APPENDIX 4.

ACCURACY ASSESSMENT PROCEDURES AND RESULTS

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PURPOSE AND DESCRIPTION OF ACCURACY ASSESSMENT

The purpose of the accuracy assessment is to assess the reliability of the map by identifying representative sites of sufficient, but manageable, size within each remotely-sensed/modeled vegetation map class and independently assessing the vegetation class identity of these sites by field observation. Matches between map class and field call identities for an individual site are considered "correctly" mapped sites. They indicate a correspondence between the mapper's interpretation and a competent field observer's interpretation of vegetation class.

A representative sample of multiple sites is selected and visited in order to derive a point estimate and confidence interval of map class accuracy (or reliability) for each map class and also to indicate patterns of frequent confusion between map classes, for sites that lack correspondence between the mapper's assertion of class and a field observer's assertion of class. User's and producer's (Environmental Systems Research Institute et al. 1994) accuracies are calculated for each class to inform the user as to whether individual error patterns involve commission, omission, or both.

ACCURACY ASSESSMENT METHODS

The accuracy assessment methods and analyses for Shenandoah National Park (SHEN) vegetation mapping followed the current National Park Service program standards (Environmental Systems Research Institute et al. 1994).

Accuracy Assessment Site Selection:

Three modifications were made to adapt the standards to the SHEN project:

Three modifications were made to adapt the standards to the SHEN project:
(1) We modified the number of accuracy assessment (AA) sites to be allocated to each map class (Table 6 of Section 8.2.1.2 of Environmental Systems Research Institute et al. (1994)). We allocated 30 accuracy assessment (AA) sites (sample units) to each map class that occupied more than 50 hectares in total area (scenario "A" of Table 6). A site is a specific location (point) defined by a set of x (easting) and y (northing) coordinates. For map classes with 50 hectares or less of total area, we allocated AA sites equal to the total map class area (in hectares) divided by 1.67. This formula allocates sites (sample units) per map class at the same ratio as the 30 site per 50 hectares requirement (Environmental Systems Research Institute et al. 1994). The map class area was calculated prior to buffering for field positioning error although the buffered areas of a map class were not considered for site placement. Buffering for field positioning error, means that land area near the edge of each polygon is not available for AA site placement. This ensures that when AA sites are located using GPS in the field that the entire AA site will fall within the correct polygon, even if the site center point falls at the edge of the area available for AA site placement, and/or there is GPS error. In the cases of very small map classes, the entire polygon was available for accuracy assessment site placement, however the requirement of sampling without replacement was used, and the AA crew was instructed on how to orient their plot (s) to fit within the polygon being assessed. This allowed

observers to keep individual AA site observations independent. In some cases the mapped area for a particular map class were fragmented into greater than 30 polygons. In such cases we did not allocate additional sites to some map classes in order to account for the fragmentation. (eg, less than 50 hectares total area, but more than 30 polygons – scenario "B" of Table 6).

(2) We used a 0.5 hectare observation area (usually a circular plot, 40 meters in radius), centered around each AA site (point) for large patch or matrix-forming map classes (Table 1). For small patch and linear map classes, a 0.25 hectare observation area (usually a circular plot, 30 meters in radius) was used (Table 1). The area reduction from the normative 0.5 hectare observation area (Environmental Systems Research Institute et al. 1994) was necessary in order to accommodate multiple AA observation plots within stands mapped as small or narrow polygons. It was also justified because it is often desirable for the minimum mapping unit to vary in size by class (Environmental Systems Research Institute et al. 1994). Finally, the vegetation representing most of these map classes are primarily nonvascular and herbaceous vegetation, in which smaller observation areas can capture an adequate number of attributes to establish class (vegetation type).

(3) We did not use the polygon level stratification suggested by in Figure (Table 6 of Section 8.2.1.2 of Environmental Systems Research Institute et al. 1994). AA sites were allocated by simple random sampling within each map class (as reduced due to buffering for access and field positioning error – see below).

Table 1. Accuracy Assessment observation area size and results of access buffer application for individual SHEN map classes.

Vegetation Identifier	Map Class	Map Class Observation Area Size (hectares)	Map Class Access Buffer in meters [1]	Percentile of Map Class Considered [2]
CEGL002591	122	0.25	300	51.1%
CEGL008536	301	0.25	250	88.1%
CEGL003939	302	0.25	250	92.4%
CEGL008508	303	0.25	250	100.0%
CEGL008504	304	0.25	250	100.0%
CEGL003683	305	0.25	250	100.0%
CEGL008529	306	0.25	300	68.1%
CEGL006037	307	0.25	250	72.0%
CEGL008540	308	0.25	300	77.7%
CEGL004142	309	0.25	250	65.8%
CEGL004143	310	0.25	300	62.5%
CEGL006249	401	0.25	250	100.0%
n.a.	992	0.25	250	81.2%
CEGL008502	107	0.50	250	71.6%
CEGL006255	111	0.50	250	87.9%
CEGL004996	101	0.50	250	68.4%
CEGL006565	102	0.50	300	52.6%
CEGL006299	103	0.50	250	51.5%
CEGL008521	104	0.50	300	53.7%
CEGL006057	105	0.50	300	56.4%
CEGL006109	108	0.50	300	55.5%
CEGL008506	109	0.50	250	76.7%
CEGL007710	110	0.50	250	76.8%
CEGL006304	112	0.50	300	58.5%
CEGL007220	113	0.50	250	65.5%
CEGL008528	114	0.50	250	53.5%
CEGL006237	115	0.50	250	51.0%
CEGL008518	116	0.50	250	54.4%
CEGL008516	117	0.50	250	63.1%
CEGL008515	118	0.50	250	75.0%
CEGL008514	119	0.50	250	53.2%
CEGL006599	121	0.50	250	56.0%
CEGL008523	123	0.50	250	63.3%
CEGL008512	124	0.50	300	57.9%
n.a.	991	0.50	250	63.1%

[1] Buffer distance from road or trail that was applied to the map class to constrain sampling to more accessible areas.
[2] Resulting percentile of entire map class area at SHEN that was considered for sampling, using the buffer distance applied (250 or 300 meters).

