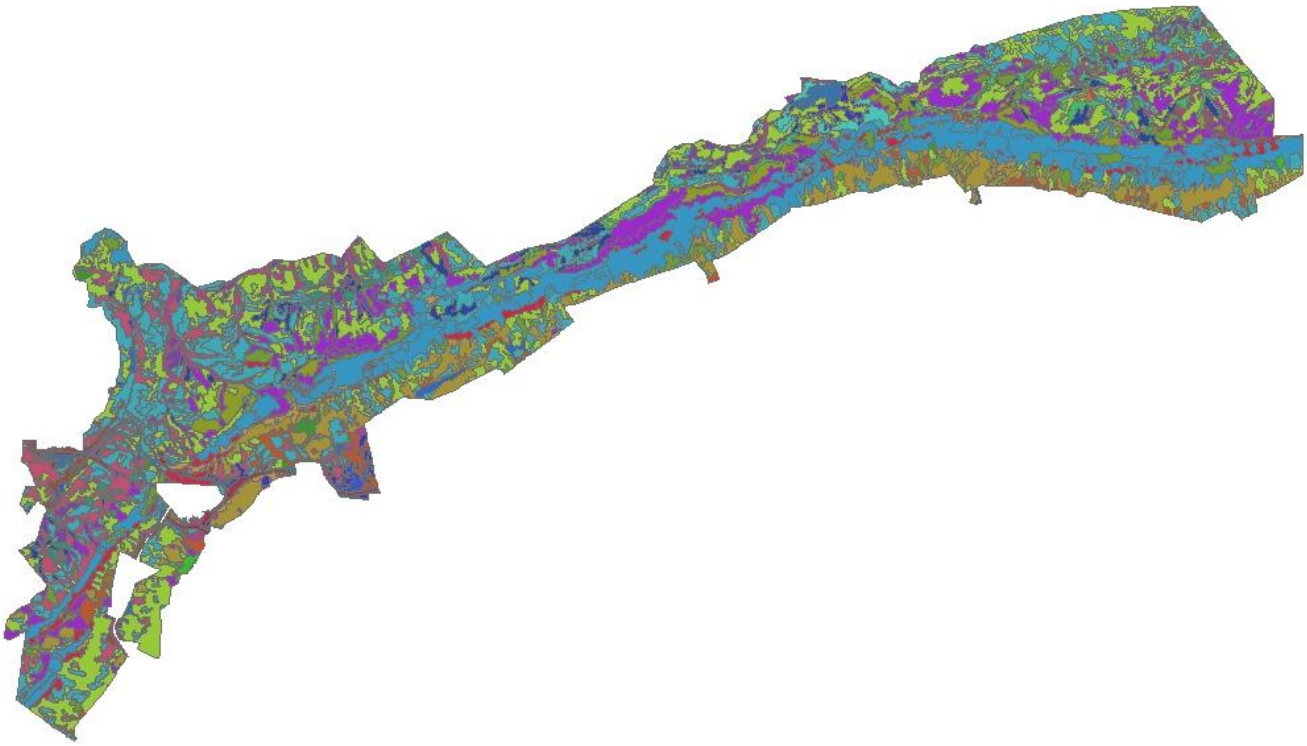
Accuracy Assessment: Cumberland Gap National Historical Park (CUGA)



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NatureServe
6114 Fayetteville Road, Suite 109
Durham, NC 27713
919-484-7857

International Headquarters
1101 Wilson Boulevard, 15th Floor
Arlington, VA 22209
www.natureserve.org

National Park Service
Southeast Regional Office
Atlanta Federal Center
1924 Building
100 Alabama St., S.W.
Atlanta, GA 30303
404-562-3163

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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 Cumberland Gap National Historical Park (CUGA). Vegetation at CUGA was mapped by The University of Georgia Center for Remote Sensing and Mapping Science (Jordan and Madden 2008) 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-senses 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 include "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 CUGA, the overall accuracy of the final map, which includes seven grouped map classes, is 77.4%, with a kappa statistic of 0.46 (46%). 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 of map classes. Vegetation associations displayed as grouped map classes on the coarse-scale map include:

a. Hi Lewis Pitch Pine Barrens (CEGL003617) and Blue Ridge Table Mountain Pine-Pitch Pine Woodland (Typic Type) (CEGL007097).

b. Southern Appalachian Mountain Laurel Bald (CEGL003814) and Cumberland Sandstone Glade Heath Shrubland (CEGL008470).

c. Ridge and Valley Limestone Oak-Hickory Forest (CEGL004793) and Dry Calcareous Forest/Woodland (White Ash-Shagbark Hickory Type) (CEGL008458).

d. Northern Mixed Mesophytic Forest (CEGL005222), Successional Tuliptree Forest (Circumneutral Type) (CEGL007220), and Mid-to-Late Successional Tuliptree-Hardwood Upland Forest (CEGL007221).

e. Appalachian Montane Oak-Hickory Forest (Red Oak Type) (CEGL006192), Chestnut Oak Forest (Xeric Ridge Type) (CEGL006271), Ridge and Valley Dry-Mesic White Oak-Hickory Forest (CEGL007240), Appalachian Montane Oak Hickory Forest (Chestnut Oak Type) (CEGL007267), Appalachian Montane Oak-Hickory Forest (Rich Type) (CEGL007692).

f. Chestnut Oak Forest (Mesic Slope Heath Type) (CEGL006286), Southern Appalachian Acidic Mixed Hardwood Forest: birch type (CEGL008558), Southern Appalachian Eastern Hemlock Forest (Typic Type) (CEGL007136), Cumberland/Appalachian Hemlock-Hardwood Forest (CEGL008407).

g. Swamp Forest-Bog Complex (Typic Type) (CEGL007565) and Cumberland Streamside Bog (CEGL007771).

The accuracy assessment for this 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. It then grouped together the most commonly confused vegetation classes.

