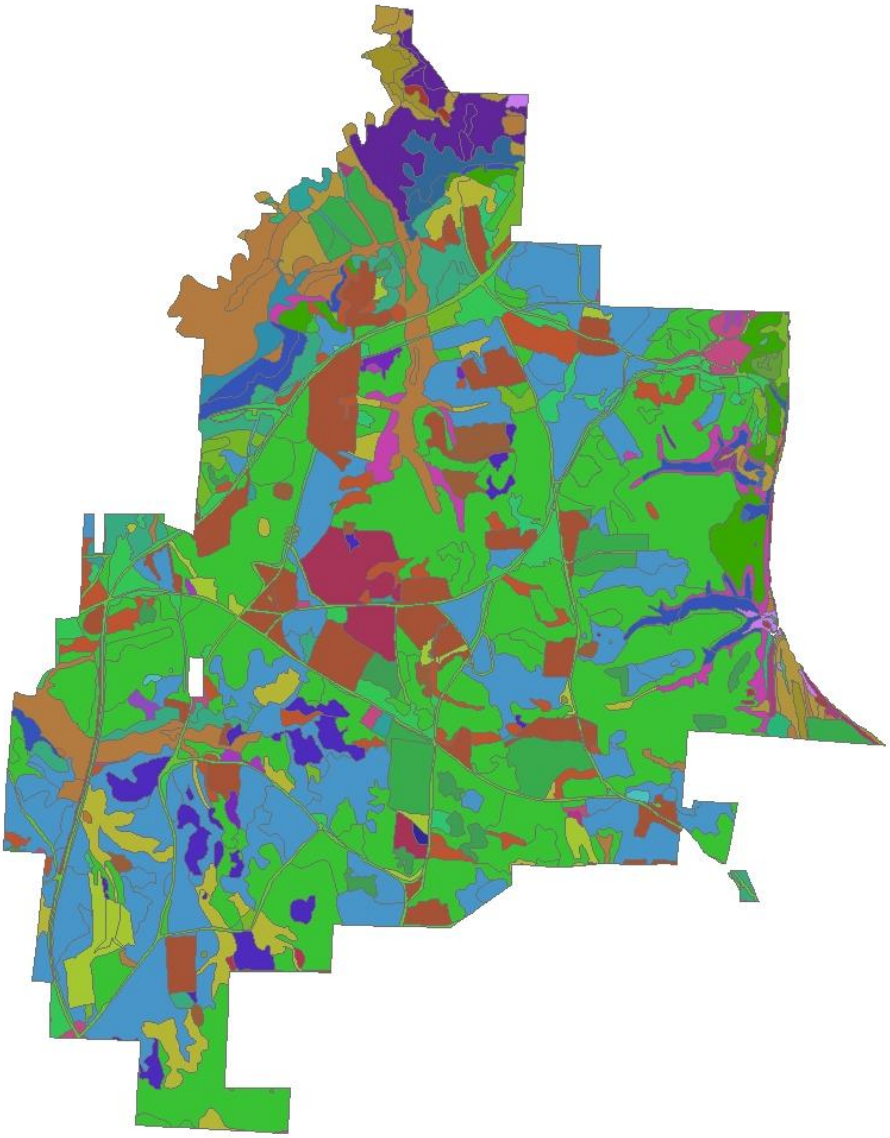
Accuracy Assessment: Shiloh National Military Park (SHIL)



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Executive Summary

This report presents the accuracy assessment for the digital vegetation map of Shiloh National Military Park (SHIL). Vegetation at SHIL was mapped by The University of Georgia Center for Remote Sensing and Mapping Science (Jordan and Madden 2010) with ecological consultation and assistance from NatureServe. The mapping was conducted as part of the National Park Service Vegetation Mapping Program.

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

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

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

For SHIL, the overall accuracy of the final map, which includes eleven map classes (nine grouped map classes and two singular map classes), is 78.8%, with a kappa statistic of 0.58 (58%). 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. White Oak/Chinquapin Oak/Cherrybark Oak Dominated Uplant Forest: (White Oak – Mixed Oak Dry – Dry Mesic Alkaline Forest **(CEGL002070)**; Central Interior Upland Cherrybark Oak Forest **(CEGL003871)**; and Upper East Gulf Coastal Plain Chinquapin Oak – Mixed Oak – Hickory Forest **(CEGL003903))**.

b. Bottomland Sweetgum-Oak Forest and Buttonbush Shrublands:(Swamp Chestnut Oak – Sweetgum Mesic Floodplain Forest **(CEGL002099)**; Southern Buttonbush Pond **(CEGL002191)**; Successional Sweetgum Floodplain Forest **(CEGL007330)**; and Sweetgum – Cherrybark Oak Floodplain Forest **(CEGL007353)**).

c. Water Tupelo Swamp Forest **(CEGL002419)** and Southeastern Smooth Alder Swamp **(CEGL008474)**.

d. Bottomland Forest dominated by Ash, Elm, Sycamore, Sugarberry, and Sweetgum: (Silver Maple – Sugarberry – Pecan Floodplain Forest **(CEGL002431)**; Southern Green Ash – Elm – Sugarberry Forest **(CEGL002427)**; River Birch Levee Forest **(CEGL007312)**; Sycamore – Silver Maple Calcareous Floodplain Forest **(CEGL007334)**; and Gulf Coastal Plain Sycamore – Sweetgum Floodplain Forest **(CEGL007335)**).

e. Successional Pine and Cedar Upland Forest: (Virginia Pine Successional Forest **(CEGL002591)**; Early – to Mid – Successional Forest **(CEGL006011)**; Shortleaf Pine Early – Successional Forest **(CEGL006327)**; Red – cedar Successional Forest **(CEGL007124)**; Loblolly Pine Plantation **(CEGL007179)**; and Mid – to Late – Successional Loblolly Pine – Sweetgum Forest **(CEGL008462)**).

f. Pasture/Meadow: (Successional Broomsedge Vegetation **(CEGL004044)**; Cultivated Meadow **(CEGL004048)**; Johnson Grass Vegetation **(CEGL004108)**; and Bahia Grass Pasture **(CEGL004700)**).

g. Dry-Mesic to Xeric Oak-Pine Upland Forest and Woodland: (East Gulf Coastal Plain Shortleaf Pine – Southern Red Oak Forest **(CEGL004052)**; East Gulf Coastal Plain Shortleaf Pine – Post Oak Forest **(CEGL004053)**; Rush Marsh **(CEGL004412)**; Western Highland Rim Post Oak Barrens **(CEGL004686)**; Western highland Rim Blackjack Oak Barrens **(CEGL004756)**; Southern Red Oak – White Oak Mixed Oak Forest **(CEGL007244)**; Dry Acid Eastern Coastal Plain Oak – Hickory Forest **(CEGL007246)**; Southern Red Oak - (Scarlet Oak, Post Oak) / (Hillside Blueberry, Deerberry) Forest **(CEGL007247)**; Interior Dry – Mesic White Oak – Hickory Forest **(CEGL007795)**).

h. Mesic Mixed Hardwood Forest and Seeps: (Interior Forested Acid Seep **(CEGL004425)**; East Gulf Coastal Plain Beech Floodplain Forest **(CEGL004745)**; Southern Mesic Beech - Tuliptree Slopes **(CEGL007201)**; and Central Interior Beech – White Oak Forest **(CEGL007881)**).

i. Successional Sweetgum and Tuliptree Dominated Upland Forest: (Successional Sweetgum Forest **(CEGL007216)**; Interior Mid – to – Late – Successional Sweetgum - Oak Forest **(CEGL007217)**; and Interior Mid – to Late – Successional Tuliptree – Hardwood Upland Forest (Acid Type) **(CEGL007221)**).

The accuracy assessment for this version of the map considered points as a match if the vegetation observed on the ground matched any of the dominant, secondary, or tertiary vegetation types attributed to the map by the mapmaking team. It then grouped together the most commonly confused vegetation classes.

A stricter analysis of the data (before combining map classes) was completed in the initial stages of this analysis. However, this stricter analysis only considered a point as a match if the vegetation observed on the ground matched any of the dominant vegetation type, secondary, or tertiary vegetation type attributed by the mappers. The accuracy of this map was only 52.2% overall with a kappa statistic of 0.39 (39%). This lower accuracy reflects the difficulty in differentiating the vegetation associations that were combined in the final analysis because of similarities in composition and/or in appearance on aerial photography.

Key findings:

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

Introduction

In 1994, the National Park Service (NPS) and the U.S. Geological Survey (USGS) embarked on a collaborative Vegetative Mapping project to catalog and map the biodiversity of the United States. The goal of the project was to map the 230+ park units within the United States (ESRI et al. 1994). As part of this national mapping initiative, a digital vegetation map of Shiloh National Military Park (SHIL) was completed in by the University of Georgia Center for Remote Sensing and Mapping Science (Jordan and Madden 2010), in consultation with NatureServe. The mapping effort included collection of field data, interpretation of aerial photography, and polygon attribution to GIS maps.

The first major battle of the Civil War's Western theatre occurred at Shiloh in 1862. It was a two-day battle resulting in nearly 24,000 casualties and a decisive victory for the Union forces that later went on to seize control of the Confederate railway system in Corinth, Mississippi. The park was established in 1894 to preserve the battle scenes and is approximately 1,607 ha.

Although the park has been preserved due to its historical significance, it is also home to ecological communities that provide habitat for a wide range of plant and animal species. Shiloh National Military Park contains alluvial floodplains, mixed bottomland and swamp forests, steep river bluffs, xeric woodlands, and rock outcrops. Water resources in the park include Bloody Pond, natural springs, the Tennessee River, and Owl Creek. Uplands are predominantly mixed oak forest and old-fields. Hardwoods dominate the river bluff slopes and ravines.

