Ecological Zones in the Southern Blue Ridge: 3rd Approximation

Steven A. Simon, Ecological Modeling and Fire Ecology Inc., Asheville, North Carolina

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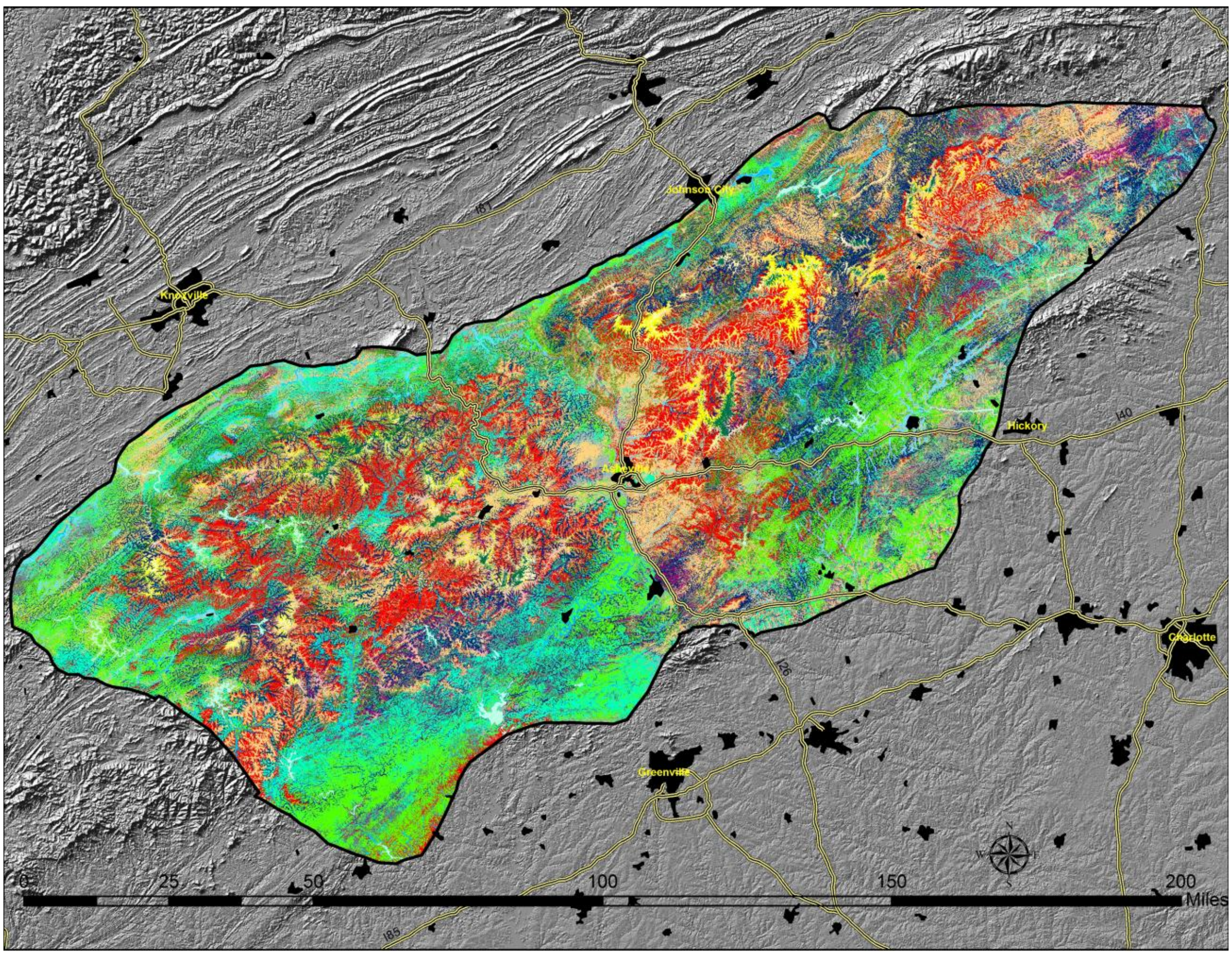


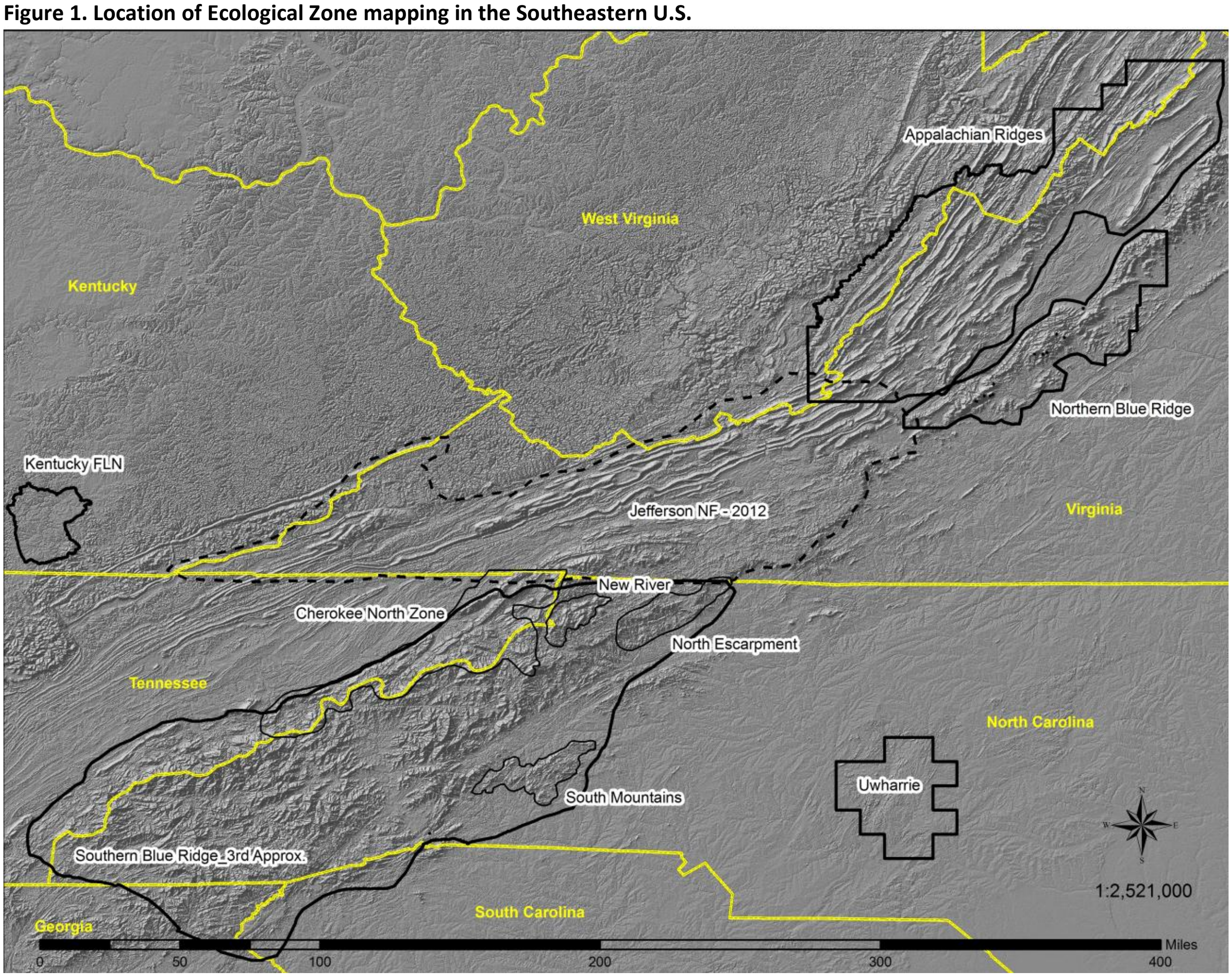
A 3rd approximation of Ecological Zones in the Southern Blue Ridge was developed from over 5,800 field reference sites, 29 computer-generated environmental variables, and intensive analysis and adjustment of ecotone boundaries using local environmental relationships between types. Oak-dominated Ecological Zones (orange, gray, bluish green, purple in map) accounted for about 45% of the over 8 million acre landscape, Cove Ecological Zones 30% (red and dark blue), and Pine-Oak Ecological Zones 17% (green). The remaining 8% of the landscape included Alluvial Forest, Northern Hardwood, Floodplain, Spruce-Fir, Heath Bald, Grassy Bald, and lakes.

INTRODUCTION

Ecological Zones are units of land that can support a specific plant community or plant community group based upon environmental factors such as temperature, moisture, fertility, and solar radiation that control vegetation distribution. They may or may not represent existing vegetation, but instead, the vegetation that could occur on a site with historical disturbance regimes. Ecological Zones are equivalent to Biophysical Settings (BpS) which 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. Map units are defined by Nature Serve Ecological Systems, a nationally consistent set of mid-scale ecological units (LANDFIRE 2009). Ecological Zones are mapped at a higher resolution than BpS and have more vegetation categories.

Ecological Zones in the Southern Appalachian Mountains, identified from intensive field data that defined plant communities, were associated with unique environmental variables characterized by digital models (Simon et. al., 2005). These zones were mapped on over 5 million acres by applying logistic regression coefficients to digital terrain models using a geographic information system. In that 2001 study, Ecological Zones subdivided the forested landscapes in the Southern Appalachian Mountains into homogeneous units for natural resource planning at a range of scales. Since that study, Ecological Zones have been mapped in Kentucky, Tennessee, in the Uwharrie Mountains, and the South Mountains, Northern Escarpment, and New River Fire Learning Network (FLN) landscapes in North Carolina, and in Virginia and West Virginia, centered on the George Washington National Forest (fig. 1). This report documents the methods and results of the most current effort to improve Ecological Zone models and mapping in the Southern Blue Ridge (SBR).

Figure 1. Location of Ecological Zone mapping in the Southeastern U.S.



SBR Ecological Zones - background: Ecological Zones were used in 2001 to define units of land that can support a specific plant community or plant community group based upon environmental and physical factors that control vegetation distribution in the SBR. In 2008, The Nature Conservancy provided support to evaluate the usefulness of an updated ecological zone map to predict landscapes that support fire-adapted plant communities in the Southern Blue Ridge Fire Learning Network (SBR-FLN). In 2011, The U.S. Forest Service provided support to develop and expand an improved 3rd Approximation of Ecological Zone mapping in the SBR. The following summarizes the progression of model development, parameter, and incremental improvements made in the different approximations (table 1).

Table 1: Comparison of SBR Ecological Zone development parameters

	1st Approximation	2nd Approximation	3rd Approximation
Extent	5.6 million acres	5.9 million acres	8.2 million acres
Grid cell size	98’x98’	33’x33’	30’x30’
Reference plots	2,475	4,300	5,842
Environmental variables in GIS	25	20	29
Number of Zones modeled	11	16	20
Analysis tools	logistic regression	maximum entropy	maximum entropy ecotone adjustment
Producers accuracy (Appendix VII)	36%	52%	79%

General description: The SBR study area consists mainly of the mountainous region of western North Carolina, eastern Tennessee, northern Georgia and northern South Carolina (cover page). The region’s climate is characterized as modified continental, with warm summers and cool winters. Recorded precipitation ranges from a low of 38 inches at Asheville to 91 inches at Lake Toxaway. Most summer precipitation results from thunderstorms associated with maritime weather patterns that are influenced by the Gulf of Mexico; winter precipitation results from continental weather systems. Generally, precipitation is evenly distributed during the year with no pronounced dry or wet seasons, although winter precipitation tends to be considerable higher in the southern part of the study area. Relief is characterized by discrete ranges of relatively high mountains with rounded peaks that are separated by broad, somewhat hilly intermountain basins. Elevation ranges from below 1,000’ near Westminster South Carolina, Forest City North Carolina, and Maryville Tennessee to 6,684’ at Mt. Mitchell. The varied gently rounded relief of the study area is primarily attributable to a combination of warm, humid climate and geologic formations of differing resistance to erosion, which has been occurring for about 300 million years during a relatively long period of geologic stability with no mountain-building episodes (Hack 1982, Pittilo and others 1998). Geologic formations of the study area are among the oldest, most complexly arranged, and compositionally varied in the Eastern Unites States. Most have undergone one or more periods of metamorphosis, during which the original rocks were weathered and eroded into components that were transformed to other rock types by varying degrees of heat and pressure, making accurate age determinations doubtful (Hatcher 1972). Generally, formations of the Blue Ridge Province are primarily metasedimentary types with lesser areas of sedimentary and intrusive rocks. Most geologic formations weather to form soils of acidic reaction. However, localized areas of hornblende gneiss are present throughout, which weathers to produce soils of less acidity. Rock formations range in age from middle Proterozoic (1 billion years) to Permian (250 million years), but age is less important than rock mineral content and texture in determining soil properties that can influence plant species composition.

METHODS

“Spatial models built with geographic information systems (GIS) provide a means to interpolate between data points to provide spatially explicit information across broad scales. By accounting for variation in environmental conditions across these broad scales, GIS models can predict the location of ecological communities within a landscape using relationships between vegetation and topography (e.g., Fells 1994, Bolstad et. al. 1998, Phillips 2000) derived from field data” Pearson and Dextraze (2002). The process of interpolating between field data points involves applying coefficients from predictive equations, developed through statistical analyses, to geospatial data that characterize terrain and environmental variables for the target landscape. Care must be taken not to extrapolate to landscapes far away from data points or to landscapes having very different environmental characteristics, therefore, since most of the data was collected on federal land in the study area, Ecological Zone predictions outside of these areas are likely less accurate.

A multi-stage process was used to model Ecological Zones in the study area that included: 1) data acquisition, i.e., identifying Ecological Zones at field locations, 2) creating a digital terrain GIS database and extracting environmental data, 3) statistical analysis, 4) modeling individual Ecological Zones and evaluating ecotones, i.e., the transition between Ecological Zones using local environments, 5) post-processing of digital model outputs, and 6) evaluating the accuracy of Ecological Zone map units.

1) Data acquisition: Much of the vegetation data used in the 1st approximation originated from the North Carolina Vegetation Survey (Peet and others 1998). Field data were obtained also from 20 investigations of vascular vegetation that had been conducted in the Southern Appalachian Mountains between 1976 and 1991 (table 2). In those studies, natural stands generally > 75 years of age and not obviously recently disturbed were subjectively and randomly selected to represent uniform site conditions. Sampling methodologies for studies after 1990 followed the North Carolina Vegetation Survey (Peet and other 1998); earlier studies used field methods of either Whittaker (1956) or Braun-Blanquet (1932). The field plots from these investigations were classified into groups of similar species composition using a sequence of constancy and ordered tables, indicator species analysis, followed by quantitative multivariate methods that included cluster analysis and indirect ordination (Ulrey 1999). The goal of the classification was to identify units of compositionally similar vegetation for the purpose of inventory and assessment. These units of vegetation were termed Ecological Zones and formed the basis for subsequent field sampling in the SBR. Vegetation data for the 2nd and 3rd approximations, therefore, did not include additional intensive plot sampling or quantitative plant community classification of field data. Because the Ecological Zone classification units are relatively coarse and fairly easy to recognize in the field, the 2nd and 3rd approximation field work consisted of documenting (through GIS, notes, and photos) the location of reference plant community types and Ecological Zones to improve the distribution of plots across the study area (fig. 2). A laptop computer attached to a Global positioning system (GPS), to enable real-time location tracking in the field, was used in conjunction with ArcGIS to document on-site observations of ecological characteristics and to access resource data layers for each site. Sample sites predominantly in forested stands >60 years of age and not recently disturbed, were subjectively selected to represent uniform site conditions, i.e., similar aspect, landform, and species composition. Specifically, these reference sites for plant community types described in the literature for the Southeastern U.S. and in the 1st SBR approximation were targeted especially if they were in 'good condition' and therefore more easily recognized. Of equal importance, was the evaluation of where these types occurred, i.e., their pattern on the landscape. 'Good' condition plant community types found repeatedly within the same environments were therefore more heavily sampled. Some large floodplains, mostly on private land, were assessed from topographic maps and LANDFIRE BpS map units (LANDFIRE 2009) for inclusion as sample points but were not sampled in the field.

Table 2: Plot intensity and data sources (field investigators) used in the different SBR approximations

Study Area	plots	Field Investigators (in order of contribution)
SBR 1st approximation	1,983	C.Newell, B.Peet, C.Ulrey, S.Simon, D.Mcleod, H.Mcnab, T.Wentworth, J.Delapp, P.White, K.Patterson, C.Small, S.Roberts
SBR 2nd approximation	1,929	S.Simon, G.Kauffman, D.Danley
SBR 3rd approximation additions	1,930	
BpS assessment	99	S.Simon
Community element occurrences	7	NC Natural Heritage Program
South Mountains FLN landscape	300	S.Simon
North Escarpment FLN landscape	159	S.Simon
New River FLN landscape	40	S.Simon
Cherokee NF North Zone	934	S.Simon, J.Kelly
Area-wide	391	J.Kelly
TOTAL SBR 3rd approximation	5,842	

Vegetation had been sampled throughout the entire study area in the 1st approximation, although sampling was clustered in about 10 locations. The distribution of plots across the study area was improved and the study area boundary expanded in the 2nd and 3rd approximations (fig. 2). There are still, however, several elevation zones where reference plant communities have not been adequately documented because of access difficulty or poorer vegetation condition. Depending upon the perspective of scale, elevations below 1500' are under-sampled across the project area but adequately sampled on federal lands. On Federal land, elevations between 2500' and 3500' have been under-sampled and could therefore lead to less accurate modeling in these areas (table 3). On the other hand, elevations greater than 4000' have been over-sampled.

Figure 2: Field reference plots used in the SBR 3rd approximation (FLN landscapes are outlined).

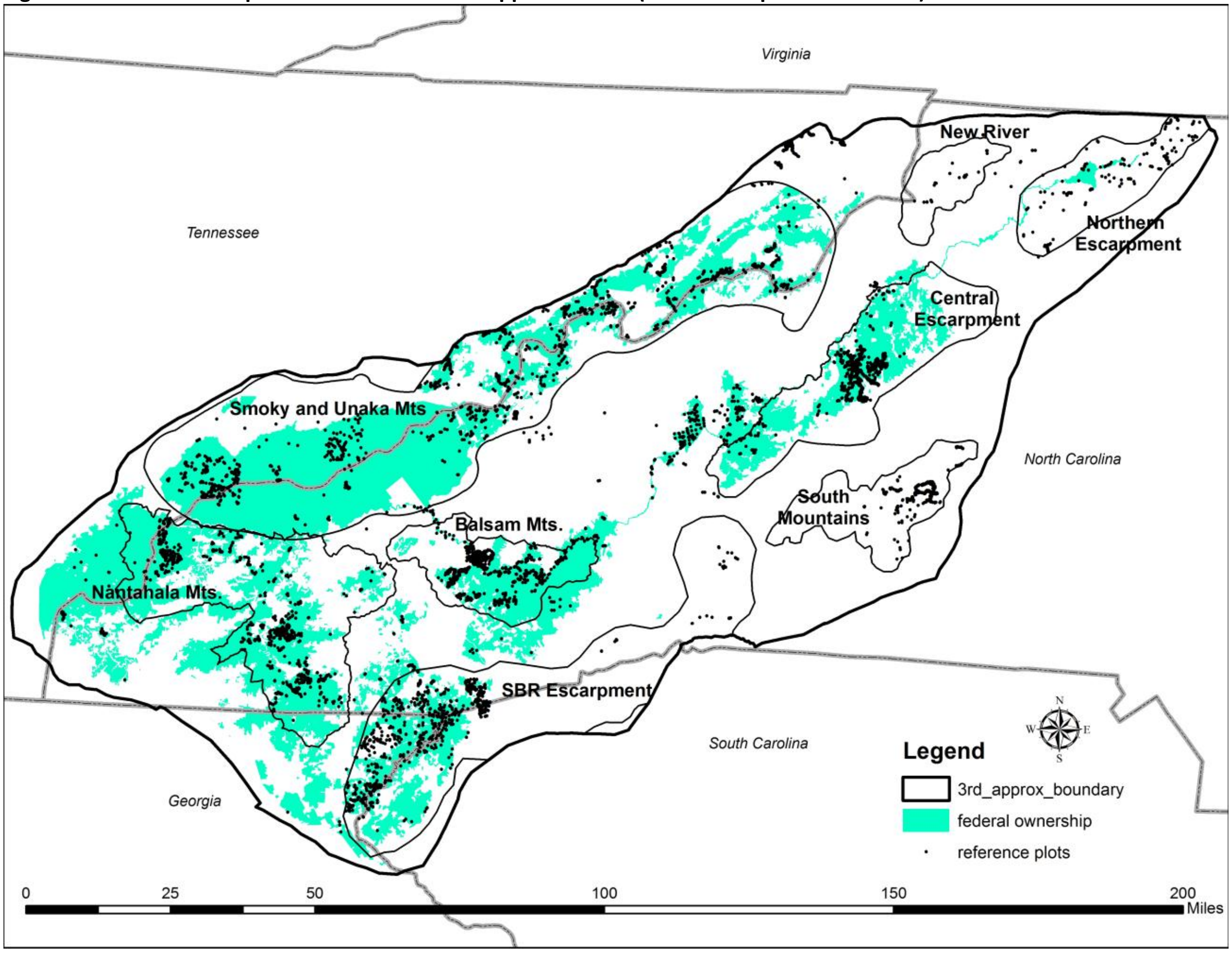


Table 3. Ecological Zone plot sampling intensity by elevation class within the SBR project area, federal land, and Nantahala-Pisgah National Forests (under-sampled classes highlighted).

elevation class	< 1,500'	1501-2000'	2001-2500'	2501-3000'	3001-3500'	3501-4000'	4001-4500'	4501-5000'	5001-5500	5501-6000'	> 6000'
SBR Project area – all lands											
% plots	8.1	14.3	13.0	14.6	12.7	12.6	10.1	8.4	3.8	1.9	0.5
% of area	21.8	14.7	18.6	16.8	12.8	8.1	4.1	1.9	0.8	0.3	0.1
All Federal ownership											
% of area	5.5	14.6	16.2	17.4	16.4	13.0	8.5	4.9	2.4	1.0	0.2
Nantahala-Pisgah NFs ownership											
% of area	2.2	10.2	13.7	19.3	20.1	16.3	10.2	4.8	2.2	0.8	0.1

__2) Creating a digital terrain database__: Development of the individual Ecological Zone models began with the creation of a spatial database that describes the study area environment using landform and environmental variables. Site conditions for each field plot were extracted from these 29 landform / environmental models (DTMS) used to characterize these variables in a GIS (table 4). For statistical analyses, data were stored in a database that included plot number, Ecological Zone, and digital landform / environment values for each plot. The methods used for developing DTMs are described in detail in Appendix III.

Table 4. Environmental variables evaluated in Ecological Zone models

Aspect (slope direction in cosine of radian degrees)
Aspect (slope direction in degrees)
Curvature of land (all directions)
Curvature of land (direction of slope)
Curvature of land (perpendicular to slope)
Elevation
Geology (distance to rock type)
Carbonate-bearing
Mafic-silicate
Siliciclastic
Carbonaceous-sulfidic
Mixed
Ultramafic
Landform10 (10x10 pixel neighborhood)
Landform30 (30x30 pixel neighborhood)
Landform index (from McNab 1993)
Precipitation (30 year average from 1971-2000)
Relief (local)
Relative slope position – local landscape (from Wilds 1997)
Relative slope position – mid-level landscape scale (Wilds modified)
Slope length
Slope steepness
Solar radiation (yearly)
Stream influence
difference in elevation from nearest stream
distance to nearest stream
River influence (4^{th} order and greater streams)
difference in elevation from nearest river
distance to nearest river
Terrain relative moisture index (from Iverson et.al. 1997)
Terrain shape index (from McNab 1993)
Valley position

3) <u>Statistical analysis</u>: The relationship between Ecological Zone and environments, described by DTMs, were analyzed and predictive equations developed at this stage of the process. Ecological Zone field locations were used to train habitat suitability models using MAXENT 3.2.1 (Phillips and Dudik 2004). MAXENT (maximum entropy) is a relatively new modeling approach (Phillips, et. al. 2004, 2006) that emphasizes the ecological characteristics of a location where a target species is observed (an Ecological Zone in our case) as the primary focus while presuming nothing about locations where these conditions are not observed. MAXENT, unlike logistic regression, is therefore a "presence only" modeling approach; it used only Ecological Zone presence (the field reference data) to estimate individual Ecological Zone models across the study area. MAXENT works by finding the largest spread (maximum entropy) in a geographic dataset of Ecological Zone presences in relation to a set of environmental predictors for these same locations and 100,000+ randomly selected points / pixels within the study area. The MAXENT logistic outputs are continuous estimates of habitat suitability (probability) for each Ecological Zone ranging from zero to one for each pixel within the study area. Rare plant communities such as barrens, bogs, cliff-talus, fens, glades, seepage swamps, or small wetlands were not included in this analysis because the digital data needed to model these unique environments, especially rock outcrops and wetlands, are incomplete or at too coarse a resolution for the objectives of this project. The process for developing models for 20 mid-scale Ecological Zones occurring in the project area is described in Appendix IV.

4a) <u>Spatial modeling / creating preliminary Ecological Zone map units</u>: To produce a preliminary aggregate Ecological Zone (Zone) map, the 20 Zone models were merged and each pixel in the study area was assigned to the Zone having the highest probability for that pixel. In the event of a "tie", preference was given to the less extensive Zone by adjusting the ArcGrid 9.3.1 Merge command preference of order (ESRI 2009).

4b) <u>Evaluating the transition area between Ecological Zones (ecotones)</u>: Although MAXENT worked well to predict the distribution of individual Zones, merging the models often did not reflect the field reference data. This was due to different model 'strengths' and the confusion between types occurring in similar environments; model and field plot discrepancies were predominantly in the transition area between Zones, the ecotone. To better balance individual Zone model strengths and improve the overall model accuracy, an analysis of these ecotones was completed. This analysis used accuracy evaluations based upon reference plots (appendix VII) at different modeling stages and within different landscapes to determine the environmental conditions, e.g., an elevation range, a slope position, etc. where minor adjustments in model probability levels would result in reduced confusion (error) between classes (types). It was assumed that, because reference plots are used to 'train' Zone suitability models in MAXENT, the environmental relationships observed at these locations should also 'train' 'correct' adjustments elsewhere. For example, at lower- to mid-elevations, MAXENT probabilities at Pine-Oak Heath reference sites were slightly lower relative to other Zones at these same locations, especially Dry-Mesic Oak. By slightly increasing Pine-Oak Heath probability levels within a narrow segment of the environment (not just at reference sites), the distribution of this Zone and overall accuracy of this type could be improved (judged by further accuracy evaluations and local knowledge of this Zone's distribution). This process is described and discussed at length in Appendixes V-VI.

5) <u>Post-processing of digital model outputs</u>: Post-processing was used to reduce "data noise" i.e., the number of isolated single 30x30 foot pixels (about 1/50th of an acre in size) within the combined Ecological Zone model area and to improve processing time for converting pixels to polygons. This post-processing included 1 ArcGrid Majority filter command which replaces cells in a raster based on the majority of their 8 contiguous neighboring cells. If there is a desire to produce maps having a defined minimum map unit size, then further processing is recommended using the ESRI "eliminate" command, however this tends to overemphasize the size of major types at the expense of less common types.

6) <u>Assessing the accuracy of Ecological Zone map units</u>: Field plots were used as reference data to evaluate the accuracy of the final Ecological Zone maps. Although this is a biased measure of accuracy because these were the same data used to produce the predictive equations, MAXENT does not force a classification upon a sample plot based upon its location, rather, environmental data from that location is used to model the **entire** landscape with no bias to where a plot is located. Also, using field plots as reference data is a reasonable means of objectively comparing different analysis methods and does indicate how well map composition reflects the plot data composition in these landscapes in comparison to other areas where Ecological Zones have been identified.

RESULTS and DISCUSSSION

The location, extent, accuracy, and usefulness of Ecological Zones modeled in the study area were evaluated from the following:

1) Relative importance of environmental factors in predicting Ecological Zones (tables 5-9, fig.4),
2) Influence of local environments on competing Zones, i.e., adjustments within the ecotone (fig. 3, appendix VI),
3) Accuracy of map units relative to field sample plot information (tables 10-12, appendix VII), and the
4) Location and extent of Ecological Zones and BpS / Nature Serve Ecological Systems based on acreage of map units (tables 13-16), and both broad-scale displays and those relative to topography (figures 5-9).

<u>1) Relative importance of environmental factors</u>: The importance of temperature, moisture, fertility, and solar insolation that control Ecological Zone distribution in the study area can be evaluated by looking at those DTM variables used most often and therefore having the most predictive contribution to the Zone models (table 5). Elevation, the distance to carbonate geology, and local relief had at least a 5% contribution in at least half of all Ecological Zone models. Five of the top 10 variables were associated with geology, and although many of the relationships were "the further away from a rock type the greater the gain in model prediction", this is still an indication of the effect that fertility has on plant community distribution in the study area. Local relief and valley position, within the top 10 variables used, reflect the broader scale influence of landscape configuration and topography on moisture and temperature gradients, so important in the area, while distance to or elevation above the closest stream or river, relative slope position, and slope steepness helped to define finer-scale variation in Ecological Zone distribution. These finer scale variables along with elevation have a strong effect on temperature and moisture regimes. On the other hand, solar radiation / aspect, terrain relative moisture index, and most surface curvature variables used to describe more fine-scale conditions, made little contribution in the initial MAXENT models. This is likely due to redundancy within the environmental variable set, i.e., other variables were better able to explain these same factors. For example, slope steepness, relative slope position, and terrain shape index individually might better explain moisture regime than terrain relative moisture index (TRMI) which combines these same variables into one value (appendix III).

Table 5. Importance of environmental variables use in predicting Ecological Zones in the SBR study area

	% of models [1/]		
Environmental variable	Total	South	North
Elevation	68	83	53
Distance to carbonate geology	68	78	58
Local relief	54	50	58
Distance to sulfidic geology	46	39	53
Distance to mixed geology	46	39	53
Distance to mafic geology	35	33	37
Distance to siliciclastic geology	32	33	32
Difference in elevation or distance from the nearest stream (Strmdiff, Strmdist)	32	50	16
Difference in elevation or distance from the nearest river (Rivdiff, Rivdist)	32	17	47
Valley position	22	22	11
Relative slope position (fine and broad scale)	22	22	21
Landform Shape (Lndform10, Lndform30)	22	28	16
Slope steepness	11	11	11
Slope direction (Aspect degrees, Aspect cosine, Solar radiation)	8	11	5
Average annual precipitation	8	11	5
Landform index	5	6	5
Surface shape (TSI, Curve, Curvepl, Curvepr)	3	0	5
Slope length	0	0	0
Terrain relative moisture index	0	0	0

[1/] percent of all models where variable made at least a 5% contribution to the prediction gain

The relationship between plant community type and the environments in which they occur (the Ecological Zone) can also be evaluated by examining the relative importance of environmental variables found by MAXENT to be the best predictors of Ecological Zone location and by assessing the mean values for each variable (tables 6-8). Some of these relationships are fairly straight-forward, others are not. For example, MAXENT (tables 7-8) identifies elevation as the primary or secondary environmental factor that defines the distribution of Grassy Balds, Heath Balds, Spruce-Fir, and Northern Hardwood (slope and cove), which have the highest mean elevation based upon plot locations, and for Shortleaf-Oak which has one of the lowest mean elevations in the project area. Mid- to fine-scale variables related to stream and river influence (Dstrm, Sdiff, Driver, Rivdiff), landform shape (Lfm10, Lfm30), and slope position (Rsp1, Rsp2) were important in defining all the cove-oriented types (Northern Hardwood Cove, Rich Cove, Acidic Cove, Montane Oak cove, and Alluvial Forests), i.e., these types are always (most always with Acidic Cove) found in lower concave positions nearer to streams or rivers than other Zones. In addition, other environmental variables used by MAXENT (when not 'masked' by the influence of geology), singly or in combination, reflect well those conditions found for types occurring in more unique or limited environments such as High Elevation Red Oak that occurs at high elevations and well away from streams or rivers, and Floodplains that occur in the lowest valley positions and nearest to rivers. However, even in these types, relief, elevation, and geology often had a greater influence on their broader landscape distribution predicted with the MAXENT modeling. This resulted in the need to use finer scale variables to refine boundary (ecotone) differences among adjacent types (see the following 'influence of local environments' discussion).

Table 6. Mean values for environmental variables that describe temperature, fertility, moisture, and insolation gradients within Ecological Systems based on reference plot locations (some values are rounded).

		Temp.	Fertility (Distance to Geologic Type, in 1,000s feet) [1/]					Moisture, Temperature, Radiant Energy, and Fertility [2/]							
map code	BpS / Ecological System	ELEV. ft.	GEO1	GEO2	GE03	GEO4	GEO6	SLOPE	VPOS	RPOS	ASP	SOL	TSI	SDIF	PREC
27	Grassy Bald	5,630	77.4	10.5	9.3	24.0	8.1	22	7	7	-.07	16.2	2.2	590	69
1	Spruce-Fir	5,420	109.6	15.7	14.9	34.3	9.1	44	26	30	.27	14.3	-.01	310	72
2	Northern HW Slope	4,500	122.9	15.5	19.9	24.2	3.6	46	44	50	.32	13.4	-2.3	140	69
3	Northern HW Cove	4,765	131.0	15.4	21.8	26.6	3.3	48	31	27	.27	13.9	1.0	270	72
4	Acidic Cove Forest	2,640	95.9	15.1	7.6	71.1	13.0	37	60	57	.11	13.5	-3.9	40	61
29	Mixed Oak/rhodo.	2,900	133.2	12.3	6.1	102.7	13.7	49	41	33	.44	12.5	0.6	170	62
5	Rich Cove Forest	3,190	113.4	16.1	15.1	42.0	6.1	46	51	51	.25	13.0	-3.3	115	64
6	Alluvial Forest	1,410	68.4	11.7	5.9	126.6	18.7	7	85	49	.10	13.6	-2.4	6	52
8	High Elevation Red Oak	4,690	138.7	14.4	18.9	37.2	3.8	38	21	16	-.08	14.9	2.7	330	72
24	Montane Oak Rich	4,190	42.0	52.4	5.6	69.0	17.8	22	9	7	.20	14.3	2.9	425	48
9	Montane Oak Slope	3,545	94.4	20.8	9.6	50.2	6.9	45	34	25	-.04	13.9	1.2	220	61
28	Montane Oak Cove	2,590	84.7	27.4	5.5	77.5	13.2	40	49	48	.02	13.6	-2.5	100	58
13	Dry-Mesic Oak	2,300	140.7	20.6	3.1	87.0	11.6	40	43	35	-.15	13.9	-.8	140	63
10	Dry Oak/ever. heath	2,840	124.4	18.8	2.9	85.5	10.5	38	34	21	-.12	14.0	2.4	200	63
11	Dry Oak/decid. heath	2,250	93.5	22.4	2.7	133.0	15.4	47	31	26	.01	13.4	2.0	220	55
16	Shortleaf Pine-Oak	1,800	169.7	27.7	2.2	62.2	10.2	30	33	18	-.21	13.9	3.0	146	60
31	Shortleaf Pine-Oak heath	1,590	30.2	.3	3.8	118.0	29.5	28	40	11	-.25	13.4	4.4	138	54
18	Pine-Oak Heath	2,690	69.1	19.8	3.5	86.4	17.3	41	27	15	-.26	13.9	3.9	280	55
23	Floodplain Forests	1,560	43.6	47.2	4.0	53.3	10.6	3	87	37	.22	13.9	-.3	5	50
30	Heath Bald	4,850	77.5	21.6	19.1	21.9	0	50	22	6	-.12	13.8	9.5	410	65

[1/] Geo1 = Carbonate-bearing rock, Geo2 = Mafic-silicate rock, Geo3 = Siliciclastic rock, Geo4 = Carbonaceous-sulfidic rock. [2/] Slope in percent, VPOS = valley position (100 = valley bottom, 0 = major ridge top), RPOS = relative slope position (100 = bottom of slope, 0 = top of secondary or major ridge), ASP = cosine of aspect (smaller = more south, larger = more north), SOL = solar radiation (unit watt hours per square meter in millions), TSI = terrain shape index (land surface shape, negative numbers are degree of concavity, positive numbers are degree of convexity), = SDIF = difference in elevation above the nearest stream (ft).

Table 7: Percent contribution of variables used in Ecological Zone models in the SBR study area (north).