To prepare the mapping units (polygons) for site selection:

First, the raster file representing the vegetation map was converted to a polygon (shape) file, suitable for geoprocessing and buffering.

To calculate the number of sites for each map class:

(1) Using ArcView ® 3.2 ((Environmental Systems Research Institute 1991), we measured the total area of each map class, by summing all individual polygon areas.
(2) We assigned 30 AA sites per 1.67 hectares of the map class total area, up to a maximum allocation of 30 AA plots per map class.
We assigned numbers of AA sites per map class on the basis of total map class area (we did not subtract the areas within each map class that was subsequently eliminated from consideration for site assignments, due to the needs of (1) buffering for field navigation/positioning error and of (2) access convenience (see below)).

We used ArcView ® 3.2 geoprocessing wizard to prepare the sampling population for each map class, as follows:

Cost surface (access buffer): Although about 98% of the area of SHEN is within 600 meters of a road or a trail, road and trail travel is often time-consuming due to the size and length of the park, and off-trail travel is often arduous and time-consuming due to steep and rocky slopes and thick vegetation. In order to collect a sufficient sample size within a field season at reasonable cost, areas to be considered for sampling were limited to more accessible sites. Prior experience indicated that restricting travel to within 250 meters of a road or trail would allow reasonable progress (approximately, 8 sites per field team per day). However, for purposes of map class representativeness, we also wanted to ensure that our sampling population covered a reasonably large percentage of each map class and also that no individual map classes were underrepresented. Vegetation types that typically occur on steep middle slopes would tend to occur away from where roads and trails are routed, whereas some vegetation types tend to occur along routes selected for trail access (eg, riparian vegetation) or road access (eg, high elevation vegetation near the Skyline Drive).

(1) Using the roads and trails line theme from the NPS database for SHEN [http://www.nps.gov/gis], we created a buffer theme consisting of 12 progressively more remote areas buffered from any road or trail, with buffers in increments of 50 meter distances. This produced a polygon theme with map classes consisting of areas within 50 meters of a road or trail, from 50 to 100 meters from a road or trail, from 100 to 150 meters from a road or trail, etc., up to from 550 to 600 meters from a road or trail.

(2) We created a union of this theme and the vegetation theme, so that each vegetation map class was divided into 12 classes, each represented that portion that occurred within each 50 meter buffer increments, and a 13th class that represented that

portion that was more remote than 600 meters (600 to 2000 meters) from a road or trail. This theme had fields of buffer distance and vegetation type (map class).

(3) We imported the attribute (.dbf) table from this union theme into Microsoft Excel ®. We created a pivot table of the buffer distance class membership (in columns) against the vegetation class membership (in rows), and the cell values the sum of the total map areas for each combination of these vegetation classes and buffer distance classes. The cell values were first converted to a percentage of the [row] total for each vegetation class. These percentages were converted to cumulative percentiles (beginning with buffer distance class of 0 to 50 meters) of the vegetation class that occurred within each buffer distance class or all less remote buffer distance classes.

(4) In order to ensure that, minimally, the most accessible 50th percentile of each vegetation map class would be included in the sampling population, we found that a 250 meter buffer would satisfy this condition for 29 of the 35 vegetation map classes and that a 300 meter buffer would satisfy this condition for the other six vegetation map classes. We designated a 300 meter buffer to be used to constrain sampling for these six classes plus four additional classes that were limited in overall area and would be further reduced in area by edge buffering. Most of these classes represented small patch types that, in total, would receive a very small proportion of all AA sites. A 250 meter buffer was designated for all other (25) vegetation map classes. The percentiles considered for each vegetation map class ranged from 51% to 100% (Table 1). Approximately 56% of the area of SHEN occurs within 250 meters of a road or a trail, while about 65% occurs within 300 meters of at least one of these features.

A minimum buffer distance from the edge of all polygons is needed in order to ensure that global positioning system (GPS) navigation and positional recording area does not create uncertainty about the map class membership of individual AA sites.

(1) We created a 40 meter buffer inside the boundary of all polygons.

(2) We created a union theme of the original map classes and this buffer theme.

(3) We selected the portions of all polygons that were within the 40 meter buffer and deleted
them from this union theme. The result of this geoprocessing step was a polygon theme (sampling population) that was comprised of the interiors of all polygons (all areas more than 40 meters from a boundary with a different map class). This buffer was to be applied to all map classes of sufficient abundance, and with polygons of sufficient size to be observed in the field at the scale of 0.5 hectare.

(4) We repeated the above process using a 30 meter buffer. The result of this geoprocessing step was a polygon theme (sampling population) that was comprised of the interiors of all polygons (all areas more than 30 meters from a boundary with a different map class). This buffer was to be applied to all map classes to be observed

in the field at the scale of 0.25 hectare. This narrower 30 meter buffer was required to allow AA sampling in map classes represented by polygons too small or narrow to be observed at the 0.5 hectare level.

To apply the appropriate access buffer to these edge buffer themes:

We created (1) a buffer theme of all SHEN areas within 300 meters of any road or trail and (2) a buffer theme of all SHEN areas within 250 meters of any road or trail.

To create the final inference area (sampling population) for each individual vegetation map class:

We used the intersection (geoprocessing) command was used with each combination of the two road/trail access buffer themes (250 meters and 300 meters) with each vegetation polygon edge buffer theme (30 meters and 40 meters) to create four themes representing the sampling population to be applied to the vegetation map classes. The third and fourth columns of Table 1 list which combination of access and polygon edge buffer distance was used for each map class.

