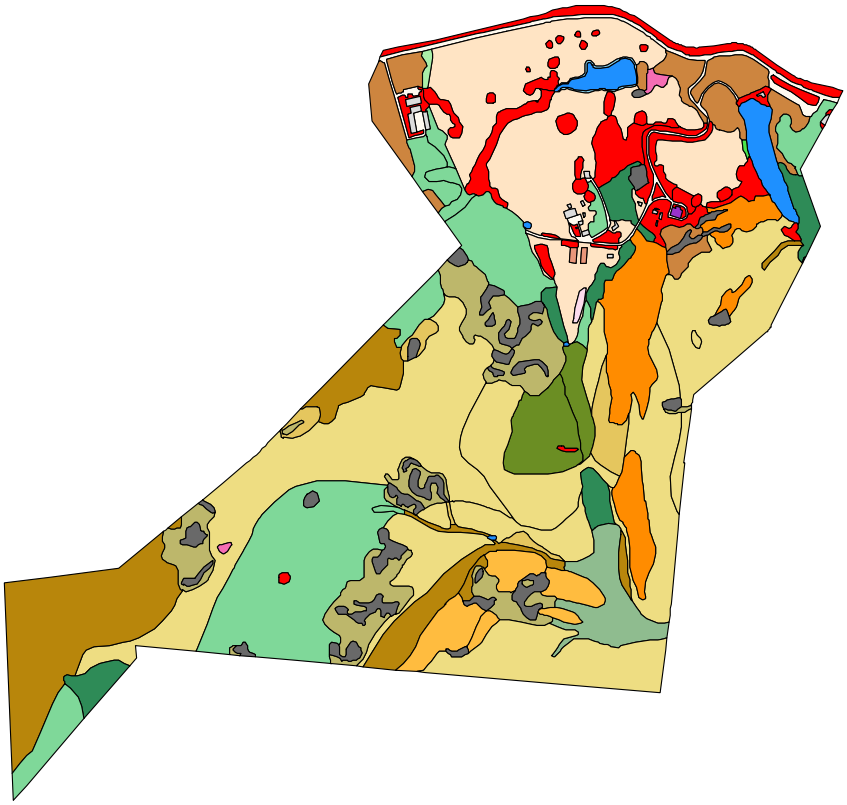
Accuracy Assessment:
Carl Sandburg Home National Historic Site
Vegetation Map



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Introduction

Conserving and managing the biodiversity of ecological communities rather than individual species has become increasingly important for land management agencies in recent years. This new focus requires an understanding of the composition and structure of vegetation on public and private lands. Over the last few decades, various organizations have collaborated to develop inventory methodology and to obtain the information necessary to aid in resource management and conservation decisions on these lands, and one aspect includes the development of vegetation community maps for many national parks. The National Park Service (NPS), one of the largest public land agencies in the country, and the U.S. Geological Survey (USGS) are committed to developing vegetation maps for 237 National Park units (Environmental Systems Research Institute et al. 1994) and have been active in this endeavor for approximately ten years.

Carl Sandburg Home National Historic Site, a park in the Cumberland Piedmont Network of the National Park Service, was mapped in 2003. The creation of the map was a joint effort between NatureServe and the University of Georgia Center for Remote Sensing and Mapping Science. The mapping project included the collection of field data, aerial photography interpretation, and polygon attribution to GIS maps. Vegetation was mapped and classified to the U.S. National Vegetation Classification (NVC) association level (Grossman et al. 1998), following NPS guidelines.

Accuracy Assessment

One aspect of the National Park Service's mapping program entails conducting Accuracy Assessments of the final products. These Assessments determine the quality and reliability of each map and therefore the map's strengths and weaknesses when making management decisions. Ideally, they are conducted shortly after the completion of the map to minimize the possibility of changes that might occur in vegetation over time, causing the map to appear less accurate than it really is.

Both positional and thematic accuracy of a map should be assessed. Positional accuracy aids in determining whether boundary lines were placed correctly on the map or whether the map is shifted in space, and these positional accuracy points are placed on cultural features of the map such as road junctions or building corners, since boundaries can be more precisely located on these features than on natural features.

