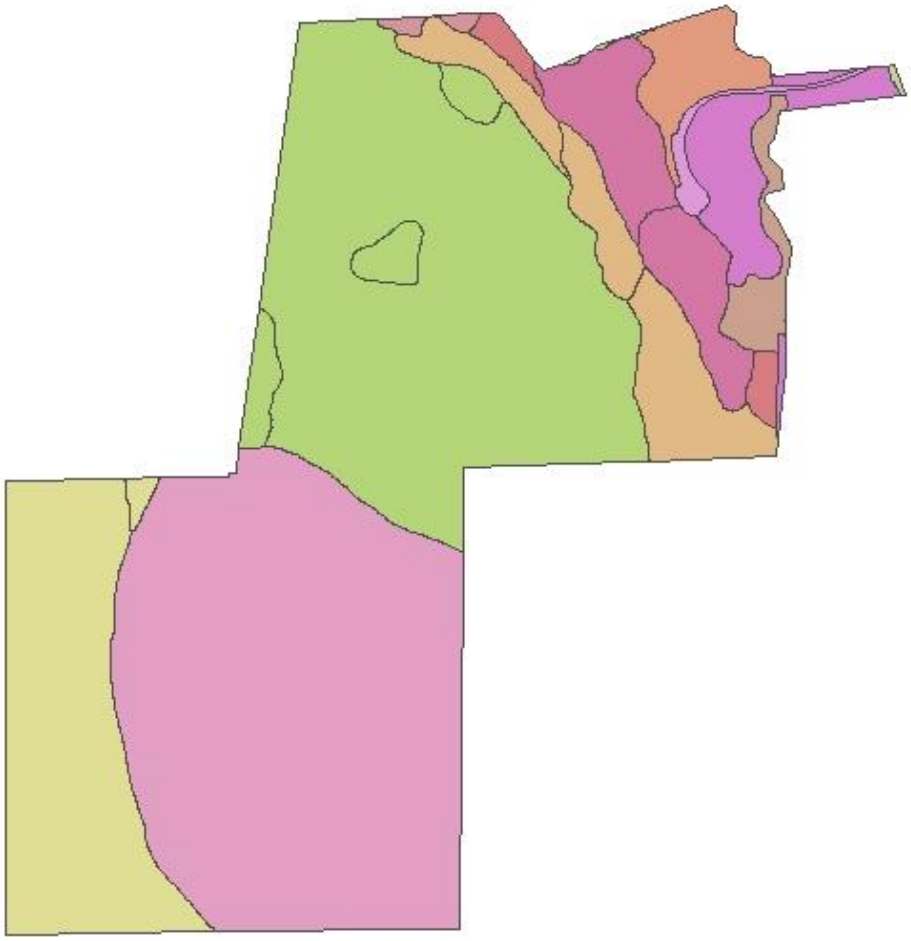
Accuracy Assessment: Russell Cave National Monument



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Electronic files have been provided to the National Park Service in addition to hard copies. Current information on all vegetation communities mentioned in this report can be found on NatureServe Explorer at www.natureserve.org/explorer.

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EXECUTIVE SUMMARY

This report presents an accuracy assessment for the digital vegetation map of Russell Cave National Monument (RUCA). Vegetation at RUCA was mapped by The University of Georgia Center for Remote Sensing and Mapping Science (Jordan and Madden in press) with ecological consultation and assistance from NatureServe. The mapping was conducted as part of the National Park Service Vegetation Mapping Program.

The map accuracy was assessed by comparing mapped vegetation types to field verified vegetation types at randomized evaluation points. The evaluation points were chosen prior to field work using statistical methods to ensure full representation of the range of map classes in the park. Accuracy was calculated for each individual map class and for all map classes combined.

The accuracy assessment process is not intended to exclusively judge the performance of the mapper or the ecologists on the project since error can be caused at any point during the process relating to any of the following: remote sensing processes, ecological classification, and the accuracy assessment exercise. Remotely-sensed imagery is limited in its ability to differentiate between certain forest types and even the most experienced mappers can't differentiate between certain species of oaks or pines in a remotely sensed image. Sources of error for the mapping project are varied and include more than solely "remote sensing error" but also included "ecologist error" caused by poor interpretation of the vegetation community concept, "field worker error" caused by mistakes made by fieldworkers while collecting the data (including misreading of the key), and temporal error when conditions on the ground change between the mapping and assessment processes. It is difficult to isolate a single error that is causing accuracy issues without more research. ***The accuracy assessment, therefore, should be used more as a tool to discern usability of map classes rather than a way to judge the performance of the mapmakers.***

The University of Georgia (UGA) Team focused on generating the highest level of detail possible during park vegetation mapping to provide the most accurate information for the National Park Service. As a consequence, assessment of the finished project requires a two step approach: (1) assessing the overall accuracy of the finest-scale map produced, and (2) combining the most "confused" map classes to determine the accuracy measures at coarser scales. The report provides the best approximation of individual map class accuracy and also suggests combinations of map classes to produce a more reliable map at a coarser scale.

For RUCA, the overall accuracy of the final map, which includes one grouped map class, is 89%, with a kappa statistic of 0.85 (85%). This version of the map is the most appropriate for use by the standard user; what it misses in fine-scale detail, it makes up for in the relatively high level of accuracy. Only two vegetation associations were combined for the purpose of increasing the

overall accuracy of the final map: White Oak - Mixed Oak Dry-Mesic Alkaline Forest (CEGL002070) and Rich Low-Elevation Appalachian Oak Forest (CEGL007233).

The accuracy assessment for this combined version of the map considered points as a match if the vegetation observed on the ground matched any of the dominant, secondary, or tertiary vegetation types attributed to the map by the mapmaking team.