The strictest analysis of the data (before any combining of map classes or NVC associations occurred and considering a point a match only if the vegetation observed on the ground matched the dominant vegetation type attributed by the mappers showed an overall map accuracy of 30.3% with a kappa statistic of 0.20 (20%). This lower accuracy reflects the difficulty in differentiating the vegetation associations that were combined in the final analysis because of similarities in composition 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 near 80%. In this way, the vegetation maps are useful for a broad audience yet retain potentially important fine-scale detail for interested scientists and managers.

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, the University of Georgia Center for Remote Sensing and Mapping Science (CRMS) completed a digital vegetation map of Cumberland Gap National Historical Park (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.

Cumberland Gap, located where the borders of Kentucky, Tennessee, and Virginia meet, is a natural pass which has been used as a transportation corridor since prehistoric times. Migratory large game created a path through the gap long before people arrived. The Gap later became a Native American route to hunting grounds in Kentucky; however, it is best known for its importance in opening the interior of our nation to settlement by early colonists. Cumberland Gap National Historical Park was authorized by Congress in 1940 and encompasses 8,274 ha. An additional 300+ hectares were added to the park at Fern Lake in 2004 with a second larger parcel of 878 hectares added in mid-2009.

This diverse park, which encompasses much of the east-west oriented Cumberland Mountain, contains 23 caves, streams, an historic settlement, beaver dams, bogs, rock outcrops, and a limestone cliff face. Much of the park is covered by second-growth forests of mixed deciduous and oak-hickory species. Common species on mesic sites include tulip poplar, northern red oak, and American beech. On drier sites, chestnut oak, white oak, and hickories are common. An unusual bog complex on the east end of the Park is dominated by white pine and eastern hemlock. Vegetation at Cumberland Gap 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 CUGA 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, with one or more polygon for each type. Points were selected from within those polygons using a GRTS selection approach which bases point selection on a generalized random tessellation stratified (GRTS) design. 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 CUGA accuracy assessment, 599 points representing 30 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. Points were distributed across dominant vegetation types, with the number of points in each class determined by and distributed proportionally to the area of these vegetation classes within the park (ESRI et al. 1994, NatureServe 2007) within the constraints that no more than 30, and no less than 5, points be located in a given class. (Note, some classes ultimately had fewer than five points when the very small size of the mapped area precluded placement of five points while maintaining minimum separation distances).Classes that took up a significantly larger portion of the park had more assessment points than classes that represented a small portion of the park. Each point was assigned a weight via the GRTS selection process based on the area of the mapped class and the number of points assigned to it; these weights are indicative of the proportion of the map a given point represents.

Locations of evaluation points were generated using the spsurvey package in the statistical software package "R Project for Statistical Computing" (R Development Core Team, 2008). 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. Polygons smaller than 0.045 hectares (452 square meters) with assessment points were flagged for special consideration by the field crew because there was increased potential that GPS error could lead to assessment of an unintended polygon. 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 CUGA, 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 599 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 calculated. Two 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 and 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 (as sometimes happened when gps measurements in the field resulted in an off-set to the planned point location) 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.

The weights assigned to each point during the GRTS selection process were used in the calculation of user's, producer's, and overall accuracy as well as for the kappa statistic. The application of such weights incorporates the inclusion probability of each point and allows for a more accurate representation of total map accuracy.

Results

The overall accuracy of the final CUGA vegetation map, which considered dominant, secondary, or tertiary vegetation types as well as several combined map classes, is 77.4% with a kappa statistic of 0.46 (46%). The tabulation of user's and producer's accuracy for each map class in this version of the analysis is provided in Appendix B, Table 2. Groupings were created based on a review of the contingency matrix for the original fine-scale analysis. Grouped associations included:

a. Hi Lewis Pitch Pine Barrens **(CEGL003617)** and Blue Ridge Table Mountain Pine-Pitch Pine Woodland (Typic Type) **(CEGL007097)**.

b. Southern Appalachian Mountain Laurel Bald **(CEGL003814)** and Cumberland Sandstone Glade Heath Shrubland **(CEGL008470)**.

c. Ridge and Valley Limestone Oak-Hickory Forest **(CEGL004793)** and Dry Calcareous Forest/Woodland (White Ash-Shagbark Hickory Type) **(CEGL008458)**.

d. Northern Mixed Mesophytic Forest **(CEGL005222)**, Successional Tuliptree Forest (Circumneutral Type) **(CEGL007220)**, and Mid-to-Late Successional Tuliptree-Hardwood Upland Forest **(CEGL007221)**.

e. Appalachian Montane Oak-Hickory Forest (Red Oak Type) **(CEGL006192)**, Chestnut Oak Forest (Xeric Ridge Type **(CEGL006271)**, Ridge and Valley Dry-Mesic White Oak-Hickory Forest **(CEGL007240)**, Appalachian Montane Oak Hickory Forest (Chestnut Oak Type) **(CEGL007267)**, Appalachian Montane Oak-Hickory Forest (Rich Type) **(CEGL007692)**.

f. Chestnut Oak Forest (Mesic Slope Heath Type) **(CEGL006286)**, Southern Appalachian Acidic Mixed Hardwood Forest: birch type **(CEGL008558)**, Southern Appalachian Eastern Hemlock

Forest (Typic Type) **(CEGL007136)**, Cumberland/Appalachian Hemlock-Hardwood Forest **(CEGL008407)**.

g. Swamp Forest-Bog Complex (Typic Type) **(CEGL007565)** and Cumberland Streamside Bog **(CEGL007771)**.

A stricter analysis, which considered dominant, secondary, or tertiary vegetation types but no combined map classes, produced an overall accuracy of 30.3% with a kappa statistic of 0.20 (20%) (Appendix B, Table 3). The strictest analysis of the CUGA map at its finest scale, which considered only the dominant mapped vegetation, also resulted in an accuracy of 30.3% with a kappa statistic of 0.20 (20%) (Appendix B, Table 4).

