USGS-NPS VEGETATION MAPPING
Mount Rushmore National Memorial, South Dakota

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EXECUTIVE SUMMARY

A vegetation association classification, vegetation map, and thematic accuracy assessment is presented for the area in and around Mount Rushmore National Memorial. This report is presented in two volumes: The Nature Conservancy report which presents the vegetation classification and this report which presents the methods and results of the mapping portion of this project.

The vegetation associations were developed by analysis of 19 vegetation plots and 51 observation points within the mapping boundary. The classification system developed uses and augments the National Vegetation Classification System (NVCS). Nine vegetation associations within 1 major physiognomic group are defined and described. Included are discussions of range, environmental variables, common species, diagnostic species, local and global descriptions, and various comments. A diagnostic key is provided for field identification of association types based on indicator plant species.

The vegetation map was developed by photographic interpretation of 1993, 1:16,000 scale color infrared photography. Two separate classification systems were used to develop the mapping units. Cultural, disturbed, or unsampled vegetation types used the Anderson Level II classification system. All other vegetation within the mapping boundary used map units derived from the NVCS. A total of 8 Anderson Level II classes and 9 NVCS classes were used. The NVCS classes were combined to form 4 vegetation mapping classes.

As part of the mapping effort, we have included an accuracy assessment for the overall mapping effort as well as for individual class accuracies. These data include reporting for both errors of omission and commission. Overall map accuracy is 74.3% within a 90% confidence interval.

Final products developed by this mapping effort include the following:

- vegetation classification system
- vegetation key
- ACCESS database with all field data
- digital and paper vegetation map
- digital coverage with all vegetation plots
- digital coverage with all observation plots
- digital coverage with all accuracy assessment points
- graphic files (*.tif) of all digital coverages
- accuracy assessment
- metadata for all digital files
- scanned aerial photography
- annotated field photographs/slides
- digital orthophoto in GRID export format (.e00)
- all products on Computer Disk (CD)

INTRODUCTION

This mapping effort originates from a long-term vegetation monitoring program that is part of a larger Inventory and Monitoring (I&M) program started by the National Park Service (NPS). I&M goals are, among others, to map the vegetation of all national parks and monuments and provide a baseline inventory of vegetation. The I&M program currently works in close cooperation with the Biological Resources Division (BRD) of the United States Geological Survey (USGS). The USGS/BRD continues overall management and oversight of all ongoing mapping efforts in close cooperation with the NPS. Contractors for each park vary. For Mount Rushmore National Memorial the principal contractor is the U.S. Bureau of Reclamation (BOR), Denver Technical Center, Remote Sensing and Geographic Information Group (D-8260). The primary subcontractor is The Nature Conservancy (TNC) who also works closely with the Wyoming Natural Heritage Program.

Objectives and Scope

The purposes of the mapping effort are varied and include the following:

- Provides support for NPS Resources Management
- Promotes vegetation-related research for both NPS and USGS/BRD
- Provides support for NPS Planning and Compliance
- Adds to the information base for NPS Interpretation
- Assists in NPS Operations

PROJECT AREA

Location: Mount Rushmore National Memorial is in Pennington County and is part of the south western Black Hills (Figure 1). The Memorial lies 11 miles north east of the town of Custer, South Dakota. The Memorial shares its southwest boundary with the Norbeck Wilderness Preserve. All other boundaries are shared with the Black Hills National Forest.

Geology: Mount Rushmore National Memorial lies within the Central Crystalline Area of the Black Hills. This is the main core or central mass of the Black Hills. All of this area is composed of a "... variety of Pre-Cambrian igneous and and sedimentary rocks (schists, slates, quartzites) in different stages of metamorphosis, together with granite and pegmatite"(Froiland 1990).

Soils: The soils in and around the mapping area are made up of two different types. These are the Pactola-Rock Outcrop and Buska-Mocmont-Rock Outcrop. The Pactola-Rock Outcrop soil type is found in the northern portion of the mapping area and the Buska-Mocmont-Rock Outcrop is in the southern portion. They are both well drained, gently sloping to very steep, loamy soils. Pactola-Rock Outcrop is formed in material weathered from steeply tilted metamorphic rock. Buska-Mocmont-Rock Outcrop is formed in material weathered from micaceous schist and

granite.(Ensz 1990). Because of the slow breakdown of quartz and the large granite crystals the soils tend to be thin (Froiland 1990).

Topography: The topography is generally very rugged and ranges from moderate to very steep. Much of the area is punctuated with a variety of exposed granite that forms knobs, pinnacles and mountains. The elevation ranges from a low of around 1524 m (5000 ft) in the south eastern portion of the mapping area to Mount Rushmore with a high of 1738 m (7725 ft). The second highest peak in the area is Old Baldy Mountain in the northern mapping area which reaches an elevation of 1708 m (5605 ft). The mapping area also has two major drainages. These are Lafferty Gulch and Grizzly Bear Creek, both of which drain towards the north east.

Climate: The area is characterized by generally warm to hot during the summer to cold punctuated with occasional milder weather during the winter. Average summer temperatures are 17 degrees C (62 degrees F) and may reach temperatures of over 38 degrees C (100 degrees F). Average winter temperatures are about -5 degrees C (25 degrees F) but may reach temperatures as low as -42 degrees C (-43 degrees F). Total annual precipitation is about 46 cm (18 inches) with most of that falling between April and September. Average snowfall is about 114 cm (45 inches) (Ensz 1990).

