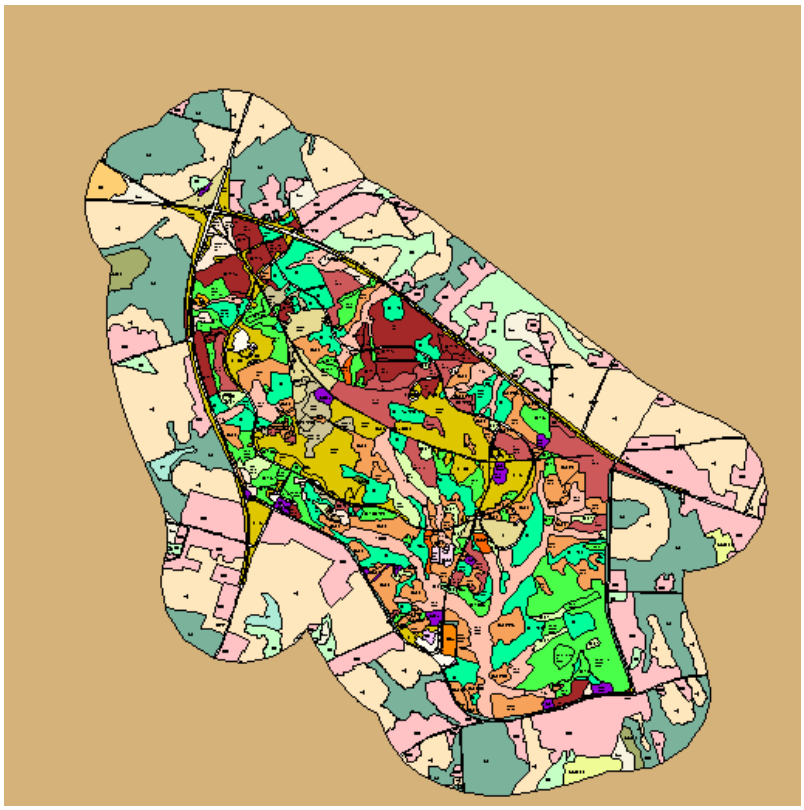
Accuracy Assessment: Cowpens National Battlefield Vegetation Map



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Executive Summary

This report presents an accuracy assessment of the digital vegetation map of Cowpens National Battlefield (COWP). Vegetation at COWP was mapped by The University of Georgia Center for Remote Sensing and Mapping Science (UGA) with ecological consultation assistance from NatureServe. The mapping was conducted as part of the National Park Service vegetation mapping program.

The map accuracy was assessed by comparing the mapped vegetation type to the field-verified vegetation type at evaluation points chosen prior to field work to represent the full range of map classes in the park in a statistically valid manner. Accuracy was calculated for each individual map class as well as for all map classes combined.

It is very important to understand that the accuracy assessment process is not meant to exclusively judge the performance of the mapper or the ecologists on the project since error can be caused at any point in the process from remote sensing to ecological classification to the accuracy assessment exercise itself. In addition, even the best mappers cannot tell the difference between certain species of oaks or pines from a remotely sensed image from above. 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), temporal error when conditions on the ground change between the mapping and assessment processes, and accuracy assessment error caused by misuse of the final field key. 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.*

Making the accuracy assessment interpretation at COWP even more complex is the fact that land management actions between the original mapping project and the accuracy assessment affected roughly 40% of the parkland. During the period between mapping and the AA, contractors used heavy machinery to remove most shrubs and small trees from the central area of the park to better approximate the look and feel of the area during Revolutionary War times. Unfortunately, this meant that the maps of old field (4048), lawn, and blackberry shrubland (4732) became meaningless since all were turned into the same successional state post-management. As a consequence, these types were all merged to create a more accurate map.

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 COWP, the overall accuracy of the final map, which includes several grouped map classes, is 80%, with a kappa statistic of 0.76 (76%). 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. Cultivated meadows (CEGL004048), old fields (OF), lawns (lawn), and blackberry/greenbrier successional shrublands (CEGL004732)
b. Piedmont small stream sweetgum - tuliptree forest (CEGL004418) and successional sweetgum floodplain forest (CEGL007730)
c. Successional loblolly pine forest (CEGL006011) and shortleaf pine early successional forest (CEGL006327)
d. Southern piedmont mesic subacid oak-hickory forest (CEGL006227) and southern red oak – white oak mixed oak forest (CEGL007244)
e. Successional sweetgum forest (CEGL007216) and successional tuliptree - hardwood forest (CEGL 7221)

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 lumping of types occurred showed an overall accuracy of the map of 65% (kappa = 61%) for natural communities. 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. Despite the lower accuracy, when used in conjunction with the accuracy assessment results, the fine-scale map will prove useful to knowledgeable users interested in highly detailed studies of specific vegetation types.

