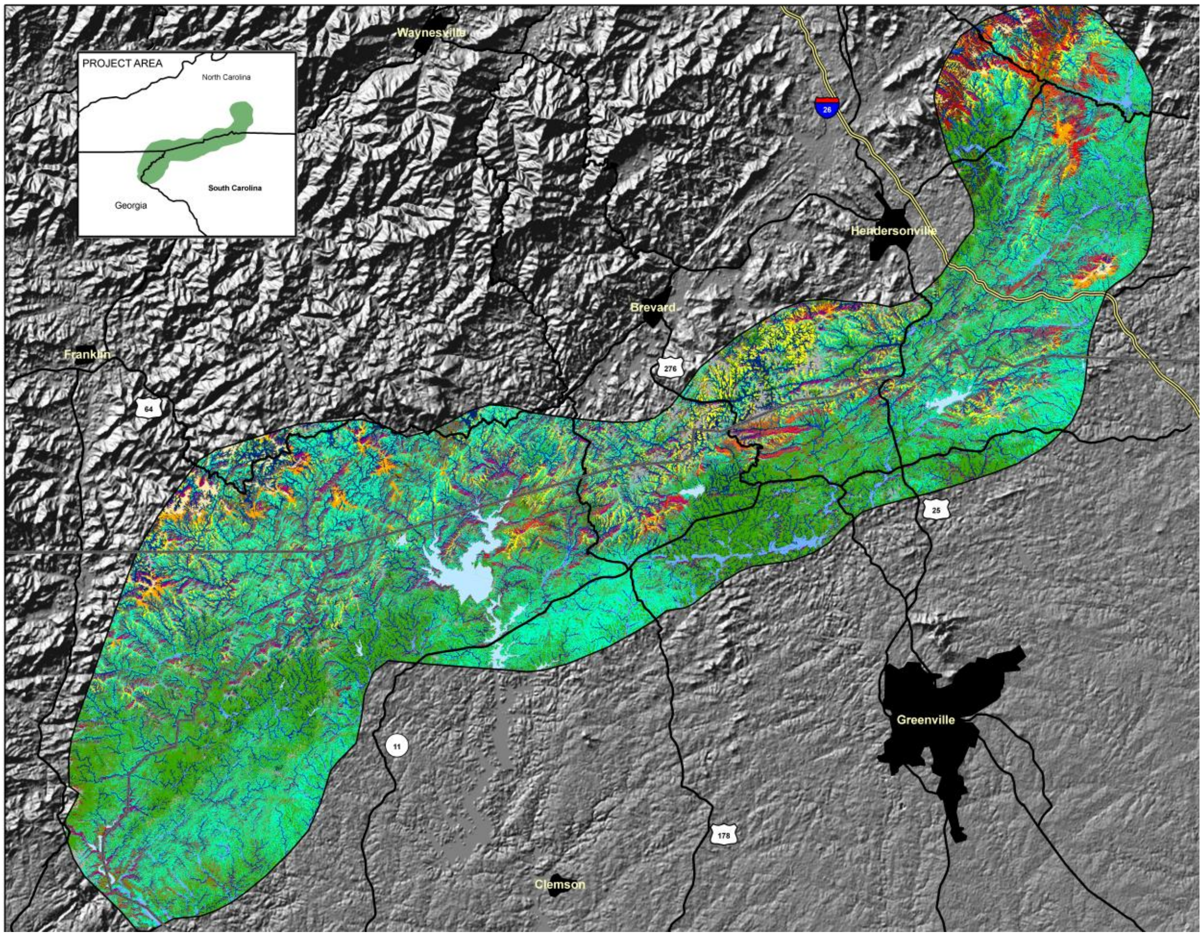
Ecological Zones in the Southern Blue Ridge Escarpment:
4th Approximation

Steven A. Simon: Ecological Modeling and Fire Ecology Inc., Asheville, North Carolina. 4/1/2015