Confidence intervals for user's and producer's accuracy were not calculated for CUGA because of the range in size of the map classes and because those classes with a smaller number of assessment points per map class inflate the size of the confidence interval and thus limit its usefulness for meaningful interpretation.

It is apparent from the comparison of Tables 2-4 that overall map accuracy is considerably higher when classes are grouped and secondary and tertiary mapped vegetation are considered. 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-scale, 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 Cumberland Gap National Historical Park provides a relatively accurate representation of vegetation types within the park and nearly meets the NPS 80% accuracy guidance. Several classes had very low user's accuracies. These included the Blue Ridge Table Mountain Pine-Pitch Pine Woodland (Typic Type) (CEGL007097), the Dry Calcareous Forest/Woodland (White Ash-Shagbark Hickory Type) (CEGL008458), the Chestnut Oak Forest (Xeric Ridge Type) (CEGL006271), and the Ridge and Valley Dry-Mesic White Oak-Hickory Forest (CEGL007240).

Low map accuracies can arise from a variety of error sources. One source that contributes most often to mapping/accuracy assessment error is the temporal difference between the period of mapping and the period of assessment. This influences the relative accuracy of the map because ecological events like succession or storm events, management activities, and other anthropogenic influences may have altered the landscape in a way that makes it different from what it looked like at the time of mapping.

Another possible reason for the low overall accuracy of the vegetation map was the lack of data on secondary or tertiary vegetation types for each polygon. There were very few secondary and tertiary vegetation types listed for the mapped polygons at CUGA. Had more polygons been assigned secondary or tertiary vegetation types instead of just the dominant vegetation type, overall accuracies at the coarser scales may have improved.

The linear features of the landscape and the geology at Cumberland Gap also made mapping and assessment problematic. Due to the linearity of many of the polygons and their associated vegetation classes, GPS navigation and accuracy within the polygon is less reliable due to the narrowness and the increased possibility of assessing the wrong polygon/vegetation type. As a result, GPS error may have contributed significantly to the lower accuracies for Cumberland Gap National Historical Park.

While the accuracy assessment is intended to provide a measure of vegetation map and map class reliability, the reader should be aware that error is also inherent in the field assessment of evaluation points. The overall accuracy of the Cumberland Gap 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 CUGA 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 large difference between the overall measure of accuracy and the kappa statistic (for the grouped analysis, overall accuracy measured 77.4% and kappa statistic measured 46.0%) can be attributed to the fact that more samples are generated for vegetation classes that comprise a large percentage of the total mapped area and they receive higher weights. Thus they contribute more to our accuracy calculations and, due to their higher proportional representation, are more likely to be correctly classified by chance and thus discounted by the kappa statistic.

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 CUGA.

Key Findings:

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 CUGA map as published by UGA. For all other users, we recommend combining map classes as specified above to allow for an overall map accuracy near 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

Key to Ecological Systems and Ecological Communities of Cumberland Gap National Historical Park.

Revised May 2009
NatureServe

This key was developed for Cumberland Gap National Historical Park and is intended to allow field workers and naturalists to quickly identify community types while in the park and its environs. This key does not cover all of the ecosystems of the adjacent region. However, within the boundary and a small buffer area outside of the boundary, we believe this key represents at least 90% of the range of variation of existing vegetation.

The document is structured like a dichotomous key. The user must make a series of choices based on the structure, composition, and environment of the vegetation to arrive at the correct association. If the key leads to a choice that is not reasonable, consider returning to the beginning of the key and reviewing your decisions to confirm that you are confident in all your choices. It may be useful to walk around the area in question to better understand the composition of the area. Small-scale variations within a matrix community may be misleading. In addition, ecotones between ecological communities may have traits of both communities and so may need to be recognized as a blend of both communities. The Ecological System is a broader concept than the association level, so similar communities may fall out in one system. Ecological systems represent recurring groups of biological communities that are found in similar physical environments and are influenced by similar dynamic ecological processes, such as fire or flooding (Comer et al. 2003). The full association name and code (e.g. CEGL002591) appears alongside an underlined title of the type. The CEGL code may be used to refer back to the document or to look association names and information up in other references that use the National Vegetation Classification. The "common name" of the community also appears with the scientific name of the association.

[ALL CAPS AND BRACKETS] signifies an ecological system
Bold faced words signify an NVC ecological community type
Italics signify a community type that hasn't been documented with a plot, but that we suspect is in the park based on past studies.

Key to Communities of Cumberland Gap National Historical Park

1.Wetland

a.Community either dominated by coniferous trees or by shrubs and herbaceous plants

1.Canopy dominated by hemlock (>50% cover) Sphagnum present. Hemlock approaches 100% of canopy in most examples and sometimes co-dominated by red maple, tuliptree, and blackgum. Great rhododendron common. Usually found in conjunction with an open bog (CEGL007771) and limited to the Martin's Fork watershed.
[SOUTHERN AND CENTRAL APP BOG AND FEN SYSTEM]
Swamp Forest-Bog Complex (Typic Type) (7565)

2.Open canopy with high herbaceous or shrub cover

a.Shrubland dominated by *Alnus serrulata*. Can occur as part of a stream floodplain but most often occurs as part of a beaver pond.
NOT A MAP UNIT.
Saturated Alder Thicket (CEGL003912)
[SOUTH-CENTRAL INTERIOR SMALL STREAM AND RIPARIAN]

b.Herbaceous dominated

1.Occurs in Martin's Fork at elevations between 2000-2500 feet and is dominated by *Carex gynandra* and *Osmunda cinnamonea*, among others. Can have a high shrub component at times.
[SOUTHERN AND CENTRAL APP BOG AND FEN]
Cumberland Streamside Bog (CEGL007771)

2.Occurs below 2000 feet elevation and contains *Carex* spp. and *Scirpus* and *Solidago canadensis* but little *Osmunda cinnamonea*. Can occur in conjuntion with other communities, especially Saturated Alder Thicket (CEGL003912). **NOT A MAP UNIT.**
[SOUTH-CENTRAL INTERIOR SMALL STREAM AND RIPARIAN]
Southern Blue Ridge Beaver Pond Complex (CEGL008433)

b.Community dominated by deciduous trees.