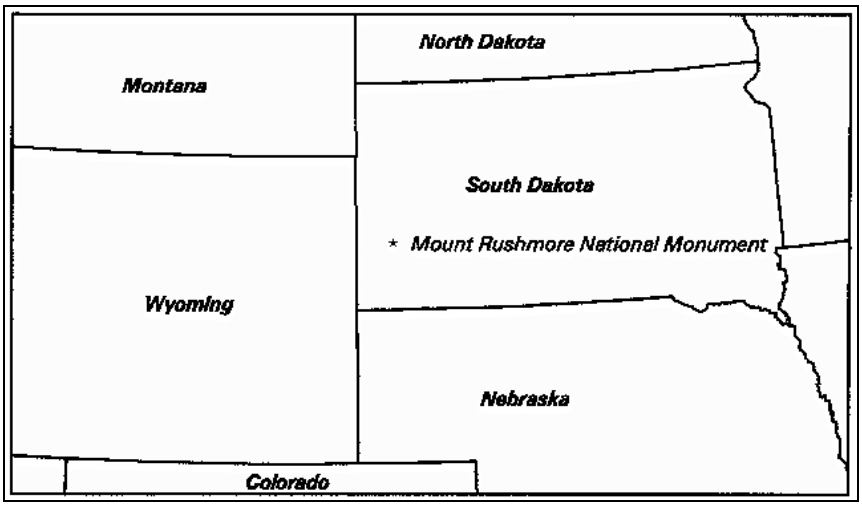

Figure 1. Location map for Mount Rushmore National Memorial

METHODS

Development of Programmatic and Technical Team: This project required the combined expertise and oversight of several organizations. Oversight and programmatic considerations are managed by the Center for Biological Informatics of the Biological Resources Division of the U.S. Geological Survey. The National Park Service provided additional guidance.

The technical responsibilities for the mapping effort were divided between TNC and BOR.

TNC responsibilities and deliverables included the following:

- Create a vegetation classification system based upon field species level data and consistent with the Standard National Classification System at the Alliance or Community Element level
- Provide documentation that describes the national classes at the local and global levels, with field keys, and field data in a *.dbf format.
- Provide technical opinion to BOR as the mapping portion of the project proceeds.
- Provide field notes and site descriptions

BOR responsibilities and deliverables included the following:

- Digital files of vegetation on Compact (CD); including topology and labeling for height, density, and pattern subclasses; location of field sample sites; and locations of sites used for accuracy assessment in Arc/Info format
- Any ancillary digital files developed during the mapping process
- Digital FGDC compliant metadata file for each digital file delivered
- Annotated field site photographs
- Original mylar overlays of interpreted photographs
- Hard copy vegetation map
- Accuracy assessment
- Final report describing all procedures used in developing the final map and accuracy assessment

Planning and Review Meeting

An initial meeting was held with all interested parties to discuss several aspects of the mapping effort. Foremost among these was the mapping extent. Figure 2 shows the Memorial boundary and the area outside the Memorial to be included in the map. Vegetation issues particular to the park were addressed. Mount Rushmore National Memorial was responsible for obtaining permission from adjacent land owners for property access for sampling purposes. Most of the private lands were under some form of grazing or farming. Consequently, sampling on these lands was not necessary. The remainder of the lands within the mapping area are U.S. Forest Service Lands so permission was not necessary.

Preliminary Data Collection and Review of Existing Information

To reduce duplicating previous work and to help in our effort we collected existing vegetation reports and maps from the staff at Mount Rushmore National Memorial. These materials were referenced during the mapping process and the information contained in them was incorporated where it was deemed useful. Because soils also affect the distribution of

vegetation, soil maps and soil descriptions were also obtained as reference (Ensz 1990). These were not converted to a digital file.

Digital elevation models (DEM) were obtained to create slope and aspect maps that helped in determining vegetation community distribution.

Vegetation Sampling

The sampling approach used in this mapping effort was typical of small park sampling, where all polygons within the mapping boundary are sampled.
Two levels of field data gathering were conducted in this park; plots and observations. Plots represented the most intensive sampling of the landscape and used TNC's 'Plot Form'.

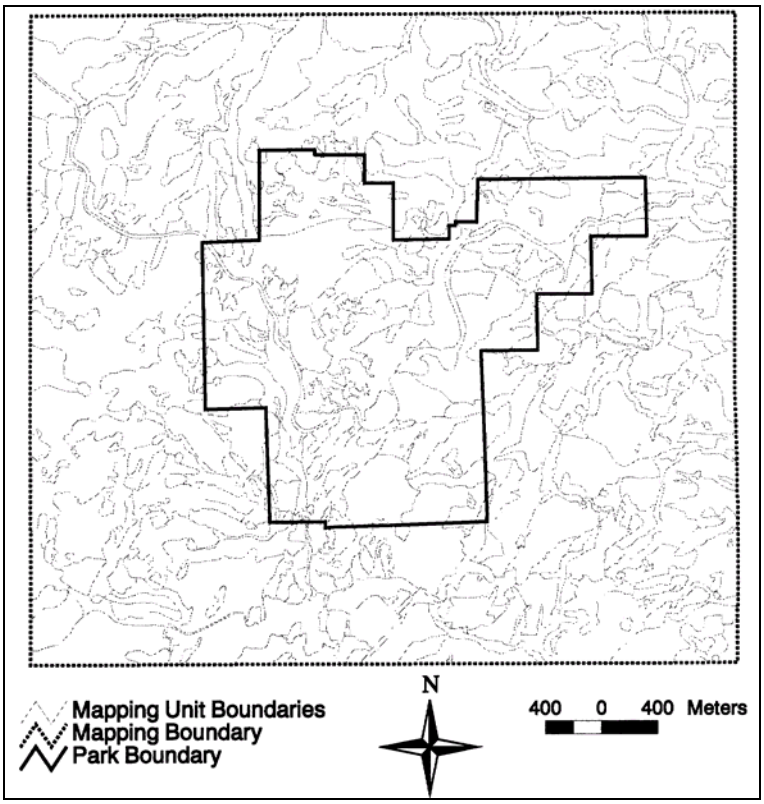

Figure 2. Memorial Boundary and Mapping Area

Observations consisted of brief descriptions and were designed to obtain a quick overview of the landscape without spending a large amount of time at each sample site. Observation points used the 'Observation Form' data sheet. Examples of both 'Plot' and 'Observation' forms are included in the companion report by TNC.

Initially, plots were used to describe the vegetation of the park. A total of 19 plots were obtained from July 22 and July 30, 1996. These plots were used by TNC to describe vegetation associations found within the park. These descriptions are in the companion report by TNC.

Before the accuracy assessment, we conducted a verification trip to assess the preliminary mapping effort. The verification used the observation forms described above. The verification data were then used to refine both the final map and the final vegetation description. Fifty one observation points were collected on June 9 through June 12, 1997. Figure 3 shows the locations of all plot and observation points.

