall of $112,490 in FY07 partially offset with additional $60,008 in FY08. Remaining difference to be absorbed by extending mapping at CHIR and CORO into FY09.**

FY07 ARSC Budget (Project Year 1)	University Rate (per hour)	Level of Effort (hours)		Total Request
Budget Category				
A. Direct Labor - Key Personnel				
1. S. Drake - Principal Investigator (27 weeks)	$27.501	1080		$29,701
2. S. Marsh - Co-Investigator (2 weeks)	$55.654	80		$4,452
ERE Positions 1-2 @ 27.5% (Faculty)				$9,392
Total Direct Labor Key Personnel:				$43,546
B. Direct Labor - Other Personnel				
3. Graduate Student Research Associate (1 @ 1/2+ time)	$15.584	1520		$23,688
4. Research Technician (2 @ full time)	$15.385	4160		$64,002
ERE Position #3 @ 34.0% (Graduate Assistant)				$8,054
ERE Position #4 @ 10.9% (Classified Staff)				$6,976
Total Direct Labor Other Personnel:				$102,719
Total Direct Labor Costs (A+B):				**$146,265**
C. Direct Costs - Equipment				
Field vehicle (used)				$8,000
eCognition software license				$3,600
Quickbird imagery for CAGR, min.64 km sq				$1,893
Total Direct Costs - Equipment:				**$13,493**
D. Direct Costs - Travel				
Travel for field work				$6,500
Total Domestic Travel:				**$6,500**
E. Other Direct Costs				
Materials and Data Processing Supplies				$1,000
Publication Costs				$1,000
Image Processing Lab Services @ $5/hr - 1520 hours	$5.00	1520		$7,600
Total Other Direct Costs				**$9,600**
F. Total Direct Project Costs				**$175,858**
G. Indirect Costs @ 17.5%				**$30,775**
H. Total Direct and Indirect Costs				**$206,633**

FY07 SODN Budget (Project Year 1)	WASO Veg Mapping Program	SODN Vital Signs Program
Budget Detail		
A. Personnel[1]		
1. GS-9 Term Botanist (8PP @2/3 time, 8PP @full time)	$30,600	
2. Two Term GS-5 Biotechs (full time, 13PP)	$44,813	
3. Two GS-7 Lead Biotechs (1/4 time, 16PP)		$17,081
4. GS-7 Cartographic Data Tech (1/4 time, 16PP)		$8,541
5. GS-11 Field Ecologist (1/10 time, 13PP)		$4,108
6. USGS Scientist (Thomas; 1.5PP)	$6,114	
	$81,527	**$29,730**
B. Equipment and supplies		
6. Field ruggedized tablets w/ accessories (2 total)	$4,100	$4,100
7. Recon GIS/GPS mapping systems (6 total)	$7,800	$3,900
8. Field sampling equipment	$2,500	$500
9. Supplies	$1,000	$500
10. Field Vehicle (purchase; additional vehicles provided by SODN)	$12,500	$12,500
11. Fuel and maintenance costs (est.)	$3,500	
12. Travel Trailer (rent)		$2,800
	$31,400	**$24,300**
C. Travel, Training and per diem		
13. Basic First Aid and WIFR	$1,500	$1,500
14. Travel and per diem (est.$1700/full time person)	$5,100	$2,000
	$6,600	**$3,500**
Total Project Cost:	**$119,527**	**$57,530**

1 no charge for other SODN personnel costs: Admin., Key Official, Data Management support.

2 Assuming 37% benefit rate; projected COLAs and step increases NOT included.

FY08-FY11 SODN Annual Budget (Project Years 2-5)	WASO Veg Mapping Program	SODN Vital Signs Program
Budget Detail		
A. Personnel[12]		
1. GS-11 Term Botanist (18PP @1/2 time, 8PP @full time)	$45,398	
2. Two Term GS-5 Biotechs (full time, 26PP)	$89,626	
3. Two GS-7 Lead Biotechs (1/4 time, 26PP)		$27,756
4. GS-7 Cartographic Data Tech (1/4 time, 26PP)		$13,878
5. GS-11 Field Ecologist (1/10 time, 26PP)		$8,220
6. USGS Scientist (Thomas; 2PP)	$8,152	
	$143,176	**$49,854**
B. Equipment and supplies		
6. Supplies	$2,000	$1,000
11. Fuel and maintenance costs (est.)	$5,000	
12. Travel Trailer (rent)		$5,600
	$7,000	**$6,600**
C. Travel, Training and per diem		
13. Travel and per diem (est.$3,400/full time person)	$10,200	$4,000
	$10,200	**$4,000**
Total Project Cost:	**$160,376**	**$60,454**