A 4th approximation of Ecological Zones within the Southern Blue Ridge Escarpment (FLN boundary) was developed from over 2,260 field reference sites, 24 computer-generated environmental variables derived primarily from a high resolution, LiDAR-generated digital elevation model, and adjustment of ecotone boundaries using local environmental relationships between types. Ecological Zones that can support dry-mesic oak-hickory dominated plant communities account for about 30% of the over 860,000 acre landscape (lightest green on map) and Pine-dominated plant communities maintained primarily by fire disturbance about 23% of the area (darker green and yellow). Ecological Zones dominated by an evergreen heath understory (rhododendron and mountain laurel) account for about 28% of the landscape (dark blue, purple, dark grey). Alluvial Forests, High Elevation Red Oak Woodlands, and Montane Oak Rich Forests are uncommon, accounting for less than 2% of the area; Rich Coves and Slopes are also uncommon, potentially occurring on only 3% of the landscape (red on map).

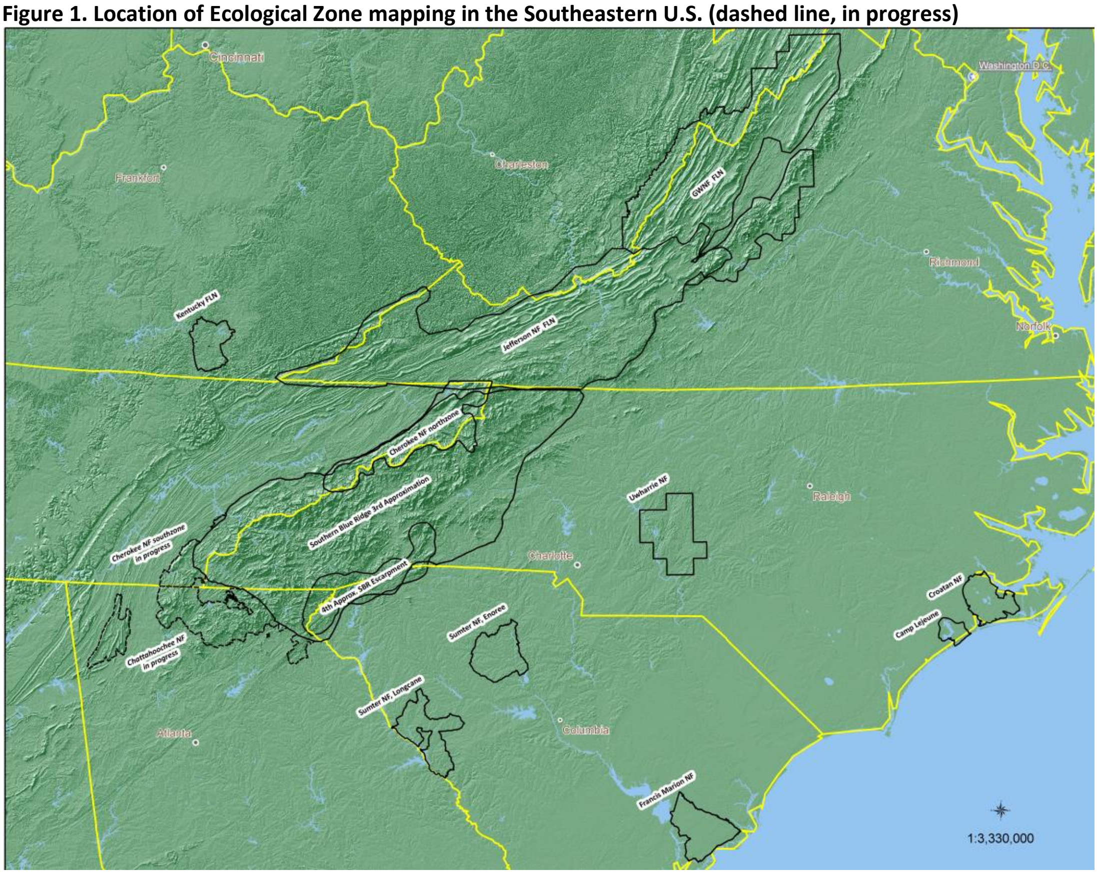
INTRODUCTION

Ecological Zones are units of land, defined by environmental models 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 (Simon et al. 2005). 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. BpS 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 type categories. A brief description of Ecological Zones taken primarily from BpS descriptions are included in Appendix I and Ecological Zone sample photos are included in Appendix II.