Thematic accuracy addresses whether polygons are correctly mapped, and the points used to assess their accuracy should be chosen by a stratified random method to capture the diversity of the vegetation types in the park. Ecological communities are continuous and rarely have discrete boundary lines in nature. Therefore, photointerpreters draw lines in the general area where a split between one vegetation type and another is most apparent on the aerial photography. It is impossible to assess the accuracy of the lines since they do not occupy any actual area, so Accuracy points must be placed sufficiently far from the boundary lines on the map to avoid any assessment of lines or their related ecotones.

Thematic accuracy requires assessments of both producer's and user's accuracy. Producer's accuracy determines the probability that a sample will be correctly classified in the field. It is an important issue for map producers, who are interested in knowing how well the area can be mapped (Story and Congalton 1986); if the sample is difficult to classify in the field due to ecotones or other ecological issues, it would also be difficult to map correctly. Producer's accuracy is also referred to as errors of omission because if a polygon was not correctly classified as unit A for example, it was omitted from the group of polygons that were classified as that map unit A (Story and Congalton 1986). User's accuracy, on the other hand, is important to map users because it refers to the reliability of the map, or in other words, the probability that a polygon on the map accurately depicts what is on the ground (Story and Congalton 1986). User's accuracy may also be called errors of commission because polygons that were incorrectly omitted from the correct map unit A were therefore incorrectly added to another map unit B (Story and Congalton 1986).

Evaluating map accuracy is not always a straightforward process. For example, as previously mentioned, clear boundaries between community types rarely exist in nature, and photointerpreters may have difficulty distinguishing between similar community types (Townsend 2000). Errors related to this issue are understandable and may be impossible to fix. Additionally, if a mapped polygon is small and care is taken to place a point in the middle of it, ecotonal variation may still affect some of the data so it may be unclear as to whether the map is incorrect or if the ecotone confused the results. Or, field crews may be in the middle of a large polygon on the map but see that there are at least two community types within that polygon; one may be correct and the other may be incorrect. The many possible scenarios that can occur when conducting an Accuracy Assessment suggest that some polygons are more obviously wrong than

others – some polygons may be entirely incorrect or entirely correct, while others may be only partially incorrect (Meidinger 2003; Townsend 2000; Gopal and Woodcock 1994). These varying degrees of accuracy led to the development of fuzzy set theory for ecological studies.

Using fuzzy sets is an alternative way to conduct Accuracy Assessments that takes ecological ambiguities into account. In the past, five different descriptions were used to analyze map sites on the ground, so that field crews rated each site with categories ranging from absolutely wrong to good answer to absolutely right (Gopal and Woodcock 1994). In a similar vein, polygons containing multiple community types have also been assessed in a manner that allows all types to be listed in the results (Meidinger 2003) and therefore polygons could be partially correct instead of having to be labeled as strictly correct or incorrect. The use of fuzzy sets makes the determination of degrees of errors possible (Gopal and Woodcock 1994) which aids in both the use of and the production of maps. Fuzzy sets may be somewhat subjective so it is important to explain the parameters for all levels of correctness, but an Accuracy Assessment using fuzzy set methodology would provide producers with a better idea of which map types could more easily be fixed, and users would know which map units may be used with more confidence than others. Most, if not all, map assessment results would be strengthened with the use of at least some level of fuzzy sets.

Carl Sandburg Home National Historic Site

Carl Sandburg Home National Historic Site (CARL) was mapped in 2003 and its Accuracy Assessment was conducted by NatureServe in the fall of 2004. CARL is located on Little River Road in Flat Rock, NC. The park contains 264 acres (approximately 107 hectares) of land that contains forest, pasture, and developed areas. Over five miles of trails provide access to the majority of the park, although damage from Hurricane Ivan in September 2004 did make parts of the park more difficult to access. The size and accessibility of CARL enabled field crews to quickly gather the necessary data in a relatively short time period.

The objective of the Accuracy Assessment was to determine whether the map met the National Biological Survey/ National Park Service (NBS/NPS) 80% accuracy standards (Environmental Systems Research Institute et al. 1994). The Assessment generally followed the Environmental Systems Research Institute et al. (1994) protocols, but was modified as necessary due to time or budgetary constraints, and to include some degree of fuzzy set theory.