EZONE	Gbald	SF	NhS	NhC	Acove	Orhodo	Rcove	Alluvial	Flood	Hero	MonR	MonS	MonC	Dmoak	DryE	DryD	Sloak	Poh	Slpoh
Asp_c			2	2	-	3	1	-		1		1	1	-	2	-	-	1	
Asp_r		-		-	1	1	2	-				1	2	2	2		3	2	
Curve			-			-	-					-	1	-	-				
Curpl		-				-		-				2		-	-		-	-	
Curpr	-	1			-		-			-	-	1	-	-	-			-	
Driver		3	1	1	1	1	1	1	-	+6		1	2	-	2	-	4		
Dstrm	3		1	-	-10	-	1	-		3	3	1	-	2	4	+11			1
Elev	+65	+86	+60	+71	3	9	3		3	+38	2	+26	4	8	2	3	-17	2	-5
Geo1		4	-5	-	-19	2	-5	4	-32	1	-6	1	1	-17	-15	-8	-23	-10	-37
Geo2		1	1	3	1	1	6	2	+11	-	+36	+18	15	2	2	1	6	1	-12
Geo3		2	1	2	4	-6	3	4	1	4	2	-	4	-5	-7	-13	-5	-6	1
Geo4			1	2	+6	+17	3	+5	1	3	-	2	+6	+17	+14	+28	+8	+10	+14
Geo6	-	-	-	2	+16	+25	2	+7		1		4	+20	+25	+14	15	+20	+22	+16
Lfm10		-		-	+14	1	3	-	2	-		-	3	-	2	-	1	-10	1
Lfm30			-	-	1	-	1	-		-		2	-5	1	-		-		-
Lfi				-	-	1	+6	4			1	1	2	-	1	-		-	-
Prec		1			+7	4	1			-	-	1	3	2	2	2	1	1	
Relief		1	1	+9	+8	+15	+38	1	-	-		+23	+13	+11	+17	+10	4	+12	+8
Rivdiff	+13	1	+22	1	1	1	-	-49	-30	+31	+18	3	3	-	2	7	1	+9	-
Rsp1	-	-	-	3	2	-	+5			-		2	1	1	3		3	1	1
Rsp2	-		-	-	2	-	+12	-		4	-9	1	3	1	-			3	-5
Sdiff		-	4	2	2	1	1	-	-	-		3	1	-	4	-	4	+5	1
Sleng			-		-	-	-	-					1	-	-				-
Slope		-		-	-	1	1	-7	-15	-	-	1	1	1	1	-	-	-	-
Solar	-	-	-	1		-8	3			-		1	3	1	2	1		-	
Trmi		-		-	-	-	1			-		-	1	-	-	-	-	1	
Tsi		-	-		-	2	-		1	-		-	6	1	2		-	1	
Vpos	-18	-	-	1	2	1	2	+12	4	-6	-23	1	1	1	1	2	1	3	
# plots	20	64	47	75	614	127	221	69	32	78	11	170	92	221	112	60	77	349	44

[1/] the + or – sign that precedes the variable value (for variables having at least a 5% contribution) indicates the relational direction of the variable. For example, elevation in Spruce-fir (SF) is +86 which indicates that as elevation increases, so does the 'gain' in the model prediction for this type. No sign indicates either that the gain is not linear or that there is confusion in interpreting the relationship. [2/] less than 1% but included in the prediction equation, blank indicates a variable that was not included in the prediction equation.

Table 8: Percent contribution of variables used in Ecological Zone models in the SBR study area (south).

EZONE	Gbald	SF	NhS	NhC	Acove	Orhodo	Rcove	Alluvial	Flood	Hero	MonS	MonC	Dmoak	DryE	DryD	Sloak	Poh	Hbald
Asp_c		1	-	1	-	+8	2	2	3	-	1	2	1	2	-	1	2	1
Asp_r	-	-	-	3	-	+8	2	2	-		1	2	-	1	-	-	4	1
Curve	-				-		-			-	2	2	-	-		1		-
Curpl						-	-				-	2	-	1	1	-	-	
Curpr	-		-		-	-		-		-	-	2	1	-			-	
Driver		-	2	1	1	1	2		-25	-	1	2	1	-	-	2	1	
Dstrm	+39	1	1	-	-32	1	-		1	1	1	1	1	1	2	-	1	-
Elev	+43	+81	+75	+69	5	+10	-14	-	1	+75	+21	+5	7	+6	1	-21	+8	+25
Geo1		2	4	7	8	+15	-5	-30	1	5	-9	-16	36	+16	24	+18	19	-6
Geo2		-	1	1	4	3	2	1	1	1	4	7	8	5	4	15	+7	+6
Geo3	-	4	+7	+5	2	4	+8	-14	2	3	4	3	-6	3	+6	3	3	1
Geo4	-	1	2	1	2	+6	2		-7	-	+7	+11	+11	+18	+12	2	3	2
Geo6		1	1	1	4	-11	3	4	2	1	2	-6	-9	-8	-9	-8	4	-17
Lfm10	1	-		2	+5		10		1		1	1	-	1	1	3	-11	-8
Lfm30		-	1	-	8	-	-	1		2	-	2	-	3		-		
Lfi		-	-		-	1	1	-	1	-	1	1	1	2	-	-	1	+10
Prec	-	3	3	1	4	2	4		-	2	1	-	1	+12	10	1	2	
Relief	-	2	1	2	+15	+16	+37		2	-	+33	+17	13	+6	+10	2	+11	-
Rivdiff	2	3	1	1	1	2	-	3	-	+6	1	2	-	3	4	+8	2	3
Rsp1		-	-	2	1	1	2	-		1	-	+6	1	-		-6	3	-8
Rsp2	-5	-		2	4	-	-		-	-	1	1	-	1	2	-	-	1
Sdiff		-	-	-	1	1	-	-8	-	-	5	-7	-	+6	+9	-	+7	-10
Sleng				-	-	-	-		2	-	2	-	-	1		-	1	-
Slope	-5	-	-	1	-	3	1	-	-6	1	1	1	-	1	3	1	-	
Solar	2	-	-	1	1	3	2			-		1	1	1	-	-	1	-
Trmi	-		1	-	1	1			-		-	-	1	-		-	-	-
Tsi				-		1	2	1			-	1	1	-	1	2	3	1
Vpos	2	-	-	-	1	1	1	+35	+45	2	-	-	1	2	1	-5	-7	-
# plots	14	102	164	257	565	100	544	16	22	308	206	97	379	117	34	206	229	19

[1/] the + or – sign that precedes the variable value (for variables having at least a 5% contribution) indicates the relational direction of the variable. For example, elevation in Spruce-fir (SF) is +63 which indicates that as elevation increases, so does the 'gain' in the model prediction for this type. No sign indicates either that the gain is not linear or that there is confusion in interpreting the relationship. [2/] less than 1% but included in the prediction equation, blank indicates a variable that was not included in the prediction equation.

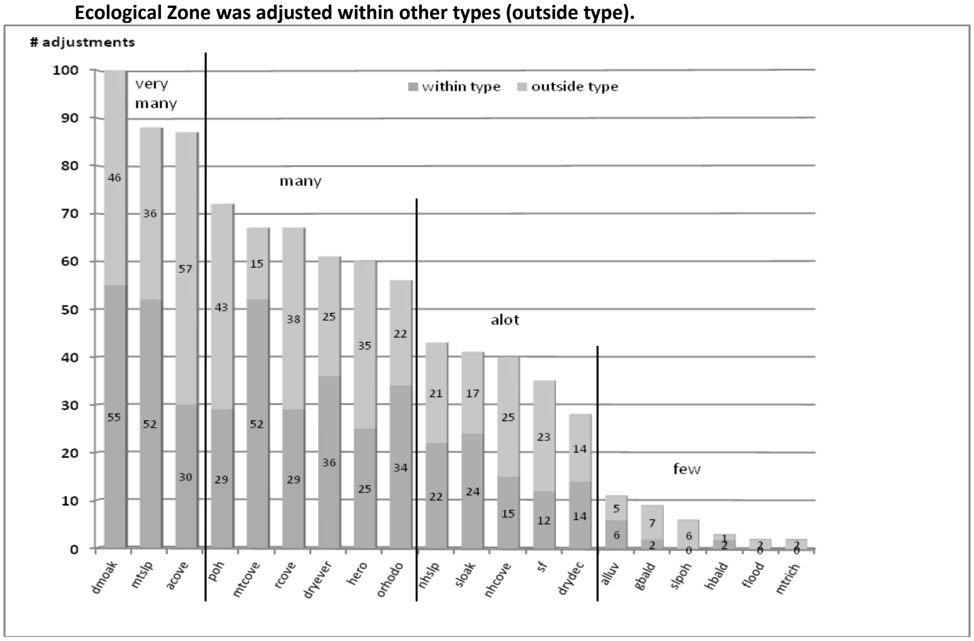
These relationships were apparent in the field and from viewing digital terrain data in comparison to individual Ecological Zone models. What was not obvious in the field was the influence of geology that MAXENT revealed and how / why multiple rock types contribute information for so many Zones. This relationship is most probably due to the fact that the influence of rock types was analyzed as a continuous "distance to" variable and not a class variable. Also, relationships between Ecological Zones and environmental variables get confusing because many variables used in this analysis provide redundant information and are therefore correlated. Elevation, relative slope position, distance to stream, and solar radiation, for example, can all have an influence on temperature and moisture (other variables too). Although MAXENT 'finds' the variable or combination of variables that contribute most to predicting each type, care must be taken in interpreting these relationships because of the complexity of variable interactions and the statistics used in 'fitting' models.

<u>2) Influence of local environments on ecotones and model adjustments made</u> (Excerpted from appendix V): To limit broad-brush refinements of Zone models, ecotone adjustments were made separately within the 'northend model', 'southend model', for each of the unique FLN landscapes (Northern Escarpment, New River Headwaters, Central Escarpment, South Mountains, Southern Blue Ridge Escarpment, Balsam Mountains, Nantahala Mountains, Smoky and Unaka Mountains), and for areas outside FLN landscapes having additional reference plots.

Adjustments of the ecotone between models can be evaluated from two perspectives; the total number of adjustments made within an Ecological Zone, and the total number of times that Ecological Zone was adjusted within other types. If both types of adjustments are considered, the Ecological Zones can be grouped into the following 4 ecotone adjustment categories (arranged from most to least adjustments within category):

<u>Very many</u>	<u>Many</u>	<u>A lot</u>	<u>Few</u>
Dry-Mesic Oak	Pine-Oak Heath	Northern Hardwood Slope	Alluvial Forest
Montane Oak (Slope)	Montane Oak (Cove)	Shortleaf Pine-Oak	Grassy Bald
Acidic Cove	Rich Cove	Northern Hardwood Cove	SL Pine-Oak Heath
	Dry-Oak/Evergreen Heath	Spruce-Fir	Heath Bald
	High Elevation Oak	Dry-Oak/Deciduous Heath	Floodplain
	Mixed Oak/Rhododendron		Montane Oak (Rich)

Figure 3: Ecotone adjustments within an Ecological Zone (within type) and the number of times that Ecological Zone was adjusted within other types (outside type).



There were around 100 adjustments made in the initial and subsequent Dry-Mesic Oak Ecological Zone models, 55 'within type' and 46 'outside type' (figure 3), the most of all types. This type along with Montane Oak Slope and Acidic Cove, which also had 'very many' adjustments, account for well over one-third (40%) of the total acres in the 8 million+ project area (thus having an extensive ecotone between other types) and certainly a major reason for needing such a large number of adjustments. This is also true for Acidic Cove which had the most 'outside type' adjustments, and accounts for a significant portion of the total landscape (17% - the most extensive of all types), and because the type can occur in narrow drainage areas that bisect most all 'upland' types, forming extensive ecotones and therefore 'confusion' between type boundaries. The fewest adjustments were made in rare Ecological Zones (Grassy Bald, Heath Bald, Montane Oak Rich, Shortleaf Pine-Oak Heath) that occur in distinct environments and are therefore less 'confused' with other types, or those that are more extensive on private lands (Alluvial Forest, Floodplain) and therefore have fewer reference plots to evaluate.

Adjustments within and between types: Although not considered entirely an ecotone adjustment, the greatest number of model changes was made to differentiate between Acidic Cove and Rich Cove Ecological Zones (17 shared 'within type' adjustments) (appendix VI). Geology, stream or river distance, and slope position or landform shape were the most frequently used local environmental variables (used 5, 4, and 3 times respectively). The next most frequent adjustments were made between Dry-Mesic Oak (Dmoak) and Pine-Oak Heath (Poh), (16 total shared adjustments; 11 within Dmoak and 5 within Poh), and in differentiating between Dmoak and Shortleaf Pine-Oak (Sloak), (15 total shared adjustments: 6 within Dmoak and 9 within Sloak). Curvature, elevation, slope, and stream distance were the most frequent environmental variables used to refine the Dmoak and Poh ecotone boundary, while stream distance, geology, and elevation were the most frequent environmental variables used to refine the Dmoak and Sloak ecotone boundary.

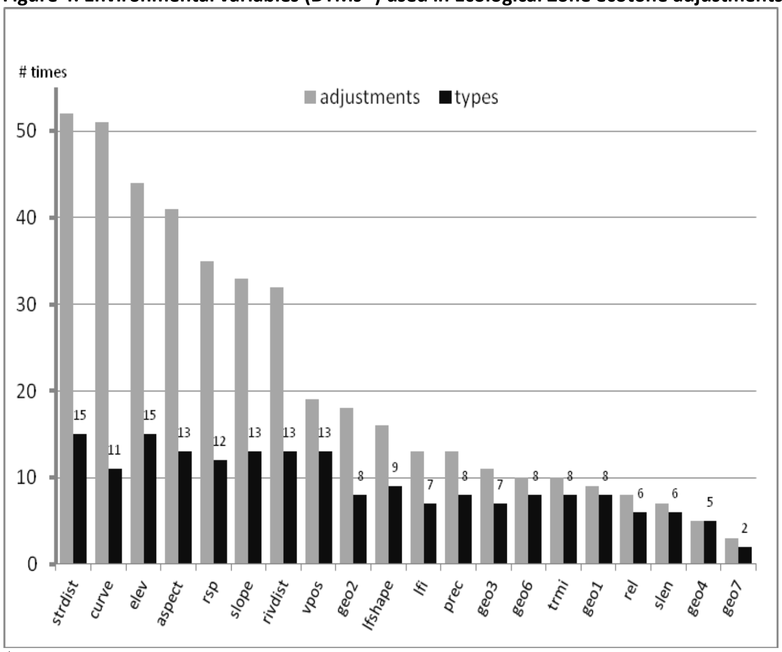
The gain in accuracy within an Ecological Zone was generally related to both the total number of adjustments and the number of types within the Zone that were adjusted, i.e., the greater the adjustment the greater the gain (appendix VI, table 1). However, there are some important exceptions: 1) most of the 'rare' types had significant gains (greater than 30% points) in map unit accuracy with very few adjustments, 2) the 3 types having the greatest number of total adjustments and with at least 10 types needing to be adjusted within their boundaries had relatively modest accuracy gains (Dmoak a 15% point gain, Montane Oak Slope an 8% point gain, and Montane Oak Cove with only a 1% point gain), and 3) one type, Heath Bald actually showed a decline in accuracy from the initial to final model.

Variables used in adjustments: DTM frequency of use can be grouped into the following categories that describe local environments:

Most frequent (40+)	Frequent (32-35)	Less Frequent (12-19)	Least Frequent (less than 12)
Stream distance (strdist)	Relative slope position (rsp)	Valley position (vpos)	Siliciclastic geology (geo3)
Surface curvature (curve)	Slope (slope)	Mafic geology (geo2)	Mixed geology (geo6)
Elevation (elev)	River distance (rivdist)	Landform shape (lfshape)	Terrain moisture index (trmi)
Aspect (aspect)		Landform index (lfi)	Carbonate geology (geo1)
		Precipitation (prec)	Relief (rel)
			Slope length (slen)
			Sulfidic geology (geo4)
			Ultramafic geology (geo7)

Topographic/environmental variables used most frequently to describe local environments that might refine ecotone boundaries between types were clearly fine-scale (from a mapping perspective) and included: stream distance, curvature, elevation, and aspect (fig. 4). These variables were used 40+ to 50+ times each in the over 400 adjustments made between the preliminary and final Ecological Zone models (appendix V, table 3). A combination of fine- and mid-scale variables that include relative slope position, slope, and river distance were frequently used. Less and least frequently used were mid-scale variables. This contrasts greatly with variables used in the original Maxent models for each type. While aspect, slope, and curvature were used frequently to adjust ecotone boundaries (over ½ of the models used these variables), they had at least a 5% contribution to prediction gain in less than 12% of the Maxent models (table 5, 9). Similarly, terrain relative moisture index and slope length, which seldom provided even a 2% gain in Maxent models, were used in at least 30% of the models for ecotone adjustments (table 9). Conversely, carbonate geology, sulfidic geology, and relief which had significant contributions in Maxent were among the least frequently used variables in the ecotone adjustments.

Figure 4: Environmental variables (DTMs[1/]) used in Ecological Zone ecotone adjustments.



[1/] **strdist**=dstream, sdiff; **curve**=curve, curvepl, curvepr, tsi; **aspect**=aspr, aspc, solar; **rsp**=rsp1, rsp2; **rivdist**=driver, rivdiff; **lfshape**=lfm10, lfm30

Table 9: Comparison of environmental variable use in ecotone adjustments vs. Maxent models

Variable	Ecotone adjustments	Maxent models [1/]	% difference in variable use
	% of types variable used		
aspect	65	8	57
slope	65	11	54
curvature	55	3	52
strdist	75	32	43
vpos	65	22	43
trmi	40	0	40
rsp	60	22	38
rivdist	65	32	33
precip	40	8	32
lfi	35	5	30
slength	30	0	30
lfshape	45	22	23
umaf_geo	10	0	10
elev	75	68	7
mafic_geo	40	35	5
silic_geo	35	32	3
mix_geo	40	46	-6
sulf_geo	25	46	-21
relief	30	54	-24
lime_geo	40	68	-28

[1/] where variable made at least a 5% contribution to prediction gain

3) <u>Map unit accuracy</u>: An accuracy assessment using random samples was not completed for this project, however, the same analysis process (termed an accuracy evaluation) was followed, i.e., a comparison was made between reference field data and classified (modeled) data for the same site (appendix VII). Although this is a biased measure of accuracy because these are the same data used to produce the MAXENT predictive equations, it is a reasonable means of objectively comparing how well map composition reflects field data across different landscapes. It was also useful for evaluating ecotones to improve map unit boundary accuracy among Zones (see discussion above).

Overall accuracy within the study area for 3rd approximation Ecological Zones is 79% (table 10) and 83% for BpS / Nature Serve-Ecological Systems (appendix VII, table 2) based on intersecting 5,842 plots with the final Ecological Zone models / map units. This compares favorably to (or better than) other Ecological Zone modeling within the Appalachians and the Kentucky FLN considering the size and number of Zones modeled, and considerably better than the 2nd approximation Ecological Zone mapping. Floodplains, Shortleaf Pine-Oak, and Spruce-Fir, had the highest accuracy (88-94%) in the 3rd approximation SBR mapping, 7 other types (Pine-Oak Heath, Shortleaf Pine-Oak Heath, Montane Oak Rich, High Elevation Red Oak, Rich Cove, Acidic Cove, and Northern Hardwood Cove exceeded 79% accuracy, the average for all types. Mixed Oak / Rhododendron, Montane Oak Cove, and Dry-Oak / Evergreen Heath had the lowest accuracy (68-69%) of all types and were confused primarily with other types associated with concave landscape positions (Montane Oak Cove or Mixed Oak / Rhododendron vs. Acidic Cove, Rich Cove, Dry-mesic Oak) or with other types associated in adjacent landscapes, e.g., Dry-Oak / Evergreen Heath vs. Pine-Oak Heath (appendix VII). The remaining 7 types had accuracy levels between 73% and 78% (Alluvial Forest, Dry Oak / Deciduous Heath, Montane Oak Slope, Dry-Mesic Oak, Grassy Bald, Heath Bald, and Northern Hardwood Slope).

Table 10: Ecological Zone accuracy across the Appalachian Mountains study areas

Ecological Zone	3rd Approx. SBR	Cherokee NF North Zone	George Washington NF		Kentucky FLN	2nd Approx. SBR
			Appalachian Ridges	Blue Ridge		
Size of area (acres-rounded)	8,234,470	1,021,600	3,761,700	1,026,200	278,000	5,922,100
	Percent correct					
Grassy Bald	74	100	-	-	-	30
Heath Bald	74	-	-	-	-	19
Spruce-Fir	89	86	89	-	-	70
N. Hardwood Slope	73	88	86	81	-	23
N. Hardwood Cove	80	71	89	100	-	53
Acidic Cove	81	84	83	90	87	66
Spicebush Cove	-	-	-	71		-
Rich Cove [1/]	81	76	82	82	92	51
Alluvial Forest	78	92	67	94	81	56
Floodplain	94	100	78	-		-
High Elevation Red Oak	81	79	86	84	-	75
Montane Oak Rich	82	100	77	68		-
Montane Oak Cove	69	66	79	-	-	43
Montane Oak Slope [2/]	75	85	72	80	-	-
Colluvial Forest	-	-	70	-	-	-
Dry-Mesic Oak	74	78	84	90	77	27
Dry-Mesic Calcareous Forest	-	-	81	-	-	-
Dry Oak Evergreen Heath [3/]	69	75	66	73	83	27
Dry Oak Deciduous Heath	78	75	65	71	-	-
Mixed Oak / Rhododendron	68	76	-	-	-	36
Shortleaf-Pine Oak [4/]	88	85	90	91	80	66
Shortleaf P-O Heath	82	-	-	-	-	58
Pine-Oak Heath (eastside)	-	-	82	-	-	-
Pine-Oak Heath (westside) [5/]	82	82	77	83	-	58
Pine-Oak Heath (ridges) [6/]	-	-	59	-	79	-
Pine-Oak Shale Woodland	-	-	89	-	-	-
Shale Barren	-	-	83	-	-	-
Alkaline Woodland	-	-	92	-	-	-
Mafic Glade and Barren	-	-	-	91		-
OVERALL	79	81	77	80	82	52
Most fire-adapted group	93	94	97	98	95	83

[1/] Mesic Forest in Kentucky, [2/] typical Montane_submesic Oak [3/] Chestnut Oak in SBR, [4/] Shortleaf Pine-Oak in SBR, [5/] typical POH, [6/] "Xeric Pine-Oak" in Kentucky.

Table 11: Comparison of 3rd approximation SBR Ecological Zone accuracy on Federal lands. [1/]

Ecological Zone	Project Area	All Federal Land	National Park Service	US Forest Service	Nantahala National Forest	Pisgah National Forest
Size (1000s' of acres-rounded)	8,234,475	2,204,370	551,540	1,652,830	532,730	508,280
Reference field plots (total #)	5,842	4,356	539	3,817	1,276	1,562
	Percent correct map accuracy					
Grassy Bald	74	74	78	73	-	68
Spruce-Fir	89	89	87	90	-	90
Northern Hardwood (slope)	73	73	67	74	73	69
Northern Hardwood (cove)	80	79	75	81	81	73
Rich Cove	81	82	77	81	86	83
Acidic Cove	81	81	82	81	83	82
Mixed Oak / Rhododendron	68	70	67	70	73	64
Alluvial Forest	78	71	50	71	*50*	81
Floodplain	94	89	*100*	88	-	*100*
High Elevation Red Oak	81	80	82	79	78	87
Montane Oak (rich)	82	*0*	-	*0*	-	*0*
Montane Oak (slope)	75	73	57	75	75	71
Montane Oak (upper cove)	69	66	50	68	62	66
Dry-Mesic Oak	74	70	66	71	73	63
Dry Oak Evergreen Heath	69	67	45	68	74	73
Dry Oak Deciduous Heath	78	73	-	73	83	43
Shortleaf Pine-Oak	88	91	82	92	95	92
SL Pine- Tblmt. Pine Oak Heath	82	82	-	82	-	82
Pine-Oak Heath	82	84	86	83	85	82
Heath Bald	74	79	79	-	-	-
OVERALL accuracy	79	79	77	79	80	79
Accuracy of the most fire-adapted category (below dashed line)	93	93	90	93	92	91

[1/] based on re-intersection of field data with modeled map units; *numbers in italics are based upon fewer than 7 plots,* a dash indicates that no plots were sampled in this area within this type or this type does not occur within this area

4) <u>Ecological Zone location and extent</u>: In general, the SBR model based on MAXENT with ecotone adjustments appears to represent both the location and extent of predicted Ecological Zones observed in the field. Oak-dominated Ecological Zones (orange, gray, bluish green, purple in maps) are predicted on about 45% of the over 8 million acre SBR landscape; (Oak group includes Mixed-Oak Rhododendron). Cove Ecological Zones are predicted on about 30% of the landscape (red and dark blue), and Pine-Oak Ecological Zones 17% (green). The remaining 8% of the landscape includes Alluvial Forests, Northern Hardwood, Floodplain, Spruce-Fir, Heath Bald, and Grassy Bald types, and lakes (cover page, figures 5-6, and table 12). Cove types were somewhat more extensive north of Asheville. Pine-Oak types were more extensive south of Asheville (16% in the north model, 19% in the south model). Within the oak types, Dry-Mesic Oak was over two times more extensive in the south while Montane Oak Slope and Cove (in combination) were nearly twice as extensive in the north. Although Pine-Oak Heath was only slightly more common in the north, Shortleaf Pine-Oak was noticeably more extensive in the south.

Figure 5: Ecological Zones in the North model area

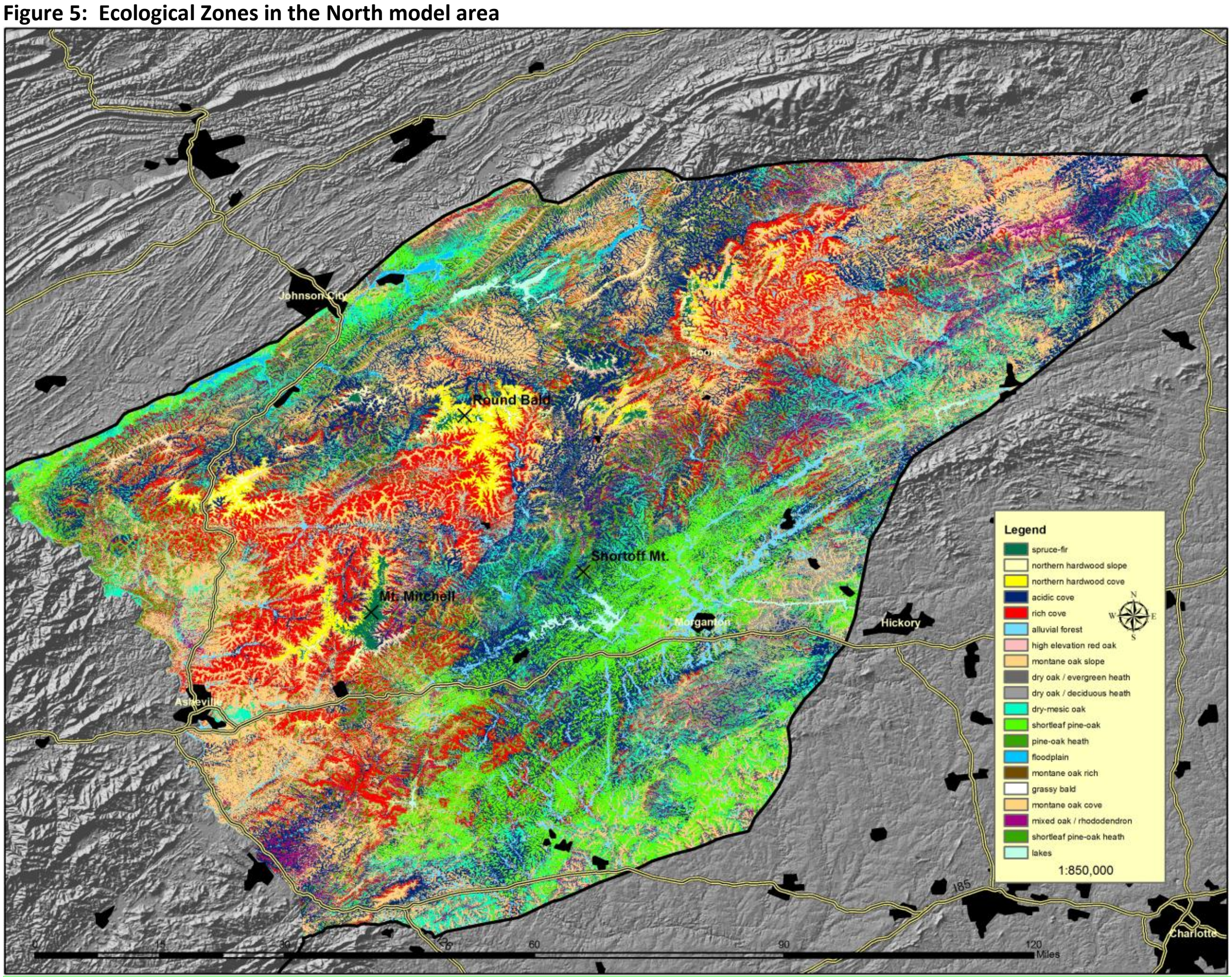


Table 12: Extent of Ecological Zones in the SBR project area and change in map unit accuracy (acres rounded)

Ecological Zone	Total all lands		Total Federal lands		Nantahala & Pisgah National Forests		Map Unit Accuracy (percent)			North Model	South Model
							initial model	final model	change	acres	
	acres	percent	acres	percent	acres	percent				3,944,596	4,288,949
Total	8,234,470	100.0	2,204,370	100.0	1,041,020	100.0	59	79	+20	percent	
Grassy Bald	1,740	0.0	1,320	0.1	670	0.1	44	74	+30	0.0%	0.0%
Spruce-Fir	64,260	0.8	47,250	2.1	16,600	1.6	50	89	+39	0.5%	1.0%
Northern Hardwood (slope)	58,280	0.7	32,200	1.5	19,560	1.9	50	73	+23	0.8%	0.6%
Northern Hardwood (cove)	143,950	1.7	71,100	3.2	34,360	3.3	48	80	+32	1.9%	1.6%
Rich Cove	993,640	12.1	328,250	14.9	189,140	18.2	68	81	+13	10.9%	13.1%
Acidic Cove	1,417,800	17.2	386,090	17.5	191,160	18.4	61	81	+20	19.3%	15.3%
Mixed Oak / Rhododendron	273,440	3.3	70,740	3.2	49,780	4.8	62	68	+6	4.4%	2.3%
Alluvial Forest	251,040	3.0	16,610	0.8	2,130	0.2	65	78	+13	4.6%	1.6%
Floodplain	84,300	1.0	3,540	0.2	510	0.0	88	94	+6	0.4%	1.6%
Lakes	62,610	0.8	5,760	0.3	850	0.1				0.4%	1.1%
High Elevation Red Oak	109,120	1.3	63,190	2.9	38,640	3.7	48	81	+33	0.8%	1.8%
Montane Oak (rich)	490	0.0	130	0.0	6	0.0	29	64	+35	0.0%	0.0%
Montane Oak (slope)	840,950	10.2	258,370	11.7	118,670	11.4	67	75	+8	12.4%	8.2%
Montane Oak (upper cove)	975,230	11.8	142,840	6.5	67,470	6.5	68	69	+1	15.2%	8.7%
Dry-Mesic Oak	1,050,860	12.8	262,900	11.9	105,990	10.2	59	74	+15	7.1%	18.0%
Dry Oak Evergreen Heath	336,920	4.1	93,340	4.2	50,150	4.8	57	69	+12	4.5%	3.7%
Dry Oak Deciduous Heath	148,450	1.8	30,330	1.4	9,530	0.9	57	78	+21	1.0%	2.5%
Shortleaf Pine-Oak	891,330	10.8	161,380	7.3	43,770	4.2	76	88	+12	9.0%	12.5%
SL Pine- Tblmt. Pine Oak Heath	980	0.0	660	0.0	680	0.1	0	82	+82	0.0%	0.0%
Pine-Oak Heath	527,140	6.4	226,440	10.3	101,280	9.7	45	82	+37	6.6%	6.2%
Heath Bald	1,960	0.0	1,950	0.1	80	0.0	84	74	-10	0.0%	0.0%

The distribution of Ecological Zones in the SBR is strongly tied to elevation, and this is also obvious in the Central Appalachians and Cumberland Plateau. How well the predicted / mapped Zone distribution fits these observations can be assessed by examination of both the proportion of different Zone map units within elevational classes relative to the elevation class size and the proportion of Zone map units within elevational classes relative to an individual Zone’s area-wide distribution. This is different than looking at the mean values for environmental variables (table 6) based on the reference plot locations because the entire predicted range of the type is being described. The model clearly shows that elevations greater than 5500’ elevation are dominated by just 2 Ecological Zones, Spruce-Fir and Northern Hardwood Slope, with appreciable amounts of Grassy Bald and Northern Hardwood Cove (table 13) and that over 75% of all Spruce-Fir and 75% of all Northern Hardwood Slope across the project area occur above 5000’ and 4500’ respectively (table 14); which seems to confirm field observations. At elevations less than 2500’, Shortleaf Oak, Dry-Mesic Oak, Acidic Cove, and Montane Oak Cove are the dominant predicted types and these have their greatest extent there; again, an observation made in the field. Between 4500 and 5500’, High Elevation Red Oak, Northern Hardwood Cove and Slope, and Spruce-Fir are the dominant predicted types. Also not surprising is the wide distribution of Acidic Cove which comprises at least 1% of all elevation classes, and Montane Oak Slope which comprise at least 1% of all elevation classes except those over 6000’. In addition, it is interesting to note that 86% of the total extent of the Rich Cove Zone is between 2000 and 4000’ (table 14) and that although there are a greater variety of Zones below 2500’ (12 of the 20 Zones make up at least 1% of the landscape), Zone diversity is at a finer scale (more types per area) at elevations greater than 5000’ which partly explains the botanical and ecological interest these elevations continue to receive.

Figure 6: Ecological Zones in the South model area

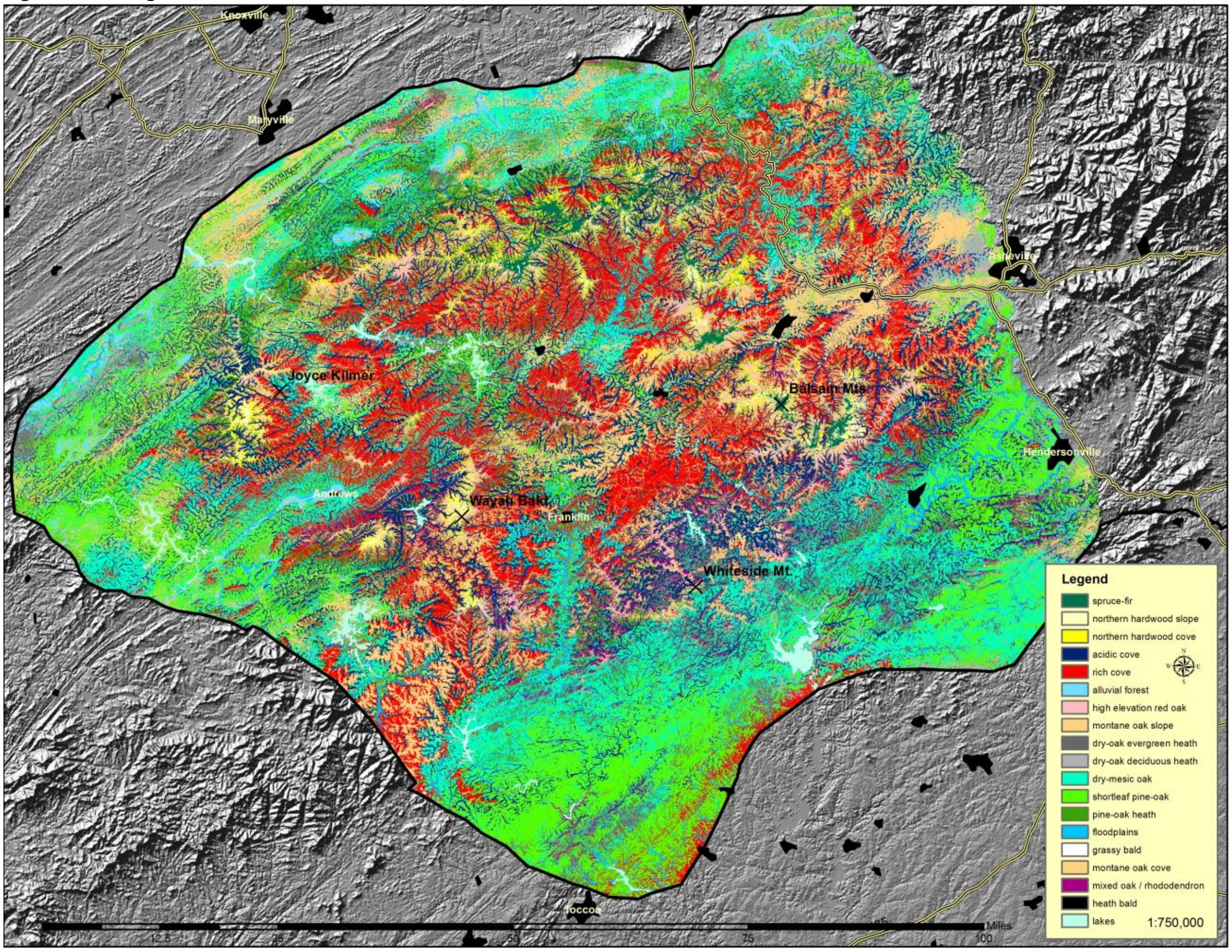


Table 13: Percent of landscape within elevational classes, e.g. Spruce-fir covers 80% of landscapes > 6000' in elevation.

Ecological Zone	Elevation in feet											# Elev. classes	% land
	< 1500	1501-2000	2001-2500	2501-3000	3001-3500	3501-4000	4001-4500	4501-5000	5001-5500	5501 6000	> 6000		
Grassy Bald									1	3	9	3	0
Heath Bald									1	2	4	3	0
Spruce-Fir							2	12	24	64	80	5	1
Northern Hardwood (slope)						1	6	11	16	14	2	6	1
Northern Hardwood (cove)						4	17	24	23	8	1	6	2
High Elevation Red Oak						1	10	25	29	5		5	1
Montane Oak (rich)					-	-	-					0	0
Montane Oak (slope)	1	1	7	14	21	28	25	10	2	2	3	11	10
Acidic Cove	18	15	19	19	17	18	13	7	3	1		10	17
Montane Oak (upper cove)	17	13	14	13	8	4	2		1	1		9	12
Mixed Oak / Rhododendron	2	4	3	4	4	4	3	2	1			9	3
Dry Oak Evergreen Heath	5	4	3	4	4	5	5	4	1			9	4
Pine-Oak Heath	1	5	9	9	10	8	6	4				8	6
Rich Cove	3	5	9	19	27	22	12					7	12
Dry-Mesic Oak	15	20	18	11	8	4						6	13
Dry Oak Deciduous Heath	3	2	3	1	1							5	2
Shortleaf Pine-Oak	25	23	8	2								4	11
Alluvial Forest	9	3	2	2								4	3
Floodplain	1	2	2									3	1
SL Pine-Oak Heath	-	-										0	0
(a) % of landscape	22	15	19	17	13	8	4	2	1	0.3	0.1		
(b) # of Zones (at least 1%)	12	12	12	11	9	11	11	9	11	9	6		
(b) /(a) = relative diversity	0.5	0.8	0.6	0.6	0.7	1.4	2.8	4.5	11.0	30.0	60.0		

Table 14: Percent of Ecological Zone within elevation classes, e.g. 26% of Spruce-Fir occurs > 6000' in elevation.