Ecological Zones in the Southern Appalachian Mountains, identified from intensive field data used to define plant communities, were associated with unique environmental variables characterized by digital data (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 study, started in 2001, 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 and Ecological Systems have been mapped in Kentucky, the Uwharrie Mts., numerous Fire Learning Networks (FLN) in North Carolina including the South Mountains, Northern Escarpment, and New River, the north zone of the Cherokee NF in Tennessee, on broad landscapes in Virginia and West Virginia centered on the George Washington and Jefferson National Forests, on the Francis Marion National Forest in Coastal South Carolina, and both the Enoree and Long Cane Districts of the Sumter National Forest in the Piedmont of South Carolina (Fig. 1).

In 2014, reference plots that characterize Ecological Zones were sampled on the Andrew Pickens District of the Sumter National Forest, and on SC, NC, and GA State Lands including Chimney Rock, Table Rock, Oconee and Gorges State Parks, Dupont and Holmes State Forests, Ashmore, Laurel Fork, Brasstown Creek and Buzzard Roost Heritage Preserves, Green River Game Land, Jocassee Gorges, and Poinsett Bridge. These data were combined with existing point data used for developing Ecological Zones in the Southern Blue Ridge 3rd Approximation, and new Zone models were created and evaluated. This report documents the methods and results of this most current effort of mapping Ecological Zones within the Southern Blue Ridge Escarpment in North Carolina, South Carolina, and Georgia.

Figure 1. Location of Ecological Zone mapping in the Southeastern U.S. (dashed line, in progress)



General description: Within the National Framework for Ecological Units developed by the US Forest Service (Cleland et al. 1997), the Southern Blue Ridge Escarpment (boundary provided by The Nature Conservancy, Georgia Chapter, 2014) lies within the Central Appalachian Broadleaf Forest- Coniferous Forest – Meadow Province (M221) and the Southeastern Mixed Forest Province (231). Ecological Sections include portions of the Blue Ridge Mountains (M221D), the Southern Appalachian Piedmont (231A), and the Central Appalachian Piedmont (231I).

The Blue Ridge Mountains Section comprises the greatest portion of the Southern Blue Ridge Escarpment and is described as a 'gently west-sloping plateau defined on the east by a steep escarpment rising 1,000 feet above Section 231I. Topography consists of moderately high (3,280'-4,920'), highly weathered mountain ranges. The Precambrian-Cambrian bedrock geology is mostly metamorphosed gneisses and schists formed from recrystallization of non-carbonate sedimentary, volcanic, or igneous parent rock material. Soils are deep, well-drained, acidic, infertile sandy and gravelly loams. Vegetation is forests consisting of oak-hickory, white-'yellow' pine cover types. Evergreen ericaceous shrubs occupy the understory on many dry ridges. Rainfall is highly variable, ranging from > 80" in areas along the escarpment that are influenced by orographic uplift, to < 50" in the nearby Asheville basin, which is situated in a rain shadow' (ECOMAP 2007).

The Southern Appalachian Piedmont Section is described as 'moderately dissected, irregular plains with occasional isolated high hills or low mountains on more resistant formations, underlain by highly metamorphosed crystalline rocks that have weathered to form deep, infertile clayey soils now highly eroded from long, intensive cultivation. Forest cover is a mixture of loblolly pine, shortleaf pine, and oak-pine cover types (ECOMAP 2007).

The Central Appalachian Piedmont Section includes the smallest portion of the Southern Blue Ridge Escarpment and is described as 'a moderately dissected irregular plain with high and low hills underlain by metamorphic formations of schists and phyllites that have weathered to form thick saprolite and deep soils with heavy clay sub horizons. Vegetation is forests of loblolly pine, shortleaf pine, and oak-hickory cover types' (ECOMAP 2007).