1.Dominant canopy trees can vary, but usually sycamore and tuliptree are dominant. Sweetgum is present but is usually less common than in the South Central Interior Large Floodplain System occasionally with buckeye and beech, especially around beaver ponds. This community grades into coves as streams and floodplains narrow upstream. Presence of sycamore is a good separator between this montane alluvial community and a cove.
[SOUTH CENTRAL INTERIOR SMALL STREAM AND RIPARIAN SYSTEM]
Sycamore-Sweetgum Piedmont Swamp Forest (CEGL007340)

2.Forest/woodland associated with old homesites and pastures in and near homesites within the floodplains of small to large creeks. Canopy is dominated by *Juglans nigra* while herbaceous layer is dominated by *Verbesina* spp. Most likely examples of this community are too small to map. **NOT A MAP UNIT.**
[HUMAN MODIFIED / SUCCESSIONAL COMMUNITY]
Successional Black Walnut Forest (CEGL007879)

1.Non-wetland

a.Not a forest or woodland

1.Substrate predominantly bedrock with only a small percentage of the surface area vegetated (0-50% vegetated) **NOT A MAP UNIT.**
[SOUTHERN INTERIOR ACID CLIFF SYSTEM]
No association created for this type since it is mostly rock.

2.Substrate bedrock or not, but with a majority of the surface area vegetated (50-100%)

a.Herbaceous community
[HUMAN MODIFIED / SUCCESSIONAL COMMUNITY]
Old field with at least 25% fescue (*Lolium spp.*) and less than 25% orchard grass (*Dactylus glomerata*) mostly occurring around the Hensley Settlement area.
Cultivated Meadow (CEGL004048)

b.Shrubland/Vineland

1.Shrubland or vineland dominated by deciduous species. Sites generally have sufficient soil to support forests.

a.Shrubland.Successional community dominated by blackberry species (*Rubus)* and/or greenbrier (*Smilax*) along with herbaceous species
[HUMAN MODIFIED / SUCCESSIONAL]
Blackberry-Greenbrier Successional Shrubland Thicket (CEGL004732)

b. Vineland.

1. Small to medium sized gap in forest matrix dominated by wild grape vines (*Vitis*) and assorted shrubs and herbs. Too small to map in most instances.
[SOUTHERN APPALACHIAN OAK FOREST]
Montane Grape Opening (CEGL003890)

2. Not in the park boundary, but just outside. Dominated by invasive exotic kudzu exclusively and typically at low elevations and near steep slopes where it was planted to control erosion. **NOT A MAP UNIT.**
[HUMAN MODIFIED / SUCCESSIONAL]
Kudzu vineland (CEGL003882)

2.Shrubland/woodland dominated by evergreen species and generally limited to sites with continuous rock outcrops and shallow soils.

a.Sparse shrubland over rock dominated by *Rhus aromatica*, often with a high component of *Juniperus virginiana* and *Quercus muehlenbergii*. This community always grades quickly into CEGL4793 and may be too small to map in most instances.
NOT A MAP UNIT.
[CENTRAL APP ALKALINE GLADE & WOODLAND]
Limestone Cliff Fragrant Sumac Shrubland (CEGL004393)

b.Shrubland dominated by shrubs other than red cedar and oak.
[SOUTHERN APP GRASS AND SHRUB BALD]

1.Shrubland dominated by Catawba rhododendron (along with mountain laurel, *Pieris floribunda*, and blueberries) on steep slopes and ridges – reportedly very rare in the Cumberlands and only at the highest elevations. Generally very open canopy.
So. App Mountain Laurel Bald (CEGL003814)

2.Shrubland dominated by mountain laurel with great rhododendron and only a small amount of Catawba rhododendron. Substrate is bedrock with exposed patches with *Pinus rigida*, *Pinus virginiana*, and *Quercu*s spp. present as stunted trees.
Cumberland Sandstone Glade Heath Shrubland (CEGL008470)

b.Forest or woodland

1.Primarily Conifer Dominated Forest (at least >40% conifer dominated) – This percentage number may be as low as 25% for recently pine beetle damaged stands and can be even lower in cases where pine beetle has killed all of the canopy.

a.Dominated or co-dominated by hemlock (>25% canopy cover) with large amounts of Rhodo max in shrub layer (at least 25% cover)
[APPALACHIAN HEMLOCK-HARDWOOD FOREST]

1.Pure hemlock stands only on lower slopes following creeks on protected slopes – usually with at least 25% cover of great rhododendron.
Southern App Eastern Hemlock Forest(Typic Type)(CEGL007136)

2.Mixed stands of hemlock and hardwood at various positions from lower to mid slope often with some cover of great rhododendron in the shrub layer but generally not greater than 25% cover. This community can often be dominated by beech instead of hemlock and can quickly grade into pure hardwood stands upslope.
Cumberland/App Hemlock-Hardwood Forest (CEGL008407)

b.Pines (alive or dead) or red-cedar dominate - Hemlock <25% of cover of forest. Rhododendron maximum <25% cover in shrub layer. Dead pines often dominate where recent pine beetle outbreaks have occurred.

1.Dominated by red cedar – mildly acidic to basic soils. Successional red-cedar dominated (at least 50% of canopy). Occurs in heavily human disturbed landscapes such as abandoned pastures and clear cuts in areas with neutral to basic soils. Only outside of park adjacent to park boundary.
[HUMAN MODIFIED / SUCCESSIONAL]
Red-cedar Successional (CEGL007124)

2.Dominated by pine spp. or dead pine/moderately to very acidic soils

a.Virginia pine dominated successional forest (at least 50% of canopy dominated by Virginia Pine). Distinguished from other pine types in this series by dominance of Virginia pine and by clear signs of recent heavy human disturbace such as plowing or cutting and lack of a diverse herbaceous layer in understory (forest is usually less than 50 years old). May sometimes contain other successional trees such as sweetgum or tuliptree.