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

Methods

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

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

Site Selection

Site selection followed a point-based approach to assess the accuracy of the map classes, with one or more evaluation points representing each map class. Different vegetation types are represented in the map as polygons, with one or more polygon for each type. Points were selected from within those polygons using a GRTS selection approach which bases point selection on a generalized random tessellation stratified (GRTS) design. Because representative points, not entire polygons, were evaluated, the assessment results should be interpreted as a measure of the accuracy of the overall map class, rather than an assessment of whether whole polygons were classified correctly. For the SHIL accuracy assessment, 317 points representing 38 vegetation types were evaluated.

In the mapping process, UGA assigned a dominant vegetation association based on the U.S. National Vegetation Classification (NVC) for each polygon. A few polygons were also assigned secondary and/or tertiary associations because of perceived ecotones, inclusions smaller than the minimum mapping unit, areas with active succession, or in blended vegetation types. For the selection of evaluation points, only the dominant vegetation type was considered. Points were distributed across dominant vegetation types, with the number of points in each class determined by and distributed proportionally to the area of these vegetation classes within the park (ESRI et al. 1994, NatureServe 2007) within the constraints that no more than 30, and no less than 5, points be located in a given class. (Note, some classes ultimately had fewer than five points when the very small size of the mapped area precluded placement of five points while maintaining minimum separation distances).Classes that took up a significantly larger portion of the park had more assessment points than classes that represented a small portion of the park. Each point was assigned a weight during the GRTS selection process based on the area of the mapped class and the number of points assigned to it; these weights are indicative of the proportion of the map a given point represents.

Locations of evaluation points were generated using the spsurvey package in the statistical software package “R Project for Statistical Computing” (R Development Core Team, 2008). Points were excluded from a 12 meter internal buffer around the boundary of each vegetation polygon to ensure that points were within polygons and to avoid misclassification due to GPS error in the field. In some instances, the size and shape of the vegetation polygons prevented selection of an adequate number of points outside the buffered area. Polygons smaller than 0.045 hectares (452 square meters) with assessment points were flagged for special consideration by the field crew because there was increased potential that GPS error could lead to assessment of an unintended polygon. A distance of at least 80 meters was maintained between adjacent points to prevent overlap in the area evaluated around each point.

Field Data Collection

Field crews located each evaluation point using a WAAS-enabled Garmin 5 GPS unit or comparable unit. Wide Area Augmentation System (WAAS) is a form of Differential GPS, which provides enhanced positional accuracy. At each point, the field crew recorded new coordinates, GPS positional accuracy, and collected limited vegetation data. When collecting vegetation data for accuracy points, the assessment area was the 40 meter radius circle around each point. Only the dominant and diagnostic species were recorded for each stratum. The primary association type at that point was determined by the field crew using an existing key to the ecological and human influenced communities at SHIL, and a “fit” value of high, medium, or low was also selected to characterize the fit of the classification key

description. The classification key used in the field can be found in Appendix A. In some cases, a secondary or alternate association was also recorded, and notes were taken on any difficulties keying out the point. A total of 317 data points with field data were used for the assessment of thematic accuracy.

Data Analysis

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

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

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

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

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

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

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

Results

The overall accuracy of the final SHIL vegetation map, which considered dominant, secondary, or tertiary vegetation types as well as several combined map classes, is 78.8% with a kappa statistic of 0.58 (58%). The tabulation of user's and producer's accuracy for each map class in this version of the analysis is provided in Appendix B, Table 2. Groupings were created based on a review of the contingency matrix for the original fine-scale analysis. Grouped associations included:

a. White Oak/Chinquapin Oak/Cherrybark Oak Dominated Upland Forest: (White Oak – Mixed Oak Dry – Dry Mesic Alkaline Forest **(CEGL002070)**; Central Interior Upland Cherrybark Oak Forest **(CEGL003871)**; and Upper East Gulf Coastal Plain Chinquapin Oak – Mixed Oak – Hickory Forest **(CEGL003903)**).

b. Bottomland Sweetgum-Oak Forest and Buttonbush Shrublands: (Swamp Chestnut Oak – Sweetgum Mesic Floodplain Forest **(CEGL002099)**; Southern Buttonbush Pond **(CEGL002191)**; Successional Sweetgum Floodplain Forest **(CEGL007330)**; and Sweetgum – Cherrybark Oak Floodplain Forest **(CEGL007353)**).

c. Water Tupelo Swamp Forest **(CEGL002419)** and Southeastern Smooth Alder Swamp **(CEGL008474)**.

d. Bottomland Forest Dominated by Ash, Elm, Sycamore, Sugarberry, and Sweetgum: (Silver Maple – Sugarberry – Pecan Floodplain Forest **(CEGL002431)**; Southern Green Ash – Elm – Sugarberry Forest **(CEGL002427)**; River Birch Levee Forest **(CEGL007312)**; Sycamore – Silver Maple Calcareous Floodplain Forest **(CEGL007334)**; and Gulf Coastal Plain Sycamore – Sweetgum Floodplain Forest **(CEGL007335)**).

e. Successional Pine and Cedar Upland Forest: (Virginia Pine Successional Forest **(CEGL002591)**; Early – to Mid – Successional Forest **(CEGL006011)**; Shortleaf Pine Early – Successional Forest

(CEGL006327); Red – cedar Successional Forest **(CEGL007124)**; Loblolly Pine Plantation **(CEGL007179)**; and Mid – to Late – Successional Loblolly Pine – Sweetgum Forest **(CEGL008462)**).

f. Pasture/Meadow: (Successional Broomsedge Vegetation **(CEGL004044)**; Cultivated Meadow **(CEGL004048)**; Johnson Grass Vegetation **(CEGL004108)**; and Bahia Grass Pasture **(CEGL004700)**).

g. Dry-Mesic to Xeric Oak-Pine Upland Forest and Woodland: (East Gulf Coastal Plain Shortleaf Pine – Southern Red Oak Forest **(CEGL004052)**; East Gulf Coastal Plain Shortleaf Pine – Post Oak Forest **(CEGL004053)**; Rush Marsh **(CEGL004412)**; Western Highland Rim Post Oak Barrens **(CEGL004686)**; Western highland Rim Blackjack Oak Barrens **(CEGL004756)**; Southern Red Oak – White Oak Mixed Oak Forest **(CEGL007244)**; Dry Acid Eastern Coastal Plain Oak – Hickory Forest **(CEGL007246)**; Southern Red Oak - (Scarlet Oak, Post Oak) / (Hillside Blueberry, Deerberry) Forest **(CEGL007247)**; Interior Dry – Mesic White Oak – Hickory Forest **(CEGL007795)**).

h. Mesic Mixed Hardwood Forest and Seeps: (Interior Forested Acid Seep **(CEGL004425)**; East Gulf Coastal Plain Beech Floodplain Forest **(CEGL004745)**; Southern Mesic Beech - Tuliptree Slopes **(CEGL007201)**; and Central Interior Beech – White Oak Forest **(CEGL007881)**).

i. Successional Sweetgum and Tuliptree Dominated Upland Forest: (Successional Sweetgum Forest **(CEGL007216)**; Interior Mid – to – Late – Successional Sweetgum - Oak Forest **(CEGL007217)**; and Interior Mid – to Late – Successional Tuliptree – Hardwood Upland Forest (Acid Type) **(CEGL007221)**).

A stricter analysis, which considered dominant, secondary, or tertiary vegetation types but no combined map classes, produced an overall accuracy of 52.2% with a kappa statistic of 0.39 (39%) (Appendix B, Table 3). The strictest analysis, which considered dominant vegetation classes only, produced an overall accuracy of 45.9% with a kappa statistic of 0.31 (31%) (Appendix B, Table 6).

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

It is apparent from the comparison of Tables 2-3 that overall map accuracy is considerably higher when classes are grouped than when secondary and tertiary mapped vegetation are considered. The fine-scale detail that is available to users of the ungrouped map classes will be invaluable to researchers and managers interested in distinct vegetation associations. However, due to the error inherent in mapping at such fine-scale, it is important that the user take into account the misclassification rates shown on the contingency tables in Appendix B when using this version of the map. Because much higher accuracies are achieved when vegetation types are grouped, we recommend that users who are less inclined to explore the accuracy assessment in depth be guided to use the coarser scale, higher accuracy version of the map.

Discussion

Overall, the vegetation map for Shiloh National Military Park provides a relatively accurate representation of vegetation types within the park and nearly meets the NPS 80% accuracy guidance. Several individual map classes had very low user's accuracies. Many of the map classes with the lowest accuracy were "confused" with other very similar and related map classes. For instance, CEGL007216, CEGL007217, and CEGL007221 are all sweetgum/tulliptree dominated successional forests. When considered separately, their individual user's accuracies are between 9 and 24% for the park. However, when grouped, the three map classes combined have an accuracy of 51%. This map class was the lowest accuracy map class of all grouped classes, but the accuracy improved substantially with the grouping.

Low map accuracies can arise from a variety of error sources. One source that contributes most often to mapping/accuracy assessment error is the temporal difference between the period of mapping and the period of assessment. This influences the relative accuracy of the map because ecological events like succession or storm events, management activities, and other anthropogenic influences may have altered the landscape in a way that makes it different from what it looked like at the time of mapping. Based on communication with staff at the park, we know that some large storm events had impacted the forests heavily between the aerial imagery dates and the dates of our fieldwork. Areas most impacted were the upland oak-hickory forests. These communities tended to be heavily confused with each other in our analysis.

In some instances, linear features such as creeks or steep slopes also made mapping and assessment problematic. Due to the linearity of many of the polygons and their associated vegetation classes, GPS navigation and accuracy within the polygon is less reliable due to the narrowness and the increased possibility of assessing the wrong polygon/vegetation type. As a result, GPS error may have contributed somewhat to lower accuracies of steeply sloped communities.

