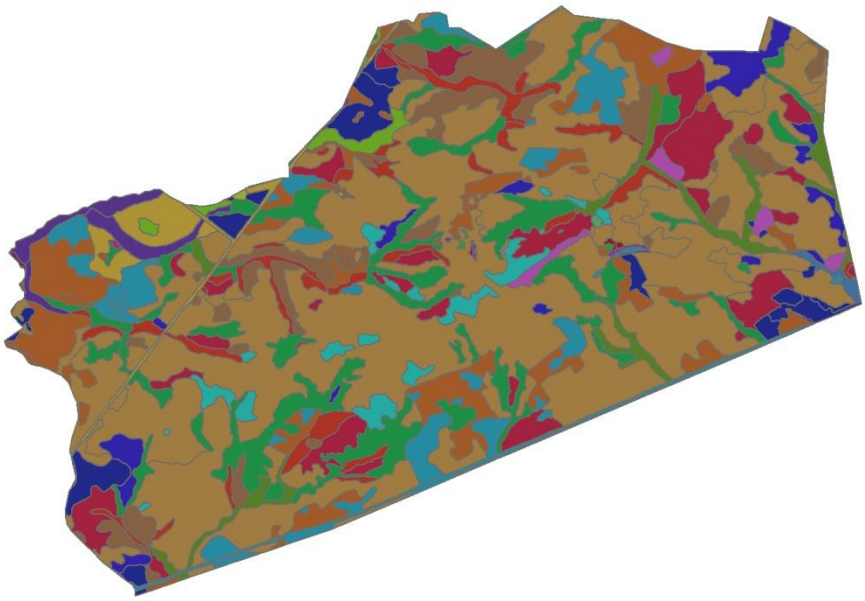
Accuracy Assessment:
Kings Mountain National Military Park



Prepared for the National Park Service by NatureServe
Durham, NC
February 2010

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: Govus, Thomas E., Regan Lyons Smyth, Rickie D. White, Jr. 2010. *Accuracy Assessment: Kings Mountain National Military Park*. 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

Our team prepared this report in cooperation with the Cumberland Piedmont Inventory and Monitoring Network, National Park Service, Department of the Interior. Network coordinator Teresa Leibfreid provided technical support whenever issues arose that needed to be addressed. Shepard McAninch, ecologist for the Cumberland Piedmont I & M Network, and Steve Thomas, Long-term Ecological Monitoring (LTEM) coordinator for Cumberland Piedmont Network, also assisted with field data collection.

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, Kyung-Ah Koo, a student working for CRMS, and Mark Whited, 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 other NatureServe Southeast staff assisted with various aspects of this accuracy assessment. We would like to thank Milo Pyne and Lindsey Smart for their assistance with assessment point selection, field data collection, data entry, and data analysis.

Table of Contents

Acknowledgements iii

Executive Summary 5

Introduction 7

Methods 7

Results 10

Discussion 11

References 15

Appendix A: Revised Vegetation Classification Key 17

Appendix B: Contingency Matrices and Accuracy Tables 24

Table 2a: Contingency Matrix Using Mapped Dominant, Secondary, or Tertiary Vegetation (Best Match), plus Combined Map Classes, and accounting for GPS error 25

Table 2b: Accuracy Calculations Using Mapped Dominant, Secondary, or Tertiary Vegetation (Best Match), plus Combined Map Classes, and accounting for GPS error 26

Table 3a: Contingency Matrix Using Mapped Dominant, Secondary, or Tertiary Vegetation (Best Match) 27

Table 3b: Accuracy Calculations Using Mapped Dominant, Secondary, or Tertiary Vegetation (Best Match) 28

Table 4a: Contingency Matrix Using Mapped Dominant Vegetation Only 29

Table 4b: Accuracy Calculations Using Mapped Dominant Vegetation Only 30

Executive Summary

This report presents an accuracy assessment of the digital vegetation map of Kings Mountain National Military Park (KIMO). Vegetation at KIMO was mapped by The University of Georgia Center for Remote Sensing and Mapping Science (Jordan and Madden 2008) with ecological consultation assistance from NatureServe. The mapping was conducted as part of the National Park Service Vegetation Mapping Program.

Our team assessed the map accuracy by comparing the mapped vegetation type to the field verified vegetation type (the field "call") at randomized evaluation points. We chose the evaluation points prior to field work so as to represent the full range of map classes in the park in a statistically valid manner. We calculated accuracy for each individual map class, as well as an overall accuracy for all map classes combined.

It is important to point out that the accuracy assessment process is not meant exclusively to judge the performance of the mapper or the ecologists on the project since error can be created at many points throughout the vegetation classification and mapping process. Sources of error for the mapping project include not just "remote sensing error" but also "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. Many errors are also caused by the constraints imposed by current technology: even the best photointerpreters cannot distinguish between species with very similar leaf shape and function, such as pines. It is not possible to tease apart which of these errors 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 or ecologists.*

In an attempt to provide the most useful information possible to NPS, the University of Georgia (UGA) Team has made a strong effort to pull out the highest level of detail possible when mapping vegetation of parks. As a consequence, assessment of the finished project requires a two step approach: assessing the overall accuracy of the finest scale map produced and then combining the most "confused" map classes and determining the accuracy of the coarser scale but higher accuracy map. In this way, we are able to report our best approximation of how accurate each individual map class is but also suggest a way to combine certain map classes to produce a more reliable map at a coarser scale.