Ecological Zone	Elevation in feet											elevation range with ≥ 75% of type extent
	< 1500	1501-2000	2001-2500	2501-3000	3001-3500	3501-4000	4001-4500	4501-5000	5001-5500	5501 6000	> 6000	
Grassy Bald								1	30	43	26	> 5000
Heath Bald							12	17	32	30	9	4501-6000
Spruce-Fir							13	30	26	26	6	4501-6000
Northern Hardwood (slope)						8	35	31	19	6		4001-5500
Northern Hardwood (cove)					3	20	39	26	11	1		3501-5000
High Elevation Red Oak				4	3	7	30	35	18	1		4001-5500
Montane Oak (rich)			3	8	28	49	13					3001-4000
Montane Oak (slope)	2	1	14	23	26	23	10	2				2501-4000
Acidic Cove	22	13	21	19	12	9	3	1				< 3001
Montane Oak (upper cove)	31	17	22	19	8	3	1					< 3001
Mixed Oak / Rhododendron	11	17	20	22	17	9	3	1				< 3501
Dry Oak Evergreen Heath	26	14	14	17	13	10	5	2				< 3501
Pine-Oak Heath	2	12	27	24	19	10	4	1				1501-3500
Rich Cove	6	6	15	27	29	15	4					2001-4000
Dry-Mesic Oak	26	23	26	14	8	3						< 2501
Dry Oak Deciduous Heath	31	17	32	13	5	2						< 2501
Shortleaf Pine-Oak	50	32	15	4								< 2001
Alluvial Forest	67	14	9	9	2							< 2001
Floodplain	29	28	38	4	1							< 2501
SL Pine-Oak Heath	42	56	2									< 2001

At larger scales (< 1:24,000), the relationship between topography and Ecological Zones is more evident as is the association among Ecological Zones (figures. 7-10). At higher elevations, Zone patterns appear more controlled by elevation, slope, and aspect than by drainage pattern as they seem to be at lower elevations, although slope position and surface shape are important at all elevations. The distribution of Zones is fairly consistent at higher elevations and not apparently controlled by geology except at very fine-scales. The sequence (from ridgeline to midslope) of Spruce-Fir (with imbedded Grassy Balds), Northern Hardwood Slopes (convex surfaces), Northern Hardwood Coves (concave surfaces), High Elevation Red Oak (with imbedded Mixed Oak / Rhododendron), and Montane Oak Slopes is fairly consistent throughout the project area. The span of this sequence depends upon the elevation of individual mountain ridges, those above 5000' in elevation often have this full range of Zones, and those from 4000 to 5000' elevation usually start the upper limits of this sequence with High Elevation Red Oak (figures 7 & 10). At lower elevations, the ridge to midslope sequence may start with Pine-Oak Heath and moves downward to Dry-Mesic Oak or Montane Oak Cove dissected by Acidic Cove (imbedded with Mixed-Oak/ Rhododendron (fig. 8); at the lowest elevation, Shortleaf pine may dominate low ridges above a similar sequence below (fig. 9).

As a way of reference to map unit accuracy, Figure 7 at Middle Ridge on the Pisgah NF, shows 34 reference plots within 15 different Zones – the overall accuracy within this scene is 79% accuracy (the SBR average). Figure 10 at Wayah Bald on the Nantahala NF shows 49 reference plots within 14 different Zones and 78% producer's accuracy; both of these examples are at higher elevations. At lower elevations, the Chimneys view (fig. 8) shows 127 reference plots and 13 different types with 79% map accuracy while the Chattooga River view (fig. 9) shows 20 reference plots and 11 different types with 70% accuracy (below the overall SBR average).

Figure 7: Ecological Zones at Middle Ridge, Pisgah NF

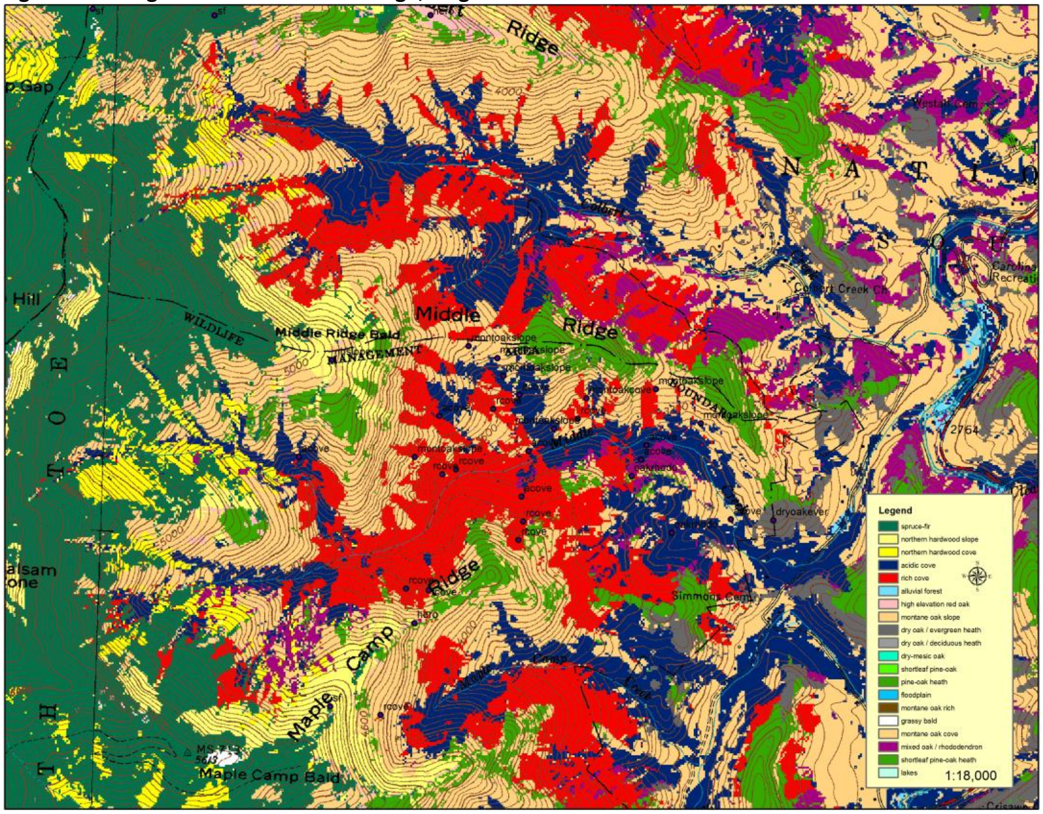


Figure 8: Ecological Zones east of The Chimneys, Pisgah NF

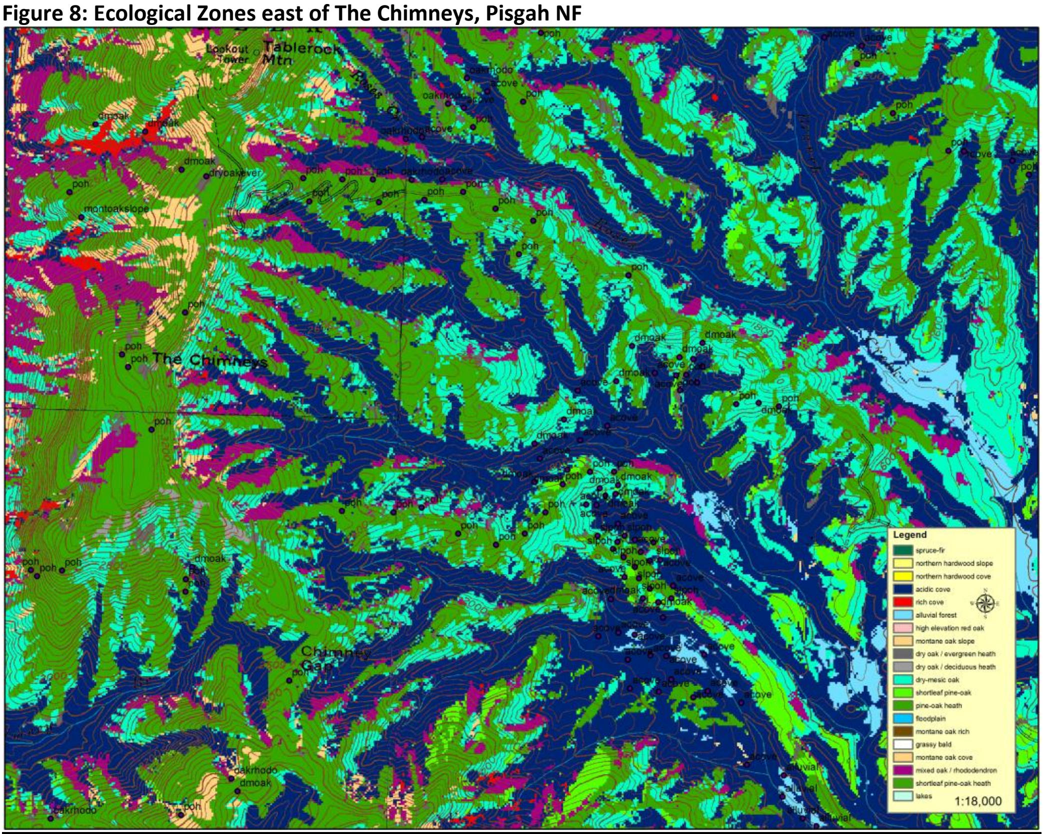


Figure 9: Ecological Zones near the lower Chattooga River, Sumter & Chattahoochee NFs

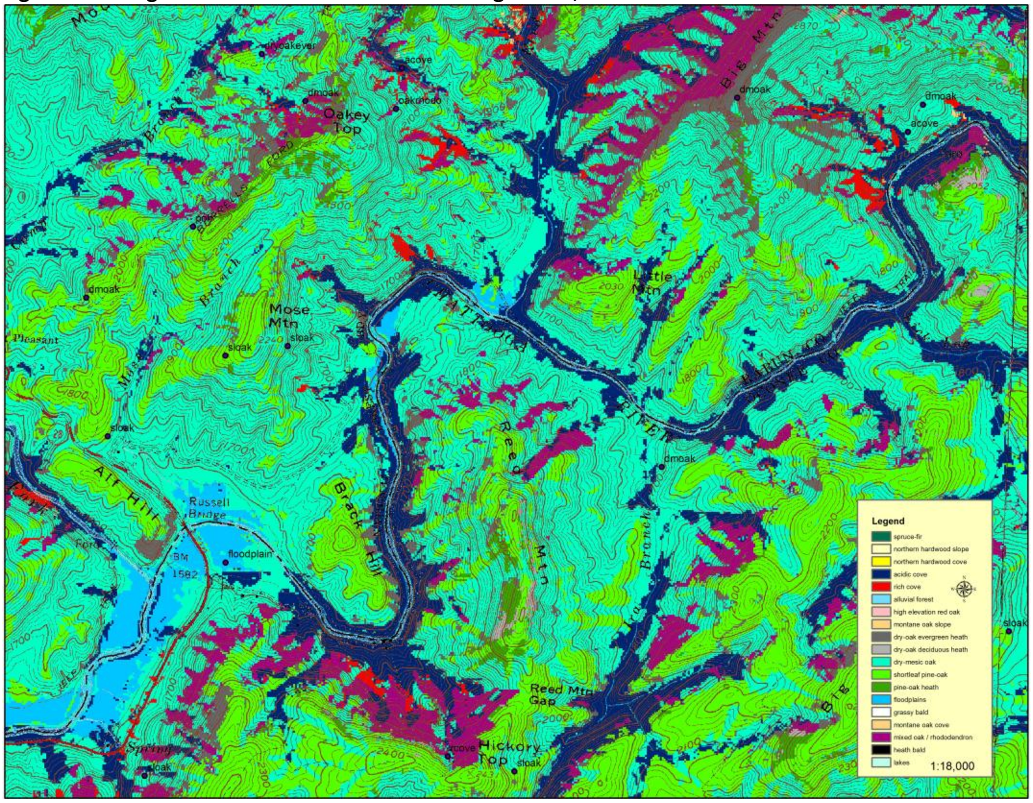
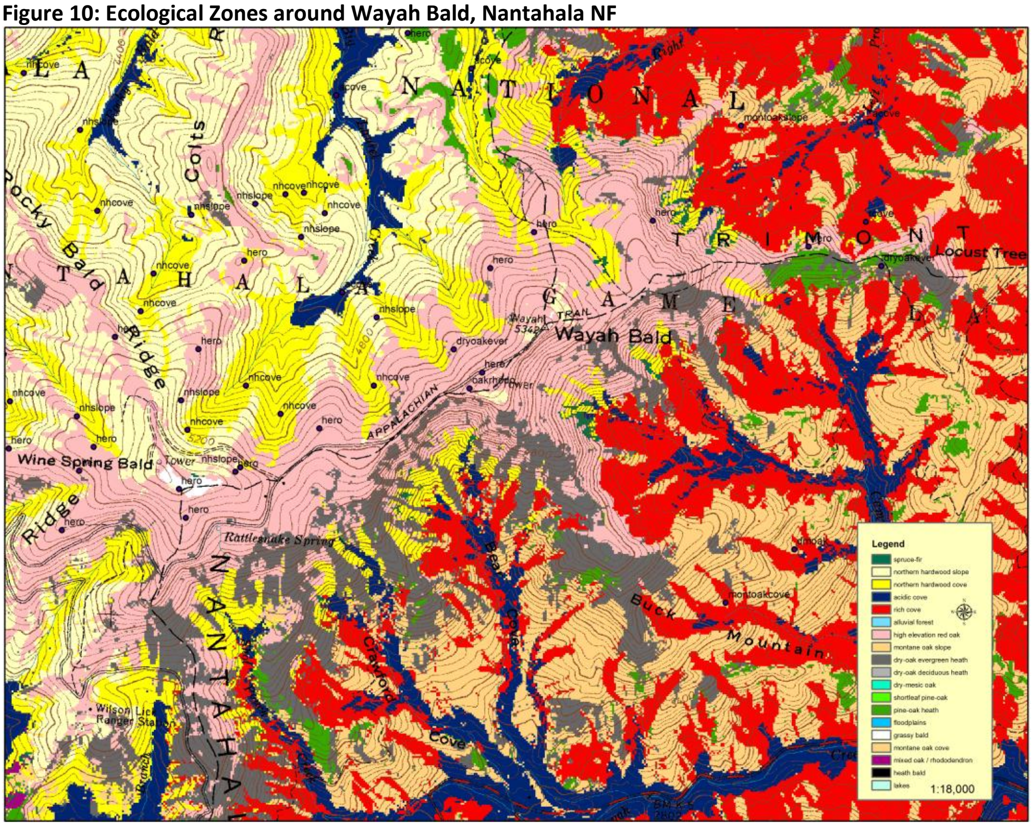


Figure 10: Ecological Zones around Wayah Bald, Nantahala NF



The 20 different Ecological Zones identified in the SBR study area, arranged from wet to xeric moisture regimes, are cross-walked below (table 13) with Nature Serve Ecological Systems (Nature Serve 2010) and represent the natural plant communities that may have been present during the reference period described in LANDFIRE Biophysical Setting Models (LANDFIRE 2009) for the area. To help in describing the composition of types observed in the field and mapped across the study area, more detailed site and species composition descriptions for Ecological Zones and BpS / Nature Serve Ecological Systems are included in Appendix I, photo examples for some of these types are included in Appendix II. These cross-walks reflect the author's ongoing refinement of Ecological Zone concepts to better fit local landscapes based upon work between 2008 and 2011 evaluating Biophysical Setting (BpS) map units in the Southern Blue Ridge Mountains of North Carolina, South Carolina, Tennessee, and Georgia, and modeling Ecological Zones in the Cumberland Plateau in Kentucky, in North Carolina's South Mountains and Northern Blue Ridge Escarpment, and in the Central Appalachians of Virginia and West Virginia. A comparison of 2nd and 3rd approximation Ecological Zone accuracy and extent within each FLN landscape area is included in appendix X.

Table 13. Crosswalk between Ecological Zones and BpS / Ecological Systems

Ecological Zone	map code	**BpS** /NatureServe Ecological System	map code
Grassy Bald	27	Southern Appalachian Shrub and Grass Bald (in part)	27
Heath Bald	30		
Spruce	1	Central and Southern Appalachian Spruce-Fir Forest	1
Northern Hardwood Slope	2	Southern Appalachian Northern Hardwood	2
Northern Hardwood Cove	3		
Acidic Cove	4	Southern and Central Appalachian Cove Forest	4
Mixed Oak / Rhododendron	29		
Rich Cove	5		
Alluvial Forest	6	Central Interior and Appalachian Riparian Systems	6
Floodplain	23	Central Interior and Appalachian Floodplain Systems	23
High Elevation Red Oak	8	Central and Southern Appalachian Montane Oak	8
Montane Oak Rich	24	Southern and Central Appalachian Northern Red Oak-Chestnut Oak (provisional type)	9
Montane Oak Cove	28		
Montane Oak-Slope	9		
Dry Mesic Oak	13	Southern Appalachian Oak Forest	13
Dry Oak Evergreen Heath	10	Allegheny-Cumberland Dry Oak Forest & Woodland	10
Dry Oak Deciduous Heath	11		
Shortleaf Pine-Oak	16	Southern Appalachian Low-Elevation Pine	16
Shortleaf Pine-Oak Heath	31		
Pine-Oak Heath	18	Southern Appalachian Montane Pine Forest and Woodland	18

Table 14. Extent of BpS / Ecological Systems in the SBR project area

map code	BpS / NatureServe Ecological System	Total acres	% of total	USFS acres	% of total
27	Southern Appalachian Grass and Shrub Bald	3,700	0.0	745	0.1
1	Central and Southern Appalachian Spruce-Fir Forest	64,260	0.8	16,600	1.6
2	Southern Appalachian Northern Hardwood	202,230	2.5	53,920	5.2
4	Southern and Central Appalachian Cove Forest	2,684,870	32.6	430,080	41.3
6	Central Interior and Appalachian Alluvial-Riparian Systems	251,040	3.0	2,130	0.2
23	Central Interior and Appalachian Floodplain Systems	84,300	1.0	510	0.0
98	Reservoirs and Ponds	62,610	0.8	850	0.1
8	Central and Southern Appalachian Montane Oak	109,120	1.3	38,640	3.7
9	Southern and Central Appalachian Red Oak-Chestnut Oak	1,816,670	22.1	186,150	17.9
13	Southern Appalachian Oak Forest	1,050,860	12.8	105,990	10.2
10	Allegheny-Cumberland Dry Oak Forest and Woodland	485,370	5.9	59,680	5.7
16	Southern Appalachian Low-Elevation Pine	892,310	10.8	44,450	4.3
18	Southern Appalachian Montane Pine Forest and Woodlands	527,140	6.4	101,280	9.7
	TOTAL	8,234,475	100.0	1,041,021	100.0

Improving Map Unit Accuracy

The accuracy of the 1st approximation Ecological Zone map is good In comparison to other similar Ecological Zone modeling efforts in the Southeastern U.S. (table 10), but can be improved. Model accuracy is affected by several major factors: 1) plot location accuracy, 2) Ecological Zone identification, 3) DTM accuracy, and 4) modeling methods.

1) Plot location accuracy: Incorrect plot locations from poor GPS readings or inaccurate topographic map interpretations can lead to erroneous data and therefore models that do not reflect reality. Furthermore 'ecotone' samples can and may have contributed to modeling errors in the study area. This reality was confirmed by results of the post-processing procedures used to reduce data noise and produce a cleaner product in 2009 within the VA-WVA FLN. Using just 3 majority filters of the 'raw' model, 52 of the 1,321 reference plots (about 4%), shifted into different Ecological Zone map units; 17 of these moved to incorrect classes and thus reduced the overall accuracy by about 2% points. The majority filter command merely replaces individual 1/40th acre cells in a grid based on the majority of their contiguous neighboring cells, a change that would only occur on the edges or interior of a type. These changes observed in plot accuracy indicate the close proximity of these 'shifted' plots to the narrow moisture-temperature-fertility gradients that occur between many Ecological Zones, i.e. the ecotone which is certainly largest around sample sites near type boundaries. Although difficult to capture in GIS modeling, this variability in environmental conditions over short distances is common in the SBR study area where numerous Ecological Zones may be encountered while traversing along only a 100 meter transect in highly dissected landscapes.

2) Ecological Zone field identification: The identification of reference condition (the Ecological Zone) at individual site locations is of equal or greater importance as plot location accuracy in developing a truer representation of landscapes that may have existed prior to Euro-American settlement. Ecological Zone models are evaluated from a sample of plot locations in a study area and from the interpretation of data collected from these areas that uses existing vegetation and often only remnant site indicator species. Incorrect identification of the Ecological Zone can therefore have a major impact on the outcome of map unit extent and accuracy especially for those zones that are hard to recognize because of past disturbance or because of lack of experience in the area by the observer. It should also be noted that these field identification 'errors' are likely accounted for by the MAXENT statistical procedure that evaluates environmental conditions at multiple plots (often in the hundreds), and therefore the models may better represent Ecological Zones than the field evaluation. This is something to consider when analyzing the accuracy assessment matrix (Appendix VII).

3) DTM accuracy: The accuracy of DTMs used to reflect temperature, moisture, and fertility gradients, especially geologic / lithologic type in the study area, has a significant impact on Ecological Zone map unit accuracy. Lithology in the study area influences soil fertility, (also slope and aspect), thus having a major influence on the distribution of Ecological Zones across the complex background of temperature and moisture regimes described by other DTMs. Although lithologic map units were aggregated into just six distinct groups, there were still differences between these grouped map units across State lines; not only map line differences but also map unit labeling differences. An improvement in map unit accuracy could be possible by correlating lithologic map units among the State-wide maps. Also, geologic map unit resolution is not fine enough to identify rock types at scales that some Ecological Zones occur, such as Montane Oak (rich) that is closely aligned with mafic rocks not often depicted by State-wide geology maps.

4) Modeling methods. The 3rd approximation Ecological Zones are based on merging 20 individual Ecological Zone models into one map based upon the zone having the highest probability of occurrence and numerous adjustments along ecotones. Although this seems to be a reasonable approach, other techniques might be evaluated. For example, choosing a threshold probability value for each type that maximizes the correct plot inclusion and minimizes inclusion of plots representing other types could be used to map the location of individual zones having their greatest probability of occurrence. This coverage could then be merged with the maximum probability model to fill areas where these conditions are not met.

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Appendix I: Ecological Zone – BpS / Nature Serve Ecological Systems cross-walk and descriptions

Ecological Zones were cross-walked with LANDFIRE Biophysical Settings (BpS) / Nature Serve Ecological Systems by comparing field observations with descriptions of indicator species and species with high constancy or abundance identified in the "Ecological Zones in the Southern Appalachians: First Approximation" (Simon et. al. 2005), from descriptions of dominant species and site relationships in Nature Serve Ecological Systems (2010), and from LANDFIRE BpS model descriptions (LANDFIRE, 2009). The following was extracted from these sources and from Schafale and Weakley (1990) and Fleming and Patterson (2010). Additional Ecological Zone site or vegetation indicators not included in the 1st approximation NC but identified from local knowledge within the Appalachian study areas are indicated by *italics*. Shortleaf Pine-Oak Heath is **not** included in these descriptions; it is considered the lowest elevational extent of Pine-Oak Heath that occupies narrow ridges within the Shortleaf Pine-Oak Ecological zone and therefore shares compositional and structural characteristics between these two types.

In general, it was not difficult to find agreement (to cross-walk) between BpS, which use Nature Serve Ecological Systems to name map units, and Ecological Zones (that may break an environmental gradient at different points), except for oak-dominated types. Although 'fire adaptation' was not considered in the Ecological Zone breaks, this disturbance component is nonetheless an important factor that can help define the limits of plant community distribution under historic disturbance regimes. Additional information that was used to develop and evaluate the cross-walk included the confusion, i.e., commission and omission errors, among oak-dominated types indicated in the accuracy evaluation matrix (Appendix VII), and the landscape distribution of Ecological Zones compared to the distribution of LANDFIRE BpS map units in the study area.

Grassy Balds and Heath Balds Ecological Zones
This zone was included in the 2nd approximation of Ecological Zones in the Southern Appalachians and represents sites at the highest elevations within the SBR study area that do not support forested plant communities. Grassy balds occur on the domes of high mountains, usually on gentle slopes and are dominated by herbaceous species with patches of shrubs and small trees. The most characteristic dominant species is mountain oak grass. Other frequent dominants are three-tooth cinquefoil, Canada cinquefoil, white-edge sedge, brown sedge, Pennsylvania sedge, perennial bentgrass, Appalachian haircap moss, and wavy hairgrass (Schafale and Weakley 1990).

- BpS / Nature Serve -- <u>Southern Appalachian Shrub and Grass Bald</u>: This ecological system consists of dense herbaceous and shrubland communities in the highest elevational zone of the southern Appalachians, generally above 1524m (5000ft) but occasionally to 1220m (4000ft), and at slightly lower elevations at its northern limit in VA and WV, and in the Cumberland Mountains along the VA-KY border. Vegetation consists either of dense shrub-dominated areas (heath balds) or dense herbaceous cover dominated by grasses or sedges (grassy balds). The combination of high elevation, non-wetland sites and dense herbaceous or shrub vegetation without appreciable rock outcrop conceptually distinguishes this system from all others in the southern Appalachians. However, widespread areas of degraded spruce-fir with grass and shrub cover and the invasion of grassy balds by trees blur the distinction somewhat.

Spruce-Fir Ecological Zone
This zone includes spruce, fir, spruce-fir, and yellow birch-spruce forests and high elevation successional tree, shrub, and sedge communities. This type is the dominant zone at the highest elevations in the Southern Blue Ridge Mountains. Indicator species and species with high constancy or abundance include: Fraser fir, red spruce, mountain ash, yellow birch, mountain woodfern, Pennsylvania sedge, mountain woodsorrel, hobblebush, fire cherry, *clubmoss*, various bryophytes, and Catawba rhododendron.

- BpS / Nature Serve -- <u>Central and Southern Appalachian Spruce-Fir Forest</u>: This system consists of forests in the highest elevation zone of the Blue Ridge and parts of the Central Appalachians generally dominated by red spruce, Fraser fir, or by a mixture of spruce and fir. Elevation and orographic effects make the climate cool and wet, with heavy moisture input from fog as well as high rainfall. Understory species are variable and include rhododendron, mountain woodsorrel, hobblebush, Pennsylvania sedge, mountain ash, and various mosses.

Northern Hardwood Ecological Zones (slope and cove)
This type was split into two zones -- Northern Hardwood Slopes, and Northern Hardwood Coves in the second approximation (Simon 2008), and in the VA_WVA FLN study area. <u>Northern Hardwood Slopes</u> include beech gaps, and Northern Hardwood plant communities occurring on upper convex slopes and ridges. Indicator species include: American beech, Pennsylvania sedge, northern red oak, *eastern hemlock*, *striped maple*, *sweet birch*, *hay-scented fern*, and Allegheny service berry. <u>Northern Hardwood Coves</u> include high elevation boulder fields, and Northern Hardwood plant communities that occur on toeslopes, and coves, i.e., broad to narrow concave drainages at higher elevations. In the Appalachians, this type can be viewed as the highest elevation extension of Rich Coves. Indicator species and species with high constancy or abundance include yellow birch, sugar maple, black cherry, northern red oak, mountain holly, *Basswood*, Canadian woodnettle, *black cohosh*, *blue cohosh*, and ramps; the lack of Tulip Poplar and Ginseng appear to be good indicators of where this type 'transitions' to Rich Coves.

- BpS / Nature Serve -- <u>Southern Appalachian Northern Hardwood</u>: High elevation sites in the Southern Appalachians. Generally occurring on all topographic positions above 1372m (4500ft) in the southern extent of the range, elevations may be considerably lower in the northern part of the range. At elevations greater than 1676m (5500ft) (975m in W. Virginia), spruce-fir forests become the predominant type, though the range of this sub-type is extremely limited within this zone. Soils are highly variable, ranging from deep mineral soils to well-developed boulderfields. Soils are most often rocky and acidic, with low base saturation. A thick organic soil layer is frequently present. Overall hydrology is mesic, ranging from wet in bogs, seeps, and the most protected sites to dry-mesic on some exposed upper slopes and ridges. Mesic conditions are maintained by high annual rainfall, frequent fog deposition, low temperatures, and heavy shading.

Acidic Cove Ecological Zone
This zone includes hemlock and mixed hardwood-conifer forests typically dominated by an evergreen understory occurring in narrow coves (ravines) and often extending up on adjacent protected, north-facing slopes. Indicator species and species with high constancy or abundance include great rhododendron, eastern hemlock, black birch, heartleaf species, partridgeberry, mountain doghobble, eastern white pine, yellow-poplar, common greenbrier, chestnut oak, and red maple.

- BpS / Nature Serve – Southern and Central Appalachian Cove Forest: This system consists of mesophytic hardwood or hemlock-hardwood forests of sheltered topographic positions. Examples are generally found on concave slopes that promote moist conditions. The system includes a mosaic of acidic and "rich" coves that may be distinguished by individual plant communities based on perceived difference in soil fertility and species richness. Both acidic and rich coves may occur in the same site, with the acidic coves potentially creeping out of the draw-up to at least midslope on well-protected north-facing slopes. Characteristic species in the canopy include yellow buckeye, sugar maple, white ash, American basswood, tulip poplar, silverbell, eastern hemlock, American beech, and magnolias. Understories can include high diversity and density in the herbaceous layer or a sparse herbaceous layer over-topped by dense rhododendron and / or dog hobble.

Mixed Oak / Rhododendron Ecological Zone
This zone was not included in the 1st approximation NC but was included in the 2nd approximation and labeled "Mixed Oak / Heath". It is confined to steep, mostly north-facing mid to upper slopes adjacent to the Acidic Cove Ecological Zone and therefore can be considered a refinement of this type, however, the overstory is dominated by oaks. Indicator species and species with high abundance include great rhododendron, northern red oak, chestnut oak, black birch, and tulip poplar.

- BpS / Nature Serve – Southern and Central Appalachian Cove Forest: See description above.

Rich Cove Ecological Zone
This zone includes mixed mesophytic forests typically dominated by a diverse herbaceous understory and occurs in broader coves and on adjacent protected slopes (mostly north to north-east facing). Indicator species and species with high constancy or abundance include black cohosh, American ginseng, blue cohosh, mandarin, bloodroot, northern maidenhair fern, Dutchman's pipe, rattlesnake fern, mountain sweet-cicely, Appalachian basswood, yellow buckeye, white ash, yellow-poplar, *wood nettle*, *cucumber magnolia*, and northern red oak.

- BpS / Nature Serve – Southern and Central Appalachian Cove Forest: This system consists of mesophytic hardwood or hemlock-hardwood forests of sheltered topographic positions. Examples are generally found on concave slopes that promote moist conditions. The system includes a mosaic of acidic and "rich" coves that may be distinguished by individual plant communities based on perceived difference in soil fertility and species richness. Both acidic and rich coves may occur in the same site, with the acidic coves potentially creeping out of the draw-up to at least midslope on well-protected north-facing slopes. Characteristic species in the canopy include yellow buckeye, sugar maple, white ash, American basswood, tulip poplar, silverbell, eastern hemlock, American beech, and magnolias. Understories can include high diversity and density in the herbaceous layer or a sparse herbaceous layer over-topped by dense rhododendron and / or dog hobble.

Alluvial Forest Ecological Zone (Riparian_Alluvial Forest & Riparian_Streamside)
This zone was not included in the 1st approximation NC. Riparian_Alluvial Forest was added in the 2nd approximation and labeled "Alluvial Forest". These zones characterize small floodplains that support alluvial forests and imbedded riparian areas and overlap with smaller riparian areas associated with sites adjacent to streams that support Acidic Cove or Rich Cove Ecological Zones. Characteristic trees in this zone include sycamore, river birch, silver maple, tulip poplar, and box elder. The understory is highly variable, depending upon the time since the last flooding event but common species may include paw-paw, spicebush, and switchgrass.

- BpS /Nature Serve – Central Appalachian Stream and Riparian: This riparian system occurs over a wide range of elevations and develops on floodplains and shores along river channels that lack a broad flat floodplain due to steeper sideslopes, higher gradient, or both. It may include communities influenced by flooding, erosion, or groundwater seepage. The vegetation if often a mosaic of forest, woodland, shrubland, and herbaceous communities. Common trees include river birch, sycamore, and box elder. Open, flood-scoured rivershore prairies feature switchgrass, big bluestem, and twisted sedge is typical of wetter areas near the channel.

  The fluvial features (river terraces, oxbows, alluvial flats, point bars, and streamside levees) typical of (large) river floodplains occur less frequently and on a smaller scale along these small streams. Fine-scale alluvial floodplain features are abundant. In pre-European settlement forests, community diversity in these streamside systems was much more complex than in the modified landscapes of today. Fire, beaver activity, and flooding of varied intensity and frequency created a mosaic whose elements included canebrake, grass and young birch / sycamore beds on reworked gravel or sand bars, beaver ponds, and grass-sedge meadows in abandoned beaver clearings, as well as the streamside zones and mixed hardwood and/or pine forests that make up more than 95% of the cover that exists today. These systems have little to no floodplain development (i.e., floodplains, if present, are not differentiated into levees, ridges, terraces, and abandoned channel segments) and are typically higher gradient than larger floodplains, experiencing periodic, strong flooding of short duration (Nature Serve 2010).

Large Floodplain Ecological Zone
This zone was first included in the VA_WVA FLN and George Washington NF study area. It relies entirely on descriptions from Nature Serve. Most all of the Floodplain Ecological Zone has been highly altered, not in USFS ownership or other conservation tracts, likely farmed by Native Americans, and therefore difficult to characterize.

- BpS / Nature Serve – <u>Central Appalachian River Floodplain</u>: This system encompasses floodplains of medium to large rivers and can include a complex of wetland and upland vegetation on deep alluvial deposits and scoured vegetation on depositional bars and on bedrock where rivers cut through resistant geology. This complex includes floodplain forests in which silver maple, cottonwood, and sycamore are characteristic, as well as herbaceous sloughs, shrub wetlands, riverside prairies and woodlands. Most areas are underwater each spring; microtopography determines how long the various habitats are inundated. Depositional and erosional features may both be present depending on the particular floodplain.

High Elevation Red Oak Ecological Zone
This zone includes forests dominated by northern red oak on exposed slopes and ridges at higher elevations. Site extremity and exposure results in stunted and often windswept tree form, however, there is a broad transition between this extreme and the more common Montane Oak-Hickory (slope) Ecological Zone; the break between these two types is complicated primarily by past management practices, especially timber harvest intensity and ground disturbance. Indicator species and species with high constancy or abundance include: northern red oak, American chestnut, flame azalea, whorled yellow loosestrife, Pennsylvania sedge, speckled wood-lily, highbush blueberry, mountain laurel, *hayscented fern*, *witchhazel*, *striped maple*, and New York fern.

- Bps / Nature Serve -- <u>Central and Southern Appalachian Montane Oak Forest</u>: This generally oak-dominated system is found in the central and southern Appalachian Mountains. These high-elevation deciduous forests occur on exposed sites, including ridgecrests and south- to west-facing slopes. In most associations attributed to this system, the soils are thin, weathered, nutrient-poor, low in organic matter, and acidic. The forests are dominated by oaks, most commonly red oak and white oak with the individuals often stunted or wind-flagged. American chestnut sprouts are common. Characteristic shrubs include mountain holly and early azalea.

Montane Oak-Hickory (rich, slope, cove) Ecological Zones
These zones includes mesic to submesic mixed-oak and oak-hickory forests that occur along broad mid- to higher elevation ridges and smooth to concave slopes below the highest and more narrow ridges where this zone forms a gradual transition to the High Elevation Red Oak and Northern Hardwood zones. It also includes drainage headlands at mid to higher elevations that merge with Rich Coves and Northern Hardwood Cove Ecological Zones, lower to mid elevations in often narrow sub-mesic coves that merge with Dry-Mesic Ecological Zones, and more exposed slopes in very close proximity with High Elevation Red Oak Ecological Zones. Forests in this zone are often floristically diverse. Indicator species and species with high constancy or abundance include: northern red oak, white oak, flowering dogwood, tulip poplar, Canada richweed, mockernut hickory, New York fern, pignut hickory, white ash, chestnut oak, *magnolias*, *sweet birch*, *striped maple*, and *witchhazel*

--- Montane Oak-Hickory (Rich): Dominance by northern red oak characterizes these forests. Community types in this zone are known from the southern part of the Central Appalachians, extending into the extreme northern portions of the Southern Blue Ridge, Southern Ridge and Valley, and Cumberland Mountains. Favorable sites are upper slopes and ridge crests with deep, base-rich soils weathered from mafic and calcareous parent material. The characteristic expression of this community is that of an oak or oak-hickory forest with an herb layer that resembles that of a rich cove forest. Northern red oak is the most constant member of the overstory but usually shares dominance with red hickory, shagbark hickory, and white ash. The shrub layer is typically sparse. Most stands have a lush and generally diverse herb layer; black cohosh and eastern waterleaf are the most characteristic herb species. At higher elevations, where the type is transitional to northern red oak forests, eastern hayscented fern often dominates the herb layer in large clones (Fleming and Patterson, 2010).