While the accuracy assessment is intended to provide a measure of vegetation map and map class reliability, the reader should be aware that error is also inherent in the field assessment of evaluation points. The overall accuracy of the Shiloh vegetation map was lower before grouping map classes. At any park, the overall accuracy and user's and producer's accuracy of individual map classes may be affected by a variety of factors including the fragmentation and severe changes in management practices, GPS error, data collection error by the field crew, poorly built and/or untested classification keys, poor ecological community concepts, inconsistent interpretation of the classification key, and potential lag times between photointerpretation and accuracy assessment. Two or more community types could be similar enough such that one assessment point could be mistakenly assigned to a particular community type by the field crew when another community type was assigned to the same area by the map producers (Townsend 2000). Points may fall into ecotones or into inclusions within the larger community type and the resulting classification in the field may not be the same as that on the map. While measures were taken to reduce these errors, they are not altogether avoidable and it is not within the scope of this project to discern what mistakes led to errors. **However, it is important to note that mapping error is but one of many types of error that combine to create accuracy issues with any given map.**

Users of the SHIL digital vegetation map should familiarize themselves with the results of this accuracy assessment, the potential sources of classification error, and the contingency tables provided in Appendix B. When interested in using the map to locate a particular association, it is useful to know what other map classes have been shown to contain points matching that association, and what other vegetation types the mapped association of interest is likely to contain. We recommend that natural

resource managers consider combining some commonly confused map classes together for display or other purposes.

The large difference between the overall measure of accuracy and the kappa statistic (for the grouped analysis, overall accuracy measured 78.8% and kappa statistic measured 58.0%) can be attributed to the fact that more samples are generated for vegetation classes that comprise a large percentage of the total mapped area and they receive higher weights. Thus they contribute more to our accuracy calculations and, due to their higher proportional representation, are more likely to be correctly classified by chance and thus discounted by the kappa statistic.

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

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 SHIL map as published by UGA. For all other users, we recommend combining map classes as specified above to allow for an overall map accuracy near 80%. These actions will allow for a map that is useful for the widest audience possible, while maintaining potentially important fine scale detail.

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Appendix A: Revised Classification Key for Shiloh National Military Park

NatureServe Key to the National Vegetation Classification (NVC) Associations at Shiloh NMP

All associations mapped by UGA-CRMS or documented by Natureserve are in bold. Associations that were **NOT** mapped may still key, but are noted as **"NOT MAPPED"** For each association the common name is given, with the Database Code in parentheses (CEGL00####), and the Alliance Code in brackets [A.###]. The Alliances are broader units (groups of associations) based on dominant species in the upper most layer of the vegetation (i.e. the forest canopy dominants). The key uses two measures of percent cover for species. Cover is canopy cover, the percent of the observation area which the canopy vegetation of that species covers. For trees this is from an outline of the canopy. Relative cover is similarly determined, except that it is the percent of that species of the total vegetation cover. So for an open tree canopy with Shortleaf Pine covering 30% and White Oak 30%, both have 30% cover, but if these are the only 2 canopy trees in an open stand with many gaps than each would have 50% relative cover.

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KEY B – UPLAND MIXED FORESTS 4

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KEY H – FORB (BROADLEAF) VEGETATION 14

KEY TO KEYS

1a. Vegetation dominated by trees; closed forests, open woodlands or grassy barrens with some trees **2**

1b. Vegetation **NOT** dominated by trees, trees absent or very sparse..... **3**

2a. Upland forests, woodlands or grassy barrens (this includes areas with scattered trees and native grasses, e.g. Little Bluestem (*Schizachyrium scoparium)*, **NOT** prone to flooding or saturation **5**

2b. Forests of bottomlands, swamps, seeps or other areas prone to flooding or saturation (if bottomland or riparian less than 20 meters wide, it may fall into upland forest category)***KEY E – WETLAND FORESTS***

3a. Shrub dominated and vine dominated areas (with few or no trees)..... .....***KEY F – DECIDUOUS SHRUBLANDS***

3b. Vegetation dominated by herbaceous plants (see also Upland Barrens at **5a** below)..... **4**

4a. Vegetation dominated or characterized by grasses or grass-like plants (perennial or annual) .... ***KEY G – GRAMINOID VEGETATION***

4b. Vegetation dominated by forbs (broadleaf plants)...***KEY H – FORB (BROADLEAF) VEGETATION***

5a. Upland grassy barrens, with scattered trees and Little Bluestem (*Schizachyrium scoparium)* and other native warm season grasses .....***KEY D – UPLAND BARRENS***

5b. Upland forests or woodlands **6**

6a. Upland deciduous forests or woodlands, if evergreen trees are present they are a minor canopy component..... ***KEY C – UPLAND DECIDUOUS FORESTS***

6b. Upland evergreen and mixed forests dominated (usually >75%) or co-dominated (>25%) by evergreen trees such as Pine (*Pinus spp.)* or Eastern Red-cedar (*Juniperus virginiana*)..... **7**

7a. Upland evergreen forests; dominated by evergreen trees (generally greater than 50% canopy cover) ....

.....***KEY A – UPLAND EVERGREEN FORESTS***

7b. Upland mixed forests; codominated by evergreen (with at least 25% cover) and deciduous trees .....

.....***KEY B – UPLAND MIXED FORESTS***

KEY A – UPLAND EVERGREEN FORESTS

1a. Evergreen forest, dominated (> 50%) by Eastern red cedar (*Juniperus virginiana*) ..... ***Red-cedar Successional Forest* (CEGL007124) [A.137]**

1b. Evergreen forest dominated by (>50% relative cover) Pine (*Pinus spp.*)..... **2**

2a. Evergreen forest dominated by Virginia Pine (*Pinus virginiana*) or Shortleaf Pine (*Pinus echinata)* .. **3**

2b. Evergreen forest dominated by Loblolly Pine (*Pinus taeda)*, which is rare at Shiloh..... **4**

3a. Dominated by Virginia Pine (*Pinus virginiana*) ..... ***Virginia Pine Successional Forest* (CEGL002591) [A.131]**

3b. Dominated by Shortleaf Pine (*Pinus echinata)* ..... ***Shortleaf Pine Early-Successional Forest* (CEGL006327) [A.119]**

4a. Monospecific stands of (generally young) planted Loblolly Pine (*Pinus taeda)*, with little understory .. .. **NOT MAPPED** ***Loblolly Pine Plantation* (CEGL007179) [A.99]**

4b. Forest dominated by Loblolly Pine (*Pinus taeda)* with a hardwood component of the canopy or subcanopy .....**5 [A.130]**

5a. Forest with monospecific canopy dominated by Loblolly Pine (*Pinus taeda)* and with subcanopy of Sweetgum (*Liquidambar styraciflua)* and/or Red Maple (*Acer rubrum var. rubrum*) ..... ***Early- to Mid-Successional Loblolly Pine Forest* (CEGL006011) [A.130]**

5b. Loblolly Pine forest with significant Sweetgum (*Liquidambar styraciflua)* in the canopy, typical of unmanaged, older planted or successional Loblolly Pine (*Pinus taeda)* stands..... ..... ***Mid- to Late-Successional Loblolly Pine - Sweetgum Forest* (CEGL008462) [A.130]**

KEY B – UPLAND MIXED FORESTS

1a. Codominated by Eastern red cedar (*Juniperus virginiana*) and Post Oak (*Quercus stellata*) .... **Western Highland Rim Post Oak Barrens (CEGL004686) [A.625]**

1b. Dominated or codominated by Shortleaf Pine (*Pinus echinata)* **2**

2a. Shortleaf Pine (*Pinus echinata)* mixed with Southern Red Oak (*Quercus falcata*)..... **NOT MAPPED** ..... ***East Gulf Coastal Plain Shortleaf Pine-Southern Red Oak Forest* (CEGL004052) [A.394]**

2b. Shortleaf Pine (*Pinus echinata)* mixed with Post Oak (*Quercus stellata*)..... ..... **NOT MAPPED** ***East Gulf Coastal Plain Shortleaf Pine - Post Oak Forest* (CEGL004053) [A.394]**

KEY C – UPLAND DECIDUOUS FORESTS

1a. Forest dominated by the exotic (not native) Tree-of-Heaven (*Ailanthus altissima*)..... ..... **NOT MAPPED** ***Successional Tree-of-Heaven Forest*** **(CEGL007191) [A.221]**

1b. Forest or woodland dominated by native trees **2**

2a. Forests dominated or codominated by Sweetgum (*Liquidambar styraciflua*) and/or Tuliptree (*Liriodendron tulipifera*) **at least 50% canopy cover of Sweetgum (*Liquidambar styraciflua*) and Tuliptree (*Liriodendron tulipifera*) combined **3**

2b. Forests **NOT** dominated nor codominated by Sweetgum (*Liquidambar styraciflua*) nor Tuliptree (*Liriodendron tulipifera*) **less than 50% cover of Sweetgum (*Liquidambar styraciflua*) plus Tuliptree (*Liriodendron tulipifera*) combined **8**

3a. Forests **NOT** successional. Stands generally have characteristics of older, uneven aged forests such as standing dead trees, downed logs, canopy gaps, and scattered large trees (i.e. ~20 inch dbh)..... **4**

3b. Forests successional (which means the forest is generally even-aged). In some cases, even aged stands may be more than 80 years old with very large Sweetgum (*Liquidambar styraciflua*) or Tuliptree (*Liriodendron tulipifera*). Usually lacking characteristics of older forests such as standing dead trees, large numbers of downed logs, canopy gaps, and large trees of vastly different ages..... **5**

4a. Mature mesic forests dominated by White Oak (*Quercus alba*) and Hickories (*Carya spp.*) .....**NOT MAPPED*****Highland Rim White Oak - Tuliptree Mesic Lower Slope Forest*** **(CEGL007709) [A.239]**

4b. Mesic forests on slopes (sometimes making it down to the flat narrow ravine bottomlands) with Beech (*Fagus grandifolia)* and usually Tuliptree (*Liriodendron tulipifera*) but generally with less than 10% canopy coverage of White Oak (*Quercus alba*)..... .....***Southern Mesic Beech - Tuliptree Slopes*** **(CEGL007201) [A.227]**

