Ecological Zone mapping in the South Mountains and New River Headwaters Landscapes

by

Steve Simon

Excerpted as-is from a report to the Southern Blue Ridge Fire Learning Network Landscape

EVALUATING FIRE NEEDS OUTSIDE THE ECOLOGICAL ZONE MODEL AREA

There are approximately 1.7 million acres within the SBR-FLN where ecological zones are not mapped (Table 7) and therefore where this tool could not be used to identify fire-adapted plant communities. Before considering the expenditure of time and funds to expand ecological zone mapping to these areas, other methods for evaluating fire needs in the SBR FLN should be examined.

Using LANDFIRE BpS to Assess Fire Needs in the SBR-FLN

LANDFIRE (Landscape Fire and Resource Management Planning Tools Project) is an interagency vegetation, fire, and fuel characteristics mapping project. The following description of this project and the models that have been produced is taken directly from the LANDFIRE homepage: http://www.landfire.gov/index.php. "LANDFIRE is producing a comprehensive, consistent, scientifically credible suite of spatial data layers for the entire United States. Principal project partners include the USFS Missoula Fire Sciences Laboratory, the USGS Center for Earth Resources Observation and Science, and The Nature Conservancy. Data products are 30-meter spatial resolution raster data sets, which will vary in accuracy by geography, product, and scale of use. LANDFIRE geospatial data products describe existing vegetation composition and structure, potential vegetation, surface and canopy fuel characteristics, historical fire regimes, and fire regime condition class. LANDFIRE mapping approaches are based on peer-reviewed science from the fields of remote sensing, ecosystem simulation, predictive landscape modeling, vegetation and disturbance ecology, and wildland fire behavior and effects."

The Biophysical Settings layer (BpS) produced by LANDFIRE is their most appropriate tool to evaluate fire needs in the SBR-FLN where ecological zones have not been mapped. BpS represent the vegetation that may have been dominant on the landscape prior to Euro-American settlement and are based on both the current biophysical environment and an approximation of the historical disturbance regime and are therefore roughly equivalent to ecological zones.

LANDFIRE BpS Accuracy

There have been some concerns that the LANDFIRE BpS layer may be too broad-scale to adequately map the location and extent of fire-adapted communities in the SBR-FLN. Also, local ecologists and botanists felt that the estimate of over 70% fire-adapted plant communities within the SBR-FLN based on BpS was too high (Table 8). Although not rigorously evaluated, it was also believed that individual BpS map units did not accurately reflect the complex landscapes and plant communities in this area.

One method of addressing these concerns is to assess BpS map unit accuracy with reference data from field plots used to develop ecological zones models Although this is not a true accuracy assessment because many of these same plots were used to develop the BpS map, it is a reasonable means of objectively comparing different modeling methods. This 'dirty accuracy assessment' method was also used to compare the accuracy of ecological zone maps produced by different methods in the South Mountains landscape (see discussion, pages 5,9). To evaluate BpS map unit accuracy, field plot locations for ecological zone data were intersected with BpS units using a GIS. BpS types were 'uncomfortably' cross-walked with ecological zone types as follows:

Ecological Zone types	BpS types
Spruce-Fir --	Central and Southern Appalachian Spruce-Fir Forest
Northern hardwood cove+Northern hardwood slope ----------------------	Southern Appalachian Northern Hardwood Forest
Rich cove,+Acidic cove ---	South and Central Appalachian Cove Forest, & Central Interior and Appalachian Riparian Systems, & Southern Piedmont Mesic Forest
Alluvial forest --	Central Interior and Appalachian Floodplain Systems
High elevation red oak ---	Central and Southern Appalachian Montane Oak Forest
Chestnut Oak+Dry-Mesic Oak+Mesic Oak-Hick.+Oak/rhododendron ---	Southern Appalachian Oak Forest
Shortleaf pine-oak+Shortleaf pine-oak heath ---------------------------------	Southern Appalachian Low Elevation Pine Forest, & Southern Piedmont Dry Oak (-Pine) Forest
Pine-Oak heath ---	Southern Appalachian Montane Pine Forest and Woodland

The error matrix (Table 9) shows the result of this analysis. The error matrix is the standard way of presenting results of an accuracy assessment. It is a square array in which accuracy assessment sites are tallied by both their classified category and their actual category according to the reference data. In our case, the rows in the matrix represent the reference data, while the columns represent the classified data. Although this is the non-traditional way of presenting an error matrix, it was the only logical approach given the need to cross-walk between BpS and ecological zone types. The major diagonal contains those sites where the classified data agree with the reference data. Overall accuracy, a common measure of accuracy, is computed by dividing the total correct samples (the diagonal elements) by the total number of assessment sites. The overall accuracy of BpS map units is low (42.8%) based on ecological zone reference plots and due primarily to confusion in the Southern Appalachian Oak, Southern and Central Appalachian Cove, Central and Southern Appalachian Montane Oak, and Southern Appalachian Montane Pine types. The accuracy of non fire-adapted vs. fire-adapted categories is fair to good at 52.9% and 78.9% respectively (total 66.8% accurate). It is also interesting to note that the reference plots characterize about 47% non fire-adapted and 53% fire-adapted types while the classified BpS map units where these plots intersected characterize about 36% non fire-adapted and 64% fire-adapted types. Accuracy of individual types was calculated by dividing the number of correct accuracy sites for a class (diagonal elements) by the total number of reference sites for that class found in the right-hand cell of each row; i.e., the probability of a reference site being correctly classified, also called 'Producer's accuracy'.

Table 8. Fire-adapted plant communities within the SBR-FLN based on LANDFIRE Biophysical Settings (BpS)

BpS_NAME	TOTAL (acres)	FEDERAL LAND
(highlighted types are fire-adapted)		
Southern Appalachian Oak Forest	3,091,053	1,001,311
Central and Southern Appalachian Montane Oak Forest	914,516	373,785
Southern and Central Appalachian Cove Forest	818,186	244,991
Southern Piedmont Dry Oak(-Pine) Forest	695,522	24,275
Central Interior and Appalachian Riparian Systems	620,961	154,273
Southern Appalachian Montane Pine Forest and Woodland	428,415	228,831
Southern Appalachian Low-Elevation Pine Forest	350,964	104,143
Southern Piedmont Mesic Forest	266,984	6,503
Southern Appalachian Northern Hardwood Forest	196,972	140,421
Central Interior and Appalachian Floodplain Systems	94,244	3,472
Open Water	93,206	6,598
Central and Southern Appalachian Spruce-Fir Forest	47,066	43,366
Allegheny-Cumberland Dry Oak Forest and Woodland	35,178	781
South-Central Interior Mesophytic Forest	13,295	4
Southern Ridge and Valley/Cumberland Dry Calcareous Forest	13,123	31
Barren-Rock/Sand/Clay	11,097	955
Southern Appalachian Grass and Shrub Bald	2,002	929
Southern Interior Low Plateau Dry-Mesic Oak Forest	150	0

Nashville Basin Limestone Glade and Woodland [1/]	29	0
South-Central Interior/Upper Coastal Plain Wet Flatwoods [1/]	8	0
Southeastern Interior Longleaf Pine Woodland [1/]	5	1
Central Interior and Appalachian Swamp Systems	5	0
TOTAL acres of all types	7,692,939	2,334,669
TOTAL acres of fire adapted types [2/]	5,528,921	1,733,157
percent of total area in fire adapted types	71.9%	74.2%

[1/] not likely to truly occur in the SBR-FLN 2/ excludes types not likely to truly occur in the SBR-FLN

Table 9. Assessment of LANDFIRE BpS map units relative to 3,673 Ecological Zone field sample plots [1/]

	non fire-adapted				fire-adapted				by type		# and % of correctly classified reference plots by fire category		
Biophysical Setting Number and Name	1	2	3	4	5	6	7	8	Total	% correct	non Fire adapted	fire adapted	% correct
1 Central and Southern App. Spruce-Fir	62	14	6		3				85	72.9	82	3	95.6
2 Southern App. Northern Hardwood	18	169	52		80				319	53.0	239	80	74.9
3 Cove, Riparian, S.Piedmont Mesic	1	14	535		239	381	21	69	1260	42.5	550	710	43.7
4 Cent. Int. and S. App. Floodplain Systems			36	1		14	1		52	1.9	37	15	71.2
Total classified data by fire category				908				808	1716	44.7	908	808	52.9
5 Central & Southern App. Montane Oak	10	158	5		81	8		8	270	30.0	173	97	35.9
6 Southern Appalachian Oak		20	193		204	551	85	143	1196	46.1	213	983	82.2
7 Low Elevation Pine, Dry Oak-Pine			19			95	77	4	195	39.5	19	176	90.3
8 Southern Appalachian Montane Pine		3	4		30	114	50	95	296	32.1	7	289	97.6
Total classified data by fire category				412				1545	1957	41.1	412	1545	78.9
Classified data by fire category (#, %)				(1320, 35.9%)				(2353, 64.1%)	3673	42.8	1320	2353	66.8
Reference data by fire category (#, %)				(1716, 46.7%)				(1957, 53.3%)	---------- Totals ----------				

[1/] **note: rows are reference data, columns are classified (BpS) data**

Another method of evaluating the usefulness of BpS to characterize fire-adapted plant communities in the SBR-FLN is to assess the sensitivity of results across different landscapes. BpS map units were used to identify fire-adapted plant communities outside the ecological zone model area and within 3 target landscapes: the Central Escarpment, Southern Blue Ridge Escarpment, and Smoky-Unaka Mountains (Table 10). The estimate of fire-adapted types varies little from the Smoky-Unaka Mountains (74%) to the Central Escarpment (78%), two very different landscapes. These figures are also much higher than estimates of fire-adapted plant communities using ecological zones (49% in the Smoky-Unaka Mountains, 57% in the Central Escarpment).

Table 10. Identification of fire-adapted plant communities outside the ecological zone model area using LANDFIRE Bio-Physical Settings

Landscape Area Name	Total Acres [1/]	Total Fire Adapted Types	High Elev. Red Oak	Mesic & Dry-mesic Oak-Hickory	Pine-Oak Heath & Oak Heath	Shortleaf Pine-Oak	Not Fire Adapted
Total area without ecozone modeling	1,776,267	1,398,105 (79%)	100,810 (7.2%)	628,011 (45%)	520,823 (37%)	148,461 (11%)	378,162
Central Escarpment	17,853	13,366 (78%)	675 (5%)	7,785 (57%)	3,092 (23%)	2,114 (16%)	3,917
Smoky and Unaka Mts.	416,559	306,657 (74%)	6,765 (2%)	180,183 (59%)	56,909 (19%)	62,800 (21%)	109,902
S.Blue Ridge Escarpment	219,059	172,651 (79%)	0 (0%)	83,405 (48%)	77,416 (45%)	11,830 (7%)	46,408
Total outside of Landscapes	1,123,066	905,131 (81%)	93,370 (10%)	356,638 (39%)	383,406 (42%)	71,717 (8%)	217,935

[1/] These figures will not match exactly other tables because of dropping 8600 acres of BpS category ‘barren’ from this analysis, rounding errors, and ARC intersection errors.