1 no charge for other SODN personnel costs: Admin., Key Official, Data Management support.
2 Assuming 37% benefit rate; projected COLAs and step increases **NOT** included.

FY08 Budget (Project Year 2)	University Rate (per hour)	Level of Effort (hours)		Total Request
Budget Category				
A. Direct Labor - Key Personnel				
1. S. Drake - Principal Investigator (27 weeks)	$28.326	1080		$30,592
2. S. Marsh - Co-Investigator (2 weeks)	$57.231	80		$4,578
ERE Positions 1-2 @ 27.5% (Faculty)				$9,672
Total Direct Labor Key Personnel:				$44,842
B. Direct Labor - Other Personnel				
3. Graduate Student Research Associates (1 @ 1/2+ time)	$16.052	1520		$24,399
ERE Position #3 @ 34.0% (Graduate Assistant)				$8,296
Total Direct Labor Other Personnel:				$32,695
Total Direct Labor Costs (A+B):				**$77,537**
C. Direct Costs - Equipment				
Field vehicle maintenance				$1,500
Quickbird imagery for GICL, min.64 km sq				$1,893
Quickbird imagery for CORO (multitemp.), min.64 km sq				$1,893
Total Direct Costs - Equipment:				**$5,286**
D. Direct Costs - Travel				
Travel for field work, mostly fuel				$6,500
Total Domestic Travel:				**$6,500**
E. Other Direct Costs				
Materials and Data Processing Supplies				$1,000
Publication Costs				$1,000
Image Processing Lab Services @ $5/hr - 1520 hours	$5.00	1520		$7,600
Total Other Direct Costs				**$9,600**
F. Total Direct Project Costs				**$98,923**
G. Indirect Costs @ 17.5%				**$17,312**
H. Total Direct and Indirect Costs				**$116,235**

FY09 ARSC Budget (Project Year 3)	University Rate (per hour)	Level of Effort (hours)		Total Request
Budget Category				
A. Direct Labor - Key Personnel				
1. S. Drake - Principal Investigator (27 weeks)	$29.176	1080		$31,510
2. S. Marsh - Co-Investigator (2 weeks)	$58.948	80		$4,716
ERE Positions 1-2 @ 27.5% (Faculty)				$9,962
Total Direct Labor Key Personnel:				$46,188
B. Direct Labor - Other Personnel				
3. Graduate Student Research Associate (1 @ 1/2+ time)	$16.534	1520		$25,132
4. Research Technician (2 @ full time)	$16.322	4160		$67,900
ERE Position #3 @ 34.0% (Graduate Assistant)				$8,545
ERE Position #4 @ 10.9% (Classified Staff)				$7,401
Total Direct Labor Other Personnel:				$108,977
Total Direct Labor Costs (A+B):				**$155,165**
C. Direct Costs - Equipment				
Field vehicle maintenance				$1,500
Total Direct Costs - Equipment:				**$1,500**
D. Direct Costs - Travel				
Travel for field work, mostly fuel				$6,500
Total Domestic Travel:				**$6,500**
E. Other Direct Costs				
Materials and Data Processing Supplies				$1,000
Publication Costs				$1,000
Image Processing Lab Services @ $5/hr - 1520 hours	$5.00	1520		$7,600
Total Other Direct Costs				**$9,600**
F. Total Direct Project Costs				**$172,765**
G. Indirect Costs @ 17.5%				**$30,234**
H. Total Direct and Indirect Costs				**$202,999**