The strictest analysis of the data (before combining map classes/ NVC associations and only considering a point a match if the vegetation observed on the ground matched the dominant vegetation type attributed by the mappers) showed an overall map accuracy of 62% with a kappa statistic of 0.55 (55%). This lower accuracy reflects the difficulty in differentiating the vegetation associations that were combined in the final analysis and that these classes most likely share similarities in composition on the ground and/or in appearance on aerial photography.

Key findings:

For users interested in preserving the full detail of the map for highly detailed studies or management of the landscape, we recommend use of the fine-scale map as published by UGA. For all other users, we recommend combining map classes as specified above to allow for an overall map accuracy well above 80%. In this way, the vegetation maps are useful for the widest audience possible and retain their potentially important fine-scale detail.

INTRODUCTION

In 1994, the National Park Service (NPS) and the U.S. Geological Survey (USGS) embarked on a collaborative Vegetative Mapping project to catalog and map the biodiversity of the United States. The goal of the project was to map the 230+ park units within the United States (ESRI et al. 1994). As part of this national mapping initiative, a digital vegetation map of Russell Cave National Monument (RUCA) was drafted in 2009 by the University of Georgia Center for Remote Sensing and Mapping Science (Jordan and Madden in press), in consultation with NatureServe. The mapping effort included collection of field data, interpretation of aerial photography, and polygon attribution to GIS maps.

Russell Cave National Monument is located in Bridgeport, Alabama. It is situated in the northeast corner of Alabama, just south of the Tennessee state line and has one of the longest and most complete archeological records in the eastern United States. Artifacts indicate intermittent human habitation for almost 9,000 years. Varying styles of spears and arrow points show that different bands of Indians used the large cave that is located within the park as a permanent home, as winter quarters, or in the case of nomadic tribes, as a stopover. Russell Cave National Monument was established in 1961 when 125 hectares were donated to the NPS by the National Geographic Society.

This site is 125 ha (309 acres) in size and contains the cave, a stream, sinkholes, and sandstone outcrops. The woods near the cave entrance are comprised of blue ash, yellow buckeye, white basswood, and tulip poplar. The stream floodplain consists of boxelder and tulip poplar. Wooded slopes contain a diverse canopy that includes black cherry, white oak, yellow buckeye, American beech, black locust, and hickory species. Vegetation at Russell Cave was mapped and classified to the association level using the United States National Vegetation Classification (Grossman et al. 1998), following NPS guidelines. The minimum mapping unit (MMU) was 0.5 hectare.

Accuracy assessments assign a measure of validity to the map product. These assessments allow users to understand the reliability with which the vegetation class mapping captures actual conditions on the ground. Knowledge of map accuracies enables potential users to determine the suitability of the map for any particular application (ESRI et al. 1994). This report describes the methods used in the accuracy assessment for RUCA and the results for each map class.

METHODS

The thematic accuracy of the map was assessed by visiting a representative sample of evaluation points and comparing the vegetation type shown on the map to the vegetation type identified on the ground. When polygons representing vegetation types are mapped and labeled with the correct community types, then the map has high thematic accuracy.

For each map class, both producer's and user's accuracy are evaluated. User's accuracy is defined as the prediction of the percentage of points mapped as a certain type which is confirmed to belong to that mapped vegetation type in the field. In other words, user's accuracy is a measure of the reliability of the map to predict what is found on the ground (i.e. how likely the map user is to encounter correct information while using the map). Producer's accuracy is defined as the percentage of points observed to be of a given vegetation type in the field that are correctly mapped to that type. In other words, producer's accuracy is a measure of the reliability of the aerial photo-interpretation to distinguish the vegetation types (i.e. how well the map maker was able to represent the ground features). In addition to the user's and producer's accuracy, measures of the overall map accuracy are calculated, and contingency tables showing the frequency of confusion (i.e. misclassification) between associations are presented.

Site Selection

Site selection followed a point-based approach to assess the accuracy of the map classes, with one or more evaluation points representing each map class. Different vegetation types are represented in the map as polygons; one or more for each type. Points were selected from within those polygons using a stratified random sampling design. Points were distributed across all map classes, with the number of points in each class determined by and distributed proportionally to the area of these vegetation classes within the park. Classes that took up a significantly larger portion of the park had more assessment points than classes that only were found in a small portion of the park. Once points were navigated to within the park, a 40 meter radius circle "plot" was used as the overall assessment area. Because representative points, not entire polygons, were evaluated, the assessment results should be interpreted as a measure of the accuracy of the overall map class, rather than an assessment of whether whole polygons were classified correctly. For the RUCA accuracy assessment, 79 points representing 8 vegetation types were evaluated.

In the mapping process, UGA assigned a dominant vegetation association based on the U.S. National Vegetation Classification (NVC) for each polygon. A few polygons were also assigned secondary and/or tertiary associations in ecotones, inclusions smaller than the minimum mapping unit, areas with active succession, or in blended vegetation types. For the selection of evaluation points, only the dominant vegetation type was considered. The number of required points for each dominant vegetation type was determined based on differences in predominance and overall size of each vegetation polygon at the park (ESRI et al. 1994, NatureServe 2007). Locations of the evaluation points were selected using the "Generate Random Points" tool in Hawth's Analysis Tools for ArcGIS, a GIS extension (Beyer 2004). Points were excluded from a 12 meter internal buffer around the boundary of each vegetation polygon to ensure that points were within polygons and to avoid misclassification due to GPS error in the field. In some instances, the size and shape of the vegetation polygons prevented selection of an adequate number of points outside the buffered area. Likewise, points were randomly placed but polygons smaller than 0.045 hectares (452 square meters) were excluded because of the potential that GPS error could lead field crews to record data for an area outside

the polygon of the mapped class. A distance of at least 80 meters was maintained between adjacent points to prevent overlap in the area evaluated around each point.