LANDFIRE BpS Accuracy Assessment
A more precise method of judging BpS map unit accuracy is a true accuracy assessment. A quantitative accuracy assessment depends on the collection of reference data. Reference data is known information of high accuracy (theoretically 100% accuracy) about a specific area on the ground (the accuracy assessment site). The assumed-true reference data can be obtained from ground visits, photo interpretation, video interpretations, or some combination of these methods. In a map accuracy assessment, sites are generally the same type of modeling unit used to create the map. Accuracy assessment involves the comparison of the categorized data for these sites to the reference data for the same sites.

Accuracy assessments are essential parts of all vegetation mapping projects but they are time-consuming and expensive especially in mixed ownerships. They provide the basis to compare different map production methods, information regarding the reliability and usefulness of the maps for particular applications, and the support for spatial data used in decision-making processes. It is useful to evaluate accuracy relative to the aerial extent of each class. For example, when a particularly common class (e.g., 10-15% of the map area) has either a very high or a very low accuracy it has a disproportionate effect on the utility of the map for general analysis applications without a corresponding effect on the accuracy assessment. Conversely, a relatively rare type (e.g., < 1% of the map area) regardless of its accuracy has relatively little effect on the utility of the map for general analysis applications but has the same effect on the accuracy assessment as the common type.

Conducting an accuracy assessment is a multi-step process that includes the following general steps:

Step 1: Develop the sampling design.
Step 2: Delineate the accuracy assessment sites.
Step 3: Interpret the assessment sites from the reference data and perform quality control.
Step 4: Build the error matrix and summarize results.

Developing the Sample Design
Ground visits were chosen as the most reliable method for collecting reference data. For practical reasons, the accuracy assessment was designed to sample only the most extensive types; proximity to roads and sample intensity were driven by budget and time constraints. BpS units that cover at least 1% of the SBR-FLN were selected to evaluate extensive types as well as those less-extensive types more important in the Piedmont area or other types important to fire management. An exception was made for Central and Southern Appalachian Spruce Fir Forest (0.6% of area). A stratified random sample of 125 BpS map units (Table 11) at least 3 acres in size was selected on Federal land within the SBR-FLN to provide reference data to evaluate BpS mapping accuracy.

Table 11. Accuracy Assessment Field Sites by BpS Type

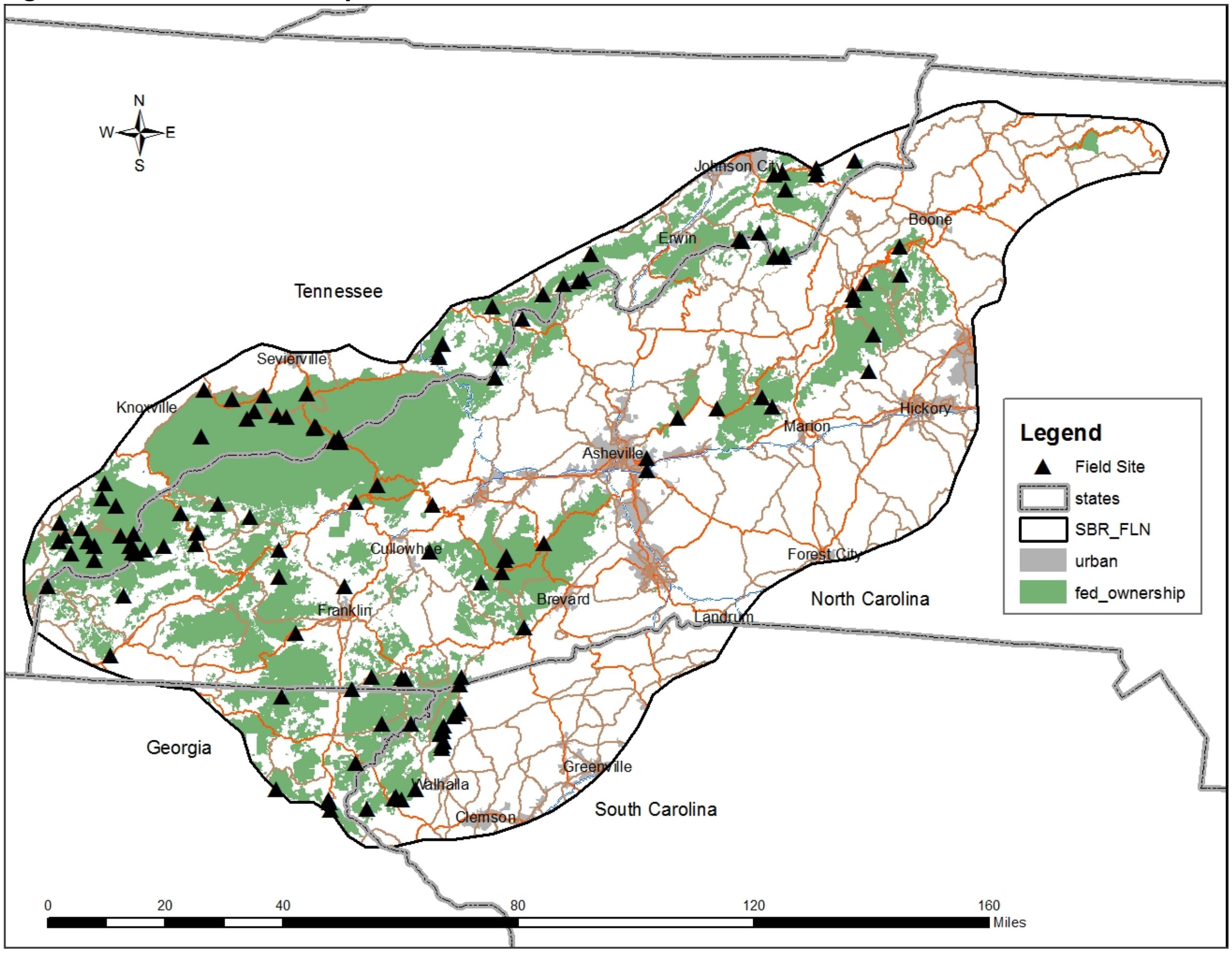
BPS_NAME	TOT %	FED AC	%	# polys	Field Plot
				GT 3 ac.	Sample #
Southern Appalachian Oak Forest	40.2%	1,001,311	47.40%	6,748	18
Central and Southern Appalachian Montane Oak Forest	11.9%	373,785	14.97%	2,745	13
Southern and Central Appalachian Cove Forest	10.6%	244,991	10.90%	11,314	12
Southern Appalachian Montane Pine Forest and Woodland	5.6%	228,831	9.21%	6,980	12
Central Interior and Appalachian Riparian Systems	8.1%	154,273	6.54%	9,340	10
Southern Appalachian Northern Hardwood Forest	2.6%	140,421	4.03%	336	10
Southern Appalachian Low-Elevation Pine Forest	4.6%	104,143	4.13%	4,494	10
Southern Piedmont Dry Oak(-Pine) Forest	9.0%	24,275	1.47%	511	10
Central and Southern Appalachian Spruce-Fir Forest	0.6%	43,366	0.62%	88	10
Southern Piedmont Mesic Forest	3.5%	6,503	0.39%	256	10
Central Interior and Appalachian Floodplain Systems	1.2%	3,472	0.12%	112	10
Total					125
Open Water	1.2%	6,598	0.12%	79	
Allegheny-Cumberland Dry Oak Forest and Woodland	0.5%	781	0.04%	27	
Barren-Rock/Sand/Clay	0.1%	955	0.05%	40	
Southern Appalachian Grass and Shrub Bald	0.0%	929	0.02%	25	
Southern Ridge and Valley/Cumberland Dry Calcareous Forest	0.2%	31	0.00%	1	
South-Central Interior Mesophytic Forest	0.2%	4	0.00%	0	
		2,334,670	1	43,096	

Delineating the Accuracy Assessment Sites

The following procedure was used to delineate accuracy assessment sites:

1. Create a GIS coverage of roads within the SBR-FLN;
   1.1. Download Topologically Integrated Geographic Encoding and Referencing (TIGER) system GIS files for Tennessee, South Carolina, Georgia and clip to SBR-FLN boundary,
      1.1.1. Tennessee Counties = Greene, Blount, Carter, Cocke, Sevier, Washington, Monroe, Polk.
      1.1.2. South Carolina Counties = Oconee, Pickens (provided by USFS, National Forests in South Carolina).
      1.1.3. Georgia Counties = Clayton, Habersham, Towns.
   1.2. Download North Carolina Department of Transportation GIS roads and clip to SBR-FLN boundary.
   1.3. Append individual State's road data into one coverage.
   1.4. Buffer all roads by 300 feet.
2. Create a GIS coverage for each of the 11 BpS types on federal lands within the SBR-FLN (Table 11),
3. Intersect buffered roads coverage from (1) with each BpS coverage from (2),
4. Randomly select polygons from the BpS /roads intersection using sample intensity from Table 11. This resulted in the following distribution of sample plots across the SBR-FLN: 54 plots in North Carolina (43% of total sample), 48 plots in Tennessee (38% of total sample), 16 plots in South Carolina (13% of total sample), and 7 plots in Georgia (6% of total sample).
5. Create a GIS point coverage (polygon center in ArcGIS 9.3.1) from the randomly selected polygons (Figure 5).
6. Create a second random selection for each of the 11 BpS types to use if individual 1st selection sites cannot be accurately assessed because of recent disturbance or site inaccessible.

Figure 5: Location of accuracy assessment field sites



Interpreting the assessment sites from the reference data and data quality control

The following procedure was used to evaluate accuracy assessment sites and perform quality control of data layers:

1. Locate reference sites in the field using the GIS point coverage from step 2. This was accomplished by using a GPS unit taking 'real time' locational information attached to a laptop computer with ArcGIS 9.3.1 software and coverages of all pertinent data for the SBR-FLN such as USGS 1:24,000 topographic quads, roads, geology, ownership, and DTMs (and other data used in the overall analysis), and the visual inspection of these data to perform quality control on coverage accuracy, especially ownership. Eight sites were found on private land (although GIS data indicated otherwise); one was dropped and replaced with another randomly selected site, and seven were retained in the random sample because either forest vegetation was intact and an accurate assessment was possible, or the site (one floodplain and one cove), although highly disturbed, could be accurately evaluated. Where necessary, permission was obtained from the landowner before ground visits.
2. Determine if a new random location needed to be chosen because of access problems or overall BpS map unit size exceeded 10,000 acres in size and therefore too large to assess; this was the case at 12 sites. A new sample location was chosen from the 'backup' random sample coverage (3 times) or by sampling the closest equivalent map unit (same type, surface slope configuration, aspect, and elevation).
3. Evaluate the current plant community composition, the extent of site indicators that may not be reflected in the current dominant vegetation type, site factors (aspect, surface slope configuration,

slope position, and data that could be interpreted from GIS coverages), and the makeup of the broader BpS mapunit represented by the point location outside the 300' road corridor. This included a "walk through" starting at the center of each randomly selected polygon and an evaluation of the accuracy of the map unit concepts (vegetation, biophysical site, and disturbance descriptions as well as adjacency or identification concerns), and an evaluation of map unit homogeneity to determine if the sample location reflected the major environmental conditions within the unit.