FY10 ARSC Budget (Project Year 4)	University Rate (per hour)	Level of Effort (hours)		Total Request
Budget Category				
A. Direct Labor - Key Personnel				
1. S. Drake - Principal Investigator (27 weeks)	$30.051	1080		$32,455
2. S. Marsh - Co-Investigator (2 weeks)	$60.716	80		$4,857
ERE Positions 1-2 @ 27.5% (Faculty)				$10,261
Total Direct Labor Key Personnel:				$47,573
B. Direct Labor - Other Personnel				
3. Graduate Student Research Associate (1 @ 1/2+ time)	$17.030	1520		$25,886
4. Research Technician (2 @ full time)	$16.812	4160		$69,938
ERE Position #3 @ 34.0% (Graduate Assistant)				$8,801
ERE Position #4 @ 10.9% (Classified Staff)				$7,623
Total Direct Labor Other Personnel:				$112,248
Total Direct Labor Costs (A+B):				**$159,821**
C. Direct Costs - Equipment				
Field vehicle maintenance				$1,500
Total Direct Costs - Equipment:				**$1,500**
D. Direct Costs - Travel				
Travel for field work, mostly fuel				$7,500
Total Domestic Travel:				**$7,500**
E. Other Direct Costs				
Materials and Data Processing Supplies				$1,000
Publication Costs				$1,000
Image Processing Lab Services @ $5/hr - 1520 hours	$5.00	1520		$7,600
Total Other Direct Costs				**$9,600**
F. Total Direct Project Costs				**$178,421**
G. Indirect Costs @ 17.5%				**$31,224**
H. Total Direct and Indirect Costs				**$209,645**

FY11 ARSC Budget (Project Year 5)	University Rate (per hour)	Level of Effort (hours)		Total Request
Budget Category				
A. Direct Labor - Key Personnel				
1. S. Drake - Principal Investigator (27 weeks)	$30.953	1080		$33,429
2. S. Marsh - Co-Investigator (2 weeks)	$62.537	80		$5,003
ERE Positions 1-2 @ 27.5% (Faculty)				$10,569
Total Direct Labor Key Personnel:				$49,001
B. Direct Labor - Other Personnel				
3. Graduate Student Research Associate (1 @ 1/2+ time)	$17.541	1520		$26,662
4. Research Technician (2 @ full time)	$17.316	4160		$72,035
ERE Position #3 @ 34.0% (Graduate Assistant)				$9,065
ERE Position #4 @ 10.9% (Classified Staff)				$7,852
Total Direct Labor Other Personnel:				$115,614
Total Direct Labor Costs (A+B):				**$164,615**
C. Direct Costs - Equipment				
Field vehicle maintenance				$1,500
Total Direct Costs - Equipment:				**$1,500**
D. Direct Costs - Travel				
Travel for field work, mostly fuel				$7,500
Total Domestic Travel:				**$7,500**
E. Other Direct Costs				
Materials and Data Processing Supplies				$1,000
Publication Costs				$1,000
Image Processing Lab Services @ $5/hr - 1520 hours	$5.00	1520		$7,600
Total Other Direct Costs				**$9,600**
F. Total Direct Project Costs				**$183,215**
G. Indirect Costs @ 17.5%				**$32,063**
H. Total Direct and Indirect Costs				**$215,277**

APPENDICES

KEY TO VEGETATION FORMATIONS:

1. What is the dominant surface cover?

- Trees …… **2**
- Shrubs …….. **3**
- Herbaceous …….. **4**
- Rock/Bare Soil ……. **5**

2. Trees:

A. Tree Cover > 60%?
YES = "Forest", NO = "Woodland"

3. Shrubs:

A. Tree Cover > 10%?
YES = "Wooded Shrubland", NO = "Shrubland"

4. Herbaceous:

A. Tree cover < 10% AND Shrub cover < 10%?
YES = "Herbaceous", NO = go to question B.
B. Tree cover > Shrub cover?
YES = "Tree savanna", NO = "Shrub savanna"

5. Rock/Bare Soil:

A. Is the site predominantly bedrock or surface rock?
YES = "Rock outcrop", NO = "Barren"

GO TO QUESTION B. TO CONSIDER QUALIFIER

B. Is the total vegetation cover of the site < 10%?
YES = add "Sparse" to A., NO = go to question C.
C. Is the vegetation primarily tree cover?
YES = add "Wooded" qualifier to A., NO = question D.
D. Is the sparse vegetation primarily shrub cover?
YES = add "Shrubby" qualifier to A., NO = add "Herbaceous"

Sonoran Desert Network
Vegetation Mapping Project
Standard Operating Procedure #1
Ground Checking Polygons and Associated Data Collection
October 19, 2006
Version 1.1

The following information is intended as a guide to field data collection procedures during the SODN vegetation mapping project. This document is intended as a general guide and should be applicable for use in all park locations.

