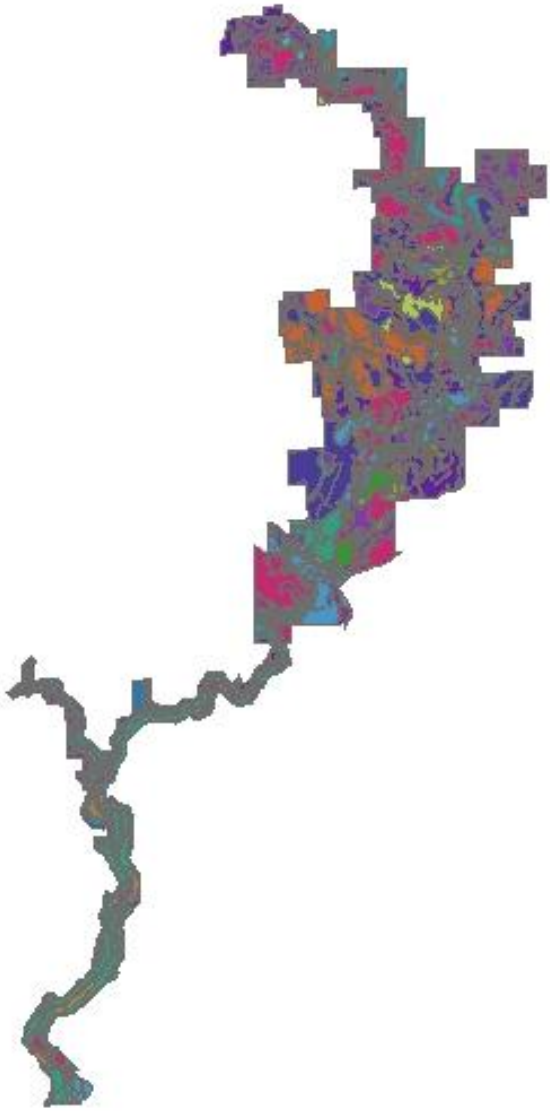
Accuracy Assessment: Little River Canyon National Preserve (LIRI)



Prepared for the National Park Service by NatureServe
Durham, NC
December 2008

NatureServe is a non-profit organization providing the scientific knowledge that forms the basis for effective conservation action.

A NatureServe Technical Report
Prepared for the National Park Service under Cooperative Agreement H 5028 01 0435

Citation: Smart, L, R. Smyth,. and R. White. 2010. *Accuracy Assessment: Little River Canyon National Preserve*. NatureServe: Durham, North Carolina.

© 2010 NatureServe

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

The view and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions of policies of the U.S. Government. Mention of trade names or commercial products does not constitute their endorsement by the U.S. Government.

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.

Acknowledgements

This report was prepared in cooperation with the Cumberland Piedmont Inventory and Monitoring Network, National Park Service, Department of the Interior. Network coordinator Teresa Leibfreid quickly responded and provided support whenever issues arose that needed to be addressed, as well as assisted with field data collection. We also greatly appreciate the contributions of other NPS staff who provided time on field crews, including Mary Shew, Shawn Waddell, Terri Hogan, Steve Thomas, and Lillian Scoggins.

Marguerite Madden, Director of the Center for Remote Sensing and Mapping Science (CRMS) at the University of Georgia (UGA), Tommy Jordan, the Associate Director of CRMS, and Phyllis Jackson, a photointerpreter/ecologist at CRMS, were actively involved in the creation of the vegetation map. We're grateful for their help in providing data and answering the questions that arose in the process of conducting the accuracy assessment.

Several NatureServe Southeast staff assisted with various aspects of this accuracy assessment. We thank Regan Lyons Smyth, Carl Nordman, and Mary Russo for their assistance with assessment point selection, field data collection, data entry, and data analysis.

We further thank Alabama Natural Heritage Program's Al Schotz for his dedication to both improving the classification and collecting most of the AA point data in the field. Finally, we thank contractor Maureen Mulligan for her fieldwork and thoughtful comments on improving the final key to communities.

TABLE OF CONTENTS

Acknowledgements IV
Executive Summary 7
Introduction 9
Methods 9
Site Selection 10
Field Data Collection 10
Data Analysis 11
Results 12
Discussion 13
Key Findings: 15
References 15
Appendix A 17
Appendix B 23
Table 1: List of CEGL Codes and Associated NVC Community Type Names 23
Table 2: Contingency Matrix Considering Only Dominant Vegetation Class Matches 25
Table 3: Error Summaries Using Dominant Vegetation Only 26
Table 4: Contingency Matrix for Best Match Considering Grouped Classes and Dominant, Secondary, and Tertiary Vegetation Class Matches 27
Table 5: Error Summaries Using the Combined Vegetation Classes 28
Table 6: GRTS-derived Weights Assigned to Each Mapped Vegetation Class 29
Appendix C 30
Figure 1: User's and Producer's accuracy measures for initial analysis. 30
Figure 2: User's and Producer's accuracy measures for the grouped analysis. 31

Executive Summary

This report presents an accuracy assessment for the digital vegetation map of Little River Canyon National Preserve (LIRI). Vegetation at LIRI 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-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 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 LIRI, the overall accuracy of the final map, which includes eight grouped map classes, is 73.4%, with a kappa statistic of 0.54 (54%). 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. Virginia Pine Successional Forest (CEGL002591), Early to Mid-Successional Loblolly Pine Forest (CEGL006011), Shortleaf Pine-Early Successional Forest (CEGL006327), Appalachian Low elevation Mixed Pine/Hillside Blueberry Forest (CEGL007119), and Mid to Late Successional Loblolly Pine-Sweetgum Forest (CEGL008462).

b. Rocky Bar and Shore (Alder-Yellowroot type) (CEGL003895), Southern Cumberland High-Energy River Oak Terrace Forest (CEGL004098), Successional Sweetgum Floodplain Forest (CEGL007330), and Montane Sweetgum Alluvial Flat (CEGL007880).