To select individual AA sites from the map:

(1) Using the appropriate inference area for each map class (Table 1), individual AA sites (plot centers) were located by allocating the specified number of points for each map class to the modified union theme derived from the operations above, using the "Select Random Features" function in the National Park Service Alaskapak tools package for ArcView® 3.2 (National Park Service 2002). This achieves the method of simple random sampling within each map class, which is appropriate for the statistical analysis of Environmental Systems Research Institute et al. (1994).

(2) When two or more AA sites were near enough to one another to produce overlapping observation areas (ie, within 80 meters of one another for classes to be observed at the 0.5 hectare scale or within 60 meters of one another for classes to be observed at the 0.25 hectare scale), one site at a time was selected randomly (using the random numbers function in Microsoft® Excel) and deleted. A replacement site was generated for each site so deleted, using the "Select Random Features" function (as above). If the replacement site were near enough to a previously located site, so as to produce overlapping observation areas (as above), it was rejected, and the process repeated, until either (1) the full complement of sites for the map class was assigned or (2) it was determined that the map class was saturated (could accommodate no more sites without observation area overlap between one or more AA plots).

Accuracy Assessment Field Methods:
We employed three teams (of one to two persons) to conduct the accuracy assessment. At least one person on each team was required to be familiar with all plant species mentioned in the field key and similar species (potential "look-alikes" that might cause erroneous key decisions).

Immediately prior to the accuracy assessment, teams were trained in the field at SHEN in order to calibrate the individual teams' interpretation of field key, cover estimates, species identification, and field observation methods. Accuracy assessment field observations were conducted from June 1 to September 30, 2008.

The site locations and unique identifiers were loaded into Garmin® 76CSX or Garmin® 76S global positioning system (GPS) units. Teams navigated to each assigned site (plot center), usually in a sequence of proximity.

The teams were not informed as to location of the map boundaries. Revealing map class boundaries can introduce biases in the field calls. Where multiple sites occur within the same polygon of a map class, field observers (knowing this) may be influenced toward making calls so that the multiple sites coincide). Similarly, where sites occur in adjoining polygons, observers (seeing the map class change) may be influenced toward making different calls.

Field keys are designed to work in observation areas of relatively homogeneous (ecologically and floristically) stands of vegetation. While gradual transition zones within the observed area are acceptable (to test the key across the full gradient of described types), sharp boundaries with two or more very different vegetation types (eg, natural/semi-natural versus cultural vegetation, vegetation versus non-vegetated land cover, forests versus non-forested types, or wetlands versus uplands) occurring in the observation area often will yield spurious key results and should be avoided. It is possible for such sharp transitions to occur within an area mapped as a single class (an error of omission). To mitigate this situation, field crews were instructed to assess whether one of more such boundary occurred within the circular (0.5 or 0.25 hectare) observation area. The general criteria for recognizing a boundary was a transition at the Formation level of the National Vegetation Classification (Federal Geographic Data Committee 1997); transitions between different alliances or associations within same Formation are generally too subtle for an observer to reliably and precisely locate on the ground; such boundaries are usually best ignored and the vegetation keyed in place.

If a sharp (Formation or higher) vegetation boundary were detected in the observation area from the AA site center point, the observer decided what vegetation type occupied the majority of the observation area. (Figure 1A). The plot center was then moved the minimal distance into the majority type along a path perpendicular to an imaginary line tangent to the ecological boundary between the most abundant type and all other types, until one association appeared to dominate the plot (Figures 1B and IC). At this point, the observer stopped and evaluated a circular observation area of 18 meters radius (0.5 ha) from this new position.

If, while moving the plot center, a new ecological boundary appeared on another side of the circular plot, the observer stopped and attempted to implement the second option , a 0.5 hectare (50 x 100 meter) rectangular observation plot (Figure 2A).

To implement a rectangular plot, the observer located the point in the majority vegetation type along the path attempted above that is equidistant between the original boundary detected and the second boundary encountered when trying to move the circular plot (Figure 2A). From this position, a 50 meter x 100 meter rectangular plot (for a 0.5 hectare site) or a 36 meter x 70 meter rectangular plot (for a 0.25 hectare site), with its short axis along the perpendicular path described above and centered on this point, was attempted (Figure 2B). If the plot was reasonably homogeneous as to NVC Association, the field call was made from this [first choice] rectangular plot. If a sharp vegetation boundary, as described above, still existed in the first choice of dimensions for a rectangular plot, so that the area was not homogeneous , the plot was rotated around the center point, and/ or slightly shifted horizontally until the plot was homogeneous (Figure 2B,C). If rotating the plot and/or implementing a slight horizontal shift did nor produce a homogeneous observation area, a 40 meter x 125 meter plot (for a 0.5 hectare site) or a 25 meter x 100 meter rectangular plot (for a 0.25 hectare site)was attempted. If the 20 meter x 50 meter plot failed to produce internal homogeneity, a 10 meter x 100 meter plot was attempted. If the 10 meter x 100 meter plot failed to produce homogeneity, data from the site were not recorded.

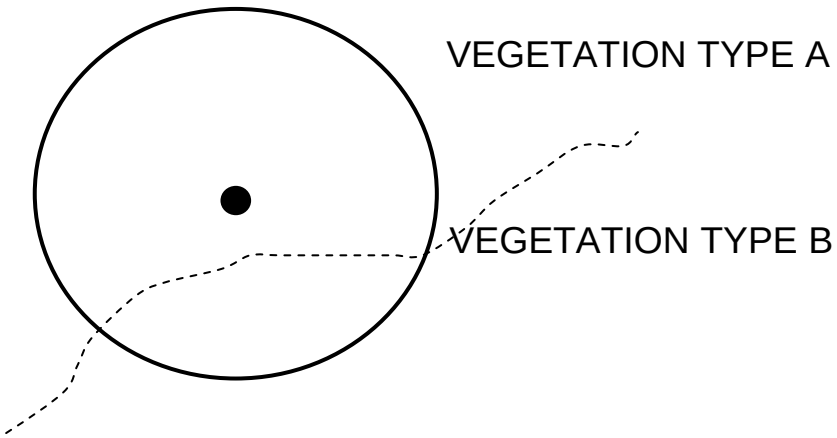

Figure 1A. Initial waypoint (black dot) places observation area (solid circle) across two different vegetation types (A and B). The distinguishable boundary between the types is estimated by the dashed line, and Vegetation Type A is determined to be the majority type in the initially attempted observation area.