UNLESS NOTED OTHERWISE ALL EQUIPMENT LISTED IS FOR A SINGLE FIELD CREW

Electronic Equipment
2 RECON units with HGIS and ArcPad software; these should be loaded with appropriate base layers, template files and the **MOST RECENT** vegetation *Formation polygon* layers for the area to be mapped, usually an entire park unit
RECON power cords and downloading cord
2 Radios with charging bases
Cell phone
Tablet or laptop for updating and editing polygon files in the field (With ArcMap)
Extra battery for tablet; power cord for re-charging
Other Equipment - Vegetation
Notebook
Plant collection book and clear tape
Vegetation datasheets x 50
Pencils, with erasers
Camera and case with power and download cords
Plant field guides
Species list for park unit
Paper maps and large map clipboard
- one large map of entire mapping area
- individual maps of smaller areas

Vegetation type descriptions if available for this area
Other Equipment – Soils
Soils datasheets x 50
Soil guides and cheat sheets
Small shovel or trowel
10% Hydrochloric acid
2mm sieve
Water bottle for texturing
Towel
Quart sized Ziploc bags for soil samples not textured in the field

Objective

The overall objectives of this field data collection are to ground check and verify the identity and accuracy of vegetation Formation-level shapefiles that have been made in the office using satellite imagery, and to delineate the vegetation Alliance(s) and Association(s) that exist within each Formation-level polygon. Formations are defined by the physiognomy or life-form of the dominant plants present; e.g., Woodland, Wooded shrubland, Grassland, Savanna, etc. Alliances are defined by the relative abundance of particular species present.

Field crews will be assigned polygons on each work day to visit and observationally verify the vegetation Formation present, making amendments to the lab-based image interpretation as necessary. An equally important part of this ground checking is to verify that the polygon boundary is as accurate as possible. If the boundary does not reflect the spatial extent of the given formation the crews will be responsible for either editing the current polygon boundary file (using ArcPad and tablet) or redrawing the polygon boundary anew using HGIS. Changes should also be notated in pencil directly onto the large scale paper maps. These will serve as the hard-copy record of any changes. Discrepancies in boundaries of up to 15 meters are acceptable due to the limited accuracy of the GPS units available. However, careful use of the paper maps can yield quite accurate results, especially when individual trees and landmarks are used as guides.

In addition to verifying the assigned Formation name and boundary, crews will be collecting plant canopy cover data on the dominant vegetation such that we can assign both an Alliance and an Association name to each distinct polygon (see below- Alliance and Association description). If there is more than one Alliance or Association within a Formation polygon, the sub-polygon boundaries will be delineated in the field. Each crew will work together to cover as much of the polygon area as possible and get a solid idea of the dominant species present and the relative areal extent of their cover.

The vegetation and soils datasheets have been designed to collect all additional relevant data which will allow us to define the vegetation community at fine scales – Alliance- and Association-level.

Methods

In general these steps should be followed in the order presented here. Depending on crew size and experience some of these tasks can be accomplished simultaneously or in a different order.

NOTE: Before leaving for the field be sure that you have the most current version of the Formation layers. These files are located at V:\Veg_Map\Data_Spatial\Processed_Data\Formations\FOBO and are labeled by date; therefore download the folder with the most current date.

1) Start GPS within HGIS or ArcPad and have Formation layers, boundaries, trails etc. loaded onto your RECON unit.

2) Go to your first assigned polygon

- Verify position using RECON units.
- If there are at least three people in the crew one person can be assigned to begin soils data collection at this point. See # 6 below.

- Fill out general information on the data sheet; date, location etc.
- Ascertain current tentative Formation type by selecting the polygon on the RECON and viewing the attribute table, or take this information from the paper map. Record this on the data sheet under "tentative Formation".

