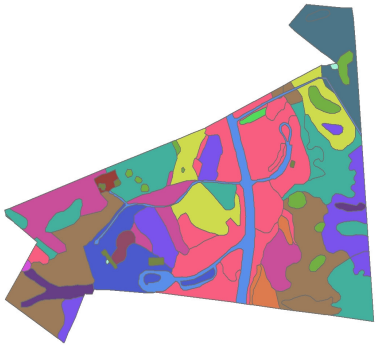
Accuracy Assessment: Abraham Lincoln Birthplace National Historic Site



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Electronic files have been provided to the National Park Service in addition to hard copies. Current information on all vegetation communities mentioned in this report can be found on NatureServe Explorer at www.natureserve.org/explorer

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Executive Summary

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

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 occur 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), and temporal error when conditions on the ground change between the mapping and assessment processes. 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.*

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 often 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 ABLI, the overall accuracy of the final map, which 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, is 80%, with a kappa statistic of 0.77 (77%). This number meets the 80% accuracy standard of the NPS. A stricter analysis of the data, which considered a point a match only if the vegetation observed on the ground matched the dominant vegetation type attributed by the mappers, showed an overall accuracy of the map of 72% with a kappa statistic of 0.67 (67%) for natural communities.

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 Abraham Lincoln Birthplace National Historic Site (ABLI) was created in 2004 by the University of Georgia Center for Remote Sensing and Mapping Science (Jordan and Madden 2008), in consultation with NatureServe. The mapping effort included collection of field data, aerial photograph interpretation, and polygon attribution to GIS maps.

Abraham Lincoln Birthplace National Historic Site consists of 2 units totaling about 139 hectares (344 acres) in Larue County, Kentucky, in the Interior Plateau, about an hour south of Louisville. Both units of the Park occur in a limestone karst region – one unit (The Birthplace Unit) characterized by sinkholes, and the other (The Boyhood Home Unit) by knobs. Most of the vegetation at the Birthplace Unit is fairly early-successional, with certain areas dominated by non-native, invasive species. In areas where turf and plantings are not maintained, oak-hickory forests are returning, and a patch of old growth oak forest is present in the northeastern extreme of the Birthplace Unit. In addition, numerous depressions and sinkholes are evident. The Boyhood Home Unit has more forested, natural and semi-natural vegetation, including steep forested knobs (small rounded hills arising starkly above adjacent landforms), mesic ravines, narrow valleys with rich agricultural soil, and limestone slope glades (Jones and Pyne 2008). Vegetation at both ABLI parcels was mapped and classified to the association level using the United States National Vegetation Classification (Grossman et al. 1998), following NPS guidelines. The minimum mapping unit (MMU) was 0.5 hectare.

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 producer's and user's accuracy are evaluated. User's accuracy is a prediction of the percentage of points mapped as a certain type which are confirmed to belong to that mapped vegetation type when visited in the field. In other words, user's accuracy is a measure of the reliability of the map to predict what is found on the ground (i.e. how likely the map user is to encounter correct information while using the map). Producer's accuracy is the percentage of points observed to be of a given vegetation type in the field that are correctly

mapped to that type. In other words, producer's accuracy is a measure of the reliability of the aerial photo interpretation to distinguish the vegetation types (i.e. how well the map maker was able to represent the ground features). In addition to the user's and producer's accuracy, 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 of 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. For the ABLI accuracy assessment, 71 points representing 10 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. 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 (ESRI et al. 1994, NatureServe 2007). The locations of the evaluation points were then selected using the Generate Random Points tool in the GIS extension "Hawth's Analysis Tools for ArcGIS" (Beyer 2004). 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; however, in some instances the size and shape of the vegetation polygons prevented selection of an adequate number of points outside the buffered area. Likewise, polygons smaller than 0.045 hectares (452 square meters) were excluded because of the potential that GPS error could lead field crews to record data for an area outside the polygon of the mapped class. A distance of at least 80 meters was maintained between adjacent points to prevent overlap in the area evaluated around each point.