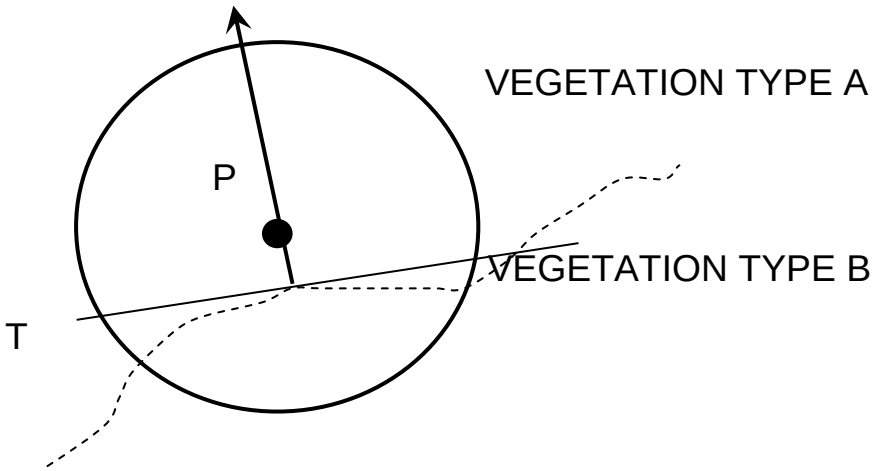

Figure 1B. A line (T), approximately tangent to the portion of the boundary that falls within this initially attempted observation area, is visualized. A line (P) from the point along this line to the center point of the initially attempted observation area (perpendicular to T) is visualized.

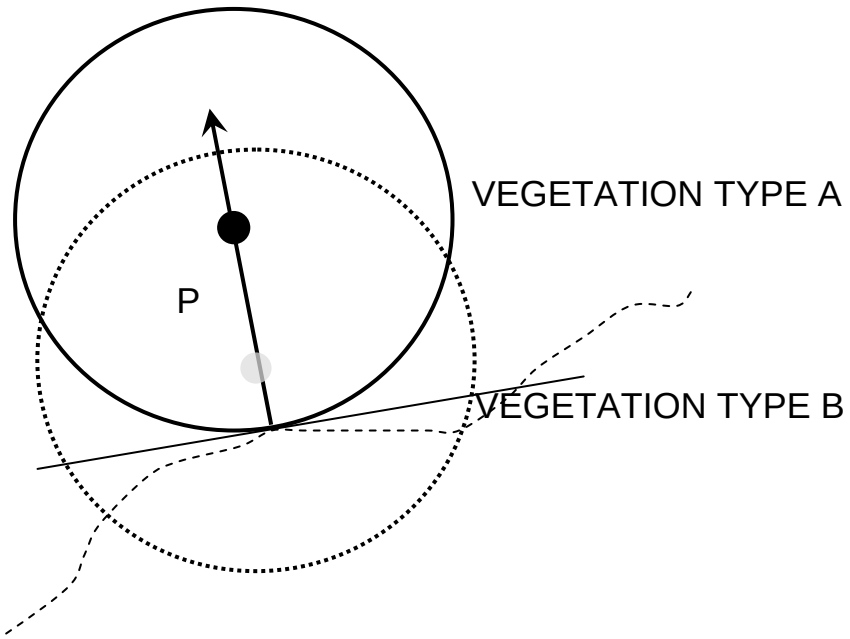

Figure 1C. The observation area center is moved from the original waypoint along P a minimal distance (always < radius of observation plot, if only two types are involved), until the observation area includes only Vegetation Type A (ie, stop when the edge of the new observation area reaches the vegetation boundary). The dashed circle and gray center dot represent the initial observation area. The vegetation is evaluated within the solid circle, with the solid back dot the new center point.

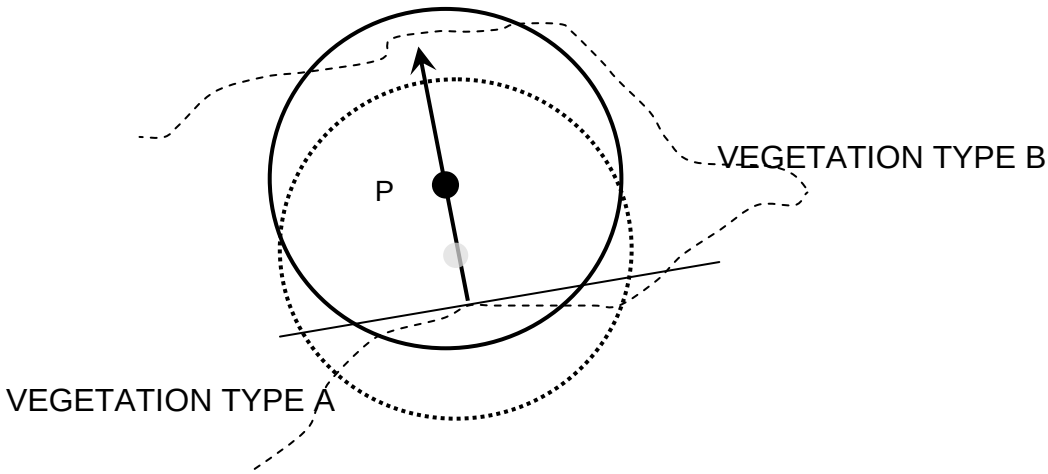

Figure 2A. As with 1A, the initial waypoint (gray dot) places initially attempted observation area (dashed circle) across two different vegetation types (A and B). However, moving the waypoint along line P makes the new observation area encroach back into Vegetation Type B. Stop where the “new” waypoint (black dot) is midway between these boundaries.