4. Evaluate if land management practices had altered vegetation composition "way" outside of these descriptions, and determine if an alternate randomly selected site should be visited (this occurred only one time and was also associated with problems in ownership base layers).

Error Matrix

The error matrix (Table 12) below is a square array in which accuracy assessment sites are tallied by both their classified category and their actual category according to the reference data (USDA 2005). The rows in the matrix represent the classified BpS data, while the columns represent the reference data (traditional approach). The major diagonal, highlighted in the following table, contains those sites where the classified data agree with the reference data. The nature of errors in the classified map can also be derived from the error matrix. In the matrix, errors (the off-diagonal elements) are shown to be either errors of inclusion (commission errors) or errors of exclusion (omission errors). Commission errors are shown in the off-diagonal matrix cells that form the horizontal row for a particular class. Omission error is represented in the off-diagonal vertical row cells. High errors of omission/commission between two or more classes indicate spectral confusion between these classes.

The following measures of accuracy were derived from the error matrix.

- Overall accuracy, a common measure of accuracy, is computed by dividing the total correct samples (the diagonal elements) by the total number of assessment sites found in the bottom right cell of the matrix.
- Producer's accuracy, which is based on omission error, is the probability of a reference site being correctly classified. It is calculated by dividing the total number of correct accuracy sites for a class (diagonal elements) by the total number of reference sites for that class found in the bottom cell in each column. Producer's accuracy indicates how many times a BpS type on the ground was identified as that BpS type on the map.
- User's accuracy, which is based on commission error, is the probability that a unit on the map actually represents that category on the ground. User's accuracy is calculated by dividing the number of correct accuracy sites for a category by the total number of accuracy assessment sites, found in the right-hand cell of each row, that were classified in that category (Story and Congalton 1986). User's accuracy indicates how many times a BpS type on the map is really that BpS type on the ground; it expresses how well a person using the map will find that BpS type on the ground.

Table 12: Assessment of LANDFIRE BpS map units from 125 randomly selected field evaluation sites [1/]

	non fire-adapted						fire-adapted					Row Total	
Biophysical Setting Number and Name	1	2	3	4	5	6	7	8	9	10	11		Proportion of Area
1 Central and Southern Appalachian Spruce-Fir	5	5										10	0.006
2 Southern Appalachian Northern Hardwood	1	9										10	0.026
3 Southern and Central Appalachian Cove Forest			7			3		2				12	0.106
4 Southern Piedmont Mesic Forest				4				2	3	1		10	0.035
5 Central Interior and S. Appalachian Riparian Systems			6		3	1						10	0.081
6 Central Interior and Appalachian Floodplain Systems						4		2		4		10	0.012
7 Central and Southern Appalachian Montane Oak		2	*5*				1	5				13	0.119
8 Southern Appalachian Oak			3					12		2	1	18	0.402
9 Southern Piedmont Dry Oak(-Pine) Forest				1				2	4	3		10	0.090
10 Southern Appalachian Low-Elevation Pine Forest			1					3		6		10	0.046
11 Southern Appalachian Montane Pine							1	8		3	0	12	0.056
Column Total	6	16	22	5	3	8	2	36	7	19	1	125	0.979

[1/] **note: columns are reference data, rows are classified (BpS) data**

Overall Type Accuracy = 55 / 125 = 44%
Overall Fire Category Accuracy = 99 / 125 = 79%

Producers Accuracy

Central and Southern App. Spruce-Fir Forest	= 5/6 = 83%
Southern App. Northern Hardwood Forest	= 9/16 = 56%
Southern and Central App. Cove Forest	= 7/22 = 32%
Southern Piedmont Mesic Forest	= 4/5 = 80%
Central Interior and App. Riparian Systems	= 3/3 = 100%
Central Interior and App. Floodplain Systems	= 4/8 = 50%
Central and Southern App. Montane Oak Forest	= 1/2 = 50%
Southern App. Oak Forest	= 12/36 = 33%
Southern Piedmont Dry Oak(-Pine) Forest	= 4/7 = 57%
Southern App. Low-Elevation Pine Forest	= 6/19 = 32%
Southern App. Montane Pine Forest &Woodland	= 0/1 = 0%
Non fire-adapted types	= 48/57 = 84%
Fire-adapted types	= 51/65 = 78%

User's Accuracy

	BY TYPE	BY FIRE GROUP
Central and Southern App. Spruce-Fir Forest	= 5/10 = 50%	100%
Southern App. Northern Hardwood Forest	= 9/10 = 90%	100%
Southern and Central App. Cove Forest	= 7/12 = 58%	83%
Southern Piedmont Mesic Forest	= 4/10 = 40%	40%
Central Interior and App. Riparian Systems	= 3/10 = 30%	100%
Central Interior and App. Floodplain Systems	= 4/10 = 40%	40%
Central and Southern App. Montane Oak Forest	= 1/13 = 8%	46%
Southern App. Oak Forest	= 12/18= 67%	83%
Southern Piedmont Dry Oak(-Pine) Forest	= 4/10 = 40%	90%
Southern App. Low-Elevation Pine Forest	= 6/10 = 60%	90%
Southern App. Montane Pine Forest &Woodland	= 0/12 = 0%	100%
Non fire-adapted types	= 48/62 = 77%	
Fire-adapted types	= 51/63 = 81%	

General Discussion
Although the overall BpS type accuracy was only 44% based on the field-based accuracy assessment (Table 12), the overall accuracy within fire categories was nearly 80%. This is due to the fact that incorrectly classified BpS units in fire adapted types fit best in similar fire adapted types, and this pattern is the same for non-fire adapted types as well (Table 12 and User's Accuracy summary). Misclassified sites were most often evaluated as belonging to types having similar landscape position, moisture/temperate regime, and other biophysical features, and therefore fell into a similar fire category. Overall accuracy for both fire categories was 79%, and higher than the 66.8% estimate based on the 3,673 ecological zone field plots used to assess BpS accuracy (Table 9). This difference is likely due to interpreting accuracy of each map unit based on a 'walk through' in the field-based assessment versus interpreting accuracy based on a GIS intersection of a single pixel (within a BpS map unit) with ecological zone field plots in the 'dirty' assessment.

The field-based accuracy assessment showed that 78% of the time the BpS fire-adapted type on the ground was identified as that BpS fire-adapted type on the map (Producer's accuracy). Stated another way, 78% of the reference data (field plots), that are considered by the FLN as fire adapted, fall within BpS map units correctly classified as fire adapted. Perhaps more importantly, for a person using the map to locate fire adapted plant communities, 81% of the time they will find that BpS category on the ground (User's accuracy). Individually, Spruce-Fir, Northern Hardwood, Riparian Systems, and Montane Pine, although varying from 0% to 90% BpS type accuracy, were 100% accurate in fire category prediction. Mesic Forest, Floodplains, and Montane Oak had the lowest accuracy for predicting fire category (40% - 46%) and also low accuracy for predicting BpS type (8%-40%). So in general, it is apparent that BpS are adequate for predicting broad landscapes that support fire adapted plant communities in the SBR-FLN.

The question still remains concerning why BpS appear to overestimate the extent of fire adapted plant communities in the SBR-FLN based on local knowledge and the ecological zone model. From the different analyses presented in this report, the following is apparent:

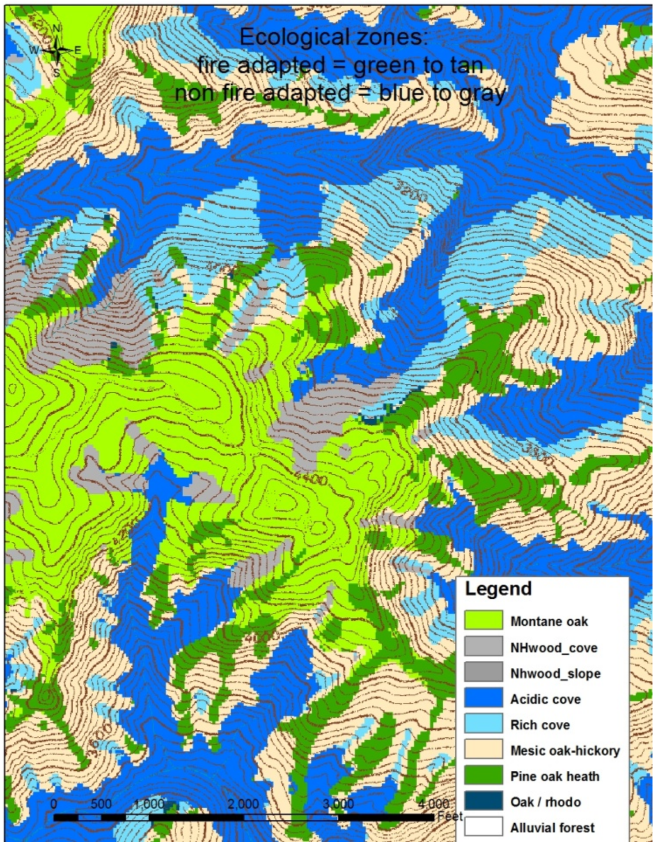
- 49% of the SBR-FLN area mapped with ecological zones is comprised of fire adapted types while 73% of this same area is mapped as fire adapted BpS types,
- 49% of the Smoky-Unaka Mountains landscape, and 57% of the Central Escarpment landscape are identified as fire adapted ecological zones; 74% and 78% or these areas (respectively) are identified as fire adapted BpS units, and
- 53.3% of the 3,673 ecological zone reference plots were fire adapted types but they occurred in 64.1% of BpS map units classified as fire adapted.

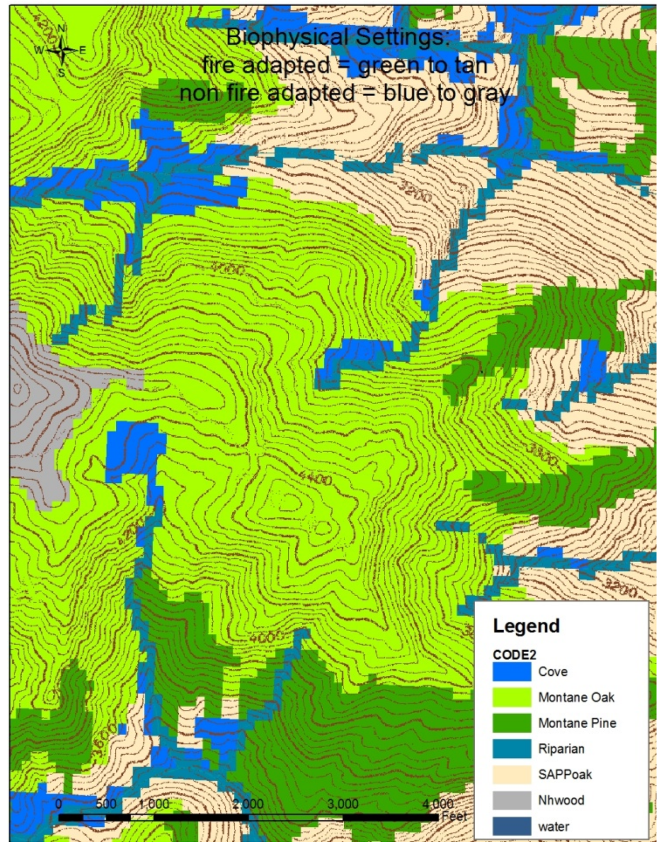
Three reasons for these differences are likely:

1) The higher resolution 10 meter DEMs used in the ecological zone model can better depict minor changes in topography and the resulting temperature and moisture regimes therefore resulting in a more detailed representation of the dissected landscapes found in the Southern Appalachian Mountains. More concave protected draws are discerned with higher resolution data and these are mapped mostly as cove or other non-fire adapted types while exposed ridges are better defined and less generalized than possible with BpS models derived from 30m DEMs. These differences can be observed wherever these models are compared. Figures 6 and 7 are an example of such a comparison from a 3,000 acre area centered on the Santeetlah Creek 1:24,000 USGS quadrangle in North Carolina. Montane Oak, a fire adapted type, is common in this area but appears over-generalized by the BpS model. Its area is reduced significantly in the ecological zone model where non-fire adapted types are mapped on adjacent more north-facing, concave slopes. This is also true for the fire adapted Montane Pine type that appears restricted to narrow upper ridges and south-facing tertiary ridges in the ecological zone model but is

mapped in broader BpS units. On this 3,000 acre area, the BpS model estimates 83% of the area in fire adapted types while the ecological zone model estimates only 52% in fire adapted types.