--- Montane Oak-Hickory (Cove and Slope): These zones more closely fit the Mesic Oak-Hickory type described in the NC 1st approximation. They are either confined to broad coves and concave lower slopes (cove type) or to the mid-to higher elevation upper slopes and form a broad transition with more exposed, wind-swept types that support High Elevation Red Oak. Indicator species and species with high abundance include northern red oak, tulip poplar, chestnut oak, and New York fern.

- BpS / Nature Serve -- <u>Central and Southern Appalachian Montane Oak Forest</u>: This generally oak-dominated system is found in the central and southern Appalachian Mountains. These high-elevation deciduous forests occur on exposed sites, including ridgecrests and south- to west-facing slopes. In most associations attributed to this system, the soils are thin, weathered, nutrient-poor, low in organic matter, and acidic. The forests are dominated by oaks, most commonly red oak and white oak with the individuals often stunted or wind-flagged. American chestnut sprouts are common. Characteristic shrubs include mountain holly and early azalea. **Based on the Nature Serve description for this type, this is an uncomfortable fit in the Montane Oak-Hickory (Slope) Ecological Zone unless a broader Nature Serve concept is assumed that includes more sub-mesic forests**. The majority of this Ecological Zone coincides with the LANDFIRE BpS - Montane Oak Ecological Systems map units within the CNF study area. This may indicate that the LANDFIRE modelers were working with a broader concept (more similar to Ecological Zones) than what is being described in this Nature Serve type.

- BpS / Nature Serve – <u>Southern and Central Appalachian Northern Red Oak-Chestnut Oak Forest</u> (provisional type used for the TN Restoration Initiative): This system consists of mixed oak forests on predominantly submesic slopes at elevations from 600 to 1200 m (2000-4000 feet) in the northern part of the Southern Appalachians. It occurs on various topographic positions from lower to upper slopes and crests, in deep, infertile soils. Mature stands have a well-developed canopy of trees 30 m or more tall. Northern Red oak is the leading overstory dominant, with only slightly higher density and basal area than Chestnut oak. Most stands are mixed, although either species can dominate small areas. One or both of the magnolias, Cucumber tree or Fraser's magnolia, are usually important in the overstory or understory. Minor canopy associates vary and can include White oak, Sweet birch, Red maple, hickories, American beech, Eastern hemlock, and Tulip poplar. Most of the preceding species may be present in the understory, along with Striped maple, Sourwood, White pine, Downy serviceberry, and Allegheny serviceberry, and sprouts of American chestnut. Striped maple is consistently the most important small tree / shrub. Other shrubs that are less constant but sometimes important include Witch-hazel, Great rhododendron, Mountain holly, Maple-leaved viburnum, and Hillside blueberry. The herb layer is often patchy to sparse, with Indian cucumber-root, Galax, Squaw root, New York fern, and Hay-scented fern. In the higher part of the elevational range, however, the latter two ferns may greatly dominate the herb layer and cover more substantial areas (Fleming and Patterson, 2010).

Dry-Mesic Oak Ecological Zone
This zone was included in the Dry and Dry-Mesic Oak-Hickory type in the 1st approximation NC but separated into its components -- Dry Oak and Dry-Mesic Oak in the 2nd approximation both in the KY FLN (Simon 2009) and in the VA_WVA FLN study areas (Simon 2010). This zone is very similar to the Montane Oak-Hickory zone but occurs at lower elevations. It includes dry-mesic, mixed-oak forests that occur along broad lower to mid elevation ridges and smooth to concave slopes and lower elevation drainage headlands, and often narrow, drier coves. Indicator species and species with high constancy or abundance include: *white oak, black oak,* scarlet oak, flowering dogwood, sourwood, low bush blueberry, and huckleberries.

- BpS / Nature Serve -- <u>Southern Appalachian Oak Forest</u>: This system consists of predominantly dry-mesic (to dry) forests occurring on open and exposed topography at lower to mid elevations. Characteristic species include chestnut oak, white oak, red oak, black oak, scarlet oak, with varying amounts of hickories, blackgum, and red maple. Some areas (usually on drier sites) now have dense evergreen ericaceous shrub layers. Northward this system grades into Northeastern Interior Dry-Mesic Oak Forest type.

Dry Oak Heath Ecological Zones (evergreen and deciduous heath types)
This zone, called Chestnut Oak Heath in the 1st approximation NC, includes xeric to dry mixed-oak forests typically dominated by an ericaceous (evergreen or deciduous) understory and represents the driest zone where oaks are the dominant species. In general, in the SBR study area, the Dry Oak/deciduous heath zone is more transitional to the Dry-Mesic Oak Ecological Zone and the Dry Oak/evergreen heath zone is more transitional to the Pine-Oak Heath Ecological Zone, however, and in VA varies considerably according to slope position (and the predominantly east or west-facing side of major ridges). Further work is needed to differentiate these two zones to separate what is truly an environmental influence and what may be an influence of current fire return interval. Indicator species and species with high constancy or abundance include: chestnut oak, *scarlet oak*, northern red oak, mountain laurel (in the evergreen heath type), *black huckleberry* & *hillside blueberry (*in the deciduous type), red maple, great rhododendron, and sourwood.

- BpS / Nature Serve -- <u>Allegheny-Cumberland Dry Oak Forest and Woodland:</u> These forests were typically dominated by White oak, Black oak, Chestnut oak, and Scarlet oak with lesser amounts of Red maple, Pignut hickory, and Mockernut Hickory. These occur in a variety of situations, most likely on nutrient-poor or acidic soils and, to a much lesser extent, on circumneutral soils. American chestnut was once dominant or codominant in many of these forests and sprouts of American chestnut can often be found where it was formerly a common tree. Small inclusions of Shortleaf pine and/or Virginia Pine may occur, particularly adjacent to escarpments or following fire. In the absence of fire, White pine may invade some stands (Nature Serve 2010). Today, subcanopies and shrub layers are usually well-developed. Some areas (usually on drier sites) now have dense evergreen ericaceous shrub layers of mountain laurel, fetterbush, or on more mesic sites rhododendron. Other areas have more open conditions.

Shortleaf Oak- Pine Ecological Zone
This zone includes dry to dry-mesic pine-oak forests dominated by shortleaf pine and/or pitch pine that occur at lower elevations on exposed broad ridges and sideslopes. Indicator species and species with high constancy or abundance include: shortleaf pine, *pitch pine*, sourwood, sand hickory, scarlet oak, southern red oak, post oak, hillside blueberry, American holly, featherbells, *black huckleberry*, and spring iris.

- BpS / Nature Serve -- <u>Southern Appalachian Low-Elevation Pine</u>: This system consists of shortleaf pine- and Virginia pine-dominated forests in the lower elevation Southern Appalachians and adjacent Piedmont and Cumberland Plateau. Examples can occur on a variety of topographic and landscape positions, including ridgetops, upper and midslopes, as well as low elevation mountain valleys in the Southern Appalachians. Under current conditions, stands are dominated by shortleaf pine and Virginia pine. Pitch pine may sometimes be present and hardwoods are sometimes abundant, especially dry-site oaks such as southern red oak, *post oak*, *blackjack oak*, chestnut oak, scarlet oak, but also pignut hickory, red maple, and others. The shrub layer may be well-developed, with hillside blueberry, black huckleberry, or other acid-tolerant species most characteristic. Herbs are usually sparse but may include narrowleaf silkgrass and goat's rue.

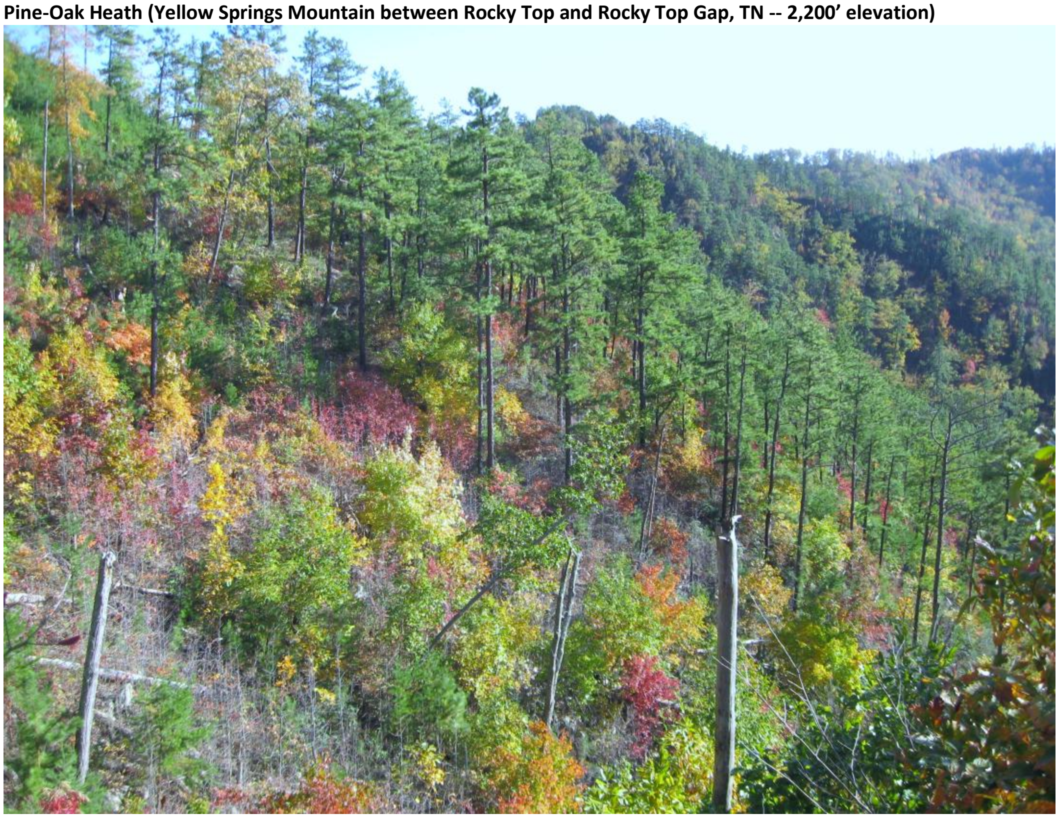
Pine-Oak Heath Ecological Zone
This zone was included in the Xeric Pine-Oak Heath-Oak Heath type in the 1st approximation NC but separated into three pine-oak heath types in the VA_WVA FLN and GW study areas. This differentiation was not made in the SBR study area. Indicator species and species with high constancy or abundance in all three types include: Table Mountain pine, scarlet oak, chestnut oak, pitch pine, black huckleberry, mountain laurel, hillside blueberry, *bear oak (occasionally in the South Mts.)*, and wintergreen.

- Bps / Nature Serve – <u>Southern Appalachian Montane Pine Forest</u>: This system consists of predominantly evergreen woodland (or more rarely forests) occupying very exposed, convex, often rocky south- and west-facing slopes, ridge spurs, crests, and cliff-tops. Most examples are dominated by Table Mountain pine, often with Pitch pine and / or Virginia pine and occasionally Carolina hemlock. Based on the component Associations, understories commonly include mountain laurel, black huckleberry, and hillside blueberry.

Appendix II: photos of plant communities in selected Ecological Zones

Shortleaf Pine-Oak (Apple Pie Mtn., Chattahoochie NF -- 1,780' elevation)

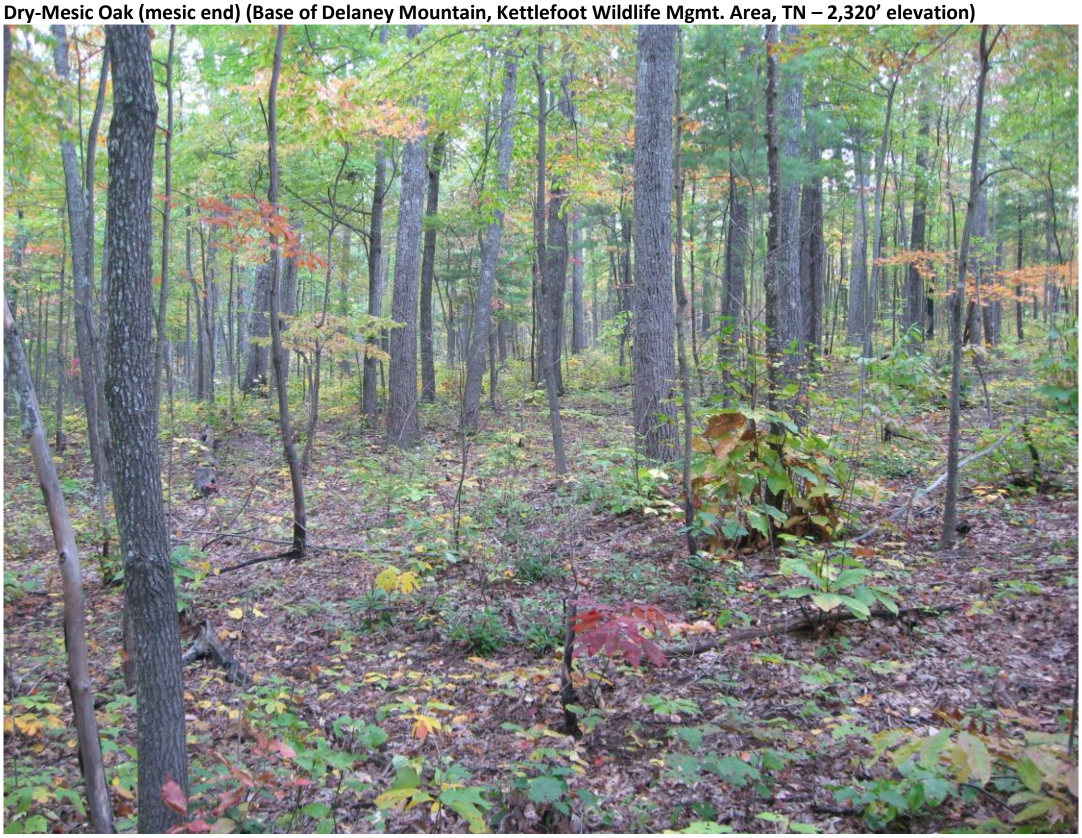
Pine-Oak Heath (Yellow Springs Mountain between Rocky Top and Rocky Top Gap, TN -- 2,200' elevation)



Dry Oak / Evergreen Heath (Ridge and Valley, VA – 3,560' elevation)

Dry Oak / Deciduous Heath (Meadow Ck. Mts., head of South fork, Yellow Spring Branch, TN – Elev. 1,940)

Dry-Mesic Oak (mesic end) (Base of Delaney Mountain, Kettlefoot Wildlife Mgmt. Area, TN – 2,320' elevation)



Montane Oak Cove (High Peak, South Mts. NC – 2,500' elevation)

Montane Oak Slope (north of Meadow Ck. Mt., GW National Forest, WVA – 3,200' elevation)

Montane Oak Slope / transition to Rich Cove (Holston Mountain, Red Eye Ridge, TN – 3,590' elevation)

Montane Oak Rich (northeast of Three Ridges Overlook, Blue Ridge Mts., VA – 3,060' elevation)

High Elevation Red Oak (Shenandoah Mt., VA, north or Middle Ridge – 3,700' elevation)

Appendix III: Methods used in developing Digital Terrain Models (DTMS)

The following DTMs were developed to characterize broad to mid-scale terrain, climate, geology, and solar radiation influences that control temperature, moisture, fertility, and solar inputs on landscapes in the Southern Blue Ridge study area. These environmental factors affect the distribution of Ecological Zones and their component plant communities in different landscapes. They were used to develop site specific probability values for each Ecological Zone based upon their correlation to reference field sample locations for each type. All processing of 2nd derivative grids (slope, aspect, etc.) used a 20 ft. DEM except Valley position, Relief, and Solar Radiation, which were evaluated with 90 ft. grid size. For the entire SBR study area, all DTMS were processed using the NAD 1983 StatePlane North Carolina FIPS 4100 Feet coordinate system.

1-2) <u>aspect (raw and transformed)</u>

Aspect is a measure of aspect at each cell location derived from the elevation DEM. The following steps were performed to produce aspect:

a. GRID function ASPECT from the DEM filled for sinks (elev_fill). = aspectraw
b. Convert degrees to radians (1 degrees = 0.0174532925 radian), in raster calculator: (ASPECT * 0.017432925). This is done because cosine measurements for a continuous aspect variable are derived from radians and not degrees.
c. Calculate cosine using ARC TOOLBOX Spatial Analyst Tools, Math, Trigometric, Cos. Value varies from -1 to 1 = aspectrans

3) <u>curve</u>

The curvature of a surface at each cell center in a 3x3 neighborhood derived from the DEM: used GRID curvature function. NOTE: if the DEM used has z units (height) in feet while the x,y units are in meters, then a z-factor of 0.3048 (1 ft = 0.3048 meters) must be used and is part of the ESRI tools options for calculation of curvature. This was not necessary for the SBR study area because x,y, and z units were all in feet.

4) <u>curveplan</u>

The curvature of a surface in a 3x3 neighborhood perpendicular to the slope direction derived from the DEM: GRID curvature function with {out_plan_curve} - an optional output grid referred to as the planiform curvature.

5) <u>curvepro</u>

The curvature of surface in a 3x3 neighborhood in the direction of slope derived from the DEM: GRID curvature function with {out_profile_curve} - an optional output grid showing the rate of change of slope for each cell.

6) <u>elevation (feet)</u>

Elevation for the North Carolina portion of the study area was extracted from digital elevation models (DEMs) available at: http://www.ncdot.org/it/gis/. These are 20 ft resolution, 16 bit unsigned integer, grids with a NAD_1983_Stateplane_North_Carolina_FIPS_3200_feet projection, and D_North_American_1983 datum. The following process was used to build the elevation DTM for the study area:

a) Download and mosaic DEMS for the following NC counties: Allegheny, Ashe, Avery, Buncombe, Burke, Caldwell, Cherokee, Clay, Cleveland, Graham, Haywood, Henderson, Jackson, Macon, Madison, Mitchell, McDowell, Polk, Rutherfordton, Surry, Swain, Transylvania, Watauga, Wilkes, Yancey .

b) Project DEM from the TN study to NAD_1983_Stateplane_North_Carolina (acquired from the National Map Seamless Server), resample, using cubic convolution to 20 ft., and mosaic with the NC DEM.

c) Use the National Map Seamless Server http://sea,;ess/isgs/gpv/website/seamless/viewer.htm
to download 1/3" NED DEM segments for the remainder of the study area in TN, SC, and GA, mosaic these, project to NAD_1983_Stateplane_ North Carolina, change z values to feet (DEM *3.28084), convert to integer, resample using cubic convolution to 20 ft., and mosaic with the NC_TN DEM above. Label as elev20ft.

e) Resample to 30 feet, and derive other DTMS from these coverages.

<u>7-12) Distance to geology type</u>

Combine state geology coverages from Tennessee, Georgia, South Carolina, North Carolina, and finer resolution Hatcher mapping and quad mapping in North Carolina. Clip to an approximately 9 million acre area. The following steps were used to create the final DTMs.

1. Add item "group" and use Peper et.al (2001), Appendix 2: 'Table of numerical lithogeochemical codes and original geologic map symbols' to match geologic map symbols to their appropriate lithogeochemical code and populate the "group" item. The following group codes were used:
   1 = CARBONATE-BEARING ROCKS
   2 = MAFIC SILICATE ROCKS
   3 = SILICICLASTIC ROCKS
   4 = SULFIDIC ROCKS
   6 = MIXED SILICICLASTIC -MAFIC ROCKS; 7 = ULTRAMAFIC ROCKS
2. Create 6 separate grids for each of the lithogeochemical groups.
3. Calculate distance (Euclidean) to each of the grids to help 'smooth' the differences in scales and mapping resolution.
4. Document geology groupings (Appendix VIII).

13-14) Landform10 and Landform 30

These two metrics estimate landform surface shape within a 10x10 and 30x30 pixel neighborhood. It is used to characterize narrow and broader ridges observed in the study area that may differentiate between High-Elevation Red Oak Forests seen on more narrow ridges from Montane Oak (rich type) seen on slightly broader ridges, and to better characterize the broad landforms at lower elevations that may support Low Elevation Pine. They are calculated by averaging the profile curvature within a moving 10x10 and 30x30 pixel, circular window.

```
c:\tn\dtms\lform10 = focalmean (c:\tn\dtms\curvepr, circle, 10)
c:\tn\dtms\lform30 = focalmean (c:\tn\dtms\curvepr, circle, 30)
```

15) lfi

LFI (landform index) is an index of landform shape (site protection) and macro-scale landform derived from the DEM. Larger number = more concave shape, more protected landform. From: *McNab, W.H. 1996. Classification of local- and landscape-scale ecological types in the Southern Appalachian Mountains. Environmental Monitoring and Assessment 39:215-229.* The software TopoMetrix is required to calculate LFI. The calculation of LFI is data intensive and requires very large RAM, and caching capability and therefore will not perform except on rather small DEMs.

Processing lfi from topometrix requires the following steps:

a) clip DEM to reasonable-sized area using 12-digit HUC boundaries (from USGS national coverage) … this ranges from 1 to 4 HUCS
b) convert the clipped elevation to .asc file
c) run lfi in topometrix and save as .asc file
d) in ArcMap, convert .asc grid TO floating point grid
e) define projection (projections get dropped between steps 2 and 4)
f) set null for all grid values < -100 (outside poly boundary)
g) mosaic these grids together – When watersheds are used as clip areas there is no overlapping area, however, the boundary areas may show some "nodata" that need to be filled; use the typical method to accomplish this, i.e., fill null values with the average values based upon the adjacent grid cells with values. If clip areas are user defined then use BLEND (the output cell value of the overlapping areas will be a blend of values that overlap; this blend value relies on an algorithm that is weight based and dependent on the distance from the pixel to the edge within the overlapping areas).
h) multiply this grid by 0.001 because raw topometrix values do not match McNab definition of LFI values.
i) Some new areas have values above 10 (just a very few)…. Set areas > 1.4 to null
   ```
   f:\3rd_approx\lficalc\merge_a = setnull(f:\3rd_approx\lficalc\mergelast5 > 1.4, f:\3rd_approx\lficalc\mergelast5)
   ```
   fill in all null values
   ```
   f:\3rd_approx\lficalc\temp1 = con(isnull(f:\3rd_approx\lficalc\merge_a), focalmean (f:\3rd_approx\lficalc\merge_a, rectangle, 3, 3), f:\3rd_approx\lficalc\merge_a)
   f:\3rd_approx\lficalc\temp2 = con(isnull(f:\3rd_approx\lficalc\temp1), focalmean (f:\3rd_approx\lficalc\temp1, rectangle, 3, 3), f:\3rd_approx\lficalc\temp1)
   ```
   done 10 times, then 5 times 10x10
j) Mosaic with North Escarpment; fill null values
k) Resample to 30 ft

16) Average Precipitation

Average precipitation in inches. Based on average annual precipitation from 1971-2000. Distribution of the point measurements to a spatial grid was accomplished using the PRISM model, developed and applied by Chris Daly of the PRISM (Parameter-elevation Regressions on Independent Slopes Model) Climate Group at Oregon State University. There are many methods of interpolating climate from monitoring stations to grid points. Some provide estimates of acceptable accuracy in flat terrain, but few have been able to adequately explain the extreme, complex variations in climate that occur in mountainous regions i.e., (orographic effects are included in the PRISM model). Point precipitation can be estimated at a spatial precision no better than half the resolution of a cell. For example, the precipitation data were distributed at a resolution of approximately 4km. Therefore, point precipitation can be estimated at a spatial precision no better than 2km.

Data was downloaded from: ftp://Prism.oregonstate.edu/pub/Prism/Maps/precipitation/total/Regional/. Files were converted from shapefile to grid after clipping to the study area boundary. Average precipitation ranges from 39" to 119".

17) Local Relief

Local relief is a measure of the difference in elevation between the watershed divide and the valley floor relative to a cell's location. See above procedure for valley position.

Fill all nodata values with mean of adjacent cells
```
h:\sbr_bu\dtms\relieftemp1 = con(isnull(h:\sbr_bu\dtms\relief2), focalmean(h:\sbr_bu\dtms\relief2, rectangle, 3, 3), h:\sbr_bu\dtms\relief2)
```
(repeated 5 times)

Resample to 30 feet

18-19) <u>(rsp1, rsp2)</u>
RSP (relative slope position) is an estimate of the slope position at each cell location relative to the nearest ridge and drainage (Wilds 1996). A value of 100 represents the bottom of the slope and 0 the top of the slope (the ridge). Relative slope position uses (1) a threshold level of flow accumulation to represent slope bottom, (2) the difference between mean elevation and highest elevation in a moving window to represent ridges, and (3) flow-length to calculate distance to the top or bottom. Steps to produce RSP performed with the raster calculator:

a) GRID commands: note* create flowdirection and flowaccumulation (floating point) coverages from the elevationgrid first
b) f:\3rd_approx\dtms\streams7temp = con(f:\3rd_approx\dtms\flowacc20 < 806, 1) 7.4 acres (for 20x20 ft grid cells)
   streams20temp = con(flowacc20 < 2178, 1) 20 acres (for 20x20 ft grid cells)

c) f:\3rd_approx\dtms\streams_flip2 = con(isnull(f:\3rd_approx\dtms\streams7temp), 1, 0)
d) f:\3rd_approx\dtms\streams_thin2 = thin(f:\3rd_approx\dtms\streams_flip2)
e) f:\3rd_approx\dtms\streams2 = setnull(f:\3rd_approx\dtms\streams_thin2 > 0, 1)
f) setmask streams2 (do in spatial analysis, options)
g) f:\3rd_approx\dtms\flow_dir2 = f:\3rd_approx\dtms\flowdir20
h) setmask off (do in spatial analysis, options)
i) f:\3rd_approx\dtms\flow_down = flowlength(f:\3rd_approx\dtms\flow_dir2, #, downstream)
j) f:\3rd_approx\dtms\mean = focalmean (f:\3rd_approx\dtms\elev_20ft, rectangle, 20, 20)
   … 10x10 for 2.75 acres, 20x20 for 7.4 acres, and 30 x 30 for 20 acres.
k) f:\3rd_approx\dtms\differ = f:\3rd_approx\dtms\mean - f:\3rd_approx\dtms\elev_20ft
l) f:\3rd_approx\dtms\ridges = con(f:\3rd_approx\dtms\differ < -20, 1, 0)
   … < -10 for 2.75 acres, < -20 for 7.4 acres, and < -40 for 20 acres
m) f:\3rd_approx\dtms\thin_ridges = thin(f:\3rd_approx\dtms\ridges, #, #, #, 15)
n) f:\3rd_approx\dtms\top = setnull(f:\3rd_approx\dtms\thin_ridges > 0, 1)
o) setmask top
p) f:\3rd_approx\dtms\flow_dir3 = f:\3rd_approx\dtms\flow_dir2
q) setmask off
r) f:\3rd_approx\dtms\flow_up = flowlength(f:\3rd_approx\dtms\flow_dir3, #, upstream)
s) f:\3rd_approx\dtms\rsp_float = f:\3rd_approx\dtms\flow_up / (f:\3rd_approx\dtms\flow_up + f:\3rd_approx\dtms\flow_down)
   (this puts large number on btm)
t) f:\3rd_approx\dtms\rspa = int(f:\3rd_approx\dtms\rsp_float * 100)
u) f:\3rd_approx\dtms\rspb = con(f:\3rd_approx\dtms\thin_ridges == 1, 0, f:\3rd_approx\dtms\rspa)
v) f:\3rd_approx\dtms\rspc= con(f:\3rd_approx\dtms\streams_thin2 == 1, 100, f:\3rd_approx\dtms\rspb)
w) f:\3rd_approx\dtms\rspfinal = focalmean (f:\3rd_approx\dtms\rspc, rectangle, 3, 3)

   This was run with both 7.4 and 20 acre minimum flow accumulation.

20) <u>Slopelength</u>
Slope length is an estimate of the cell position along a slope segment, from the ridges (major and tertiary) to the bottom of the slope. The ridges and slope bottom were estimated following similar procedures the RSP calculation (Wilds 1996) equals the sum of 'flowup' and 'flowdown' from rsp1 (uses 7.4 acres to accumulate enough to start stream).

Steps to produce slopelength performed with the raster calculator:

a) GRID commands: note* create flowdirection and flowaccumulation (floating point) coverages from the elevation grid first.
   f:\3rd_approx\dtms\streams7temp = con(f:\3rd_approx\dtms\flowacc20 < 806, 1) 7.4 acres (for 20x20 ft grid cells)
b) f:\3rd_approx\dtms\streams_flip2 = con(isnull(f:\3rd_approx\dtms\streams7temp), 1, 0)
c) f:\3rd_approx\dtms\streams_thin2 = thin(f:\3rd_approx\dtms\streams_flip2)
d) f:\3rd_approx\dtms\streams2 = setnull(f:\3rd_approx\dtms\streams_thin2 > 0, 1)
e) setmask streams2 (do in spatial analysis, options)
f) f:\3rd_approx\dtms\flow_dir2 = f:\3rd_approx\dtms\flowdir20
g) setmask off (do in spatial analysis, options)
h) f:\3rd_approx\dtms\flow_down = flowlength(f:\3rd_approx\dtms\flow_dir2, #, downstream)
i) f:\3rd_approx\dtms\mean = focalmean (f:\3rd_approx\dtms\elev_20ft, rectangle, 20, 20)
j) f:\3rd_approx\dtms\differ = f:\3rd_approx\dtms\mean - f:\3rd_approx\dtms\elev_20ft
k) f:\3rd_approx\dtms\ridges = con(f:\3rd_approx\dtms\differ < -20, 1, 0)
l) f:\3rd_approx\dtms\thin_ridges = thin(f:\3rd_approx\dtms\ridges, #, #, #, 15)
m) f:\3rd_approx\dtms\top = setnull(f:\3rd_approx\dtms\thin_ridges > 0, 1)
n) setmask top
o) f:\3rd_approx\dtms\flow_dir3 = f:\3rd_approx\dtms\flowdir20
p) setmask off
q) f:\3rd_approx\dtms\flow_up = flowlength(f:\3rd_approx\dtms\flow_dir3, #, upstream)
r) f:\3rd_approx\dtms\slopelength1 = f:\3rd_approx\dtms\flow_up + f:\3rd_approx\dtms\flow_down
   This results in values > 7000ft scattered, set these to null
s) f:\3rd_approx\dtms\slopelength2 = setnull(f:\3rd_approx\dtms\slopelength1 > 7000, f:\3rd_approx\dtms\slopelength1)
   Fill in null values from above and streams

t) f:\3rd_approx\dtms\slopelength4 = con(isnull(f:\3rd_approx\dtms\slopelength3), focalmean(f:\3rd_approx\dtms\slopelength3, rectangle, 3, 3), f:\3rd_approx\dtms\slopelength3)

21) <u>slope</u>
The rate of maximum change in z value (elevation_ft) from each cell derived from the DEM: GRID function slope with percentrise.

22) <u>solar</u>
The yearly solar radiation per cell derived from the DEM. See "Area Solar Radiation" in ARC TOOLBOX, Spatial Analyst Tools, Radiation.
Processing was performed on the elevation grid re-sampled to 90.00 ft. grid cell size.
This elevation grid must be converted to a floating point – AND – environmental settings need to be at default levels.

<u>23-24) Stream influence</u>

<u>DSTRM (distance to stream</u>) is a measure of each cell's distance to the nearest stream, regardless of stream order. Streams are modeled from the elevation DEM using ESRI hydrology tools. The steps were used to produce distance to streams:

Make streams from 20 ft. DEM (6.096 meters); use ESRI hydrology tools to calculate a) flow direction, and b) flow accumulation (integer), Set 13 acres to accumulate water (526 10x10 meter cells, 1633 – 20x20ft cells). In raster calculator = streamgrid = setnull(flowaccumulation < 526, 1). Calculate Euclidean distance to stream (GRID command, Dstrm = eucdistance stream).

Stream_diff (each cell's difference in elevation relative to the ***<u>closest</u>*** **stream,** is a measure of the difference in elevation of the individual cell and the closest stream (above stream = positive number, below river = negative number). Create a coverage describing river elevations using the raster calculator:

h:\sbr_bu\dtms\streamelev = setnull(h:\sbr_bu\dtms\streams13 ne 1, h:\sbr_bu\dtms\elev_20ft)
Fill in areas that are not streams through a series of focalmin commands:
outgrid = con(isnull(stream_elev), focalmin (stream_elev, circle, 3), stream_elev).
h:\sbr_bu\dtms\temp1 = con(isnull(h:\sbr_bu\dtms\stream_elev), focalmin(h:\sbr_bu\dtms\stream_elev, circle, 3\,
h:\sbr_bu\dtms\stream_elev)

This is an attempt to fill in the non-stream landscape with the closest stream elevation to allow easy subtraction with grid algebra. A 3x3 circular neighborhood was used for iterations, then a 5x5 rectangular neighborhood for the remainder (in this case, 10, 5x5 iterations). = strm_el_fill.

Calculate difference in elevation between each cell and the closest stream: stream_diff = elevation – strm_el_fill

This results in many areas below streams. Create nodata values for these areas (setnull command),
H:\sbr_bu\dtms\temp = setnull(h:\sbr_bu\dtms\stream_diff < 0, h:\sbr_bu\dtms\stream_diff) … then fill the null values with the surrounding average stream_diff values, until all are filled (in this case, h:\sbr_bu\dtms\temp3 = con(isnull(h:\sbr_bu\dtms\temp2), focalmean(h:\sbr_bu\dtms\temp1, rectangle, 3,3), h:\sbr_bu\dtms\temp2) .. 39 iterations.

25-26) <u>River influence</u>

<u>distance to rivers (Rivdist)</u>
Same process as distance to streams but using 4^{th} order and greater streams only.

<u>Distance above rivers (i.e., streams 4^{th} order and greater) (Riveldiff)</u>
The following process was used:
Create stream order coverage
Create elevation of Rivers using 20 ft. elevation DEM
H:\sbr_bu\dtms\river4 = con(h:\sbr_bu\dtms\sorder > 3, 1)
H:\sbr_bu\dtms\river_elev = con(h:\sbr_bu\dtms\river4 == 1, h:\sbr_bu\dtms\elev_20ft, 0)

Expand this elevation to the landscape; this process fills in the non-river landscape with the closest river elevation to allow easy subtraction with grid algebra using the following commands in the raster calculator, i.e., Fill in areas that are not rivers through a series of focalmin commands:

h:\sbr_bu\dtms\temp1 = con(isnull(h:\sbr_bu\dtms\river_elev), focalmin (h:\sbr_bu\dtms\river_elev, circle, 3), h:\sbr_bu\dtms\river_elev)
h:\sbr_bu\dtms\temp2 = con(isnull(h:\sbr_bu\dtms\temp1), focalmin (h:\sbr_bu\dtms\temp1, circle, 3), h:\sbr_bu\dtms\temp1)

Used 3x3 for 25 iterations, 5x5 for 15 iterations, 10x10 for 5 iterations, 10 x 10 for 15 iterations using rectangle instead of circle which is faster, 30x30 rectangle for 100 iterations.