3) Split up and observe the polygon's vegetation, then use the vegetation *Formation key* to assign a Formation name. Work through the Formation key and record the result on the data sheet under "keyed Formation". This may or may not match the tentative Formation name.

4) Once a Formation name has been assigned, three things need to be accomplished.

a. The entire boundary should be walked to ascertain that it accurately defines this Formation area. If the boundary needs to be expanded, contracted or split, draw the changes on the paper maps but also sketch the changes made on the back of the data sheet, including as much contextual detail (landmarks, washes, disturbances, direction, fence lines etc) as possible. When possible, polygon changes should be digitized in the field the same day (or each night) using either a tablet or a laptop, such that new shapefiles are created for all changes made, and these are added to the unchanged polygons.

b. Review your maps to see if any dotted lines or "area of interest" boundaries are present. These represent areas that could not be interpreted from the satellite imagery but could be significant disturbances or have some bearing on mapping Formations or Alliances. These should be visited and a description of what they are recorded on the data sheet. These could in theory represent a change in the vegetation and therefore necessitate separate polygons.

c. The polygon(s) then need to be walked through by one or two people and dominant species in each of the three height classes recorded. These species will determine the Alliance and Association classes present. If the dominant shrub species or the dominant herbaceous species should change within one Formation polygon then this would constitute reason to split the polygon into sub-polygons representing Alliance(s) or Association(s). A separate data sheet needs to be filled out for each unique sub-polygon. Modify the polygon name to reflect the new sub-polygons using A, B, C etc.

Example: You arrive at polygon SL20 (Shrubland #20). You determine that it is a shrubland using the key. After walking around, you decide that half the area clearly has *Aristida* grasses dominant and the other half has *Bouteloua* grasses dominant. You therefore draw on the map where the herbaceous dominance changes and sketch changes on the data sheet. You then assign SL20A to the *Aristida* dominated half and SL20B to the *Bouteloua* half. Fill out a new data sheet for SL20B, where the tree and shrub categories should remain the same if the Formation polygon is homogeneous with respect to the relative abundance of tree and shrub species.

5) Finish filling out the vegetation data sheet by recording other common associates in each category. Also write a paragraph giving a detailed description of the vegetative community, including percent cover estimates for each stratum, uncommon and rare species, general height classes of strata, and differences of this community from other similar ones (i.e. What makes this a new community). Describe any features of interest in this polygon, such as built structures, overall landscape features and modifications, and general observations about the vegetation that would be useful in a written report.

Example: There is an old concrete water tank in the northwest corner. Shrub cover is consistent but herbaceous cover dominance keeps changing between *Chloris* and *Setaria sp*. More *Opuntia spinosior* as you move westward up-slope. Large stands of *Verbesinia* and *Salsola*. Shrub cover is estimated at 50 %. Many large rock outcrops on hill slope. Lower portion of polygon has many deep gullies that run into main wash (see diagram). Major trail bi-sects polygon and there is heavy rodent burrowing throughout.

6) Fill out qualitative soils data sheet. If you have split a polygon into two or more smaller areas on the basis of vegetation changes you should complete one data sheet for each distinct polygon. Observational categories should be filled out taking the entire area into consideration; therefore you may check several boxes under each category. The back side of the data sheet has space for data on up to four texture samples (refer to soils reference materials below for instructions on how to texture). The number of samples taken will be determined by observed differences within each area. If the soils appear to be consistent throughout the polygon then one texture sample will be sufficient. Small areas (less than 1/2 hectare) that have distinctly different soil color and texture should be ignored unless the observer determines them characteristic of the area or significant in the aggregate. Also, should the polygon encompass several changes in slope and aspect (backslope, footslope and toeslope), one sample could be taken from each area as these often will be subject to different erosional regimes and therefore represent different soil types. GPS coordinates should be recorded at each texture location. Write them on the data sheet and store them in either an ArcPad or HGIS file. One file can be created and used for the entirety of the work period (day or week). Name the file following this convention:
Parkcode_date(YYMMDD)_soil_tex_pt.
Example: FOBO_070312_soil_tex_pt.