Methods

Point selection – thematic accuracy

Points selected in ArcView 3.3 served as the centers of the assessed areas, whose sizes were determined by average minimum map unit (Environmental Systems Research Institute et al. 1994). Surveyed areas were circular with a 25 m radius unless they were in riparian polygons or other linear polygons; then the assessed areas were linear and 25 m long, with a width of 5-10 m, to ensure that the assessment stayed within the correct polygon.

Thematic accuracy points were randomly selected by community type and were placed 35 m from the polygon boundary to account for a ten meter GPS error and to ensure that the area surveyed would fall entirely within the polygon in question. Less than one third of the points were scattered throughout the developed cultural areas and the rest were placed in the forested areas.

The number of points placed in each community type was generally determined based on differences in predominance and overall size of each type at the park (Environmental Systems Research Institute et al. 1994). Therefore, the larger, more common communities generally contained more sample units than the less predominant communities (Table 1). Some rare communities were contained within only one polygon; in order to avoid placing too much emphasis on the results of rare community types, sample sizes were noted along with the results. The four digit map units in this document refer to the last four digits of the NatureServe global database codes for the U.S. National Vegetation Classification associations that begin with "CEGL00…" (NatureServe 2004). For purposes of brevity, the "CEGL00" was removed, but it should be understood that map unit 7221, for example, refers to CEGL007221.

The time expected to complete data collection at a point was estimated based on information provided by scientists with experience conducting similar studies (J. Drake, pers. comm.; J. Teague, pers. comm.). The expected timeframe for the study at each park was subsequently calculated, with additional time allotted for travel to and from each point. The Environmental Systems Research Institute et al. (1994) standards required more field time than was possible for this project, so the final numbers of points in some polygon types were reduced. However, in order to make field work as efficient as possible, extra points were generated in the GIS so that those that were inaccessible could be omitted while retaining a sufficient sample size.

A total of eighty-seven points were assessed at CARL. Seventy-seven points were used to assess thematic accuracy (Table 1).

Point selection – positional accuracy

Positional accuracy points were not generated randomly for field work; instead, they were placed on areas that had clearly delineated boundaries such as corners of buildings or crossroads. Ten points were used to assess positional accuracy in the field (Table 1). An additional twenty positional accuracy points were assessed by overlaying the vegetation map onto digital orthophotography. The spatial distances between points on selected roads or buildings on the vegetation map versus on the orthophotos were assessed, and with errors from the orthophotography and the vegetation maps taken into account, positional accuracy was further determined.

Equipment

Equipment required for field data collection included data sheets, pencils, clipboards, a metric measuring tape, a key to vegetation association types for CARL, a compass, vegetation maps with the points at the park, ArcPad, and a Garmin differential GPS unit or a WAAS enabled GPS unit.

The positional accuracy of a Garmin 5 GPS unit could range from 1 m accuracy up to 30+ meters (pers. observation), and its inaccuracies could direct a person to an area that was in a community type next to the one intended. This issue could be particularly problematic for association level maps which often contain fairly small polygons. To mitigate this problem, points were located in the field when possible with either a WAAS enabled Garmin 5 GPS unit, or a Garmin 5 differential GPS unit.

WAAS, the Wide Area Augmentation System, corrects some GPS signal errors caused by satellites, the atmosphere, and the ionosphere, through the use of two master stations and 25 ground reference stations (Garmin Ltd. What is WAAS? 1996-2004). These corrections can result in 3 m or higher accuracy 95% of the time (Garmin Ltd. What is WAAS? 1996-2004). A differential GPS unit is essentially the same as a WAAS enabled unit (Garmin Ltd. FAQs. 1996-2004). While this equipment helped, aspect, canopy cover, and elevation occasionally interfered with the success of these two mitigation techniques; in those instances, the regular GPS reading

was taken. Regardless of method, the GPS accuracy was noted along with data and was taken into account during data analysis.

Plot work

Due to the park's small size, fieldwork took approximately one and a half weeks. Community types were classified at each point in the field using vegetation keys written specifically for CARL. If multiple communities occurred in the surveyed area around one point, all were noted. If another community type was just beyond the 25 m radius circle, it was documented as well. Stipulations for documentation of this situation included that the additional community type must be no more than ten meters away from the 25 m radius circles, and it had to have a radius equivalent to the minimum map unit for the park. If it was not that large, then it was described on the data sheets but not marked as a separate community type, because it may not have been large enough to be mapped. These types were used when trying to understand inaccuracies on the map. The cover class for the dominant species in the canopy stratum was recorded along with overall percent cover for the rest of the strata, and pertinent environmental attributes were also recorded. The additional environmental and vegetative data permitted further evaluation of the plot once out of the field.