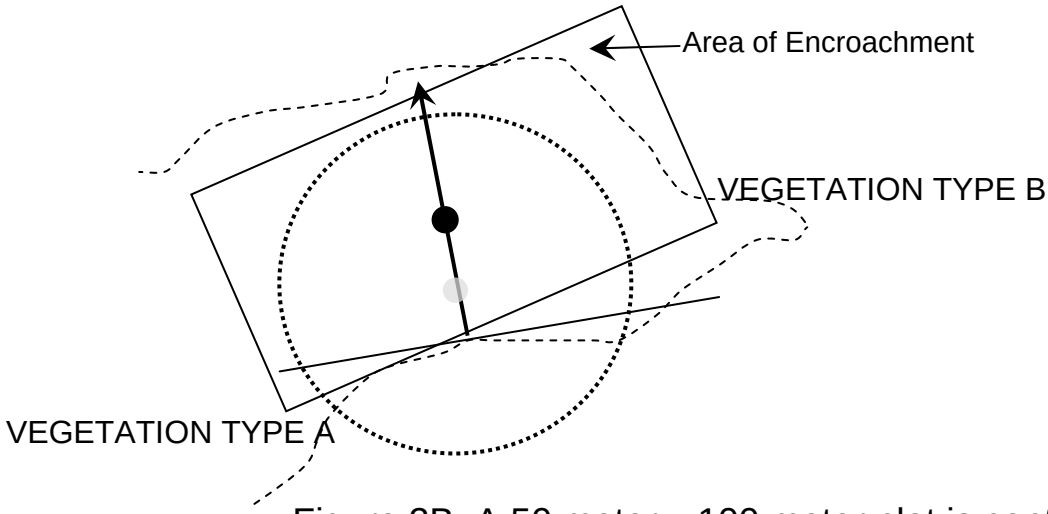

Figure 2B. A 50 meter x 100 meter plot is centered on the new waypoint (and rotated as needed to fall within Vegetation Type A). In this case, the rectangular configuration still leaves encroachment of the observation area into Vegetation Type B.

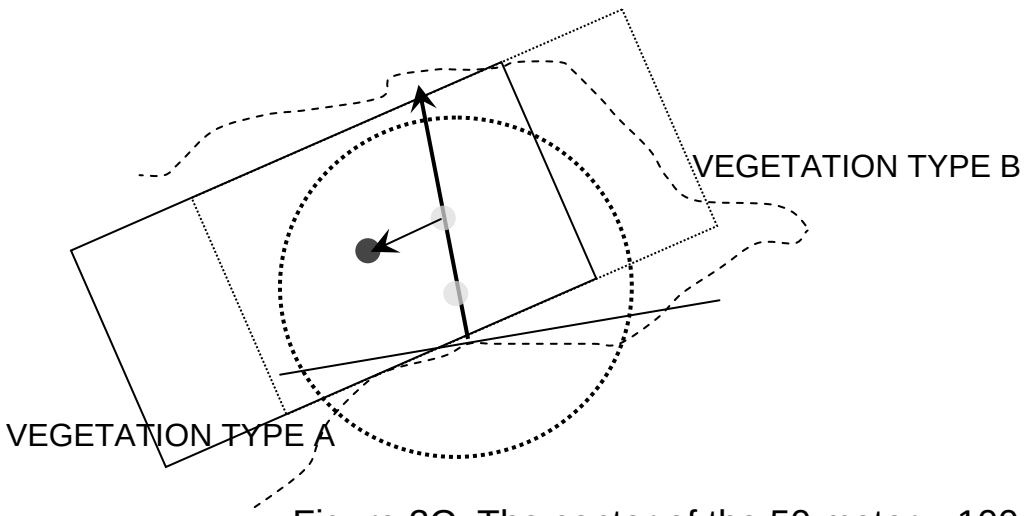

Figure 2C. The center of the 50 meter x 100 meter plot is moved (represented by the arrow) a minimal distance into Vegetation Type A, so that the observation area is entirely within Vegetation Type A.

ACCURACY ASSESSMENT RESULTS

We generated a sample size total of 779 AA sites (among all map classes tested). Because of field time and logistical constraints, field observers collected data from plots representing 703 of these sites. Since a reasonably large complement of sites were visited for every map class, this sample size was considered adequate.

We created the misclassification matrix (contingency table) (Environmental Systems Research Institute et al. 1994) as follows:

(1) We converted the field position (GPS) data to a point theme in ArcView ® 3.2, and each point attributed with the vegetation field call and the positioning (GPS) error recorded on the forms.

(2) We spatially joined this point theme to the SHEN vegetation class (polygon theme) to produce a joined theme with fields representing both the vegetation class of the site as identity of the site as identified in the field (from the point theme) and the identity of the site as the mapper identified it (from the polygon theme).

(3) We exported the table derived from the joined file to Microsoft ® Excel 2002. A pivot table representing a misclassification matrix (contingency table) was created in Excel, with the table columns representing the field calls, the table rows representing map classes (in the same order for rows and columns), and the cell totals representing the total number of plots for each possible combination of map class assignment and field class assignment. We calculated point estimates for User's (1 – commission error rate) and producer's (1 – omission error rate) accuracy rates (Environmental Systems Research Institute et al. 1994) for each map and field class by dividing the number of sites with matching map class and field calls (ie., each cell along the contingency table diagonal) by the (row) total number of sites assigned to that map class (for user's accuracy) or the (column) total number of sites in which that class was identified in the field (for producer's accuracy). We calculated 90% confidence intervals for these point estimates, using the formulas of Environmental Systems Research Institute et al. (1994):

90% C. I. =

$$\hat{p} \pm \left\{ z_{\alpha} \sqrt{\frac{\hat{p}(1-\hat{p})}{n}} + \frac{1}{(2n)} \right\}$$

where p^ = the point estimate of accuracy (of a map class or a field call class), z_{α} = the value of the z distribution statistic at the alpha level selected for a confidence interval (a two-sided 90% (α = 0.1) confidence interval (= 1.645) was used for all classes), and n = the total number of sites (in the map class or in the field call sample).