[HUMAN MODIFIED / SUCCESSIONAL]

Virginia Pine Successional (CEGL002591)

b.*Pinus rigida* woodland/forest maintained by fire and/or extreme xeric conditions. Much of the *Pinus rigida* in these examples has been beetle killed over the past 6 years, so these communities may be dominated by younger understory trees such as chestnut oak or red maple in places. The herbaceous layer should still be the same.

[SOUTHERN APP MONTANE PINE FOREST & WOODLAND]

1. Open canopy (10-80% canopy coverage). Shrub stratum sparse, but herb layer includes such barrens species as little bluestem, Indian grass, and *Tephrosia virginiana*. Canopy sometimes dominated by *Quercus prinus* or *Q. marilandica*. Steep south to southwest facing slopes. Very rare type only documented with one plot.

Hi Lewis Pitch Pine Barrens (CEGL003617)

2.Usually dominated by *Pinus rigida*, but many examples in park have a closed canopy due to red maple invasion. High cover of *Vaccinium pallidum*. in understory. South and west facing exposed ridges and upper slopes. Herbaceous layer sparse and not terribly diverse (typical species include *Galax urceolata* and *Epigaea repens*.

Blue Ridge Table Mountain Pine – Pitch Pine Woodland (Typic Type) (7097)

2.Primarily deciduous (at least 60% deciduous canopy)

a.Dominated almost exclusively by oak and/or hickory with =< 50% cover of other tree species in canopy (but sometimes tuliptree can be more than 50% cover in stands that were disturbed in the past. Less than 25% cover of basswood and buckeye and ash combined.

1.Usually >75% chestnut and scarlet oak combined in canopy although black oak can be common. Very few “mesic” canopy species. Acidic lower and mid slopes.

[SOUTHERN AND CENTRAL APPLACHIAN OAK FOREST]

a.Dry forests on exposed slopes and ridgetops with very low herbaceous cover

1.Ridgetop and exposed south facing slopes of chestnut oak and/or scarlet oak with a heavy red maple understory and an ericaceous understory with at least 20% cover of mountain laurel. Very sparse herbaceous layer sometimes including galax or wintergreen, but generally not much diversity. Elevation varies widely.
Chestnut Oak Forest (Xeric Ridge Type) (CEGL006271)

2.Exposed lower, mid, and upper slopes. This community is dry-mesic (less dry than CEGL006271). Mountain laurel is usually not present in significant numbers but *Vaccinium pallidum* is usually present. Herbaceous layer is sparse and typical of highly acidic substrate, usually with low diversity but sometimes with higher diversity (but always low cover). Some common species include *Desmodium nudiflorum* and *Chimaphila maculata*. This community can be distinguished from other communities by its acid-loving herb layer, its relative lack of mountain laurel, and its position on lower to midslopes of most all aspects. Mostly on Kentucky side.
Appalachian Montane Oak Hickory Forest (Chestnut Oak Type) (CEGL007267)

b.Mesic forest on north facing slopes or very protected sights below rock outcrops or steep slopes on various exposures – heaths such as great rhodoendron and mountain laurel are usually present in large amounts, often approaching 100% cover. May often be dominated by red maple instead of chestnut oak.
Chestnut Oak Forest (Mesic Slope Heath Type) (CEGL006286)

2.Highest canopy cover oak is usually a mesic to dry-mesic oak (*Quercus rubra, Q. muehlenbergii, Q. alba, Q. falcata*) with usually <75% cover by *Quercus velutina, Q. prinus, or Q. coccinea. Carya* spp. sometimes co-dominate the canopy.

Site often is rocky but also is often not rocky and can be extremely acidic to somewhat basic.

a.Very rare communities either dominated by *Quercus muehlenbergii* or mostly dominated by *Q. muehlenbergii*. Short statured and near small patches of limestone on low to mid slopes.
[CENTRAL APP ALKALINE GLADE & WOODLAND]
Ridge and Valley Limestone Oak - Hickory Forest (CEGL004793)

b.Not dominated by *Quercus muehlenbergii*. Common communities, usually mostly northern red oak, though sometimes black oak, white oak, southern red oak, hickory spp. or chestnut oak can dominate or co-dominate.

[SOUTHERN AND CENTRAL APP OAK FOREST]

1.Acidic, low diversity forest with <25% cover of herbs in herb layer at 1200-2900 feet elevation. Normal open acidic forest usually with some *Vaccinium* spp. on slope. Usually dominated by oaks such as chestnut oak or scarlet oak but occasionally dominated by white oak.
App Montane Oak Hickory Forest (Chestnut Oak Type) (CEGL00 7267)

2.Acidic to basic with low to high base status, high to moderate diversity forest with >25% cover of herbs in herb layer

1.High fern cover (>50% of herb layer are ferns. Can be either white oak or northern red oak dominated.

App Montane Oak-Hickory Forest (Red Oak Type) (CEGL006192)

2.High herb cover, but low fern cover (<50% of total herbaceous cover). Very common on VA side – usually northern red oak dominated, but sometimes with high percentages of *Carya ovalis*, chestnut oak, white oak, black oak. Substrate very rocky to only slightly rocky and mesic to somewhat dry. Forms two to three distinct bands as one proceeds downslope from ridgecrest on Virginia side of park. Herbaceous cover approaches cove, but can be distinguished from CEGL005222 by having very little *Tilia americana* and *Aesculus* in understory and canopy. If measuring soil, base status usually in 50's-90's (exceptions where limestone inclusions create greatly variable base status measurements. Only on VA side of park.
App Montane Oak–Hickory Forest (Rich Type) (CEGL007692)

3. White oak dominated with low to moderate herb cover but moderate to high diversity. Understory has plants of both acidic and calcophilic character. Some indicators include *Cercis canadensis* and *Lindera benzoin* alongside *Oxydendrum arboreum*. Herbaceous plants variable but always more diverse than 7267 and not as high cover and rich as 7692. Elevations below 2000 feet on Virginia side of park (down to Tennessee).