Plot locations: The location of each vegetation plot or observation point was based upon several factors. These factors included the preliminary photo signature and other physiographic variables such as slope, aspect, soils, and geology. We attempted to sample the vegetation in a way that recorded the greatest amount of variability across the landscape. Plots were placed subjectively in areas that best represented the immediate landscape.

The geographic coordinates of the plot locations were determined by marking our approximate position on a mylar overlay on aerial photographs with ink. These positions were later transferred to a digital file using the digital orthophoto quad (DOQ) as a base map. Observation points were located by a global positioning system (GPS) using a Precision Light Weight GPS Receiver (PLGR) device. Plot locations in dense canopies are estimated to be within 10 to 20 meters of their actual location. Observation points are generally within 10 meters of their actual location.

Vegetation and Map Classification

This mapping effort includes a description of vegetation at two levels. The primary and most informative level is that of the vegetation classification at the association level. Because many plant associations cannot be mapped from the photography at this level, we also include a mapping classification. The map classification may be the same as the vegetation association but is usually a combination of associations in either a complex or mosaic of associations.

Vegetation Classification: The association descriptions for the vegetation and methods used to derive those descriptions are included in the TNC companion report. (See Table 1 for a summary of the associations. The methods used by TNC and this office (Bureau of Reclamation, D-8260) for collecting and processing these data are also described in *Field Methods for Vegetation Mapping* (The Nature Conservancy 1994).

Mapping Classification: The final map contains elements of two separate classification systems. All vegetation sampled and described by this project use the NVCS. All other land cover types within the mapping area use the Anderson Level II classification system (Anderson et al. 1976).

Map classes were derived from the vegetation classification and modified such that the photo-interpreted classes represented at least one vegetation class. Because many vegetation classes did not have a distinct photo signature, some vegetation classes were combined to make a map class. For example, many Ponderosa Pine types were not distinguishable by photo signature and had to be combined into ‘complexes’. Before combining and producing the final map classes, we worked with preliminary map classes. The preliminary map classes were typically equivalent to the association descriptions. These preliminary map classes were unworkable due

to the complexity of the vegetation distribution. Consequently, the accuracy assessment was done on the final map classes. Table 2 describes the map classes and the component community types.

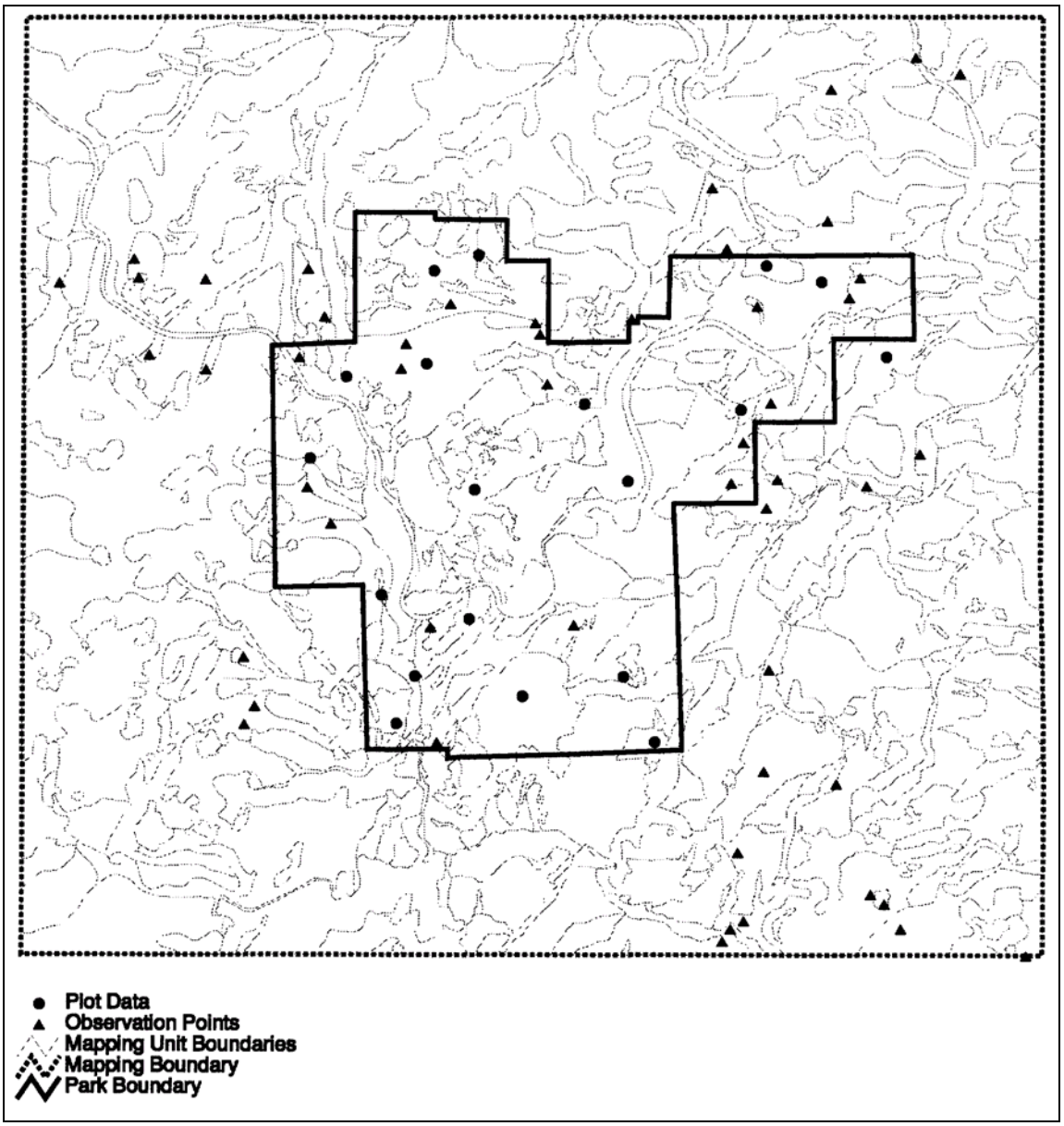

Figure 3. The Location of Observation Points and Plot Data in Mount Rushmore National Memorial

Vegetation Association
Ponderosa Pine / Little Bluestem Woodland
Ponderosa Pine / Bearberry Woodland
Ponderosa Pine / Common Juniper Woodland
Ponderosa Pine / Bur Oak Woodland
Ponderosa Pine / Rough Leafed Rice Grass Woodland
Bur Oak / Ironwood Forest
Paper Birch / Beaked Hazel Forest
Wooly Sedge / Blue Joint Herbaceous Vegetation
Black Hills Rock Outcrop Sparse Vegetation

Table 1. Vegetation Associations Within Mount Rushmore National Memorial.