Figure 6: Fire adapted types represented by Ecological Zones **Figure 7: Fire adapted BpS types**





2) Not only does a particularly common type (e.g., 10-15% of the map area) have a disproportionate effect on the overall accuracy of types and therefore utility of a map, this effect carries over when types are aggregated into categories such as fire adapted versus non-fire adapted. Even a small difference in accuracy of the most common type can make a large difference in the predicted extent of that category. For example, the fire adapted Southern Appalachian Oak BpS type is predicted on 40% of the landscape, and although User's accuracy for the fire category prediction is very good (83%) even a 1% change can make a large overall change in map extent. Furthermore, except for Southern Appalachian Montane Oak, all other fire adapted types have a very high (90%-100%) fire category accuracy (Southern Piedmont Dry Oak-Pine, Southern Appalachian Low-Elevation Pine, and Southern Appalachian Montane Pine) and combined represent about 20% of the landscape. These types add substantially to the overall accuracy of this category. However, the Central and Southern Appalachian Montane Oak Forest type has very low BpS accuracy (8%) and the lowest fire category accuracy (46%) in the group, and alone represents 12% of the landscape. This could account for a good portion of the difference between model estimates of fire category.

3) Another potential reason for differences between models estimates of fire category is the interpretation of model concepts. Oak/rhododendron, is an ecological type that occupies the upper slopes of acidic coves and is therefore placed in the non-fire adapted category in the ecological zone analysis. However, this type fits the BpS map unit concept description for Southern Appalachian Oak BpS and was analyzed both in the 'dirty accuracy assessment' and the field accuracy assessment within the

fire adapted category. The ecological zone model estimates this type as occupying approximately 280,000 acres or 4.7% of the area. Simply adding this 4.7% to the overall 49% ecological zone estimate for fire adapted types would increase this estimate to just 54% and well below that derived from BpS. However, this can still be considered a contributing factor in explaining the discrepancy between model estimates of fire category.

The following section is a summary of assessment results for each BpS type and includes:

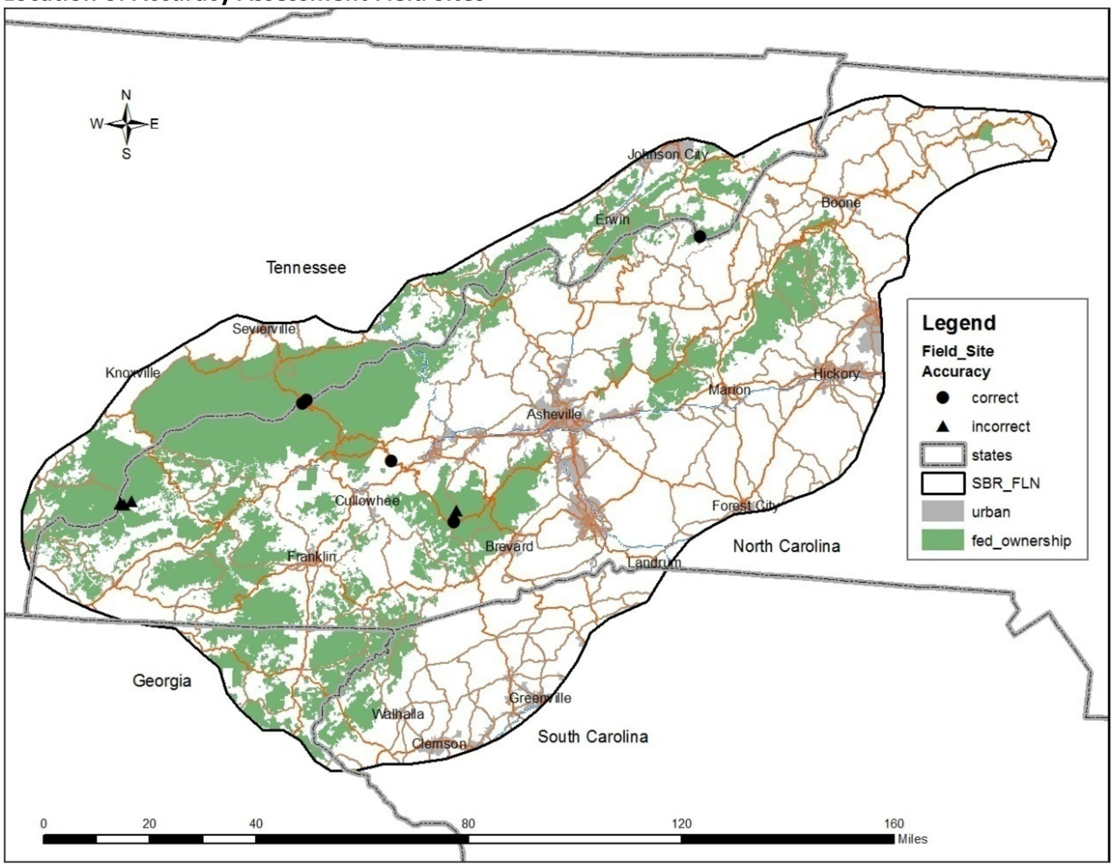
1. Excerpts from LANDFIRE Biophysical Setting Model descriptions (Latin names in Appendix V),
2. a map of the accuracy assessment field plot locations within the SBR-FLN, and
3. user's accuracy assessment results and suggestions for improvement of map unit accuracy beyond increasing base data resolution.

A separate appendix includes photos for each accuracy assessment field site and a description of the dominant vegetation found on those sites**.**

Central and Southern Appalachian Spruce-Fir Forest

Model Concepts
This system consists of forests in the highest elevation zone of the Southern Blue Ridge generally occurring on all topographic positions above 1676m (5500ft), up to the highest peaks (NatureServe 2007). Natural patches range from hundreds to thousands of acres in size. Vegetation consists primarily of forests dominated by red spruce and Fraser fir especially at the highest elevations. Associated species at higher elevations include yellow birch, mountain ash, pin cherry, mountain maple, hobble bush, and bearberry. With decreasing elevations, typical northern hardwood species: yellow birch, beech, and yellow buckeye mix with red spruce.

Location of Accuracy Assessment Field Sites



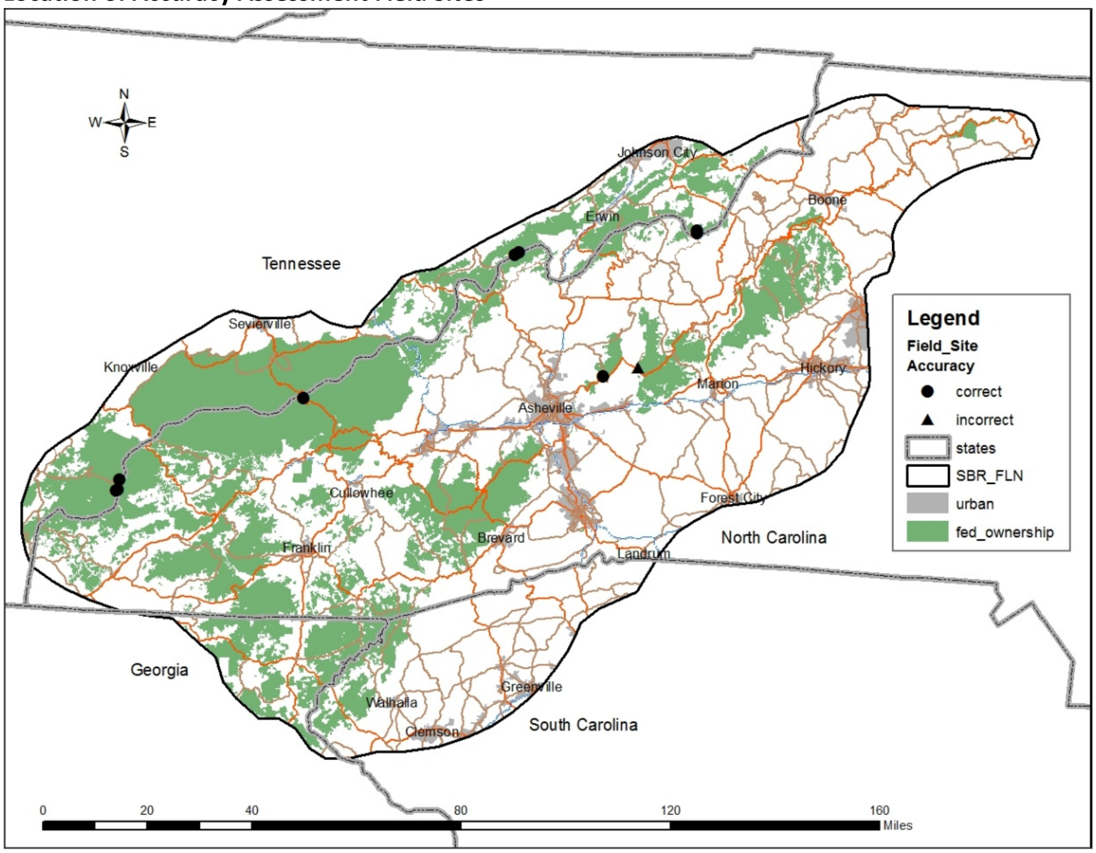
Accuracy Assessment Results
Overall map unit accuracy was 50%; one-half of the randomly selected field sites within this type did not fit the described model concepts and were assessed in the field to better fit the Southern Appalachian Northern Hardwood Forests type. All but one of these map units occurred in the western portion of the SBR_FLN on the North Carolina side of the Unicoi Mountains near Haw Knob, an area having little to no indicators of Spruce-Fir communities at the sample sites or remnants of Spruce-Fir plant communities in the general area. The model could be improved by incorporating more local knowledge and research of the historic extent of Spruce-Fir in the western extent of its range in the Southern Blue Ridge.