5a. Forests dominated or codominated by Sweetgum (*Liquidambar styraciflua*).....**6 [A.234]**

5b. Forests dominated or codominated by Tuliptree (*Liriodendron tulipifera*).....**7 [A.236]**

6a. Early successional forest nearly completely dominated by Sweetgum (*Liquidambar styraciflua*) on disturbed or formerly cut over sites .....***Successional Sweetgum Forest*** **(CEGL007216) [A.234]**

6b. Mid to late successional forest dominated by Sweetgum (*Liquidambar styraciflua*) with White Oak (*Quercus alba*), Tuliptree (*Liriodendron tulipifera),* and/or Southern Red Oak (*Quercus falcata*) in the overstory ..... ***Interior Mid- to Late-Successional Sweetgum - Oak Forest*** **(CEGL007217) [A.234]**

7a. Forest dominated or codominated by Tuliptree (*Liriodendron tulipifera*), with a hardwood component indicative of acidic conditions (i.e. with Red Maple (*Acer rubrum),* White Oak (*Quercus alba*), or Southern Red Oak (*Quercus falcata*). While this is considered a successional stand, there are some stands more than 80 years of age at Shiloh that have a significant White Oak (*Quercus alba*) canopy..... ***Interior Mid- to Late-Successional Tuliptree - Hardwood Upland Forest (Acid Type)*** **(CEGL007221) [A.236]**

7b. Forest dominated or codominated by Tuliptree (*Liriodendron tulipifera*), with a hardwood component indicative of basic or circumneutral conditions, for instance with Black Walnut (*Juglans nigra),* White Ash (*Fraxinus americana),* Slippery Elm (*Ulmus rubra),* Chinquapin Oak (*Quercus muehlenbergii),*

and/or Shagbark Hickory (*Carya ovata)*. Species often found in the subcanopy include Sugar Maple (*Acer saccharum),* Redbud *(Cercis canadensis),* and Spicebush (*Lindera benzoin)*..... ..... **NOT MAPPED** ***Successional Tuliptree Forest (Circumneutral Type)*** **(CEGL007220) [A.236]**

8a. Forests **NOT** dominated or codominated by American Beech (*Fagus grandifolia*) or Sugar Maple (*Acer saccharum*)..... **9**

8b. Forests dominated or codominated by American Beech (*Fagus grandifolia*) or Sugar Maple (*Acer saccharum*) **at least 50% cover of beech plus sugar maple combined..... **10**

9a. The canopy is strongly dominated by *Quercus prinus* (at least 20% canopy cover)..... .....**NOT MAPPED** ***Lower Piedmont Chestnut Oak Forest*** **(CEGL007261) [A.249]**

9b. Forests **NOT** dominated nor codominated by Chestnut Oak (*Quercus prinus*) (*Quercus prinus* less than 20% canopy cover)..... **11**

10a (one of three). Forests dominated or codominated by American Beech (*Fagus grandifolia*) or Sugar Maple (*Acer saccharum*) **at least 50% cover of beech plus sugar maple combined and often with large component of white oak.....***Central Interior Beech - White Oak Forest* **(CEGL007881) [A.229]**

10b (one of three). Sugar maple (*Acer saccharum)* codominant (usually >25% canopy cover of sugar maple) with less than 25% cover of white oak or tuliptree..... .....**NOT MAPPED** ***Beech - Maple Unglaciated Forest*** **(CEGL002411) [A.227]**

10c (one of three). Tuliptree (*Liriodendron tulipifera)* codominant (usually >25% canopy cover of tuliptree) will less than 25% cover of white oak..... .....***Southern Mesic Beech - Tuliptree Slopes*** **(CEGL007201) [A227]**

11a. Forests with chinquapin oak (*Quercus muehlenbergii)* at least 25% cover or black oak plus chinquapin oak of at least 50% cover**…..** **..... 12**

11b. Forests with less than 25% cover of chinquapin oak in canopy and/or less than 50% combined cover of chinquapin oak and black oak in canopy**..... 13**

12a. Significant canopy coverage of white oak or red oak. Forest canopy contains a heavy component (at least 25% combined) of Chinquapin Oak (*Quercus muehlenbergii)* and/or Black Oak *(Quercus velutina*. Typical associates include *Carya ovata* (shagbark hickory), Sugar Maple (*Acer saccharum*), Hop hornbeam (*Ostrya virginiana),* Redbud (*Cercis canadensis*) and *Liriodendron tulipifera* (tuliptree) **NOT** all associates need be present at any one observation point..... .....***White Oak - Mixed Oak Dry-Mesic Alkaline Forest*** **(CEGL002070) [A.239]**

12b. No significant canopy coverage of white oak, black oak, or red oak. ..... ***Upper East Gulf Coastal Plain Chinquapin Oak – Mixed Oak – Hickory Forest*** **(CEGL003903) [A.1912]**

13a. Forest dominated or codominated by Cherrybark Oak (*Quercus pagoda)*..... .....***Central Interior Upland Cherrybark Oak Forest*** **(CEGL003871) [A252]**

13b. Forest not dominated or codominated by cherrybark oak**..... 14**

14a. Forests with Southern Red Oak (*Quercus falcata)* an important or codominant canopy tree with >25% canopy cover of Southern Red Oak (*Quercus falcata)*..... **15**

14b. Southern Red Oak (*Quercus falcata*) **NOT** an important or codominant canopy tree (<25% cover) **18**

15a. Flatwoods (upland flats with poor drainage and having some ponding of water after heavy rains), dominated by Southern Red Oak (*Quercus falcata*)..... ..... ***Southern Red Oak Flatwoods Forest* (CEGL004412) [A.243]**

15b. Dry forests of upland ridges or slopes (generally facing southeast to northwest) **16**

16a. Scarlet Oak (*Quercus coccinea*) more than 20% relative canopy cover. Codominated by Southern Red Oak (*Quercus falcata)*, Scarlet Oak (*Quercus coccinea*), and/or Post Oak (*Quercus stellata)*. .... **MAPPED BUT NOT DOCUMENTED BY NATURESERVE** ***Quercus falcata - Quercus (coccinea, stellata) / Vaccinium (pallidum, stamineum) Forest* (CEGL007247) [A.243**

16b. Codominated by Southern Red Oak (*Quercus falcata)*, but **NOT** dominated nor codominated by Scarlet Oak (*Quercus coccinea*) which is generally less than 20% relative canopy cover **17**

17a. Dominated by Southern Red Oak (*Quercus falcata)* with White Oak (*Quercus alba*) as an important component of the canopy with more than 2 canopy White Oaks (*Quercus alba*) within the observation area, and less Post Oak (*Quercus stellata)* or Scarlet Oak (*Quercus coccinea*). .... ***Southern Red Oak - White Oak Mixed Oak Forest* (CEGL007244) [A.241]**

17b. Dominated by Southern Red Oak (*Quercus falcata)*, and Post Oak (*Quercus stellata),* with less Scarlet Oak (*Quercus coccinea*) and less White Oak (*Quercus alba*),.less than 3 White Oak (*Quercus alba*) canopy trees in the observation area .. ..***Dry Acid Eastern Coastal Plain Oak - Hickory Forest* (CEGL007246) [A.243]**

18a. Forest codominated by Red Oak (*Quercus rubra*) and White Oak *(Quercus alba)* **More than 20% relative canopy cover of Red Oak (*Quercus rubra*).....**19[A.239]**

18b. Forest codominated by White Oak *(Quercus alba)* without Red Oak (*Quercus rubra*). **Less than 20% cover of Red Oak (*Quercus rubra*)..... **20**

19a. Forest with Sugar Maple (*Acer saccharum*), Hop hornbeam (*Ostrya virginiana),* Redbud (*Cercis canadensis*) or other indicators of circumneutral or alkaline conditions ....***White Oak - Mixed Oak Dry-Mesic Alkaline Forest* (CEGL002070) [A.239]**

19b. Forest with Mockernut Hickory (*Carya alba*) and other plants indicative of acid conditions .... **NOT MAPPED** ***White Oak - Red Oak Dry-Mesic Acid Forest* (CEGL002067) [A.239]**

20a. American Beech (*Fagus grandifolia*), and Tuliptree (*Liriodendron tulipifera)* **NOT** present in canopy or subcanopy, or if present less than 25% of either stratum..... .....**NOT MAPPED** ***Interior Dry-Mesic White Oak - Hickory Forest* (CEGL007795) [A.239]**

20b. American Beech (*Fagus grandifolia*), and/or Tuliptree (*Liriodendron tulipifera)* in the subcanopy or canopy (usually >25% canopy and/or subcanopy cover of these two species combined **21**

21a. Mesic to dry-mesic f\orest dominated by White Oak (*Quercus alba)* usually with Mockernut Hickory (*Carya alba)*, and/or Pignut Hickory (*Carya glabra)*, Sand Hickory *(Carya pallida*), Shagbark Hickory

(Carya ovata). Sometimes also Southern Red Oak (*Quercus falcata*), and/or Post Oak (*Quercus stellata*). The subcanopy is usually dominated by American Beech (*Fagus grandifolia*) and can have a rich herbaceous layer, but does **NOT** generally contain herbs of circumneutral or basic soils (no Cystopteris sp, for instance).....***Central Interior Beech - White Oak Forest*** **(CEGL007881) [A.229]**

21b. Mesic forest dominated by White Oak (*Quercus alba*) and Mockernut Hickory (*Carya alba),* with Pignut Hickory (*Carya glabra)* and with American Beech (*Fagus grandifolia*), Tuliptree (*Liriodendron tulipifera)* and Red Maple (*Acer rubrum*). Herbaceous species include basic/circumneutral indicators..... .....**NOT MAPPED** ***Basic Mesic Coastal Plain Oak-Hickory Forest*** **(CEGL007225) [A.238]**