Field Data Collection

Field crews located each evaluation point using a WAAS-enabled Garmin 5 GPS unit. Wide Area Augmentation System (WAAS) is a form of Differential GPS, which provides enhanced positional accuracy. At each point, the field crew recorded new coordinates, GPS positional accuracy, and collected limited vegetation data. When collecting vegetation data for accuracy points, the assessment area was the 40 meter radius circle around each point. Only the dominant and diagnostic species were recorded for each stratum. The primary association type at that point was determined by the field crew using an existing key to the ecological and human influenced communities at RUCA (Schotz et al. 2006), and a "fit" value of high, medium, or low was also selected to characterize the fit of the classification key description. The classification key used in the field can be found in Appendix A. At some more confusing points, a secondary or alternate association was also recorded, and notes were taken on any difficulties keying out the point. A total of 79 data points with field data were used for the assessment of thematic accuracy.

Data Analysis

Contingency tables were generated summarizing misclassification rates for each vegetation type. User's and producer's accuracy for each vegetation type and overall accuracy of the map including the kappa statistic (Cohen 1960) were also calculated. Three scenarios were analyzed using the data. The first scenario was a strict interpretation of map accuracy at the finest scale. An evaluation point was considered correctly classified only if the dominant vegetation type assigned on the map matched the observed value on the ground. The second scenario considered a point a match if the dominant, secondary, or tertiary vegetation type assigned to the mapped polygon matched the observed type. The third scenario was similar to the second in that it used dominant, secondary, or tertiary vegetation, but this scenario also combined map classes into broader groups when evaluation of the first scenario results indicated they were difficult to differentiate. If questions arose with regard to the proper assignment of a point to a map class, the supplemental notes recorded by the field crew were also considered. In addition, any points that fell within the 12 meter polygon edge buffer that were observed to have the same type as that of an adjacent mapped polygon were regarded as correct in the third analysis.

A contingency matrix was constructed for each scenario. This table lists sample data (i.e. mapped values) as rows and reference data (i.e. the type observed in the field) as columns. An example of a contingency matrix is presented below (Table 1). Cell values equal the number of points mapped or field-verified as belonging to that type, with numbers along the diagonal representing correctly classified points and all others cells representing misclassifications. In this example, four of the five evaluation points mapped as belonging to Class B were mapped correctly, while the fifth point was found to belong to Class D in the field. In addition, the field crew identified two evaluation points that were mapped as Class C but were shown to belong in

Class B in the field. They also identified three evaluation points that were mapped in class D but were shown to belong in class C in the field. Examining the contingency table in this manner allows the users to discern patterns in misclassifications between classes.

Table 1. A sample contingency matrix with shaded cells representing correctly classified points.

		Observed as:				Row Totals
		A	B	C	D	
Mapped as:	A	5	0	0	0	5
	B	0	4	0	1	5
	C	0	2	8	0	10
	D	0	0	3	2	5
Column Totals		5	6	11	3	25

User's and producer's accuracy were derived from the values in the contingency table. Producer's accuracy, or (1 - errors of omission), is calculated by dividing the number of correctly classified points for a map class by the total number of points determined to belong to that class in the field (i.e. the column total). In our example, the producer's accuracy for Class B is 4 divided by 6, or 67%. User's accuracy (1 - errors of commission) is determined by dividing the number of correctly classified points in one map class by the total number of evaluation points originally generated for that class (i.e. the row total). In our example, the users' accuracy for Class B is 4 divided by 5, or 80%.

Overall map accuracy was determined by dividing the number of correct points by the total number of points assessed. A kappa statistic, which takes into account that some polygons are correctly classified by chance (ESRI et al. 1994, Foody 1992), was also calculated. The overall accuracy and kappa statistic were calculated based on all map classes for all three analysis scenarios.

RESULTS

The overall accuracy of the final RUCA vegetation map, which considered dominant, secondary, or tertiary vegetation types as well as one combined map class, is 89% with a kappa statistic of 0.85 (85%). The contingency matrix for this scenario, along with a tabulation of user's and producer's accuracy for each map class, is provided in Appendix B, Tables 2a-b. Groupings were created based on a review of the contingency matrix for the fine-scale analysis. Only one grouping was made: White Oak - Mixed Oak Dry-Mesic Alkaline Forest (CEGL002070) and Rich Low-Elevation Appalachian Oak Forest (CEGL007233).

A stricter analysis, which considered dominant, secondary, or tertiary vegetation types but no combined map classes, produced an overall accuracy of 62% with a kappa statistic of 0.55 (55%)

(Appendix B, Tables 3a-b). The strictest analysis of the RUCA map at its finest scale, which considered only the dominant mapped vegetation, also resulted in an accuracy of 62% with a kappa statistic of 0.55 (55%) (Appendix B, Tables 4a-b). This is essentially the same as the previous assessment considering dominant, secondary, and tertiary vegetation types because there were very few recorded secondary and tertiary vegetation types for the RUCA map.

It is apparent from the comparison of Tables 2-4 that overall map accuracy is considerably higher with the grouped associations (see Appendix B, Figures 1 and 2). The fine-scale detail that is available to users of the ungrouped map classes will be invaluable to researchers and managers interested in distinct vegetation associations. However, due to the error inherent in mapping at such fine-scales, it is important that the user take into account the misclassification rates shown on the contingency tables in Appendix B when using this version of the map. Because much higher accuracies are achieved when vegetation types are grouped, we recommend that users who are less inclined to explore the accuracy assessment in depth be guided to use the coarser scale, higher accuracy version of the map.

DISCUSSION

Overall, the vegetation map for Russell Cave National Monument provides an accurate representation of vegetation types within the park and meets the NPS 80% accuracy guidance. Only two vegetation classes had very low user's accuracy before they were combined into a single map class: White Oak Mixed Oak Dry Mesic Alkaline Forest (CEGL002070) with a user's accuracy of 0% and Rich Low Elevation Oak Forest (CEGL007233) with a user's accuracy of 12%. Producer's accuracies were relatively high for most classes except for the White Oak Mixed Oak Dry Mesic Alkaline Forest (CEGL002070) with a producer's accuracy of 0%.