Subtract elevation from the river_elev_fill …. H:\sbr_bu\dtms\rivdiff = H:\sbr_bu\dtms\elev_projarea – h:\sbr_bu\dtms\rivelev_fill

This creates some areas that are negative (BELOW the river), most of which are reservoirs where the DEM is still showing the elevation below water, at least on the edges. However, some could be due to the constant filling in of nodata areas with the focalmin of elevation that are actually on the other side of the watershed divide and truly below the closest river. To partially fix this:

Change negative values within 300 ft of a river to zero:
C:\CNF\dtms\temp1 = con(c:\CNF\dtms\rivdiff < 0, con(c:\CNF\dtms\driver < 300, 0, c:\CNF\dtms\rivdiff), c:\CNF\dtms\rivdiff)
Change negative values > 3000 ft from river to zero:
C:\CNF\dtms\temp2 = con(c:\CNF\dtms\rivdiff < 0, con(c:\CNF\dtms\driver > 3000, 0, c:\CNF\dtms\temp1), c:\CNF\dtms\temp1)

Fill zero values > 3000 ft from river with focalmax of surrounding areas:
C:\CNF\dtms\temp3 = con(c:\CNF\dtms\temp2 == 0, con(c:\CNF\dtms\driver > 3000, focalmax (c:\CNF\dtms\temp2, rectangle, 10, 10), c:\CNF\dtms\temp2), c:\CNF\dtms\temp2)
Done 12 times
Go back to areas near rivers:
C:\CNF\dtms\temp13 = con(c:\CNF\dtms\temp12 < 0, con(c:\CNF\dtms\driver < 3001, 0, c:\CNF\dtms\temp12), c:\CNF\dtms\temp12)

27) trmi

TRMI (terrain relative moisture index) is an estimate of the moisture regime for each cell based upon 3 variables: aspect, slope position, and slope curvature using the weighted scalar developed by Parker (1982). TRMI combines aspect, slope (measured in degrees), slope configuration (planiform curvature and profile curvature) and relative slope position. The following GRID commands were used in the raster calculator. These commands require additional reclassification tables found in *.rmt files. The directory location for the *.rmt files needs to be specified in the equations. Steps include:

a) config_a = reclass (curvepl, plan.rmt) f:\3rd_approx\dtms\config_a = reclass(f:\3rd_approx\dtms\curvepl, f:\3rd_approx\dtms\trmi_files\plan.rmt)
b) config_b = reclass (curvepr, prof.rmt) f:\3rd_approx\dtms\config_a = reclass(f:\3rd_approx\dtms\curvepl, f:\3rd_approx\dtms\trmi_files\plan.rmt)
c) config1 = con(config_a < 0 & config_b < 0, 10, 0) f:\3rd_approx\dtms\config1= con(f:\3rd_approx\dtms\config_a < 0 & f:\3rd_approx\dtms\config_b < 0, 10, 0)
d) config2 = con(config_a == 0 & config_b < 0, 8, 0) f:\3rd_approx\dtms\config2 = con(f:\3rd_approx\dtms\config_a == 0 & f:\3rd_approx\dtms\config_b < 0, 8, 0)
e) config3 = con(config_a < 0 & config_b == 0, 7, 0) f:\3rd_approx\dtms\config3 = con(f:\3rd_approx\dtms\config_a < 0 & f:\3rd_approx\dtms\config_b == 0, 7, 0)
f) config4 = con(config_a == 0 & config_b == 0, 5, 0) f:\3rd_approx\dtms\config4 = con(f:\3rd_approx\dtms\config_a == 0 & f:\3rd_approx\dtms\config_b == 0, 5, 0)
g) config5 = con(config_a > 0 & config_b == 0, 3, 0) f:\3rd_approx\dtms\config5 = con(f:\3rd_approx\dtms\config_a > 0 & f:\3rd_approx\dtms\config_b == 0, 3, 0)
h) config6 = con(config_a == 0 & config_b > 0, 2, 0) f:\3rd_approx\dtms\config6 = con(f:\3rd_approx\dtms\config_a == 0 & f:\3rd_approx\dtms\config_b > 0, 2, 0)
i) config = config1 + config2 + config3 + config4 + config5 + config6 f:\3rd_approx\dtms\config = f:\3rd_approx\dtms\config1 + f:\3rd_approx\dtms\config2 + f:\3rd_approx\dtms\config3 + f:\3rd_approx\dtms\config4 + f:\3rd_approx\dtms\config5 + f:\3rd_approx\dtms\config6
j) trmi_slope = reclass(slope, slope.rmt) f:\3rd_approx\dtms\trmi_slope = reclass (f:\3rd_approx\dtms\slope_degrees, f:\3rd_approx\dtms\trmi_files\slope.rmt)
k) trmi_asp = reclass(aspect, aspect.rmt) f:\3rd_approx\dtms\trmi_asp = reclass(f:\3rd_approx\dtms\aspraw, f:\3rd_approx\dtms\trmi_files\aspect.rmt)
(results in many values > 20, set these to null and fill in nulls with surrounding values)
F:\3rd_approx\dtms\trmitemp2 = con(isnull(f:\3rd_approx\dtms\trmitemp1), focalmean(f:\3rd_approx\dtms\trmitemp1, rectangle, 3,3), f:\3rd_approx\dtms\trmitemp1)
l) trmi_rsp = reclass(rsp, rsp.rmt) (used rsp2 based on larger drainage area) f:\3rd_approx\dtms\trmi_rsp = reclass(f:\3rd_approx\dtms\rsp2, f:\3rd_approx\dtms\trmi_files\rsp.rmt)
m) trmi_final = trmi_asp + trmi_slope + trmi_rsp + config f:\3rd_approx\dtms\trmitemp3 = f:\3rd_approx\dtms\trmi_asp + f:\3rd_approx\dtms\trmi_slope + f:\3rd_approx\dtms\trmi_rsp + f:\3rd_approx\dtms\config
n) setnull all trmi values > 100 and fill these with focalmean 3x3
f:\3rd_approx\dtms\trmitemp5 = setnull(f:\3rd_approx\dtms\trmitemp4 > 100, f:\3rd_approx\dtms\trmitemp4)
f:\3rd_approx\dtms\trmitemp5= con(isnull(f:\3rd_approx\dtms\trmitemp4), focalmean(f:\3rd_approx\dtms\trmitemp4, rectangle, 3,3), f:\3rd_approx\dtms\trmitemp4)

28) <u>Terrain shape index</u>

This DTM estimates local convexity or concavity slightly broader than curvature and is calculated by subtracting elevation value of center cell from value of each of 8 neighbors.

a) H:\sbr_bu\dtms\gw_tsi = h:\sbr_bu\dtms\elev_20ft – focalmean(h:\sbr_bu\dtms\elev_20ft, circle, 5)

This looks much like curvature from ESRI only a bit smoother.

From: McNab, H.W. 1993. A topographic index to quantify the effect of mesoscale landform on site productivity. Can. J. For. Res. 23: 1100-1107.

<u>29) Valley position:</u>

Valley position is a measure of the elevational position of a cell relative to the <u>watershed divide</u> and the <u>valley floor</u>. The old method of calculating this DTM used the original DEM (meters x, y, and z) to model streams with a 13 acre accumulation area and stream order, to identify valley floor and the same DEM to identify watershed divide. This resulted in many areas with negative numbers due to the closest stream (and its elevation) and required extensive and questionable methods to fill these areas. The new method determines the watershed divide as the maximum elevation within a 3/4 mile x 3/4 mile window, i.e., it is an estimate (model) of where major ridges occur and the elevation of grid cells at those locations and the minimum elevation in a similar manor. It uses 66 foot DEM (resampled from the original 20 foot DEM) because: this is a mesoscale indicator meant to evaluate environments at a broader scale than Relative Slope Position that does not require micro-scale data.

GRID commands:

H:\sbr_bu\dtms\maxelev = focalmax(h:\sbr_bu\dtms\elev_66ft, rectangle, 60,60)
H:\sbr_bu\dtms\minelev = focalmin(h:\sbr_bu\dtms\elev_66ft, rectangle, 60,60)
H:\sbr_bu\dtms\relief = h:\sbr_bu\dtms\maxelev – h:\sbr_bu\dtms\minelev

This results in a few some areas with “negative” or zero relief. Set all values < 1 to “1”
H:\sbr_bu\dtms\relief2 = con(h:\sbr_bu\dtms\relief < 1, 1, h:\sbr_bu\dtms\relief)

H:\sbr_bu\dtms\down = h:\sbr_bu\dtms\elev_66ft - h:\sbr_bu\dtms\minelev

Convert both relief2 and down to floating point

H:\sbr_bu\dtms\vposfloat = 1 – (h:\sbr_bu\dtms\downfloat / h:\sbr_bu\dtms\relief2float)
Use focalmean 3x3 once
H:\sbr_bu\dtms\vposfloat2 = focalmean(h:\sbr_bu\dtms\vposfloat, rectangle, 3, 3)
This still results in some zero values adjacent to values of “1”, change all zero values to 1
H:\sbr_bu\dtms\vposfloat3 = con(h:\sbr_bu\dtms\vposfloat2 == 0, 1, h:\sbr_bu\dtms\vposfloat2)

Fill all nodata values with mean of adjacent cells
h:\sbr_bu\dtms\vpostemp2 = con(isnull(h:\sbr_bu\dtms\vpostemp1), focalmean(h:\sbr_bu\dtms\vpostemp1, rectangle, 3, 3), h:\sbr_bu\dtms\vpostemp1) (repeated 5 times)

Resampled to 30 feet

APPENDIX IV: Analysis Process

Maximum Entrophy (MAXENT)

Create DTMs with the same extent as study area boundary: Extract each DTM by Mask (Arc tools) to ensure that grids are the same extent.
Covert all Grids to ASCII DO THESE as a BATCH process.
Create CSV file with the following variables: **TYPE, Xcoordinate, Ycoodinate, DTM values**.
Use Hawth tools to attach X, Y to original plot coverage
Use Hawth tools to attach DTM data to points: Hawth Analysis, point intersection.
Export table and check that format, otherwise, strip all but TYPE, X, Y and DTM from file, save as CSV file.
i.e., (open an .xl file and select 'open as dbf', edit if necessary and SAVE AS [MSDOS] CSV file), i.e., (Comma delimited)

Run Maxent
Follow wizard and locate plot data file with attributes
Follow wizard and locate folder with environmental data, wizard inserts all .asc files.
Identify location for results (make separate directory)
Export all the resulting .asc files with floating point to create a Grid for each Ecological Zone.

Maximum probability Grid

Uses multiple Ecological Zone models to determine the maximum value on a cell-by-cell basis within the Analysis window, for example:

```
c:\tn\models3\max3o = max ~
(c:\tn\models3\gbald2, c:\tn\models3\sf2, c:\tn\models3\nhslope2, c:\tn\models3\nhcove2, ~
c:\tn\models3\montoakrich2, c:\tn\models3\montoakcove4, c:\tn\models3\montoakslope3, c:\tn\models3\dmoak4, ~
c:\tn\models3\oakrhodo, c:\tn\models3\rcove2,c:\tn\models3\acove3, c:\tn\models3\hero3, c:\tn\models3\poh4, ~
c:\tn\models3\dryoakkallat2,c:\tn\models3\dryoaklite, c:\tn\models3\floodplain, c:\tn\models3\alluvial3, ~ c:\tn\models3\sloak)
```

Creating the Ecological Zone model

Read each model Grid to compare to the maximum probability for that grid cell; if a match occurs, insert Ecological Zone model code.

```
c:\tn\models3\zoneo  = con(c:\tn\models3\max3o == c:\tn\models3\gbald2, 27, ~
c:\tn\models3\max3o == c:\tn\models3\sf2, 1, ~
c:\tn\models3\max3o == c:\tn\models3\nhslope2, 2, ~
c:\tn\models3\max3o == c:\tn\models3\nhcove2, 3, ~
c:\tn\models3\max3o == c:\tn\models3\montoakrich2, 24, ~
c:\tn\models3\max3o == c:\tn\models3\alluvial3, 6, ~
c:\tn\models3\max3o == c:\tn\models3\floodplain, 23, ~
c:\tn\models3\max3o == c:\tn\models3\montoakcove4, 28, ~
c:\tn\models3\max3o == c:\tn\models3\montoakslope3, 9, ~
c:\tn\models3\max3o == c:\tn\models3\oakrhodo, 29, ~
c:\tn\models3\max3o == c:\tn\models3\rcove2, 5, ~
c:\tn\models3\max3o == c:\tn\models3\acove3, 4, ~
c:\tn\models3\max3o == c:\tn\models3\dmoak4, 13, ~
c:\tn\models3\max3o == c:\tn\models3\hero3, 8, ~
c:\tn\models3\max3o == c:\tn\models3\poh4, 18, ~
c:\tn\models3\max3o == c:\tn\models3\dryoakkallat2, 10, ~
c:\tn\models3\max3o == c:\tn\models3\dryoaklite, 11, ~
c:\tn\models3\max3o == c:\tn\models3\sloak, 16, 0)
```

Appendix V: Ecotone evaluation and Ecological Zone model adjustments.

The following steps were used for evaluating / adjusting ecotone model areas:

1. Examine the accuracy assessment matrix to identify an Ecological Zone (Zone) with a large '**omission error'**, i.e., field reference plots that are incorrectly classified (modeled) into another type (the off-diagonal elements). Acidic Cove (Acove) will be used as an example; 49 of the total 614 Acove plots were modeled as Dry-Mesic Oak (Dmoak) in the 'northern' model (table 1). Because Acove was the Zone identified in the field, it is considered the reference data (type). Reference data is known information of high accuracy (theoretically 100% accuracy) and therefore we assume that the Dmoak model is wrong (it was over-mapped) because it does not match the reference data and may therefore need adjustment. The focus here is on adjusting pixel values **only** within areas modeled / mapped as Dmoak. If Acove had a large omission error in Rich Cove (which it does), then the focus would be on adjusting pixels within the Rich Cove model area.
2. Intersect all field plots with the preliminary GIS model and extract only those plots that occur in Dmoak (the Zone assumed to have been over-mapped) along with all environmental variables associated with **all** field plots that fall within this zone. Convert this to a spreadsheet (table 2).
3. Calculate the difference between the reference type probability and the maximum probability at the plot location for that same pixel. This is labeled as the **'difference value1 (DV1)'** (table 2); .0001 is added to this difference value so that it becomes the maximum value at that pixel **(labeled DV1+)**. The maximum probability is derived from Maxent and the maximum probability algorithm and is used to assign the model / map prediction (appendix IV) and is being compared here to the reference or 'true' Zone probability value. DV1+ is the value that if added to the original Acove MAXENT model, would result in a correct classification of the unadjusted 'incorrectly classified' reference plot(s), and theoretically other pixels away from these plots to be correctly modeled. This is because the maximum probability algorithm assigns a model prediction based upon the Zone having the highest probability for that pixel; by adding DV1 to the pixels that constitute the omission error, the highest probability is transferred to the correct type (table 2).
4. Sort the data on DV1+, from low to high and choose a realistic threshold value (around .10) to highlight those Acove plots having the least difference between the modeled type and the reference type, i.e., where the model error is smallest. Disregard values greater than the threshold but maintain data from all plots within the Dmoak model area including omission errors for types other than Acove (table 2).
5. Add DV1+ threshold value (.1154) to **all plots** within the Dmoak model (table 3, column 8 (c)); the result is the new Acove probability, i.e., the adjustment value that would be added to the Acove Maxent model (ONLY WITHIN the Dmoak model area) and would compete with other Zone Maxent models in the maximum probability algorithm.
6. Subtract the original maximum probability value from the new Acove probability value = (DV2), maintain the highlight for those plots (rows) where DV1+ was added, and sort on Acove probability, high to low (table 3). This sort is done to examine the relationship between Acove probability and plot misclassifications. Adjusting plots having an original Maxent probability less than .4 was seldom done unless this was considered a relatively large value by comparison.
7. The final step for adjusting the ecotone between Acove and Dmoak, in this example, includes a close examination of each environmental variable within the threshold limit (highlighted plots / rows) to see which is most associated with the greatest number of 'least different' reference vs. model values and results in the greatest gain for Acove. The point here is not only to adjust pixels that decrease the omission error to improve the accuracy assessment matrix. The point is to consider what environmental variables make sense in separating Acove from Dmoak because any adjustment made at plot locations also occurs in pixels away from plot areas within these specified environmental conditions (table 4). It is assumed that, because reference plots are used to 'train' habitat suitability models using MAXENT, the environmental relationships observed at these locations should also 'train' adjustments elsewhere. The result of this analysis was to: **"add .115 to all Acove probabilities greater than .42 within the Dmoak model area where Relative Slope Position (RSP2) values are > 16**, i.e., slope positions lower on the hill".
8. Re-evaluate additional threshold limits and cycle through steps 4-8 to get the greatest gain.
9. Rerun the maximum probability model (combining all types again) using the "new Acove" model. Display the 'before and after' combined models (figures 1-3 below) to evaluate if they make any sense at all, e.g., does the ecotone adjustment reflect a true environmental difference between the types under question and do the new type distributions (mapping) fit local knowledge. If they don't make sense, drop this analysis. If they do, build from this point by going back to step 1 for another type or for this same type within another area. Figures 4-6 display the results of multiple adjustments in another example area (Waynesville Watershed).
10. Complete this procedure for the 'northend model', 'southend model', for each of the FLN landscapes, and for areas outside FLN landscapes having additional reference plots not included in these areas, restricting adjustments to the models within these individual areas.

Step 1: Identify Zone with a large number of field plots incorrectly modeled (high <u>omission</u> error). Acove in this example with 49 of the total 614 plots modeled as Dmoak (type # 13). Note the number of plots being modeled into the Dmoak type = 316, and higher than the number of reference Dmoak plots = 222. This indicates a high <u>commission</u> error for Dmoak.

Table 1: Accuracy Assessment Matrix for the initial / 1st preliminary North-end model

#	#	1	27	2	3	4	29	5	6	23	8	24	9	28	13	10	11	16	18	31	total	% cor
1	sf	28	1	19	8	2		1			4		1								64	44%
27	gbald	4	12	3									1								20	60%
2	nhslope	1		34	5			1			1		5								47	72%
3	nhcove	2		4	49	1		11			3		4	1							75	65%
4	acove			3	5	352	43	59	13		1		15	33	49	14		25	2		614	57%
29	oakrhodo				2	5	80	4					7	4	13	6	4		2		127	63%
5	rcove				1	15	7	158	2				11	19	2	3	2	1			221	71%
6	alluv					10			51					7				1			69	74%
23	floodplain								2	29					1						32	91%
8	hero			12	5		4				34		18	1	1	2			1		78	44%
24	mont_rich										5	2	2		1	1					11	18%
9	montoakslope			2	2		4	2			1		133	5	5	11			5		170	78%
28	montoakcove					5	3	4					3	73	2	1	1				92	79%
13	dmoak					7	8	1					6	13	140	18	5	19	5		222	63%
10	dryoakEheath					1	6	2			1		6	3	10	72		10	1		112	64%
11	dryoakDheath						4	1					4	2	10	4	33		2		60	55%
16	sloak					2								1	6	1	2	64	1		77	83%
18	poh			1		3	23				6		22	7	67	36	35	21	128		349	37%
31	slpoh					1									9			33		1	44	2%
	TOTAL correct	28	12	34	49	352	80	158	51	29	34	2	133	73	140	72	33	64	128	1	1473	**59%**
	TOTAL column	35	13	78	77	404	182	244	68	29	56	2	238	169	316	169	82	174	147	1	2484	

Table 2: Results for Steps 2-4.

row #	Reference Type	Model Type	Dmoak-13 Probability	(a) Max Prob.	(b) – (a) **DV1** **DV1+** DV1+.0001	(b) Ac ove Prob.	aspc	aspr	cur	23 variables →	tsi	slope
1	acove	13	0.79	0.79	-0.0050	0.7857	0.24	75.10	-0.58	→	-7	72
2	acove	13	0.22	0.22	-0.0068	0.2171	-0.83	152.59	-4.51	→	-16	34
3	acove	13	0.87	0.87	-0.0179	0.8505	0.27	74.61	-0.07	→	-2	19
4	acove	13	0.85	0.85	-0.0267	0.8193	0.99	8.28	0.57	→	3	63
5	acove	13	0.60	0.60	-0.0275	0.5693	0.75	41.74	0.71	→	2	26
6	acove	13	0.82	0.82	-0.0405	0.7836	0.47	62.27	0.53	→	0	62
7	acove	13	0.80	0.80	-0.0426	0.7543	0.71	45.33	-1.88	→	-6	77
8	acove	13	0.59	0.59	-0.0439	0.5471	0.37	68.33	-0.78	→	-8	50
9	acove	13	0.78	0.78	-0.0475	0.7295	-0.87	150.98	0.92	→	-5	60
10	acove	13	0.84	0.84	-0.0489	0.7925	-0.97	197.32	-0.05	→	-10	42
11	acove	13	0.73	0.73	-0.0540	0.6740	0.52	58.45	0.08	→	2	50
12	acove	13	0.47	0.47	-0.0540	0.4147	-0.84	212.69	0.79	→	-3	58
13	acove	13	0.73	0.73	-0.0575	0.6755	0.25	75.42	-1.29	→	-4	49
14	acove	13	0.41	0.41	-0.0601	0.3468	0.30	72.35	1.00	→	-2	28
15	acove	13	0.70	0.70	-0.0611	0.6390	0.98	11.26	-0.94	→	-8	72
16	acove	13	0.83	0.83	-0.0633	0.7634	0.60	53.15	-1.70	→	-3	58
17	acove	13	0.75	0.75	-0.0634	0.6864	0.35	68.82	-1.75	→	-12	35
18	acove	13	0.72	0.72	-0.0675	0.6574	0.77	40.06	0.30	→	7	63
19	acove	13	0.79	0.79	-0.0703	0.7244	0.33	70.80	0.32	→	-6	55
20	acove	13	0.58	0.58	-0.0826	0.4930	-0.80	216.62	-1.52	→	-12	39
21	acove	13	0.58	0.58	-0.0826	0.4930	-0.80	216.62	-1.52	→	-12	39
22	acove	13	0.64	0.64	-0.0881	0.5553	0.06	86.60	-0.39	→	1	66
23	acove	13	0.64	0.64	-0.0882	0.5543	0.26	74.80	-0.26	→	-4	81
24	acove	13	0.75	0.75	-0.0908	0.6605	0.85	32.10	-0.73	→	-5	60
25	acove	13	0.74	0.74	-0.0945	0.6475	-0.41	95.70	-1.16	→	-12	38
26	acove	13	0.77	0.77	-0.0946	0.6796	0.75	38.87	-0.14	→	-7	49
27	acove	13	0.61	0.61	-0.0955	0.5189	-0.66	133.07	-1.31	→	-10	27
28	acove	13	0.84	0.84	-0.0971	0.7401	0.54	57.15	1.65	→	1	79
29	acove	13	0.60	0.60	-0.1151	0.4802	0.79	38.19	1.47	→	2	72
30	acove	13	0.70	0.70	-0.1154	0.5816	-0.66	228.55	-0.19	→	5	38
31	acove	13	0.71	0.71	-0.1212	0.5863	0.51	59.77	-0.06	→	-12	62
32	acove	13	0.67	0.67	-0.1228	0.5468	-0.91	155.37	0.10	→	-10	61
33	acove	13	0.87	0.87	-0.1359	0.7295	0.39	66.98	0.26	→	-7	61
34	acove	13	0.85	0.85	-0.1396	0.7111	0.39	20.91	-8.08	→	-24	17
35	acove	13	0.84	0.84	-0.1459	0.6977	0.31	71.74	0.79	→	-3	53
36	acove	13	0.56	0.56	-0.1518	0.4082	1.00	330.07	0.69	→	2	53
37	acove	13	0.35	0.35	-0.1616	0.1911	0.57	55.09	-0.22	→	-1	65
38	acove	13	0.71	0.71	-0.1638	0.5423	0.44	63.74	0.31	→	4	80
39	acove	13	0.82	0.82	-0.1671	0.6506	0.27	74.52	-0.20	→	-2	27
40	acove	13	0.74	0.74	-0.1840	0.5563	-0.93	213.93	0.22	→	-7	28
41	acove	13	0.74	0.74	-0.1860	0.5531	0.51	57.97	-0.38	→	-9	46
42	acove	13	0.80	0.80	-0.2173	0.5798	0.51	58.95	-0.77	→	-6	10
43	acove	13	0.72	0.72	-0.2863	0.4293	-0.65	131.16	-3.09	→	-15	19
44	acove	13	0.85	0.85	-0.3016	0.5511	0.56	55.92	0.73	→	4	57
45	acove	13	0.79	0.79	-0.3149	0.4745	0.23	283.48	0.52	→	-1	59
46	acove	13	0.91	0.91	-0.3177	0.5892	0.81	36.35	-0.52	→	-10	52
47	acove	13	0.80	0.80	-0.3246	0.4781	0.76	40.49	-2.81	→	-10	79
48	acove	13	0.74	0.74	-0.3905	0.3452	-0.72	135.68	0.79	→	-8	60
49	acove	13	0.82	0.82	-0.6543	0.1628	0.89	333.03	0.61	→	1	10
50	dmoak	13	0.77	0.77		0.6666	-0.93	160.20	-1.54	→	-15	49
51	dmoak	13	0.67	0.67		0.5658	0.35	69.57	0.35	→	0	24
↓	↓	↓	↓	↓		↓	↓	↓	↓	↓	↓	↓
315	slpoh	13	0.80	0.80		0.6546	0.86	31.37	0.19	→	1	35
316	slpoh	13	0.65	0.65		0.0867	-0.89	207.12	0.97	→	9	25

<u>Threshold Value</u>, add .0001 to Acove to exceed max .0001 + .1153 = .1154

Rows 49 and 316 are highlighted to show the total number of misclassified Acove plots and total number of plots that occur within the Dmoak model area

Table 3: Results for Steps 5 – 6.

row	Reference Type	Model Type	Dmoak Prob.	(a) Max Prob.	(b) - (a) **DV1**	(b) Acove Prob.	(c) (b) +.1154 New Acove	(c) - (a) **DV2**	aspc	aspr	cur	23 variables →	tsi	slope
1	acove	13	0.87	0.87	-0.0178	0.8505	0.9659	0.0976	0.27	74.61	-0.07	→	-2	19
2	acove	13	0.85	0.85	-0.0266	0.8193	0.9347	0.0888	0.99	8.28	0.57	→	3	63
3	acove	13	0.84	0.84	-0.0488	0.7925	0.9079	0.0666	-0.97	197.32	-0.05	→	-10	42
4	acove	13	0.79	0.79	-0.0049	0.7857	0.9011	0.1105	0.24	75.10	-0.58	→	-7	72
5	acove	13	0.82	0.82	-0.0404	0.7836	0.8990	0.0750	0.47	62.27	0.53	→	0	62
6	acove	13	0.83	0.83	-0.0632	0.7634	0.8788	0.0522	0.60	53.15	-1.70	→	-3	58
7	acove	13	0.80	0.80	-0.0425	0.7543	0.8697	0.0729	0.71	45.33	-1.88	→	-6	77
8	acove	13	0.84	0.84	-0.0970	0.7401	0.8555	0.0184	0.54	57.15	1.65	→	1	79
9	acove	13	0.78	0.78	-0.0474	0.7295	0.8449	0.0680	-0.87	150.98	0.92	→	-5	60
10	dryoakever	13	0.75	0.75	-0.0224	0.7267	0.8421	0.0930	-0.63	129.20	3.00	→	-1	57
11	acove	13	0.79	0.79	-0.0702	0.7244	0.8398	0.0452	0.33	70.80	0.32	→	-6	55
12	slpoh	13	0.78	0.78	-0.0940	0.6877	0.8031	0.0214	0.75	41.38	0.47	→	3	29
13	slpoh	13	0.79	0.79	-0.1006	0.6870	0.8024	0.0148	0.26	75.12	0.14	→	4	61
14	acove	13	0.75	0.75	-0.0633	0.6864	0.8018	0.0521	0.35	68.82	-1.75	→	-12	35
15	acove	13	0.77	0.77	-0.0945	0.6796	0.7950	0.0209	0.75	38.87	-0.14	→	-7	49
16	acove	13	0.73	0.73	-0.0574	0.6755	0.7909	0.0580	0.25	75.42	-1.29	→	-4	49
17	acove	13	0.73	0.73	-0.0539	0.6740	0.7894	0.0615	0.52	58.45	0.08	→	2	50
18	dmoak	13	0.77	0.77	-0.1023	0.6666	0.7820	0.0131	-0.93	160.20	-1.54	→	-15	49
19	acove	13	0.75	0.75	-0.0907	0.6605	0.7759	0.0247	0.85	32.10	-0.73	→	-5	60
20	acove	13	0.72	0.72	-0.0675	0.6574	0.7728	0.0479	0.77	40.06	0.30	→	7	63
21	acove	13	0.74	0.74	-0.0944	0.6475	0.7629	0.0210	-0.41	95.70	-1.16	→	-12	38
22	acove	13	0.70	0.70	-0.0610	0.6390	0.7544	0.0544	0.98	11.26	-0.94	→	-8	72
23	rcove	13	0.74	0.74	-0.1123	0.6251	0.7405	0.0031	-0.51	120.54	1.32	→	0	53
24	oakrhodo	13	0.72	0.72	-0.1106	0.6093	0.7247	0.0048	-1.00	185.20	0.49	→	-2	51
25	acove	13	0.70	0.70	-0.1153	0.5816	0.6970	0.0001	-0.66	228.55	-0.19	→	5	38
26	poh	13	0.67	0.67	-0.0837	0.5815	0.6969	0.0317	0.00	89.90	0.50	→	8	38
27	acove	13	0.60	0.60	-0.0274	0.5693	0.6847	0.0880	0.75	41.74	0.71	→	2	26
28	dmoak	13	0.67	0.67	-0.1057	0.5658	0.6812	0.0097	0.35	69.57	0.35	→	0	24
29	acove	13	0.64	0.64	-0.0880	0.5553	0.6707	0.0274	0.06	86.60	-0.39	→	1	66
30	acove	13	0.64	0.64	-0.0881	0.5543	0.6697	0.0273	0.26	74.80	-0.26	→	-4	81
31	acove	13	0.59	0.59	-0.0438	0.5471	0.6625	0.0716	0.37	68.33	-0.78	→	-8	50
32	sloak	13	0.61	0.61	-0.0711	0.5372	0.6526	0.0443	-0.70	225.95	0.89	→	3	72
33	acove	13	0.61	0.61	-0.0954	0.5189	0.6343	0.0200	-0.66	133.07	-1.31	→	-10	27
34	acove	13	0.58	0.58	-0.0825	0.4930	0.6084	0.0329	-0.80	216.62	-1.52	→	-12	39
35	acove	13	0.58	0.58	-0.0825	0.4930	0.6084	0.0329	-0.80	216.62	-1.52	→	-12	39
36	acove	13	0.60	0.60	-0.1150	0.4802	0.5956	0.0004	0.79	38.19	1.47	→	2	72
37	acove	13	0.47	0.47	-0.0539	0.4147	0.5301	0.0615	-0.84	212.69	0.79	→	-3	58
38	dmoak	13	0.47	0.47	-0.0697	0.4003	0.5157	0.0457	0.48	298.96	0.56	→	2	23
39	rcove	13	0.40	0.40	-0.0265	0.3778	0.4932	0.0889	0.85	295.01	-1.97	→	-10	39
40	acove	13	0.41	0.41	-0.0602	0.3468	0.4622	0.0552	0.30	72.35	1.00	→	-2	28
41	acove	13	0.22	0.22	-0.0067	0.2171	0.3325	0.1087	-0.83	152.59	-4.51	→	-16	34
42	dmoak	13	0.14	0.14	-0.0215	0.1179	0.2333	0.0939	0.75	31.36	-0.83	→	-7	10
43	sloak	13	0.08	0.08	-0.0163	0.0646	0.1800	0.0991	0.22	283.33	1.12	→	11	28
44	dmoak	13	0.08	0.08	-0.0350	0.0468	0.1622	0.0804	0.13	82.79	1.09	→	10	38
45	dmoak	13	0.06	0.06	-0.0218	0.0395	0.1549	0.0936	1.00	12.33	0.08	→	-5	49
46	dmoak	13	0.12	0.12	-0.0822	0.0351	0.1505	0.0332	-0.96	163.33	-0.32	→	-2	76
47	dmoak	13	0.03	0.03	-0.0225	0.0090	0.1244	0.0929	0.19	281.37	0.72	→	2	15
48	acove	13	0.71	0.71		0.5863	0.7017	-0.0058	0.51	59.77	-0.06	→	-12	62
49	dmoak	13	0.17	0.17		0.0439	0.1593	-0.0069	0.96	16.17	0.73	→	5	13
↓	↓	↓	↓	↓		↓	↓	↓	↓	↓	↓	↓	↓	↓
315	slpoh	13	0.83	0.83		0.0152	0.1306	-0.6999	-0.65	229.64	0.17	→	4	51
316	poh	13	0.92	0.92		0.0535	0.1689	-0.7513	-1.00	179.79	-1.62	→	2	43

Highlighted boxes in this column indicate adjustments that would result in a correct classification for Acove.

Non-highlighted boxes in this column indicate adjustments that would result in an incorrect classification for Dmoak (the correct type) and for other types.

Note: the table is sorted on Acove probability, from high to low and shows that although 49 plots were misclassified into Dmoak, most of these have a probability value exceeding .5 (from Maxent).

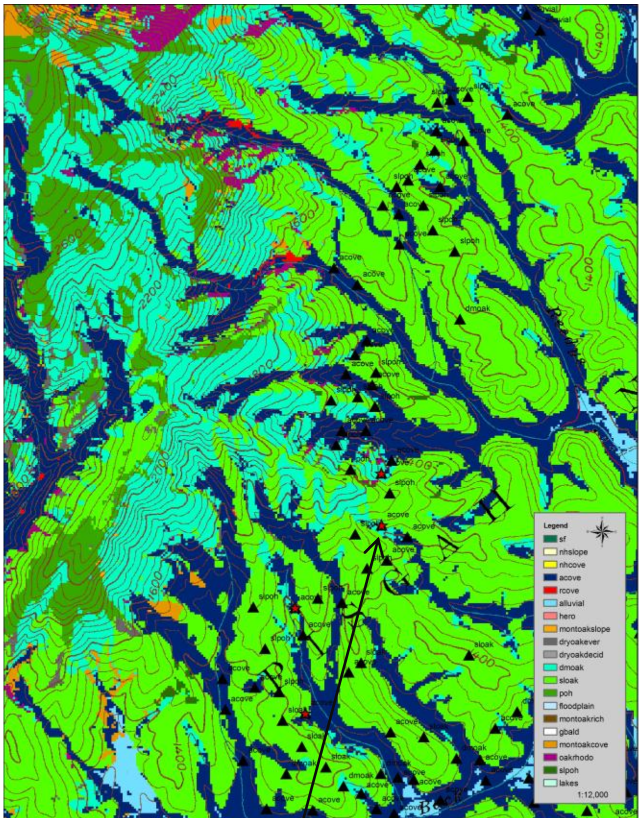
Table 4: Results for steps 7-8.

row	Reference Type	Model Type	Dmoak Prob.	(a) Max Prob.	(b) - (a) **DV1**	(b) Acove Prob.	(c) (b) +.1154 New Acove	(c) - (a) **DV2**	rsp2	25 variables →	tsi	slope
1	acove	13	0.84	0.84	-0.0488	0.7925	0.9079	0.0666	97	→	-10	42
2	dmoak	13	0.77	0.77	-0.1023	0.6666	0.7820	0.0131	82	→	-15	49
3	acove	13	0.47	0.47	-0.0539	0.4147	0.5301	0.0615	79	→	-3	58
4	acove	13	0.73	0.73	-0.0574	0.6755	0.7909	0.0580	74	→	-4	49
5	acove	13	0.58	0.58	-0.0825	0.4930	0.6084	0.0329	74	→	-12	39
6	acove	13	0.58	0.58	-0.0825	0.4930	0.6084	0.0329	74	→	-12	39
7	acove	13	0.79	0.79	-0.0049	0.7857	0.9011	0.1105	72	→	-7	72
8	acove	13	0.87	0.87	-0.0178	0.8505	0.9659	0.0976	65	→	-2	19
9	dryoakever	13	0.75	0.75	-0.0224	0.7267	0.8421	0.0930	52	→	-1	57
10	acove	13	0.75	0.75	-0.0633	0.6864	0.8018	0.0521	48	→	-12	35
11	acove	13	0.73	0.73	-0.0539	0.6740	0.7894	0.0615	45	→	2	50
12	sloak	13	0.61	0.61	-0.0711	0.5372	0.6526	0.0443	45	→	3	72
13	acove	13	0.85	0.85	-0.0266	0.8193	0.9347	0.0888	45	→	3	63
14	acove	13	0.59	0.59	-0.0438	0.5471	0.6625	0.0716	45	→	-8	50
15	acove	13	0.82	0.82	-0.0404	0.7836	0.8990	0.0750	43	→	0	62
16	acove	13	0.78	0.78	-0.0474	0.7295	0.8449	0.0680	38	→	-5	60
17	oakrhodo	13	0.72	0.72	-0.1106	0.6093	0.7247	0.0048	37	→	-2	51
18	acove	13	0.64	0.64	-0.0880	0.5553	0.6707	0.0274	31	→	1	66
19	acove	13	0.77	0.77	-0.0945	0.6796	0.7950	0.0209	31	→	-7	49
20	acove	13	0.61	0.61	-0.0954	0.5189	0.6343	0.0200	31	→	-10	27
21	acove	13	0.72	0.72	-0.0675	0.6574	0.7728	0.0479	31	→	7	63
22	acove	13	0.60	0.60	-0.1150	0.4802	0.5956	0.0004	30	→	2	72
23	rcove	13	0.74	0.74	-0.1123	0.6251	0.7405	0.0031	29	→	0	53
24	acove	13	0.70	0.70	-0.1153	0.5816	0.6970	0.0001	28	→	5	38
25	acove	13	0.83	0.83	-0.0632	0.7634	0.8788	0.0522	27	→	-3	58
26	acove	13	0.74	0.74	-0.0944	0.6475	0.7629	0.0210	25	→	-12	38
27	acove	13	0.64	0.64	-0.0881	0.5543	0.6697	0.0273	23	→	-4	81
28	acove	13	0.80	0.80	-0.0425	0.7543	0.8697	0.0729	20	→	-6	77
29	acove	13	0.70	0.70	-0.0610	0.6390	0.7544	0.0544	18	→	-8	72
30	acove	13	0.75	0.75	-0.0907	0.6605	0.7759	0.0247	17	→	-5	60
31	slpoh	13	0.79	0.79	-0.1006	0.6870	0.8024	0.0148	15	→	4	61
32	slpoh	13	0.78	0.78	-0.0940	0.6877	0.8031	0.0214	15	→	3	29
33	acove	13	0.79	0.79	-0.0702	0.7244	0.8398	0.0452	14	→	-6	55
34	acove	13	0.84	0.84	-0.0970	0.7401	0.8555	0.0184	14	→	1	79
35	acove	13	0.60	0.60	-0.0274	0.5693	0.6847	0.0880	12	→	2	26
36	poh	13	0.67	0.67	-0.0837	0.5815	0.6969	0.0317	8	→	8	38
37	dmoak	13	0.67	0.67	-0.1057	0.5658	0.6812	0.0097	8	→	0	24
38	dmoak	13	0.47	0.47	-0.0697	0.4003	0.5157	0.0457	32	→	2	23
39	rcove	13	0.40	0.40	-0.0265	0.3778	0.4932	0.0889	43	→	-10	39
40	acove	13	0.41	0.41	-0.0602	0.3468	0.4622	0.0552	52	→	-2	28
41	acove	13	0.22	0.22	-0.0067	0.2171	0.3325	0.1087	17	→	-16	34
42	dmoak	13	0.14	0.14	-0.0215	0.1179	0.2333	0.0939	54	→	-7	10
43	dmoak	13	0.06	0.06	-0.0218	0.0395	0.1549	0.0936	49	→	-5	49
44	dmoak	13	0.12	0.12	-0.0822	0.0351	0.1505	0.0332	24	→	-2	76
45	dmoak	13	0.03	0.03	-0.0225	0.0090	0.1244	0.0929	12	→	2	15
46	sloak	13	0.08	0.08	-0.0163	0.0646	0.1800	0.0991	11	→	11	28
47	dmoak	13	0.08	0.08	-0.0350	0.0468	0.1622	0.0804	10	→	10	38
48	acove	13	0.71	0.71		0.5863	0.7017	-0.0058	78	→	-12	62
49	dmoak	13	0.17	0.17		0.0439	0.1593	-0.0069	43	→	5	13
↓	↓	↓	↓	↓		↓	↓	↓	↓	↓	↓	↓
315	slpoh	13	0.83	0.83		0.0152	0.1306	-0.6999	3	→	4	51
316	poh	13	0.92	0.92		0.0535	0.1689	-0.7513	4	→	2	43

Rsp2 greater than 16 is the chosen cut-off value that results in the greatest net gain in Acove accuracy

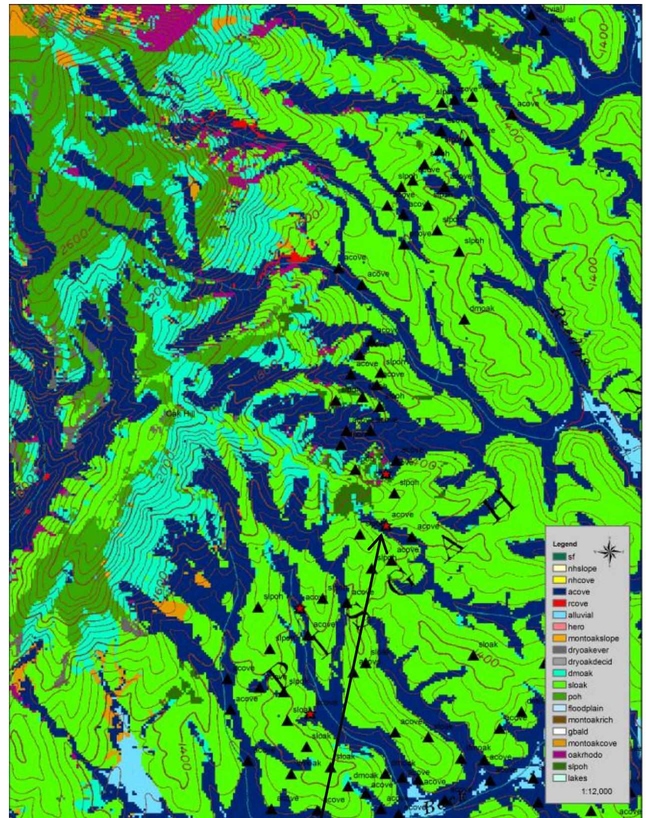
A cut-off value of > 11 was not chosen because just 3 additional gains were possible with 2 likely losses, and the smaller the Rsp2 value the higher up the slope, a position not considered typical for Acove

Figure 1: Zones based on maximum probability method.