Key finding:

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 above 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 Cowpens National Battlefield (COWP) was created in 2004 by the University of Georgia Center for Remote Sensing and Mapping Science in consultation with NatureServe. The mapping effort included collection of field data, aerial photograph interpretation, and polygon attribution to GIS maps.

COWP is located two miles southeast of the town of Chesnee, South Carolina in Cherokee County. The park contains 843 acres (approximately 341 hectares) of land including forest, fields, and riparian areas. Vegetation at COWP was mapped and classified to the association level using the United States National Vegetation Classification (NVC) (Grossman et al. 1998), following NPS guidelines. The minimum mapping unit (MMU) was 0.5 hectare. This document contains the results of an accuracy assessment performed on that map.

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

The thematic accuracy of the map was assessed by comparing the vegetation type shown on the map to the vegetation type identified on the ground for 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, both producers' and users' accuracy are evaluated. Users' accuracy indicates the probability that a sample point mapped as a given vegetation type will be shown to be of that type on the ground. Producers' accuracy indicates the probability that a sample point classified as a given vegetation type on the ground will have been assigned to that association on the map. In addition to the users' and producers' accuracy, measures of the overall map accuracy are calculated, and contingency tables showing the frequency of confusion (i.e. misclassification) between associations are presented.

Point Selection

A point-based approach was used 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. Points were selected from within those polygons using a stratified random sampling design, so that points were distributed across all map classes with a higher number or points placed within map classes with large areas. 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.

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, only the dominant vegetation type was considered. The number of required points for each dominant vegetation type was determined based on differences in predominance and overall size of each type at the park (Environmental Systems Research Institute et al. 1994). The locations of the evaluation points were then selected using the GIS extension "Simple Random Sampling 1.0". To the extent possible, points were excluded from a 12 meter internal buffer around the boundary of each polygon to avoid misclassification due to GPS error in the field; however, in some instances points were placed less than 12 meters from a polygon edge, particularly if the size and shape of the vegetation class prevented selection of an adequate number of points outside the buffered area. Likewise, points were randomly placed so as to avoid being within polygons smaller than 0.045 hectares (452 square meters) because of the potential that GPS error could lead field crews to record data for an area outside 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

A field crew visited each evaluation point and assessed vegetation in a 15 meter radius surrounding each point. Points were located using either a WAAS enabled Garmin 5 GPS unit, or a Garmin 5 differential GPS unit.

At each point, the field crew determined whether the association in which the point fell encompassed at least one MMU of 0.5 hectare. Unless the point had been flagged prior to sampling as one located in a polygon smaller than the MMU, if the area occupied by the association was smaller than the MMU, the point was understood to be in an inclusion. In these instances, the crew would shift their position so that they were within the closest community to the original point that occupied at least one MMU. The coordinates of this location were recorded as a new point and another form was filled out.

When collecting the data for the thematic accuracy points, the vegetation was considered in an approximately 15 meter radius circle around each point. The height range and percent cover of each stratum was collected. Only the dominant and diagnostic species were recorded in each stratum. The primary association type at that point was determined by the field crew using a key to the ecological and human influenced communities at COWP that was modified specifically for use in the accuracy assessment (Attachment A). At some points, a secondary association was also recorded, and notes were taken on any difficulties keying out the point. Environmental attributes of the area surrounding the point were also recorded. A total of 148 data points with field data were used for the assessment of thematic accuracy.

Data Analysis

Data analysis for the accuracy assessment consisted of creation of contingency tables which summarize misclassification rates for each vegetation type, calculation of users and producers accuracy for each vegetation type, and evaluation of the overall accuracy of the map using the kappa statistic (Cohen 1960). The data was analyzed for two scenarios. 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 matched the observed type. In addition, this scenario lumped 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, the supplemental notes and environmental data recorded by the field crew were also considered. In addition, any points that fell within the 12 meter polygon edge buffer that were observed to have the same type as that of an adjacent mapped polygon were regarded as correct in the second analysis.