Data analysis

Data collected to assess map accuracy were analyzed using Microsoft Excel Version 2002. A misclassification table was generated to indicate how many polygons in each class were accurately or inaccurately mapped (Table 2). Overall map accuracy was determined by dividing the number of correct polygons by the total number of polygons assessed. A Kappa index, which takes into account that some polygons are correctly classified by chance (Environmental Systems Research Institute et al. 1994, Foody 1992), was also calculated.

Producer's and user's accuracy were assessed for each type of map unit. To calculate producer's accuracy for each type of map unit, the number of polygons assessed in the field that were correct according to the map type was divided by the total number of polygons of that class that were found in the field. To calculate user's accuracy for each type of map unit, the number of polygons assessed in the field that were correct according to the map was divided by the total number of polygons of that class that should have been found, according to the map

(Environmental Systems Research Institute et al. 1994). Ninety percent confidence intervals for both producer's and user's accuracy were determined with the use of the binomial distribution equation:

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

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

Data were analyzed with a derivation of fuzzy sets (Gopal and Woodcock 1994); the fuzzy sets were not applied during field work but afterwards during data analysis. Points that fell into ecotones were marked correct if the type classified matched a community type on either side of the ecotone.

Positional accuracy points were analyzed separately from the thematic accuracy points. The field points were assessed based on the National Map Accuracy Standards – in order to be considered accurate, 90% of the points on the map had to be within approximately 12 m of where they were on the ground (Environmental Systems Research Institute et al. 1994); the same qualifications were used when comparing the digital orthophotography to the map. If fewer than 90% of the points were correct, it would be assumed that the map was slightly shifted in space from where the polygons actually lay on the earth.

Results and Discussion

The Carl Sandburg map had an overall thematic accuracy of 71.4%. However, when taking the GPS error into account, accuracy increased to 79.2%, and accounting for ecotonal issues further increased accuracy to 83.1%, with 90% confidence intervals of 7.7% and a Kappa index of 82.2%, which reached the NBS/NPS standards of an overall 80% map accuracy. The classification matrix (Table 2) incorporates the corrections for both GPS and ecotonal errors. Mappers should not be held responsible for GPS errors or for marking polygon boundaries perfectly since community types are continuous, so the overall accuracy of 83.1% best explains this map's accuracy. Large overall confidence intervals due to small sample sizes do warrant

some caution in using the results of this Assessment (Figure 1), although the high overall map accuracy lends credence to the validity of the results from thematic accuracy points.

Errors are inevitable in data collection and attempts were made to eliminate them but some were unavoidable, such as GPS error due to inclement weather or "dead" times when insufficient satellites were available for use. When these dead times occurred, the GPS readings were erratic and made field work difficult or impossible; these times were noted and avoided once this problem was understood. The GPS error also occasionally led the field crew to points in polygons other than those that were intended. The error was somewhat reduced by the use of a WAAS enabled GPS unit and a differential GPS unit, but accuracy still varied from 1 m to 10 m, which affected smaller polygons. Therefore, if the surveyed area was classified in the field as one community type that was incorrect on the map according to where the GPS placed the point, and the GPS error indicated that the point could be in another polygon on the map that matched the classification in the field, then the surveyed area was considered correct. The final accuracy should account for these errors and the map should not be considered inaccurate if the field equipment causes the problems.

Similarly, polygons cannot be perfectly delineated on a map when dealing with vegetation – there is always an ecotonal area where at least two community types blend to some degree. Despite efforts to prevent it, points sometimes fell into ecotones at CARL which made classification difficult, although the use of fuzzy set theory (Gopal and Woodcock 1994) helped clarify those issues. Since these areas are more difficult to classify and map, it made sense to consider polygons correct if the sampled area fell into an ecotone and the community type on either side of the point fit the classification from the vegetation map.

Enough data were collected in the field that polygon classifications could be checked in the office, and waiting to implement the fuzzy sets in the office worked well. Waiting made it possible to ascertain whether using the fuzzy set theory would produce overly biased results; had that occurred, the fuzzy sets would not have been used. Applying fuzzy sets in the office also saved some field time since the map needed to be checked and distances had to be drawn on it in order to see where the point might have fallen with the GPS error.