Air Photo Interpretation

All map classes were interpreted from existing 1:16,000 scale, color photography flown on August 28, 1993. The photographs were acquired from the U.S. Forest Service (USFS). Photointerpretation used the standard identification features such as tone, texture, color, pattern, topographic position, and shadow. In addition, field sample locations and their vegetation descriptions aided in assigning map class to each polygon. All photographs were examined using a stereoscope. Digital elevation models (DEM's) were processed and converted to slope and aspect coverages. These helped to provide additional perspectives of the landscape. Six photographs were interpreted for the entire mapping area. A photointerpretive key is included in the appendix. Digital scans of these photographs are included as .tif files on the CD included with this report.

Map Validation

A field trip was conducted in June of 1997 to assess the initial mapping effort and to refine map classes. This trip included additional 'observation points' (see Vegetation Sampling above). Map classes were modified to reflect inadequacies in the initial photointerpretation.

Digital Files

All digital files were created with a standard format. All files are delivered with a UTM projection, zone 13, and a north American datum of 1983. Attributes and file format for each coverage are as follows:

Vegetation coverage: **moru_veg**

Attributes

Item name		**width**	**output**	**type**	**n. dec**	
map_unit		10	10		C	-
anderson_code		3	5		I	-
height		4	4		I	-
density	4	4		I	-	
pattern	4	4		I	-	
hectares		10	10		N	2

Plot data coverage: **plot_data**

Attributes

Item name	**width**	**output**	**type**	**n. dec**	
plot_no	2	2		N	-
veg_code	14	14		C	-

Verification data coverage: **verif_data**

Attributes

Item name	**width**	**output**	**type**	**n. dec**	
plot_no	14	14		C	-
veg_code	14	14		C	-

Accuracy assessment coverage: **error_pts**

Attributes

Item name	**width**	**output**	**type**	**n. dec**	
veg_code	14	14		C	**-**
map_unit	3	3		C	-

Map Boundary Coverage: **map_boundary**

Attributes

Item name	**width**	**output**	**type**	**n. dec**	
hectares	10	10		N	-

Park Boundary Coverage: **park_boundary**

Attributes

Item name	**width**	**output**	**type**	**n. dec**	
hectares	10	10		N	-

Transfer to Digital Format

The digital products produced specifically for this mapping effort include a digital vegetation polygon coverage with labels and digital point coverages for plot, observation, and accuracy locations.

Photo-interpreted polygons and labels were transferred to a digital format using 'heads-up' digitizing on a digital orthophoto quad (DOQ). This process entails the visual transfer (digitizing) of line and label data directly to the computer screen with the DOQ as a backdrop/base map. A small portion of the eastern part of the mapping area was transferred by projection of the photointerpreted mylar onto a 1:24,000 scale USGS quadrangle using a Salzman vertical reflecting projector. The digital version of the ortho quad was created in-house by scanning and registering the Mount Rushmore and Iron Mountain orthophotographs. These scanned orthophotographs were then joined into one file. The original orthophotograph was produced from 1:80,000 scale aerial photographs taken October 13, 1977. The DOQ produced by this office is included on the CD accompanying this report.

The digital point coverages were created two different methods. 1.) The original plot data collected was done without the benefit of a GPS unit. Plot locations were noted on each photograph and later transferred to a digital file by using the DOQ base map as reference. 2.) Observation points and accuracy assessment points were collected in the field using a GPS unit. These data points were transferred directly from the GPS unit into a digital file and attributed in Arc/Info using the field data sheets as reference for the attribute. Coordinate system descriptions were added after creation of the digital files.

Data Description

Vegetation

Coverage name: **moru_veg**

map_unit: This attribute refers to the vegetation map unit. The vegetation codes and map unit names are listed in Table 2. The map unit names can also be accessed using a lookup table (veg_lut) provided with the digital coverage.

anderson_code: This item refers to the map classification using the Anderson Level II classification. The classification codes and map unit names are listed in Table 3. The map unit names can also be accessed using a lookup table (anderson_lut) provided with the digital coverage.

The height, density, and pattern items are structural descriptions of each vegetation class described under the NVCS. Table 4 describes the structural categories and the codes associated with each. Figure 4 illustrates each category associated with each code.

hectares: This item is simply a numeric figure representing the area covered by each polygon.

Plot Data

Coverage name: **plot_data**

plot_no: This item refers to the number assigned to each plot.

veg_code: This item refers to the association assigned to each plot location. Veg_code and descriptions are listed in Table 5.

map_unit	map unit name	associations included
HB	Bur Oak / Ironwood Forest	• Bur Oak / Ironwood Forest
PJ	Ponderosa Pine / Common Juniper Woodland	• Ponderosa Pine / Common Juniper Woodland
P1	Ponderosa Pine Complex I	• Ponderosa Pine / Little Bluestem Woodland • Ponderosa Pine / Sun Sedge Woodland • Ponderosa Pine / Bearberry Woodland • Ponderosa Pine / Rough Leafed Rice Grass Woodland
P2	Ponderosa Pine Complex II	• Ponderosa Pine / Bur Oak Woodland • Paper Birch / Beaked Hazel Forest

Table 2. Map unit designations and component vegetation associations descriptions for Mount Rushmore National Memorial for NVCS classification system (note: the wet meadow classification surveyed for the accuracy assessment is now included under the Anderson Level II classification)**.**

Verification Data
Coverage name: **verif_data**

plot_no: This item refers to the number assigned to each verification plot.
veg_code: This item refers to the association assigned to each verification plot location.
Veg_code and descriptions are listed in Table 5.