A contingency table (also called a confusion 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 table 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 table 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

Users' and producers' accuracy were derived from the values in the contingency table. Producers' 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 producers' accuracy for Class B is 4 divided by 6, or 67 percent.

Users' accuracy 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 percent. The users' accuracy is equal to (1 - errors or commission).
Ninety percent confidence intervals for both producers' and users' accuracy were determined for each map class with the use of the binomial distribution equation:

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

where p is either the users' or producers' accuracy, t is the t-score for α, which is 0.1 for a 90% confidence interval, and n is the sample size. Confidence intervals were only generated for map units with a sample size greater than two because one or two samples do not provide enough information to produce meaningful intervals.

Overall map accuracy was determined by dividing the number of correct points by the total number of points assessed. A Kappa index, which takes into account that some polygons are correctly classified by chance (Environmental Systems Research Institute et al. 1994, Foody 1992), was also calculated. The overall accuracy and kappa index were calculated based on all map classes for both the fine-scale and grouped scenarios.

Results

The overall accuracy of the map *at the finest scale* was 65% with a kappa statistic of 0.61 (61%). The contingency table for the fine-scale scenario, along with a tabulation of users' and producers' accuracy, is provided in Appendix B. Users' and producers' accuracy, with 95 percent upper confidence intervals, is summarized on Figure 1.

The only NVC vegetation cover class to reach a statistically interpretable 80% producers' and users' accuracy was 4044 (Broomsedge Successional Vegetation). The OF-L (old field / lawn) type, which includes various successional stages of maintained grassy areas, also had high users' and producers' accuracy. Types 6011 (Loblolly Pine / Deerberry Forest), 7221 (Tuliptree – Mixed Deciduous Forest), and 8560 (Golden Bamboo Shrubland) had high users' accuracy but lower producers' accuracy. Type 4638 (Water Oak Successional Forest) had a high users' accuracy, but with and two few sample points to make interpretation of the confidence interval meaningful. The overall map accuracy was also affected by several types such as 7330 (Sweetgum Successional Forest), 3722 (Piedmont Granitic Woodland), PIs (White Pine Planted), and SAV (Savannah) which had values of zero for users' and/or producers' accuracy. Removing the successional field and cultural types improved the overall accuracy measure by 10 percentage points.

In the course of this analysis, and after discussion with the mapping team, it was determined that their PIs type (white pine planted) was essentially a subset of "human influenced" type since the

white pine is not native to the area and instead indicates old homesites with home foundations nearby. As a consequence, the labeling of the map was changed to HI:PIs and all those points were changed to "correct" in the accuracy assessment.