Other errors that arose could have been due to the classification key – occasionally the point did not fit well into any community description so the closest one was chosen, but it may not have been a perfect fit. The vegetation key had been created before planning the Accuracy

Assessment, but the key had not been field-tested. This could result in errors in the Assessment that should not be attributed to the map but to the key. This part of the Assessment could possibly be fixed in the future by adding a "fit" category to the data sheets, which would increase the amount of fuzziness in the final results because the better fits would be separated out from the less perfect fits.

Thematic accuracy

The results of user's accuracy indicated that twenty-three (77%) out of thirty map classes were at least 80% accurate, four fell into the 80% accuracy range when using the 90% confidence intervals (Figure 1), and three were inaccurate. The three inaccurate types were not causes for concern because they had sample sizes of only one or two; one type was a garden which can easily change from year to year; one type (7221) was a mid- to late- successional type that could have potentially shifted in composition from the mapping year to the AA year; and the last inaccurate map class (7221/ 7230) did not contain rare community types and was a mixed association tuliptree- hardwood/ oak hickory forest polygon type (NatureServe 2004).

Results of the producer's accuracy indicated that twenty-five of the thirty map classes (83%) had at least 80% accuracy, and only five were less than 80% accurate (Figure 1). Three of these five classes were in the accurate range when using 90% confidence intervals (Figure 1). One inaccurate vegetation class (7221/7230) was the same as the class in error for user's accuracy (Table 2).

There was some confusion in dealing with combinations of classes on the map such as 7221/7230 (Table 2), and whether polygons that could be designated as either or both classes should be kept as one class or if they should be separated and added to the polygons that could only be one of the two classes (7221 or 7230). Ultimately, they were kept as combinations so as not to confuse the final tally of the number of polygons of each class. However, this particular 7221/7230 combination affected the producer's accuracy since no polygons were found in the field to be a combination of the two classes; they were classified as one type or the other. Since the combination was not found to exist in the field, it could be eliminated from the producer's accuracy, increasing its final result to 87% correct. While the 7221/7230 combination confused the results of the Accuracy Assessment to some degree, other combinations such as 7221/7231 were useful because some polygons did contain two associations. Perhaps this source for error

may be decreased if the vegetation key contained the potential combinations that described complexes within map classes or if it compared similar classification types.

The other polygons that did not agree with the map were found in the field to be Appalachian white pine – xeric oak forests (7519, Tables 1, 2). The map, however, labeled some of these polygons as chestnut oak forests (6286), Southern Appalachian low elevation granitic dome (7690) or chestnut oak forests (xeric ridge types) (6271), Blue ridge table mountain pine-pitch pine woodland (typic type) (7097), or Eastern white pine successional forests (7944) (Tables 1, 2). All of the types except for the Eastern white pine successional forest are xeric, and all contain pine or oak, if not both. It is possible, therefore, that the errors were either due to the field crew not obtaining sufficiently detailed environmental information for the Accuracy Assessment, problems using the vegetation key, the mappers having difficulties with the aerial vegetation signatures, or a combination of the three.

Positional accuracy

Positional points also reached the NBS/NPS standards. Of the ten points that were tested, one had to be discarded because it was in the middle of a building instead of on the corner, and the remaining eight (89%), with a mean accuracy of 8.9 m, were within the required 12 meters (Environmental Systems Research Institute et al. 1994) of the actual point. Of the twenty points selected at CARL to be assessed on the vegetation map versus on the digital orthophotography, four were unable to be compared because they did not show up as developed areas on the orthophoto. The remaining 16 points on the vegetation map, with a mean accuracy of 4.5 m, were all less than 9.5 m away from the same points on the orthophoto. With a horizontal positional accuracy of 3 – 10 m on the orthophotos (U.S. Geological Survey 1996), this high accuracy suggests that the map is positionally accurate and does meet the NBS/NPS standards, particularly since the data collected in the field also suggest that the map is accurate.