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. Model extrapolation to landscapes far away from field reference sites or to landscapes having very different environmental characteristics can lead to erroneous map unit predictions. Most all of the data for this study was collected on Federal and State ownerships within the Southern Blue Ridge Escarpment boundary, therefore Ecological Zone predictions outside of this area on private land is 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 (reference sites),
2) Creating a digital terrain GIS database and extracting environmental data,
3) Statistical analysis / modeling individual Ecological Zones,
4) Merging Ecological Zone models / creating preliminary Ecological Zone maps,
5) Evaluating the accuracy of Ecological Zone map units, relative to reference plots,
6) Evaluating ecotones and creating new models to improve accuracy, and
7) Post-processing of digital Zone model outputs.

1) Data acquisition: The vegetation field reference data used to develop the Southern Blue Ridge Escarpment Ecological Zone models included plots from numerous sources; the older (SBR 3rd Ecological Zone Approximation) and new surveys of 'natural forests, floodplains, and woodlands' (Table 1). Ecological Zones are relatively coarse and fairly easy to recognize in the field so instead of classifying intensive vegetation plot survey data from The North Carolina Vegetation Survey (NCVS), (Peet and others 1998), or plot data collected using the stratified, random plot selection method from the Chattooga Watershed study (USDA 1995), the 2014 field work consisted of documenting (through GIS, notes, and photos) the location of reference sites for Ecological Zones identified by field investigators.

Table 1. Plot data sources (field investigators) contributing to the Southern Blue Ridge Escarpment 4th Approximation Ecological Zones

Study Area	#plots	Field Investigators (in order of contribution and/or most recent date)
SBR Escarpment	885	S.Simon 2014
	522	J.Kelly 2014
	124	J.Kelly and S.Simon 2014
SBR_general	41	J.Kelly 2010
SBR	19	S.Simon 2009 (Biophysical Settings model accuracy assessment)
SBR 1st-3rd approx.	711	Ellicott Rock Wilderness Area, USFS Chattooga River Watershed Study, NC Vegetation Survey (K.Patterson, C.Ulrey, A.Smith, S.Simon, G.Kauffman, D.Danley, R.Peet, M.Schafale, A.Weakley, T.Wentworth, P.White)
TOTAL	2,261	

All plots from both the NCVS and the Chattooga study were re-evaluated based upon the authors field experience in observing Ecological Zones in a broader context (from the Southern to Central Appalachians), a consideration of the improvement in model pixel scale, feedback from users of the 3rd Approximation Zone model in the Warwoman Ecological Departure Assessment (Brod, Mike 2014), and some rethinking (or bias) on the role of fire exclusion and evergreen heath expansion in the Escarpment. This resulted in re-classifying about 5% of the plots used in the 3rd Approximation Ecological Zone model especially for Zones representing Dry-Mesic Oak, Montane Oak Cove (Mesic Oak), and Acidic Cove.

New field surveys of reference Zone plots in the Southern Blue Ridge Escarpment included a laptop computer attached to a global positioning system (GPS) in conjunction with ArcGIS (ESRI 2009) to enable real-time location tracking, 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 landform, soils, and species composition. Reference sites for Ecological Zones 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.

Southern Blue Ridge Escarpment Ecological Zones - background: Ecological Zones were used in the original 2001 study 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, 'Ecological Zones in the Southern Appalachians: 1st Approximation', (Simon et al. 2005). In 2008, The Nature Conservancy provided support to re-evaluate Zone predictions on a larger landscape with emphasis on fire-adapted plant communities. No additional field reference plots were sampled within the Escarpment for this 2nd Approximation of Ecological Zones in the SBR. In 2011, The U.S. Forest Service provided support to develop a 3rd Approximation of Ecological Zone mapping in the SBR with an expanded (refinement) of Zone types using higher resolution DEMs, and some additional data points.

This current study, funded by both the USFS and TNC, defined the Southern Blue Ridge Escarpment in more detail, used the most current higher resolution 10'x10' liDAR generated DEMs to develop finer-scale terrain models (DTMs), and included more than 1,500 additional field reference plots to define Ecological Zones. The following table summarizes the progression of model development, parameters, and incremental improvements made in the different SBR Escarpment approximations (Table 2).