Ridge-and-Valley Dry-Mesic White Oak - Hickory Forest (CEGL007240)

b.Canopy may include oaks and hickories, but is predominantly composed of non-oak/hickory species (usually > 50% of canopy.)

1.Community restricted to upper slopes and interfluves of the highest elevations of the park (>2500 feet)

a.Forest containing a substantial amount of *Betula lenta* in canopy (>25%). Shrub layer dominated by *Rhododendron* spp and/or *Kalmia latifolia* along with a high density of ferns. Usually a product of past disturbance. Only found on KY side of park.
[CENTRAL AND SOUTHERN APP OAK FOREST]
Chestnut Oak Forest (Mesic Heath Subtype): Betula lenta subtype (CEGL006286)

b.Community on rich, disturbed ridgetop soil. Dominated by black walnut with *Verbesina* spp. in understory. Usually too small to map, so it will be embedded within a polygon of the matrix type **NOT A MAP UNIT.**.
[HUMAN MODIFIED / SUCCESSIONAL]
Successional Black Walnut Forest (CEGL007879)

2.Community present exclusively on the mid to lower slopes and cove areas of the park (< 3000 feet elevation)

a.Young to medium even aged forest dominated by early successional tree species (age=10-60 years old) (>50% tuliptree or sassafras or red maple.
[HUMAN MODIFIED / SUCCESSIONAL]

1.Dominated by tuliptree (at least >50% of canopy)

a.Acidic version (no *Cercis canadensis* in understory and plenty of indicators of acidic soil (*Mitchella repens, Goodyera pubescens, Oxydendrum arboreum, Cypripedium acaule*). Disturbed >40 years ago and with oaks or other mid successional trees in understory now.
Mid- to Late-Successional Tuliptree - Hardwood Upland Forest (CEGL007221)

b.Calcareous version – *Cercis canadensis* present – sometimes dominated by young *Juglans nigra* or *Fraxinus americana* and can have *Quercus muehlenbergii*.
Successional Tuliptree Forest (Circumneutral Type) (CEGL007220)

2.Dominated by other than tuliptree.

a.Dominated by *Sassafras albidum* (probably fire induced community type)
Southern Blue Ridge Successional Sassafras Forest (CEGL004096)

a.Dominated by other than Sassafras

Dominated by a variety of species, usually including *Acer rubrum, Nyssa sylvatica, Liriodendron tulipifera, Ilex opaca*, and *Betula lenta* with a fairly sparse shrub and herb layer (although ferns and shrubs such as *Rhododendron maximum* and *Kalmia latifolia* can often be dominant. Various aspects including on occasion flat areas near creeks up to mid and upper slopes. Only found on KY side.

Southern Appalachian Acidic Mixed Hardwood Forest (CEGL008558)

b.Older (> 60 years old) uneven aged stand not dominated by early successional tree species (although *Liriodendron tulipifera, Acer rubrum,* and *Betula lenta* can sometimes dominate young versions of these communities)

1.Low to high diversity forest dominated by *Betula lenta* or *Fagus grandifolia* or *Acer rubrum* or sometimes *Liriodendron tulipifera*

a.dominated by *Rhododendron maximum* in understory and very low to moderate herb cover.

1.Canopy dominated by beech in overstory, usually with some hemlock - generally in coves.
[APP (HEMLOCK)- N. HARDWOOD FOREST]
Cumberland/Appalachian Hemlock-Hardwood Forest (CEGL008407)

2.Canopy dominated by red maple, usually with some chestnut oak and sometimes with *Betula lenta* – North facing slopes.
[SOUTHERN APP OAK FOREST]
Chestnut Oak Forest (Mesic Heath Subtype) (CEGL006286)

b.Canopy dominated by beech or tuliptree and sometimes co-dominated by white oak and/or red maple. Without *Rhododendron maximum* in understory and with some herbs typical of acidic (*Smilax rotundifolia, Polystichum acrosticoides*) and dry-mesic to mesic habitat. Can be more diverse where it begins to intergrade with cove habitat towards lower end of slope.
[SOUTH-CENTRAL INTERIOR MESOPHYTIC FOREST]
Central Interior Beech - White Oak Forest (CEGL007881)

2.High diversity forest or woodland dominated by mesic and/or calcophilic species, but not generally oaks (except occasionally over 50% cover of northern red oak)

a.Dry south facing woodland exclusively in Virginia (60% coverage or less) dominated by *Fraxinus americana* and *Carya ovata* with some *Quercus rubra* with *Ostrya virginiana* and/or *Frangula caroliniana* present in the shrub layer and a diverse herbaceous layer usually dominated by species such as *Helianthus hirsutus* and *Salvia urticifolia*. Often the canopy

is as open as a woodland, but sometimes closed like a forest. Limestone rock usually present.
[CENTRAL APP ALKALINE GLADE AND WOODLAND]
Dry Calcareous Forest/Woodland (White Ash - Shagbark Hickory Type) (CEGL008458)

b.Closed to somewhat open canopy dominated by mesic forest species that can include *Fraxinus americana, Liriodendron tulipifera, Tilia, Aesculus*, *Acer saccharum*, etc. Usually in cove or rich slope area. Very mesic
[SOUTH-CENTRAL INTERIOR MIXED MESOPHYTIC FOREST]
Northern Mixed Mesophytic Forest (CEGL005222)