c. Successional Broomsedge Vegetation (CEGL004044) and Cultivated Meadow (CEGL004048).

d. Cumberland Sandstone Glade (CEGL004622) and Cumberland Sandstone Glade with extra Virginia Pine (CEGL004622x).

e. Successional Silktree Forest (CEGL007192) and Loblolly Pine-Tuliptree Successional Bottomland Forest (CEGL007546).

f. Southern Red Oak-White Oak Mixed Forest (CEGL007244), Xeric Ridgetop Chestnut Oak Forest (CEGL008431), Southeastern Interior Southern Red Oak-Scarlet Oak Forest (CEGL007247), Southern Blue Ridge Escarpment Shortleaf Pine-Oak Forest (CEGL007493), Appalachian Shortleaf Pine-Xeric Oak Forest (CEGL007500), and Appalachian Shortleaf Pine-Mesic Oak Forest (CEGL008427).

g. Cumberland Forested Acid Seep (CEGL007443), Upland Sweetgum-Red Maple Pond (CEGL007388), Southern Ridge and Valley Small Stream Hardwood Forest (CEGL008428), Cumberland Plateau Dry-Mesic White Oak Forest (CEGL008430), Southern Ridge and Valley Basic Mesic Hardwood Forest (CEGL008488), and Xeric Ridgetop Chestnut Oak Forest (CEGL008431).

h. Rocky bar and shore (Cumberland/Ridge and Valley Type) (CEGL008495), Cobblebars (COBBLE), and Water-willow Rocky Bar and Shore (CEGL004286).

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 22.7% with a kappa statistic of 0.16 (16%). 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.

<u>Key findings:</u>

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, a digital vegetation map of Little River Canyon National Preserve (LIRI) was completed 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.

Little River Canyon is a 5,543 hectare preserve that protects the nation's longest mountaintop river, which flows for almost its entire length down the middle of Lookout Mountain in northeast Alabama. The free-flowing Little River is one of the cleanest, wildest waterways in the South and its canyons are some of the deepest (183 m) in the Southeast. This is the newest park unit in either network, being authorized in 1992.

At the coarsest scale, Little River Canyon can be divided into four broad environmental types: oak-hickory forests, canyon shoulders, sandstone rock outcrops, and riparian areas. Oak-hickory forests occupy deep soils above the canyon shoulders. Downslope, shortleaf and loblolly pine are common, grading into Virginia pine on the glade-like canyon shoulders. Sandstone rock outcrops are common along the canyon shoulder and mainly harbor stunted Virginia or scrub pine. The shrub layer consists of sparkleberry, fringe tree, Georgia holly, and black gum. Riparian areas usually are narrow except in broader channels where oxbows exist, with woods of mainly red maple, beech, umbrella magnolia, sycamore, and river birch. In completing the vegetation mapping, mappers and ecologists attempted to discern the finest scale vegetation communities possible. As a consequence, vegetation at Little River Canyon 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.

An accuracy assessment was performed on the Little River Canyon National Preserve map. 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 LIRI 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 LIRI accuracy assessment, 576 points representing 28 of the 33 vegetation types identified for the park 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 LIRI (Schotz et al. 2008), 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 576 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. 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 LIRI vegetation map, which considered dominant, secondary, or tertiary vegetation types as well as several combined map classes, is 73.4% with a kappa statistic of 0.54 (54%). 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. Virginia Pine Successional Forest (CEGL002591), Early to Mid-Successional Loblolly Pine Forest (CEGL006011), Shortleaf Pine-Early Successional Forest (CEGL006327), Appalachian Low elevation Mixed Pine/Hillside Blueberry Forest (CEGL007119), and Mid to Late Successional Loblolly Pine-Sweetgum Forest (CEGL008462).

b. Rocky Bar and Shore (Alder-Yellowroot type) (CEGL003895), Southern Cumberland High-Energy River Oak Terrace Forest (CEGL004098), Successional Sweetgum Floodplain Forest (CEGL007330), and Montane Sweetgum Alluvial Flat (CEGL007880).

c. Successional Broomsedge Vegetation (CEGL004044) and Cultivated Meadow (CEGL004048).

d. Cumberland Sandstone Glade (CEGL004622) and Cumberland Sandstone Glade with extra Virginia Pine (CEGL004622x).

e. Successional Silktree Forest (CEGL007192) and Loblolly Pine-Tuliptree Successional Bottomland Forest (CEGL007546).

f. Southern Red Oak-White Oak Mixed Forest (CEGL007244), Xeric Ridgetop Chestnut Oak Forest (CEGL008431), Southeastern Interior Southern Red Oak-Scarlet Oak Forest (CEGL007247), Southern Blue Ridge Escarpment Shortleaf Pine-Oak Forest (CEGL007493), Appalachian Shortleaf Pine-Xeric Oak Forest (CEGL007500), and Appalachian Shortleaf Pine-Mesic Oak Forest (CEGL008427).

g. Cumberland Forested Acid Seep (CEGL007443), Upland Sweetgum-Red Maple Pond (CEGL007388), Southern Ridge and Valley Small Stream Hardwood Forest (CEGL008428), Cumberland Plateau Dry-Mesic White Oak Forest (CEGL008430), Southern Ridge and Valley Basic Mesic Hardwood Forest (CEGL008488), and Xeric Ridgetop Chestnut Oak Forest (CEGL008431).

h. Rocky bar and shore (Cumberland/Ridge and Valley Type) (CEGL008495), Cobblebars (COBBLE), and Water-willow Rocky Bar and Shore (CEGL004286).

A stricter analysis, which considered dominant, secondary, or tertiary vegetation types but no combined map classes, produced an overall accuracy of 22.7% with a kappa statistic of 0.16 (16%) (Appendix B, Table 3).