For KIMO, the overall accuracy of the final map, which includes several grouped map classes, is 78%, with a kappa statistic of 0.74 (74%). 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). Successional Broom-sedge Vegetation (CEGL004044) and Blackberry - Greenbrier Successional Shrubland Thicket (CEGL004732) – open herbaceous and shrubby successional vegetation.

b). Red-cedar Successional Forest (CEGL007124), Successional Sweetgum Forest (CEGL007216) and Interior Mid- to Late-Successional Tuliptree - Hardwood Upland Forest (Acidic Type) (CEGL007221) – successional deciduous forests.

c). Virginia Pine Successional Forest (CEGL002591) and Shortleaf Pine Early-Successional Forest (CEGL006327) – successional evergreen forests.

d). Piedmont / Ridge and Valley Small Stream Sweetgum - Tuliptree Forest (CEGL004418) and Sycamore - Sweetgum Swamp Forest (CEGL007340) – mesic stream bottom forest types.

e). Piedmont Chestnut Oak - Heath Bluff (CEGL004415) and Piedmont Dry-Mesic Oak - Hickory Forest (CEGL008475) – low slope mesic oak forests.

f). Appalachian Shortleaf Pine - Post Oak Woodland (CEGL003765), Southern Blue Ridge Escarpment Shortleaf Pine - Oak Forest (CEGL007493) and Appalachian Shortleaf Pine - Mesic Oak Forest (CEGL008427) – mixed oak and shortleaf pine forests.

g). Felsic Monadnock Forest (CEGL006281), Southern Red Oak - White Oak Mixed Oak Forest (CEGL007244) and Xeric Ridgetop Chestnut Oak Forest (CEGL008431) – upper slope dry-mesic to xeric oak forests.

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.

The strictest analysis of the data (before any combining of map classes of ecological communities 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 accuracy of the map of 44% with a kappa statistic of 0.40 (40%). This lower accuracy reflects the difficulty in differentiating the vegetation associations that were combined in the final analysis and that are similar in their composition on the ground and/or in their appearance on aerial photography. The lower accuracy may also indicate successional changes and stand-level disturbances that occurred between the time of the mapping effort and the accuracy assessment.

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 map as published by UGA. For all other users, we recommend combining map classes as specified above to allow for an overall map accuracy of approximately 80%. These actions will allow for a map that is useful for the widest audience possible while not losing potentially important fine scale detail.

Introduction

In an effort to catalog and map the biodiversity of the United States, in 1994 the National Park Service (NPS) and the U.S. Geological Survey (USGS) embarked on a collaborative vegetative mapping project with the goal of mapping 230+ National Park units (ESRI et al. 1994). As part of this national mapping initiative, a digital vegetation map of Kings Mountain National Military Park (KIMO) was created in 2004 by the University of Georgia Center for Remote Sensing and Mapping Science (Jordan and Madden 2008), in consultation with NatureServe. The mapping effort included collection of field data, aerial photograph interpretation, and polygon attribution to GIS maps.

Kings Mountain National Military Park is located in Cherokee and York counties, South Carolina (just southwest of Gastonia, North Carolina), on rugged terrain that served as an important Revolutionary War battlefield. The park's approximately 1,597 hectares (3,946 acres) are composed primarily of acidic, second growth oak forests on steep ground and successional forests on old agricultural land. Many of the forested stands are young and currently recovering from past disturbances such as cultivation and logging (White and Govus 2005). Kings Mountain National Military Park occurs in the Kings Mountain subregion of the Piedmont ecoregion (Griffith et al 2002). Vegetation at Kings Mountain was mapped and classified to the association level using the United States National Vegetation Classification (Grossman et al. 1998, White 2005), following NPS guidelines. The minimum mapping unit (MMU) was 0.5 hectare.

The accuracy assessment assigns a measure of validity to the map product and allows users to understand the reliability with which the mapped vegetation classes capture conditions on the ground. Knowing the accuracy of the map will enable 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 and the results for each map class.

Methods

Our team assessed the thematic accuracy of the map by comparing the vegetation type shown on the map to the vegetation type identified on the ground from a representative sample of evaluation points. 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, we evaluated both producer's and user's accuracy. User's accuracy is a prediction of the percentage of points mapped as a certain type, which are confirmed to belong to that mapped vegetation type when visited 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 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, this

report contains calculated measures of the overall map accuracy and contingency tables showing the frequency of confusion (i.e. misclassification) between associations.

Point Selection

We used a point-based approach to assess the accuracy of the map classes, with one or more evaluation points representing each map class. The map represents vegetation types using one or more polygons per type. We selected points from within those polygons using a stratified random sampling design, so that points were distributed across all map classes with a higher number of points placed within map classes with large areas. Because we evaluated representative points, not entire polygons, 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 KIMO accuracy assessment, we evaluated 349 points representing 22 vegetation types.

In the mapping process, UGA assigned a dominant vegetation association based on the U.S. National Vegetation Classification (NVC) for each polygon. Many polygons were also assigned secondary and/or tertiary associations where ecotones, inclusions smaller than the minimum mapping unit, active succession, or blended vegetation types made assignment to one association unrepresentative of the situation on the ground. For the selection of evaluation points, we only considered the dominant vegetation type. We determined the number of required points for each dominant vegetation type based on the area of each vegetation association at the park (ESRI et al. 1994, NatureServe 2007). At that point, we then selected the locations of the evaluation points using the "Generate Random Points" tool in the GIS extension "Hawth's Analysis Tools for ArcGIS" (Beyer 2004). The tool excluded points 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; however, in some instances the size and shape of the vegetation polygons prevented selection of an adequate number of points outside the buffered area. Likewise, the tool randomly placed sample points throughout the park, but polygons smaller than 0.045 hectares (452 square meters) were excluded because of the potential that GPS error could lead field crews to record data for an area outside the polygon of the mapped class. A distance of at least 80 meters was maintained between adjacent points to prevent overlap in the area evaluated around each point.