7) Take a minimum of four photos within each polygon. These should be taken last, after any changes or splitting of polygons has occurred. Take one photo from the approximate center of the polygon facing in each of the cardinal directions beginning with North (then East-South-West). Record the camera used and the photo numbers on the data sheet. **NOTE**: Please use the last **four** digits of the photo numbers found in the top right corner of the review screen (123-**3245**). GPS coordinates should be recorded for each photo location in each polygon. Write them on the data sheet and store them in one digital file to be used throughout the field trip. Create this file in either ArcPad or HGIS. Name the file following this convention:
Park code_ Date(YYMMDD)_Photo_points.
Example: FOBO_070312_Photo_points. Save this to the storage card.

Data storage and manipulation.
Any changes that are made to polygon boundaries must be noted in the field on the paper maps. At the end of the day (or during the day if time and conditions permit) shapefiles should be edited to reflect these changes.
Using ArcMap on the tablet or laptop computers, open the existing Formation polygon files that you will need to edit. Depending on how much needs to be changed, you can either:

A) Make edits to the original polygon by moving individual nodes along the boundary. Using this method may be preferable but will also entail the manipulation of surrounding polygons such that you are not left with holes between polygons or overlapping areas.

or B) Create a whole new polygon. In this case be sure to import the attribute table from one of the original polygon files such that we retain all fields for naming, etc.

In general any polygon that is changed from its original form (reduced, expanded, split, etc) will be renamed during the digital editing stage in ArcMap. When editing a polygon in the ways listed above the new name(s) will likely reflect the creation of an additional sub-polygon; in this case the new name given will be the next consecutive numbered polygon in that particular Formation layer. On occasion polygon Formation names will be changed as a result of field ground truthing but the boundaries will remain unchanged. In this case you would also assign a new name based on the number of previously existing polygons in that particular Formation layer.
Example: you have visited Shrubland #20 and found that the upper half of the polygon actually keys to be a Wooded Shrubland. Therefore on a separate data sheet you would notate a split and call the Wooded Shrubland polygon SL20 a, to notate from whence it came. Later when you have access to a computer you would edit the original polygon into two separate polygons and rename SL20a with an appropriate name. Assuming there were already 4 Wooded Shrubland polygons in the Wooded Shrubland layer, this one would be number 5 (WS5).

Photos.
Photos can be left on the camera for the duration of the field trip provided the camera is equipped with a 1GB memory card. Otherwise they should be downloaded each night to the tablet or laptop and renamed to include the camera name; jag_2378, puma_1209, etc. Each photo will then be labeled uniquely even if photo numbers are duplicated between cameras, and each photo will be traceable back to a paper data sheet.

Shapefiles; points and polygons.
Point files containing photo locations and soil texturing locations can be downloaded each evening to the laptop or tablet. Any files containing lines, points or polygons related to boundary changes or points of interest within polygons should also be downloaded each evening to appropriate folders.

Vegetation Mapping
Field Data Sheet: Polygon ground check
Version #1

Proofread by: _____ Date Completed:
Copied by: _____ Completed by:
Entered by: _____ New Poly ID:
Verified by: _____ Association:

Location and Event Information

Park Code:	Sub-map #:	Date (mm/dd/yyyy):	Time (00:00):
Polygon ID:		New poly ID (if applicable) :	
Observer Name :		Recorder Name :	
Protocol Name : Vegetation Mapping		Protocol Version: 1	

Formation type

Tentative formation:	
Keyed formation:	

List top three dominant (common) species by class; notate in second column 1= dominant or co-dominant, 2= second dominant, 3= least dominant.

TREE >2m		SHRUB <2m		HERBACEOUS (incl. grasses)	

Other common associates

TREE >2m	SHRUB <2m	HERBACEOUS (incl. grasses)

Association name; Use – within strata, / between strata and ( ) to denote less constancy. (Ex. PRVE-QUAR/ALWR (ISTE) WOODLAND

NOTES: - Write a paragraph describing the overall vegetative community, esp. noting differences from other similar communities. Please try to estimate % cover & heights in each stratum as well as high %'s bare ground or outcrops. Make note of past & present disturbances, trails, structures etc. Please include diagrams of any splits\ additions or subtractions to the polygon.