Temporal difference between the period of mapping and the period of accuracy assessment influences the relative accuracy of the map due to management activities, ecological events like succession or storm events, and other anthropogenic influences that occurred during the lag time. In the case of RUCA, the ridge top and certain slopes were burned since the map was created. Burns were completed in May 2005 from the mountain road to the ridge top and in April 2006 from the mountain road to the cave and boardwalk. Also, a storm event felled many of the canopy trees between the period of photointerpretation and the accuracy assessment. The burns seemed to have been prevalent in the White Oak Mixed Oak Dry Mesic Alkaline Forest (CEGL002070) and Rich Low Elevation Forest (CEGL007233) which makes appropriate vegetation classification more difficult. This disturbance may have affected the accuracy assessment results.

While the accuracy assessment is intended to provide a measure of the reliability of the vegetation map and the mapped classes, the reader should be aware that error is also inherent in the field assessment of evaluation points. The overall accuracy of the Russell Cave vegetation map was lower before grouping map classes. At any park, the overall accuracy and user's and producer's accuracy of individual map classes may be affected by a variety of factors including the fragmentation and severe changes in management practices, GPS error, data collection error by the field crew, poorly built and/or untested classification keys, poor ecological

community concepts, inconsistent interpretation of the classification key, and potential lag times between photointerpretation and accuracy assessment. Two or more community types could be similar enough such that one assessment point could be mistakenly assigned to a particular community type by the field crew when another community type was assigned to the same area by the map producers (Townsend 2000). Points may fall into ecotones or into inclusions within the larger community type and the resulting classification in the field may not be the same as that on the map. While measures were taken to reduce these errors, they are not altogether avoidable and it is not within the scope of this project to discern what mistakes led to errors. **However, it is important to note that mapping error is but one of many types of error that combine to create accuracy issues with any given map.**

Users of the RUCA digital vegetation map should familiarize themselves with the results of this accuracy assessment, the potential sources of classification error, and the contingency tables provided in Appendix B. When interested in using the map to locate a particular association, it is useful to know what other map classes have been shown to contain points matching that association, and what other vegetation types the mapped association of interest is likely to contain. We recommend that natural resource managers consider combining some commonly confused map classes together for display or other purposes. The results of the accuracy assessment indicate that the White Oak - Mixed Oak Dry-Mesic Alkaline Forest (CEGL002070) and Rich Low-Elevation Appalachian Oak Forest (CEGL007233) were most likely difficult for the mappers to distinguish from one another. This is probably because both are relatively dense closed canopied forests dominated by oak species. The density of the canopy can make it difficult to distinguish the two groups because of the inability to observe the differences in the understories.

For casual map users and general display purposes, use of the higher-accuracy map which includes these lumped classes will be most useful. For researchers and managers interested in fine-scale detail and rare vegetation types, a version of the map that preserves the full detail as published by UGA should be maintained. This more detailed version of the map, while less accurate for some map classes, contains valuable information for those interested in locating vegetation types that are inherently difficult to map. Used in conjunction with the results of this accuracy assessment, the original map provides the best tool available for understanding the spatial distribution of vegetation types at RUCA.

<u>Key Findings:</u>

For users interested in preserving the full detail of the map for the purpose of highly detailed studies or management of the landscape, we recommend use of the fine-scale RUCA map as published by UGA. For all other users, we recommend combining map classes as specified above to allow for an overall map accuracy above 80%. These actions will allow for a map that is useful for the widest audience possible, while maintaining potentially important fine scale detail.

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APPENDIX A: Revised Classification Key

NatureServe Key to the National Vegetation Classification (NVC) Associations which occur At Russell Cave National Monument (RUCA)

All of these associations have been documented from Russell. For each association, the common name is given, with the Element Code in brackets, (CEGL00####).

1a. Vegetation of bottomlands, swamps, seeps or other areas prone to flooding or saturation (e.g. Wetlands; only one option)

Rich Levee Mixed Hardwood Bottomland Forest [CEGL008429]

1b. Upland forests and woodlands, not prone to flooding or saturation (e.g. Non-wetlands)..... **2**

2a. Forest or woodland (stands dominated by trees) **3**

3a. Primarily evergreen (conifer) forests; dominated by Eastern red-cedar (*Juniperus virginiana*)
Red-cedar Successional Forest [CEGL007124]

3b. Primarily deciduous forests **4**

4a. Dry to xeric forests on sandy and gravelly soils occupying exposed slope positions. Canopy dominated by or exhibiting strong presence of chestnut oak (*Quercus prinus*) with other oaks and hickories in the canopy and subcanopy **5**

5a. Forests of west and north facing high slopes and ridgetops over soils derived from sandstone with closed canopies dominated by or exhibiting strong presence of *Quercus prinus* and sometimes scarlet oak (*Quercus coccinea*). Understory is characterized by a dense to open layer of ericaceous (heath family) shrubs and sparse herbaceous layer.
Xeric Ridgetop Chestnut Oak Forest [CEGL008431]

5b. Forests of north- and east-facing high slopes and ridges over soils derived from sandstone. The most abundant canopy tree is usually *Quercus prinus*, but typical associates include other oaks (*Quercus rubra* and *Quercus velutina*), sometimes with shagbark hickory (*Carya ovata*), pignut hickory (*Carya glabra*) and sugar maple (*Acer saccharum*) which may be dominant in fire suppressed stands. Ericaceous (heath family) shrubs such as *Kalmia latifolia* and *Vaccinium* species are absent to rare. Sub-canopies are sparse with typically less than 25% cover of stems of canopy and subcanopy species.
Chestnut Oak – Shagbark Hickory - Sugar Maple Forest [CEGL007268]

4b. Mesic and dry-mesic forests of a variety of slope positions; some are on calcareous slopes. Canopies are typically dominated or co-dominated by a

mixture of oak species, which may include *Quercus alba, Quercus rubra, Quercus velutina, Quercus muehlenbergii,* or *Quercus shumardii*. Some more mesic stands may exhibit at least co-dominance by other mesic hardwoods such as *Fagus grandifolia, Fraxinus americana, Aesculus flava,* and maples (*Acer saccharum, Acer leucoderme, Acer barbatum*). **6**