Field Data Collection

Field crews collected accuracy assessment data during the Fall of 2009. Fieldworkers 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 the data for the accuracy points, field crews considered the vegetation in an area approximately 0.5 hectare, within a 40 meter radius circle around each point. Field crews recorded only the dominant and diagnostic species for each stratum. They also determined the primary association type at that point using an existing key to the ecological and human influenced communities at KIMO (found in White and Govus 2005), and a "fit" value of this type of high, medium, or low. During the accuracy assessment data collection, it became

evident that the vegetation key required some modification. As a consequence, we made some changes to the original field key and have included the modified version in this report as Attachment A. When points were particularly difficult to key, field crews also recorded a secondary or alternate association, and took notes on any difficulties keying out the point. In total, crews collected field data from a total of 349 points.

Data Analysis

Data analysis for the accuracy assessment consisted of creation of contingency tables which summarize misclassification rates for each vegetation type, calculation of user's and producer's accuracy for each vegetation type, and evaluation of the overall accuracy of the map using the kappa statistic (Cohen 1960). Our team analyzed the data for three scenarios. The first scenario was a strict interpretation of map accuracy at the finest scale. We considered an evaluation point correctly classified only if the dominant vegetation type assigned on the map matched the observed value on the ground. The second scenario considered a point a match if the dominant, secondary, or tertiary vegetation type assigned to the mapped polygon matched the observed type. The third scenario was similar to the second in that it used dominant, secondary, or tertiary vegetation, but in addition, this scenario combined several map classes into broader groups where 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, we also considered the supplemental notes recorded by the field crew. In addition, for the third scenario, we regarded any points that fell within the 12 meter polygon buffer that appeared to have the same type of vegetation as that of an adjacent mapped polygon as correct. This accounts for any GPS error that may have occurred during data collection.

Once all data was entered, we constructed a contingency matrix 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. 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 are 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%.

For the project, we determined overall map accuracy by dividing the number of correct points by the total number of points assessed. We also calculated a kappa index, which takes into account that some polygons are correctly classified by chance (Cohen 1960, ESRI et al. 1994, Foody 1992). We calculated the overall accuracy and kappa index based on all map classes for all three analysis scenarios.

Results

The overall accuracy of the final KIMO vegetation map, which considered dominant, secondary, or tertiary vegetation types as well as several combined map classes, is 78% with a kappa statistic of 0.74 (74%). The contingency matrix for this scenario, along with a tabulation of user's and producer's accuracy for each map class, is provided in Appendix B, Tables 2a-b. We created groupings based on a review of the contingency matrix for the fine-scale analysis. In grouping the types, we attempted to group those associations that were related in habitat requirements, landscape distribution and floristic composition. This resulted in groups that are related from a land management point of view. Groups of ecologically related associations that were used include:

a). Successional Broom-sedge Vegetation (CEGL004044) and Blackberry - Greenbrier Successional Shrubland Thicket (CEGL004732) – this groups open herbaceous and shrubby successional vegetation.

b). Red-cedar Successional Forest (CEGL007124), Successional Sweetgum Forest (CEGL007216) and Interior Mid- to Late-Successional Tuliptree - Hardwood Upland Forest (Acidic Type) (CEGL007221) – this groups successional deciduous forests.

c). Virginia Pine Successional Forest (CEGL002591) and Shortleaf Pine Early-Successional Forest (CEGL006327) – this groups successional evergreen forests.

d). Piedmont / Ridge and Valley Small Stream Sweetgum - Tuliptree Forest (CEGL004418) and Sycamore - Sweetgum Swamp Forest (CEGL007340) – this groups mesic stream bottom forest types.

e). Piedmont Chestnut Oak - Heath Bluff (CEGL004415) and Piedmont Dry-Mesic Oak - Hickory Forest (CEGL008475) – this groups low slope, mesic oak forests.

f). Appalachian Shortleaf Pine - Post Oak Woodland (CEGL003765), Southern Blue Ridge Escarpment Shortleaf Pine - Oak Forest (CEGL007493) and Appalachian Shortleaf Pine - Mesic Oak Forest (CEGL008427) – this groups all of the mixed oak and shortleaf pine forests.

g). Felsic Monadnock Forest (CEGL006281), Southern Red Oak - White Oak Mixed Oak Forest (CEGL007244) and Xeric Ridgetop Chestnut Oak Forest (CEGL008431) – this groups upper slope dry-mesic to xeric oak forests.

A stricter analysis, which considered dominant, secondary, or tertiary vegetation types but no combined map classes, produced an overall accuracy of 61% with a kappa statistic of 0.57 (57%) (Appendix B, Tables 3a-b). The strictest analysis of the KIMO map at its finest scale, which considered only the dominant mapped vegetation, resulted in an accuracy of 44% with a kappa statistic of 0.40 (36%) (Appendix B, Tables 4a-b).

We did not calculate confidence intervals for user's and producer's accuracy for KIMO because the generally small number of assessment points per map class inflates the size of the confidence interval and thus limits 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 classes 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. This is particularly true for the Chestnut Oak - Blackjack Oak Piedmont Woodland (CEGL003708) a highly ranked rare Piedmont association (G2) which had a 100% producer accuracy. A few other associations also showed high producer accuracy at the finest scale. However, because mapping at such fine-scale is inherently difficult, 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 combined classes vegetation map for Kings Mountain National Military Park provides an accurate representation of vegetation types within the park and meets the NPS accuracy standard of approximately 80%. A few of the vegetation classes had low user's or producer's accuracy, and thus map users should be very cautious in interpreting areas mapped or identified in the field as belonging to those classes. The low accuracy recorded for these communities is likely a result of the difficulty of distinguishing associations that are ecologically similar (i.e. occur in similar topographic positions and share floristic similarities).