Confidence intervals for user's and producer's accuracy were not calculated for LIRI 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 2-3 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 Little River Canyon 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 Successional Broomsedge Vegetation (CEGL004044), the Shortleaf Pine-Early Successional Forest (CEGL006327), the Southern Red Oak-White Oak Mixed Forest (CEGL007244), the Southern Blue Ridge Escarpment Shortleaf Pine-Oak

Forest (CEGL007493), the Appalachian Shortleaf Pine-Mesic Oak Forest (CEGL008427), and the Mid to Late Successional Loblolly Pine-Sweetgum Forest (CEGL008462) to list a few. A complete list of user's and producer's accuracies for the original mapped classes can be found in Appendix B, Table 3.

Low map accuracies can arise from a variety of sources of error. One source that contributes most to the mapping/accuracy assessment error is the temporal difference between the period of mapping and the period of the accuracy 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 LIRI. 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 at Little River Canyon 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 possibility of assessing the wrong polygon/vegetation type. As a result, GPS error may have contributed significantly to the lower accuracies for LIRI.

While the accuracy assessment is intended to provide a measure of vegetation map reliability and associated map classes, the reader should be aware that error is also inherent in the field assessment of evaluation points. The overall accuracy of the Little River Canyon 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 LIRI 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 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 LIRI.

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 LIRI 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.

References

Cohen, J. 1960. A coefficient of agreement for nominal scales, Educational and Psychological Measurement 20: 37–46.

Environmental Systems Research Institute (ESRI), National Center for Geographic Information and Analysis, and The Nature Conservancy. 1994. NBS/NPS Vegetation Mapping Program: Accuracy Assessment Procedures. Prepared for the United States Department of Interior, National Biological Survey and National Park Service. Washington, D.C.

Foody, G. M. 1992. On the compensation for chance agreement in image classification accuracy assessment. Photogrammetric Engineering and Remote Sensing. 58: 1459-1460.

Grossman, D.H., D. Faber-Langendoen, A.S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K.D. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. International classification of ecological communities: Terrestrial vegetation of the United States. Volume I. The national vegetation classification system: Development, status, and applications. The Nature Conservancy, Arlington, VA.

Jordan, T. and M. Madden. 2008. Digital Vegetation Maps for the NPS Cumberland-Piedmont I&M Network. Athens, GA: The University of Georgia, Center for Remote Sensing and Mapping Science, Department of Geography.

NatureServe. 2004. International Ecological Classification Standard: Terrestrial Ecological Classifications. NatureServe Central Databases. Arlington, VA. U.S.A. Data current as of March 29, 2005.

NatureServe. 2007. Procedure for Selecting Assessment Points: Guilford Courthouse Accuracy Assessment Workshop. Durham, North Carolina: NatureServe.

Olsen, T. and T. Kincaid. 2009 Package 'spsurvey': Spatial Survey Design and Analysis.

Schotz, A., M. Hall, and R.D. White, Jr. 2006. Vascular Plant Inventory and Ecological Community Classification for Russell Cave National Monument. Durham, North Carolina: NatureServe.

Townsend, P. A. 2000. A quantitative fuzzy approach to assess mapped vegetation classifications for ecological applications. Remote Sensing of Environment 72:253-267.

Appendix A

Key to the National Vegetation Classification (NVC) Associations which occur, or potentially occur, at Little River Canyon National Preserve

NatureServe
April 2009

Associations which are documented by NatureServe from Little River Canyon are in **bold type**.
Those which are potential, but undocumented for any of the plots in this project, are in normal type.
Associations highlighted in yellow are vegetation map units used by UGA – CRMS.
Those associations which were not mapped, are noted in bold before the name. For each association, the common name is given, with the Element Code in brackets [CEGL00####].

1. Communities in river or on floodplain of river or creek tributaries **2**

1. Upland communities or wetland communities isolated from river or creek tributaries (such as depression ponds) **13**

2. Shrublands, herbaceous, or sparse herbaceous communities **3**

2. Forests or woodlands, stands dominated by trees..... **7**

3. Aquatic community regularly inundated, becoming dry only during extreme drought; often dominated by *Justicia americana* and frequently contains the rare Kral's water-plantain (*Sagittaria secundifolia*) as a secondary species..... **(This association not mapped) Water-Willow Rocky Bar and Shore [CEGL004286]**

3. Community occasionally inundated by water but is usually above water's edge **4**

4. Fern-dominated community primarily limited as riverside occurrences that are patchy and very small **(This association not mapped) Cumberland Royal Fern Seep [CEGL008404]**

4. Shrub-dominated community **5**

5. Dense exotic shrub cover along creeks dominated by *Ligustrum sinense* ..... **(This association not mapped) Privet Shrubland [CEGL003807]**

5. Sparse to dense shrub cover not dominated by *Ligustrum sinense*, but comprised of various native species **6**

6. Dense shrub cover of *Alnus serrulata* with *Xanthorhiza simplicissima* in low shrub layer below. Generally occurs as a thin linear community along the river bank ..... **Rocky Bar and Shore (Alder-Yellowroot type) [CEGL003895]**

6. Sparse to relatively dense shrub cover of various shrubs including *Alnus serrulata*, *Kalmia latifolia*, *Rhododendron* spp., *Vaccinium elliottii*, *Fothergilla major*, *Viburnum dentatum*, and *Cephalanthus occidentalis*, among others (sometimes very sparse where little soil exists, with as low as 10% cover and 90% exposed rock). Most frequently occurs along banks or on boulder-strewn areas in the middle of channels, but occasionally occupies the understory of transitional oak forest types on the lower portions of steep stream banks and old beaver impoundments ..... **Rocky Bar and Shore (Cumberland / Ridge and Valley Type) [CEGL008495]**

7. Seepage forest dominated by *Acer rubrum* and *Quercus alba* along flat secondary waterways, where the soil is typically saturated or at least moist as a result of a continuous supply of groundwater **Cumberland Forested Acid Seep [CEGL007443]**