Appendix B

Table 1: List of CEGL Codes and Associated NVC Community Type Name	
CEGL Code Names (in numerical order)	
2591	Virginia Pine Successional Forest
3617	Hi Lewis Pitch Pine Barrens
3814	Southern Appalachian Mountain Laurel Bald
3890	Montane Grape Opening
3912	Alder shrubland/thicket
4048	Cultivated Meadow
4096	Southern Blue Ridge Successional Sassafras Forest
4732	Blackberry-Greenbrier Successional Shrubland Thicket
4793	Ridge and Valley Limestone Oak - Hickory Forest
5222	Northern Mixed Mesophytic Forest
6192	Appalachian Montane Oak-Hickory Forest (Red Oak Type)
6271	Chestnut Oak Forest (Xeric Ridge Type)
6286	Chestnut Oak Forest (Mesic Slope Heath Type)
7097	Blue Ridge Table Mountain Pine - Pitch Pine Woodland (Typic Type)
7124	Red-cedar Successional Forest
7136	Southern Appalachian Eastern Hemlock Forest (Typic Type)
7220	Successional Tuliptree Forest (Circumneutral Type)
7221	Mid-to Late-Successional Tuliptree - Hardwood Upland Forest
7240	Ridge and Valley Dry-Mesic White Oak - Hickory Forest
7267	Appalachian Montane Oak Hickory Forest (Chestnut Oak Type)
7340	Sycamore-Sweetgum Piedmont Swamp Forest
7565	Swamp Forest-Bog Complex (Typic Type)
7692	Appalachian Montane Oak-Hickory Forest (Rich Type)
7771	Cumberland Streamside Bog
7881	Central Interior Beech - White Oak Forest
8407	Cumberland/Appalachian Hemlock-Hardwood Forest
8433	Southern Blue Ridge Beaver Pond Complex
8458	Dry Calcareous Forest/Woodland (White Ash - Shagbark Hickory Type)
8470	Cumberland Sandstone Glade Heath Shrubland
8558	Southern Appalachian Acidic Mixed Hardwood Forest: birch type

Table 2: Contingency Matrix Considering Matches with Only the Dominant Vegetation Type

Mapped Vegetation Classes	Vegetation Classes Observed in the Field																													
	2591	3617	3814	3890	3912	4048	4096	4732	4793	5222	6192	6271	6286	7097	7124	7136	7220	7221	7240	7267	7340	7565	7692	7771	7881	8407	8433	8458	8470	8558	Totals
2591	13						1		2	1	1		2		2		3	3		2											30
3617	1	0										9	6	8						3						1					28
3814			6									1	7	1															3		18
3890				0																								1			1
3912					0																										n/a
4048						27		2												1											30
4096							4										7	2		2											15
4732						5		7									2	1							1		1				17
4793	1								0								3	1													5
5222									1	5	3		3				3	6	1	3			2		1		1				29
6192											16	1	1					1		9			2								30
6271											4	4	1				1		1	18					2						31
6286											4	4	15	1						3						2				1	30
7097	1											9	10	2						5						1					28
7124										1					0																1
7136			1				1			2			9			4										14					31
7220										7		1					7	3	1	5	3		2		1			1			31
7221													1				1	12		2			1								17
7240										1	1								2	26											30
7267	1										1	5	3				1	1	2	18					2						34
7340										1	2		2			1	3	2		1	11				3						26
7565													1			3		1				3		1		2					11
7692									1	3	3	2					2		1	9			8								29
7771					2								1											1							4
7881										1	3									7					9						20
8407	1										1	2	11			2						1				12					30
8433																											0				n/a
8458	1								6	3							3			6	1		5					3			28
8470			1									2	5	2															0		10
8558							1					1	3																	0	5
Totals	19	n/a	8	n/a	2	32	7	9	10	25	39	41	81	14	2	10	36	33	8	120	15	4	20	2	19	32	2	5	3	1	599

Table 3: Error Summaries for Dominant Vegetation Types				
Map Classes	**User's Accuracy**		**Producer's Accuracy**	
	Accuracy	**N**	**Accuracy**	**N**
2591	43.3%	30	23.1%	19
3617	0.0%	28	n/a	n/a
3814	33.3%	18	51.5%	8
3890	0.0%	1	n/a	n/a
3912	n/a	n/a	0.0%	2
4048	90.0%	30	86.7%	32
4096	26.7%	15	53.0%	7
4732	41.2%	17	74.3%	9
4793	0.0%	5	0.0%	10
5222	17.2%	29	16.2%	25
6192	53.3%	30	47.2%	39
6271	12.9%	31	26.8%	41
6286	50.0%	30	16.2%	81
7097	7.1%	28	29.6%	14
7124	0.0%	1	0.0%	2
7136	12.9%	31	48.1%	10
7220	22.6%	31	14.8%	36
7221	70.6%	17	11.9%	33
7240	6.7%	30	22.4%	8
7267	52.9%	34	25.3%	120
7340	42.3%	26	40.3%	15
7565	27.3%	11	45.0%	4
7692	27.6%	29	78.1%	20
7771	25.0%	4	27.0%	2
7881	45.0%	20	9.4%	19
8407	40.0%	30	46.0%	32
8433	n/a	n/a	0.0%	2
8458	10.7%	28	70.9%	5
8470	0.0%	10	0.0%	3
8558	0.0%	5	0.0%	1

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.

n/a Not applicable. For user's accuracy, no evaluation points were mapped in this class. For producer's accuracy, no evaluation points were assigned to this class in the field.