Table 2: Comparison of SBR Escarpment Ecological Zone approximation development parameters

	1st Approximation (within the SBR 1st)	2nd Approximation (within the SBR 2nd)	3rd Approximation (within the SBR 3rd)	4th Approximation SBR Escarpment modeled alone
Extent	647,380 acres	792,295 acres	792,295 acres	864,830 acres
Pixel cell size	98'x98'	33'x33'	30'x30'	10'x10'
Base data source	USGS DEM	USGS DEM	USGS&liDAR	liDAR DEM
Reference plots	710	710	730	2,261
Environmental variables in GIS	25	20	29	24
Number of Zones modeled	11	16	20	15
Analysis tools	logistic regression	maximum entropy	maximum entropy ecotone adjustment	maximum entropy ecotone adjustment
Accuracy [1/]	36%	52%	79%	79%

[1/] Accuracy of plots within the 1st thru 3rd SBR approximations in total and within the 4th Approximation SBR Escarpment modeled alone

The distribution of plots across the study area was improved by sampling within State lands and increasing plot density on the USFS Andrew Pickens District (Figure 2). There are several elevation zones, however, where reference Ecological Zones may not have been adequately sampled because of poorer vegetation condition or access difficulty. The adequacy of sampling is judged here by how close the proportion of plots matches the proportion of land defined by 8 elevation classes. Landscapes 1,501 to 2,000 feet in elevation were somewhat under-sampled across the study area however this discrepancy is diminished when viewed from the perspective of federal lands only. On the other hand, elevations between 1,001 and 1,500 feet in elevation were somewhat over-sampled (Table 3) across the landscape.

Figure 2: Field reference plots used in the Southern Blue Ridge Escarpment Ecological Zone Model

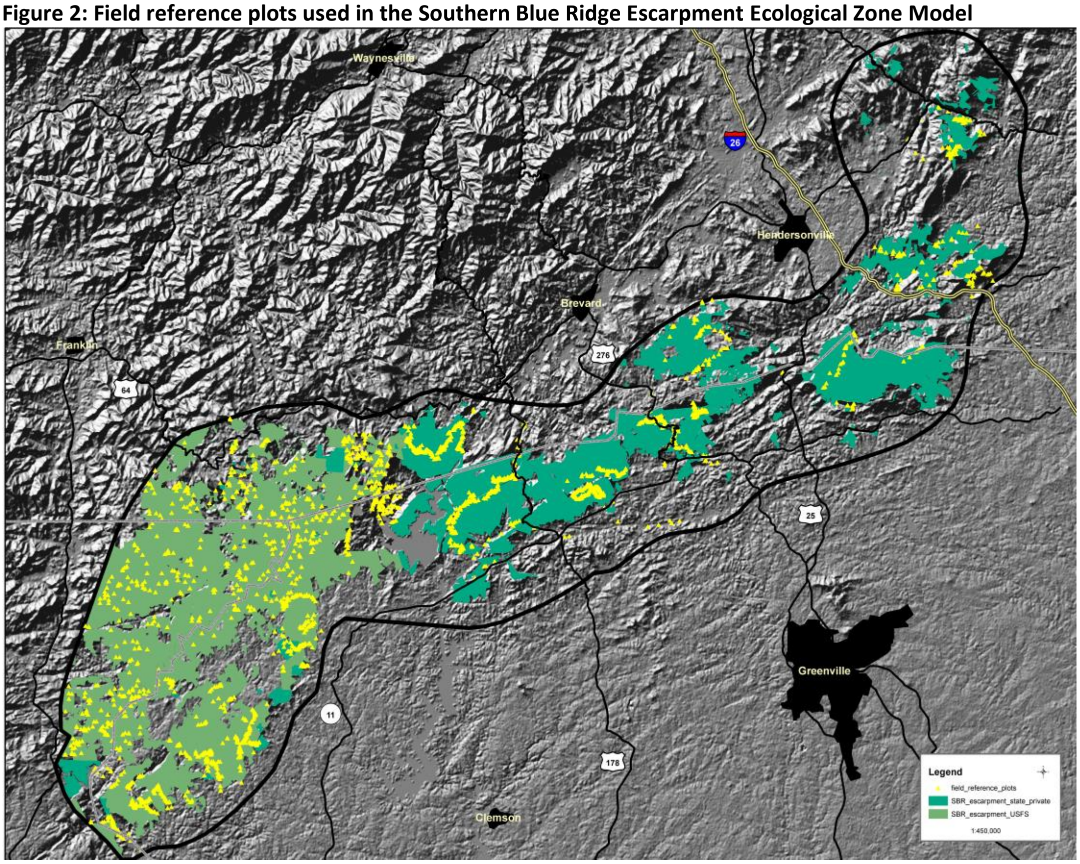


Table 3. Ecological Zone plot sampling intensity by elevation classes within the Southern Blue Ridge Escarpment, under-sampled [1/] classes highlighted in yellow, over-sampled classes highlighted in blue.