6a. Dry-mesic stands with canopies dominated by or exhibiting strong presence of *Quercus shumardii* and *Quercus muehlenbergii* and/or *Carya ovata* with other basophilic hardwood species including maples *(Acer saccharum, Acer barbatum, Acer leucoderme) and Fraxinus americana.* These are generally forests of limestone substrates with rocks and boulders, on low to middle slopes.
Shumard Oak - Chinquapin Oak Mesic Limestone Forest [CEGL008442]

6b. Mesic or dry-mesic stands with canopies typically dominated by some combination of *Quercus alba, Quercus rubra,* and *Quercus velutina,* EITHER generally dry-mesic to dry with admixtures of *Quercus muehlenbergii* and/or *Quercus prinus*, but without dominance by *Quercus muehlenbergii*, and lacking *Quercus shumardii*; OR generally mesic with canopies dominated by *Quercus alba* and *Quercus rubra*, and with various mixtures of *Fagus grandifolia, Fraxinus americana, Liriodendron tulipifera, Quercus velutina,* and various hickories (*Carya spp*.). **7**

7a. Dry-mesic to dry calcareous forests with canopies dominated by *Quercus alba, Quercus rubra, Quercus velutina,* and *Quercus muehlenbergii,* commonly with *Carya alba* and *Carya ovata* associated. Herbaceous layer are generally less diverse and vines such as *Parthenocissus quinquefolia* and *Toxicodendron radicans* are common. Some examples have abundant rock fragments.
White Oak - Mixed Oak Dry-Mesic Alkaline Forest [CEGL002070]

7b. Mesic forests of east and north aspects with canopies dominated by *Quercus alba* and *Quercus rubra*, with various mixtures of *Fagus grandifolia, Fraxinus americana, Liriodendron tulipifera, Quercus velutina,* and hickories (*Carya spp*.) with a rich shrub and herbaceous layer (but this may be harder to discern in the summer and fall).
Rich Low-Elevation Appalachian Oak Forest [CEGL007233]

2b. Shrub or herbaceous vegetation (stands not dominated by trees)..... **8**

8a. Herbaceous dominated vegetation of frequently mowed areas such as fields and meadows. Stands dominated by fescues (*Lolium arundinaceum, Lolium pratense*)
Cultivated Meadow [CEGL004048]

8b. Other shrub and herbaceous dominated vegetation, of naturally rocky areas (shelves, cliffs, etc.); dominated by variable mixtures of native plants **9**

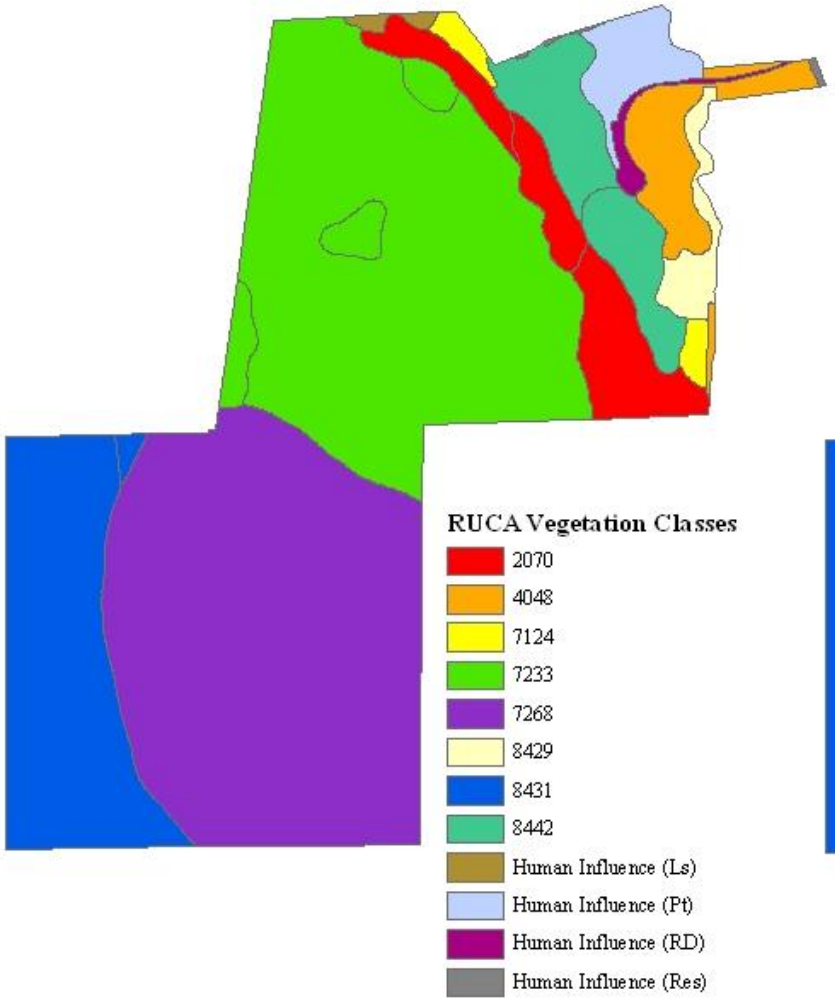
9a. Shrub and vine dominated vertical or near vertical limestone rock exposures. Dominated by *Hydrangea arborescens, Toxicodendron radicans ssp. radicans, Parthenocissus quinquefolia, Philadelphus hirsutus, Philadelphus inodorus*, and *Cercis canadensis*.
Appalachian Mafic Cliff (Low-Elevation Type) [CEGL004395]