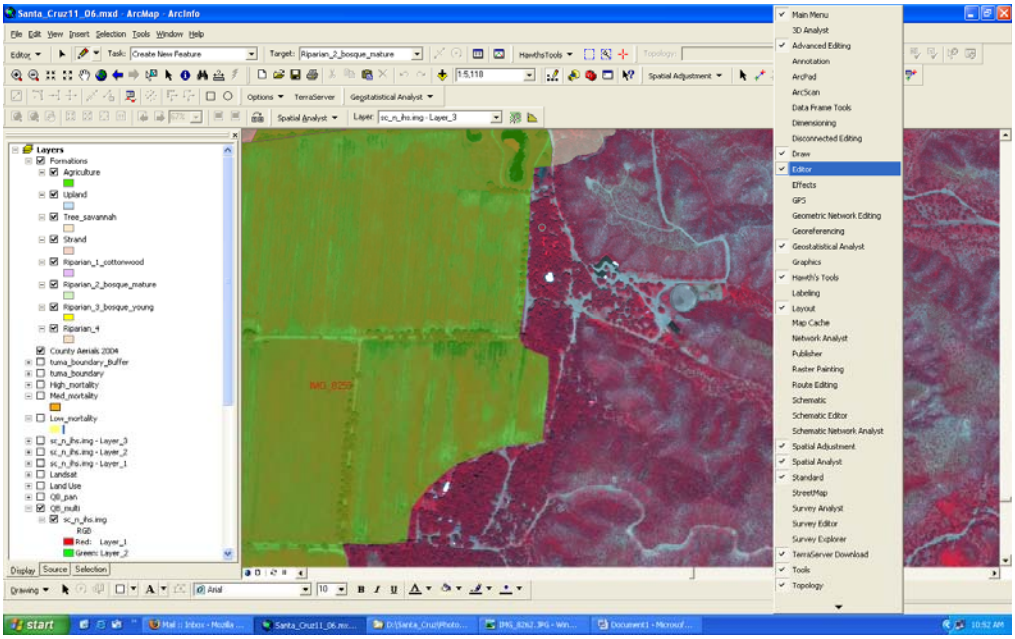
PHOTOS: - From approximate center of polygon take 4 photos one in each cardinal direction, in order (N E S W).
Write photo number (<u>last four digits from upper right corner</u>) in table and record camera used.

Camera name:	
North	
East	
South	
West	

**** Please note the numbers of any additional photos taken and a description of what they are of.**

TECHNICAL GUIDELINES FOR MANIPULATING MAP POLYGONS (DRAFT)