Error Data
Coverage name: **error_pts**

veg_code: This item refers to the vegetation association assigned to each accuracy plot location. Veg_code and descriptions are listed in Table 5.
map_unit: This item refers to the map unit code

Ancillary Data
Coverage name: **map_boundary**

hectares: This item is simply a numeric figure representing the area covered by the mapping area.

Coverage name: **park_boundary**

hectares: This item is simply a numeric figure representing the area covered by the park.

anderson_code	description
11	Residential
12	Commercial and Services
14	Transportation, Communications, and Utilities
21	Cropland and Pasture
53	Reservoirs
62	Nonforested Wetland
75	Strip Mines, Quarries, and Gravel Pits

Table 3. Anderson Level II Codes and Descriptions

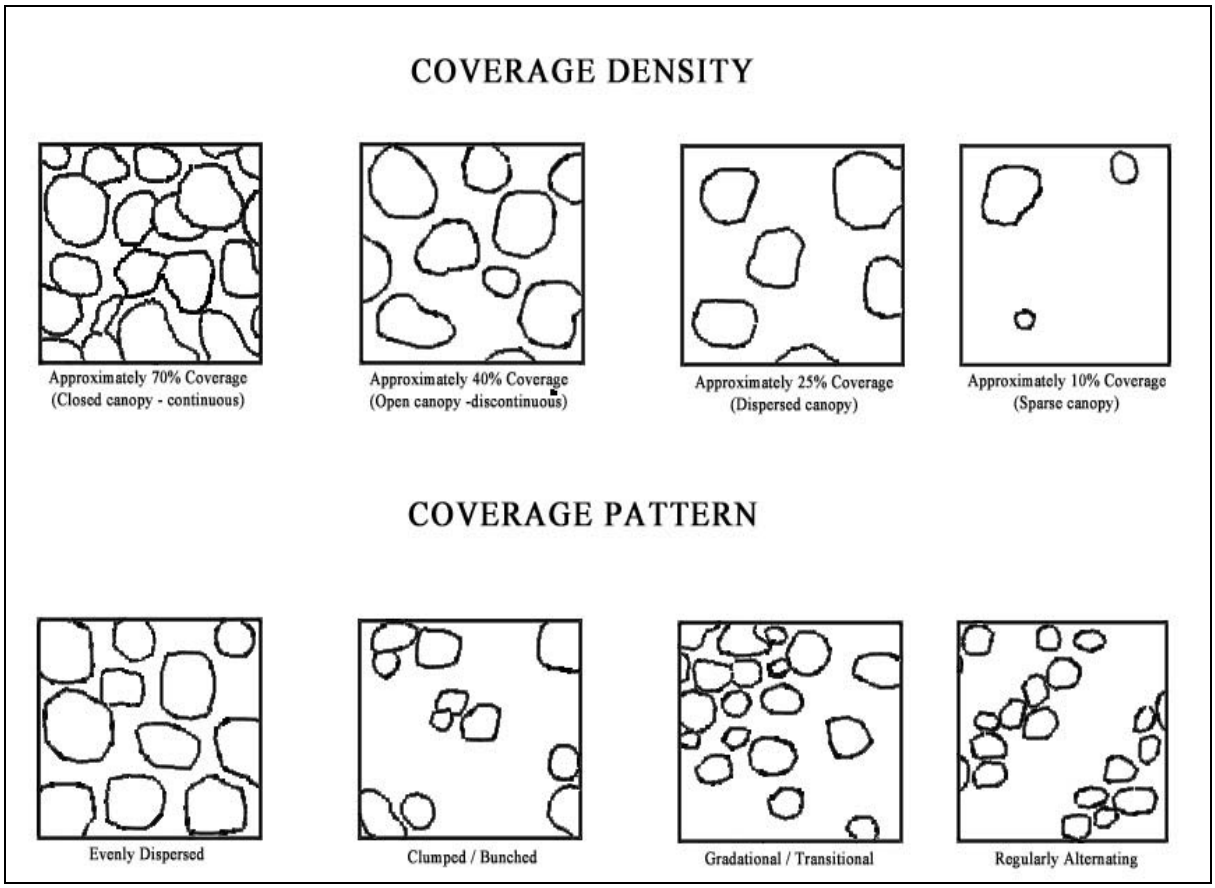

Figure 4. Standard Interpretative Conventions / Structural Categories

Structural Categories	
HEIGHT	
6	> 30 Meters
5	15 - 30 Meters
4	5 - 15 Meters
3	1 - 5 Meters
2	0.5 - 1 Meter
COVERAGE DENSITY	
1	Closed Canopy / Continuous
2	Discontinuous
3	Dispersed
4	Sparse
COVERAGE PATTERNS	
1	Evenly Dispersed
2	Clumped / Bunched
3	Gradational / Transitional
4	Alternating

Table 4. Structural Categories for Vegetation Mapped Using NVCS.

veg_code	description
PB	Ponderosa Pine / Bur Oak Woodland
PL	Ponderosa Pine / Little Bluestem Woodland
PJ	Ponderosa Pine / Common Juniper Woodland
PR	Ponderosa Pine / Rough Leafed Rice Grass Woodland
PS	Ponderosa Pine / Sun Sedge Woodland
PW	Ponderosa Pine / Bearberry Woodland
SS	Stream side Shrubland
HB	Bur Oak / Ironwood Forest
PH	Paper Birch / Beaked Hazel Forest
WM	Wooly Sedge / Blue Joint Herbaceous Vegetation (Wet Meadow)

Table 5. List of Vegetation Code (veg_code) and Vegetation Association Descriptions**.**

Accuracy Assessment

To assess the thematic accuracy of the vegetation map we conducted an accuracy assessment that allows the user of the digital information an additional perspective upon the data. The final product attempts to achieve the 80% per class accuracy required for this product.