KEY D – UPLAND BARRENS

1a. Barrens dominated by Post Oak (*Quercus stellata*)..... ***Western Highland Rim Post Oak Barrens*** **(CEGL004686) [A.625]**

1b. Barrens dominated by Blackjack Oak *(Quercus marilandica)*..... ***Western Highland Rim Blackjack Oak Barrens*** **(CEGL004756) [A.625]**

KEY E – WETLAND FORESTS

1a. Forested acid seep – small wetland at the base of steep to moderate slopes where water slowly percolates out through subsoil (Cretaceous) sands and gravels, keeping the soil saturated. Red Maple (*Acer rubrum)* and Netted Chain Fern (*Woodwardia areolata)* are common plants..... **NOT MAPPED** ***Interior Forested Acid Seep*** **(CEGL004425) [A.348]**

1b. Forest or Woodland associated with ponds, lakes, riparian areas, bottomlands or swamps..... **2**

2a. Swamps, seasonally or semi-permanently (long duration) flooded (non-alluvial ponds key here)..... **3**

2b. Bottomlands or riparian areas, temporarily (short duration) flooded **6**

3a. Swamps including non-alluvial ponds, seasonally or semi-permanently (long duration) flooded, dominated or codominated by Oaks (*Quercus* spp.)..... **5**

3b. Swamps, seasonally or semi-permanently (long duration) flooded, dominated by Planertree (*Planera aquatica)* or Water Tupelo (*Nyssa aquatica)* sometimes with Bald Cypress (*Taxodium distichum)*..... **4**

4a. Planertree (*Planera aquatica)* dominated swamp forest..... **NOT MAPPED** ***Coastal Plain Planertree Floodplain Swamp*** **(CEGL007394) [A.326]**

4b. Semi-permanently flooded swamp dominated by Water Tupelo (*Nyssa aquatica)* with less Bald Cypress (*Taxodium distichum)* .... **NOT MAPPED** ***Water Tupelo Swamp Forest*** **(CEGL002419) [A.345]**

5a. Forest dominated or codominated by Overcup Oak (*Quercus lyrata)* and Sweetgum (*Lyquidambar styraciflua*)..... **NOT MAPPED** ***Overcup Oak - Sweetgum Bottomland Forest*** **(CEGL002424) [A.328]**

5b. Forest dominated or codominated by Willow Oak (*Quercus phellos)* found in poorly drained areas in upland flats ..... **NOT MAPPED** ***Highland Rim Upland Depression Flatwoods*** **(CEGL007405) [A.330]**

6a. Forest canopy dominated by Box-elder (*Acer negundo*) ..... **NOT MAPPED** ***Box-elder Floodplain Forest*** **(CEGL005033) [A.278]**

6b. Forest canopy **NOT** dominated by Box-elder (*Acer negundo*) **7**

7a. Forest canopy dominated by Silver Maple (*Acer saccharinum)* often with Sugarberry (*Celtis laevigata)*, and Pecan (*Carya illinoinensis*)..... **NOT MAPPED** ***Silver Maple - Sugarberry - Pecan Floodplain Forest*** **(CEGL002431) [A.279]**

7b. Forest canopy **NOT** dominated by Silver Maple (*Acer saccharinum),* Sugarberry (*Celtis laevigata),* and Pecan (*Carya illinoinensis*)..... **8**

8a. Forest dominated by River Birch (*Betula nigra)* with Sycamore (*Platanus occidentalis*) generally near or on the banks of creeks or rivers..... **NOT MAPPED** ***River Birch Levee Forest*** **(CEGL007312) [A.280]**

8b. Forest **NOT** dominated or codominated by River Birch (*Betula nigra)*..... **9**

9a. Forest dominated or codominated by Sycamore (*Platanus occidentalis*).....**10 [A.288]**

9b. Forest **NOT** dominated nor codominated by Sycamore (*Platanus occidentalis*)..... **11**

10a. Canopy dominated by Sycamore (*Platanus occidentalis)* and Sweetgum (*Liquidambar styraciflua)*... .....***Gulf Coastal Plain Sycamore - Sweetgum Floodplain Forest*** **(CEGL007335) [A.288]**

10b. Canopy dominated by Sycamore (*Platanus occidentalis)* and other hardwoods, such as Silver Maple (*Acer saccharinum*), Green Ash (*Fraxinus pennsylvanica*), or Box-elder (*Acer negundo*), but without Sweetgum (*Liquidambar styraciflua)* ....***Sycamore - Silver Maple Calcareous Floodplain Forest*** **(CEGL007334) [A.288]**

11b. Forest dominated by Oaks (*Quercus spp.*) and Hickories (*Carya spp.*), or dominated by Sweetgum (*Liquidambar styraciflua)* and/or Tuliptree (*Liriodendron tulipifera)*, with or without codominant Oaks (*Quercus spp.),* lacking or with low cover of American Elm (*Ulmus americana),* Green Ash *(Fraxinus pennsylvanica*), Sugarberry (*Celtis laevigata),* Southern Shagbark Hickory (*Carya carolinae-septentrionalis),* or American Beech (*Fagus grandifolia)*..... **13**

11b. Forest dominated or codominated **either** by American Elm (*Ulmus americana),* Sugarberry (*Celtis laevigata),* Green Ash *(Fraxinus pennsylvanica*); or by Red Hickory (*Carya ovalis*), Southern Shagbark Hickory (*Carya carolinae-septentrionalis),* and American Beech (*Fagus grandifolia)*..... **12**

12a. Forest codominated by some combination of Sugarberry (*Celtis laevigata*), American Elm (*Ulmus americana*), and Green Ash *(Fraxinus pennsylvanica*) ....***Southern Green Ash - Elm - Sugarberry Forest*** **(CEGL002427) [A.286]**

12b. Forest canopy some combination of American Beech (*Fagus grandifolia),* Red Hickory (*Carya ovalis*), Southern Shagbark Hickory (*Carya carolinae-septentrionalis),* or Blackgum *(Nyssa sylvatica)*..... .....***East Gulf Coastal Plain Beech Floodplain Forest*** **(CEGL004745) [A.284]**

13a. Successional, post-disturbance forest dominated by Sweetgum (*Liquidambar styraciflua)* and/or Tuliptree (*Liriodendron tulipifera)* without codominant Oaks (*Quercus spp.)* **15**

13b. Forest (natural, **NOT** post-disturbance) dominated by Oaks (*Quercus spp.*) and Hickories (*Carya spp.*), with or without Sweetgum (*Liquidambar styraciflua)* and/or Tuliptree (*Liriodendron tulipifera)*.. **14**

14a. Canopy codominated by Swamp Chestnut Oak (*Quercus michauxii),* Sweetgum *(Liquidambar styraciflua)*, Kingnut Hickory (*Carya laciniosa)* and/or Shumard Oak (*Quercus shumardii)* in codominance..... ***Swamp Chestnut Oak - Sweetgum Mesic Floodplain Forest*** **(CEGL002099) [A.291]**

14b. Canopy **NOT** dominated or codominated by Swamp Chestnut Oak (*Quercus michauxii),* but instead dominated by Sweetgum (*Liquidambar styraciflua),* Cherrybark Oak (*Quercus pagoda),* and usually some combination of Shagbark Hickory (*Carya ovata),* Kingnut Hickory (*Carya laciniosa),* and /or Red Hickory (*Carya ovalis)* .....***Sweetgum - Cherrybark Oak Floodplain Forest*** **(CEGL007353) [A.291]**

15a. Successional, post-disturbance forest dominated by Sweetgum (*Liquidambar styraciflua)* ....***Successional Sweetgum Floodplain Forest*** **(CEGL007330) [A.287]**

15b. Forest dominated or codominated by Tuliptree (*Liriodendron tulipifera*), with a hardwood component indicative of acidic conditions (i.e. with Red Maple (*Acer rubrum),* White Oak (*Quercus alba*), or Southern Red Oak (*Quercus falcata*) and a sparse understory of herbaceous plants also indicative of acidic conditions. Very rarely in wetland situations – generally considered an upland type. .***Interior Mid- to Late-Successional Tuliptree - Hardwood Upland Forest (Acid Type)*** **(CEGL007221) [A.236]**

15c. Forest dominated or codominated by Tuliptree (*Liriodendron tulipifera*), with a hardwood component indicative of basic or circumneutral conditions, for instance with Black Walnut (*Juglans nigra),* White Ash (*Fraxinus americana),* Slippery Elm (*Ulmus rubra),* Chinquapin Oak (*Quercus muehlenbergii),* and/or Shagbark Hickory (*Carya ovata).* Species often found in the subcanopy include Sugar Maple (*Acer saccharum),* Redbud *(Cercis canadensis),* and Spicebush (*Lindera benzoin)* .... **NOT MAPPED** ***Successional Tuliptree Forest (Circumneutral Type)*** **(CEGL007220) [A.236]**

KEY F – DECIDUOUS SHRUBLANDS

1a. Deciduous shrublands in wetlands (ponds, lakes or floodplain areas near rivers or creeks) **2**

1b. Upland deciduous shrublands (generally **NOT** prone to flooding), includes groundcovering vine areas**3**

2a. Shrubland dominated by Buttonbush (*Cephalanthus occidentalis*)..... .....***Southern Buttonbush Pond*** **(CEGL002191) [A.1011]**

2b. Shrubland dominated by Smooth Alder (*Alnus serrulata*) ....**NOT MAPPED** ***Southeastern Smooth Alder Swamp*** **(CEGL008474) [A.994]**

3a. Vegetation dominated by Kudzu (*Pueraria montana* var. *lobata*), with few or no trees. Small trees may occasionally be present, but generally are completely covered by kudzu foliage, creating a "mounding" effect..... **NOT MAPPED** ***Kudzu Vineland*** **(CEGL003882) [A.904]**