Future Accuracy Assessments

Future Accuracy Assessments should entail more detailed data collection; for this project, only environmental data that seemed pertinent when in the field were collected. The extra time needed to collect more environmental information at each point may reduce the total number of points collected, but the additional data would help in the classification of different polygons

when in the office. Additionally, map units that contain fewer than five polygons do need to be sampled in their entirety as the Environmental Systems Research Institute et al. (1994) protocols state, and a sufficient number of samples should be taken for each map unit so that confidence intervals may be calculated. Therefore, more field time should be budgeted into future Accuracy Assessments to ensure the highest quality of data collection and the largest possible dataset that would minimize the width of confidence intervals. These were minor issues that did not affect the final outcome of this Assessment, but their correction would strengthen future Assessments.

In addition to collecting more data, field keys to the vegetation types should be tested prior to data collection for Accuracy Assessments. Errors in field keys can affect the results of the Accuracy Assessment, and mappers should not be considered responsible for errors resulting from the key. A few days should be spent testing and revising the key prior to conducting the Assessment to ensure that errors would be attributed to mapping issues rather than to potential vegetation key issues.

When conducting field work, satellites should be checked to determine at which times of day they will provide the weakest signals for GPS units. There are typically a few short times per day that the GPS unit will not work well, and it will save time and resources to know when those times are and to avoid them; this may be done using Trimble's Planning Software program (Trimble 2001). This is particularly important for Accuracy Assessment work, since a GPS point with high error could cause field crews to assess the wrong polygon and possibly indicate lower map accuracy than the map actually has. Finally, since a real-time differentially corrected GPS unit provides more data accuracy than a regular GPS, one of these units should be available for field work, and it should ideally be a mapping/resource grade rather than a recreational grade unit in order to minimize GPS accuracy errors.

Conclusions

Although there were some errors at CARL, its Assessment indicated high map accuracy and aside from a few difficult areas, the map may be used with confidence. The few errors on the CARL map may be corrected or perhaps map users may simply be forewarned of the few difficult community types that they may encounter in the field. Some error is unavoidable and while the map could perhaps be improved, it is also possible that in revising it other errors may

be created. Since the overall map accuracy exceeds the NBS/NPS mapping standards, it does not seem necessary to spend additional resources to improve it.

Tables and Figures

Table 1. Association types and map units, number of polygons, cumulative sizes of polygons, and the number of samples visited at Carl Sandburg Home in Fall, 2004. The number of samples recommended by ESRI et al. (1994) is in parentheses.

Map unit*	Association Name	No. of polygons	Class size (ha)	No. of samples
2386/W	Water lily aquatic wetland/Water	1	1.04	(1) 1
4048	Cultivated meadow	6	13.81	(5) 3
4112	Rush marsh	1	0.14	(1) 1***
6192*	Appalachian montane oak hickory forest (red oak type)	2	2.74	(2) 2
6271	Chestnut oak forest (xeric ridge type)	5	1.48	(5) 3***
6286	Chestnut oak forest	8	10.29	(5) 4
7097*	Blue ridge table mountain pine- pitch pine woodland (typic type)	5	2.61	(5) 5***
7221*	Interior mid- to late-successional tuliptree - hardwood upland forest (acid type)	7	2.88	(5) 5***
7230	Appalachian montane oak hickory forest (typic acidic type)	11	14.10	(5) 5
7231**	Dry-Mesic Southern Appalachian White Oak - Hickory Forest	0	0.00	0
7267	Appalachian montane oak hickory forest (chestnut oak forest)	11	31.16	(5) 5
7519	Appalachian white pine- xeric oak forest	4	5.17	(4) 3
7543	Southern Appalachian acid cover forest (typic type)	1	2.20	(1) 1
7690*	Southern Appalachian low elevation granitic dome	42	9.45	(20) 7***
7944	Eastern white pine successional forest	10	4.19	(5) 4***
8427	Appalachian shortleaf pine- mesic oak forest	1	0.11	(1) 1***
Buildings		20	0.27	(5) 4***
Culturally modified		43	6.25	(20) 10***
Exotics		3	0.16	(3) 2***
Gardens		2	0.07	(2) 2***
Home		1	0.04	(1) 1***
Old orchards		1	0.08	(1) 1***
Roads		2	1.78	(2) 2***
Shrubs		1	0.03	(1) 1***
Water		4	0.57	(4) 4***
Subtotals		192	110.62	**(109) 77**
Positional				10
Total				**87**

*Some polygons on the map are labeled with two association types due to differentiation difficulties. In order to avoid repeating data, only the first type listed on the map was used to determine the number of polygons, the class size, and the number of samples .