elevation class	< 1,001'	1,001 - 1,500'	1,501-2,000'	2,001-2,500'	2,501-3,000'	3,001-3,500'	3,501-4,000'	> 4,000'
Southern Blue Ridge Escarpment – 'all lands' (2,261 plots on 864,830 acres)								
% plots	6.7	29.9	19.2	16.8	15.1	7.8	3.5	1.0
% of area	4.4	22.6	26.4	19.0	15.1	7.8	2.9	1.7
US Forest Service Proclamation Boundary within 'all lands' (1,429 plots on 351,912 aces)								
% plots	3.1	23.8	26.7	16.8	15.0	7.5	4.5	2.7
% of area	2.9	18.4	30.4	13.6	14.0	10.8	7.7	2.3
US Forest Service, State ownership and Private Protected (NC, SC, GA) within 'all lands'								
% plots	3.7	22.6	26.4	19.1	15.8	7.7	2.8	1.8
% of area	2.3	21.4	27.6	18.8	17.4	8.6	2.9	1.1

[1/] where the difference in percentage of total plots sampled versus elevation class area proportion differs by more than 5% points

2) Creating a digital terrain database: Development of the individual Ecological Zone models began by producing a spatial database that described the study area environment using landform and environmental variables. Site conditions for each field plot were extracted from these 24 landform / environmental digital terrain 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, lat/long, Ecological Zone code, 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 Zones models

Aspect (raw)
Aspect (cosine)
Curvature of land (all directions)
Curvature of land (direction of slope)
Curvature of land (perpendicular to slope)
Elevation
Parent Material (distance to)
  mafic rock
  siliciclastic rock
  mixed geology
Landform index (from McNab 1993)
Precipitation (annual)
Relief
River influence (4th order and larger streams)
  difference in elevation from the nearest river
  distance to the nearest river
Relative slope position – local landscape (from Wilds 1997)
Relative slope position - broader landscape
Slope steepness
Slope length – local landscape
Slope length – broader landscape
Solar radiation (yearly)
Stream influence
  difference in elevation from nearest stream
  distance to nearest stream
Terrain shape index (modified from McNab 1993)
Valley position

3) Statistical analysis / modeling individual Zones: The relationships between Ecological Zones 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 which was used in earlier ecological modeling efforts, 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 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. The process for developing models for the 15 Ecological Zones that occur within the Southern Blue Ridge Escarpment is described in Appendix IV. One additional 'Zone' was created to characterize large reservoirs using source data from the National Hydrography Dataset (NHD 2011.)

4) Merging Ecological Zone models / creating preliminary Ecological Zone map units: To produce a preliminary aggregate Ecological Zone map, the 15 Zone models were merged and each pixel in the study area was assigned to the Ecological Zone having the highest probability for that pixel (Appendix IV).

5) Assessing the accuracy of Ecological Zone map units: Field plots were used as reference data to evaluate the accuracy of the preliminary 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 are used to model the entire landscape with no bias to where a plot is located. Furthermore, this accuracy evaluation was critical in evaluating ecotones between Zones.

6) <u>Evaluating ecotones and adjusting models to improve accuracy</u>: Although MAXENT worked well to predict the distribution of individual Ecological Zones, merging the models sometimes resulted in a mapped landscape that did not reflect the field reference data. This was due to different model 'strengths' and the confusion between types that occur in similar environments. Model and field plot discrepancies were predominantly in the transition area between Ecological Zones, i.e., the ecotone. To better balance individual Zone model strengths and improve overall model accuracy an analysis of these ecotones was completed. This analysis used accuracy evaluations based upon reference plots at different modeling stages and within different landscapes to determine the environmental conditions, e.g., an elevation or slope range, where minor adjustments in model probability levels would result in reduced confusion (error) between classes (Zones). It was assumed that, because reference plots are used to 'train' Ecological Zone suitability models in MAXENT, the environmental relationships observed at these locations should also 'train' or 'correct' adjustments elsewhere.