In addition, parks with active ecosystem management, such as Kings Mountain, are by their nature difficult candidates for accurate mapping to the NVC association level for all map classes. Disturbed and/or successional vegetation types resulting from prior human activities do not lend themselves easily to being mapped at the association level. Kings Mountain National Military Park is composed of a patchwork of mature second growth forest, late successional forest types, small patch types, and recovering old agricultural land resulting in a continuum of spatial and temporal vegetation patterns. Due to floristic similarity in dominant strata, upland oak forest types were often mistaken for one another in the field and on the map. When visiting a polygon, the surveyors sometimes were obligated to choose a map class among upland types that appeared to form an aggregation of a few classes rather than a homogenous type. In addition, occasionally the field assessment point did not fit well into any community description so the surveyors chose the closest one, which may not have been a perfect fit.

For example, Felsic Monadnock Forests (CEGL006281), Southern Red Oak - White Oak Mixed Oak Forests (CEGL007244) and Xeric Ridgetop Chestnut Oak Forests (CEGL008431) all occur in more exposed, upland situations. These have canopies dominated by dry oak species, primarily chestnut oak (*Quercus prinus*) and southern red oak (*Quercus falcata*). Field workers identified thirty-four observations points that best fit the concept of the Felsic Monadnock Forests while the mappers had no polygons attributed to this type. Most of these were assigned to the Southern Red Oak - White Oak Mixed Oak Forest. Similarly, the Xeric Ridgetop Chestnut Oak Forest was also most frequently confused with the Southern Red Oak - White Oak Mixed Oak Forest. Field workers identified thirty-seven points that best fit the concept of a Xeric Ridgetop Chestnut Oak Forest and only sixteen points were correctly mapped as this type. Nine were mapped as Southern Red Oak - White Oak Mixed Oak Forest. It is clear that these dry oak forests (which undoubtedly intergrade with one another at many sites) are too difficult to map accurately as separate vegetation types and often too difficult to discern on the ground as separate types.

Lower slope, mesic oak forests were also difficult to separate by mappers. Piedmont Chestnut Oak - Heath Bluff (CEGL004415) and Piedmont Dry-Mesic Oak - Hickory Forests (CEGL008475) occur generally close to streams and can both be dominated by white oak (*Quercus alba*). Separately they had a producer accuracy of 61% and 36% respectively and were most frequently confused with one another. These therefore make a very natural grouping from an ecological perspective.

Similarly, the two types of successional pine forests proved difficult for mappers to accurately delineate. Treated individually, Virginia Pine Successional Forest (CEGL002591) and Shortleaf Pine Early-Successional Forest (CEGL006327) had somewhat low mapping accuracy and were most often confused with one another. When combined, this class had a high producer mapping accuracy of 93%.

As mentioned earlier, one of the most ecologically significant vegetation types for this site, the Chestnut Oak - Blackjack Oak Piedmont Woodland was mapped with remarkable accuracy. This rare (G2) Piedmont woodland had a 100% producer’s accuracy and a 79% user’s accuracy. For researchers interested in this plant association, the vegetation map can be used with a high degree of confidence to locate examples for investigative purposes.

A final and unusual error that deserves discussion was an apparent communication error between CRMS mappers and NatureServe ecologists. Photointerpreters mapped a class of vegetation associated with high order streams that was not included in the vegetation classification for this park and thus not included in the key and could not be properly evaluated by this effort. Four polygons along Kings Creek were attributed to Sycamore - Sweetgum Swamp Forest (CEGL007340) even though this association had not been recognized by the NatureServe inventory for this park (White and Govus, 2005). This type of error could be, and should be avoided by a more careful coordination of the two teams to make sure that mapping units are agreed upon by both parties.

While the accuracy assessment is intended to provide a measure of the reliability of the map classes, the reader should be aware that error is also inherent in the field assessment of evaluation points. The overall accuracy of the Kings Mountain vegetation map was relatively low 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 many factors. These include: the fragmented state and changes in management practices, GPS error, data collection error by the field crew, poorly written 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 which 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 KIMO digital vegetation map should familiarize themselves with the results of this accuracy assessment, potential sources of classification error, and the contingency tables provided in Appendix B. When interested in using the map to locate a particular association, it is useful to know what other map classes have been shown to contain points matching that association, and what other vegetation types the mapped association of interest is likely to contain. We recommend that natural resource managers consider combining some commonly confused map classes together for display or other purposes. The results of the accuracy assessment indicate that Successional Broom-sedge Vegetation (CEGL004044) and Blackberry - Greenbrier Successional Shrubland Thicket (CEGL004732) cannot be consistently distinguished from each other on aerial imagery and may be best displayed as a combined map class. Likewise, Felsic Monadnock Forests (CEGL006281), Southern Red Oak - White Oak Mixed Oak Forests (CEGL007244) and Xeric Ridgetop Chestnut Oak Forests (CEGL008431) were difficult for the mappers to distinguish from one another and also may best be displayed as a combined upland class. Additionally, Appalachian Shortleaf Pine - Post Oak Woodlands (CEGL003765), Southern Blue Ridge Escarpment Shortleaf Pine - Oak Forests (CEGL007493) and Appalachian Shortleaf Pine - Mesic Oak Forest (CEGL008427) were problematic for mappers to delineate, indicating that these classes may also be best displayed as a combined

class. Other combined classes that should be evaluated as groups include most of the successional types of vegetation and mesic oak forest associated with the lower slopes and stream corridors.