3b. Upland deciduous shrublands dominated by Sumac (*Rhus* spp.) species (may include grasses and small trees), occurring on disturbed or successional sites..... . **NOT MAPPED** ***Sumac Shrubland*** **(no NVC association, rekey under key F - graminoid vegetation)**

KEY G – GRAMINOID VEGETATION

1a. Vegetation mainly non-native perennial grasses (or grasses mixed with forbs), may be kept open by mowing or bushhogging. Components can include European Tall Fescue or Meadow Fescue (*Lolium arundinaceum, L. pratense*); Bahia grass (*Paspalum notatum*); Johnson grass (*Sorghum halepense*)..... .....**2 (has 3 choices)**

1b. Vegetation **NOT** with the above combination of characteristics, mainly dominated by native plants... **3**

2a. Grassland pastures and hayfields, more-or-less cultural, but may no longer be actively maintained, dominated by European Tall Fescue or Meadow Fescue (*Lolium arundinaceum, L. pratense*)..... .....***Cultivated Meadow* (CEGL004048) [A.1213]**

2b. Grass lawns or frequently mowed areas with Bahia grass (*Paspalum notatum*) ....**NOT MAPPED *Bahia Grass Pasture* (CEGL004700) [A.1219]**

2c. Grass areas dominated by Johnson grass (*Sorghum halepense*) .... **NOT MAPPED *Johnson grass vegetation* (CEGL004108*)* [A.2020]**

3a. Vegetation dominated by Common Broomsedge (*Andropogon virginicus* var. *virginicus*), a blond colored grass which gets about 1 m tall .. ***Successional Broomsedge Vegetation* (CEGL004044) [A.1208]**

3b. Vegetation **NOT** dominated by Common Broomsedge (*Andropogon virginicus* var. *virginicus*)..... **4**

4a. Vegetation is characterized by saturation, temporary, or seasonal flooding, mainly in winter or early spring **5**

4b. Vegetation is **NOT** characterized by saturation or flooding, upland restored vegetation of ecological restoration sites, vegetation characterized by a wide variety of grasses, forbs and vines, mainly native..... ..... ***Ecological Restoration Site***

5a. Dominated by Soft Rush (*Juncus effusus)*, includes marsh ....**NOT MAPPED *Rush Marsh* (CEGL004112) [A.1375]**

5b. Vegetation flooded temporarily or seasonally, especially in winter and spring, but **NOT** permanently or semi-permanently flooded (i.e. vegetation can dry out during a normal summer and early fall) dominated by Smartweed species (*Polygonum spp.*) and/or cutgrass (*Leersia spp.*)..... .....**NOT MAPPED *Smartweed - Cutgrass Beaver Pond* (CEGL004290) [A.1881]**

KEY H – FORB (BROADLEAF) VEGETATION

1a. Vegetation permanently or semi-permanently flooded (i.e. dominated by emergent or floating aquatic plants)..... **2**

1b. Vegetation flooded temporarily or seasonally, especially in winter and spring, but **NOT** permanently or semi-permanently flooded (i.e. vegetation can dry out during a normal summer and early fall) dominated by Smartweed species (*Polygonum spp.*) and/or cutgrass (*Leersia spp.*)..... .....**NOT MAPPED** ***Smartweed - Cutgrass Beaver Pond*** **(CEGL004290) [A.1881]**

2a. Vegetation dominated by Pickerelweed (*Pontederia cordata*) and Green Arrow-arum (*Peltandra virginica*). These are emergent wetland plants growing in semi-permanently flooded wetlands, which can dry out during dry periods.....**NOT MAPPED** ***Pickerelweed Marsh*** **(CEGL004291) [A.1669]**

2b. Vegetation dominated by floating aquatic plants..... **3**

3a. Vegetation dominated by exotic (non-native) floating aquatic plants, including Water hyacinth (*Eichhornia crassipes*) or Alligator weed (*Alternanthera philoxeroides*) **4**

3b. Vegetation dominated by native floating aquatic plants, including Broadleaf Pond-lily (*Nuphar lutea* ssp. *advena*), White Water-lily (*Nymphaea odorata*), Pondweed species (*Potamogeton* spp.), Coontail species (*Ceratophyllum* spp.), Waterweed species (*Elodea* spp.), or Fanwort (*Cabomba caroliniana*) **5**

4a. Vegetation dominated by Water hyacinth (*Eichhornia crassipes*) ....**NOT MAPPED** ***Water-hyacinth Aquatic Vegetation*** **(CEGL007671) [A.1716]**

4b. Vegetation dominated by Alligator weed (*Alternanthera philoxeroides*)..... .....**NOT MAPPED** ***Alligator-weed Exotic Emergent Vegetation*** **(CEGL003858) [A.2015]**

5a. Vegetation dominated by the rooted, floating-leaved aquatic species, generally Broadleaf Pond-lily (*Nuphar lutea* ssp. *advena*) and White Water-lily (*Nymphaea odorata*), but can include small patches of other native floating leaved aquatic species (i.e. *Hydrocotyle ranunculoides, Brasenia schreberi*) .... ***Water-lily Aquatic Wetland*** **(CEGL002386) [A.1984]**

5b. Vegetation dominated by submerged aquatic species such as Pondweed species (*Potamogeton* spp.), Coontail species (*Ceratophyllum* spp.), Waterweed species (*Elodea* spp.), or Fanwort (*Cabomba caroliniana*) ... .**NOT MAPPED** ***Pondweed - Coontail - Waterweed Permanently Flooded Herbaceous Vegetation*** **(CEGL004725) [A.1754]**

Appendix B: Contingency Matrices and Accuracy Tables for Shiloh National Military Park

Table 1: List of CEGL Codes for Shiloh National Military Park and Associated NVC Community Type Name

CEGL Code Names (in numerical order)	
2070	White Oak - Red Oak - Dry-Mesic Alkaline Forest
2099	Swamp Chestnut Oak - Sweetgum Mesic Floodplain Forest
2191	Southern Buttonbush Pond
2419	Water Tupelo Swamp Forest
2427	Southern Green Ash - Elm - Sugarberry Forest
2431	Silver Maple - Sugarberry - Pecan Floodplain Forest
2591	Virginia Pine Successional Forest
3807	Chinese Privet Upland Shrubland
3871	Central Interior Upland Cherrybark Oak Forest
4044	Successional Broomsedge Vegetation
4048	Johnson Grass Vegetation
4052	East Gulf Coastal Plain Shortleaf Pine-sOuthern Red Oak Forest
4053	East Coast Gulf Coastal Plain Shortleaf Pine - Post Oak Forest
4412	Southern Red Oak Flatwoods Forest
4425	Interior Forested Acid Seep
4686	Western Highland Rim Post Oak Barrens
4745	East Gulf Coastal Plain Beech Floodplain Forest
4756	Western Highland Rim Blackjack Oak Barrens
6011	Early- to Mid-Successional Loblolly Pine Forest
6327	Shortleaf Pine Early-Successional Forest
7124	Red-cedar Successional Forest
7201	Southern Mesic Beech - Tuliptree Slopes
7216	Successional Sweetgum Forest
7217	Interior Mid- to Late-Successional Sweetgum-Oak Forest
7221	Mid - to Late - Successional Tuliptree - Hardwood Upland Forest (Acid Type)
7244	Southern Red Oak - White Oak Mixed Oak Forest
7246	Dry Acid Eastern Coastal Plain Oak - Hickory Forest
7247	Southern Red Oak - (Scarlet Oak, Post Oak) / (Hillside Blueberry, Deerberry) Forest
7312	River Birch Levee Forest
7330	Successional Sweetgum Floodplain Forest
7334	Sycamore - Silver Maple Calcaerous Floodplain Forest
7335	Gulf Coastal Plain Sycamore - Sweetgum Floodplain Forest
7353	Sweetgum - Cherrybark Oak Floodplain Forest
7795	Interior Dry - Mesic White Oak - Hickory Forest
7881	Central Interior Beech - White Oak Forest
8441	Willow Oak - Sweetgum / Slender Woodoats Cumberland / Southern Ridge and Valley Forest
8462	Mid - to Late - Successional Loblolly Pine - Sweetgum Forest
8474	Southeastern Smooth Alder Swamp

Table 2: Contingency Matrix Considering Matches with Dominant, Secondary, or Tertiary Vegetation Type Matches.

Mapped Vegetation Classes	Vegetation Classes Observed in the Field																																						Totals
	2070	2099	2191	2419	2427	2431	2591	3807	3871	4044	4048	4052	4053	4412	4425	4686	4745	4756	6011	6327	7124	7201	7216	7217	7221	7244	7246	7247	7312	7330	7334	7335	7353	7795	7881	8441	8462	8474	
2070	6								2												1	3	1			6	1									1				21
2099		1			1																											1	1							4
2191		3	0																																					3
2419				2																																			1	3
2427			1		5																		1								3	1	1						12
2431						0																																	n/a
2591							0																																n/a
3807								1																															1
3871	1								4					1										5		5	1												18
4044										0	4					1					1																		6
4048											3																1												4
4052												0									1					1	3											1		6
4053													0																										n/a
4412														0												5	4	1											10
4425															0							1																	1
4686																0				1						1	1												3
4745																	0																		1				1
4756																1		0																					1
6011																			6	1															1		2		10
6327							1					2							1	7	1					3				1							2		18
7124									1												1			3		2											1		8
7201																						8											1		3				12
7216	2												1					1					2	6		2	4								2		1		21
7217	1								1														1	7		1	1	2											14
7221					1																	2		1	2	1									1				8
7244	1																									21	5	1							4				32
7246	1													2		2										5	21	1							2				34
7247																												0											n/a
7312					1																								1										2
7330						4																2			1		1		1	9	3	1	2						26
7334						1																									2	1							4
7335					1																									1		1							4
7353					1																									1			14						16
7795																																		1					1
7881	1																					1					1								7				10
8441														1																						0			1
8462																			1																		1		2
8474																																						0	n/a
Totals	13	5	1	4	10	5	1	1	8	n/a	7	2	1	4	n/a	4	n/a	1	8	9	5	17	5	22	3	53	45	5	2	12	8	5	19	1	23	n/a	8	1	317