Not all mapping units were tested for accuracy. Since the final map contains two separate classification systems (see 'Vegetation Classification'), only the mapped areas that fall under the NVCS were included in the accuracy assessment. Areas such as agricultural and undescribed vegetation units and other areas classified using Anderson Level II classification were eliminated from the sample process.

The remaining areas for sampling were then stratified and sampled according to the number of polygons in each class and the area occupied by each class. Table 6 shows the recommended number of samples per class using a stratified sampling process (*Accuracy Assessment Procedures*, The Nature Conservancy 1994).

Field Procedure: The field crew consisted of two botanists that were not involved in any part of the previous work on the park. This crew either worked together or separately depending upon local conditions. Both botanists were supplied with a list of points to visit, a field key for map class identification, field data forms, and a GPS to navigate to each site (see Plant Association Key and sample field forms attached with TNC report). Both crew members worked "blind',

meaning that neither one was aware of the existing mapped class designations. Upon arriving at each site, the crews scanned a wide area around the immediate location and observed any local variation in the plant associations. Using the key, the crew then assigned a plant association to the accuracy point. In cases where the variation was significant the crew made a "best fit" judgment to the class name. In addition, other associations in the area and those that might be confused with other plant associations were also noted on each field form.

Site Selection: The stratified random selection of accuracy assessment sites was done on the original map classes (see 'Vegetation Classification'). The original map classes, the number of sites selected and the number of sites visited are listed in Table 7.

The x and y coordinates of each accuracy point were derived from the original vegetation coverage. The coverage was gridded into 50 x 50 meter cells using ArcGrid. A 50-meter grid was chosen because it approximates the minimum mapping unit (MMU) for the project. Using a random number generator, we then re-selected the appropriate number of grids/samples from each class and put them into a separate grid. Additional points were selected for each class over the required number to allow the field crew some latitude in case some sites were inaccessible. The reselected cells where then converted into a point coverage. The x and y coordinate for each point was then transferred to an ascii file. This coordinate file was then used by the field team along with a GPS PLGR unit to locate the position in the field. The locations of all accuracy points are shown in Figure 5. The point coverage with the accuracy locations and the assigned map unit code are included as a digital coverage.

Data Analysis and Statistical Methods: Using the data collected we created a contingency matrix to identify the source and magnitude of map errors (Table 8). This mapping effort only evaluates the thematic accuracy of the final product and ignores the positional accuracy. Positional accuracy is assumed to have been met because polygon delineations were transferred to a highly accurate base map. In addition, the lines transferred to the base map are often abstractions and really represent a continuum of change from one plant association to another. The continuum may also be considered an ecotone. These ecotones are not being mapped nor classified.

The statistical methods for the creation of the contingency tables are discussed in *Accuracy Assessment Procedures* (The Nature Conservancy 1994). The statistical parameters are as follows: the overall and individual accuracies are calculated using overall measures of accuracy rather than the Kappa index (Kappa index for overall accuracy is included in the contingency table) The confidence intervals are calculated using a two tailed 90% confidence interval. Accuracy standards for overall or individual class accuracies are assumed to have been met if they fall within the confidence interval.

Scenario	Description	Polygons in class	Area occupied by class	Recommended number of samples in class
A	Abundant. Many polygons that cover a large area	≥ 30	≥ 50 ha	30
B	Relatively abundant. Class has few polygons that cover a large area	< 30	≥ 50 ha	20
C	Relatively rare. Class has many polygons, but covers a small area. Many polygons are close to the MMU.	> 30	< 50 ha	20
D	Rare. Class has few polygons, which may be widely distributed. Most or all polygons are close to the MMU.	≥ 5, ≤ 30	< 50 ha	5
E	Very rare. Class has too few polygons to permit sampling. Polygons are close to the MMU.	< 5	< 50 ha	Visit all and confirm

Table 6. Number of Sites per Class. The recommended sample sizes for the stratified sampling process (MMU = Minimum Mapping Unit) *Accuracy Assessment Procedures* (The Nature Conservancy 1994).

Map Class Name	Number of sites selected for sample	Number of sites actually visited
Ponderosa Pine Complex I	30	32
Ponderosa Pine Complex II	30	35
Ponderosa Pine Common Juniper	30	27
Bur Oak / Ironwood Forest	3	3
Wooly Sedge / Blue Joint Herbaceous Vegetation	5	5

Table 7. List of map classes used during the accuracy assessment.