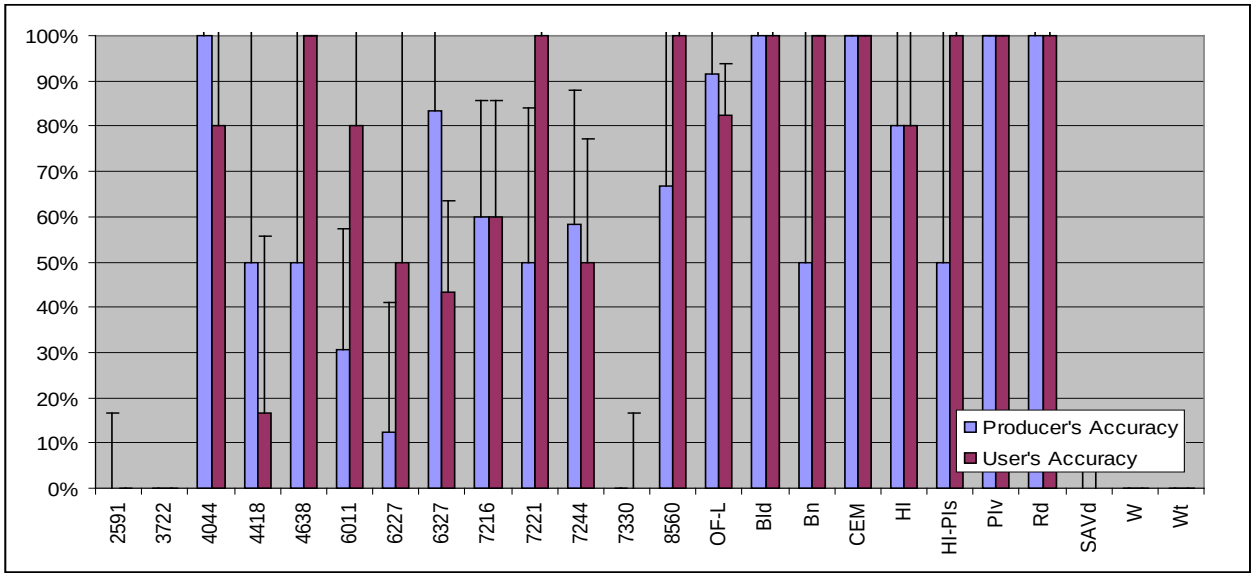

Figure 1 . Users' and producers' accuracy for the fine-scale ("strict") assessment. An evaluation point is considered correct if the association identified on the ground matches the dominant vegetation map attribute. Error bars show the upper 95 percent confidence interval. The four digit codes are derived from the last four digits of the NatureServe global database codes for the U.S. National Vegetation Classification associations that begin with "CEGL00…".

The second analysis that involved incorporating secondary and tertiary vegetation, GPS error, and map class groupings yielded an overall accuracy of 80% with a kappa statistic of 0.76%. Groupings were created based on a review of the contingency matrix for the fine-scale analysis. Grouped associations included:

a. Cultivated meadows (CEGL004048), old fields (OF), and blackberry/greenbrier successional shrublands (CEGL004732)

b. Piedmont small stream sweetgum - tuliptree forest (CEGL004418) and successional sweetgum floodplain forest (CEGL007730)

c. Successional loblolly pine forest (CEGL006011) and shortleaf pine early successional forest (CEGL006327)

d. Southern piedmont mesic subacid oak-hickory forest (CEGL006227) and southern red oak – white oak mixed oak forest (CEGL007244)

e. Successional sweetgum forest (CEGL007216) and successional tuliptree - hardwood forest (CEGL 7221)

The average users' accuracy for this analysis was 80% and producers' accuracy was 72%. The contingency table for this scenario, along with a tabulation of users' and producers' accuracy, is

provided in Appendix B. Users' and producers' accuracy, with 90 percent upper confidence intervals, is summarized on Figure 2.

It is apparent from the comparison of Figures 1 and 2 that the users' and producers' accuracy of many classes is considerably higher when classes are grouped, secondary and tertiary mapped vegetation is considered, and GPS error is taken into account. 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 above and 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.