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 is especially true for the Chestnut Oak - Blackjack Oak Piedmont Woodland. The 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 KIMO.

References

Bailey, R. G.; Avers, P. E.; King, T.; McNab, W. H., eds. 1994. Ecoregions and subregions of the United States (map). Washington, DC: USDA Forest Service. 1:7,500,000. With supplementary table of map unit descriptions, compiled and edited by W. H. McNab and R. G. Bailey.

Beyer, H. L. 2004. Hawth's Analysis Tools for ArcGIS. Available at http://www.spatialecology.com/htools.

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.

Griffith, G.E., Omernik, J.M., Comstock, J.A., Schafale, M.P., McNab, W.H., Lenat, D.R., and MacPherson, T.F., 2002, Ecoregions of North Carolina, U.S. Environmental Protection Agency, Corvallis, OR, (map scale 1:1,500,000).

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.

Keys, J. E., Jr., C. A. Carpenter, S. L. Hooks, F. G. Koenig, W. H. McNab, W. E. Russell, and M-L. Smith. 1995. Ecological units of the eastern United States - first approximation (map and booklet of map unit tables). Atlanta, GA, USDA Forest Service, presentation scale 1:3,500,000, colored.

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.

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

White, R.D. Jr. and T. E. Govus. 2005. Vascular plant inventory and plant community classification for Kings Mountain National Military Park. Durham, North Carolina: NatureServe.

Appendix A: Revised Vegetation Classification Key

Key to Ecological Communities of Kings Mountain National Military Park

This key was developed for Kings Mountain National Military Park and is intended to allow field workers and naturalists to quickly identify community types while in the field. Due to the small size of the park and the limited habitat types available within the park boundary, this key does not cover all of the ecosystems of the adjacent region. However, within the boundary, we believe this key represents the range of variation of existing vegetation.

This document is 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 get a feel for the composition of the area. This exercise may help you arrive at the correct place in the key since 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 classified as both communities if they cannot be assigned with confidence to one or the other.

Where appropriate, the name of the NatureServe Ecological Group appears in [brackets]. The EcoGroup is a broader concept than the association level, so similar communities may fall out in one ecogroup. 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.

1a. Wetland Vegetation: Wetland habitats such as flatlands adjacent to creeks inundated during local flooding events. These "floodplains" may only be inundated once a year and may have little to no herbaceous cover. There is often little to distinguish them from uplands besides topography (flat) and species composition (usually sweetgum, tuliptree, and red maple are good canopy indicators, although white oak can often be a co-dominant)

2a. Forested wetland (canopy cover >20%)

3a.: Older forest (canopy trees at least 70 years old and uneven aged)

4a.Forest dominated by tuliptree and/or sweetgum, but little red maple (<25%). Usually near perennial streams on narrow to wide floodplains. **[SOUTHERN PIEDMONT SMALL FLOODPLAIN AND RIPARIAN]**

5a. Forest canopy is <25% pine species. Canopy is dominated by either sweetgum, tuliptree, red maple, or a combination of all three. Distinguished from CEGL007330 by a higher diversity of herbaceous

plants and an older uneven aged tree canopy. Herbaceous cover often over 50% and often containing large cover of ferns.
Piedmont Small Stream Sweetgum Forest (CEGL004418)

5b.Forest canopy contains at least 25% pine, usually loblolly pine. Otherwise, canopy is similar to CEGL004418. Canopy often dominated by invasive exotics or sparse and low diversity relative to other bottomland types. This community is generally limited to the widest floodplains in the park (at least 30 meters wide).
Loblolly Pine – Tuliptree Successional Bottomland Forest (CEGL007546)

4b. Streamhead seepages that are often dry but show evidence of past water (streamcut or sphagnum moss). Dominated by red maple with co-dominants including tuliptree, sweetgum, and white oak comprising up to 50% of canopy. This community often grades into small stream communities such as CEGL004418 or CEGL007546).
[PIEDMONT SEEPAGE WETLAND]
Piedmont Low-Elevation Headwater Seepage Swamp (CEGL004426)

3b.Successional forested wetland (heavily disturbed by either logging or plowing less than 70 years ago). Indicators include sweetgum, tuliptree, loblolly pine, black walnut, etc.). Oaks may be present but are overtopped by larger pines and successional hardwoods and are less than 50% of total canopy.
[HUMAN MODIFIED/SUCCESSIONAL]

6a.Canopy dominated by hardwoods (<25% pine)

7a. Canopy not dominated by red maple.

8a. Canopy dominated or co-dominated by black walnut, usually with an herbaceous/shrub layer of wingstem (*Verbesina* spp.). and/or coralberry. Usually found on old homesites, especially wet areas that were heavily fertilized by livestock.
Successional Black Walnut Forest (CEGL007879)

8b.Canopy dominated by sweetgum. Distinguished from CEGL004418 by its relatively low herbaceous diversity and even aged young stand of sweetgum.
Successional Sweetgum Floodplain Forest (CEGL007330)

7b. Streamhead seepages that are often dry but show evidence of past water (streamcut or sphagnum moss). Dominated by red maple with co-dominants including tuliptree, sweetgum, and white oak comprising up to 50% of canopy. This community often grades into small stream communities such as CEGL004418 or CEGL007546 or CEGL007330)
Piedmont Low-Elevation Headwater Seepage Swamp (CEGL004426)