7. Forest on occasionally flooded terraces or floodplains along Little River or one of its main tributaries **8**

8. Woodland presently maintained by mowing and/or fire with approximately 40% coverage of canopy species and nearly continuous herbaceous cover. This community contains oak species usually associated with sandy coastal plain habitats such as *Quercus margarettiae* and *Quercus incana* and also has high levels of *Carya pallida*. In addition, this community contains a prominence of *Pinus echinata* and *Pinus taeda* in the canopy ..... **Loblolly Pine – Shortleaf Pine Managed Woodland [CEGL003618]**

8. Forest with greater than 60% canopy cover and sparse to moderate herbaceous cover **9**

9. Forest dominated by *Pinus taeda* and occasionally *Pinus echinata* and/or *Pinus virginiana* (with at least 40% canopy cover of pine), with *Liriodendron tulipifera* occupying at least 10% of the canopy. The canopy can also contain substantial *Fagus grandifolia* and other mesophytic tree species. There may be a lot of shrub cover, and moderate herbaceous cover (0-25%). Similar to CEGL004098 (below), but with more *Pinus taeda*. ..... **Loblolly Pine – Tuliptree Successional Bottomland Forest [CEGL007546]**

9. Forest not dominated by *Pinus taeda* (less than 40% in canopy) **10**

10. Forest dominated by the exotic species, silktree (*Albizia julibrissin*) ..... **Successional Silktree Forest [CEGL007192]**

10. Forest not dominated by silktree, but instead dominated by native species **11**

11. Forest dominated by *Liriodendron tulipifera* and/or *Liquidambar styraciflua* **12**

11. Forest dominated by oaks (usually a combination of *Quercus alba*, *Q. velutina*, *Q. coccinea*, and/or *Q. falcata* comprise at least 40% of the canopy). Other species include pines and mesic species such as *Liriodendron tulipifera* and *Liquidambar styraciflua*. Shrub layer generally has at least 40% total cover dominated by *Kalmia latifolia*. Herbaceous cover varies, but usually has 10% or more cover of *Chasmanthium sessiliflorum* ..... **Southern Cumberland High-Energy River Oak Terrace Forest [CEGL004098]**

12. Successional community that includes young *Liriodendron tulipifera* and/or *Liquidambar styraciflua* stands along creeks and rivers within the park ..... **Successional Sweetgum Floodplain Forest [CEGL007330]**

12. Late successional/older forest occurs in bottomland areas along Little River that were cultivated 30-80 years ago and now contains large amounts of *Liriodendron tulipifera*, *Liquidambar styraciflua*, and *Magnolia acuminata*. Most examples of this type are dominated by *Liriodendron tulipifera* and are flat! Occasionally *Quercus falcata* and *Quercus alba* are co-dominants **(This association not mapped) Montane Sweetgum Alluvial Flat [CEGL007880]**

13. Wetland (isolated bog or ephemeral pond) **14**

13. Non-wetland **15**

14. Ephemeral pond, either natural or caused by backup from a backcountry road. Canopy includes *Liquidambar styraciflua* (usually more than 50% cover) with *Pinus taeda* (about 25%) and *Nyssa sylvatica* or *Acer rubrum* (about 25%) serving as secondary species ..... **Upland Sweetgum – Red Maple Pond [CEGL007388]**

14. Swale, not a pond, containing pitcher-plants (*Sarracenia oreophila*) and other wetland species, though the area is dry for part of the year. Examples may contain *Pinus taeda* and various hardwoods in the canopy, especially if not regularly burned. Sphagnum is present in the herbaceous layer – bog**Southern Appalachian Low Mountain Seepage Bog [CEGL003914]**

15. Forested (forest or woodland), stand dominated by trees **16**

15. Non-forested (vine dominated, herb dominated or sparsely vegetated) **33**

16. Pine-dominated or co-dominated community (usually more than 40% pine in the canopy) **17**

16. Hardwood-dominated (at least 60% hardwoods in the canopy) **25**

17. Even aged stand dominated almost exclusively by young-mid aged pine trees (generally less than 50 years of age) with a poorly developed herbaceous layer. Successional. **18**

17. Uneven aged stand dominated by pines, but usually with a significant component of oaks. Generally tree ages are greater than 60 years **22**

18. Dominated by either *Pinus echinata* or *Pinus taeda* **20**

18. Dominated by *Pinus virginiana* **19**

19. Dominated by *Pinus virginiana* (at least 50% of the canopy). Usually very dense trees on the edge of the canyon where disturbance may have recently occurred. ..... **Virginia Pine Successional Forest [CEGL002591]**

19. Flat to moderately steep rocky sandstone glades, with sparse to continuous herbaceous vegetation and substantial areas with trees and scrub *Pinus virginiana* on sandstone ..... **Cumberland Sandstone Glade with extra Virginia Pine [CEGL004622x]**

20. Virtually 100% *Pinus echinata* with a scattering of oaks and successional vegetation. Occasionally shared dominance of *Pinus virginiana* or *Pinus taeda*. ..... **Shortleaf Pine – Early Successional Forest [CEGL006327]**

20. Dominated by *Pinus taeda* usually with some hardwoods in the canopy or subcanopy **21**

21. Strongly codominated by *Pinus taeda* and *Liquidambar styraciflua*, other hardwoods may be present**Mid to Late Successional Loblolly Pine-Sweetgum Forest [CEGL008462]**

21. Canopy greater than 60% *Pinus taeda*, which is the monospecific canopy dominant often with various amounts of *Liquidambar styraciflua* and/or *Acer rubrum var. rubrum* or other hardwoods in the subcanopy..... **Early to Mid-Successional Loblolly Pine Forest [CEGL006011]**

22. Forest stand comprised of at least 25% *Pinus echinata* in the canopy.....**23**

22. Community comprised of less than 25% *Pinus echinata* in the canopy. Most examples exist along the rim of the canyon and exposed south-facing slopes usually and can coexist of anywhere from 30% to 100% canopy coverage mostly of *Pinus virginiana*, but also occasionally with a *Quercus prinus* component and a prominence of *Pinus taeda* in disturbed examples. Some examples are dominated by *Vaccinium arboreum* (near 100% cover) or *Deschampsia flexuosa* (near 100% cover) in the shrub and herb layers, respectively; *Quercus marilandica* can often be a small part of the canopy..... ..... **Appalachian Low Elevation Mixed Pine / Hillside Blueberry Forest [CEGL007119]**