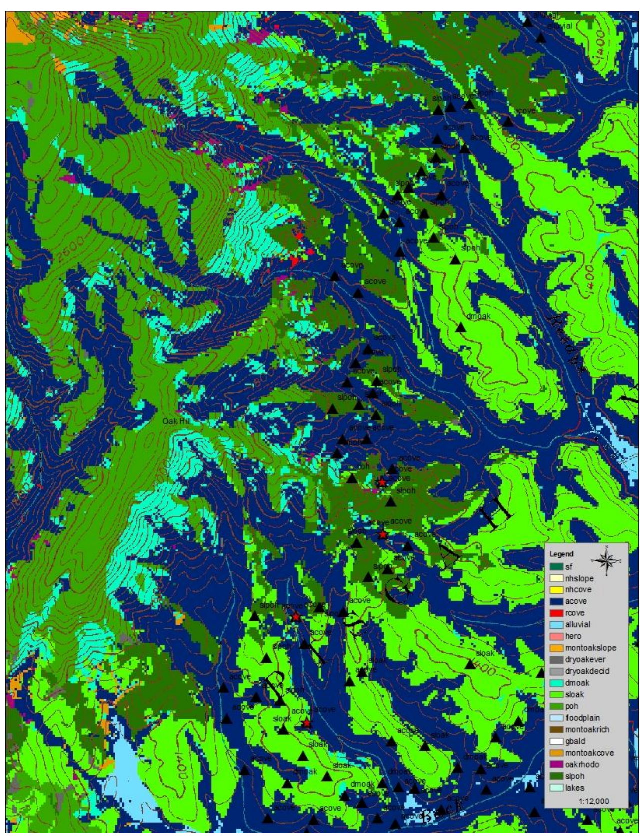
Plot data used for adjustment (stars)

Figure 2: Zones with one ecotone adjustment.

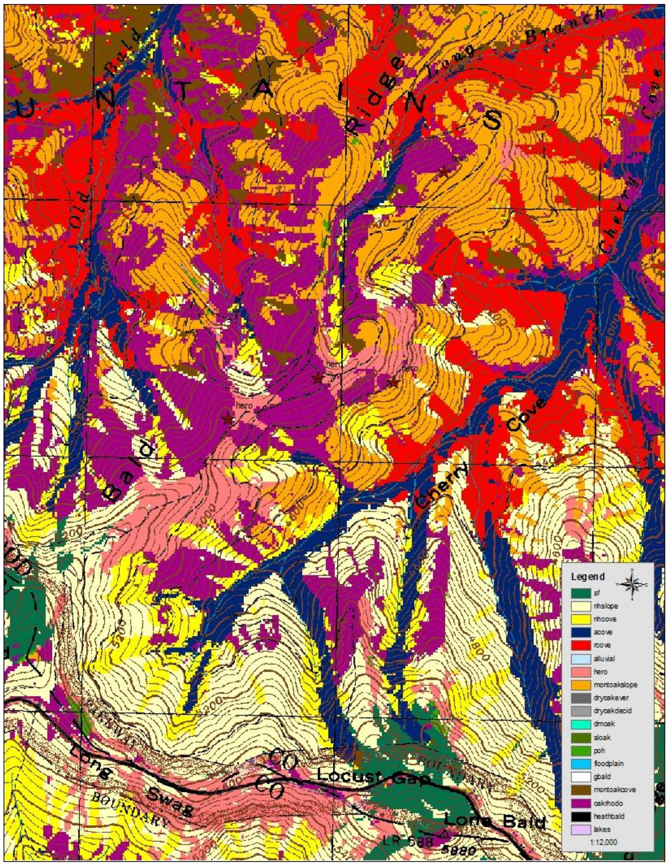


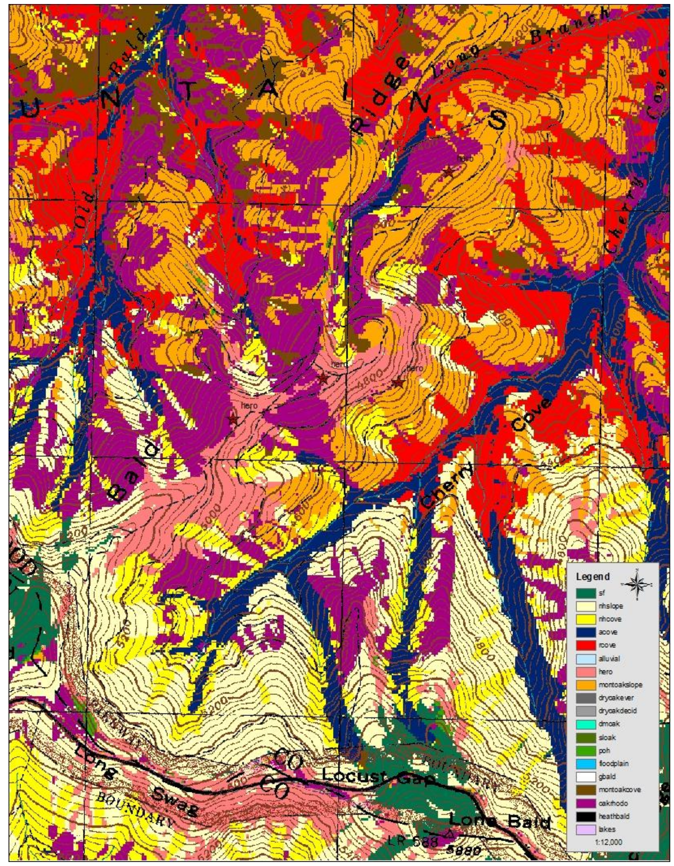
Changed to acove model

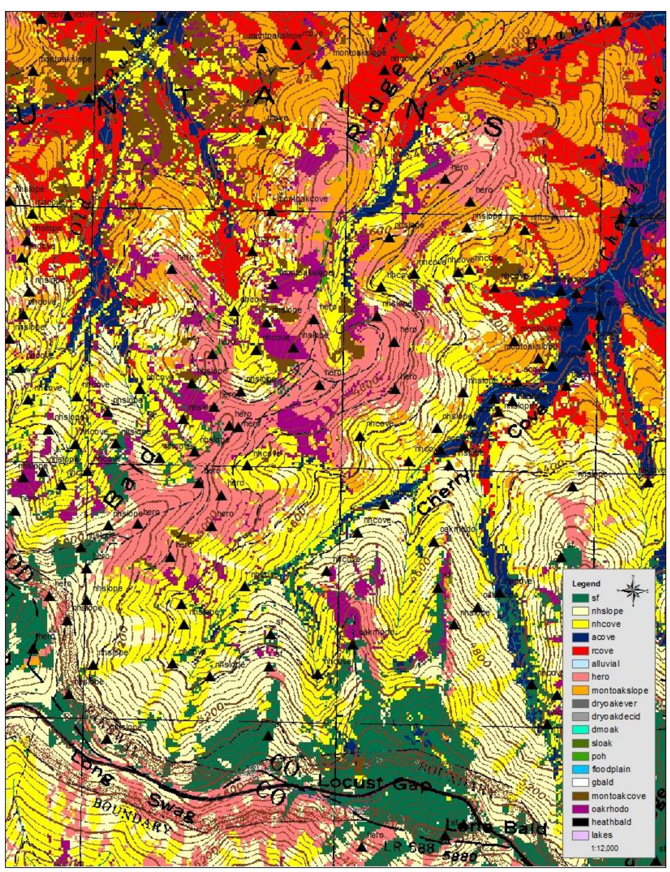
Figure 3: Ecological Zones with all ecotone adjustments.



Figures 4-6: Change in extent and producers accuracy in the upper Waynesville watershed from the maximum probability method through 100+ ecotone adjustments across the SBR (south) project area.







Appendix VI: Results and discussion all ecotone evaluation and Ecological Zone model adjustments

The procedure outlined in Appendix V was completed for the 'northend model', 'southend model', for each of the unique FLN landscapes (Northern Escarpment, New River Headwaters, Central Escarpment, South Mountains, Southern Blue Ridge Escarpment, Balsam Mountains, Nantahala Mountains, Smoky and Unaka Mountains), and for areas outside FLN landscapes having additional reference plots. Details of the model adjustments are listed in Tables 4-5 below. The following is a description and evaluation of these project area-wide adjustments.

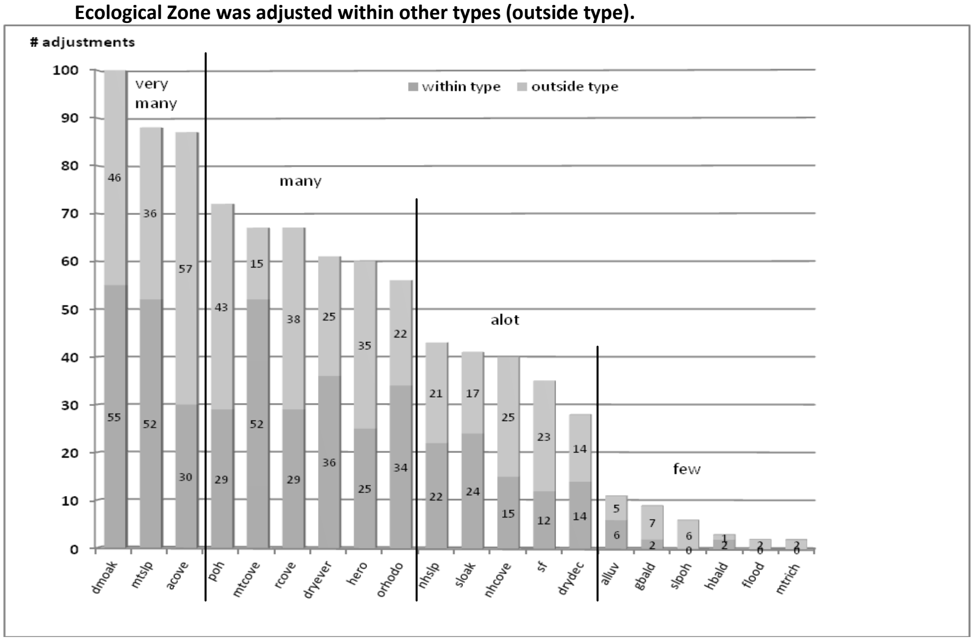
Total adjustments: Adjustments of the ecotone between models can be evaluated from two perspectives; the total number of adjustments made within an Ecological Zone, and the total number of times that Ecological Zone was adjusted within other types. These are referred to as 'within type' and 'outside type' adjustments respectively (table 1). If both types of adjustments are considered, the Ecological Zones can be grouped into the following 4 ecotone adjustment categories (arranged from most to least adjustments within category):

Very many	Many	A lot	Few
Dry-Mesic Oak	Pine-Oak Heath	Northern Hardwood Slope	Alluvial Forest
Montane Oak (Slope)	Montane Oak (Cove)	Shortleaf Pine-Oak	Grassy Bald
Acidic Cove	Rich Cove	Northern Hardwood Cove	SL Pine-Oak Heath
	Dry-Oak/Evergreen Heath	Spruce-Fir	Heath Bald
	High Elevation Oak	Dry-Oak/Deciduous Heath	Floodplain
	Mixed Oak/Rhododendron		Montane Oak (Rich)

There were around 100 adjustments made in the initial and subsequent Dry-Mesic Oak Ecological zone models, 55 'within type' and 46 'outside type' (fig. 1), the most of all types. This type along with Montane Oak Slope and Acidic Cove, also had 'very many' adjustments, and account for well over one-third (40%) of the total acres in the 8 million+ project area (thus an extensive ecotone between other types) and certainly the reason for needing such a large number of adjustments. This is also true for Acidic Cove which had the most 'outside type' adjustments, and accounts for a significant portion of the total landscape (17% - the most extensive of all types), and because the type can occur in even narrow drainage areas that bisect most all 'upland' types, forming extensive ecotones and therefore 'confusion' between type boundaries.

The second category 'many' also accounts for about 40% of the landscape and includes the remainder of the most-extensive Ecological Zones except Shortleaf Pine-Oak. It also includes High Elevation Red Oak that occurs in only about 1% of the landscape but because of its landscape position (ridges and upper slopes) its extensive ecotone can be confused with numerous other types. The 3rd category 'a lot' accounts for about 15% of the landscape but most of this is within the Shortleaf Pine-Oak Ecological Zone (11%). Although there were a lot of adjustments made with this category, there were relatively fewer (about one-half) for Shortleaf Pine-Oak which accounts for roughly the same acreage as Montane Oak Slope and Dry-Mesic Oak, 2 types where the most adjustments were made. This is likely due to less confusion within Shortleaf Pine-Oak, and its occurrence on broader lower elevation landscapes with less evident ecotones. The remainder of the types in this category, however, occur at higher elevations and are either a finer definition of a broader type (northern hardwood, or dry-oak), and / or have more extensive ecotone. The fewest adjustments were made in rare Ecological Zones (Grassy Bald, Heath Bald, Montane Oak Rich, Shortleaf Pine-Oak Heath) that occur in distinct environments and are therefore less 'confused' with other types, or those that are more extensive on private lands (Alluvial Forest, Floodplain) and therefore have fewer reference plots to evaluate (Figure 1).

Figure 1: Ecotone adjustments within an Ecological Zone (within type) and the number of times that Ecological Zone was adjusted within other types (outside type).



Adjustments within and between types: Although not considered an ecotone adjustment, the greatest number of model changes was made to differentiate between Acidic Cove and Rich Cove Ecological Zones (17 shared 'within type' adjustments). Geology, stream-river distance, and slope position or landform shape were the most frequently used local environmental variables (used 5, 4, and 3 times respectively). The next most frequent adjustments were made between Dry-Mesic Oak (Dmoak) and Pine-Oak Heath (Poh), (16 total shared adjustments; 11 within Dmoak and 5 within Poh), and in differentiating between Dmoak and Shortleaf Pine-Oak (Sloak), (15 total shared adjustments: 6 within Dmoak and 9 within Sloak). Curvature, elevation, slope, and stream distance were the most frequent environmental variables used to refine the Dmoak and Poh ecotone boundary, while stream distance, geology, and elevation were the most frequent environmental variables used to refine the Dmoak and Sloak ecotone boundary. The number of different types within a specific Ecological Zone where ecotones were adjusted, not just the total number of adjustments, can also be used to identify taxa having more 'confused' map unit boundaries. Ecological Zones needing the greatest number of different types to be adjusted (greater than 10) within their preliminary models to improve accuracy included Montane Oak Slope, Montane Oak Cove, Mixed Oak/Rhododendron, Pine-Oak Heath, Rich Cove, and High Elevation Red Oak (table 1). Ecological Zones with the fewest number of types being adjusted within their preliminary model boundaries include most all 'rare' types such as Grassy Bald and SL Pine-Oak Heath.

The gain in accuracy within an Ecological Zone was generally related to both the total number of adjustments and the number of types within the Zone that were adjusted, i.e., the greater the adjustment the greater the gain. However, there are some important exceptions: 1) most of the 'rare' types had significant gains (greater than 30% points) in map unit accuracy with very few adjustments, 2) the 3 types having the greatest number of total adjustments and with at least 10 types needing to be adjusted within their boundaries had relatively modest accuracy gains (Dmoak a 15% point gain, Montane Oak Slope an 8% point gain, and Montane Oak Cove with only a 1% point gain), and 3) one type, Heath Bald actually showed a decline in accuracy from the initial to final model. Although few adjustments were made within this type, the reason for the accuracy loss is likely due to Heath Bald being extensively over-mapped in the initial model which resulted in a low omission error but a very high commission error (other types being confused with this type – see Appendix VII for more detail on error types).

Table 1: Within type adjustments

	Dmoak	Mtslp	Mtcove	Dryever	Orhodo	Acove	Poh	Rcove	Hero	Sloak	Nhslope	Nhcove	Drydec	Sf	Alluv	Gbald	Hbald	Slpoh	Mrich	Flood
# adjusts	55	52	52	36	34	30	29	29	25	24	22	15	14	12	6	2	2	0	0	0
8+	poh	acove	dmoak					acove		dmoak										
	acove	hero	rcove																	
			acove																	
5-7	mtslp	rcove	mtslp	dmoak	acove	rcove	dmoak	nhcove	nhslope	acove	hero		poh							
	sloak	dmoak		mtslp							sf									
	rcove	nhslope		poh																
		poh																		
2-4	dryever	orhodo	dryever	hero	hero	dmoak	drydec	mtslp	poh	slpoh	nhcove	sf	dmoak	nhcove	acove	sf		dmoak		
	drydec	dryever	sloak	acove	mtslp	mtcove	hero	dryever	dryever	dryever	gbald	hero		gbald	flood			sloak		
	mtcove	drydec	hero	nhslp	rcove	orhodo	mtslp	mtcove	nhcove	drydec		nhslope		nhslope						
	orhodo		poh	orhodo	dmoak	nhcove	sloak	nhslp	sf	poh		acove								
	slpoh		alluvial	rcove	poh	alluvial	acove		gbald			mtslp								
			orhodo		dryever	sloak	dryever													
					drydec		orhodo													
					mtcove															
					nhcove															
					sf															
1		mtcove	drydec	sf	nhslope	dryever	mtcove	dmoak	acove	rcove	acove	mtcove	mtslp	hero	rcove		hero		hero	alluvial
		nhcove	nhcove	sloak		sf	nhcove	hero	mtrich		hbald		orhodo	mtcove			sf		mtslp	
		mtrich					nhslp	orhodo	mtslp		mtslp		rcove	orhodo						
		sf					sf	poh	orhodo		orhodo		sloak							
								sf	rcove											
0	alluvial	alluvial	flood	alluvial	alluvial	drydec	alluvial	alluvial	alluvial	alluvial	alluvial	alluvial	acove	acove	dmoak	acove	acove	acove	acove	acove
	flood	flood	gbald	drydec	flood	flood	flood	drydec	dmoak	flood	dmoak	dmoak	alluvial	alluvial	drydec	alluvial	alluvial	alluvial	alluvial	dmoak
	gbald	gbald	hbald	flood	gbald	gbald	gbald	flood	drydec	gbald	dryever	dryever	dryever	dmoak	dryever	dmoak	dmoak	drydec	dmoak	drydec
	hbald	hbald	mtrich	gbald	hbald	hbald	hbald	gbald	flood	hbald	drydec	drydec	flood	dryever	gbald	drydec	drydec	dryever	drydec	dryever
	hero	sloak	nhslp	hbald	mtrich	hero	mtrich	hbald	hbald	hero	flood	flood	gbald	drydec	hbald	dryever	dryever	flood	dryever	flood
	mtrich	slpoh	sf	mtcove	sloak	mtrich	rcove	mtrich	mtcove	mtcove	mtcove	gbald	hbald	flood	hero	flood	flood	hbald	flood	hbald
	nhcove		slpoh	mtrich	slpoh	mtslp	slpoh	sloak	sloak	mtrich	mtrich	hbald	hero	hbald	mtcove	hbald	hbald	hero	hbald	hero
	nhslope			nhcove		nhslp		slpoh	slpoh	mtslp	poh	mtrich	mtcove	mtrich	mtrich	hero	mtcove	mtcove	mtcove	mtcove
	sf			slpoh		poh				nhcove	rcove	orhodo	mtrich	mtslp	mtslp	mtcove	mtrich	mtrich	mtrich	mtrich
						slpoh				nhslope	sloak	poh	nhcove	poh	nhcove	mtrich	mtslp	mtslp	nhcove	mtslp
										orhodo	slpoh	rcove	nhslope	rcove	nhslp	mtslp	nhcove	nhcove	nhslope	nhcove
										sf		sloak	sf	sloak	orhodo	nhcove	nhslope	nhslope	orhodo	nhslope
												slpoh	slpoh	slpoh	poh	nhslope	orhodo	orhodo	poh	orhodo
															sf	orhodo	poh	poh	rcove	poh
															sloak	poh	rcove	rcove	sf	rcove
															slpoh	rcove	sloak	sf	sloak	sf
																sloak	slpoh	slpoh	slpoh	sloak
																slpoh				slpoh
North	30	26	19	16	13	14	11	8	9	16	10	8	7	4	3	1	0	6	2	0
South	25	26	33	20	21	16	18	21	16	8	12	7	7	8	3	1	2	0	0	1
# types	10	13	12	10	12	9	12	11	11	7	8	6	6	6	3	1	2	2	2	1
gain %	+15	+8	+1	+12	+6	+20	+37	+13	+33	+12	+23	+32	+21	+39	+13	+30	-10	+82	+35	+6

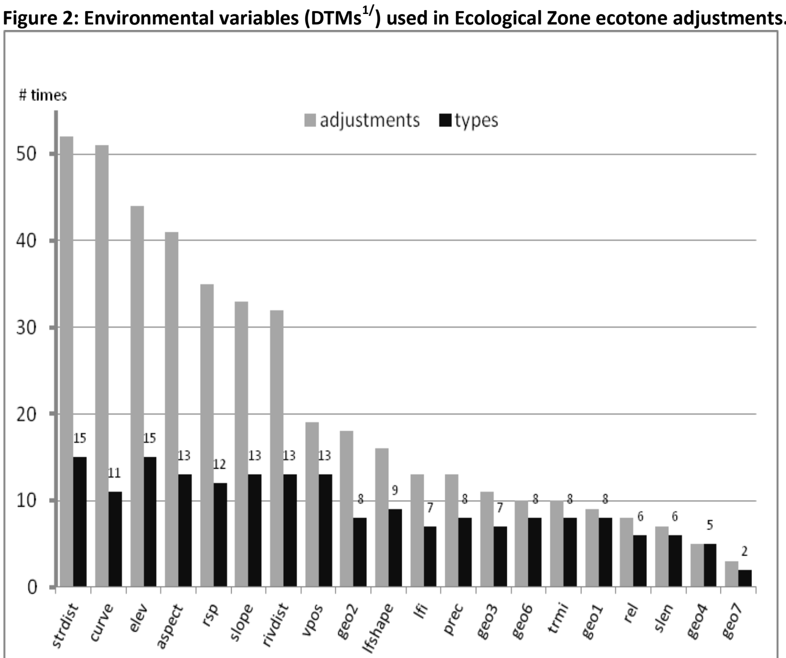
The 'north' and 'south' models did not always have the same Ecological Zone boundary issues and they were usually but not always related to the different size of the areas, i.e., the 'south' model is 8% larger and thus would logically have more adjustments. For example, Shortleaf Pine-Oak had ½ as many adjustments in the 'south' model but was nearly twice as common (acre extent) there. This could reflect the more extensive and/or more intact nature of this system, especially in Georgia and South Carolina, which could improve reference plot accuracy and therefore model accuracy. Five types had as much as twice the number of adjustments in the 'south' as in the 'north' model areas. They included Pine-Oak Heath, Montane Oak Cove, Mixed Oak/ Rhododendron, Rich Cove, and High Elevation Red Oak. There are many reasons for this, some of which could be DTM accuracy or modeling nuances. Pine-Oak Heath **is** more distinctive and more extensive in the 'north' area, especially around Linville Gorge and in Tennessee and therefore may have been easier to reference in the field and less difficult to model. High Elevation Red Oak (Hero) and Rich Cove (Rcove) **are** more extensive in the 'south' area (2-times as much Hero, 24% more Rcove) which probably explains most of the reason for greater adjustments there. Both Montane Oak Cove (Mtcove) and Mixed Oak/Rhododendron (Orhodo), however are much more common in the 'north' (nearly 2 times more extensive there) but needed fewer adjustments (13 north vs. 21 south for Orhodo, 19 north vs. 33 south for Mtcove, table 1), and they have roughly the same number of reference plots, respectively. One possible explanation for this discrepancy is that the concept (what the reference type looks like in the field), for both types, has undergone revision since the 1995 start of Ecological Zone mapping in the Appalachians; this could have differentially affected reference plot accuracy and therefore model accuracy in the different areas. There are certainly other explanations, but they are beyond the scope of this document.

Variables used in adjustments: DTM frequency of use can be grouped into the following categories that describe local environments:

Most frequent (40+)	Frequent (32-35)	Less Frequent (12-19)	Least Frequent (less than 12)
Stream distance (strdist)	Relative slope position (rsp)	Valley position (vpos)	Siliciclastic geology (geo3)
Surface curvature (curve)	Slope (slope)	Mafic geology (geo2)	Mixed geology (geo6)
Elevation (elev)	River distance (rivdist)	Landform shape (lfshape)	Terrain moisture index (trmi)
Aspect (aspect)		Landform index (lfi)	Carbonate geology (geo1)
		Precipitation (prec)	Relief (rel)
			Slope length (slen)
			Sulfidic geology (geo4)
			Ultramafic geology (geo7)

Topographic/environmental variables used most frequently to describe local environments that might refine ecotone boundaries between types were clearly fine-scale (from a mapping perspective) and included: stream distance, curvature, elevation, and aspect (fig. 2). These variables were used 40+ to 50+ times each in the over 400 adjustments made between the preliminary and final Ecological Zone models (table 3). A combination of fine- and mid-scale variables that include relative slope position, slope, and river distance were frequently used. Less and least frequently used were mid-scale variables. This contrasts greatly from variables used in the original Maxent models for each type. While aspect, slope, and curvature were used frequently to adjust ecotone boundaries (over ½ of the models used these variables), they had at least a 5% contribution to prediction gain in less than 12% of the Maxent models (table 2). Similarly, terrain relative moisture index, and slope length, which seldom provided even a 2% gain in Maxent models (table 5, report), were used in at least 30% of the models for ecotone adjustments. Conversely, carbonate geology, sulfidic geology, and relief which had significant contributions in Maxent were among the least frequently variables in the ecotone adjustments.

Figure 2: Environmental variables (DTMs[1/]) used in Ecological Zone ecotone adjustments.



[1/] **strdist**=dstream, sdiff; **curve**=curve, curvepl, curvepr, tsi; **aspect**=aspr, aspc, solar; **rsp**=rsp1, rsp2; **rivdist**=driver, rivdiff; **lfshape**=lfm10, lfm30

Table 2: Comparison of environmental variable use in ecotone adjustments vs. Maxent models

Variable[1/]	Ecotone adjustments	Maxent models [1/]	% difference in variable use
	% of types variable used		
aspect	65	8	57
slope	65	11	54
curvature	55	3	52
strdist	75	32	43
vpos	65	22	43
trmi	40	0	40
rsp	60	22	38
rivdist	65	32	33
precip	40	8	32
lfi	35	5	30
slength	30	0	30
lfshape	45	22	23
umaf_geo	10	0	10
elev	75	68	7
mafic_geo	40	35	5
silic_geo	35	32	3
mix_geo	40	46	-6
sulf_geo	25	46	-21
relief	30	54	-24
lime_geo	40	68	-28

[1/] where variable made at least a 5% contribution to prediction gain

Variables used within Ecological Zones: The most variables were used (greater than 10) for ecotone adjustments in Dry-Mesic Oak, Acidic Cove, Rich Cove, Pine-Oak Heath, Montane Oak Slope, Montane Oak Cove, Shortleaf-Oak, and Mixed Oak/Rhododendron (table 3). Stream distance, curvature, slope, and elevation were the most frequently used variables for adjusting these models.

Table 3: Environmental variables used for adjustments within Ecological Zones

Variable[1/]	# adj.	# types	Dmoak	Mtslp	Mtcov	Dryeve	Acove	Rcove	Poh	Orhodo	Hero	Sloak	Nhslp	Nhcov	Drydec	Sf	Alluv	Gbald	Hbald	Flood	Mrich	Slpoh
			number of adjustments made for the top 6 variables used in a least 2 adjustments (- indicates other adjustments)																			
strdist	52	15	6	8	7	6	4	6	3	3	2	5	-	2	2		3			-		
curvature	51	11	10	8	7	6	6		4			3	4	2	-	2						
elev	44	15	5	-	-	4	3	3	4	3	-	2	3	-	-	-			2			
aspect	41	13	-	7	-	3	2		-	-	4	2	3	2	3	-						
rsp	35	12	5	-	-	3	-	-		-	6	3		2	-	-						
slope	33	13	4	4	4	-	3	-	3	4	2		4		2		-	-				
rivdist	32	13	-	-	4	-		5	-	4	3	-			-	2	-	-				
vpos	19	13		-	-		-	-	2	-	-	-	2	-	-	-	-					
mafic_geo	18	8	-	3			2	3		-		-				-						
lfshape	16	9	4	-	-		-	2	-			2				-						
lfi	13	7	-	-	-	-	-	-	3	3				2								
precip	13	8	-					-		-	-											
silic_geo	11	7	-	-		-		2	-			-				2						
mix_geo	10	8	-	-	-	-	-	-	-		2	-										
trmi	10	8	-				-	-	-	-	-				-							
lime_geo	9	8	-	-	-		-	-	-					-	-							
relief	8	6	-		-		-					-		-								
slength	7	6	-				-	-	-	2				-								
sulf_geo	4	5										-										
umaf_geo	3	2	-													-						
Total	429	20	55	52	52	36	30	29	29	25	24	24	22	15	14	12	6	2	2	1	0	0
Total Variables used			18	14	13	10	15	15	14	12	10	13	6	10	10	10	4	2	1	1	-	-

1/ Rsp = rsp1, rsp2; Aspect = aspr, aspc, solar; Curve = curve, curvepl, curvepr, tsi; Strdist = dstream, sdiff; Rivdist = driver, rivdiff; Lfshape = lfm10, lfm30

Table 4: Number of times variable was used in local environment / ecotone adjustment – Northend model.

EZONE	Gbald	SF	NhS	NhC	Acov	Orho	Rcov	Alluvial	Flood	Hero	MonR	MonS	MonC	Dmoak	DryE	DryD	Poh	Sloak	Total
total	1	4	10	8	14	13	8	3	0	9	0	26	19	30	16	7	11	16	195
Asp_r						dmoak							rcove			poh		slpoh	4
Asp_c			hero										alluvial					dmoak	3
Curve			nhcove			drydecid						acove		acove		poh			5
Curpl				nhslope		acove									dmoak		dryever acove dmoak		6
Curpr			hero	sf								acove		acove	orhodo				5
Dstrm			acove		rcove					dryever			rcove dmoak acove	montslp	montslp			dmoak	9
Driver							acove					orhodo dmoak dryever	poh						5
Elev					orhodo		sf acove					acove hero	poh montslp dmoak	slpoh poh	acove orhodo hero		drydecid		14
Geo1				hero	alluvial								rcove						3
Geo2			sf		montcov		montcov					poh drydecid rcove	acove dmoak						8
Geo3		nhslope												sloak slpoh				poh	4
Geo6					dmoak							dmoak poh		slpoh	poh		montslp	dryeve	7
Lfi						acove poh rcove													3
Lfm10			sf									rcove		drydecid					3
Lfm30					alluvial		acove						dryever	poh				acove slpoh	6)
Precip												hero	montslp	montslp					3
Relief				hero	rcove									orhodo				dryever	4
Rivdiff							acove					poh orhodo drydecid	rcove	sloak	dmoak				7
Rsp1		gbald								poh		hero acove montcov		acove rcove		sloak		acove dmoak	10
Rsp2				montslp	rcove					mtrich nhslope		nhslope		acove poh	montslp			acove	9
Slength			gbald	sf		poh								dryever					4
Slope	sf		montslp		alluvial orhodo	poh dryever	nhcove	rcove		sf montslp		sf montrich	acove	orhodo poh acove dryever	dmoak montslp poh	dmoak	hero orhodo dmoak		24
Solyr		nhcove	nhcove		moncove					sf		nhslope acove		acove poh mtcove	poh				10
Solgw																			0
Stmdiff				acove	sloak	montslp montcov		acove		poh			acove montslp	poh drydecid	poh	rcove	montslp	dmoak slpoh acove	16
Trmi														dryever	dmoak	poh			3
Tsi					dmoak	hero	orhodo							dryever poh			dmoak	rcove	7
Vpos		gbald	sf	acove	nhcove	rcove		floodpl		nhcove		hero	alluvial		acove	poh	drydecid	acove	13
n_north	1-sf	2-gbald 1-nhslp 1-nhcove	3-sf 2-hero 2-nhcov 1-acove 1-gbald 1-mslp	2-sf 2-hero 2-acove 1-mslp 1-nhslp	3-rcove 3-alluvial 2-oakrho 2-dmoak 2-mtcov 1-nhcove 1-sloak	3-poh 2-acove 2-rcove 1-dryeve 1-hero 1-mtslp 1-mtcov 1-dmoak 1-drydec	4-acove 1-nhcov 1-mtcov 1-sf 1-orhod	1-flood 1-acove 1-rcove		2-sf 2-poh 1-mtslp 1-mtrich 1-nhslp 1-nhcov 1-dryeve		5-acove 4-hero 3-poh 2-nhslp 2-drydec 2-dmoak 2-orhod 2-rcove 1-mtcov 1-dryeve 1-sf 1-mtrich	4-rcove 4-acove 3-dmoak 3-mtslp 2-poh 2-alluv 1-dryeve	7-poh 6-acove 4-dryeve 3-slpoh 2-sloak 2-orhod 2-mtslp 2-drydec 1-rcove 1-mtcov	4-dmoak 4-poh 3-mtslp 2-acove 2-oakrho 1-hero	4-poh 1-sloak 1-dmoak 1-rcove	3-dmoak 2-drydec 2-mtslp 1-acove 1-dryever 1-hero 1-oakrho	5-acove 4-dmoak 3-slpoh 2-dryeve 1-poh 1-rcove	33-acove 26-poh 18-dmoak 14-mtslp 15-rcove 11-dryever 11-hero 10-sf 10-oakrho 7-drydec 6-nhcov 6-slpoh 6-montcov 5-alluvial 5-nhslope 4-sloak 3-gbald 2-mtrich 1-flood

Table 5: Number of times variable was used in local environment / ecotone adjustment, Southend model.