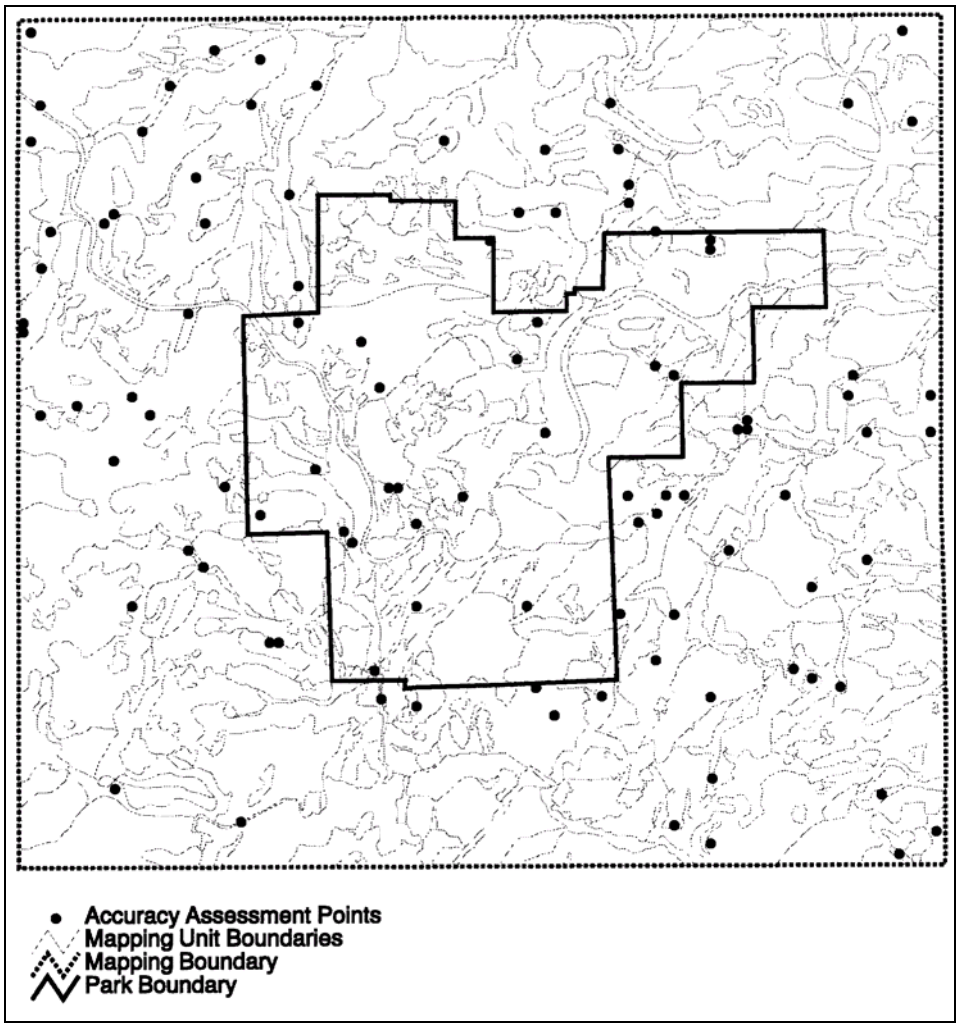

Figure 5. Locations of accuracy assessment points for Mount Rushmore National Memorial

													COMMISSION	CONFIDENCE	
		REFERENCE CLASS											ERROR - %	INTERVAL	
												TOTAL	CORRECT		
C	C		HB	PB	PH	PJ	PL	PR	PW	SS	WM			-	+
L	L	HB	3	0	0	0	0	0	0	0	0	3	100	46.4	100
A	A	PB	0	5	0	0	0	0	0	0	0	5	100	63.1	100
S	S	PH	0	9	15	2	0	0	0	0	3	29	51.7	38.3	64.8
S	S	PJ	0	0	1	19	1	1	5	0	0	27	70.4	55.1	81.1
I		PL	0	0	0	0	0	0	0	0	0	0	0	0	0
F		PR	0	0	0	7	0	3	2	0	0	12	25	9.6	55.8
I		PW	0	0	0	7	2	0	12	0	0	21	57.1	41	71.4
		SS	0	0	0	0	0	0	0	1	0	1	100	10	100
		WM	0	1	0	0	0	0	0	3	1	5	20	2.1	82.4
TOTAL			3	15	16	35	3	4	19	4	4	103			
OMMISSION ERROR - % CORRECT															
% CORRECT			100	33.3	93.8	54.3	0	75	63.2	25	25				
90% CONFIDENCE INTERVAL															
-			46.4	17.1	71.8	41	0	32.1	45.7	2.6	2.6				
+			100	56.9	97.2	66.8	0	92.7	76.8	86.2	86.2				
OVERALL KAPPA ACCURACY = 57.3%															
OVERALL KAPPA INDEX = 47.6%															
OVERALL TOATAL ACCURACY 90% LOWER & UPPER CONFIDENCE INTERVALS: 48.4%, 65.6%															
(OMMISSION & COMMISSION ERRORS CALCULATED USING TOTAL ACCURACY, NOT KAPPA INDEX)															

Abbreviations:

HB	Bur Oak / Ironwood Forest	PL	Ponderosa Pine / Little Bluestem Woodland
PB	Ponderosa Pine / Bur Oak Woodland	PR	Ponderosa Pine / Rough Leafed Rice Grass Woodland
PH	Paper Birch / Beaked Hazel Forest	PW	Ponderosa Pine / Bearberry Woodland
PJ	Ponderosa Pine / Common Juniper Woodland	SS	Stream side Shrubland
		WM	Wooly Sedge / Blue Joint Herbaceous Vegetation (Wet Meadow)

Table 8. Preliminary Contingency Table for Vegetation Accuracy Assessment.

								COMMISSION	CONFIDENCE	
	REFERENCE CLASS							ERROR	INTERVAL	
							TOTAL N	% CORRECT	-	+
		P1	P2	WM	HB	PJ				
	P1	19	0	0	0	13	32	59.4	44.8	72
MAP	P2	0	29	4	0	2	35	82.9	70.8	89.5
CLASS	WM	0	1	4	0	0	5	80	41.6	93.4
	HB	0	0	0	3	0	3	100	46.4	100
	PJ	10	1	0	0	16	27	70.4	55.1	81.1
TOTAL N		29	31	8	3	31	102			
OMISSISION ERROR										
% CORRECT		65.5	93.5	50	100	51.6				
90% CONFIDENCE INTERVAL										
-		50.8	83.4	24	46.4	38.3				
+		77	96.7	76	100	64.6				
OVERALL TOTAL ACCURACY = 69.6%										
OVERALL KAPPA INDEX = 57.9%										
OVERALL TOTAL ACCURACY 90% LOWER & UPPER CONFIDENCE INTERVALS 62.7%, 75.4%										
(OMISSION & COMMISSION ERRORS CALCULATED USING TOTAL ACCURACY, NOT USING KAPPPA INDEX)										

Abbreviations:

P1	Ponderosa Pine Complex 1	WM	Wet Meadow (Carex lanuginosa - Calamagrostis stricta HV
P1	Ponderosa Pine Complex 2	HB	Bur Oak / Ironwood Woodland
		PJ	Ponderosa Pine / Common Juniper Woodland

Table 9. Final Contingency Table for Vegetation Accuracy Assessment

RESULTS

Hectares for all mapping units are summarized in Table 10 for both the entire mapping area and the park itself. The listed codes are described in Tables 2 and 3.

map_unit	anderson_code	Hectares	
		Within Mapping Area	Within Park Boundary
-	11	2.6	0.8
-	12	21.4	3.5
-	14	49.0	22.7
-	31	13.0	0
-	52	6.3	0
-	62	2.7	0.7
-	74	110.4	45.5
-	75	9.0	0
HB	-	7.0	0
P1	-	973.7	220.6
P2	-	186.4	29.5
PJ	-	959.5	199.8
Total		**2341**	**523.1**

Table 10. Hectares of mapping units within the mapping area and within Mount Rushmore National Memorial.