23. *Pinus echinata* and often *Pinus virginiana* usually constitute more than 50% of the canopy with *Quercus alba*, *Quercus rubra*, and *Quercus velutina*, but without a large component of dry-site oaks such as *Quercus coccinea* or *Quercus prinus*. The understory is often heavily invaded by *Acer rubrum* in fire suppressed areas. Shrub and herb layers are very sparse except in some cases where *Piptochaetium avenaceum* is dominant. *Carya alba* is sometimes also present in the canopy**Appalachian Shortleaf Pine – Mesic Oak Forest [CEGL008427]**

23. Forest comprised of at least 25% *Pinus echinata* and less than 10% *Pinus virginiana*.....**24**

24. Forest comprised of at least 25% *Pinus echinata* and between 0 and 50% *Quercus prinus*, *Quercus falcata*, *Quercus coccinea*, or *Quercus stellata*, also without a thick component of *Oxydendrum arboreum* in the understory and dense stands of *Vaccinium pallidum* in the shrub layer. Usually on the most exposed slopes, but occasionally occurs on other aspects in less extreme situations and can occur on low slopes on north aspects..... .....**Southern Blue Ridge Escarpment Shortleaf Pine – Oak Forest [CEGL007493]**

24. *Pinus echinata*-dominated forest, with *Quercus alba*, *Quercus coccinea*, *Quercus falcata*, and/or *Quercus stellata* serving as co-dominants. Similar to CEGL007493 above, but contains a prominence (>75%) of dry-site herbs in the understory, generally as a result frequent burning or high grading. Examples are confined to broad ridges and upper slopes..... .....**Appalachian Shortleaf Pine – Xeric Oak Forest [CEGL007500]**

25. Forest of dry to mesic moderately protected to exposed ridgetops and upper ravines on acidic soils.....**26**

25. Forest of mesic lower to mid slopes or of bouldery steep streams cascading down the slopes (or occasionally protected slopes just below the cliff line). Canopy is composed of at least some mesophytic forest species.....**31**

26. Contains greater than 50% *Quercus prinus* and/or *Quercus coccinea* in the canopy.....**27**

26. Contains less than 50% *Quercus prinus* and/or *Quercus coccinea* in the canopy.....**30**

27. Mesic north- to east-facing slopes or protected slopes just below the cliff line dominated by *Quercus prinus* in the canopy and at least 25% shrub cover of either *Rhododendron catawbiense* or *Kalmia*

latifolia. Sometimes *Pinus* spp. or *Liriodendron tulipifera* dominate. *Rhododendron catawbiense* is always present..... **Piedmont Beech Heath Bluff [CEGL004539]**

27. *Quercus prinus* and/or *Quercus coccinea*-dominated forest containing less than 25% *Rhododendron catawbiense* and/or *Kalmia latifolia* in the shrub layer **28**

28. Dry-mesic slope forest often with *Quercus alba* as a canopy species and *Hydrangea quercifolia* and/or *Viburnum acerifolium* in the shrub layer ..... **Cumberland Plateau Dry-Mesic White Oak Forest [CEGL008430]**

28. Dry forest of ridgetops and upper slopes seldom, if ever, contains *Hydrangea quercifolia* and/or *Viburnum acerifolium* in the shrub layer **29**

29. Xeric ridgetop or upper slope forest with *Quercus prinus* and/or *Quercus coccinea*, with *Quercus alba* dominating in some examples. Herb layer varies from sparse to heavy depending upon canopy closure. *Vaccinium pallidum* usually present – some *Pinus echinata* but less than 40% - *Piptochaetium avenaceum* and/or *Danthonia spicata* can form a significant cover where fire has been present. High graded examples often have a dense herbaceous cover..... **Xeric Ridgetop Chestnut Oak Forest [CEGL008431]**

29. Dry-mesic ridgetops and gentle upper slopes co-dominated by a partially open to sparse cover of *Quercus falcata*, *Quercus coccinea*, and *Quercus prinus* in the canopy, with a dense understory comprised of *Quercus marilandica*, *Carya* spp., and sometimes *Quercus stellata* and *Fagus grandifolia* (namely in fire-excluded examples) in the understory..... **(This association not mapped)** ..... **Southeastern Interior Southern Red Oak – Scarlet Oak Forest [CEGL007247]**

30. Community found on flat to gently sloping land in the backcountry. Dominated by a combination of *Quercus falcata*, *Quercus velutina*, *Quercus alba*, with an occasional *Quercus stellata* and *Quercus rubra*. This community is sometimes part of a bog complex where an open version of this form, thinned out by fire, surrounds the bog ..... **Southern Red Oak – White Oak Mixed Oak Forest [CEGL007244]**

30. Mesic slope forest dominated by *Quercus alba* and/or various *Carya* spp. in the canopy and with *Hydrangea quercifolia* and/or *Viburnum acerifolium* in the shrub layer. This is the most common slope forest in the preserve and exhibits a great deal of variation in the canopy, shrub, and herb layers**Cumberland Plateau Dry-Mesic White Oak Forest [CEGL008430]**

31. Community usually a very narrow band of vegetation adjacent to streams and/or occupies boulderfields, occasionally occupying lower slopes that dissect the canyon walls or where streams meet terraces. *Quercus alba* and/or *Quercus rubra* usually >25%, along with mesophytic species such as *Fagus grandifolia* in the canopy. The subcanopy nearly always contains *Acer leucoderme* and *Calycanthus floridus* (at least 10% cover) in the shrub layer; the herb layer is diverse with at least 20% cover. *Hydrangea quercifolia* and *Viburnum acerifolium* are generally absent. Sometimes a heavy *Pinus taeda* component is present, which may intergrade with CEGL008430 on steep slopes adjacent to stream beds..... **Southern Ridge and Valley Small Stream Hardwood Forest [CEGL008428]**