EZONE	Gbald	SF	NhS	NhC	Acov	Orho	Rcov	Alluvial	Flood	Hero	MonR	MonS	MonC	Dmoak	DryE	DryD	Poh	Sloak	heathb	Total
total	1	8	12	7	16	21	21	3	0	16	0	26	33	25	20	7	18	8	2	244
Asp_r												dmoak	sloak		dmoak					3
Asp_c					nhcove							hero rcove dmoak poh	mtslope dmoak sloak dryever		hero mtslope	mtslope poh	drydecid			14
Curve		hero	orhodo		mtcove sloak					poh		acove nhslope	sloak rcove	poh rcove				drydecid dmoak		13
Curpl		gbald			sf orodo	nhcove dryever						poh hero	hero acove	rcove acove	nhslope					12
Curpr					rcove	mtcove hero						nhslope	mtslope dmoak		hero rcove					8
Dstrm					nhcove		poh dryever mtslope nhcove					rcove	orhodo	poh mtslope		orhodo		dmoak		11
Driver		nhslope nhcove				hero rcove mtslope acove	dryever acove	acove		nhslope dryever sf		dryever	poh			poh		dmoak		16
Elev		mtcove	nhcove sf gbald	nhslope	orhodo dryever	dmoak sf nhcove	nhslope			gbald			dmoak dryever sloak hero	dryever sloak mtslope	nhslope poh hero	dmoak	dryever nhcove dmoak	poh dmoak	sf hero	29
Geo1							dmoak					rcove	dmoak	rcove		dmoak	sf			6
Geo2					rcove		nhcove acove					rcove	acove rcove	mtcove	dmoak rcove			dmoak		10
Geo3		orhodo					mtslope acove					orhodo	rcove	sloak			sloak			7
Geo4							acove					hero	nhcove				nhslope	drydecid		5
Geo6							hero			rcove nhslope										3
Geo7		nhcove												acove rcove						3
Lfi			hero	sf nhslope	montcov							acove		acove dryever			dmoak mtcove hero			10
Lfm10		nhcove					acove							sloak orhodo			mtslope			5
Lfm30					dmoak								dmoak							2
Precip			hero			mtslope	nhcove			acove gbald		nhslope dryever	acove mtslope		mtslope					10
Relief												hero		mtslope poh			sloak			4
Rivdiff	sf						nhcove							sloak			hero			4
Rsp1						acove				nhslope		acove orhodo	drydecid	mtslope	acove mtslope					8
Rsp2				mtcove		acove	mtcove acove			nhcove dryever		drydecid rcove								8
Slength					rcove	hero							rcove							3
Slope			hero nhcove heatbald		dmoak	mtslope nhslope							dryever orhodo			poh				9
Solyr			sf	hero sf						nhcove nhslope orhodo		dmoak								7
Solgw																				0
Stmdiff				mtslope	rcove	drydecid	nhslope	floodpl acove				nhcove	acove	poh	poh sloak dmoak		hero sloak			14
Trmi					nhcove	rcove	mtslope			poh					poh		drydecid orhodo			7
Tsi			hero			sf dmoak								mtslope mtcove	mtslope					6
Vpos			sf										rcove dmoak hero		sf		acove			6
total	1-sf	3-nhcove 1-mtcove 1-nhslope 1-orhodo 1-hero 1-gbald	4-hero 3-sf 2-nhcove 1-heat 1-gbald 1-orhodo	2-sf 2-nhslp 1-hero 1-mtslp 1-mtcov	4-rcove 3-nhcov 2-dmoak 2-mtcov 2-orhod 1-sloak 1-sf 1-dryever	3-acove 3-mtslp 3-hero 2-dmoak 2-sf 2-nhcove 2-rcove 1-mtcov 1-dryd 1-drye 1-nhslp	6-acove 4-nhcov 3-mtslp 2-nhslp 2-dryev 1-mtcov 1-hero 1-poh 1-dmoak	2-acove 1-fld		4-nhslp 2-poh 2-nhcov 2-dryev 2-gbald 1-sf 1-orhod 1-acove 1-rcove		5-rcove 4-hero 3-dmoak 3-acove 3-nhslp 2-orhodo 2-dryeve 2-poh 1-nhcove 1-drydec	6-dmoak 5-rcove 4-acove 4-sloak 3-mtslp 3-dryeve 3-hero 2-orhod 1-nhcov 1-drydec 1-poh	5-mtslp 4-poh 4-sloak 4-rcove 3-acove 2-dryeve 2-mtcov 1-orhodo	3-dmoak 3-poh 3-hero 4-mtslp 2-nhslp 2-rcove 1-sf 1-sloak 1-acove	3-poh 2-dmoak 1-orhod 1-mtslp	3-hero 3-sloak 2-drydec 1-acove 1-oakrho 1-mtslp 1-moncov 2-dmoak 1-nhslp 1-sf 1-dryeve 1-nhcov	5-dmoak 2-drydec 1-poh i	1-sf 1-hero	26-dmoak 24-hero 24-acove 23-rcove 21-mtslope 19-nhcove 17-poh 16-nhslope 14-dryever 13-sloak 13-sf 12-orhodo 9-mtcove 7-drydecid 4-gbald 1-heat 1-flood

Appendix VII: Accuracy Evaluation

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 overall 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.

A true accuracy assessment was not completed for this project, hence the title "Accuracy Evaluation". However, the same procedure was followed, i.e., a comparison was made of reference data for a site to categorized (classified, modeled) data (map units) on the same site. 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 unit accuracy assessment, sites are generally the same type of modeling unit used to create the map. In a true field accuracy assessment, the evaluation would be made around randomly generated points on the ground or more realistically within a 'stand' or other reasonable-size area (ground truthing).

Error Matrix

The error matrix (tables 1, 2) below are a square array in which accuracy assessment sites are tallied by both their classified category and their actual category according to the reference data. For this study, the columns in the matrix represent the classified Ecological Zone map units, while the rows represent the reference data; this is a non-traditional approach in arranging the error matrix. 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). High errors of omission/commission between two or more classes indicate spectral confusion between these classes.

Omission error is represented in the off-diagonal vertical cells (columns). An example of an error of omission is when pixels of a certain thing, for example maple trees, are not classified as maple trees. This accuracy measure indicates the probability of a reference pixel being correctly classified.

Commission errors are shown in the off-diagonal matrix cells that form the horizontal row for a particular class. An example of an error of commission is when a pixel reports the presence of a feature (such as trees) that, in reality, is absent (no trees are actual present). This accuracy measure is indicative of the probability that a pixel classified on the map actually represents that category on the ground.

The following measures of accuracy were derived from the Ecological Zone 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 right-hand cell of each row (Story and Congalton 1968). Producer's accuracy indicates how many times an Ecological Zone on the ground was identified as that Ecological Zone on the map.
>
> **User's Accuracy**: the total number of correct pixels in a category divided by the total number of pixels that were classified in that category (commission error). This is the probability that a pixel classified on the map actually represents that category on the ground; also called reliability.

Table 1: Evaluation of Ecological Zones in the SBR 3rd approximation study area from 5,842 field plots

#		1	27	2	3	4	29	5	6	23	8	24	9	28	13	10	11	16	18	31	30	total	% corr.
1	sf	147	1	6	7	4					1											166	**89%**
27	gbald	4	25	3							2											34	**74%**
2	nhslope	5		153	18	2	3	2			18		6	2					2			211	**73%**
3	nhcove	4		13	266	18	2	15			8		4	1					1			332	**80%**
4	acove	1		5	11	954	24	79	6		2		10	25	39	6	1	7	4	1		1175	**81%**
29	orhodo	1		2	2	18	154	6			3		7	9	10	4	5	1	5			227	**68%**
5	rcove				3	75	7	622			4		21	15	11	4	1		2			765	**81%**
6	alluv					14			65	3				1								83	**78%**
23	floodplain								2	48					1							51	**94%**
8	hero	3	1	13	12	1	5	3			314		17	2	1	3			11			386	**81%**
24	mont_rich			1							4	9										14	**64%**
9	montoakslope			5	3	5	12	15			9		279	6	13	13	1		11			372	**75%**
28	montoakcove				2	11	5	13	1				3	127	14	2	2	2	3			185	**69%**
13	dmoak					28	8	7	2				14	24	442	31	6	16	21	1		600	**74%**
10	dryoakEheath					6	5	4			7		10	4	13	158	2	8	11	1		229	**69%**
11	dryoakDheath						2	1						1	3	3	73	3	8			94	**78%**
16	sloak					5	1						1	2	18	3		246	5			281	**88%**
18	poh					5	6				5		8	4	28	17	18	15	468			574	**82%**
31	slpoh					1									1	1		4	1	36		44	**82%**
30	heathbald	2																	3		14	19	**74%**
	TOTAL correct	147	25	153	266	954	154	622	65	48	314	9	279	127	442	158	73	246	468	36	14	4600	**79%**
	total column	167	27	201	324	1147	234	767	76	51	377	9	380	223	594	245	109	302	556	39	14	5842	
	% correct	**88%**	**93%**	**76%**	**82%**	**83%**	**66%**	**81%**	**86%**	**94%**	**83%**	**100%**	**73%**	**57%**	**74%**	**64%**	**67%**	**81%**	**84%**	**92%**	**100%**		

Most fire-adapted = 93% correct, Least fire-adapted = 92% correct

Table 2: Evaluation of Biophysical Settings / Ecological Systems in the 3rd approx. SBR study area from 5,842 field sites [1/]

#		27	1	2	4	6	23	8	9	13	10	16	18	total	correct class
27	Southern Appalachian Grass and Shrub Bald	39	6	3				2					3	53	74%
1	Central and Southern Appalachian Spruce-Fir Forest	1	147	13	4			1						166	89%
2	Southern Appalachian Northern Hardwood		9	450	42			26	13				3	543	83%
4	Southern and Central Appalachian Cove Forest		2	23	1939	6		9	87	60	21	9	11	2167	89%
6	Central Interior and Appalachian Riparian Systems				14	65	3		1					83	78%
23	Central Interior and Appalachian Floodplain Systems					2	48			1				51	94%
8	Central and Southern Appalachian Montane-Oak	1	2	25	8			314	19	1	3		11	384	82%
9	Southern and Central Appalachian N. Red Oak-Chestnut Oak			11	61	1		13	424	27	18	2	14	571	74%
13	Southern Appalachian Oak Forest				43	2			38	442	37	17	21	600	74%
10	Allegheny-Cumberland Dry Oak Forest and Woodland				18			7	15	16	236	12	19	323	73%
16	Central Appalachian Low-Elevation Pine				7				3	19	4	286	6	325	88%
18	Southern Appalachian Montane Pine Forest and Woodland				11			5	12	28	35	15	468	574	82%
	TOTAL Correct [2/]													4858	83%

[1/] rows are reference (field plot) data, columns are classified (modeled) data, [2/] Total Correct percent = 4858 (correctly modeled field plots / 5842 (total field plots)

Appendix VIII: Geology grouping and mapunit details.

Map unit	Source	ROCKTYPE_1	ROCKTYPE_2	acres
CARBONATE-BEARING ROCKS – group 1				
Cc3	TN001	shale (calcareous)	limestone	1,531
Ccl2	TN001	flaky clay shale, shaly limestone lenses	stromatolitic (algae gw) limestones	863
Ccr	TN001	dolostone (dolomite)	chert	2,038
Ccu2	TN001	limestone	dolostone (dolomite)	2,465
Chk	TN001	dolostone (dolomite)	limestone	15,016
Cmn	TN001	limestone	dolostone (dolomite)	317
Cs1	NC002	dolostone (dolomite)		3,031
Cs2	TN001	dolostone (dolomite)	limestone	76,657
Mgg	TN001	limestone	shale	8,389
Oa	TN001	calcareous, graptolitic shale (fossils)	calcareous sandstone, siltstone, conglom	8,528
Oc	TN001	dolostone (dolomite)	limestone	260
OCk	TN001	dolostone (dolomite)	limestone	64,871
Oh	TN001	limestone	shale	1,916
Olv	TN001	dolostone (dolomite)	limestone	1,078
On	TN001	dolostone (dolomite)	limestone	3,156
Onc	TN001	dolostone (dolomite)	limestone	6,174
Oo	TN001	calcareous shale	fossiliferous limestone	4,919
Osv	TN001	calcareous shale, limestone	sandstone	50,096
MAFIC SILICATE ROCKS – group 2				
am	NCquad	amphibolite		15,422
am1	NCquad	amphibolite	biotite granitic gneiss	474
am2	NCquad	amphibolite	biotite hornblende migmatite	230
ams	NCquad			1,187
bag2	NCquad	biotite augen gneiss	biotite hornblende migmatite	1,047
bg	NCquad	biotite gneiss	muscovite-biotite gneiss, biotite schist	18,540
bg1	GA001	biotite gneiss		98,802
bg2	NCquad	biotite gneiss	amphibolite, biotite hornblende	707
bg3	NCquad	biotite gneiss	amphibolite, quartzite, calc-silicate	199
bgb	NCquad	metagabbro, metadiabase		313
bgg1	NCquad	biotite granitic gneiss	amphibolite, hornblende migmatite	12,980
bggs	NCquad	biotite-muscovite gneiss and schist	biotite-muscovite gneiss, mica schist, a	9,621
bgn	NCquad	biotite granitic gneiss	lenses-bands of amphibolite, pegmatite p	297
bgs	NCquad	biotite gneiss, pelitic schist,	amphibolite, calc-silicate granofels	968
bhg2	NCquad	biotite hornblende migmatite	biotite hornblende gneiss	827
bhgb	NCquad	hyperstene metagabbro		1,431
bhm2	NCquad	biotite hornblende migmatite	amphibolite, biotite-hornblende-gneiss	13,150
bogb	NCquad	metaolivine gabbro	grades outward to amphibolite	830
bpg	NCquad	biotite paragneiss and schist	biotite-plagioclase-quartz gneiss	8,618
bs	NCquad	biotite-muscovite mylonite gneiss	biotite schist,w/plagioclase porphyrobla	7
bw	NCquad	biotite metasandstone	granitic and pegmatitic lenses, mudstone	7,422
ck	NCquad	mafic-ultramafic complex of Carroll knob	amphibolite, hornblende-gneiss	3,891
ckg	NCquad	metagabbro units at Carroll knob	labradorite, hornblende	37
cmy	NCquad	calcareous mylonite (Brevard zone)		0
crp	NCquad	biotite-garnet schist, pelitic schist	metaorthoquartzite, metasandstone	891
cs	NCquad	calc-silicate (85% quartz and feldspar)	15% amphibole	1,661
cs1	NCquad	calc-silicate	biotite granitic, amphibolite	291
cs2	NCquad	calc-silicate	biotite hornblende migmatite	17
cs3	NCquad	calc-silicate	diopside lenses	136
csam2	NCquad	amphibolite and calc-silicate		1,078
CZab	NC002	amphibolite	biotite gneiss	56,291
CZam	NC002	amphibolite	basalt	531
CZba	NC002	megacrysitic biotite gneiss	and quartz,local micaschist,amph,biog	9,526
CZbf	NC002	biotite gneiss	amphibolite	1,092
CZbg	NC002	biotite gneiss and schist	interlayed with calc-silicate rock	391,055
CZbg	SC001	biotite gneiss and schist	interlayed with calc-silicate rock	928
CZpg	NC002	biotite gneiss		35,130
CZpg	SC001	biotite gneiss		19,502
CZsg	SC001	biotite gneiss	schist	63,016
CZwa	SC001	mafic gneiss	amphibolite	119,735

fg3	GA001	biotite gneiss	mica schist	495
g	NCquad	gabbro(olivine-pyroxene-hornblende)		2
gb	NCquad	metagabbro (pyroxene, hornblende,	plagioclase)	4
ggn	Hatcher	biotite-muscovite granitite gneiss	locally hornblende	10,391
hbgg1	NCquad	biotite granitic gneiss	hornblende-biotite gneiss	26
hbm1	NCquad	hornblende-biotite migmatite	biotite granitic gneiss	353
hg	NCquad	hornblende gneiss		1,106
hgn	NCquad	hornblende gneiss		5,545
hmg1	NCquad	hornblende-magnetite gneiss	biotite granite, amphibolite	31
hybh2	NCquad	biotite-hornblende migmatite	hyperstene-biotite hornblende gneiss	14
hyp1	NCquad	hyperstene-plageoclase	magnetite, hornblende, biotite	134
ig	TN001	peridotite	diorite	61
lbg	NCquad	biotite gneiss (layered)	xenoliths (mafic gneiss)	108
lgn	NCquad	biotite-plagioclase-quartz gneiss	and biotite-muscovite gneiss, calc-sili	72
m	NCquad	marble		90
mbg2	NCquad	magnetite-biotite gneiss	biotite hornblende migmatite	23
mm1	GA001	amphibolite		140
mm3	GA001	hornblende gneiss	amphibolite	11,283
mp3	GA001	amphibolite		6,436
P	NCquad			2
pCaa	NCquad	amphibolite and amphibole gneiss		3,097
pCam	NCquad	amphibolite and hornblende gneiss		31
pCba	TN001	gabbro	diorite	190
pCcm	NCquad	biotite-muscovite mylonite gneiss	biotite schist & biotite mylonite gneiss	1,917
pCcs	NCquad	biotite schist	includes(biotite,clinozoisite, quartz)	234
pCgn	NCquad	biotite gneiss, ranges to biotite schist	(composed of quartz,plagioclase,bio,ms)	1,550
pgn	NCquad	biotite-plagioclase-quartz gneiss	minor muscovite-biotite schist	3,162
pms8	GA001	biotite schist	(this is cross-biotite schist)	129
pmy	NCquad	porphyroblastic mylonite schist & gneiss		6,681
PzZmb	NCquad	muscovite-chlorite schist or phyllite	cross-biotite schist, metasand.,metasilt	73
PzZmma	NCquad	calcitic to dolomitic marble	calcareous quartzite	387
Qal	NCquad	alluvium		500
tf	NCquad	biotite paragneiss & schist	pelitic schist, metasandstone	13,482
Ya	NCquad	amphibolite	if retrogressed, then biotite schist	622
Yam2	NCquad	amphibolite		184
Ybag2	NCquad	biotite augen gneiss	migmatitic biotite-hornblende gne.amp	19
Ybgg	NC002	biotite granitic gneiss	amphibolite, calc-silicate rock, marble	493,924
Ybhg2	NCquad	migmatic biotite-hornblende gneiss		36
Ybhm2	NCquad	migmatic biotite-hornblende gneiss		14,340
Ybn	NCquad	biotite granitic gneiss & biotite gneiss	interlayed with amphibolite&felsic gneis	613
Ycs2	NCquad	calc-silicate granofels	amphibolite, hornblende gneiss	134
Ydga	NCquad	amphibolite	where retrogressed, then biotite schist	80
Ygcs2	NCquad	migmatic biotite-hornblende gneiss	grossular-calc-silicate granofels	245
Yhyp2	NCquad	pyroxene granulite	amphibolite, mafic granulite	15
Ymam	NC002	amphibolite	metasedimentary rock	6,282
Ymg	NC002	migmatic biotite-hornblende gneiss	amphibolite	140,002
Ymg2	NCquad	migmatic biotite-hornblende gneiss	mafic granulite (hornblende)	391
Ypgg2	NCquad	migmatic biotite-hornblende gneiss	biotite augen gneiss	19
Ysa	NCquad	amphibolite	retrogressed to biotite schist	23
Ysca	NCquad	amphibolite	retrogressed to biotite schist	131
Zaa	NCquad	layered amphibolite	meta-calcareous sediments	355
Zaba	NC002	amphibolite	metasedimentary rock	18,296
Zabg	NC002	biotite gneiss	musc.-bio-gneiss, calc-silicate,amphibol	485,072
Zacs	NCquad	calc-silicate granofels	amphibolite, quartz-clinozoisite	1,466
Zata	NC002	amphibolite	metasedimentary	127,125
Zatb	NC002	biotite gneiss	mica schist	398
Zbgb	NCquad	metagabbro (Bakersville) dikes		9
Zgmg	NC002	greenstone	metasedimentary rock, metabasalt	10,074
Zlm	NC002	metadiabase, greenstone, amphib.dikes		6,252
Zman	NC002	marble	schist	10,567
ZYba	NC002	amphibolite	metasedimentary rock	10,859
ZYbn	NC002	biotite gneiss-migmatitic	with biotite garnet gneiss & amphibolite	370,666
ZYfcs	NCquad	ferriferous calc-silicate granofels	magnetite-garnet-epidote-hornblende-q	16

SILICICLASTIC ROCKS – group 3				
aa	Hatcher			554
as	NCquad	actinolite schist	schistose to acinolite-chlorite talc	2
bc	NCquad	conglomerate metasandstone?	unconformity	5
bmg	NCquad	feldspathic mica gneiss	thin bands neosomal pegmatite	8,618
bmy	NCquad	feldspar set in mylonitic matrix	(this is a blastomylonite)	197
bp	Hatcher			1,130
bpm	Hatcher			30,661
bz	NC002	schist	phyllonite	18,819
c	NCquad	quartz metaconglomerate, metasandstone	metasiltstone, metatuff, greenstone	23
Cag	NCquad	augen gneiss, quartz monzonite		51,283
Cc1	NCquad	quartzite		848
Cch	TN001	quartz-pebble conglomerate, gray arkose	siltstone and shale; irreg bedding	12,355
Cchi	TN001	quartzite	shale	2,255
Ccl1	NC002	arenite	shale	31,141
Ccu1	NC002	arenite	siltstone	21,648
Ce1	NCquad	metasandstone and quartzite	(is Erwin Formation)	2,101
Ce2	TN001	quartzite	shale	82,494
cg	NCquad	cataclastic gneiss (gran&bio gneiss)	mylonitie gneiss and myonite schist	3,765
Ch1	NCquad	Hampton formation (micaceous shale?)		968
Ch2	TN001	silty, sandy, micaceous shale	feldspathic sandstone	62,798
Che	TN001	quartzite	sandstone	8,255
Chg	NC002	monzonitic to granodioritic gneiss		185,594
Chg	SC001	monzonitic to granodioritic gneiss		12,821
Cmu	TN001	silty, sandy, shale, micaceous		2,603
cn	Hatcher			108
Cnb	TN001	quartzite		3,941
Cni	TN001	silty and sandy micaceous shale&siltstone	feldspathic quartzite	3,905
Cu	TN001	sandstone	arkose	99,944
Cuu	NCquad	conglomeratic metasandstone	quartzite and phyllitic metamudstone	4,003
cw	NCquad	metasandstone, metaconglomerate	and biotite-muscovite schist	11,854
CZcp	SC001	metasedimentary rock	(Chauga River and Poor Mt. undivided)	27,557
CZms1	NC002	mica schist-garnet, staurolite	micaceous quartzite	129,649
CZms2	SC001	sillimanite-mica schist	muscovite-biotite schist	1,561
CZtp	NC002	porphyroblastic gneiss, granodioritic	and migmatitic	31,700
Dsc	Hatcher			18,490
DSc	NC002	granitic gneiss		63
DSg	SC001	granitic gneiss		16,590
DSwg	NCquad	muscovite-biotite granitoid	granodiorite to quartz monzonite	10,417
ehga	Hatcher			23,356
ehgc	Hatcher			2,666
ehgf	Hatcher			314
fs	NCquad	porphyroclastic phyllonite	and phyllonitic schist	15,963
gam	NCquad	metasandstone w/metasiltstone, musc.schi	minor calc-silicate granofels	5,274
gbb	NCquad	greywacke metaconglom.,slate, metasiltst		163
gbgs	NCquad	feldspathic metagreywacke	rare greywacke metaconglomerate	2,600
gch	NCquad	metagreywacke	greywacke metaconglom, garnet ms.schis	5,721
gd	NCquad	granodiorite		91
gdf	NCquad	metasandstone, porphyroblastic musco.sch	minor metaquartzite,metasilt. muscovite,	1,216
gg1a	NCquad	granitic gneiss	magnetite, sphene, biotite	643
gg1b	GA001	granitic gneiss		8,268
ggs	NCquad	porphyroblast. muscovite schist,metasand	minor muscovite schist, calc-sili. grano	319
gmg	NCquad	mylonitic gneiss and schist	(granitic gneiss)	14,070
gms	NCquad	garnetiferous muscovite schist	garnet mica schist	21,506
ma	Hatcher			1,096
mag	NCquad	mylonite gneiss, protomylonite	aegirine granitic gneiss(E ForkRdgfault)	1,158
mChg	NCquad	mylonitic Henderson gneiss		925
mg	NCquad	muscovite gneiss and schist		1,296
Mg	TN001	shale, siltstone, glauconitic sandstone	quartz pebble conglomerate	2,198
mgn2	NCquad	magnetite granitic gneiss		487
mmg	NCquad	mixed mica gneiss		10
mp	NCquad	metamudstone, phyllitic	metamorphism between slate and mi.shc	24

ms	NCquad	mica schist	muscovite schist, metasandstone	19,935
mss	NCquad	metasandstone and schist		6,498
my	NCquad	mylonite and ultramylontite	porphyroblastic mostly	3,944
none	NCquad			2,002
ntq	NCquad	metaquartzite, thin black schist	dark-grey schist and metasiltstone	349
Ob	TN001	claystone,siltstone	sandstone, metabentonite	6,312
OCg	NC002	metamorphosed granitic rock, granite		106,692
Omg	SC001	granitic gneiss		204,255
OSgg	NCquad	granitic gneiss	augen gneiss on eastern contact	16,951
P	NCquad			2
pa1	GA001	schist		1,842
pCags	NCquad	mica gneiss and schist		484
pCc	NCquad	mylonitic quartz-feldspar gneiss	minor garnet	23,249
pCc2	TN001	migmatite	Gneiss	49,266
pCca	TN001	feldspathic metasandstone	slate and metasiltstone	25,004
pCcg	NCquad	quartzo-feldspathic gneiss	minor biotite	1,079
pCg	TN001	greywacke	Arkose	225,815
pCgq	NCquad	quartz monzonite(mylonitzed)	(composed of microcline,	3
pCo	TN001	sandstone (clastic sedimentary)	Shale	43,858
pCrb	TN001	sandstone (feldspathic, fine grained)	Slate	5,233
pCs	TN001	siltstone	Sandstone	127,495
pCss	TN001	argillaceous, micaceous shale	feldspathic sandstone and quartz congl.	20,910
pctg	Hatcher	greywacke schist (Tallulah Falls form)		202,187
pCtg	NCquad	banded granitic gneiss	(an unconformity - Toxaway gneiss)	266
pctp	Hatcher	aluminous schist	(Tallulah Falls Formation)	18,326
pctq	Hatcher	Tallulah Falls formation: quartz member		30,581
pCw	TN001	argillaceous, micaceous shale	feldspathic sandstone	245,461
pCwg	NCquad	sheared granitic unit	Grandfather Mts window (Wilson Creek)	1,472
pCwmg	NCquad	mica gneiss to augen gneiss		2,375
pCwq	NCquad	(quartz monzonite) = muscovite, plagiocl	..quartz,microcline, chlorite ...	409
pCwrg	NCquad	gneiss, quartz veins and aplite dikes		4,715
pCwrm	NCquad	mylonite gneiss (mylonite schist	and quartzofeldspathic mylonite gneiss	9,162
pg	NCquad	pegmatite (quartz, plagioclase,microclin	minot biotite, garnet	54
pg1	GA001	garnet mica schist		4,945
pgc	NCquad	porphyroclastic mica gneiss		4,249
pm2	GA001	metagreywacke	mica schist	33,890
pma	Hatcher			21,799
pmg	Hatcher			1,458
pmm	Hatcher			16
pmq	Hatcher			1,085
pzg	Hatcher	granitic gneiss		5,049
pzgr	Hatcher	granite (Rabun granite)		29,360
pzgw	Hatcher	granite (Whiteside granite)		27,077
Pzp	NCquad	pegmatite	too small to depict at map scale?	22
PzZbt	NCquad	cross-biotite, phyllite, schist	metasandstone,metasiltstone&feldspahic	2,143
PzZbts	NCquad	cross-biotite, phyllite, schist, graphitic	metasandstone,metasiltstone&feldspahic	557
PzZn	NCquad	quartzose metasandstone	muscovite schist	119
q	Hatcher	quartzite		1,007
q1	GA001	quartzite		8,216
q1a	GA001	quartzite	mica schist	8,889
q2	GA001	quartzite	granitic gneiss	215
Qal	NCquad	alluvium		4,056
qm	NCquad	quartz monzonite	(composed of quartz, microcline, oligoc	167
SOg	SC001	granitic gneiss		3,462
SOgg	NC002	granitic gneiss	augen gneiss	25,399
SOgg	SC001	granitic gneiss	augen gneiss	48,899
ssg	NCquad	sillimanite schist and gneiss		1,013
t	NCquad	trondhjemite with olioclase in quartz	plagioclase, plagioclase-quartz	12
tq	NCquad			384
tw	NCquad	metasandstone & schist	schist locally w/graphite & garnet	1,725
Ygg	NC002	granitic gneiss		75,621
Yscm	NCquad	protomylonitic granitoid gneiss		1,938
Yscu	NCquad	mylonitic granitoid gneiss		945

Zabs	NC002	mica schist	Phyllite	65,526
Zacb	NCquad	mica-rich metasiltstone, mica schist	Metastandstone	597
Zagg	NCquad	garnet-muscovite-biotite gneiss		399
Zahb	NCquad	metasiltstone, phyllite, schist	phyllite, metaconglomerate, metagrayw.	2,802
Zams	NCquad	phyllite, schist, metagraywacke		7,730
Zamy	NCquad	mylonitic muscovite-feldspar-quartz gneis		22
Zats	NC002	mica schist	Gneiss	3,051
Zatw	NC002	metagraywacke	mica schist	105,982
Zb	NC002	mica schist	Quartzite	58,920
Zg	NC002	metamorphosed granitic	Mylonite	23,679
Zgma	NC002	meta-arkose-sericitic, conglomeratic	metasiltstone and slate	23,977
Zgmf	NC002	felsic metavolcanic rock		2,371
Zgmu	NC002	felsic metavolcanic rock	metasedimentary rock	17,451
Zgmw	NC002	metagraywacke, locally conglomeratic	metasiltstone and phyllite	36,854
Zgsm	NCquad	garnet-mica schist	locally graphitic and sulfidic, calc silicate	2,389
Zm	NC002	granite		18,867
Zmb	NC002	schist	Phyllite	43,966
Zrb	NC002	sandstone - feldspathic		6,196
Zs	NC002	feldspathic metasiltstone, metasandstone	phyllite, schist; conglomerate	29,090
Zsl	NC002	quartzite, feldspathic	slate, metasiltstone	26,336
Zsp	NC002	siltstone, metamorphosed	locally argillite, calcareous-arke. Msil	4,743
Zsr	NC002	sandstone, metamorphosed	metasiltstone and phyllite	22,487
Zsw	NC002	sandy slate, pebbly metagraywacke	basal quartz-sericite schist or phyllite	7,849
Zwc	NC002	slate	metasedimentary rock	17,100
ZYmgm	NCquad	monzongranitic gneiss	protomylonitic phase	2,110
ZYmgu	NCquad	monzongranitic gneiss	mylonitic phase	907
SULFIDIC ROCKS – group 4				
ga1	NCquad	muscovite schist, metasandstone	Anakeesta formation(black schist unit)	2,100
ga2	NCquad	metasandstone w/schist and muscovite sch	Anakeesta formation(metasandstone)	1,891
ga3	NCquad	schist, metasandstone	Anakeesta formation(black schist unit)	1,799
ga4	NCquad	metasandstone w/schist and muscovite sch	Anakeesta formation(up.metasandstone)	2,096
ga5	NCquad	muscovite schist	Anakeesta formation(up.black schist unit	2,872
gbg	NCquad	slate & metasiltstone, sulfurous and	Graphitic	2,768
gf	NCquad	sulfidic phyllite	feldspathic metagraywacke	1,312
ghb	NCquad	sulphidic mica schist & metasiltstone	metasandstone, muscovite schist	423
gs	NCquad	graphite-muscovite schist	pyrite abundant in places	762
gw	NCquad	sulfidic phyllitite & muscovite schist	slate & garnet-muscovite schist	378
MDc	TN001	black shale		827
nt	NCquad	sulphidic schist & quartzose metasiltstone	Metaquartzite	310
pCr	TN001	gneiss	Migmatite	10,129
PzZnt	NCquad	graphitic&sulfidic phyllite,schist,metsl	quartzose metasandstone	6,353
sms	NCquad	sulfidic muscovite schist	amphibolite in thin interlay portions	57
Za	NC002	slate	schist, metasedimentary3	19,942
Zbg	NC002	slate, highly sulphidic	metasiltstone, metagraywacke	11,975
Zchs	NC002	slate to phyllite, graphitic, sulfidic	Metagraywacke	28,495
Zf	NC002	phyllite, graphitic and sulfidic		2,020
Zgs	NC002	metagraywacke and metasiltstone	sulfidic slate and schist	93,127
Zgsk	NCquad	syanite-garnet-mica schist	locally sulfidic, calc-silicate	2,897
Znt	NC002	slate and metasiltstone, sulfidic	tusquitee quartzite, thin slate layers	62,632
Zwe	NC002	slate to schist, graphitic and sulfidic	mica schist, metagraywacke, metacong.	90,184
MIXED SILICICLASTIC -MAFIC ROCKS – group 6				
agg	NCquad	aegirine granitic gneiss	amphibole gneiss	5,579
agg1	NCquad	augen granitic gneiss	biotite granitic gneiss	131
bpl	Hatcher			3,079
bpu	Hatcher			2,312
bpu	NCquad			91
ccr	NCquad	metasandstone, quartz feldspar gneiss	peltic schist & calc-silicate quartzite	4,539
cpc	NCquad	quartz diorite gneiss	metasandsone,quartz-feldspar gneiss, sc	8,002
cq	Hatcher	calcsilicate quartzite		1,268
Cr1	NC002	shale&siltstone (Rome formation)	interbedded sandstone, shaley dolomite	2,575
Cr2	TN001	shale&siltstone (Rome formation)	interbedded sandstone,	72,148
crc	Hatcher			1,147

Cul	NCquad	metaconglomerate:metatuff, greenstone,	metamudstone w/arkosic metasand-silt	1,499
CZbb	NC002	gneiss	metasedimentary rock, amphib	5,269
CZgms	NC002	mica schist	Amphibolites	38,468
CZgs	SC001	mica schist	Amphibolites	31,076
CZma1	NC002	metasedimentary rock	Amphibolites	2,962
Dqd	NC002	quartz diorite	Granodiorite	60,037
DSwl	NCquad	quartz diorite to granodiorite	(this is the Looking Glass Gneiss)	508
DSwp	NCquad			1,889
egg1	NCquad	epidote-veined granitic gneiss	amphibolite, biotite granite, gneiss	479
egg2	NCquad	epidote-veined granitic gneiss	hornblende migmatite and amphibolites	31
gg	NCquad	granitic gneiss to protomylonite	biotite granitic gneiss(SE BrevFault)	3,285
ggg	NCquad	metasandstone with muscovite schist	many beds of calcareous concretions	1,389
gp	Hatcher			909
gt	NCquad	metasandstone with calcareous concretion	muscovite schist	18,848
kgms	NCquad	kyanite-garnet-muscovite-biotite schist		32
mbg3	NCquad	muscovite-biotite gneiss	biotite gneiss, metasubgreywacke	284
mgm	NCquad	banded gneiss and migmatite	biotite quartz,feldspar gneiss,micaschis	5,839
mgn	NCquad	mica gneiss	biotite schist, metasandstone, mica schi	11,866
mps	NCquad	muscovite-biotite paraschist	grades to biotite schist, quartz biotite	294
myg1	NCquad	mylonite (flaser) gneiss	biotite granitic gneiss	2,183
mz	Hatcher			158
mz-gp	Hatcher			1,061
OCgm	NC002	granitic gneiss	biotite gneiss	232,421
oek	Hatcher			19
pbu	Hatcher			50
pCb	TN001	granite (interstitial mafics)	(chloritized biotite, hornblende)	64,646
pcbt	Hatcher	granite gneiss; quartz, plagioclase	biotite rich layers	10,200
pcbw	Hatcher	feldspar-biotite-muscovite-augen gneiss	w/apatite, zircon,clinozorizite,	3,634
pct	Hatcher			359
pctl	Hatcher	greywacke-schist-amphibolite	(Tallulah Falls Formation)	104,465
pgw	NCquad	paragneiss & metagraywacke	biotite schist, metasandstone, garnet sc	13,520
pms3	GA001	mica schist	Gneiss	3,010
Qal	NCquad	alluvium		23,588
qbgn	NCquad	quartz-biotite-plagioclase gneiss		6,887
qfgf	NCquad	quartzo-feldspathic granofels	granitic gneiss, amphibolite, metaquartzi	4,345
x	Hatcher			39
Ybrg	NC002	gneiss, feldspar megacrysts	biotite schist, locally calcareous	32,085
Ydg	NCquad	granitic to granodioritic	biotite granitic gneiss, amphibolites	2,085
Yfg	NCquad	felsic gneiss	interlayed w/biotite gneiss&amphibolites	82
Ymgn2	NCquad	magnetite granitic gneiss	migmatitic biotite hornblende gneiss	76
Ys	NCquad	granitic gneiss, biotite granitic gneiss	amphibolite, calc-silcate granofels	1,970
Ysc	NCquad	biotite granitic gneiss	biotite granodioritic gneiss (amphib?)	16,695
Zag	NCquad	muscovite-biotite gneiss	kyanite-garnet schist, metagraywacke	16,813
Zags	NCquad	schist and cross-biotite schist	metasand.,metasilt. calc-silicate granof	3,193
Zakgs	NCquad	kyanite-garnet schist	garnet-muscovite-biotite gneiss	644
Zaqc	NCquad	quartz-slinozoisite gneiss	calc-silicate granodiorite, amphibolites	44
Zatm	NC002	muscovite-biotite gneiss-locally sulphidic	grades w/mica schist, minor amphib, hrn.	627,856
Zaw	NCquad	metagraywacke	schist, gneiss,calc-silicate metagreywacke	1,932
Zch	NC002	metagraywacke	slate,mica schist, calc-silicate nodule	368,306
Zco	NC002	quartz dioritic gneiss	feldspar-quartz-biotite gneiss, metasand	4,129
Zd	NC002	sericite schist, biotite, staurolite	metagraywacke, quartz metaconglom.	54,459
Zgms	NC002	metasiltstone, thin bedded dolomiticmarb	phyllite, metagraywacke, meta-arkose	16,286
Zgsg	NCquad	metagraywacke, cyanite-garnet-mica schis	garnet-mica schist, calc-silicate granof	4,220
Zhha	NC002	metasandstone,metagraywacke,metasiltston	mica schist, calc-silicate local abundant	113,203
Zml	NC002	metasedimentary rock	slate, greenstone; meta-rhyolite	2,352
Zss	NC002	slate & metasiltstone	calcareous metasandstone,sandy m.limes	5,173
ULTRAMAFIC ROCKS – group 7				
ckum	NCquad	ultramafic, dunite, soapstone, serpentine	(Carrol Knob complex)	85
d	Hatcher	diorite (dikes w/hornblende, plagioclase	biotite, chlorite, serpentine, muscovite	41
du	NCquad	dunite		96
PzZu	NC002	meta-ultramafic (dunite,peridotite)	and serpentine, soapstone	10,099
PzZU	Hatcher	meta-ultramafic (dunite,peridotite)	and serpentine, soapstone	75
um	GA001	ultramafic		1,642

um	Hatcher	ultramafic		240
Zud	NCquad	dunite	unaltered=olivine, altered=serpenite	314
WATER				
water	GA001	water		6,206

Apendix IX: Use of Ecological Zones

The Chattooga River Ecosystem Management Demonstration Project started in 1993 in South Carolina, Georgia, and North Carolina, was the first attempt at applying environmental models, like those used for developing Ecological Zones, to predict 'potential' plant community distribution across extensive landscapes in the Southeastern U.S. One of the primary goals of this project was to produce an ecological classification that would provide the information for implementing ecosystem management tied to the National Hierarchical Framework of Ecological Units, "a regionalization, classification and mapping system for stratifying the Earth into progressively smaller areas of increasingly uniform ecological potential for use in ecosystem management" (ECOMAP, 1993). What are now termed Ecological Zones were then called "plant association predictive models" or "Potential Vegetation". In the Chattooga project, plant association predictive models were developed, under the guidance of Henry McNab - Southern Forest Service Experiment Station, based upon the relationships between field locations of example plant association types and digitally derived landform factors such as elevation, landform index, and relative slope position (McNab 1991). These models were used in combination with soil maps to develop ecological units at different resolutions, i.e., Landtype Associations, Landtypes, and Landtype Phases.