9b. Sparse herbaceous vegetation restricted to sandstone rock shelves and crevices where soil accumulation is sufficient to sustain a low diversity of shrubs and herbs. Principal species include *Kalmia latifolia*, *Heuchera parviflora* var. *parviflora*, *Mitchella repens*, and *Dichanthelium dichotomum*; species of secondary importance include *Vaccinium pallidum*, *Hydrangea cinerea*, *Parthenocissus quinquefolia*, *Porteranthus trifoliatus*, and *Carex virescens*.
Cumberland Plateau Sandstone Cliff (Dry Type) [CEGL004392]

APPENDIX B: Contingency Matrices and Accuracy Tables

KEY TO CEGL CODES (in numerical order)	
2070	White Oak - Mixed Oak Dry-Mesic Alkaline Forest
4048	Cultivated Meadow
7124	Red-cedar Successional Forest
7233	Rich Low-Elevation Appalachian Oak Forest
7268	Chestnut Oak – Shagbark Hickory - Sugar Maple Forest
8429	Rich Levee Mixed Hardwood Bottomland Forest
8431	Xeric Ridgetop Chestnut Oak Forest
8442	Shumard Oak - Chinquapin Oak Mesic Limestone Forest

ORIGINAL CLASSIFICATION



REVISED CLASSIFICATION

The revised classification includes the one grouped map class: 2070/7233

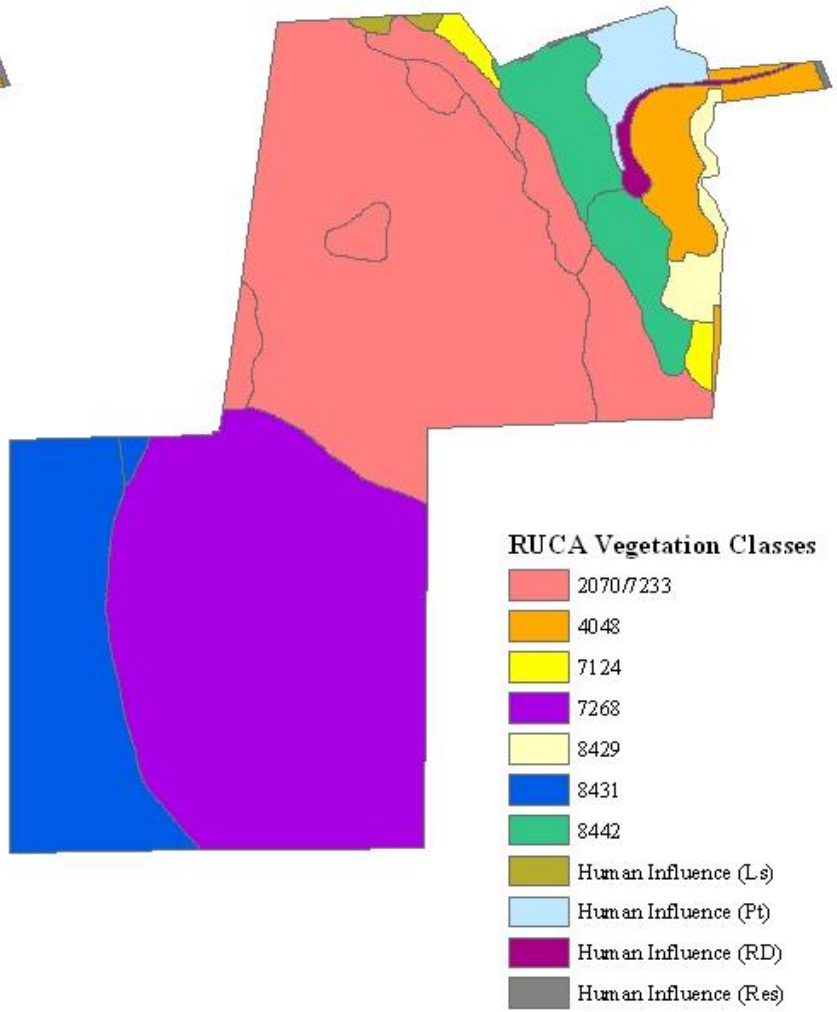


TABLE 2a: Russell Cave National Monument

Contingency Matrix Using Mapped Dominant, Secondary, and Tertiary Vegetation (Best Match) Plus One Combined Group Class

		Observed Vegetation Classes							Grand Total:	User's Accuracy:
		4048	7124	7268	8429	8431	8442	2070/7233		
Mapped Vegetation Classes:	4048	5							5	100%
	7124		2						2	100%
	7268			22		3			25	88%
	8429				2				2	100%
	8431					10			10	100%
	8442						5		5	100%
	2070/7233						5	24	30	80%
Grand Total:		5	2	23	3	13	10	24	79	
Producer's Accuracy:		100%	100%	96%	100%	77%	50%	100%		

Samples: 79 Overall Accuracy: 89% Kappa Statistic: 85%

KEY TO CEGL CODES (in numerical order)

2070/7233	White Oak - Mixed Oak Dry-Mesic Alkaline Forest/ Rich Low-elevation Appalachian Oak Forest
4048	Cultivated Meadow
7124	Red-cedar Successional Forest
7268	Chestnut Oak – Shagbark Hickory - Sugar Maple Forest
8429	Rich Levee Mixed Hardwood Bottomland Forest
8431	Xeric Ridgetop Chestnut Oak Forest
8442	Shumard Oak - Chinquapin Oak Mesic Limestone Forest

Using the Accuracy Assessment Contingency Table: The contingency table or error matrix is an array of numbers set out in rows and columns corresponding to a particular vegetation map unit relative to the actual vegetation type as verified on the ground. The column headings represent the vegetation classification as determined in the field and the row headings represent the vegetation classification taken from the vegetation map. The highlighted diagonal indicates the number of points assessed in the field that agree with the map label. Conversely, the inaccuracies of each map unit are described as both errors of inclusion (user's or commission errors) and errors of exclusion (producer's or omission errors). By reading across this table (i.e., rows) one can calculate the percent error of commission, or how many polygons for each map unit were incorrectly labeled according to the field ecologist. By reading down the table (i.e., columns) one can calculate the percent error of omission, or how many polygons for that type were left off the map. Numbers "on the diagonal" tell the user how well the map unit was interpreted and how confident they can be in using it. Numbers "off the diagonal" yield important information about the deficiencies of the map including which types were under- or over-represented.