6b. Canopy with a large percentage of loblolly pine in canopy (>25% cover of pine)
Loblolly Pine – Tuliptree Successional Bottomland Forest (CEGL007546)

2b. Shrub dominated wetland (forest canopy <20% over shrubs)
[HUMAN MODIFIED/SUCCESSIONAL]

9a.Shrubland dominated by the exotic golden bamboo (*Phyllostachys aurea*). Usually found around old homesites where it may have been planted by farmers and spread from plantings.
Golden Bamboo Shrubland (CEGL008560)

9b.Shrubland dominated by the native shrub alder (*Alnus serrulata*) and found mainly where streams enter manmade ponds and other semipermanently inundated sites.
Saturated Alder Thicket (CEGL003912)

1b. Terrestrial Vegetation: Upland habitats not inundated by flood waters

10a. Vegetation dominated by herbaceous vegetation or shrubs, but not trees (<40% cover of trees)
[HUMAN MODIFIED/SUCCESSIONAL]

11a.Successional shrubland dominated by blackberry and/or greenbrier.
Blackberry-Greenbrier Successional Shrubland Thicket (CEGL004732)

11b. Successional herbaceous vegetation

12a. Herbaceous vegetation dominated by exotic species, especially fescue (*Lolium* spp.). Heavily disturbed (plowed/mowed) within the past decade.
Cultivated meadow (CEGL004048)

12b.Vegetation dominated by native herbaceous species, especially broomsedge, asters, etc.
Broomsedge Old Field (CEGL004044)

10b. Forests and woodlands (>40% cover of trees)

13a Successional forests and woodlands resulting from recent disturbance (plowing/ stand initiating clearcut); stand usually a young to medium aged forest with few trees more than 70 years old and very even aged.; sites are former fields, pastures, clearcuts, burned or eroded areas. Indicators include pine species, redcedar, tuliptree, sweetgum, and red maple.
[SEMI-NATURAL WOODED UPLAND]

14a. Evergreen/mixed canopy (canopy at least 40% evergreen)

15a. Canopy dominated by red cedar (>50% of canopy)
Red-Cedar Successional Forest (CEGL007124)

15b. Canopy dominated by at least 50% pine.

16a.Canopy dominated by loblolly pine or a combination of loblolly pine and sweetgum.
Successional Loblolly Pine – Sweetgum Forest (CEGL008462)

16b. Canopy dominated by Virginia pine or shortleaf pine.

17a. Canopy dominated by shortleaf pine
Shortleaf Pine Early Successional Forest (CEGL006327)

17b. Canopy dominated by Virginia pine
Virginia Pine Successional Forest (CEGL002591)

14b Hardwood dominated canopy (at least 60% of canopy)

18a. Canopy dominated by black walnut. Sometimes this may have very low canopy coverage, approaching that of a woodland.

Successional Black Walnut Forest (CEGL007879)

18b. Canopy not dominated by black walnut.

19a. Dominant stratum dominated by tuliptree with oaks and maples often in understory.
Successional Tuliptree – Hardwood Forest (CEGL007221)

19b. Sweetgums dominate the dominant stratum.
Successional Sweetgum Forest (CEGL007216)

13b Mature, relatively undisturbed vegetation (at least 70 years since plowing or other severe human-induced disturbance). Canopy usually uneven aged and with fewer signs of recent human disturbance. Indicators include oak and hickory species greater than 50 years old.

20a. Site on well protected lower slope within 100 meters of perennial stream.
[SOUTHERN PIEDMONT MESIC FOREST]

21a. Mesic slope dominated by northern red oak with mesic species such as umbrella magnolia and sometimes beech.
Piedmont Mesic Basic Oak-Hickory Forest (CEGL003949)

21b. Protected but with shallow soils, so somewhat dry. Any combination of chestnut oak, scarlet oak, or white oak may dominate. Usually contains no northern red oak or umbrella magnolia. Understory almost 100% mountain laurel.
Piedmont Chestnut Oak - Heath Bluff (CEGL004415)

20b. Site not a well protected lower slope. Dry-mesic to xeric forests and woodlands.

22a.Canopy containing at least 25% pine.
[SOUTHERN APPALACHIAN LOW MOUNTAIN PINE FOREST]

23a.Canopy consists of at least 50% Virginia pine
Appalachian Low-Elevation Mixed Pine / Hillside Blueberry Forest (CEGL007119)

23b. Canopy consists of at least 25% shortleaf pine and at least 25% oak species.

24a. Forested (canopy and understory cover >60%)

25a.Dry-mesic oak species (especially white oak) present and accounting for at least 25% of canopy. Very little if any mountain laurel present.
Appalachian Shortleaf Pine – Mesic Oak Forest (CEGL008427)

25b.Oak species associated with dry /xeric forests (southern red oak and scarlet oak and chestnut oak) account for at least 25% of canopy. Mountain laurel usually >25% of shrub layer.
Southern Blue Ridge Escarpment Shortleaf Pine – Oak Forest (CEGL007493)

24b. Xeric/dry-mesic ridgetop or ridgecrest woodland with post oak and shortleaf pine (canopy/understory cover <60%)
Appalachian Shortleaf Pine-Post Oak Woodland (CEGL003765)

12b.Oak and/or hickory spp. dominate the canopy (<25% pine in canopy)
[SOUTHERN PIEDMONT DRY OAK – (PINE) FOREST]

26a. Chestnut oak or blackjack or scarlet oak dominated forest (>75% chestnut and/or scarlet oak in canopy). Usually exposed upper slopes or ridgetops, but one type found in more protected situations.