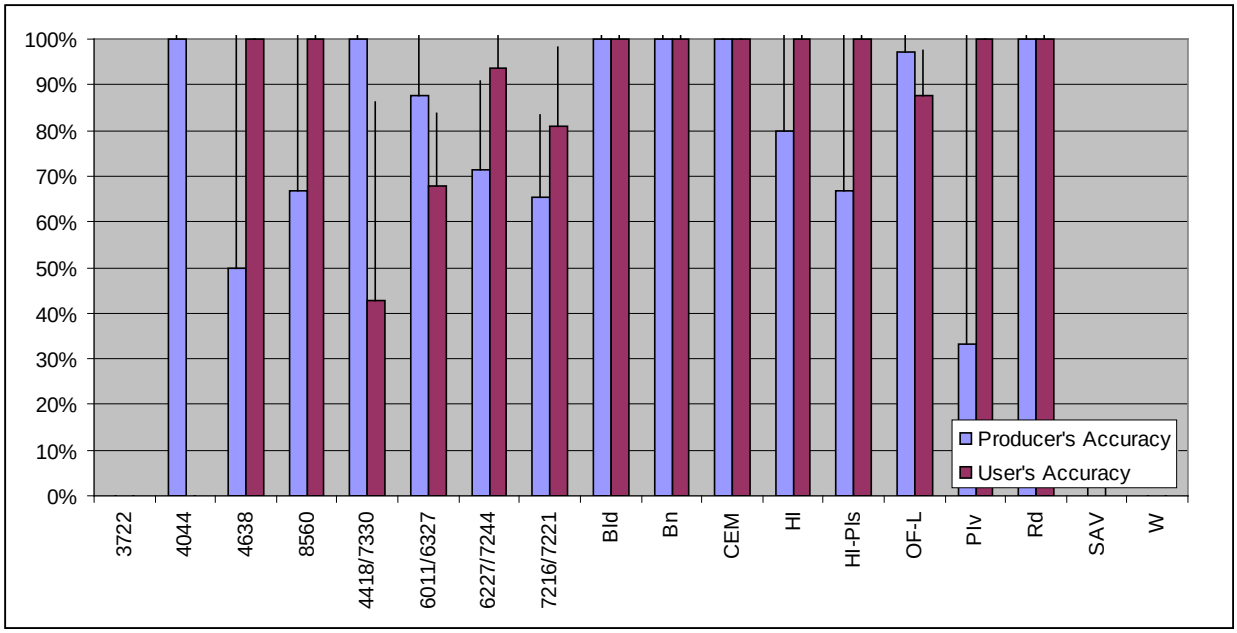

Figure 2. Users' and producers' accuracy for the second accuracy assessment scenario. This considers a point a match if the observed vegetation type matches the dominant, second, or third mapped vegetation type, corrects for points located near adjacent polygons, and includes several grouped classes.

Discussion

The overall accuracy of the Cowpens vegetation map was relatively low at 65% (kappa = 0.61) before grouping map classes. The fragmented state and severe changes in management practices at Cowpens National Battlefield, GPS error, using an untested key to map classes, point stratification methods, and the lag between photointerpretation and accuracy assessment most likely account for most of this error. **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.**

Small fragmented parks with active management plans such as Cowpens are by their nature difficult candidates for accurate mapping to the NVC association level for all map classes.

Disturbed and/or successional vegetation types like those found at Cowpens do not lend themselves easily to being mapped at the association level. At Cowpens, the most influential factors preventing high map accuracies at the association level include landscape fragmentation, succession, land management practices, and lag time between photointerpretation and accuracy assessment. Unlike more intact landscapes, Cowpens National Battlefield is composed of a patchwork of late successional forest types, managed cultural vegetation, small patch types, and early successional shrub, grassland and forest types resulting in a continuum of spatial and temporal vegetation patterns. Due to floristic similarity in dominant strata, late and early successional upland and palustrine forests were often mistaken for one another in the field. However, the temporal aspects of vegetation among successional shrub, grassland, and field types were the cause of the majority of map inaccuracy. When visiting a polygon, the surveyors were obligated to choose a map class among successional types which often form an aggregation of several classes rather than a homogenous type. In addition, much of the land management practices at Cowpens are intended to preserve the historic aspect of the battlefield. As a result, many of the successional types were mowed, bush hogged, or bull dozed during the time between photointerpretation and accuracy assessment field work. In turn, many of the polygons visited by the surveyors did not match those classified by the photointerpreter.

In addition, errors are also inevitable in data collection and while attempts were made to minimize them , some were unavoidable. The GPS error also occasionally led the field crew to points in polygons other than those that were intended. The error was somewhat reduced by the use of a WAAS enabled GPS unit and a differential GPS unit, but accuracy still varied from 1 m to 20 m, which affected smaller polygons. Therefore, if the surveyed area was classified in the field as one community type that was incorrect on the map according to where the GPS placed the point, and the GPS error indicated that the point could be in another polygon on the map that matched the classification in the field, then the surveyed area was considered correct. The final accuracy should account for these errors and the map should not be considered inaccurate if the field equipment causes the problems.

Similarly, polygons cannot be perfectly delineated on a map when dealing with vegetation – there is always an ecotonal area where at least two community types blend to some degree. Points sometimes fell into ecotones at COWP which made classification difficult. Since these areas are more difficult to classify and map, it made sense to consider polygons correct if the sampled area fell into an ecotone and the community type on either side of the point fit the classification from the vegetation map. Other errors that arose could have been due to the classification key – occasionally the point did not fit well into any community description so the closest one was chosen, but it may not have been a perfect fit. The vegetation key had been created before planning the accuracy assessment, but the key had not been field-tested. This could result in errors in the assessment that should not be attributed to the map but to the key.

Users of the COWP 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 in likely to contain.

We recommend that natural resource managers consider lumping some commonly confused map classes together for display or other purposes (as detailed in the results section above). 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 COWP.

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 above 80%. These actions will allow for a map that is useful for the widest audience possible while not losing potentially important fine scale detail.