Southern Appalachian Northern Hardwood Forest

Model Concepts

This system consists of forests in high elevation sites in the Southern Appalachians, generally occurring on all topographic positions above 1372m (4500ft) in the southern extent of the range. Co-dominant trees are sugar maple, American beech, yellow birch, and yellow buckeye in variable proportions. Overall floristic composition varies with specific site conditions: Sugar maple and yellow buckeye may be prominent in the overstory, along with yellow birch and American beech. Black cherry, white ash, and northern red oak are very minor overstory associates. Striped maple and, more locally, mountain maple are abundant understory species. Smooth blackberry is the only common shrub in gaps. Herb layers are moderately dense and usually contain nutrient-demanding species such as blue cohosh and wood nettle.

Location of Accuracy Assessment Field Sites



Accuracy Assessment Results

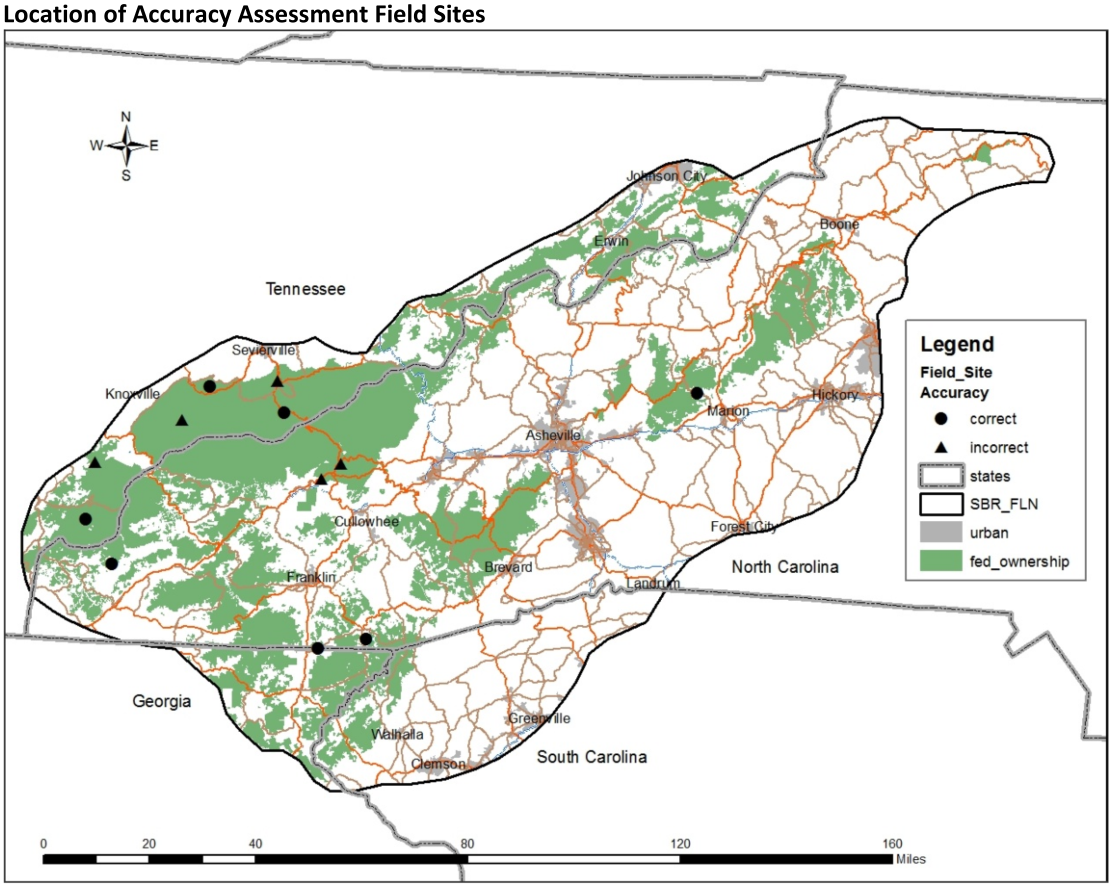
Overall map unit accuracy was 90%, the highest of all types evaluated. Just one of the randomly selected field sites within this type did not fit the described model concepts and was assessed in the field to better fit the Central and Southern Appalachian Spruce-Fir Forest type, a type occurring in near proximity. This singular, incorrectly identified map unit occurred on the lower slopes of Mount Mitchell at 5,400' elevation on an east-facing slope. This is by far the most accurate of all BpS map units, however, the commission error, i.e., the probability of a reference site being correctly classified was only 58%, which may indicate that the true distribution of the type on the landscape is being under-represented by the BpS model.

Southern and Central Appalachian Cove

Model Concepts

This BpS model represents the "cove forests" or mixed-mesophytic forests (including "Acid Coves" with Hemlock) of sheltered topographic positions in the Southern Blue Ridge that range from northwestern Georgia through the southern Appalachians of the Carolinas. This type occurs on moist, topographically protected areas (e.g. coves, v-shaped valleys, N and E facing toe slopes and excluding broad u-shaped floodplains) within highly dissected hills and mountains. The diverse dominant species include American beech, yellow-poplar, American basswood, sugar maple, yellow buckeye, northern red oak, white oak and formerly American chestnut (Braun 1950, Muller 1982). NatureServe (2007) notes that white ash, yellow buckeye, sweet birch, cucumber tree, Fraser magnolia, silverbell, black cherry, and Canadian hemlock are the most frequent co-dominant canopy species.

Location of Accuracy Assessment Field Sites



Accuracy Assessment Results

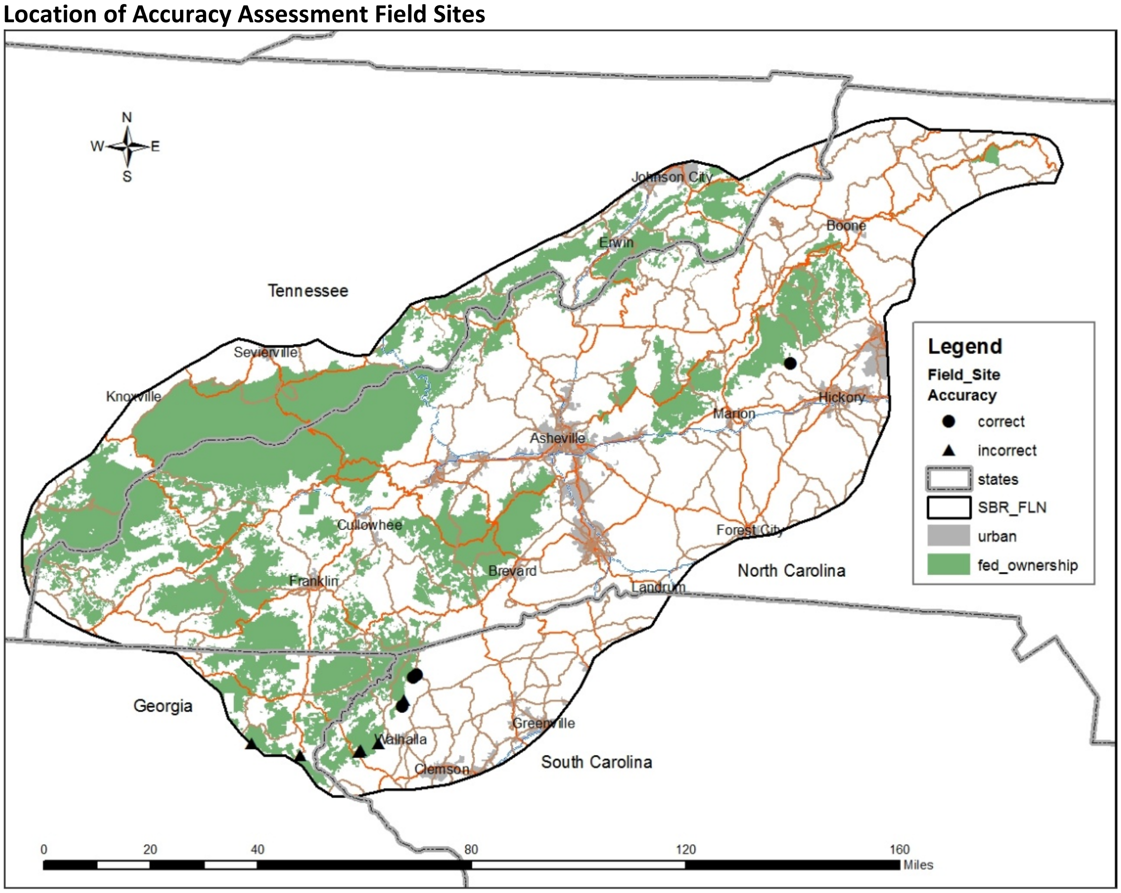
Overall map unit accuracy was 58%. The randomly selected field sites within this type that did not fit the described model concepts were found to better fit the Central Interior and Appalachian Floodplains (3 sites) or Southern Appalachian Oak Forests (2 sites) models. All of the misclassified map units occurred in the north-western portion of the SBR_FLN although correctly classified map units were located in this area also. Map unit accuracy might be improved by adjusting criteria that separate true floodplains from u-shaped, lower slope coves.

Southern Piedmont Mesic Forests

Model Concepts

This system encompasses mixed deciduous hardwood or occasionally hardwood-pine forests of mesic sites in the Piedmont of the southeastern United States. Most examples occur on lower or north-facing slopes where topography creates mesic moisture conditions. A mix of a small number of mesophytic trees is usually dominant, with American beech, tulip poplar, and most prominent, white oak and/or northern red oak may also be present or co-dominant. Both acidic and basic substrates are currently included in this concept, where shrub layers of mesophytic ericaceous shrubs may occur beneath an open tree canopy. Herb species may include Christmas fern, violets, panicums, licorice bedstraw, wild evergreen ginger, naked-flowered ticktrefoil, dimpled troutlily, hepatica, fairywand, beechdrops, foamflower, alumroot, star chickweed, mayapple, rattlesnake fern, and cankerweed (Schafale and Weakley 1990). This system generally occurs as large to small patches, often in convoluted bodies following slopes in the dissected lands along streams and rivers.