31. Community broad, neither consisting of a narrow band of vegetation along streams nor confined to boulderfields.....**32**

32. Diverse hardwood canopy that includes *Quercus rubra*, *Tilia americana* var. *heterophylla*, *Betula lenta*, and *Liriodendron tulipifera*, along with the occasional *Quercus alba*. *Tilia* and/or *Betula* are usually key indicators, as the herbaceous understory, which tends to be comprised of species that prefer basic

soils. This forest occupies bands of limestone geology on the lower to mid slopes within the southern portion of the canyon ..... **Southern Ridge and Valley Basic Mesic Hardwood Forest [CEGL008488]**

32. Mesic north- to east-facing slopes or protected slopes just below the cliff line dominated by *Quercus prinus* in the canopy and at least 25% shrub cover comprised of either *Rhododendron catawbiense* or *Kalmia latifolia*. Sometimes various *Pinus* spp. or *Liriodendron tulipifera* dominate. *Rhododendron catawbiense* is always present ..... **Piedmont Beech Heath Bluff [CEGL004539]**

33. Vine-dominated vegetation, dominated by *Wisteria sinensis*, *Wisteria floribunda,* or very often hybrids of these two exotic vines, which overtop other vegetation and dominate areas ..... **Wisteria Vineland [CEGL008568]**

33. Vegetation not vine dominated, sparse and rocky or sandy or grass dominated and may have some Virginia Pine (*Pinus virginiana*) **34**

34. Grasslands of pastures or old fields **35**

34. More natural stands, rocky or sandy, may have some Virginia Pine (*Pinus virginiana*) **36**

35. Successional old field dominated by *Andropogon* spp. and other weedy herbaceous vegetation ..... **Successional Broomsedge Vegetation [CEGL004044]**

35. Pasture or old field dominated by Fescue, i.e. *Lolium* (*arundinaceum, pratense*) and other weedy herbaceous vegetation ..... **Cultivated Meadow [CEGL004048]**

36. Terrain consisting of overhangs and vertical rock faces called "rockhouses," sparsely vegetated with *Heuchera parviflora* var. *parviflora* serving as an indicator species ..... **(This association not mapped) Cumberland Acidic Cliff and Rockhouse [CEGL004301]**

36. Flat to moderately steep rocky sandstone glades, with sparse to continuous herbaceous vegetation and may have some Virginia Pine (*Pinus virginiana*) **37**

37. Characterized by some sparse vegetation, some herbaceous cover, and substantial areas with trees and scrub *Pinus virginiana* on sandstone ..... **Cumberland Sandstone Glade with extra Virginia Pine [CEGL004622x]**

37. Terrain relatively level to moderately steep (about 30% slope), characterized by sparse vegetation, nearly 100% herbaceous cover, and contains areas with scrub *Pinus virginiana* on sandstone**Cumberland Sandstone Glade [CEGL004622]**

Appendix B

Table 1: List of CEGL Codes and Associated NVC Community Type Names	
CEGL Code Name (in numerical order)	
2591	Virginia Pine Successional Forest
3618	Loblolly Pine-Shortleaf Pine Managed Woodland
3895	Rocky Bar and Shore (Alder-Yellowroot type)
3914	Southern Appalachian Low Mountain Seepage Bog
4044	Successional Broomsedge Vegetation
4048	Cultivated Meadow
4098	Southern Cumberland High-Energy River Oak Terrace Forest
4286	Water-Willow Rocky Bar and Shore (this association not mapped)
4539	Piedmont Beech Heath Bluff
4622	Cumberland Sandstone Glade
6011	Early to Mid-Successional Loblolly Pine Forest
6327	Shortleaf Pine-Early Successional Forest
7119	Appalachian Low Elevation Mixed Pine/Hillside Blueberry Forest
7192	Successional Silktree Forest
7244	Southern Red Oak-White Oak Mixed Forest
7247	Southeastern Interior Southern Red Oak-Scarlet Oak Forest
7330	Successional Sweetgum Floodplain Forest
7388	Upland Sweetgum-Red Maple Pond
7443	Cumberland Forested Acid Seep
7493	Southern Blue Ridge Escarpment Shortleaf Pine-Oak Forest
7500	Appalachian Shortleaf Pine-Xeric Oak Forest
7546	Loblolly Pine-Tuliptree Successional Bottomland Forest
7880	Montane Sweetgum Alluvial Flat (this association not mapped)
8427	Appalachian Shortleaf Pine-Mesic Oak Forest
8428	Southern Ridge and Valley Small Stream Hardwood Forest
8430	Cumberland Plateau Dry-Mesic White Oak Forest
8431	Xeric Ridgetop Chestnut Oak Forest
8462	Mid to Late Successional Loblolly Pine-Sweetgum Forest
8488	Southern Ridge and Valley Basic Mesic Hardwood Forest
8495	Rocky Bar and Shore (Cumberland/Ridge and Valley Type)
8568	Wisteria Vineland
4622x	Cumberland Sandstone Glade with Extra Virgina Pine