Field Data Collection

Field crews located each evaluation point using a WAAS-enabled Garmin 5 GPS unit. Wide Area Augmentation System (WAAS) is a form of Differential GPS, which provides enhanced positional accuracy. At each point, the field crew recorded new coordinates, GPS positional accuracy, and collected limited vegetation data. When collecting the data for the accuracy points, the vegetation was considered in an area of approximately 0.5 hectares, in a 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 ABLI (found in Jones and

Pyne 2008). At some more confusing points, a secondary or alternate association was also recorded, and notes were taken on any difficulties keying out the point. A total of 71 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 user's and producer's accuracy for each vegetation type, and evaluation of the overall accuracy of the map using the kappa statistic (Cohen 1960). 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 polygon matched the observed type. 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.

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. 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 or 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 index, 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 index were calculated based on all map classes for all three analysis scenarios.

Results

The overall accuracy of the final ABLI vegetation map, which considered dominant, secondary, or tertiary vegetation types, is 80% with a kappa statistic of 0.77 (77%). This number meets the 80% accuracy standard of the NPS. A stricter analysis of the ABLI map at its finest scale, which considered only the dominant mapped vegetation, resulted in an accuracy of 72% with a kappa statistic of 0.67 (67%). The contingency matrices for both of these scenarios, along with a tabulation of user's and producer's accuracies for each map class, are provided in Appendix A, Tables 2-4.

Confidence intervals for user's and producer's accuracy were not calculated for ABLI because the generally small number of assessment points per map class inflates the size of the confidence interval and thus limits its usefulness for meaningful interpretation.

Discussion

Overall, the vegetation map for Abraham Lincoln National Historic Site provides an accurate representation of vegetation types within the park and meets the NPS 80% accuracy standard. The association with the lowest producer's accuracy (38%), Interior Low Plateau Mesic Sugar Maple - Hickory Forest (CEGL004741), represents a very small area of the park (less than 3% of the park's total acreage), and the small polygons within this map class present difficulties in both the mapping and accuracy assessment phases. Based on the results presented in Table 2, areas that were observed to be this community type during the accuracy assessment fieldwork were often mapped as White Oak - Mixed Oak Dry-Mesic Alkaline Forest (CEGL002070). Therefore, it is likely that an additional analysis combining these 2 vegetation types would slightly increase the overall accuracy of the map. However, for reporting purposes, we did not feel it was necessary to combine these types as part of the accuracy assessment.

While the accuracy assessment is intended to provide a measure of the reliability of the map classes, the reader should be aware that error is also inherent in the field assessment of evaluation points. At any park, the overall accuracy and user's and producer's accuracy of individual map classes may be affected by the fragmented state and severe changes in management practices, GPS error, data collection error by the field crew, poorly written and/or

untested classification keys, poor ecological community concepts, inconsistent interpretation of the classification key, and potential lag times between photointerpretation and accuracy assessment. Two or more community types could be similar enough such that one assessment point could be mistakenly assigned to a particular community type by the field crew when another community type was assigned to the same area by the map producers (Townsend 2000). Points may fall into ecotones or into inclusions within the larger community type and the resulting classification in the field may not be the same as that on the map. While measures were taken to reduce these errors, they are not altogether avoidable and it is not within the scope of this project to discern what mistakes led to 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.**

Small fragmented parks with active management plans such as Abraham Lincoln Birthplace National Historic Site are by their nature difficult candidates for accurate mapping to the NVC association level for all map classes. Disturbed and/or successional vegetation types do not lend themselves easily to being mapped at the association level. Unlike larger and more intact landscapes, Abraham Lincoln is composed of a patchwork of successional grassland and forest types, managed cultural vegetation, and small patch types, resulting in a continuum of spatial and temporal vegetation patterns. In conducting the accuracy assessment fieldwork, the surveyors would occasionally encounter a field assessment point that did not fit well into any community description so the surveyors chose the closet one, which may not have been a perfect fit.

Users of the ABLI 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 A. 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. 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 ABLI.