Location of Accuracy Assessment Field Sites



Accuracy Assessment Results

Overall map unit accuracy was 40%. All of the randomly selected field sites not fitting the described model concepts were on drier sites and better fit concepts described for Southern Piedmont Dry Oak-Pine Forest and Woodland (3 sites), Southern Appalachian Oak Forests (2 sites), or Southern Appalachian Low Elevation Pine Forests (1 site). Most all (5 of the 6) incorrectly identified map units occur in the most southern end of the model range; two-thirds or these occur in South Carolina. Map unit accuracy could be improved by: 1) re-evaluating the zone between this type and the Central Interior and Appalachian Riparian Systems: most of the areas mapped as 'Riparian' systems, in this transition between the Blue

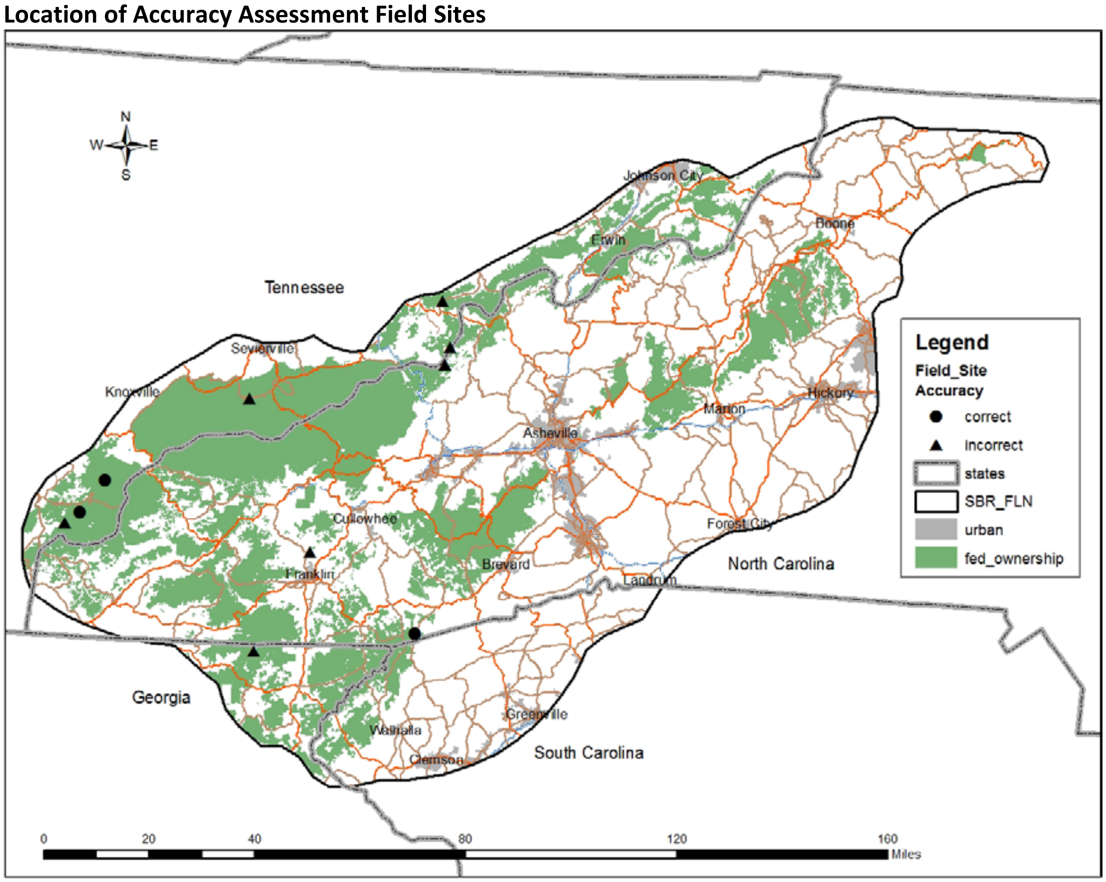
Ridge Mountains and Southern Piedmont, fit well with concepts described for 'Mesic' forests, and 2) adjusting the mid- and upper slopes out of the mapped 'Mesic' forest zone.

Central Interior and Southern Appalachian Riparian Systems

Model Concepts

This model encompasses the small stream forests of the Piedmont and Southern Appalachians but does not include the broad vegetated floodplains or the high gradient, narrow small streams of the Appalachian Mountains. These river scour-influenced systems occur on moderately to very high-gradient streams over a wide range of elevations. They develop on small floodplains and shores along river channels that lack a broad, flat floodplain due to steeper sideslopes, higher gradient, or both (NatureServe 2007). Most of the system is forest vegetation. The succession of woody plants (particularly trees) is retarded by the force of "flashy," high-velocity water traveling down the stream channels (NatureServe 2007). The canopy is usually dominated by hardwoods, with pines a small component. Species may include sycamore, river birch, box elder, eastern cottonwood, sugarberry, green ash, sweetgum, red maple, swamp chestnut Oak, cherrybark oak, hackberry, Canadian hemlock or pines. Sub-canopy species include American holly, deciduous holly, red mulberry, ironwood, and hop hornbeam. Shrubs such as spicebush, beautyberry, and yellowroot; cane and other grasses; and false nettle may be present. Sedges may dominate some areas.

Location of Accuracy Assessment Field Sites



Accuracy Assessment Results

Overall map unit accuracy was 30%. Most (6 sites) of the randomly selected field sites not fitting the described model concepts were in intermittent headwater drainages or narrow small streams with little to no true riparian vegetation and better fit concepts described for Southern and Central Appalachian Coves. The only other incorrect map unit included a more significant extent of Central Interior and

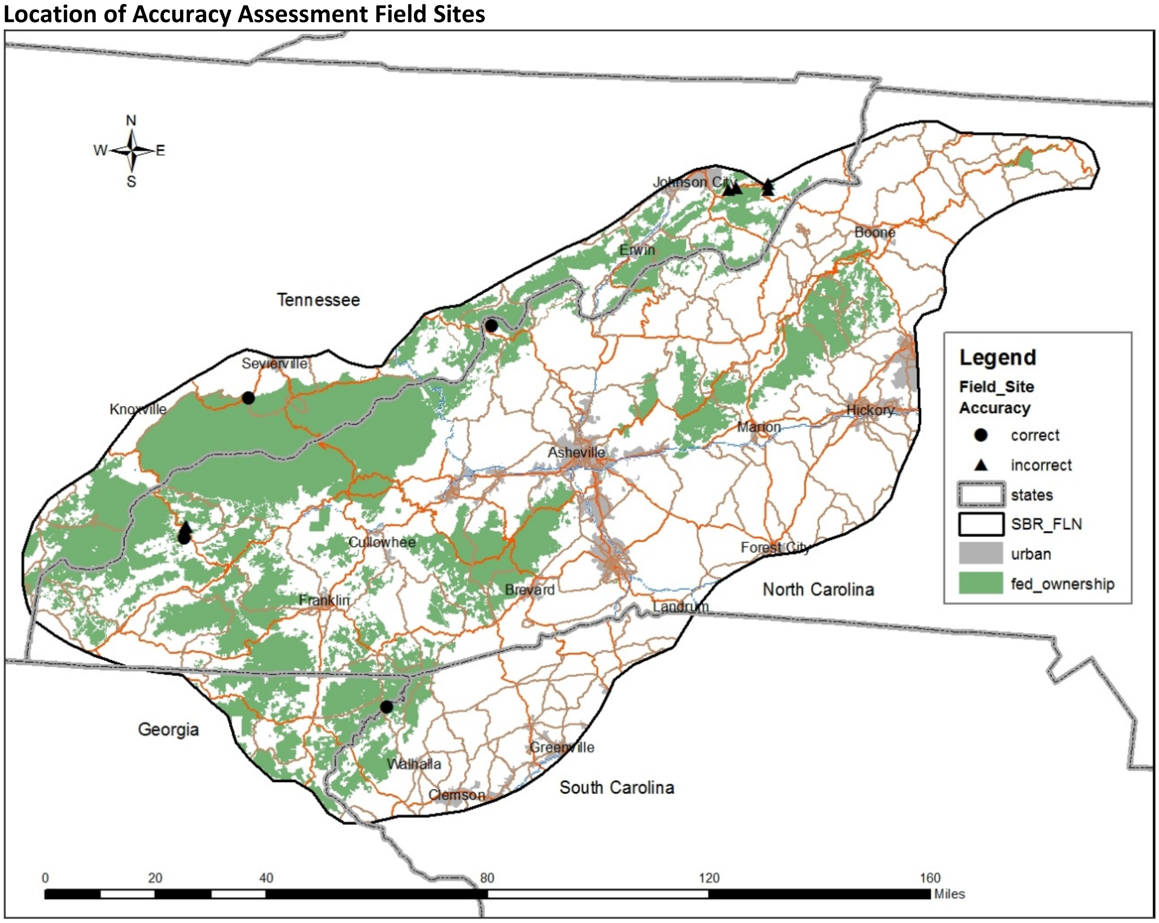
Appalachian Floodplains than riparian areas. There was no distinct geographic or elevational pattern to these misclassified sites. Map unit accuracy could be improved by re-evaluating the basic concept of 'riparian' vegetation in this portion of the Appalachians.

Central Interior and Appalachian Floodplain Systems

Model Concepts

This system encompasses large-river floodplains over much of the eastern United States (NatureServe 2007). The substrate is primarily alluvium and much of the system is forest vegetation. The canopy is usually dominated by a mix of characteristic alluvial and bottomland species such as sycamore, river birch, box elder, eastern cottonwood, sugarberry, green ash, sweetgum, and red maple. Successional areas are often dominated by sweetgum, or tulip poplar. Shrubs such as spicebush, beautyberry, yellowroot, common buttonbush, roughleaf dogwood, and pawpaw; sedges; and grasses including eastern bottlebrush grass, Canada wildrye, and Indian woodoats, and false nettle may be present.

Location of Accuracy Assessment Field Sites



Accuracy Assessment Results

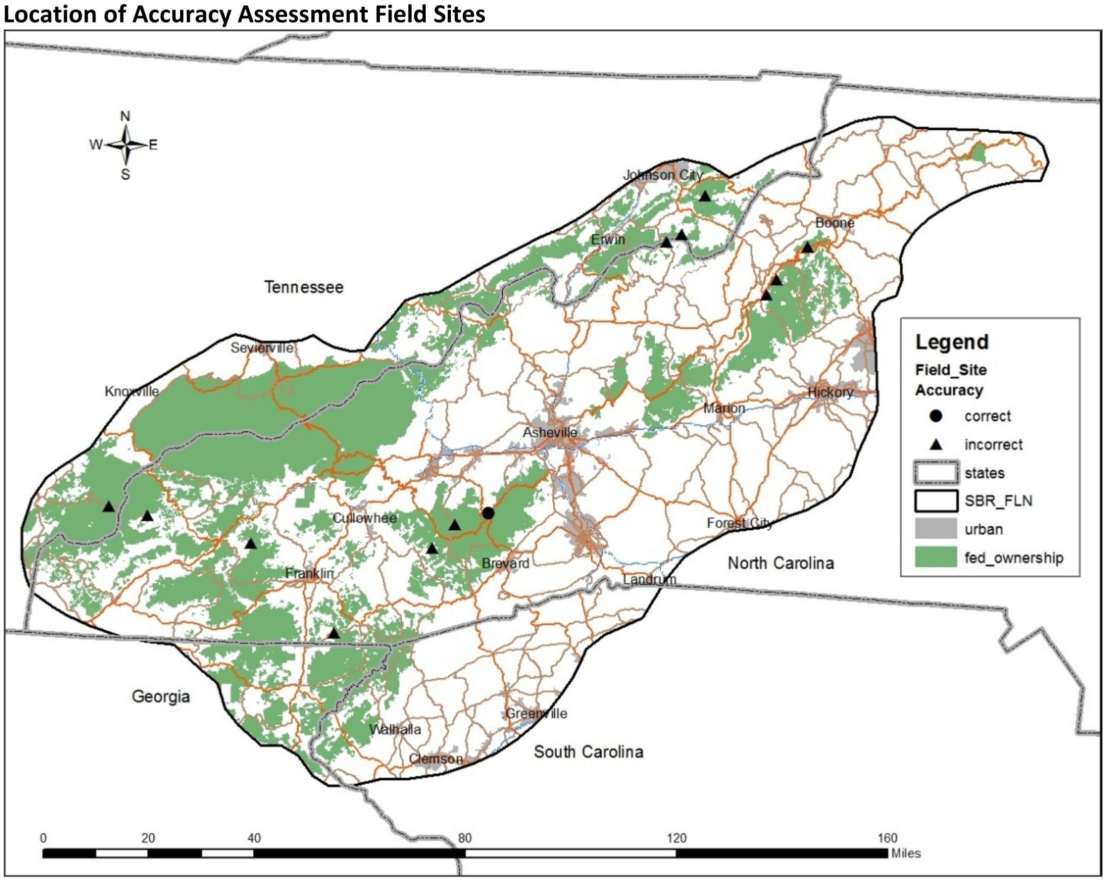
Overall map unit accuracy was 40%. All of the randomly selected field sites not fitting the described model concepts were in uplands adjacent to reservoirs (Watauga Lake in Tennessee and Santeetlah Lake in North Carolina) and better fit concepts described for Southern Appalachian Low Elevation Pine Forest (4 sites), or Southern Appalachian Oak Forest (2 sites). This model could be improved by incorporating DEM and other base layers to better differentiate between man-made water bodies, i.e., reservoirs versus natural water bodies and true alluvial situations.