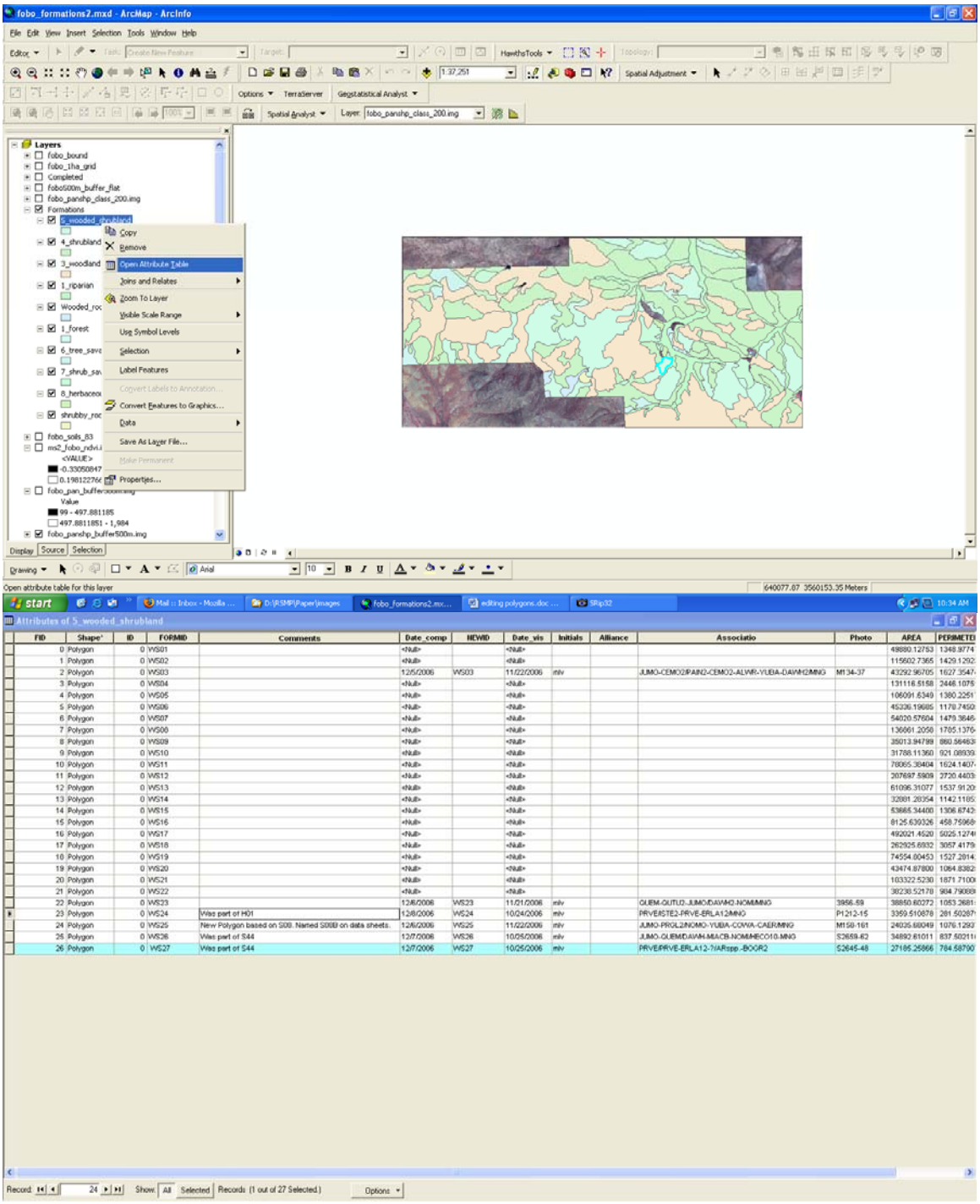
Updating and Editing Polygon Boundaries:
Open the ArcMap project document (.mxd file). Make sure the ArcMap Editor extension is activated. If not, right-click on the main menu bar (a list of extensions should appear) and select Editor, shown in the figure below. When the Editor Toolbar is activated, select "start editing" from the Editor drop down menu. When prompted, select the directory that contains the shapefiles to be edited (note: the shapefiles must be active layers in the ArcMap project).



Activating the Editor toolbar.

Now you can begin editing. In the "target" box of the Editor toolbar select the Formation type you want to edit. In the "Task" box select "Modify Feature". Select on the polygon you plan to modify. Once selected, all of the polygon vertices should appear. To simply move a vertex, select it and drag it. To add additional vertices right-click on the activated polygon (best to do it near the line segment you intend to insert the vertex) and select "Insert Vertex". Add, delete and move as many vertices as needed to reshape the polygon. When finished editing, select "Save Edits" from the Editor drop down menu.

Updating Polygon Attributes:
To update the polygon attributes with field data sheet information, select "start editing" from the Editor drop down menu and select the directory that contains the shapefiles to be edited. To add information to an attribute table, right-click the class type in the table of contents (e.g. tree savanna) and select "open attribute table", as shown in the combined figure below. Find the Formation ID (FORMID) that corresponds with your data sheet, click inside the field box you want, and then update. Save your edits when you are finished.



Opening an attribute table, and an example attribute table.

Saving an Archive:

Once you have finished updating all the polygons with the most recent field information, you will save the directory that contains the edited Formation shapefiles as a .zip file under a new name. To do this, right-click the Formations directory and select Send To>Compressed (zipped) Folder. The naming convention for this folder should follow this example: Fobo_Formations_year_month_day.zip, or

Fobo_Formations_07_01_31.zip. These .zip archives will ensure that we can access earlier drafts of the data.

The working directory will contain the most recent edits. This directory should be transferred to the tablet or Recons prior to field work.