Table 3: Error Summaries for Dominant/Secondary/Tertiary Mapped Vegetation Classes

Mapped Vegetation Classes	User's Accuracy		Producer's Accuracy	
	N	Accuracy	N	Accuracy
2070	21	25%	13	18%
2099	4	77%	5	49%
2191	3	100%	1	0%
2419	3	67%	4	30%
2427	12	42%	10	56%
2431	n/a	n/a	5	0%
2591	n/a	n/a	1	0%
3807	1	100%	1	100%
3871	18	22%	8	50%
4044	6	0%	n/a	n/a
4048	4	95%	7	35%
4052	6	0%	2	0%
4053	n/a	n/a	1	0%
4412	10	0%	4	0%
4425	1	0%	n/a	0%
4686	3	0%	4	0%
4745	1	0%	n/a	0%
4756	1	0%	1	0%
6011	10	60%	8	84%
6327	18	39%	9	87%
7124	8	15%	5	18%
7201	12	66%	17	41%
7216	21	10%	5	36%
7217	14	66%	22	51%
7221	8	25%	3	48%
7244	32	62%	53	77%
7246	34	53%	45	58%
7247	n/a	n/a	5	0%
7312	2	100%	2	50%
7330	26	34%	12	84%
7334	4	50%	8	3%
7335	4	1%	5	1%
7353	16	87%	19	74%
7795	1	100%	1	100%
7881	10	70%	23	5%
8441	1	0%	n/a	n/a
8462	2	50%	8	2%
8474	n/a	n/a	1	0%

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

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

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

Vegetation Mapped Classes	Vegetation Classes Observed in the Field											
	3807	8441	2070/3903/3871	2099/2191/7330/7353	2419/8474	2431/2427/7312/7334/7335	2591/6011/6327/7124/7179/8462	4044/4048/4108/4700	4052/4053/4412/4686/4756/7244/7246/7247/7795	4425/4745/7201/7881	7216/7217/7221	Totals
3807	1											1
8441									1			1
2070/3903/3871			13				1		10	5	5	34
2099/2191/7330/7353				35	2	11			1	2	1	52
2419/8474					3							3
2431/2427/7312/7334/7335						9						9
2591/6011/6327/7124/7179/8462			1	1			25		2	1	2	32
4044/4048/4108/4700							1	7	2			10
4052/4053/4412/4686/4756/7244/7246/7247/7795			2	1		9	3		89	6	1	111
4425/4745/7201/7881			1						1	21		23
7216/7217/7221			4			1	1		9	5	21	41
Totals	1	n/a	21	37	5	30	31	7	115	40	30	317

Table 5: Error Summaries for Grouped Community Types

Mapped Vegetation Classes	USER'S ACCURACY		PRODUCER'S ACCURACY	
	N	Accuracy	N	Accuracy
3807	1	100%	1	100%
8441	1	0%	n/a	n/a
2070/3903/3871	34	36%	21	33%
2099/2191/7330/7353	52	60%	37	96%
2419/8474	3	100%	5	39%
2431/2427/7312/7334/7335	9	100%	30	18%
2591/6011/6327/7124/7179/8462	32	79%	31	82%
4044/4048/4108/4700	10	74%	7	100%
4052/4053/4412/4686/4756/7244/7246/7247/7795	111	84%	115	96%
4425/4745/7201/7881	23	92%	40	15%
7216/7217/7221	41	59%	30	73%

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

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

Table 6: Contingency Matrix Considering Dominant Vegetation Mapped Classes Only

Mapped Vegetation Classes	Vegetation Observed in the Field																																						Totals
	2070	2099	2191	2419	2427	2431	2591	3807	3871	3903	4044	4048	4052	4053	4412	4425	4686	4745	4756	6011	6327	7124	7201	7216	7217	7221	7244	7246	7247	7312	7330	7334	7335	7353	7795	7881	8441	8462	8474	
2070	5								2													1	3	1			6	1									1				20
2099		0			1																												1	1							3
2191		3	0																																						3
2419				2																																			1		3
2427			1		5																			1									3	1	1						12
2431						0																																			n/a
2591							0																																		n/a
3807								1																																	1
3871	1								4						1										5		5	1								1	1				19
3903	1									0																							1								2
4044											0	6					1			1		2																			10
4048												1																1													2
4052													0							1		1					1	3										1			7
4053														0																											n/a
4412															0												5	4	1												10
4425																0							1																		1
4686																	0				1						1	1													3
4745																		0																			1				1
4756																			0																						1
6011																				4	1																1	2		8
6327							1						2							1	7	1					3				1							2		18
7124									1													0			3		2											1		7
7201																							7											1		3				11
7216	2													1					1					2	6		3	4								2	1			22
7217	1								1															1	5		2	9	2											21
7221					1																		2		2	2	1									1				9
7244	1																										17	6	1							4				29
7246	1														2		2								1		6	12	1							2				27
7247																													0											n/a
7312					1																									0										1
7330				2		4																	2			1		1		2	8	3	1	2						26
7334						1																										2	1							4
7335		1			1																										1		0	2						5
7353		1			1																										2			12						16
7795																											1								0					1
7881	1																						2					1								7				11
8441															1																						0			1
8462																				1																	1	0		2
8474																																								n/a
Totals	13	5	1	4	10	5	1	1	8	n/a	7	2	1	4	n/a	4	n/a	1	8	9	5	17	5	22	3	53	45	5	2	12	8	5	19	1	23	n/a	8	1	317

Table 7: Error Summaries for Dominant Mapped Vegetation Classes

Mapped Vegetation Classes	User's Accuracy		Producer's Accuracy	
	N	Accuracy	N	Accuracy
2070	20	25%	13	18%
2099	3	0%	5	0%
2191	3	0%	1	0%
2419	3	67%	4	30%
2427	12	42%	10	56%
2431	n/a	n/a	5	0%
2591	n/a	n/a	1	0%
3807	1	100%	1	100%
3871	19	21%	8	50%
3903	2	0%	n/a	0%
4044	10	0%	n/a	0%
4048	2	50%	7	2%
4052	7	0%	2	0%
4053	n/a	n/a	1	0%
4412	10	0%	4	0%
4425	1	0%	n/a	0%
4686	3	0%	4	0%
4745	1	0%	n/a	0%
4756	1	0%	1	0%
6011	8	50%	8	56%
6327	18	39%	9	87%
7124	7	0%	5	0%
7201	11	64%	17	37%
7216	22	9%	5	36%
7217	21	24%	22	19%
7221	9	22%	3	48%
7244	29	59%	53	74%
7246	27	44%	45	47%
7247	n/a	n/a	5	0%
7312	1	0%	2	0%
7330	26	31%	12	78%
7334	4	50%	8	3%
7335	5	0%	5	0%
7353	16	75%	19	65%
7795	1	0%	1	0%
7881	11	64%	23	5%
8441	1	0%	n/a	0%
8462	2	50%	8	2%
8474	n/a	0%	1	0%

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

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

Table 8: GRTS-Assigned Weights for Each Map Class Assessed

Vegetation Class	GRTS-Assigned Weight	Inclusion Probabilities
2070	9770.751826	0.000102346
2099	1104.056432	0.000905751
2191	748.829729	0.001335417
2419	7586.321947	0.000131816
2427	7602.734568	0.000131532
3807	171.543485	0.005829426
3871	8880.709491	0.000112604
3903	203.076351	0.004924256
4044	8273.872068	0.000120862
4048	954.255582	0.001047937
4052	10206.4068	9.79777E-05
4412	13902.26736	7.19307E-05
4425	163.241441	0.006125895
4686	921.827688	0.001084801
4745	705.254354	0.001417928
4756	44.071146	0.022690583
6011	9243.621388	0.000108183
6327	9469.941883	0.000105597
7124	6494.020338	0.000153988
7201	7865.63193	0.000127135
7216	7504.437346	0.000133254
7217	9143.199481	0.000109371
7221	8332.917277	0.000120006
7244	112978.0757	8.85127E-06
7246	67972.60334	1.47118E-05
7312	57.272605	0.017460355
7330	18057.2177	5.53795E-05
7334	1298.79508	0.000769944
7335	9330.087143	0.00010718
7353	10907.47818	9.16802E-05
7795	424.640528	0.002354933
7881	5192.867747	0.000192572
8441	557.869809	0.001792533
8462	1485.132381	0.000673341