The overall [project] accuracy rate was computed as the total number of plots with matches in field calls and map classes divided by the total number of plots (this accuracy

rate is a "pooled" total, rather than an average accuracy by map class). A kappa (κ) index (Foody, 1992) was calculated for the overall accuracy. The overall accuracy of the SHEN vegetation map at the National Vegetation Classification level of Association is 48.9% (κ=47.0%) (Table 2).

We used Appendix H of the version 2 of the National Vegetation Classification standard (Federal Geographic Data Committee 2008) to aggregate association level map classes to provisional Group and MacroGroup map classes (Alliance level accuracy and resolution is similar to that of the Association level) Tables 3 and 4 are contingency tables showing these results. The overall accuracy of the SHEN vegetation map at the National Vegetation Classification level of Group is 56.5% (κ=51.1%) (Table 3), and at MacroGroup is 70.6% (κ=57.9%) (Table 4).

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TABLE 2. Confusion matrix (contingency table) for association-level map classes, Shenandoah National Park.

MAP CLASS NAME	MAP CLASS #:	124	110	115	114	109	304	107	116	117	119	104	112	111	113	121	118	123	105	103	102	309	310	108	991	101	122	308	302	303	301	305	307	306	401	992	TOTAL	USER'S ACCURACY POINT ESTIMATE	90% CONF. INTERVAL (LOWER)	90% CONF. INTERVAL (UPPER)
Central Appalachian Acidic Cove Forest	124	10										1	3			1	1	2		2				9													29	34.5%	21.7%	50.7%
Southern Appalachian Cove Forest	110		17		1								2		2	3																					25	68.0%	54.7%	85.3%
Central Appalachian Rich Cove Forest	115			19	1				4				1			4									1												30	63.3%	50.5%	79.5%
Central Appalachian Basic Boulderfield Forest	114		2		2	1		3	9							4			6																		27	7.4%	1.0%	17.6%
Northern Red Oak Forest	109					26		1	1							2																					30	86.7%	78.1%	98.5%
Central Appalachian High-Elevation Boulderfield Forest	304						5	2																													7	71.4%	50.5%	106.7%
Central Appalachian Northern Hardwood Forest	107			1		6	1	20																	1												29	69.0%	56.6%	84.8%
Central Appalachian Montane Oak - Hickory Forest (Basic Type)	116		1	1		4			16							3			2						1												28	57.1%	43.5%	74.3%
Central Appalachian Montane Oak - Hickory Forest (Acidic Type)	117									7	2					2		4	2	1					7												25	28.0%	15.2%	44.8%
Central Appalachian Basic Oak - Hickory Forest	119		4						2	1	10		3			2		2	4							1						1					30	33.3%	20.8%	49.2%
Mixed Oak / Heath Forest	104											11					9	4		2																	26	42.3%	28.3%	60.2%
Central Appalachian Acidic Cove Forest (White Pine - Mixed Hardwoods Type)	112	4	4										7	1		3	3		2	1							1										26	26.9%	14.5%	43.2%
Northern Blue Ridge Montane Alluvial Forest	111		1										7	4	3	12									2												29	13.8%	5.0%	26.1%
Successional Tuliptree Forest	113	1	6										5		13	4																					29	44.8%	31.4%	61.7%
Northeastern Modified Successional Forest	121		3			1										18									6												28	64.3%	51.2%	81.0%
Central Appalachian Acidic Oak - Hickory Forest	118		1								1	3	2		1	1	10	1		4					1		1	1									27	37.0%	23.6%	54.2%
Central Appalachian Dry Chestnut Oak - Northern Red Oak / Heath Forest	123									5	1							4	6	7						1											24	16.7%	6.2%	31.3%
Central Appalachian Dry-Mesic Chestnut Oak - Northern Red Oak Forest	105	2	1								1		1						9	4	1					1											20	45.0%	29.2%	65.8%
Central Appalachian / Northern Piedmont Low-Elevation Chestnut Oak Forest	103	1								1		1						1		16						8											28	57.1%	43.5%	74.3%
Chestnut Oak - Black Birch Wooded Talus Slope	102															1		2	5	5	7				3	1											24	29.2%	16.0%	46.5%
Central Appalachian Acidic Boulderfield	309																				1	9				2											12	75.0%	58.6%	99.7%
Central Appalachian Mafic Boulderfield	310																														1						1	0.0%	0.0%	50.0%
Hemlock - Northern Hardwood Forest	108			1		3										1				4				17		1											27	63.0%	49.5%	80.1%
Forests with > 75% canopy mortality	991				2	1												1	2	2					10	1						5	1				25	40.0%	25.9%	58.1%
Central Appalachian Pine - Oak / Heath Woodland	101					1												1		3	1	2				19		1									28	67.9%	55.1%	84.2%
Virginia Pine Successional Forest	122									1						9		1	2																		13	0.0%	0.0%	3.8%
Central Appalachian Xeric Chestnut Oak - Virginia Pine Woodland	308																									5		1									6	16.7%	0.0%	50.0%
Central Appalachian Heath Barrens	302																												2								2	100.0%	100.0%	100.0%
High-Elevation Outcrop Barren	303																													4							4	100.0%	100.0%	100.0%
High-Elevation Greenstone Barren	301																											1			2	2	1				6	33.3%	10.0%	73.3%
Central Appalachian Basic Woodland	305										1										1											12		1			15	80.0%	66.3%	100.0%
Central Appalachian Circumneutral Barren	307																															3	2				5	40.0%	14.0%	86.0%
Central Appalachian Mafic Barren	306																																	1			1	100.0%	100.0%	100.0%
Northern Blue Ridge Mafic Fen	401																																		4	3	7	57.1%	33.5%	95.1%
Anthropogenic Meadows	992																																			30	30	100.0%	100.0%	100.0%
TOTALS:		18	40	22	6	43	6	26	32	15	16	16	31	5	19	70	23	23	40	51	11	11	0	26	32	40	2	4	2	4	3	23	4	2	4	33	703			
PRODUCER'S ACCURACY: POINT ESTIMATE		55.6%	42.5%	86.4%	33.3%	60.5%	83.3%	76.9%	50.0%	46.7%	62.5%	68.8%	22.6%	80.0%	68.4%	25.7%	43.5%	17.4%	22.5%	31.4%	63.6%	81.8%	N/A	65.4%	31.3%	47.5%	0.0%	25.0%	100.0%	100.0%	66.7%	52.2%	50.0%	50.0%	100.0%	90.9%		OVERALL (POOLED) ACCURACY:		
PRODUCER'S ACCURACY: 90% CONF. INTERVAL (LOWER)		39.1%	30.9%	76.6%	10.0%	49.4%	66.6%	65.3%	37.0%	28.8%	45.7%	52.8%	11.8%	60.6%	53.5%	17.8%	28.6%	6.6%	12.9%	21.7%	44.3%	67.2%	N/A	52.0%	19.3%	35.8%	0.0%	1.9%	100.0%	100.0%	38.6%	37.2%	21.4%	16.8%	100.0%	84.2%		48.9%	45.9%	52.1%
PRODUCER'S ACCURACY: 90% CONF. INTERVAL (UPPER)		61.1%	45.0%	90.9%	50.0%	62.8%	100.0%	80.8%	53.1%	53.3%	68.8%	75.0%	25.8%	100.0%	73.7%	27.1%	47.8%	21.7%	25.0%	33.3%	72.7%	90.9%	N/A	69.2%	34.4%	50.0%	25.0%	50.0%	100.0%	100.0%	100.0%	56.5%	75.0%	100.0%	100.0%	93.9%		K = 47.0%		