Table 2b: Russell Cave National Monument Error Summaries Using Dominant, Secondary, and Tertiary (Best Match) plus One Combined Vegetation Class				
Class	Producer's Accuracy		User's Accuracy	
	Accuracy	N	Accuracy	N
4048	100%	5	100%	5
7124	100%	2	100%	2
7268	96%	23	88%	25
8429	100%	2	100%	2
8431	77%	13	100%	10
8442	50%	10	100%	5
2070/7233	100%	24	80%	30

n	The sample size. For user's accuracy, this is the number of points mapped in this class. For producer's accuracy, it is the number of points assigned to that class in the field.

TABLE 3a: Russell Cave National Monument

Contingency Matrix Using Mapped Dominant, Secondary, and Tertiary Vegetation (Best Match)

		Observed Vegetation Classes								Grand Total	User's Accuracy
		2070	4048	7124	7233	7268	8429	8431	8442		
Mapped Vegetation Classes:	2070	0							5	5	0%
	4048		5							5	100%
	7124			2						2	100%
	7233	21			3	1				25	12%
	7268					22		3		25	88%
	8429						2			2	100%
	8431							10		10	100%
	8442								5	5	100%
Grand Total		21	5	2	3	23	2	13	10	79	
Producer's Accuracy		0%	100%	100%	100%	96%	100%	77%	50%		

Total Correct: 49 Total Samples: 79 Overall Accuracy: 62% Kappa Statistic: 55%

KEY TO CEGL CODES (in numerical order)

2070	White Oak - Mixed Oak Dry-Mesic Alkaline Forest
4048	Cultivated Meadow
7124	Red-cedar Successional Forest
7233	Rich Low-Elevation Appalachian Oak Forest
7268	Chestnut Oak – Shagbark Hickory - Sugar Maple Forest
8429	Rich Levee Mixed Hardwood Bottomland Forest
8431	Xeric Ridgetop Chestnut Oak Forest
8442	Shumard Oak - Chinquapin Oak Mesic Limestone Forest

Using the Accuracy Assessment Contingency Table: The contingency table or error matrix is an array of numbers set out in rows and columns corresponding to a particular vegetation map unit relative to the actual vegetation type as verified on the ground. The column headings represent the vegetation classification as determined in the field and the row headings represent the vegetation classification taken from the vegetation map. The highlighted diagonal indicates the number of points assessed in the field that agree with the map label. Conversely, the inaccuracies of each map unit are described as both errors of inclusion (user's or commission errors) and errors of exclusion (producer's or omission errors). By reading across this table (i.e., rows) one can calculate the percent error of commission, or how many polygons for each map unit were incorrectly labeled according to the field ecologist. By reading down the table (i.e., columns) one can calculate the percent error of omission, or how many polygons for that type were left off the map. Numbers "on the diagonal" tell the user how well the map unit was interpreted and how confident they can be in using it. Numbers "off the diagonal" yield important information about the deficiencies of the map including which types were under- or over-represented.

TABLE 3b: Russell Cave National Monument Error Summaries Using Dominant, Secondary, and Tertiary Vegetation Classes (Best Match)				
	Producer's Accuracy		**User's Accuracy**	
Class	**Accuracy**	**N**	**Accuracy**	**N**
2070	0%	21	0%	5
4048	100%	5	100%	5
7124	100%	2	100%	2
7233	100%	3	12%	25
7268	96%	23	88%	25
8429	100%	2	100%	2
8431	77%	13	100%	10
8442	50%	10	100%	5

n	The sample size. For user's accuracy, this is the number of points mapped in this class. For producer's accuracy, it is the number of points assigned to that class in the field.

TABLE 4a: Russell Cave National Monument

Contingency Matrix Using Mapped Dominant Vegetation Only

		Observed Vegetation Classes								Grand Total	User's Accuracy
		2070	4048	7124	7233	7268	8429	8431	8442		
Mapped Vegetation Classes:	2070	0							5	5	0%
	4048		5							5	100%
	7124			2						2	100%
	7233	21			3	1				25	12%
	7268					22		3		25	88%
	8429						2			2	100%
	8431							10		10	100%
	8442								5	5	100%
Grand Total		21	5	2	3	23	2	13	10	79	
Producer's Accuracy		0%	100%	100%	100%	96%	100%	77%	50%		

Total Correct: 49 Total Samples: 79 Overall Accuracy: 62% Kappa Statistic: 55%

KEY TO CEGL CODES (in numerical order)

2070	White Oak - Mixed Oak Dry-Mesic Alkaline Forest
4048	Cultivated Meadow
7124	Red-cedar Successional Forest
7233	Rich Low-Elevation Appalachian Oak Forest
7268	Chestnut Oak – Shagbark Hickory - Sugar Maple Forest
8429	Rich Levee Mixed Hardwood Bottomland Forest
8431	Xeric Ridgetop Chestnut Oak Forest
8442	Shumard Oak - Chinquapin Oak Mesic Limestone Forest

Using the Accuracy Assessment Contingency Table: The contingency table or error matrix is an array of numbers set out in rows and columns corresponding to a particular vegetation map unit relative to the actual vegetation type as verified on the ground. The column headings represent the vegetation classification as determined in the field and the row headings represent the vegetation classification taken from the vegetation map. The highlighted diagonal indicates the number of points assessed in the field that agree with the map label. Conversely, the inaccuracies of each map unit are described as both errors of inclusion (user's or commission errors) and errors of exclusion (producer's or omission errors). By reading across this table (i.e., rows) one can calculate the percent error of commission, or how many polygons for each map unit were incorrectly labeled according to the field ecologist. By reading down the table (i.e., columns) one can calculate the percent error of omission, or how many polygons for that type were left off the map. Numbers "on the diagonal" tell the user how well the map unit was interpreted and how confident they can be in using it. Numbers "off the diagonal" yield important information about the deficiencies of the map including which types were under- or over-represented.