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Appendix A: Contingency Matrices and Accuracy Table

Table 2
Contingency Matrix Using Mapped Dominant, Secondary, or Tertiary Vegetation (Best Match)
Abraham Lincoln Birthplace National Historic Site

		Observed as:											Grand Total	User's Accuracy:
		2070	2411	2591	4133	4741	5018	5131	7124	7220	8429	successional		
Mapped as:	2070	11	0	0	0	5	0	0	0	2	0	0	18	61%
	2411	1	15	0	0	0	0	0	0	0	0	0	16	94%
	2591	0	0	3	0	0	0	0	0	0	0	0	3	100%
	4133	0	0	0	3	0	0	0	0	0	0	1	4	75%
	4741	1	0	0	1	3	0	0	0	0	0	0	5	60%
	5018	0	0	0	0	0	4	0	1	0	0	0	5	80%
	5131	0	0	0	0	0	0	2	0	0	0	0	2	100%
	7124	0	0	0	0	0	0	0	6	0	0	1	7	86%
	7220	0	0	0	0	0	1	0	0	5	0	0	6	83%
	8429	0	0	0	0	0	0	0	0	0	5	0	5	100%
	successional	0	0	0	0	0	0	0	0	0	0	0	0	n/a
Grand Total		13	15	3	4	8	5	2	7	7	5	2	71	
Producer's Accuracy:		85%	100%	100%	75%	38%	80%	100%	86%	71%	100%	0%		

Overall accuracy= 80.28%

Kappa statistic= 77.19%

Table 3
Contingency Matrix Using Mapped Dominant Vegetation Only
Abraham Lincoln Birthplace National Historic Site

		Observed as:											Grand Total	User's Accuracy:
		2070	2411	2591	4133	4741	5018	5131	7124	7220	8429	successional		
Mapped as:	2070	11	0	0	0	5	0	0	0	2	0	0	18	61%
	2411	2	13	0	0	2	0	0	0	0	0	0	17	76%
	2591	0	0	3	0	0	0	0	1	0	0	0	4	75%
	4133	0	0	0	3	0	0	0	0	0	1	1	5	60%
	4741	1	0	0	1	2	0	0	0	1	0	0	5	40%
	5018	0	0	0	0	0	4	0	1	0	0	0	5	80%
	5131	0	0	0	0	0	0	2	0	0	0	0	2	100%
	7124	0	0	0	0	0	0	0	5	0	0	1	6	83%
	7220	0	0	0	0	0	1	0	0	4	0	0	5	80%
	8429	0	0	0	0	0	0	0	0	0	4	0	4	100%
	successional	0	0	0	0	0	0	0	0	0	0	0	0	n/a
Grand Total		14	13	3	4	9	5	2	7	7	5	2	71	
Producer's Accuracy:		79%	100%	100%	75%	22%	80%	100%	71%	57%	80%	0%		

Overall accuracy= 71.83%

Kappa statistic= 67.47%

Table 4
Summary of User's and Producer's Accuracy
Abraham Lincoln Birthplace National Historic Site

CEGL	Association Name	Matching Vegetation (a)				Dominant Vegetation Only			
		User's Accuracy	n	Producer's Accuracy	n	User's Accuracy	n	Producer's Accuracy	n
2070	White Oak - Mixed Oak Dry-Mesic Alkaline Forest	61%	18	85%	13	61%	18	79%	14
2411	Beech - Maple Unglaciated Forest	94%	16	100%	15	76%	17	100%	13
2591	Virginia Pine Successional Forest	100%	3	100%	3	75%	4	100%	3
4133	Southeastern Successional Black Cherry Forest	75%	4	75%	4	60%	5	75%	4
4741	Interior Low Plateau Mesic Sugar Maple - Hickory Forest	60%	5	38%	8	40%	5	22%	9
5018	Southern Red Oak - Mixed Oak Forest	80%	5	80%	5	80%	5	80%	5
5131	Central Limestone Glade	100%	2	100%	2	100%	2	100%	2
7124	Eastern Red-cedar Successional Forest	86%	7	86%	7	83%	6	71%	7
7220	Successional Tuliptree Forest (Circumneutral Type)	83%	6	71%	7	80%	5	57%	7
8429	Rich Levee Mixed Hardwood Bottomland Forest	100%	5	100%	5	100%	4	80%	5

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.

Notes:

(a) The matching vegetation column considers a point a match if either the mapped dominant or secondary vegetation attribute matches the vegetation type observed in the field.