DISCUSSION

During this mapping effort we encountered situations that, in retrospect, we would have approached differently. These include both the initial field work and the photointerpretation. However, this mapping effort gave great insight into the feasibility of mapping to the association level.

Initial field work included the placement of vegetation plots which were used to describe the vegetative associations that exist within Memorial boundaries. These vegetation plots were very time intensive and provided us with a limited perspective of the variation present within the park. During the map validation field trip we used the more rapid observation plots which

allowed us to visit a larger portion of the park during the time allotted. The validation trip provided us with a much greater perspective of the variation and spatial extent of these associations. The information gathered from the second field trip would have benefitted us greatly during the first field trip. Future mapping efforts should begin with a broader and quicker 'look' at the vegetation with observation plots and followed up with vegetation plots.

Problems with the photointerpretation were related to the lack of a firm classification system from which to work. We originally thought we could map to the association level. Therefore, initial photointerpretive classes were the same as the initial vegetation association classes. We thought we could probably separate many classes with similar signatures on some environmental indicator such as soils, slope, aspect, etc. This did not bear out. For example, the distribution of pine types had only very general tendencies for north and south aspects. Consequently, our final mapping units reflected these tendencies. An initial review of preliminary association classes and subsequent combining of classes into realistic map units would prevent a great deal of confusion and frustration.

Of the five final map classes, three exceeded or met the 80% minimum standard for individual class accuracy for errors of either omission or commission. The classes that met the accuracy standards are riparian or wetland classes. The remaining two classes that did not meet the minimum requirement are the two pine classes, Ponderosa Pine Complex I and Ponderosa Pine / Common Juniper Woodland. Photographic signatures for pine types are indistinguishable and what little separation that can be achieved must be made on environmental variables. With the pine types in the Black Hills we have found very little predictability for pine distribution based on environmental variables. That is, pine types will generally occur on all soil types, aspects, and slopes. Elevation range is negligible and was not considered. Nonetheless, we have found some very general tendencies that allow some separation based upon aspect. Ponderosa Pine / Common Juniper Woodlands are mostly found on all aspects except southerly. That is not to say it can not be found on southerly aspects but generally speaking this relationship is true. Ponderosa Pine Complex I is made up of all remaining pine types whose distribution is quite ubiquitous and are always found on all aspects in varying abundance. An examination of Table 8 shows the weak separation between the two classes. These classes may have been combined with others to produce an even higher map accuracy for both individual class accuracy and overall map accuracy. This option was discussed at length with members of the USGS/BRD and NPS staff. Any further combination of classes was rejected due to the significant loss of information. For example, the final classification contained two Ponderosa Pine complexes that showed considerable confusion between the two. Both complexes were below the 80% requirement for individual class accuracy. Combining the two would have created a pine complex with almost 100% accuracy. However, these two pine types also make over 80% of the entire mapping area. We decided to accept the lower individual accuracies for some classes to preserve some detail. Information about the distribution of vegetation associations can still be acquired from the three point coverages delivered with this report. These point coverages can be accessed and queried with most GIS's.

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APPENDICES

Annotated List of Slides

1) Ponderosa Pine / Bearberry Woodland with significant Common Juniper
2) Ponderosa Pine / Bearberry Woodland with significant Common Juniper
3) Ponderosa Pine / Common Juniper Woodland
4) Ponderosa Pine / Common Juniper Woodland
5) Paper Birch / Beaked Hazel Forest
6) Paper Birch / Beaked Hazel Forest
7) Paper Birch / Beaked Hazel Forest, Pine Creek
8) Paper Birch / Beaked Hazel Forest, Pine Creek
9) Paper Birch / Beaked Hazel Forest, unnamed tributary of Grizzly Bear Creek, west of memorial
10) Paper Birch / Beaked Hazel Forest, unnamed tributary of Grizzly Bear Creek, west of memorial
11) Ponderosa Pine / Bur Oak Woodland
12) Aspen Grove adjacent to Old Baldy Mountain
13) View north east from Old Baldy Mountain
14) View of north side of Mt. Rushmore from Old Baldy Mountain
15) View towards The Needles, Custer State Park, from Old Baldy Mountain
16) Ponderosa Pine / Common Juniper Woodland
17) Ponderosa Pine / Common Juniper Woodland
18) Paper Birch / Beaked Hazel Forest
19) Location of vegetation and verification plots
20) Location of accuracy assessment points

Photointerpretive Key to the Map Units for Mount Rushmore National Memorial

1. Tree cover > 10%
    2. Color dark green, topographic position not in valleys/draws
        3. Topographic position on south facing aspect, slopes variable, tree crowns often not completely concealing ground cover.
        Ponderosa Pine Complex I
        3. Topographic position on north facing aspect, slopes variable, tree crowns (canopy and sub-canopy) often completely interlocking, ground cover not usually visible.
        Ponderosa Pine / Common Juniper Woodland
    2. Color light to medium green, topographic position in valleys/draws
        3. **Ponderosa Pine Complex II**
        3. **Bur Oak / Ironwood Forest ***

1. Tree cover < 10%
    4. Ground cover not urban, built up, or actively under agricultural use
        5. Ground cover removed, pits or quarries visible, usually extensive off road use visible
        Barren Land - Strip Mines, Quarries, and Gravel Pits
        5. Ground not cultivated or hayed. Color light green, often mottled, topographic position in basin or draw
        Wetland - Nonforested Wetland

    4. Ground cover urban, built up, or actively under agricultural use
        6. Ground not tilled but grazing evident - native grasses prevail *
        Agricultural Land - Herbaceous Rangeland
        7. Other urban or built-up land
            7. Transportation corridor
            Urban and Build-up Land - Transportation, Communication, and Utilities
            8. Not as above
                9. Buildings present, residential
                Urban and Build-up Land - Residential
                9. Buildings present, commercial and services
                Urban and Build-up Land - Commercial

* Confirmed by site visit