Table 2: Contingency Matrix Considering Only Dominant Vegetation Class Matches

Mapped Vegetation Classes	Vegetation Classes Observed in the Field																																
	2591	3618	3895	3914	4044	4048	4098	4286	4539	4622	6011	6327	7119	7192	7244	7247	7330	7388	7443	7493	7500	7546	7880	8427	8428	8430	8431	8462	8488	8495	8568	4622x	COBBLE	Totals
2591	11								1		3		3		2					2	1			3		1	4			1		3		35
3618		1																																1
3895			0				4										1					1	3		2					1				12
3914				2																														2
4044					0	1					1																							2
4048						0																												n/a
4098							17		1		2		1		2		6				1	1			3	3								37
4286								0																										n/a
4539									12				1									1		1	3	3								21
4622	1				1					2			1																			4		9
6011	4										13	3	3		3					2	1			1		1		3						34
6327	4					1					2	2	3		1					2	10			2		1	2							30
7119	4								2				11								2			6		3	1							29
7192														0	0							2												2
7244							1								4	0				2					1	3	16							27
7247																0																		n/a
7330	1						1										1					1	2		3								1	10
7388																	1	0			3													4
7443				2			1						1		5			5	5			1			8		1							29
7493															1					1	11			1		4	13							31
7500															4					3	9			1			15	1						33
7546							3										1					12	4		1		1			5				27
7880																							0											n/a
8427		1		1	1				1				1		4	1				3	11			2		1	4	1						32
8428							2		1						5			1							8	9	2							28
8430									1						4		1			1	1				2	18	4		1					33
8431	1								1						4					1	4			1			15							27
8462	1	1							1		3	3	1		6	1					4			5			2	1						29
8488									2																9	13			6					30
8495								1														1								5			6	13
8568																															1			1
4622x										2			2												2	1						1		8
COBBLE																																	0	n/a
Totals	27	3	n/a	5	2	2	29	1	23	4	24	8	28	n/a	45	2	11	6	5	17	58	20	9	23	42	61	80	6	7	12	1	8	7	576

Table 3: Error Summaries Using Dominant Vegetation Only				
Map Class	Producer's Accuracy		User's Accuracy	
	Accuracy	N	Accuracy	N
2591	12.0%	27	31.4%	35
3618	0.3%	3	100.0%	1
3895	n/a	n/a	0.0%	12
3914	0.9%	5	100.0%	2
4044	0.0%	2	0.0%	2
4048	0.0%	2	n/a	n/a
4098	27.3%	29	45.9%	37
4286	0.0%	1	n/a	n/a
4539	7.0%	23	57.1%	21
4622	51.2%	4	22.2%	9
6011	22.6%	24	38.2%	34
6327	51.8%	8	6.7%	30
7119	46.0%	28	37.9%	29
7192	n/a	n/a	0.0%	2
7244	16.8%	45	14.8%	27
7247	0.0%	2	n/a	n/a
7330	1.6%	11	10.0%	10
7388	0.0%	6	0.0%	4
7443	100.0%	5	17.2%	29
7493	8.2%	17	3.2%	31
7500	2.9%	58	27.3%	33
7546	75.4%	20	44.4%	27
7880	0.0%	9	n/a	n/a
8427	24.2%	23	6.3%	32
8428	39.0%	42	28.6%	28
8430	51.0%	61	54.5%	33
8431	24.5%	80	55.6%	27
8462	20.4%	6	3.4%	29
8488	46.4%	7	20.0%	30
8495	15.5%	12	38.5%	13
8568	100.0%	1	100.0%	1
4622x	4.4%	8	12.5%	8
COBBLE	0.0%	7	n/a	n/a

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 for Best Match Considering Grouped Classes and Dominant, Secondary, and Tertiary Vegetation Class Matches

	Vegetation Classes Observed in the Field													
Mapped Vegetation Classes	3618	3914	4286	4539	8568	2591/6011/6327/7119/8462	3895/4098/7330/7880	4044/4048	4622/4622x	7192/7546	7244/8431/7247/7493/7500/8427	7443/7388/8428/8430/8488/8439	8495/COBBLE/4286	Totals
3618	1													1
3914		2												2
4286			0											n/a
4539				12		1				1	1	6		21
8568					1									1
2591/6011/6327/7119/8462	1			4		79		1	3		58	6	1	153
3895/4098/7330/7880				1		4	37			3	2	11	2	60
4044/4048						1		1						2
4622/4622x						4		1	9			3		17
7192/7546							8			14	1	1	1	25
7244/8431/7247/7493/7500/8427	1	1		2		3		1			142	9		159
7443/7388/8428/8430/8488/8439		2		4		1	4			1	21	85		118
8495/COBBLE/4286			1							1			15	17
Totals	3	5	1	23	1	93	49	4	12	20	225	121	19	576

Table 5: Error Summaries Using the Combined Vegetation Classes				
Map Class	**Producer's Accuracy**		**User's Accuracy**	
	Accuracy	**N**	**Accuracy**	**N**
3618	0.3%	3	100.0%	1
3914	0.9%	5	100.0%	2
4286	0.0%	1	n/a	n/a
4539	7.0%	23	57.1%	21
8568	100.0%	1	100.0%	1
2591/6011/6327/7119/8462	89.5%	93	44.1%	153
3895/4098/7330/7880	73.6%	49	81.3%	60
4044/4048	31.3%	4	50.0%	2
4622/4622x	34.5%	12	53.3%	17
7192/7546	76.0%	20	52.4%	25
7244/8431/7247/7493/7500/8427	76.4%	225	86.3%	159
7443/7388/8428/8430/8488/8431	71.4%	121	70.6%	118
8495/COBBLE/4286	64.5%	19	92.9%	17

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 Assigned to Each Mapped Vegetation Class	
Mapped Class	GRTS-Assigned Weight
2591	11302.32134
3618	879.255739
3895	810.3787711
3914	877.5907264
4044	9850.577673
4098	6009.369742
4539	4533.293969
4622	2018.926127
4622x	1921.084953
6011	10704.60331
6327	117331.7298
7119	53666.09167
7192	256.157755
7244	142479.9994
7330	2721.497807
7388	2071.794051
7443	4690.592876
7493	129118.6412
7500	18734.73473
7546	5276.456422
8427	190516.367
8428	51488.65614
8430	125283.6066
8431	131527.7895
8462	62019.51428
8488	18080.3605
8495	1409.074318
8568	1092.078992