Table 4: Contingency Matrix Considering Grouped Classes and Dominant, Secondary, and Tertiary Vegetation Classes

Mapped Vegetation Classes	Vegetation Classes Observed in the Field																	
	2591	3890	3912	4048	4096	4732	7124	7340	7881	8433	3617/7097	3814/8470	4793/8458	5222/7220/7221	6192/6271/7240/7267/7692	6286/8558/7136/8407	7565/7771	Totals
2591	13				1		2						2	7	3	2		30
3890		0											1					1
3912			0															n/a
4048				27		2									1			30
4096					4									9	2			15
4732				5		7			1	1				3				17
7124							0							1				1
7340								11	3					6	3	3		26
7881									9					1	10			20
8433										0								n/a
3617/7097	2										10				26	18		56
3814/8470											3	10			3	12		28
4793/8458	2							1					9	10	11			33
5222/7220/7221								3	2	1			2	44	21	4		77
6192/6271/7240/7267/7692	1								4				1	10	133	5		154
6286/8558/7136/8407	1				2						1	1		2	15	73	1	96
7565/7771			2											1		7	5	15
Totals	19	n/a	2	32	7	9	2	15	19	2	14	11	15	94	228	124	6	599

Table 5: Error Summaries for Grouped Community Types				
Map Class	**User's Accuracy**		**Producer's Accuracy**	
	Accuracy	**N**	**Accuracy**	**N**
2591	43.3%	30	23.1%	19
3890	0.0%	1	n/a	n/a
3912	n/a	n/a	0.0%	2
4048	90.0%	30	86.7%	32
4096	26.7%	15	53.0%	7
4732	41.2%	17	74.3%	9
7124	0.0%	1	0.0%	2
7340	42.3%	26	40.3%	15
7881	45.0%	20	9.4%	19
8433	n/a	n/a	0.0%	2
3617/7097	12.9%	56	72.8%	14
3814/8470	32.5%	28	71.0%	11
4793/8458	28.8%	33	41.6%	15
5222/7220/7221	52.5%	77	34.2%	94
6192/6271/7240/7267/7692	84.6%	154	92.3%	228
6286/8558/7136/8407	75.5%	96	49.5%	124
7565/7771	35.0%	15	54.4%	6

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.
n/a	Not applicable. For user's accuracy, no evaluation points were mapped in this class. For producer's accuracy, no evaluation points were assigned to this class in the field.

Table 6: GRTS-derived Weights & Inclusion Probabilities Assigned to Each Mapped Vegetation Class		
Map Class	**Weight**	**Inclusion Probabilities**
2591	9524.07	0.000104997
3617	10484.84	9.53758E-05
3814	5345.96	0.000187057
3890	1444.60	0.000692235
3912	n/a	n/a
4048	11892.55	8.40863E-05
4096	11199.55	8.92893E-05
4732	9821.84	0.000101814
4793	23850.33	4.19281E-05
5222	65571.51	1.52505E-05
6192	163456.77	6.11783E-06
6271	260254.23	3.8424E-06
6286	32396.16	3.08679E-05
7097	28686.58	3.48595E-05
7124	36829.96	2.71518E-05
7136	22744.18	4.39673E-05
7220	43204.88	2.31455E-05
7221	12209.94	8.19005E-05
7240	181564.67	5.50768E-06
7267	280982.61	3.55894E-06
7340	10166.56	9.83617E-05
7565	8531.85	0.000117208
7692	329429.41	3.03555E-06
7771	3161.25	0.00031633
7881	14255.42	7.01488E-05
8407	31228.93	3.20216E-05
8433	n/a	n/a
8458	36257.14	2.75808E-05
8470	7452.28	0.000134187
8558	7503.46	0.000133272

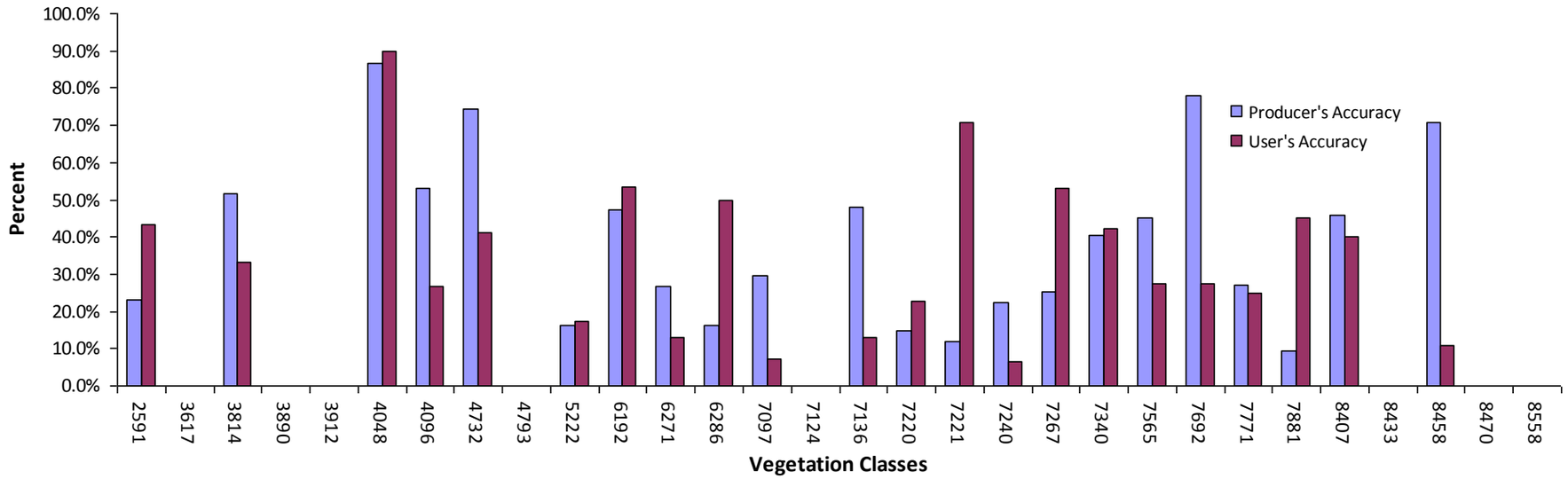

Figure 1: User's and Producer's accuracy measures for dominant vegetation types only.

Figure 2: User's and Producer's accuracy measures for the grouped analysis.