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Appendix A
Classification Key for Field Identification of Evaluation Points

Cowpens National Battlefield
Accuracy Assessment

Key to Ecological and Human Influenced Communities of Cowpens

A. Area is clearly influenced by human activity –
   a. physical artifacts usually present
      i. Area is old or present homesite
         Human influence (HI)
      ii. Area is cemetery
         Cemetery (CEM)
   b. Vegetation obviously planted
      i. Vegetation is evergreen
         1. Canopy dominated by *Pinus strobus*, planted
            White pine (*Pinus strobus)*, planted (PIs)
         2. Canopy dominated by *Pinus virginiana,* planted
            Virginia pine *(Pinus virginiana)*, planted (PIv)
      ii. Vegetation otherwise – See below

1a. Early successional vegetation dominates. Stands of this type have been cut and/or plowed and/or grazed and/or burned heavily within the last 50 years. Grasses and forbs, shrubs, and/or early successional tree species characteristic of high levels of human-initiated disturbance such as pines, sweetgum, and tuliptree are always dominant. Few to no oak trees are present as canopy trees (except for water and willow oaks in one example).

2a. Wetland vegetation: Wetland habitats such as flatlands along creeks inundated during local flooding events.

3a. Vegetation usually along a stream.

4a. Canopy usually dominated by either *Liquidambar styraciflua* or *Liriodendron tulipifera*, but sometimes co-dominated by *Acer rubrum, Platanus occidentalis*, and other trees associated with wet environments.
[SOUTHERN PIEDMONT SMALL STREAM AND FLOODPLAIN FOREST]

5a. Herbaceous and shrub layer highly impacted by invasive exotics (> 25% cover of invasive exotics in shrub and herb layer). [May contain Arundinaria gigantea (native giant cane) (modifier).]
Successional Sweetgum-Tuliptree Floodplain Forest (CEGL007330)

5b. Herbaceous and shrub layer only slightly impacted by invasive exotic species. A healthy and diverse herbaceous layer still persists with less than 25% cover of invasive exotics. [May contain Acer rubrum or Quercus alba (modifiers)]
Piedmont Small Stream Sweetgum – Tuliptree Forest (CEGL004418)

4b. Bottomland dominated by native giant cane (currently only very degraded examples exist in the park, though there is potential for future high quality occurrences if land management practices change and fire is promoted.
[SOUTH-CENTRAL INTERIOR LARGE FLOODPLAIN]
Floodplain Canebrake (CEGL003836)

3b. Vegetation along a highly disturbed watercourse that may now be a stream but was formerly a farm pond – at this point, much of the vegetation in the old pond areas are so highly disturbed as to be "unclassifiable". As a consequence, these areas will be

mapped as **human modified vegetation**. Vegetation can be heavily privet infested but also can contain large amounts of *Betula nigra* (river birch).

3bi. Vegetation dominated by *Betula nigra*
River birch herbaceous wetland (Bn)

3bii. Vegetation dominated by herbaceous species
Herbaceous wetland (Wt)

2b. Terrestrial Vegetation: Upland habitats not inundated by flood waters (includes upland areas with ephemeral ponds or hardpan soils that drain poorly).
[EARLY SUCCESSIONAL OR EXOTIC SPECIES DOMINATED STANDS]

6a. Old fields

6ai. Mainly exotic fescue dominated old field
Cultivated Meadow (CEGL004048)

6aii. Mainly native grass dominated old field. May contain scattered trees (mod).
Successional Broomsedge Vegetation (CEGL004044)

6aiii. Obviously formerly crop-land
Old Field (OF)

6b. Shrublands, thickets, woodlands, savannahs, and forests (but not old fields)

7a. Shrublands, thickets, and woodlands

8a. Dominated by exotic species, especially Phyllostachys aurea
Golden Bamboo Shrubland (CEGL008560)

8b. Dominated by native species of shrubs.
Upland dominated by blackberry and greenbrier
Blackberry-Greenbrier Successional Shrubland Thicket (CEGL004732)

7b. Savanna– Scattered trees in a herbaceous landscape maintained by fire or mowing
Savanna

7c. Forests

9a. Hardwood forest

10a. Canopy dominated by tuliptree or sweetgum

11a. Canopy dominated by tuliptree. May contain Pinus echinata (shortleaf pine) or Quercus nigra (water oak) (modifiers).**Successional Tuliptree-Hardwood Forest(CEGL007221)**

11b. Canopy dominated by young sweetgum. [May be very early successional or may contain Prunus serotina (black cherry) or Quercus phellos (willow oak) or Quercus nigra (water oak) (modifiers).]
Successional Sweetgum Forest (CEGL007216)

10b. Canopy dominated by water and willow oak
Water Oak Forest (CEGL004638)