Central and Southern Appalachian Montane Oak Forest

Model Concepts

This system is found at higher elevations mostly between 610 and 1372 m (2000-4500 feet), of the central and southern Appalachian Mountains. They are characterized as rocky, talus slopes, high ridgelines, and exposed upper slopes. These are open woodland talus fields primarily comprised of often-stunted, overstory northern red oak, and more rarely, white oak, chestnut oak, black birch and/or yellow birch are also present. There are lesser amounts of American basswood, red maple, and other oak species. Mountain maple and striped maple are small trees that form a sparse mid-story. Mountain laurel, blueberry, and various grasses occur between rocks. NatureServe (2007) also notes that the understory is usually dominated by ericaceous shrubs, but some communities are either dominated by graminoid species or ferns. Only rarely are the communities dominated by other herbs. Mountain holly and early azalea are characteristic shrubs. American chestnut sprouts are also common today, but the importance of chestnut in these forests has been dramatically altered by chestnut blight.

Location of Accuracy Assessment Field Sites



Accuracy Assessment Results

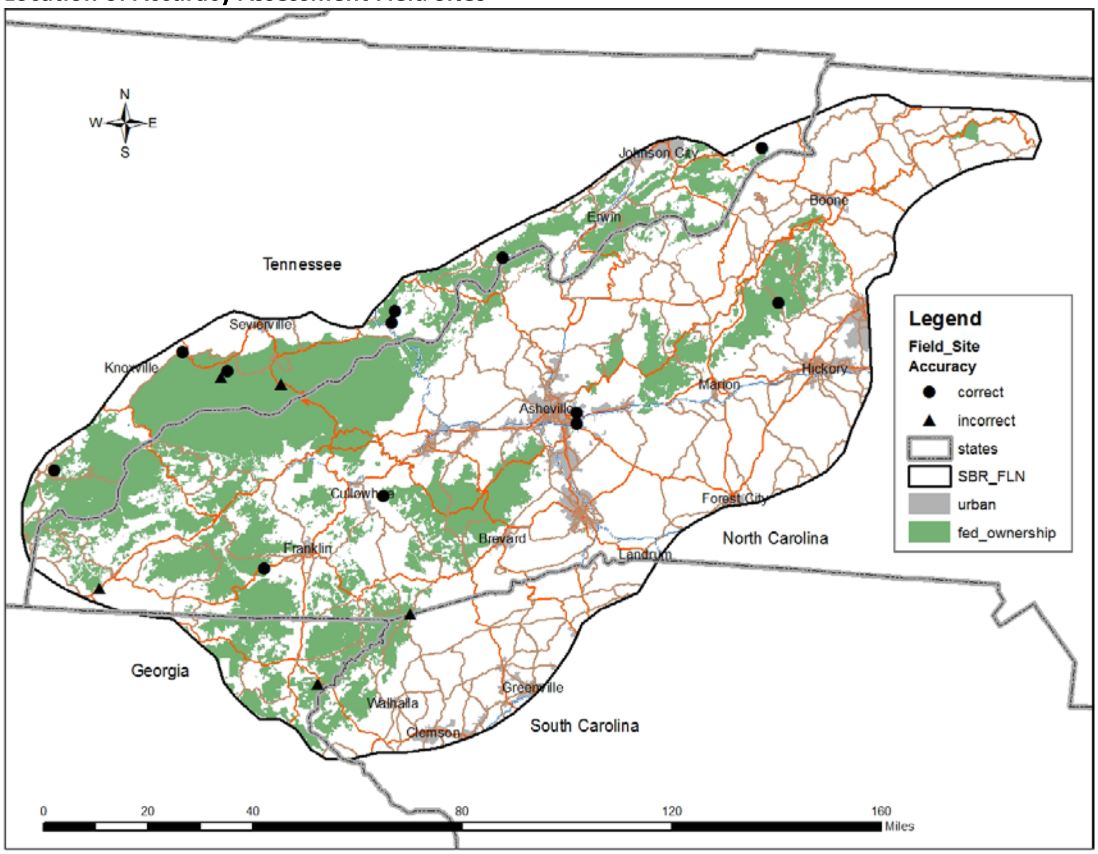
Overall map unit accuracy was 8%, the second lowest of all types. Most of the randomly selected field sites fit better with concepts described for Southern Appalachian Oak Forest (5 sites) or Southern and Central Appalachian Cove Forest (5 sites). In many of the higher elevation areas, map units in this type occurred on protected and concave slopes below instead of (more properly) above Southern Appalachian Northern Hardwood Forests. This model could be improved by re-evaluating type concepts among Central and Southern Appalachian Montane Oak Forests, Southern Appalachian Oak Forests, Southern Appalachian Northern Hardwood Forests, and the upper slopes limits of Southern and Central Appalachian Cove Forests.

Southern Appalachian Oak Forest

Model Concepts

This system consists of predominantly dry-mesic (to dry) forests occurring on open and exposed topography at lower to mid-elevations in the Southern Blue Ridge and Southern Ridge and Valley ecoregions. This is the upland forest that characterizes much of the lower elevations of these areas. Typically, the vegetation consists of forests dominated by oaks, especially chestnut oak, white oak, northern red oak, and scarlet oak, with varying amounts of hickory species. Currently subcanopies and shrub layers are usually well-developed. Some areas (usually on drier sites) now have dense evergreen ericaceous shrub layers of mountain laurel, with rhododendron on more mesic sites. Some other areas have deciduous ericad layers, sometimes consisting of blueberries or huckleberries. Herbs, forbs, and ferns are sparse to moderate in density.

Location of Accuracy Assessment Field Sites



Accuracy Assessment Results

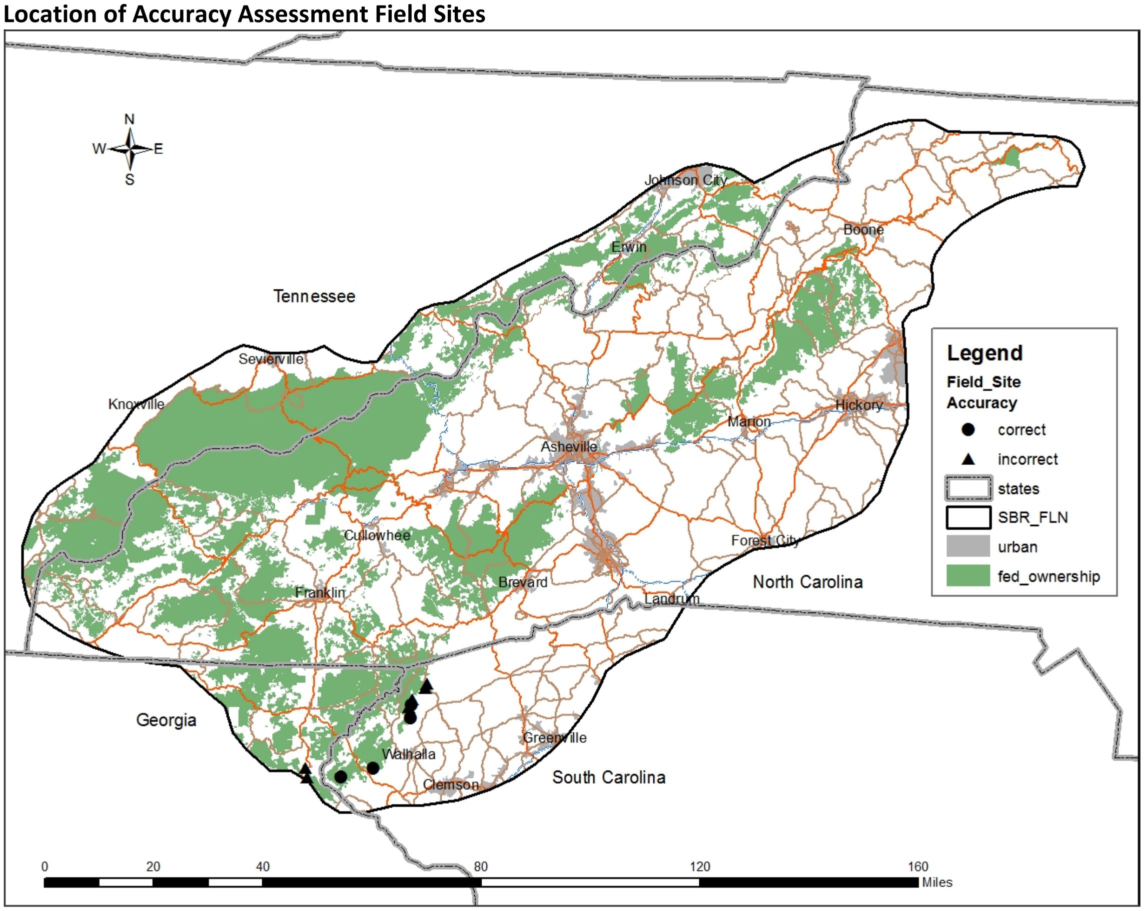
Overall map unit accuracy was 67%, the second highest of all types. Randomly selected field sites that did not fit concepts described for this type included Southern and Central Appalachian Cove Forest (3 sites), Southern Appalachian Low Elevation Pine Forest (2 sites), and Southern Appalachian Montane Pine Forest and Woodland (1 site). In general, map units tended to over-generalize the distribution of this type. There are 230 map units on federal land within the SBR_FLN that are greater than 1,000 acres in size that are defined as the Southern Appalachian Oak Forest BpS type; 24 of these are greater than 10,000 acres in size. The largest map unit exceeds 325,000 acres in size and likely misrepresents the complex topography, climate, and resulting temperature, moisture, and fertility gradients found in the Southern Blue Ridge. Map unit accuracy for these larger units might only be improved by incorporating higher resolution base data DEMS.