In 1999, as part of the forest planning process on the Croatan National Forest, pre-settlement vegetation maps, equivalent to Ecological Zones (Frost 1996), were used to develop an Ecological Classification that included: Landtype Associations, Landtypes, and Landtype Phases, "A new tool that needed to be incorporated into the revised Plan" (USDA 2002). An ecological classification system was developed for the Croatan National Forest that provided a basis for ecologically based land management decisions. This classification organized the landscape into "units having similar topography, geology, soil, climate, and natural disturbance regimes" (USDA 2002) and was used to define management areas, management prescription boundaries, standards, and to set forest-wide objectives. Similarly, in 2001, the Forest Service in cooperation with the Department of Defense (DOD), Camp Lejeune Marine Corps. Base, developed an Ecological Classification System (ECS) to guide conservation management decisions for their Integrated Natural Resource Management Plan (INRMP). The ECS was based, in part, on a report titled "Presettlement Vegetation and Natural Fire Regimes of Camp Lejeune" by Cecil Frost, January 24, 2001, a map analogous to Ecological Zones. In DOD's most current INRMP, Camp Lejeune continues to refer to the ECS for overall guidance on the desired future condition for specialized habitat areas, i.e., natural areas (DOD 2006).

In 2001, the staff of the National Forests of North Carolina conducted a status review of management indicator species (MIS) habitats and population trends using Ecological Zone mapping to quantify the amount and distribution of plant community types on the Nantahala and Pisgah National Forests (USDA 2004a). Ecological Zones were also used to identify sites capable of supporting eastern and Carolina hemlock plant communities as part of a conservation area design to prioritize areas for Hemlock Woolly Adelgid control. Ecological Zones were used in the Uwharrie National Forest plan revision process to develop a map of the potential extent of Nature Serve Ecological Systems. This mapping provided the basis for the Ecological Sustainability Analysis and was used to help define management areas, restoration areas, and desired conditions, and to help set objectives and guidelines (USDA, 2009). Ecological Zones were used in a Plan amendment to evaluate the appropriateness of various management indicator species on the Nantahala and Pisgah National Forests (USDA, 2005), and were combined with satellite imagery to map existing vegetation on the Nantahala National Forest in a multi-year, USFS Southern Region pilot project to demonstrate a process for mid-level existing vegetation mapping suitable in the hardwood dominated forests of the Southern Region (USDA 2006).

In 2008, The Nature Conservancy provided support to evaluate the usefulness of an updated ecological zone map to predict landscapes that support fire-adapted plant communities in the Southern Blue Ridge Fire Learning Network (SBR-FLN). This updated map of ecological zones (titled the 2nd approximation) was completed by incorporating higher resolution digital elevation data and additional plot data from other areas within the Southern Appalachian Mountains. The result of this work expanded ecological zone modeling, i.e., mapping, to 5.9 million acres in the Southern Appalachians.

From 2008 to 2011, Ecological Zones were mapped in the Cumberland Plateau of Kentucky, in the South Mountains, Northern Escarpment, and New River Fire FLN landscapes within the Southern Blue Ridge (SBR) in North Carolina to evaluate the location and extent of fire-adapted plant communities. From 2009 to 2010, Ecological Zones were mapped in the Virginia-West Virginia Fire Learning Network study area and for the George Washington National Forest to evaluate fire-adapted plant communities and to provide vegetation mapping for the Forest Plan revision. In 2011, Ecological Zones were mapped on the Cherokee National Forest – northend as part of a landscape restoration initiative

Appendix X: FLN Landscape Area Comparisons, 3rd approximation Ecological Zone accuracy improvement

Table 1: Ecological Zone accuracy across the Southern Blue Ridge (SBR) study area [1/]

Ecological Zone	Project Area	North Escarp.	New River	Central Escarp.	South Mts.	Smoky / Unaka Mts.	Balsam Mts.	Nantahala Mts.	SBR Escarp.
Size (1000s' of acres-rounded)	8,235	226	110	419	217	1,535	236	629	783
Reference field plots	5,842	165	24	945	300	1,401	924	755	730
	Percent correct map accuracy								
Grassy Bald	74	-	*100*	-	-	95	*17*	-	-
Spruce-Fir	89	-	*100*	*67*	-	89	88	-	-
Northern Hardwood (slope)	73	-	*50*	*75*	-	81	66	78	*100*
Northern Hardwood (cove)	80	-	*100*	*100*	-	80	77	85	-
Rich Cove	81	87	*100*	79	50	79	82	85	63
Acidic Cove	81	83	-	84	80	80	80	90	76
Mixed Oak / Rhododendron	68	84	-	72	65	59	50	75	63
Alluvial Forest	78	91	-	81	*100*	82	-	*33*	*40*
Floodplain	94	-	-	-	-	94	-	100	*100*
High Elevation Red Oak	81	83	*100*	*40*	-	79	86	75	68
Montane Oak (rich)	64	-	-	-	-	-	-	-	-
Montane Oak (slope)	75	*33*	*60*	68	*33*	78	82	73	80
Montane Oak (upper cove)	69	82	-	67	74	73	67	63	58
Dry-Mesic Oak	74	96	-	65	71	73	*33*	71	78
Dry Oak Evergreen Heath	69	*40*	-	75	74	60	67	55	70
Dry Oak Deciduous Heath	78	-	-	*75*	80	79	-	*80*	*50*
Shortleaf Pine-Oak	88	-	-	94	70	78	-	70	90
SL Pine- Tblmt. Pine Oak Heath	82	-	-	82	-	-	-	-	-
Pine-Oak Heath	82	67	-	82	75	89	73	88	63
Heath Bald	74	-	-	-	-	79	*60*	-	-
OVERALL accuracy	79	81	86	80	75	79	79	82	76
Accuracy of the most fire-adapted category (below dashed line)	93	86	100	94	96	95	90	89	95

[1/] based on re-intersection of field data with modeled map units; *numbers in italics based upon fewer than 7 plots*

Table 2: Extent of 3rd approximation Ecological Zones across FLN landscapes

Ecological Zone	Total FLN	North Escarp.	New River	Central Escarp.	South Mts.	Smoky / Unaka Mts.	Balsam Mts.	Nantahala Mts.	SBR Escarp.
	4,155,540	419,310	109,850	419,310	216,580	1,535,300	235,670	629,010	783,440
	Extent in acres (rounded to nearest 10 acres)								
Grassy Bald	1,370	-	12	11	-	1,070	170	110	-
Spruce-Fir	54,550	1	2,650	1,130	-	35,600	12,560	2,540	70
Northern Hardwood (slope)	39,660	-	3,060	1,210	-	18,530	8,460	8,290	110
Northern Hardwood (cove)	103,800	1	8,470	510	-	63,260	15,300	16,200	60
Rich Cove	516,740	10,640	26,680	40,120	11,110	201,120	48,000	140,560	38,510
Acidic Cove	760,710	46,250	19,420	99,820	48,910	267,380	44,430	132,080	102,420
Mixed Oak / Rhododendron	144,000	37,890	2,850	24,940	8,180	11,040	7,740	19,910	31,450
Alluvial Forest	87,720	10,830	2,010	18,440	12,200	40,500	-	820	2,920
Floodplain	31,190	-	-	280	-	18,730	430	3,230	8,520
Lakes	18,560	-	-	-	-	-	-	7,780	10,780
High Elevation Red Oak	78,260	4,890	4,070	1,400	-	22,180	27,190	16,920	1,610
Montane Oak (rich)	140	-	-	-	-	140	-	-	-
Montane Oak (slope)	397,710	13,290	23,330	18,450	1,160	184,480	40,700	82,220	34,080
Montane Oak (upper cove)	380,290	52,530	7,700	40,380	26,570	151,500	7,920	46,190	47,500
Dry-Mesic Oak	563,390	25,650	900	37,030	21,770	191,450	6,900	57,290	222,400
Dry Oak Evergreen Heath	202,170	12,860	3,490	29,450	16,520	53,350	5,860	15,600	65,040
Dry Oak Deciduous Heath	69,800	30	1	600	15,290	24,370	90	8,210	21,210
Shortleaf Pine-Oak	357,250	10	-	47,540	44,610	78,940	610	21,800	163,880
SL Pine- Tblmt. Pine Oak Heath	870	-	-	870	1	-	-	-	-
Pine-Oak Heath	345,250	11,500	5,210	57,130	10,260	169,790	9,270	49,210	32,880
Heath Bald	1,960	-	-	-	-	1,870	40	50	-

Table 3: Ecological Zone accuracy and extent in the Balsam Mtns. Landscape [1/]

<table>
<tr><th rowspan="3">Ecological Zone</th><th colspan="3">3rd Approximation</th><th colspan="3">2st Approximation</th></tr>
<tr><th rowspan="2">accuracy</th><th colspan="2">extent</th><th rowspan="2">accuracy</th><th colspan="2">extent</th></tr>
<tr><th>acres</th><th>%</th><th>acres</th><th>%</th></tr>
<tr><td>Grassy Bald</td><td>17</td><td>170</td><td>0.1</td><td>0</td><td>60</td><td>0.0</td></tr>
<tr><td>Spruce-Fir</td><td>88</td><td>12,560</td><td>5.3</td><td>55</td><td>3,930</td><td>1.7</td></tr>
<tr><td>Northern Hardwood (slope)</td><td>66</td><td>8,460</td><td>3.6</td><td>23</td><td>10,300</td><td>4.4</td></tr>
<tr><td>Northern Hardwood (cove)</td><td>77</td><td>15,300</td><td>6.5</td><td>50</td><td>16,630</td><td>7.1</td></tr>
<tr><td>Rich Cove</td><td>82</td><td>48,000</td><td>20.4</td><td>65</td><td>42,400</td><td>18.0</td></tr>
<tr><td>Acidic Cove</td><td>80</td><td>44,430</td><td>18.9</td><td>42</td><td>48,830</td><td>20.7</td></tr>
<tr><td>Mixed Oak / Rhododendron</td><td>50</td><td>7,740</td><td>3.3</td><td>5</td><td>15,510</td><td>6.6</td></tr>
<tr><td>Alluvial Forest</td><td>-</td><td>-</td><td>-</td><td>-</td><td rowspan="2">1,230</td><td rowspan="2">0.5</td></tr>
<tr><td>Floodplain</td><td>-</td><td>430</td><td>0.1</td><td>-</td></tr>
<tr><td>High Elevation Red Oak</td><td>86</td><td>27,190</td><td>11.5</td><td>78</td><td>31,700</td><td>13.5</td></tr>
<tr><td>Montane Oak (rich)</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Montane Oak (slope)</td><td>82</td><td>40,700</td><td>17.3</td><td>-</td><td rowspan="2">49,810</td><td rowspan="2">21.1</td></tr>
<tr><td>Montane Oak (upper cove)</td><td>67</td><td>7,920</td><td>3.4</td><td>37</td></tr>
<tr><td>Dry-Mesic Oak</td><td>33</td><td>6,900</td><td>2.9</td><td>0</td><td>5,310</td><td>2.3</td></tr>
<tr><td>Dry Oak Evergreen Heath</td><td>67</td><td>5,860</td><td>2.5</td><td>0</td><td rowspan="2">5,550</td><td rowspan="2">2.4</td></tr>
<tr><td>Dry Oak Deciduous Heath</td><td>-</td><td>90</td><td>0.0</td><td>-</td></tr>
<tr><td>Shortleaf Pine-Oak</td><td>-</td><td>610</td><td>0.3</td><td>-</td><td>400</td><td>0.2</td></tr>
<tr><td>SL Pine- Tblmt. Pine Oak Heath</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td><td>0.0</td></tr>
<tr><td>Pine-Oak Heath</td><td>73</td><td>9,270</td><td>3.9</td><td>0</td><td>3,750</td><td>1.6</td></tr>
<tr><td>Heath Bald</td><td>60</td><td>40</td><td>0.0</td><td>40</td><td>5</td><td>0.0</td></tr>
<tr><td>not modeled</td><td>-</td><td>-</td><td>-</td><td></td><td>-</td><td>-</td></tr>
<tr><td>OVERALL</td><td>79</td><td>235,520</td><td>100</td><td>51</td><td>235,520</td><td>100</td></tr>
<tr><td>Most fire-adapted category (below dashed line)</td><td>90</td><td>98,580</td><td>41.9</td><td>81</td><td>96,620</td><td>41.0</td></tr>
</table>

[1/] based on re-intersection of 924 field plots with modeled map units; *numbers in italics are based upon fewer than 7 plots,* a dash indicates that no plots were sampled in this area within this type or this type does not occur within this area; rounded to the nearest 10 acres

Table 4: Ecological Zone accuracy and extent within the Central Escarpment Landscape [1/]

Ecological Zone	3rd Approximation			2nd Approximation		
	accuracy	extent		accuracy	extent	
		acres	%		acres	%
Grassy Bald	-	11	0.0	-	1,030	0.3
Spruce-Fir	*67*	1,130	0.3	*0*	260	0.1
Northern Hardwood (slope)	*75*	1,210	0.3	*0*	1,770	0.4
Northern Hardwood (cove)	*100*	510	0.1	*100*	1,580	0.4
Rich Cove	79	40,120	9.4	5	28,780	7.1
Acidic Cove	84	99,820	23.5	80	108,340	26.6
Mixed Oak / Rhododendron	72	24,940	5.9	0	4,610	1.1
Alluvial Forest	81	18,440	4.3	37	30,890	7.6
Floodplain	-	280	0.1	-	0	0.0
High Elevation Red Oak	*40*	1,400	0.3	*60*	3,280	0.8
Montane Oak (rich)	-	-	-	-	-	-
Montane Oak (slope)	68	18,450	4.3	59	122,610	30.1
Montane Oak (upper cove)	67	40,380	9.5			
Dry-Mesic Oak	65	37,030	8.7	1	4,190	1.0
Dry Oak Evergreen Heath	75	29,450	6.9	6	11,680	2.9
Dry Oak Deciduous Heath	*75*	600	0.1			
Shortleaf Pine-Oak	94	47,540	11.2	37	33,960	8.3
SL Pine- Tblmt. Pine Oak Heath	82	870	0.2	34	3,410	0.8
Pine-Oak Heath	82	57,130	13.4	65	51,300	12.6
Heath Bald	-	-	-	-	60	0.0
OVERALL	80	419,311	100	50	407,750	100
not modeled					10,561	
Most fire-adapted category (below dashed line)	94	232,840	54.7	88	230,478	56.5

[1/] based on re-intersection of 945 field plots with modeled map units; *numbers in italics are based upon fewer than 7 plots*
a dash indicates that no plots were sampled in this area within this type or this type does not occur within this area; rounded to the nearest acre

Table 5: Ecological Zone accuracy and extent in the Nantahala Mtns. Landscape [1/]

Ecological Zone	3rd Approximation			2st Approximation		
	accuracy	extent		accuracy	extent	
		acres	%		acres	%
Grassy Bald	-	110	0.0	-	810	0.1
Spruce-Fir	-	2,540	0.4	-	510	0.1
Northern Hardwood (slope)	78	8,290	1.3	18	5,330	0.8
Northern Hardwood (cove)	85	16,200	2.6	64	14,230	2.3
Rich Cove	85	140,560	22.3	22	50,350	8.0
Acidic Cove	90	132,080	21.0	86	209,280	33.3
Mixed Oak / Rhododendron	75	19,910	3.2	30	44,190	7.0
Alluvial Forest	33	820	0.1	14	20,180	3.2
Floodplain	100	3,230	0.5	-		
High Elevation Red Oak	75	16,920	2.7	81	29,860	4.7
Montane Oak (rich)	-	-	-	-	-	-
Montane Oak (slope)	73	82,220	13.1	-	178,000	28.3
Montane Oak (upper cove)	63	46,190	7.3	22		
Dry-Mesic Oak	71	57,290	9.1	13	12,530	2.0
Dry Oak Evergreen Heath	55	15,600	2.5	0	14,020	2.2
Dry Oak Deciduous Heath	80	8,210	1.3	-		
Shortleaf Pine-Oak	70	21,800	3.5	20	4,390	0.7
SL Pine- Tblmt. Pine Oak Heath	-	-	-	-	720	0.1
Pine-Oak Heath	88	49,210	7.8	44	44,560	7.1
Heath Bald	-	50	0.0	-	50	0.0
lakes	-	7,780	1.2	-	-	-
OVERALL	82	629,010	100	47	629,010	100
Most fire-adapted category (below dashed line)	89	297,480	47.3	78	284,120	45.2

[1/] based on re-intersection of 924 field plots with modeled map units; *numbers in italics are based upon fewer than 7 plots,* a dash indicates that no plots were sampled in this area within this type or this type does not occur within this area; rounded to the nearest 10 acres

Table 6: Ecological Zone accuracy and extent in the New River Landscape[1/]

<table>
<tr><th rowspan="3">Ecological Zone</th><th colspan="3">2rd Approximation</th><th colspan="3">1st Approximation</th></tr>
<tr><th rowspan="2">accuracy</th><th colspan="2">extent</th><th rowspan="2">accuracy</th><th colspan="2">extent</th></tr>
<tr><th>acres</th><th>%</th><th>acres</th><th>%</th></tr>
<tr><td>Grassy Bald</td><td>100</td><td>12</td><td>0.0</td><td>0</td><td>-</td><td>-</td></tr>
<tr><td>Spruce-Fir</td><td>100</td><td>2,650</td><td>2.4</td><td>0</td><td>15</td><td>0.0</td></tr>
<tr><td>Northern Hardwood (slope)</td><td>50</td><td>3,060</td><td>2.8</td><td>0</td><td>4,140</td><td>3.8</td></tr>
<tr><td>Northern Hardwood (cove)</td><td>100</td><td>8,470</td><td>7.7</td><td>80</td><td>2,210</td><td>2.0</td></tr>
<tr><td>Rich Cove</td><td>100</td><td>26,680</td><td>24.3</td><td>0</td><td>750</td><td>0.7</td></tr>
<tr><td>Acidic Cove</td><td>-</td><td>19,420</td><td>17.7</td><td>-</td><td>36,110</td><td>33.1</td></tr>
<tr><td>Mixed Oak / Rhododendron</td><td>-</td><td>2,850</td><td>2.6</td><td>-</td><td>1,480</td><td>1.4</td></tr>
<tr><td>Alluvial Forest</td><td>-</td><td>2,010</td><td>1.8</td><td>-</td><td>2,600</td><td>2.4</td></tr>
<tr><td>Floodplain</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>High Elevation Red Oak</td><td>100</td><td>4,070</td><td>3.7</td><td>83</td><td>3,720</td><td>3.4</td></tr>
<tr><td>Montane Oak (rich)</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Montane Oak (slope)</td><td>60</td><td>23,330</td><td>21.2</td><td rowspan="2">80</td><td rowspan="2">56,080</td><td rowspan="2">51.4</td></tr>
<tr><td>Montane Oak (upper cove)</td><td>-</td><td>7,700</td><td>7.0</td></tr>
<tr><td>Dry-Mesic Oak</td><td>-</td><td>900</td><td>0.8</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Dry Oak Evergreen Heath</td><td>-</td><td>3,490</td><td>3.2</td><td rowspan="2">-</td><td rowspan="2">2</td><td rowspan="2">0.0</td></tr>
<tr><td>Dry Oak Deciduous Heath</td><td>-</td><td>1</td><td>0.0</td></tr>
<tr><td>Shortleaf Pine-Oak</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>SL Pine- Tblmt. Pine Oak Heath</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Pine-Oak Heath</td><td>-</td><td>5,210</td><td>4.7</td><td>-</td><td>2,100</td><td>1.9</td></tr>
<tr><td>Heath Bald</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>not modeled</td><td>-</td><td>-</td><td>-</td><td></td><td>-</td><td>-</td></tr>
<tr><td>OVERALL</td><td>88</td><td>109,850</td><td>100</td><td>54</td><td>109,200</td><td>100</td></tr>
<tr><td>Most fire-adapted category (below dashed line)</td><td>100</td><td>44,700</td><td>40.7</td><td>100</td><td>61,910</td><td>56.7</td></tr>
</table>

[1/] based on re-intersection of 24 field plots with modeled map units; *numbers in italics are based upon fewer than 7 plots,* a dash indicates that no plots were sampled in this area within this type or this type does not occur within this area; rounded to the nearest acre

Table 7: Ecological Zone accuracy and extent within the Northern Escarpment Landscape [1/]

<table>
<tr><th rowspan="3">Ecological Zone</th><th colspan="3">2nd Approximation</th><th colspan="3">1st Approximation</th></tr>
<tr><th rowspan="2">accuracy</th><th colspan="2">extent</th><th rowspan="2">accuracy</th><th colspan="2">extent</th></tr>
<tr><th>acres</th><th>%</th><th>acres</th><th>%</th></tr>
<tr><td>Grassy Bald</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Spruce-Fir</td><td>-</td><td>1</td><td>0.0</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Northern Hardwood (slope)</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Northern Hardwood (cove)</td><td>-</td><td>1</td><td>0.0</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Rich Cove</td><td>87</td><td>10,640</td><td>4.7</td><td>87</td><td>3,330</td><td>1.4</td></tr>
<tr><td>Acidic Cove</td><td>83</td><td>46,250</td><td>20.4</td><td>83</td><td>40,260</td><td>17.3</td></tr>
<tr><td>Mixed Oak / Rhododendron</td><td>84</td><td>37,890</td><td>16.7</td><td>81</td><td>39,750</td><td>17.1</td></tr>
<tr><td>Alluvial Forest</td><td>91</td><td>10,830</td><td>4.8</td><td>91</td><td>6,290</td><td>2.7</td></tr>
<tr><td>Floodplain</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>High Elevation Red Oak</td><td>83</td><td>4,890</td><td>2.2</td><td>75</td><td>3,750</td><td>1.6</td></tr>
<tr><td>Montane Oak (rich)</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Montane Oak (slope)</td><td>33</td><td>13,290</td><td>5.9</td><td rowspan="2">88</td><td rowspan="2">90,630</td><td rowspan="2">39.0</td></tr>
<tr><td>Montane Oak (upper cove)</td><td>82</td><td>52,530</td><td>23.2</td></tr>
<tr><td>Dry-Mesic Oak</td><td>96</td><td>25,650</td><td>11.3</td><td>70</td><td>37,400</td><td>16.1</td></tr>
<tr><td>Dry Oak Evergreen Heath</td><td>40</td><td>12,860</td><td>5.7</td><td rowspan="2">0</td><td rowspan="2">-</td><td rowspan="2">-</td></tr>
<tr><td>Dry Oak Deciduous Heath</td><td>-</td><td>30</td><td>0.0</td></tr>
<tr><td>Shortleaf Pine-Oak</td><td>-</td><td>10</td><td>0.0</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>SL Pine- Tblmt. Pine Oak Heath</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Pine-Oak Heath</td><td>67</td><td>11,500</td><td>5.1</td><td>90</td><td>11,130</td><td>4.8</td></tr>
<tr><td>Heath Bald</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>OVERALL</td><td>81</td><td>226,370</td><td>100</td><td>79</td><td>232,540</td><td>100</td></tr>
<tr><td>not modeled</td><td>-</td><td>6,180</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Most fire-adapted category (below dashed line)</td><td>86</td><td>120,750</td><td>53.3</td><td>87</td><td>182,660</td><td>78.5</td></tr>
</table>

1/ based on re-intersection of 165 field plots with modeled map units; numbers in italics are based upon fewer than 7 plots, a dash indicates that no plots were sampled in this area within this type or this type does not occur within this area; rounded to the nearest acre

Table 8: Ecological Zone accuracy and extent in the Smoky-Unaka Landscape[1/]

<table>
<tr><th rowspan="3">Ecological Zone</th><th colspan="3">3rd Approximation</th><th colspan="3">2st Approximation</th></tr>
<tr><th rowspan="2">accuracy</th><th colspan="2">extent</th><th rowspan="2">accuracy</th><th colspan="2">extent</th></tr>
<tr><th>acres</th><th>%</th><th>acres</th><th>%</th></tr>
<tr><td>Grassy Bald</td><td>95</td><td>1,070</td><td>0.1</td><td>33</td><td>1,870</td><td>0.2</td></tr>
<tr><td>Spruce-Fir</td><td>89</td><td>35,600</td><td>2.3</td><td>49</td><td>24,970</td><td>2.2</td></tr>
<tr><td>Northern Hardwood (slope)</td><td>81</td><td>18,530</td><td>1.2</td><td>5</td><td>22,960</td><td>2.0</td></tr>
<tr><td>Northern Hardwood (cove)</td><td>80</td><td>63,260</td><td>4.1</td><td>50</td><td>54,150</td><td>4.8</td></tr>
<tr><td>Rich Cove</td><td>79</td><td>201,120</td><td>13.1</td><td>21</td><td>82,940</td><td>7.3</td></tr>
<tr><td>Acidic Cove</td><td>80</td><td>267,380</td><td>17.4</td><td>79</td><td>354,630</td><td>33.1</td></tr>
<tr><td>Mixed Oak / Rhododendron</td><td>59</td><td>11,040</td><td>0.7</td><td>0</td><td>9,390</td><td>0.8</td></tr>
<tr><td>Alluvial Forest</td><td>82</td><td>40,500</td><td>2.6</td><td rowspan="2">73</td><td rowspan="2">39,100</td><td rowspan="2">3.4</td></tr>
<tr><td>Floodplain</td><td>94</td><td>18,730</td><td>1.2</td></tr>
<tr><td>High Elevation Red Oak</td><td>79</td><td>22,180</td><td>1.4</td><td>50</td><td>60,850</td><td>5.3</td></tr>
<tr><td>Montane Oak (rich)</td><td>-</td><td>140</td><td>0.0</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Montane Oak (slope)</td><td>78</td><td>184,480</td><td>12.0</td><td rowspan="2">25</td><td rowspan="2">242,090</td><td rowspan="2">21.3</td></tr>
<tr><td>Montane Oak (upper cove)</td><td>73</td><td>151,500</td><td>9.9</td></tr>
<tr><td>Dry-Mesic Oak</td><td>73</td><td>191,450</td><td>12.5</td><td>6</td><td>8,130</td><td>0.7</td></tr>
<tr><td>Dry Oak Evergreen Heath</td><td>60</td><td>53,350</td><td>3.5</td><td rowspan="2">49</td><td rowspan="2">33,230</td><td rowspan="2">2.9</td></tr>
<tr><td>Dry Oak Deciduous Heath</td><td>79</td><td>24,370</td><td>1.6</td></tr>
<tr><td>Shortleaf Pine-Oak</td><td>78</td><td>78,940</td><td>5.1</td><td>7</td><td>9,610</td><td>0.8</td></tr>
<tr><td>SL Pine- Tblmt. Pine Oak Heath</td><td>-</td><td>-</td><td>-</td><td>75</td><td>2,600</td><td>0.2</td></tr>
<tr><td>Pine-Oak Heath</td><td>89</td><td>169,790</td><td>11.1</td><td>71</td><td>191,910</td><td>16.9</td></tr>
<tr><td>Heath Bald</td><td>79</td><td>1,870</td><td>0.1</td><td>0</td><td>110</td><td>0.0</td></tr>
<tr><td>OVERALL</td><td>79</td><td>1,535,300</td><td>100</td><td>42</td><td>1,138,540</td><td>100</td></tr>
<tr><td>not modeled</td><td></td><td></td><td></td><td></td><td>396,740</td><td></td></tr>
<tr><td>Most fire-adapted category (below dashed line)</td><td>95</td><td>878,070</td><td>57.2</td><td>80</td><td>548,530</td><td>48.2</td></tr>
</table>

[1/] based on intersection of 1,401 field plots with modeled map units (1.214 plots in 2rd approximation); *numbers in italics are based upon fewer than 7 plots,* a dash indicates that no plots were sampled in this area within this type or this type does not occur within this area; rounded to the nearest 10 acres

Table 9: Ecological Zone accuracy and extent in the Southern Blue Ridge Escarpment Landscape [1/]

Ecological Zone	3rd Approximation accuracy	3rd Approximation extent acres	3rd Approximation extent %	2nd Approximation accuracy	2nd Approximation extent acres	2nd Approximation extent %
Grassy Bald	-	-	-	-	720	0.1
Spruce-Fir	-	70	0.0	-	90	0.0
Northern Hardwood (slope)	100	110	0.0	18	2,250	0.3
Northern Hardwood (cove)	-	60	0.0	64	210	0.0
Rich Cove	63	38,510	4.9	22	41,320	6.4
Acidic Cove	76	102,420	13.1	86	138,610	21.4
Mixed Oak / Rhododendron	63	31,450	4.0	30	96,270	14.9
Alluvial Forest	40	2,920	0.4	14	20,190	3.1
Floodplain	100	8,520	1.1	-		
High Elevation Red Oak	68	1,610	0.2	81	1,350	0.2
Montane Oak (rich)	-	-	-	-	-	-
Montane Oak (slope)	80	34,080	4.4	-	91,290	14.1
Montane Oak (upper cove)	58	47,500	6.1	22		
Dry-Mesic Oak	78	222,400	28.4	13	133,930	20.7
Dry Oak Evergreen Heath	70	65,040	8.3	0	9,050	1.4
Dry Oak Deciduous Heath	50	21,210	2.7	-		
Shortleaf Pine-Oak	90	163,880	20.9	20	89,640	13.8
SL Pine- Tblmt. Pine Oak Heath	-	-	-	-	5,640	0.9
Pine-Oak Heath	63	32,880	4.2	44	16,980	2.6
Heath Bald	-	-	-	-	50	0.0
lakes	-	10,780	1.4	-	-	-
Total modeled	76	783,440	100	47	647,590	100
not modeled		84,030			219,730	
Most fire-adapted category in modeled area (below dashed line)	95	588,480	75.1	78	347,930	53.7

[1/] based on re-intersection of 945 field plots with modeled map units; *numbers in italics are based upon fewer than 7 plots,* a dash indicates that no plots were sampled in this area within this type or this type does not occur within this area; rounded to the nearest 10 acres

Table 10: Ecological Zone accuracy and extent in the South Mountains Landscape [1/]

Ecological Zone	2rd Approximation			1nd Approximation		
	accuracy	extent		accuracy	extent	
		acres	%		acres	%
Grassy Bald	-	-	-	-	-	-
Spruce-Fir	-	-	-	-	-	-
Northern Hardwood (slope)	-	-	-	-	-	-
Northern Hardwood (cove)	-	-	-	-	-	-
Acidic Cove	80	48,910	22.6	62	9,690	4.5
Mixed Oak / Rhododendron	65	8,180	4.8			
Alluvial Forest	*100*	12,200	0.2	*100*	17,590	8.1
Floodplain	-	-	-	-	-	-
Rich Cove	50	11,110	5.1	63	26,074	12.0
Montane Oak (upper cove)	74	26,570	6.5			
High Elevation Red Oak	-	-	-	-	-	-
Montane Oak (rich)	-	-	-	-	-	-
Montane Oak (slope)	*33*	1,160	11.4	-	-	-
Dry-Mesic Oak	71	21,770	10.2	60	21,000	9.7
Dry Oak Evergreen Heath	74	16,520	4.8	59	21,030	9.7
Dry Oak Deciduous Heath	80	15,290	0.9			
Shortleaf Pine-Oak	70	44,610	4.2	100 [2/]	[2/] 116,930	54.0
SL Pine- Tblmt. Pine Oak Heath	-	1	0.1	-	-	-
Pine-Oak Heath	75	10,260	9.7	62	4,270	2.0
Heath Bald	-	-	-	-	-	-
OVERALL	75	216,580	100	63	216,580	100
Most fire-adapted category (below dashed line)	96	136,180	62.9	95	189,300	87.4

[1/] based on re-intersection of 300 field plots with modeled map units; *numbers in italics are based upon fewer than 7 plots,* a dash indicates that no plots were sampled in this area within this type or this type does not occur within this area rounded to the nearest 10th acre.

[2/] overestimate based upon too many plots in private land and too few plots on public land

Table 11: Ecological Zone accuracy and extent on State lands in the South Mountains Landscape [1/]

Ecological Zone	2nd Approximation accuracy	2nd Approximation extent acres	2nd Approximation extent %	1st Approximation accuracy	1st Approximation extent acres	1st Approximation extent %
Grassy Bald	-	-	-	-	-	-
Spruce-Fir	-	-	-	-	-	-
Northern Hardwood (slope)	-	-	-	-	-	-
Northern Hardwood (cove)	-	-	-	-	-	-
Acidic Cove	80	5,170	13.7	66	3,180	8.5
Mixed Oak / Rhododendron	65	3,410	9.1			
Alluvial Forest	*100*	420	1.1	*100*	470	1.2
Floodplain	-	-	-	-	-	-
Rich Cove	*33*	1,330	3.5	68	8,640	23.0
Montane Oak (upper cove)	85	5,710	15.2			
High Elevation Red Oak	-	-	-	-	-	-
Montane Oak (rich)	-	-	-	-	-	-
Montane Oak (slope)	*50*	310	0.8	-	-	-
Dry-Mesic Oak	69	5,390	14.3	56	5,220	13.9
Dry Oak Evergreen Heath	78	4,490	11.9	60	7,840	20.8
Dry Oak Deciduous Heath	79	6,650	17.7			
Shortleaf Pine-Oak	*100*	870	2.3	*100*	[2/] 9,250	24.6
SL Pine- Tblmt. Pine Oak Heath	-	-	-	-	-	-
Pine-Oak Heath	76	3,890	10.3	65	3,030	8.1
Heath Bald	-	-	-	-	-	-
OVERALL	75	37,630	100	64	37,630	100
Most fire-adapted category (below dashed line)	97	27,310	72.6	95	33,980	90.3

[1/] based on re-intersection of 237 field plots with modeled map units; *numbers in italics are based upon fewer than 7 plots,* a dash indicates that no plots were sampled in this area within this type or this type does not occur within this area rounded to the nearest 10th acre.

[2/] overestimate based upon too many plots in private land and too few plots on public land

Appendix XI: Codes for Ecological Zones and NatureServe Ecological Systems

Code	Ecological Zone name
1	Spruce
2	Northern Hardwood Slope
3	Northern Hardwood Cove
4	Acidic Cove
5	Rich Cove
6	Alluvial Forest
8	High Elevation Red Oak
9	Montane Oak Hickory Slope
10	Dry Oak Evergreen Heath
11	Dry Oak Deciduous Heath
13	Dry Mesic Oak
16	Low Elevation Pine
18	Pine-Oak Heath
23	Large Floodplain
24	Montane Oak-Hickory Rich
27	Grassy Bald
28	Montane Oak-Hickory Cove
29	Mixed Oak / Rhododendron
30	Heath Bald
31	Shortleaf pine-oak heath
98	Reservoirs, Lakes, and Ponds

Code	NatureServe Ecological System
1	Central and Southern Appalachian Spruce-Fir Forest
2	Appalachian (Hemlock)-Northern Hardwood
4	Southern and Central Appalachian Cove Forest
6	Central Interior and Appalachian Riparian Systems
8	Central and Southern Appalachian Montane Oak
9	Southern and Central Appalachian Northern Red Oak-Chestnut Oak Forest
10	Allegheny-Cumberland Dry Oak Forest and Woodland
13	Southern Appalachian Oak Forest
16	Southern Appalachian Low-Elevation Pine
18	Southern Appalachian Montane Pine Forest and Woodland
23	Central Interior and Appalachian Floodplain Systems
27	Southern Appalachian Grass and Shrub Bald

98 Other: Reservoirs, Lakes, and Ponds