27a. Forest

28a. Xeric ridgetop/upper slope forest with ericaceous understory (at least 20% cover of blueberry or mountain laurel).
Xeric Ridgetop Chestnut Oak Forest (CEGL008431)

28b. Ridgetop and upper slope forest without ericaceous understory. Usually dominated instead by muscadine or very sparse. Very shallow soil. (<20% cover of blueberry or mountain laurel)
Felsic Monadnock Forest (CEGL006281)

27b. Woodland (<60% canopy cover) with some blackjack oak in tall shrub layer/understory and often with chestnut oak overtopping the blackjack oak.
Piedmont Rock Chestnut Oak – Blackjack Oak Woodland (CEGL003708)

26b.Dry-mesic to mesic forests of uplands and gentle to moderate slopes but not ridgetops – usually not dominated by chestnut oak, scarlet oak, or blackjack oak. More often, dominated by white oak, black oak, and/or southern red oak.

29a.Less than 40% of canopy covered by white oak Usually southern red oak, black oak, and white oak, with some scarlet and chestnut oak, but usually less than 25% cover. Key indicator – southern red oak
Southern Red Oak – White Oak Forest (CEGL007244)

29b.More than 40% of canopy covered by white oak. Other associated species include black oak, northern red oak, and only occasionally scarlet oak. Key indicator is white oak.
Piedmont Dry-Mesic Oak-Hickory Forest (CEGL008475)

Appendix B: Contingency Matrices and Accuracy Tables

Table 2a. Contingency Matrix Using Mapped Dominant, Secondary, or Tertiary Vegetation (Best Match), plus Combined Map Classes, and accounting for GPS error Kings Mountain National Military Park

	Observed As													
Mapped As	**3708**	**3949**	**4426**	**7330**	**7879**	**2591/6327**	**3765/7493/8427**	**4044/4732**	**4415/8475**	**4418/7340**	**6281/7244/8431**	**7124/7216/7221**	**Grand Total**	**User's Accuracy**
3708	15	0	0	0	0	0	1	0	0	0	3	0	19	79%
3949	0	0	0	0	0	0	0	0	0	1	0	0	1	0%
4426	0	0	0	0	0	0	0	0	0	0	0	1	1	0%
7330	0	0	0	1	0	0	0	0	0	0	0	0	1	100%
7879	0	0	0	0	1	0	0	0	0	0	0	0	1	100%
2591/6327	0	0	0	0	0	39	0	0	0	0	1	4	44	89%
3765/7493/8427	0	0	0	0	0	1	31	0	2	0	16	4	54	57%
4044/4732	0	0	0	0	0	2	0	1	0	0	0	0	3	33%
4415/8475	0	0	0	0	0	0	2	0	44	2	16	1	65	68%
4418/7340	0	1	0	0	0	0	0	0	7	26	2	0	36	72%
6281/7244/8431	0	0	0	0	0	0	1	0	3	0	57	0	61	93%
7124/7216/7221	0	0	0	0	0	0	1	0	2	0	2	58	63	92%
Grand Total	15	1	0	1	1	42	36	1	58	29	97	68	349	
Producer Accuracy	100%	0%	N/A	0%	100%	93%	86%	100%	76%	90%	59%	85%		

Overall accuracy = 78.22%
Kappa statistic = 74.17%

Table 2b
Accuracy Calculations Using Mapped Dominant, Secondary, or Tertiary Vegetation (Best Match), plus Combined Map Classes and accounting for GPS error Kings Mountain National Military Park

Map Class	Producer's Accuracy		User's Accuracy	
	Accuracy	n	Accuracy	n
3708	100%	15	79%	19
3949	0%	1	0%	1
4426	n/a	n/a	0%	1
7330	0%	1	100%	1
7879	100%	1	100%	1
2591/6327	93%	42	89%	44
3765/7493/8427	86%	36	57%	54
4044/4732	100%	1	33%	3
4415/8475	76%	58	68%	65
4418/7340	90%	29	72%	36
6281/7244/8431	59%	97	93%	61
7124/7216/7221	85%	68	92%	63

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.

-- A confidence interval could not be calculated due to the small sample size.

Table 3a. Contingency Matrix Using Mapped Dominant, Secondary, or Tertiary Vegetation (Best Match), Kings Mountain National Military Park

	Observed As																							
Mapped As	**2591**	**3708**	**3765**	**3949**	**4044**	**4415**	**4418**	**4426**	**4732**	**6281**	**6327**	**7124**	**7216**	**7221**	**7244**	**7330**	**7340**	**7493**	**7879**	**8427**	**8431**	**8475**	**Grand Total**	**User's Accuracy**
2591	20	0	0	0	0	0	0	0	0	0	6	0	0	2	1	0	0	0	0	0	0	0	29	69%
3708	0	15	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	19	79%
3765	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0	0	0	0	4	0%
3949	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0%
4044	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
4415	0	0	0	0	0	26	0	0	0	1	0	0	0	1	1	0	0	1	0	1	3	0	34	76%
4418	0	0	0	0	0	2	17	0	0	0	0	0	0	0	1	0	0	0	0	0	1	5	26	65%
4426	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0%
4732	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	3	0%
6281	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
6327	3	0	0	0	0	0	0	0	0	0	10	0	0	2	0	0	0	0	0	0	0	0	15	67%
7124	0	0	0	0	0	0	0	0	0	0	0	1	0	5	0	0	0	0	0	0	0	0	6	17%
7216	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
7221	0	0	1	0	0	0	0	0	0	0	0	0	1	51	2	0	0	0	0	0	0	2	57	89%
7244	0	0	0	0	0	0	0	0	0	12	0	0	0	0	9	0	0	1	0	0	0	0	22	41%
7330	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	100%
7340	0	0	0	1	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0%
7493	0	0	0	0	0	0	0	0	0	4	0	0	0	1	3	0	0	16	0	1	3	1	29	55%
7879	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	100%
8427	0	0	0	0	0	0	0	0	0	3	0	0	0	0	1	0	0	5	0	9	2	1	21	43%
8431	0	0	0	0	0	1	0	0	0	7	0	0	0	0	4	0	0	0	0	0	25	2	39	64%
8475	0	0	0	0	0	7	2	0	0	4	0	0	0	0	4	0	0	0	0	0	3	11	31	35%
Grand Total	23	15	1	1	1	36	29	0	0	34	19	1	1	66	26	1	0	24	1	11	37	22	349	
Producer Accuracy	87%	100%	0%	0%	0%	72%	59%	N/A	N/A	0%	53%	100%	0%	77%	35%	100%	N/A	67%	100%	82%	68%	50%		