**This association did not have its own polygons on the map but was assessed in combination with 7221.

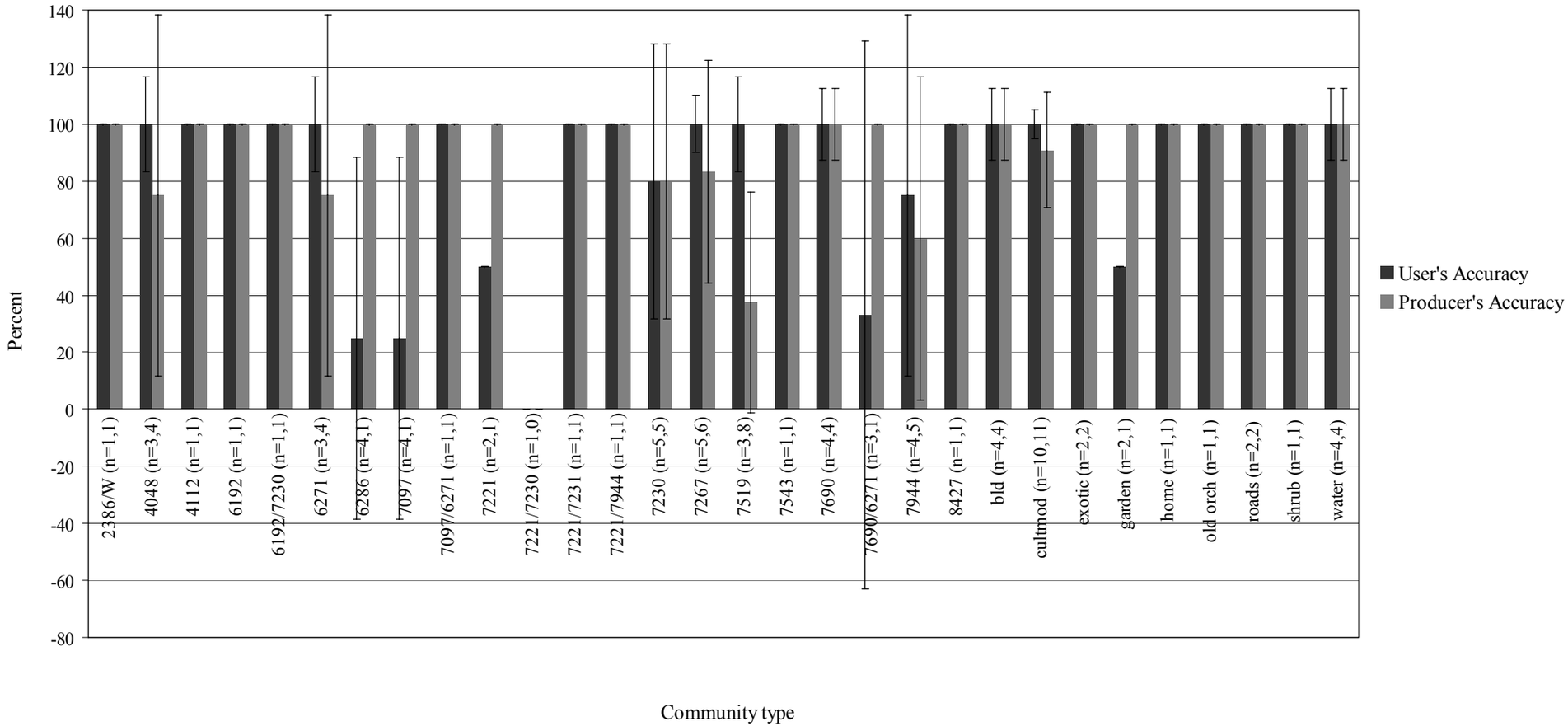
***Associations too small in area or polygon size to follow the .02 ha circular plot size. Plot shapes will be adjusted for these polygons.

Table 2. Misclassification matrix for CARL, Fall 2004. Gray boxes indicate the number of polygons in the field that agree with the polygons on the map.