Appendix C: Graphs of Error Summaries for Shiloh National Military Park

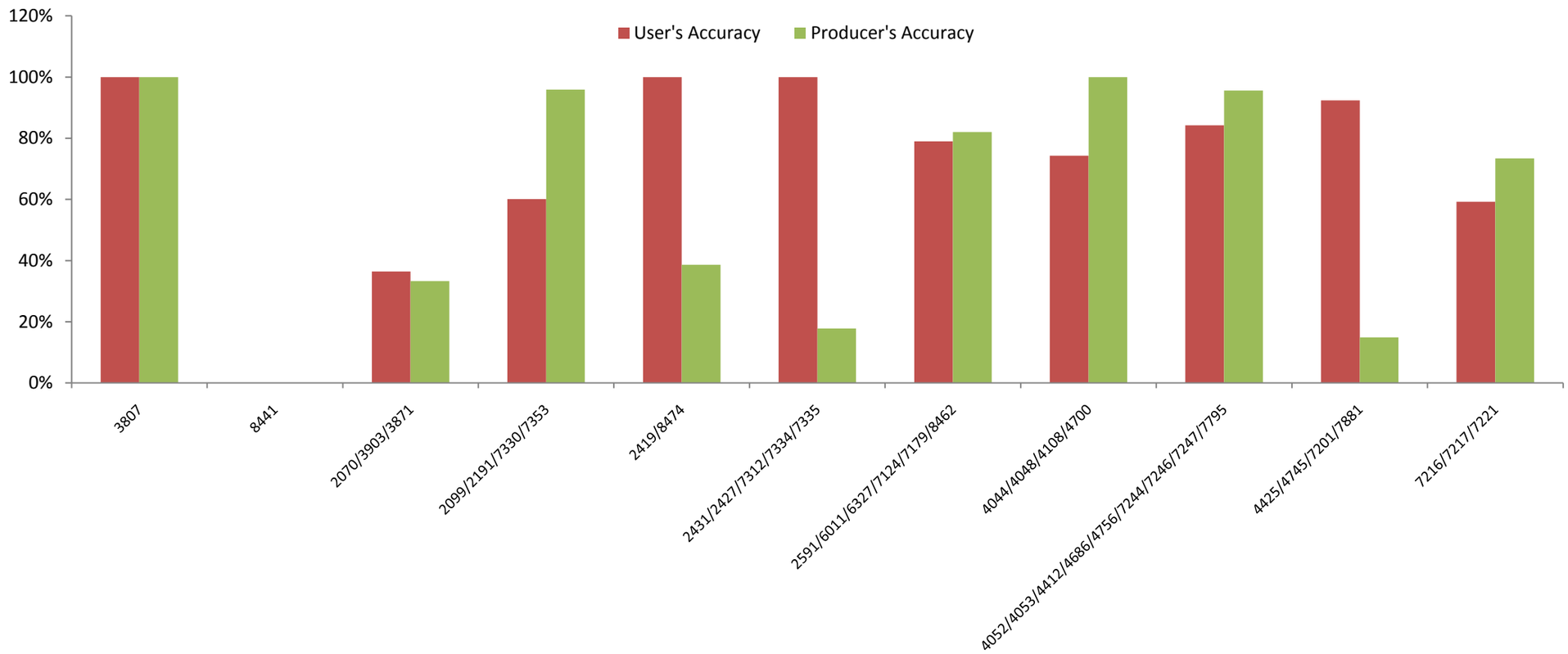

Figure 1: Graph displaying error summary results (user's and producer's accuracy) for the analysis using grouped vegetation classes.

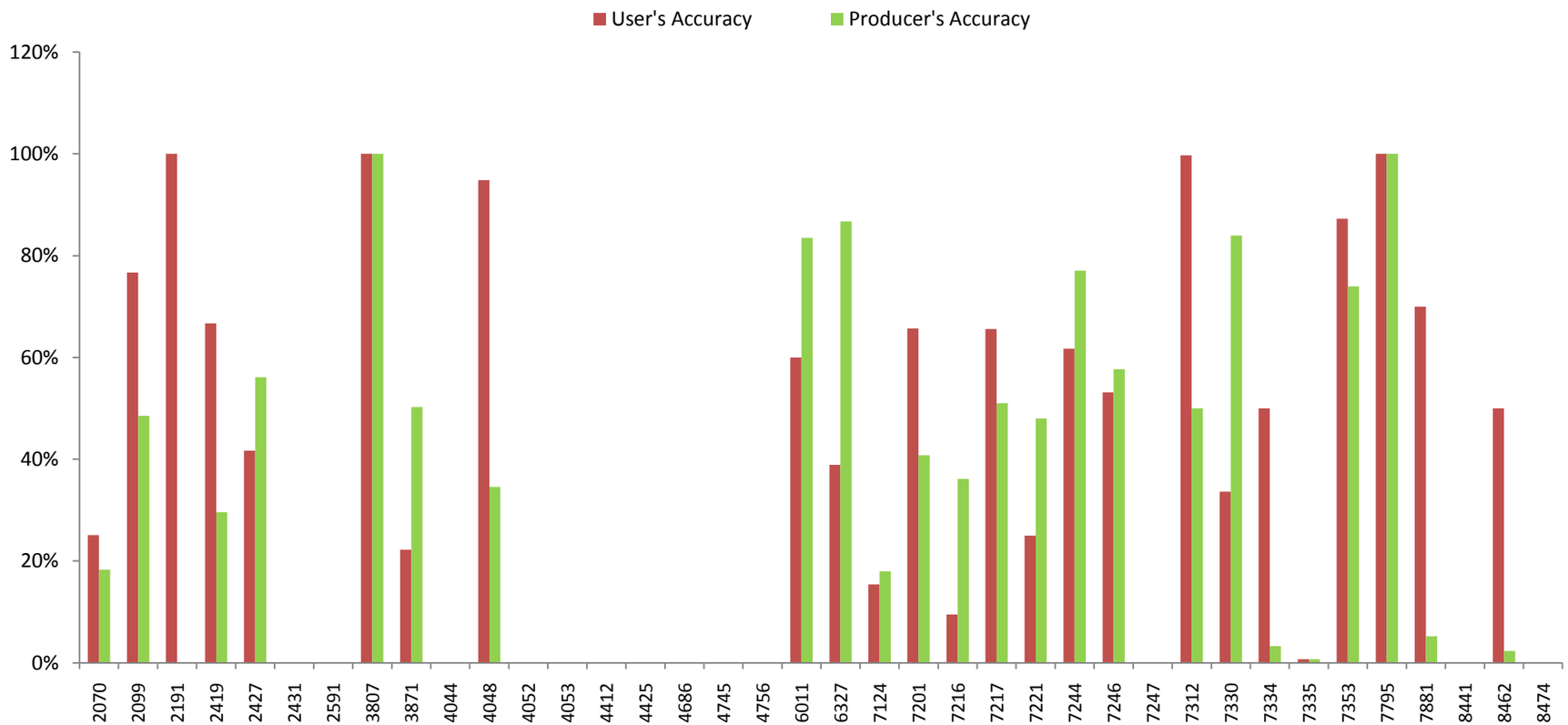

Figure 2: Graph displaying error summary results (user's and producer's accuracy) for the analysis using dominant, secondary, and tertiary vegetation classes.

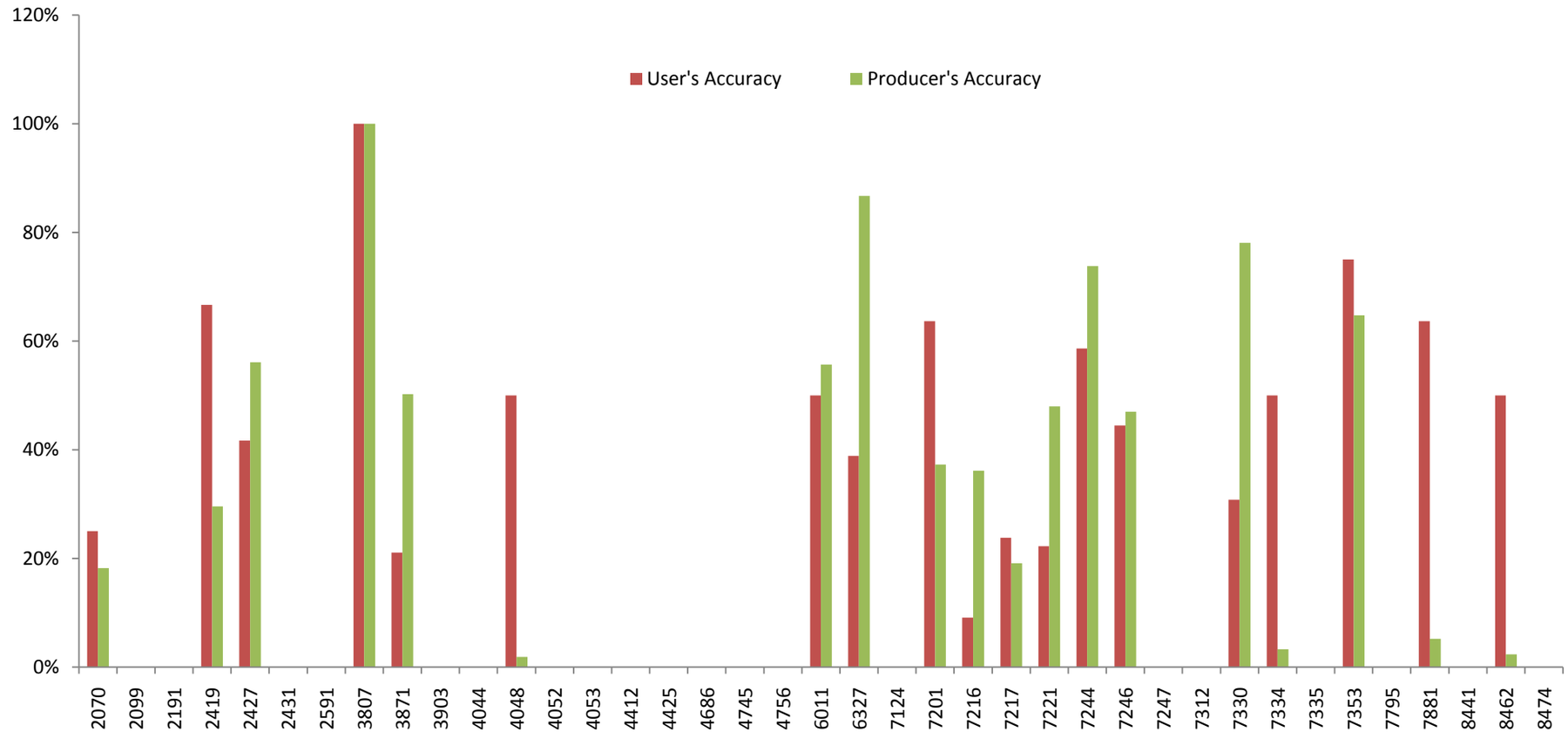

Figure 3: Graph displaying error summary results (user's and producer's accuracy) for the analysis using dominant vegetation classes only.