Appendix C

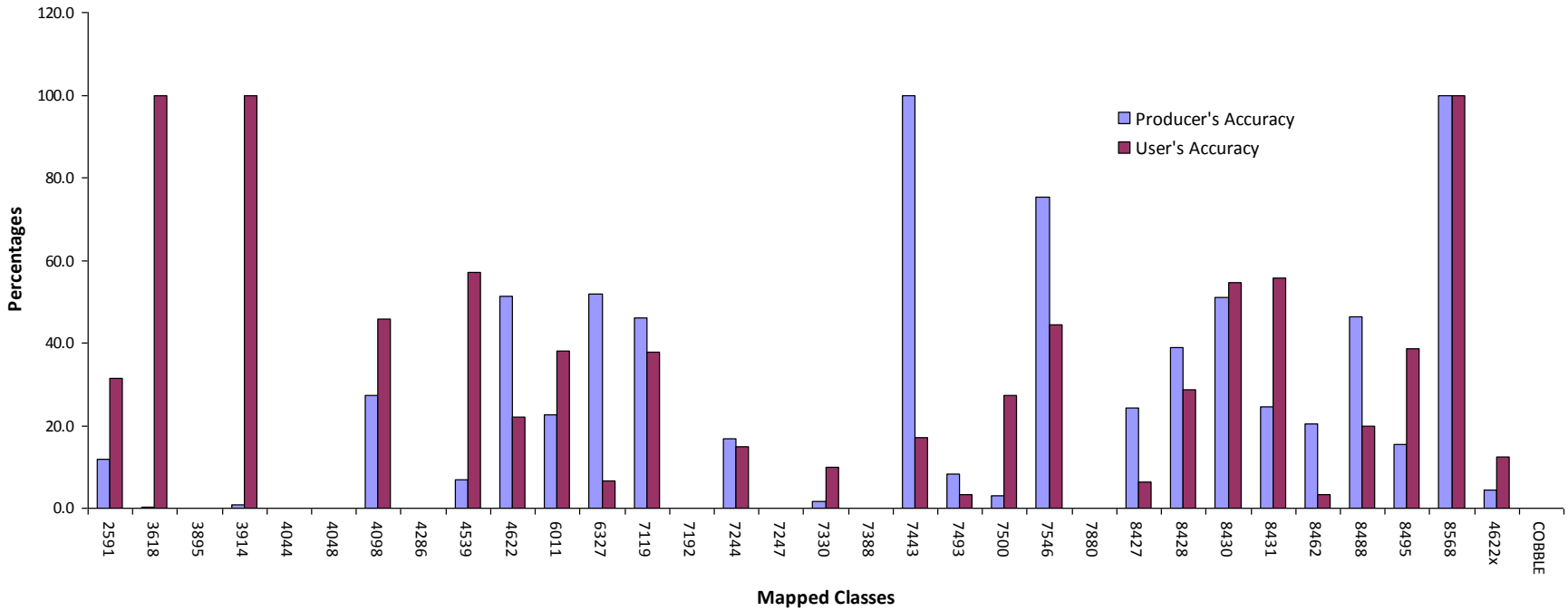


Figure 1: User's and Producer's accuracy measures for initial analysis.

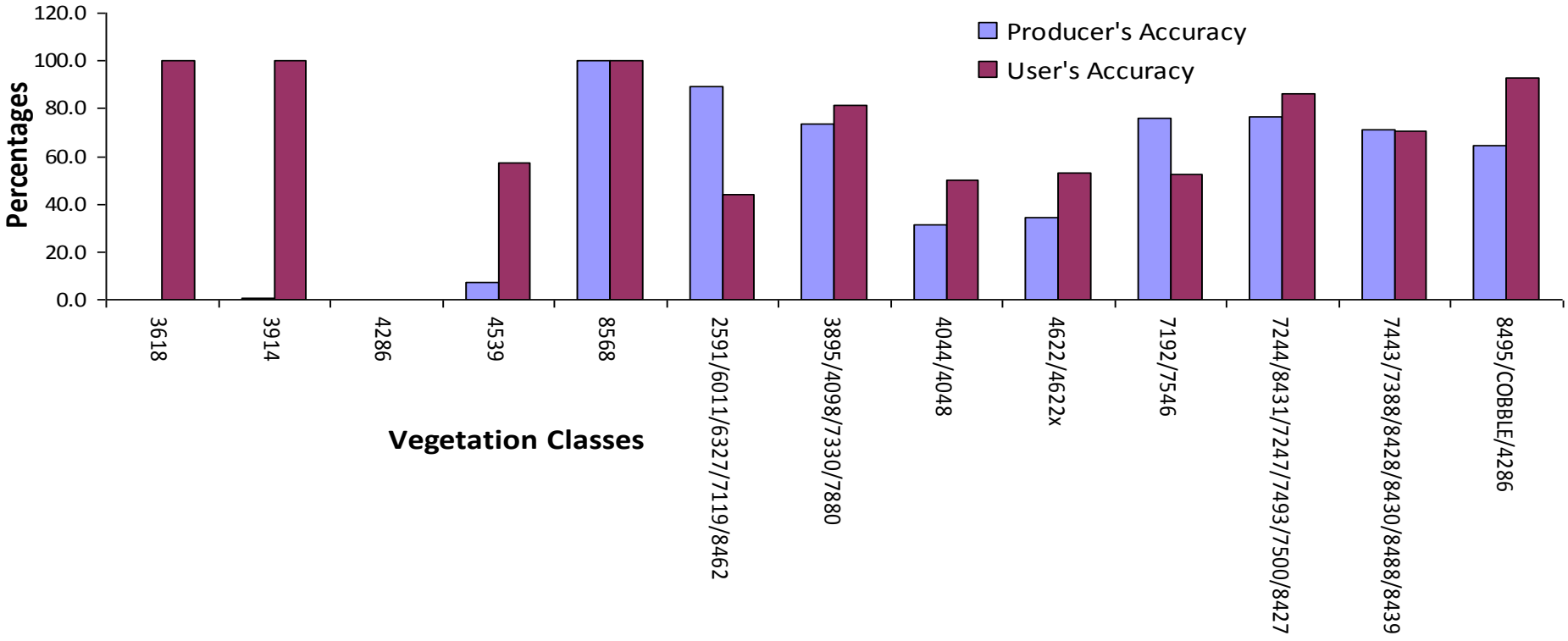


Figure 2: User's and Producer's accuracy measures for the grouped analysis.