Map units found in the field

Map units- on the map	2386/W	4048	4112	6192	6192/7230	6271	6286	7097	7097/6271	7221	7221/7230	7221/7231	7221/7944	7230	7267	7519	7543	7690	7690/6271	7944	7944/7543	8427	bld	cultmod	exotic	garden	home	old orch	roads	shrub	water	Grand Total	Producer's accuracy (%)	Upper 90% confidence interval (%)	Lower 90% confidence interval (%)
2386/W	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	100	n/a	n/a
4048	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	75	138.4	11.6
4112	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	100	n/a	n/a
6192	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	100	n/a	n/a
6192/7230	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	100	n/a	n/a
6271	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	75	138.4	11.6
6286	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	4	100	n/a	n/a
7097	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	4	100	n/a	n/a
7097/6271	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	100	n/a	n/a
7221	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	100	n/a	n/a
7221/7230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	n/a	n/a
7221/7231	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	100	n/a	n/a
7221/7944	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	100	n/a	n/a
7230	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	80	128.1	31.9
7267	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	83.3	122.3	44.3
7519	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	37.5	76.2	-1.2
7543	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	100	n/a	n/a
7690	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	4	100	112.5	87.5
7690/6271	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3	100	n/a	n/a
7944	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0	0	0	0	0	0	0	4	60	116.7	3.3
7944/7543	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--	--
8427	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	100	n/a	n/a
bld	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	4	100	112.5	87.5
cult mod	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	10	90.9	111.2	70.6
exotic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	100	n/a	n/a
garden	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	100	n/a	n/a
home	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	100	n/a	n/a
old orch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	100	n/a	n/a
roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	100	n/a	n/a
shrub	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	100	n/a	n/a
water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	100	112.5	87.5
Grand Total	1	4	1	1	1	4	1	1	1	1	0	1	1	5	6	8	1	4	1	5	1	1	4	11	2	1	1	1	2	1	4	77		
User's accuracy	100	100	100	100	100	100	25	25	100	50	0	100	100	80	100	100	100	100	33	75	--	100	100	100	100	50	100	100	100	100	100			
Upper 90% confidence interval (%)	n/a	116.7	n/a	n/a	n/a	116.7	88.4	88.4	n/a	n/a	n/a	n/a	n/a	128.1	110	116.7	n/a	112.5	129.1	138.4	--	n/a	113	105	n/a	n/a	n/a	n/a	n/a	n/a	112.5			
Lower 90% confidence interval (%)	n/a	83.3	n/a	n/a	n/a	83.3	-38.4	-38.4	n/a	n/a	n/a	n/a	n/a	31.9	90	83.3	n/a	87.5	-63.1	11.6	--	n/a	87.5	95	n/a	n/a	n/a	n/a	n/a	n/a	87.5			

Figure 1. The percent of producer's and user's accuracy, with 90% confidence intervals, of the community types at CARL, Fall 2004. Sample sizes are noted after community type; the first is for user's accuracy and the second is for producer's accuracy.



References

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

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

Gallyoun, M., G. Meyer, A. Andreu, W. Slocumb. 1996. Mapping vegetation communities with The Nature Conservancy's vegetation classification system on five small national parks in the southeastern USA. Unpublished report. The Nature Conservancy, Southeast Regional Office, Conservation Science Department, Chapel Hill, NC.

Garmin Ltd. What is WAAS? 1996-2004. Accessed March 25, 2005 <http://www8.garmin.com/aboutGPS/waas.html>

Garmin Ltd. FAQs. 1996-2004. Accessed March 25, 2005 <http://www.garmin.com/garmin/cms/site/us/support/>

Gopal, S. and C. Woodcock. 1994. Theory and methods for Accuracy Assessment of thematic maps using fuzzy sets. Photogrammetric Engineering & Remote Sensing 60(2):181-188.

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

Meidinger, D. 2003. Protocol for accuracy assessment of ecosystem maps. Research Branch, B.C. Ministry of Forests, Victoria B.C. Technical Report 011.

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

Story, M. and R. Congalton. 1986. Accuracy assessment: A user's perspective. Photogrammetric Engineering and Remote Sensing 52:397-399.

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

Trimble Navigation Ltd. Trimble's Planning Software. 2001. Accessed March 31, 2005 <http://www.trimble.com/planningsoftware.html>

U.S. Geological Survey, Department of the Interior. 1996. Standards for digital orthophotos: National Mapping Program technical instructions.