9b. Pine dominated or mixed forest

12a. Canopy of stand dominated by loblolly pine (shortleaf pine may be present but not dominant). [May contain Pinus echinata or may be planted, even aged stand or may be regeneration, even-age saplings, may be very early successional (modifiers).]
Successional Loblolly Pine Forest (CEGL006011)

12b. Canopy of stand dominated by shortleaf pine (loblolly pine may be present but not dominant). [May contain dead vegetation or Liriodendron tulipifera (tulip tree), may be planted or even- age stand, or may contain Pinus virginiana (Virginia pine), or may be very early successional (modifiers).]
Shortleaf Pine Early Successional Forest (CEGL006327)

1b. Late successional forest and woodland vegetation dominates. Canopy trees generally are those that are considered to be "late successional", such as oaks and hickories. These stands have generally not been plowed or clearcut for at least 50-100 years, although the understories of some stands may have been burned or mowed more recently.

13a. Forest with a canopy dominated by white oak and with a fairly sparse understory. May contain Quercus phellos (willow oak).
[Southern Piedmont Mesic Forest]
Southern Piedmont Mesic Subacid Oak-Hickory Forest (CEGL006227)

13b. Forest or woodland with a canopy not completely dominated by white oak.
[SOUTHERN PIEDMONT DRY OAK – (PINE) FOREST/WOODLAND]

14a. Upland woodland (canopy coverage is usually less than 60 %) with open understory that consists of large amounts of native grasses and forbs and very few shrubs. Understory disturbance has occurred in the form of mowing but may have occurred as sporadic low intensity fires in the past. [May contain Successional tree saplings and shrubs or scattered trees (modifier)]
Piedmont Granitic White Oak-Black Oak Woodland (CEGL003722)

14b. Dry-mesic upland forest (canopy closure is usually more than 60%) with a sparse herbaceous layer. Understory disturbance very minimal. [May contain Liriodendron tulipifera (tulip tree) or may be maintained by mowing, so there is now new recruitment, or may contain Pinus echinata (shortleaf pine) or Pinus virginiana (Virginia pine) or Quercus alba (white oak), Quercus phellos (willow oak), Quercus falcata (southern red oak), Quercus marilandica (Blackjack oak). May be very early successional (modifiers).]
Southern Red oak – White Oak Mixed Oak Forest (CEGL007244)

Appendix B
Contingency Matrices and Error Tables

Cowpens National Battlefield
Accuracy Assessment

Table B-1

Confusion Matrix Using Recommended Groupings and Mapped Dominant, Second, or Third Vegetation (Best Match)

		Observed As:																			
		3722	4044	4638	8560	4418 / 7330	6011 / 6327	6227 / 7244	7216 / 7221	Bld	Bn	CEM	HI	HI-Pls	OF-L	Plv	Rd	SAV	W	Grand Total	Users Accuracy
Mapped As	3722	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA
	4044	0	4	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	5	80%
	4638	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	100%
	8560	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	100%
	4418/7330	0	0	0	0	3	0	0	3	0	0	0	0	0	0	1	0	0	0	7	43%
	6011/6327	0	0	0	1	0	21	1	4	0	0	0	0	1	0	1	0	2	0	31	68%
	6227/7244	0	0	0	0	0	1	15	0	0	0	0	0	0	0	0	0	0	0	16	94%
	7216/7221	0	0	1	0	0	2	1	17	0	0	0	0	0	0	0	0	0	0	21	81%
	Bld	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5	100%
	Bn	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	100%
	CEM	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	100%
	HI	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	4	100%
	HI-Pls	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	100%
	OF-L	0	0	0	0	0	0	2	1	0	0	0	0	0	35	0	0	2	0	40	88%
	Plv	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	100%
	Rd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5	100%
	SAV	1	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	4	0%
	W	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0%
Grand Total		1	1	4	2	3	3	24	21	26	5	2	1	5	3	36	3	5	4		
Producers' Accuracy:		0%	100%	50%	67%	100%	88%	71%	65%	100%	100%	100%	80%	67%	97%	33%	100%	0%	NA		