7) <u>Post-processing of digital model outputs</u>: Post-processing was used to reduce "data noise" i.e., the number of isolated single 10x10 foot pixels within the final Ecological Zone aggregate model. This included just one majority filter that replaced pixels in the 'raw' grid based on the majority of their 8 contiguous neighboring pixels (ESRI ArcGIS Spatial Analyst). This grid was used for the accuracy evaluation (Appendix V).

Thirty additional majority filters were completed to further reduce "data noise" and create a GIS map coverage with map units having a standard minimum size of .05 acres. Although the resulting map still includes map units smaller than this minimum size, it was considerably better for visualizing the extent of Zones in relation to topographic features (especially with topographic lines) than the single majority filter map (and the raw map) and was easier to convert to a polygon coverage to calculate Zone extent.

RESULTS and DISCUSSSION

The location, extent, and accuracy, of Ecological Zones modeled in the SBR Escarpment were evaluated from the following:

1) Relative importance of environmental variables for predicting Ecological Zones (Tables 5-8),
2) Influence of local environments on adjacent Ecological Zones, i.e., ecotones (Figures 3-4), and comparison of MAXENT model variables and ecotone adjustment variables (Table 9),
3) Accuracy of map units relative to field reference plots (Table 10, Appendix V),
4) Location and extent of Zones based on map unit acreage (Tables 11-16), and
5) Broad scale displays of Ecological Zones and finer scale displays of Zones relative to landform and topography (Figures 5-12).

<u>1) Relative importance of environmental factors</u>: The importance of temperature, moisture, fertility, and disturbance, all of which affect Ecological Zone distribution, can be evaluated by considering the environmental variables (DTMs) used most often in individual Zone model predictions. Of equal importance are those environmental variables that contribute most to the prediction of Zone models in the MAXENT statistical analysis (Tables 5-6). From this perspective, Ecological Zones in the SBR Escarpment are correlated primarily with elevation, relief, and river elevation similarity (Riverdiff). These 3 variables were included in more models (> 50% with a 5% gain in model prediction, > 70% with a 3% gain in model prediction), and had the largest contribution to total model predictions, (Table 7). This is similar to the SBR 3rd Approximation where the most important environmental variables included were (in order of importance), elevation, carbonate geology, and relief, and to the Jefferson NF Ecological Zone study where river influence, geology, and elevation were the primary environmental Zone predictors.

These ‘primary’ environmental factors in the SBR Escarpment do not however fully explain the complexity and distribution of Ecological Zones in the study area. Other very important variables identified by MAXENT include Landform Index (LFI), precipitation, geology, and valley position; these variables had at least a 5% gain in model prediction in at least 40% of the Zone models. In addition, some variables were very important in predicting a specific Ecological Zone but contributed very little to other Zone predictions, e.g. slope in the Rich Slope Forest and stream distance in Acidic Cove Forests (Table 7).

Table 5. Importance of environmental variables used for predicting Ecological Zones

Environmental variable (DTM)	number [1/] of models	Percent [2/] of models
Elevation	9	80
Relief	8	80
River elevation similarity	8	73
Mafic geology	7	73
Precipitation (average annual)	7	67
Landform Index (LFI)	6	53
Valley position	6	53
Mixed Geology	5	60
Stream elevation similarity	5	40
Stream proximity	5	33
Slope	4	33
Relative slope position (RSP1)	3	46
Aspect raw and cosine	2	53
River proximity	2	27
Relative slope position (RSP2)	2	13
Solar radiation	1	20
Siliciclastic Geology	1	20
TSI	1	13
Slope Length1 or 2	0	27
Curve, curpl, curpr	0	0

[1/] # of models where variable made at least a 5% contribution to prediction gain
[2/] % of models where variable made at least a 3% contribution to prediction gain