TABLE 4b: Russell Cave National Monument Error Summaries Using Dominant, Secondary, and Tertiary Vegetation Classes (Best Match)				
	Producer's Accuracy		**User's Accuracy**	
Class	**Accuracy**	**N**	**Accuracy**	**N**
2070	0%	21	0%	5
4048	100%	5	100%	5
7124	100%	2	100%	2
7233	100%	3	12%	25
7268	96%	23	88%	25
8429	100%	2	100%	2
8431	77%	13	100%	10
8442	50%	10	100%	5

n The sample size. For user's accuracy, this is the number of points mapped in this class. For producer's accuracy, it is the number of points assigned to that class in the field.

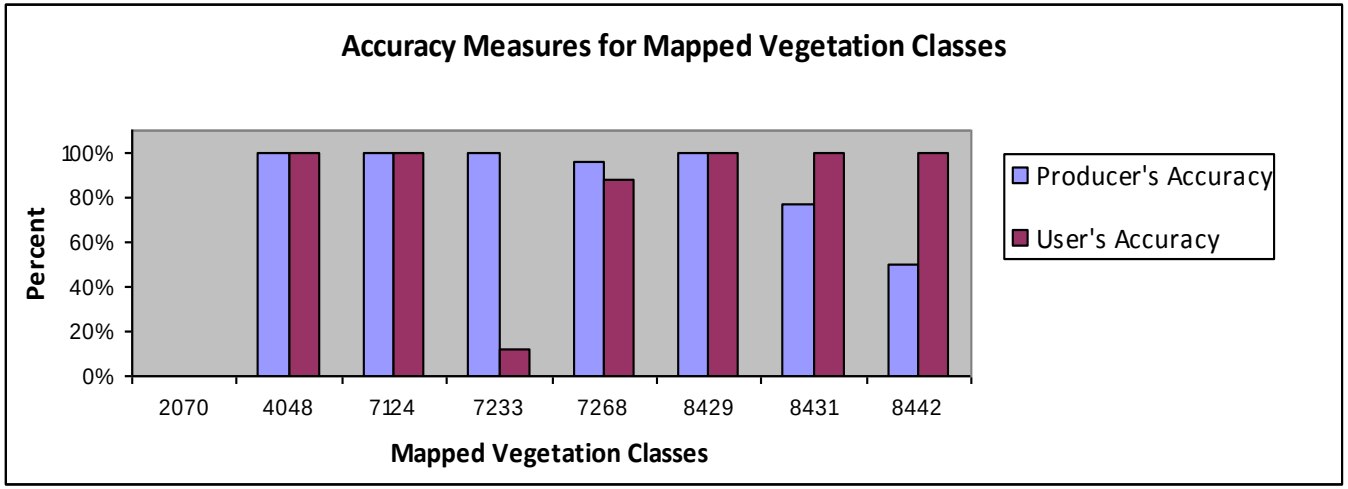


Figure 1: User's and Producer's Accuracy for the ungrouped mapped vegetation classes.

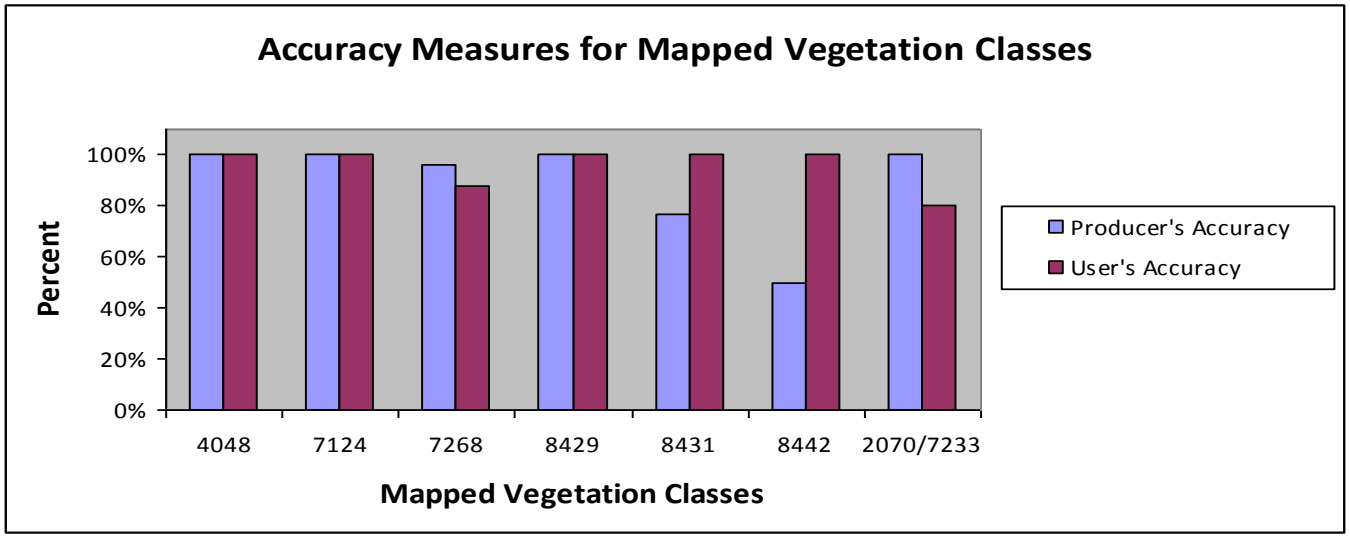


Figure 2: User's and Producer's Accuracy for the grouped mapped vegetation classes.