TABLE 3. Confusion matrix (contingency table) for Group-level map classes (Federal Geographic Data Committee 2008, Appendix H), Shenandoah National Park.
* - alliance not included in Appendix H; presumed to be distinct Group. **- Cultural Vegetation SubGroup

MAP CLASS NAME	Appalachian Mesophytic Montane Forest Group	Beech - Maple - Birch - Basswood Forest Group	White Oak - Red Oak - Black Oak Forest and Woodland Group	White Pine - Red Pine - Oak Forest and Woodland Group	Hackberry - Green Ash - Silver Maple Floodplain Group	Northern and Central Hardwood and Conifer Ruderal Forest Group	Chestnut Oak - American Chestnut Forest Group	*Lasallia (papulosa, pensylvanica)* Nonvascular Alliance*	Eastern Pine - Hemlock - Hardwood Forest Group	Forests with > 75% canopy mortality*	Pitch Pine - Virginia Pine - Oak Forest and Woodland Group	*Kalmia latifolia - Gaylussacia baccata* Shrubland Alliance*	*Saxifraga michauxii* Herbaceous Alliance*	Chinquapin Oak - Ash - Red Cedar Alkaline Forest Group	*(Fraxinus americana, Juniperus virginiana) / Carex pensylvanica - Schizachyrium scoparium* Wooded Herbaceous Alliance*	*Alnus serrulata - Spiraea* spp. / *Sanguisorba canadensis* Saturated Shrub Herbaceous Alliance*	Cool-season Lawn**	TOTAL	USER'S ACCURACY: POINT ESTIMATE	90% CONF. INTERVAL (LOWER)	90% CONF. INTERVAL (UPPER)
Appalachian Mesophytic Montane Forest Group	**27**	1	1	5		6	5		9									*54*	50.0%	39.7%	62.1%
Beech - Maple - Birch - Basswood Forest Group	2	**54**	20	1		10	6			1								*94*	57.4%	49.6%	66.4%
White Oak - Red Oak - Black Oak Forest and Woodland Group	5	13	**69**	3		7	30			9	1			1				*138*	50.0%	43.4%	57.4%
White Pine - Red Pine - Oak Forest and Woodland Group	8			**7**	1	3	6				1							*26*	26.9%	14.5%	43.2%
Hackberry - Green Ash - Silver Maple Floodplain Group	1			7	**4**	15				2								*29*	13.8%	5.0%	26.1%
Northern and Central Hardwood and Conifer Ruderal Forest Group	10	1		5		**35**				6								*57*	61.4%	51.7%	72.9%
Chestnut Oak - American Chestnut Forest Group	5		13	3		3	**82**			4	13							*123*	66.7%	60.1%	74.1%
Lasallia (papulosa, pensylvanica) Nonvascular Alliance*							1	**9**			2		1					*13*	69.2%	52.0%	94.1%
Eastern Pine - Hemlock - Hardwood Forest Group		4				1	4		**17**		1							*27*	63.0%	49.5%	80.1%
Forests with > 75% canopy mortality*		3					5			**10**	1			5	1			*25*	40.0%	25.9%	58.1%
Pitch Pine - Virginia Pine - Oak Forest and Woodland Group		1	1			9	8	2			**26**							*47*	55.3%	44.5%	68.3%
Kalmia latifolia - Gaylussacia baccata Shrubland Alliance*												**6**						*6*	100.0%	100.0%	100.0%
Saxifraga michauxii Herbaceous Alliance*											1		**2**	2	1			*6*	33.3%	10.0%	73.3%
Chinquapin Oak - Ash - Red Cedar Alkaline Forest Group			1				1							**12**	1			*15*	80.0%	66.3%	100.0%
(Fraxinus americana, Juniperus virginiana) / Carex pensylvanica - Schizachyrium scoparium Wooded Herbaceous Alliance*														3	**3**			*6*	50.0%	24.8%	91.9%
Alnus serrulata - Spiraea spp. / *Sanguisorba canadensis* Saturated Shrub Herbaceous Alliance*																**4**	3	*7*	57.1%	33.5%	95.1%
Cool-season Lawn**																	**30**	*30*	100.0%	100.0%	100.0%
TOTALS:	*58*	*77*	*105*	*31*	*5*	*89*	*148*	*11*	*26*	*32*	*46*	*6*	*3*	*23*	*6*	*4*	*33*	703			
PRODUCER'S ACCURACY: POINT ESTIMATE	46.6%	70.1%	65.7%	22.6%	80.0%	39.3%	55.4%	81.8%	65.4%	31.3%	56.5%	100.0%	66.7%	52.2%	50.0%	100.0%	90.9%		**OVERALL (POOLED) ACCURACY:**		
PRODUCER'S ACCURACY: 90% CONF. INTERVAL (LOWER)	36.6%	62.2%	58.6%	11.8%	60.6%	31.4%	49.0%	67.2%	52.0%	19.3%	45.6%	100.0%	38.6%	37.2%	24.8%	100.0%	84.2%		56.5%	53.5%	59.6%
PRODUCER'S ACCURACY: 90% CONF. INTERVAL (UPPER)	48.3%	71.4%	66.7%	25.8%	100.0%	40.4%	56.1%	90.9%	69.2%	34.4%	58.7%	100.0%	100.0%	56.5%	66.7%	100.0%	93.9%		**K = 51.1%**		