Table B-2
Confusion Matrix Using Mapped Dominant Vegetation Only, No Groupings

		Observed As:																								
		2591	3722	4044	4418	4638	6011	6227	6327	7216	7221	7244	7330	8560	Bld	Bn	CEM	HI	HI-Pls	OF-L	Plv	Rd	SAV	W	Wt	Grand Total	Users' Accuracy
Mapped As:	2591	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA
	3722	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA
	4044	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	5	80%
	4418	0	0	0	1	0	0	1	0	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	6	17%
	4638	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	100%
	6011	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	5	80%
	6227	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	50%
	6327	1	0	0	0	0	5	0	10	2	2	1	0	1	0	0	0	0	1	0	0	0	0	0	0	23	43%
	7216	1	0	0	0	1	2	0	0	9	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	15	60%
	7221	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	100%
	7244	0	0	0	0	0	0	5	1	0	0	7	0	0	0	0	0	0	0	1	0	0	0	0	0	14	50%
	7330	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0%
	8560	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	100%
	Bld	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	5	100%
	Bn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	100%
	CEM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	100%
	HI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	1	0	0	5	80%
	HI-Pls	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	100%
	OF-L	0	0	0	0	0	1	0	0	2	0	1	0	0	0	0	0	1	0	33	0	0	2	0	0	40	83%
	Plv	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	100%
	Rd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	5	100%
	SAV	0	1	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0%
	W	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0%
	Wt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0%
Grand Total		3	1	4	2	2	13	8	12	15	10	12	1	3	5	2	1	5	4	36	1	5	3	0	0		
Producers' Accuracy:		0%	0%	100%	50%	50%	31%	13%	83%	60%	50%	58%	0%	67%	100%	50%	100%	80%	50%	92%	100%	100%	0%	NA	NA		

Table B-3
Accuracy Calculations with Recommended Groupings & Incorporating Dominant, Second, and Third Mapped Vegetation Types
Cowpens National Battlefield

Class	Producers'			Users'		
	Accuracy	CI	n	Accuracy	CI	n
3722	0%	--	1	NA	--	0
4044	100%	0.13	4	80%	--	5
4638	50%	2.48	2	100%	--	1
8560	67%	0.96	3	100%	--	2
4048 / 4732 / OF	97%	0.06	37	90%	0.09	40
4418/7330	100%	0.17	3	43%	0.43	7
6011 / 6327	88%	0.13	26	79%	--	29
6227 / 7244	71%	0.19	21	94%	0.14	16
7216 / 7221	68%	0.18	25	81%	0.17	21
Bld	100%	0.10	5	100%	0.10	5
Bn	100%	0.25	2	100%	--	2
CEM	100%	--	1	100%	--	1
HI	100%	0.10	5	100%	0.10	5
Pls / Plv	60%	0.57	5	75%	--	4
Rd	100%	0.10	5	100%	--	5
SAV	50%	0.71	4	40%	0.57	5
W	NA	--	0	0%	--	1

CI The 90% confidence interval.
n The sample size. For users' accuracy, this is the number of points mapped in this class. For producers' accuracy, it is the number of points assigned to that class in the field.
NA Not applicable. No evaluation points were assigned to that association in the field.
-- A confidence interval could not be calculated due to the small sample size.

Table B-4
Accuracy Calculations Using the Mapped Dominant Vegetation Type Only
Cowpens National Battlefield

Class	Producers' Accuracy			Users' Accuracy		
	Accuracy	CI	n	Accuracy	CI	n
2591	0%	--	1	--	--	0
3722	100%	13%	4	--	--	5
4044	50%	248%	2	100%	--	1
4418	67%	96%	3	100%	25%	2
4638	100%	17%	3	43%	43%	7
6011	88%	14%	24	68%	16%	31
6227	71%	19%	21	94%	14%	16
6327	65%	18%	26	81%	17%	21
7216	100%	10%	5	100%	10%	5
7221	100%	25%	2	100%	25%	2
7244	100%	--	1	100%	--	1
7330	80%	48%	5	100%	13%	4
8560	67%	96%	3	100%	25%	2
OF-L	97%	6%	36	88%	10%	40
Bld	33%	96%	3	100%	--	1
Bn	100%	10%	5	100%	10%	5
CEM	0%	13%	4	0%	13%	4
HI	--	--	0	0%	--	1
HI-PIs	0%	--	1	--	--	0
PIv	100%	13%	4	--	--	5
Rd	50%	248%	2	100%	--	1
SAVd	67%	96%	3	100%	25%	2
W	100%	17%	3	43%	43%	7

CI The 90% confidence interval.

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

NA Not applicable. No evaluation points were assigned to that association in the field.

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