Overall accuracy = 60.74%

Kappa statistic = 57.00%

Table 3b
Accuracy Calculations Using Mapped Dominant, Secondary, or Tertiary Vegetation (Best Match)
Kings Mountain National Military Park

Map Class	Producer's Accuracy		User's Accuracy	
	Accuracy	n	Accuracy	n
2070	79%	28	79%	28
2103	50%	2	100%	1
3871	76%	17	72%	18
4044	25%	4	11%	9
4048	27%	11	50%	6
4049	100%	1	100%	1
7105	100%	1	20%	5
7124	67%	6	50%	8
7217	17%	6	25%	4
7220	79%	24	83%	23
7330	0%	3	n/a	0
7334	100%	2	40%	5
7881	50%	6	100%	3

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.
--	A confidence interval could not be calculated due to the small sample size.

Table 4a Contingency Matrix Using Mapped Dominant Vegetation Only, Kings Mountain National Military Park

	Observed As																							
Mapped As	**2591**	**3708**	**3765**	**3949**	**4044**	**4415**	**4418**	**4426**	**4732**	**6281**	**6327**	**7124**	**7216**	**7221**	**7244**	**7330**	**7340**	**7493**	**7879**	**8427**	**8431**	**8475**	**Total**	**User's Accuracy**
2591	16	0	0	0	0	0	0	0	0	0	7	0	0	4	1	0	0	0	0	0	0	0	28	57%
3708	0	15	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	19	79%
3765	0	0	0	0	0	2	0	0	0	0	1	0	0	4	0	0	0	0	0	0	0	0	7	0%
3949	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0%
4044	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
4415	0	0	0	0	0	22	0	0	0	1	0	0	0	1	1	0	0	1	0	1	3	0	30	73%
4418	0	0	0	0	0	2	10	0	0	0	0	0	0	0	1	0	0	0	0	0	1	8	22	45%
4426	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0%
4732	0	0	0	0	1	0	0	0	0	0	2	0	0	15	0	0	0	0	0	0	0	0	18	0%
6281	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
6327	7	0	0	0	0	0	0	0	0	0	9	0	0	11	0	0	0	0	0	0	0	0	27	33%
7124	0	0	0	0	0	0	0	0	0	0	0	1	0	5	0	0	0	0	0	0	0	0	6	17%
7216	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
7221	0	0	1	0	0	1	0	0	0	0	0	0	1	24	2	0	0	0	0	0	0	2	31	77%
7244	0	0	0	0	0	0	0	0	0	12	0	0	0	0	8	0	0	1	0	0	9	0	30	27%
7330	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0%
7340	0	0	0	1	0	0	9	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	12	0%
7493	0	0	0	0	0	1	0	0	0	4	0	0	0	1	3	0	0	16	0	1	3	1	30	53%
7879	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
8427	0	0	0	0	0	0	0	0	0	3	0	0	0	0	1	0	0	5	0	9	2	1	21	43%
8431	0	0	0	0	0	1	0	0	0	7	0	0	0	0	4	0	0	0	0	0	16	2	30	53%
8475	0	0	0	0	0	7	3	0	0	4	0	0	0	0	5	0	0	0	0	0	3	8	30	27%
Total	23	15	1	1	1	36	29	0	0	34	19	1	1	66	26	1	0	24	1	11	37	22	349	
Producer Accuracy	70%	100%	0%	0%	0%	61%	34%	N/A	N/A	0%	47%	100%	0%	36%	31%	0%	N/A	67%	0%	82%	43%	36%		

Overall accuracy = 44.13%
Kappa statistic = 39.81%

Table 4b
Accuracy Calculations Using Mapped Dominant Vegetation Only
Kings Mountain National Military Park

Map Class	Producer's Accuracy		User's Accuracy	
	Accuracy	n	Accuracy	n
2591	70%	23	57%	28
3708	100%	15	79%	19
3765	0%	1	0%	7
3949	0%	1	0%	1
4044	0%	1	N/A	0
4415	61%	36	73%	30
4418	34%	29	45%	22
4426	N/A	0	0%	2
4732	N/A	0	0%	18
6281	0%	34	N/A	0
6327	47%	19	33%	27
7124	100%	1	17%	6
7216	0%	1	N/A	0
7221	36%	66	77%	31
7244	31%	26	27%	30
7330	0%	1	0%	5
7340	N/A	0	0%	12
7493	67%	24	53%	30
7879	0%	1	N/A	0
8427	82%	11	43%	21
8431	43%	37	53%	30
8475	36%	22	27%	30

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

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.

-- — A confidence interval could not be calculated due to the small sample size.