TABLE 4. Confusion matrix (contingency table) for Macrogroup-level map classes (Federal Geographic Data Committee 2008, Appendix H), Shenandoah National Park.
* - alliance not included in Appendix H; presumed to be distinct Macrogroup. **- Cultural Vegetation Group

MAP CLASS NAME	Northern and Central Mesophytic Hardwood and Conifer MacroGroup	Central Oak - Hardwood and Pine MacroGroup	Northern & Central Hardwood Flooded / Swamp MacroGroup	Eastern North America Ruderal Forest and Plantation MacroGroup	*Lasallia (papulosa, pensylvanica)* Nonvascular Alliance*	Forests with > 75% canopy mortality*	*Kalmia latifolia - Gaylussacia baccata* Shrubland Alliance*	*Saxifraga michauxii* Herbaceous Alliance*	*(Fraxinus americana, Juniperus virginiana) / Carex pensylvanica - Schizachyrium scoparium* Wooded Herbaceous Alliance*	*Alnus serrulata - Spiraea* spp. / *Sanguisorba canadensis* Saturated Shrub Herbaceous Alliance*	Temperate and Tropical Lawns**	TOTAL	USER'S ACCURACY: POINT ESTIMATE	USER'S ACCURACY: 90% CONF. INTERVAL (LOWER)	USER'S ACCURACY: 90% CONF. INTERVAL (UPPER)
Northern and Central Mesophytic Hardwood and Conifer MacroGroup	135	42	1	20								***198***	**68.2%**	**63.0%**	**73.9%**
Central Oak - Hardwood and Pine MacroGroup	30	**258**		19	2	13						***322***	**80.1%**	**76.6%**	**83.9%**
Northern & Central Hardwood Flooded / Swamp MacroGroup	8		**4**	15		2						***29***	**13.8%**	**5.0%**	**26.1%**
Eastern North America Ruderal Forest and Plantation MacroGroup	16			**35**		6						***57***	**61.4%**	**51.7%**	**72.9%**
Lasallia (papulosa, pensylvanica) Nonvascular Alliance*		3			**9**			1				***13***	**69.2%**	**52.0%**	**94.1%**
Forests with > 75% canopy mortality*	3	11				**10**			1			***25***	**40.0%**	**25.9%**	**58.1%**
Kalmia latifolia - Gaylussacia baccata Shrubland Alliance*							**6**					***6***	**100.0%**	**100.0%**	**100.0%**
Saxifraga michauxii Herbaceous Alliance*		3						**2**	1			***6***	**33.3%**	**10.0%**	**73.3%**
(Fraxinus americana, Juniperus virginiana) / Carex pensylvanica - Schizachyrium scoparium Wooded Herbaceous Alliance*		3							**3**			***6***	**50.0%**	**24.8%**	**91.9%**
Alnus serrulata - Spiraea spp. / *Sanguisorba canadensis* Saturated Shrub Herbaceous Alliance*										**4**	3	***7***	**57.1%**	**33.5%**	**95.1%**
Temperate and Tropical Lawns**											**30**	***30***	**100.0%**	**100.0%**	**100.0%**
TOTALS:	***192***	***320***	***5***	***89***	***11***	***31***	***6***	***3***	***5***	***4***	***33***	**703**			
PRODUCER'S ACCURACY: POINT ESTIMATE	**70.3%**	**80.6%**	**80.0%**	**39.3%**	**81.8%**	**32.3%**	**100.0%**	**66.7%**	**60.0%**	**100.0%**	**90.9%**		**OVERALL (POOLED) ACCURACY:**		
PRODUCER'S ACCURACY: 90% CONF. INTERVAL (LOWER)	**65.1%**	**77.1%**	**60.6%**	**31.4%**	**67.2%**	**20.1%**	**100.0%**	**38.6%**	**34.0%**	**100.0%**	**84.2%**		**70.6%**	**67.8%**	**73.5%**
PRODUCER'S ACCURACY: 90% CONF. INTERVAL (UPPER)	**70.8%**	**80.9%**	**100.0%**	**40.4%**	**90.9%**	**35.5%**	**100.0%**	**100.0%**	**80.0%**	**100.0%**	**93.9%**		**K = 57.9%**		