Southern Piedmont Dry Oak-Pine Forest or Woodland

Model Concepts

This system encompasses the prevailing upland forests of the southern Piedmont. NatureServe (2007) notes that this system occurs on upland ridges and upper to mid slopes. Moisture conditions, determined by topography, are dry to dry-mesic. High-quality and historic examples are typically dominated by combinations of upland oaks, sometimes with pines as a significant component, especially in the southern portions of the region. Shortleaf pine dominates drier south and west facing slopes often with white oak, post oaks and mockernut hickory. On moister areas like north slopes and sites that burned at a lower intensity due to partial protection from natural landscape features, more densely forested conditions prevail. Southern red oak, white oak, and black oak were frequent. The midstory typically contained dogwood, sourwood, blackgum, and sweetgum. The shrub layer included blueberries, huckleberries, beautyberry, St. John's wort, and the vines Carolina jessamine and wild grape (NatureServe, 2007).

Location of Accuracy Assessment Field Sites



Accuracy Assessment Results

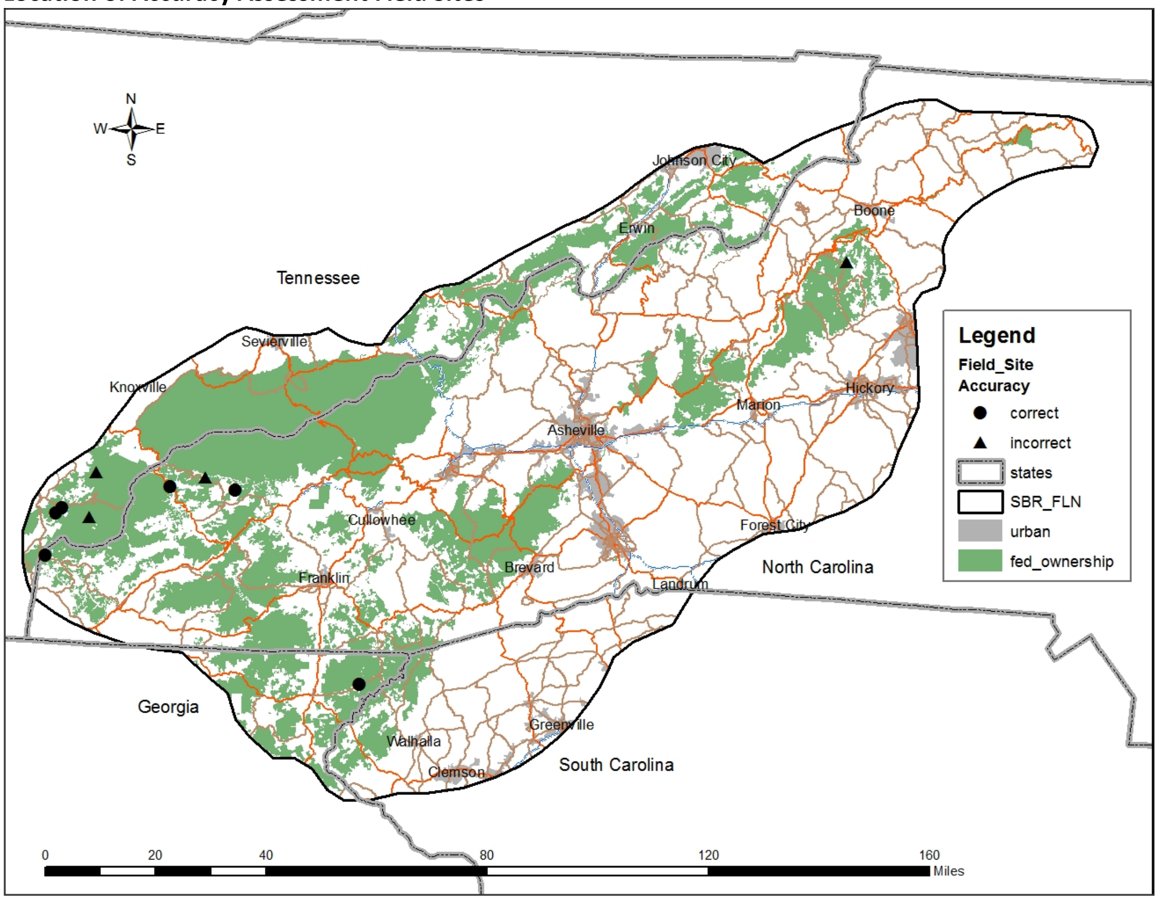
Overall map unit accuracy was 40%. Randomly selected field sites occurred only in South Carolina and Georgia. Those not fitting the type concept included Southern Appalachian Low Elevation Pine Forest (3 sites) found on drier sites, and Southern Appalachian Oak Forest (2 sites) found closer to the Blue Ridge province. Map units that best fit the concept occurred at midslope positions below drier ridgetop pine sites and above more mesic oak-dominated lower slopes. This was the most difficult of all types to evaluate due to historic land use and the rather broad model concepts. Differentiating between 'pine-oak' and 'oak-pine' will always be problematic because of the difficulty in separating true site differences from plant succession. Some believe that the 'oak-pine' type should be eliminated entirely because of its origin as a category used by foresters to merely identify where pine would be favored within an oak system and therefore may not represent true differences in biophysical factors.

Southern Appalachian Low Elevation Pine Forest

Model Concepts

In the Southern Blue Ridge, this system is found primarily in northern Georgia, western North Carolina, and southeastern Tennessee. It is common to the Southern Appalachians but less so in the adjacent Piedmont, typically occupying xeric to dry sites at elevations generally below 700 m on ridge tops, western, south and southwestern aspects. Vegetation consists of closed to open forest dominated by shortleaf pine or Virginia pine. Pitch pine may sometimes be present. Hardwoods may be abundant at times, especially dry-site oaks such as Southern red oak, chestnut oak, and scarlet oak. The shrub layer may be well developed, with hillside blueberry, bear huckleberry, black huckleberry, or other acid-tolerant species most characteristic; herbs are usually sparse.

Location of Accuracy Assessment Field Sites



Accuracy Assessment Results

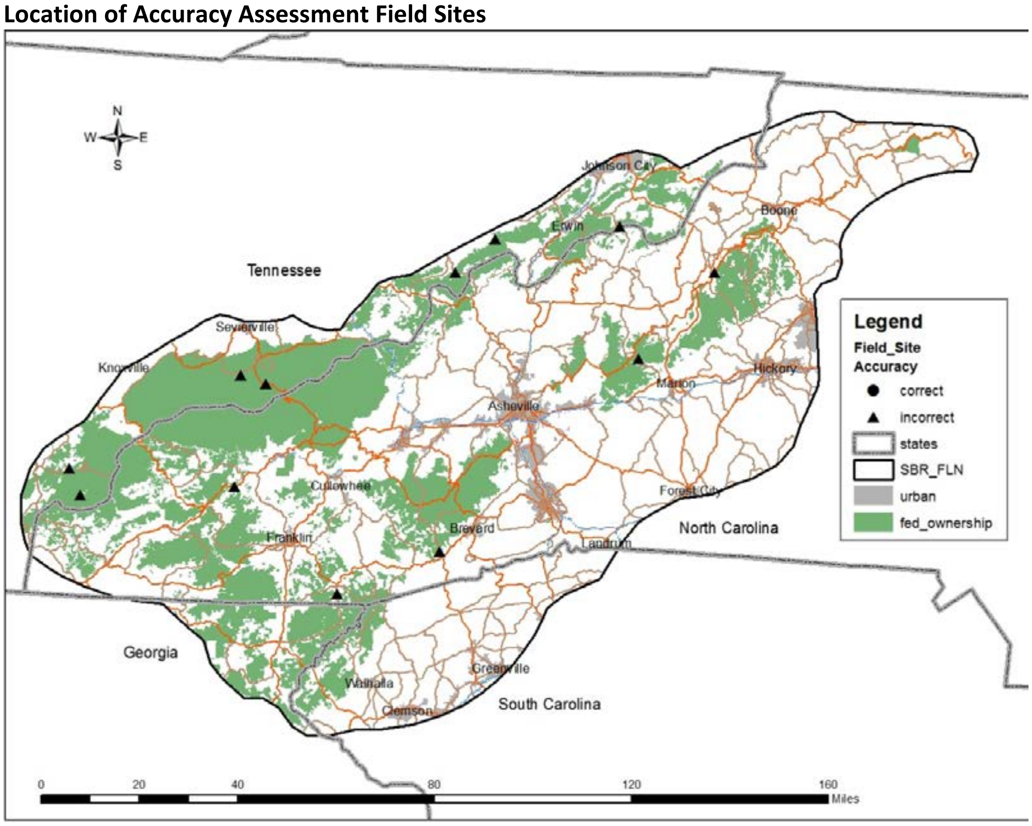
Overall map unit accuracy was 60%. Randomly selected field sites that did not fit concepts described for this type included Southern Appalachian Oak Forest (3 sites) and one highly mixed map unit comprised of Southern Appalachian Oak Forest and Southern and Central Appalachian Cove Forest. Moisture regime and the presence of dry site indicators were the major criteria for differentiating between Southern Piedmont Dry Oak-Pine Forest and Woodland from this type which is found on dryer more exposed sites. Model accuracy could be improved by broadening the concept to include sites currently identified as 'oak-pine', and restricting 'montane pine' to narrow ridges.

Southern Appalachian Montane Pine Forest and Woodland

Model Concepts

This system occurs on xeric to dry sites at moderate to upper elevations between 1000 and 4000 feet. Typically Described as "ridgetop communities" this community occupies the driest and most fire-prone of sites. Sites are typically located on convex, south to west faces of steep spur ridges, narrow rocky crests, and cliff tops. Overstory pine species dominate with up to 70% species specific (e.g. table mountain pine or pitch pine, sometimes with Virginia pine or rarely shortleaf pine codominant (NatureServe 2007). Chestnut oak and scarlet oak and other pines may also be in the overstory. Midstories, when present, may include mountain laurel, blackgum, red maple, sourwood, black locust and sprouts of American chestnut. Understories can include hobblebush, blueberries, huckleberries, galax, sedges and other herbaceous species. Short-statured table-mountain pine and pitch pine are usually the dominants forming an open overstory, often with co-dominant chestnut oak. Less important tree associates include scarlet oak, Virginia pine, and sassafras.

Location of Accuracy Assessment Field Sites



Accuracy Assessment Results

Overall map unit accuracy was the lowest of all types evaluated; none of the randomly selected field sites fit the concept for this type. Sample sites better fit concepts described for Southern Appalachian Oak Forest (8 sites), Southern Appalachian Low Elevation Pine Forest (3 sites), or Central and Southern Appalachian Montane Oak Forest and Woodland (1 site). Map unit errors were due mainly to incorrect placement of this type below ridges dominated by Southern Appalachian Oak map units (instead of the reverse) or on broad ridges (instead of narrow ridges) at lower elevation more likely to support Southern Appalachian Low Elevation Pine Forest. Model accuracy could be improved by modifying concepts to better reflect Southern Blue Ridge environments where this type is near or at the western limit of its distribution,