The most commonly used environmental variables such as relief, mafic geology, and precipitation reflect the broader scale influence of landscape configuration and topography on moisture, fertility, and temperature gradients; distance to- or elevation above- the closest stream or river, relative slope position, slope, and landform index helped to define finer-scale variation in Ecological Zone boundaries within the SBR Escarpment (Tables 5-8). Other variables that reflect more fine-scale environmental relationships, notably soil moisture, include surface curvature (curve, curpr, curpl) and aspect. These variables made little to no contribution in the MAXENT models (Table 5, 7) which may be due to redundancy within the environmental variable set. However, these variables were important for understanding and making ecotone adjustments (Table 9).

The relationship between Ecological Zones and DTMs (and ultimately the reliability of models) can also be evaluated by comparing the mean values for each variable at reference plot locations to the relative importance of environmental variables found by MAXENT. Some of these relationships are straight-forward, other are not. For example, the primary factors that define the potential distribution of High Elevation Red Oak Forest and Woodlands (MAXENT model) include elevation, river elevation difference,

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

	Moisture and Temperature indicators									Fertility indicators		Topographic factors affecting moisture, temperature and fertility		
Ecological Zone	River elevation above (feet)	Stream elevation above (feet)	River distance to (feet)	Stream distance to (feet)	Elev. ft.	Ave. Annual Precip.	LFI[1/]	RSP1[1/]	RSP2[1/]	mafic geology distance to (miles)	mixed geology distance to (miles)	Valley Position[1/]	Relief (feet)	Slope
Floodplain Forest	7	4	230	80	990	57	.37	.40	.52	1.56	1.15	1.00	511	5
Alluvial Forest	8	2	232	65	1,400	61	.47	.43	.65	2.75	0.84	.93	506	5
Acidic Cove Forest	140	13	1,150	40	1,955	68	.75	1.00	1.00	3.34	1.53	.76	792	37
Mixed Oak / Rhododendron Forest	290	90	1,465	185	1,995	67	.81	.47	.43	3.45	0.91	.60	866	63
Rich Cove Forest	290	30	1,690	105	1,780	64	.77	.81	.43	3.34	1.26	.66	973	39
Rich Slope Forest	300	42	1,280	115	1,880	66	1.00	.79	.43	4.03	1.50	.64	1038	67
Montane Oak-Hickory Cove Forest	210	17	1,680	65	1,835	66	.69	.97	.35	2.87	1.06	.65	698	34
Montane Oak-Hickory Rich Forest	490	210	2,825	430	2,340	64	.27	.07	.01	4.32	1.75	.28	886	38
High Elevation Red Oak Forest & Woodlnd.	1,000	195	3,040	440	4,070	76	.40	.33	.09	2.50	0.57	.18	1226	38
Montane Oak-Hickory Slope Forest	700	120	2,820	315	3,010	72	.39	.29	.13	3.80	0.43	.37	1233	43
Dry-Mesic Oak-Hickory Forest	260	55	1,695	175	1,930	67	.54	.45	.22	2.40	0.93	.57	740	52
Dry Oak Deciduous Heath For.& Woodlnd.	455	115	2,655	312	2,285	68	.30	.19	.03	4.28	0.88	.28	740	26
Dry Oak Evergreen Heath For. & Woodlnd.	380	92	1,780	235	2,295	69	.48	.28	.17	3.02	0.62	.43	870	40
Pine Oak Heath Woodland	520	125	2,405	342	2,570	71	.30	.14	.09	3.87	0.93	.35	910	32
Shortleaf Pine-Oak Forest and Woodland	290	85	1,960	280	1,670	62	.26	.16	.09	3.92	0.90	.43	590	40

[1/] values relativized (relative to the highest average LFI Zone value) and valley position (Table 7). Reference plots used to characterize this Zone had the highest average elevation, the smallest valley position index (meaning the furthest above the valley floor, i.e, the ridge), and were furthest above rivers relative to all other Zones. Similarly, just 2 factors (slope and LFI) account for 76% of the Rich Slope Forest model gain and reference plots used to characterize this Zone have the highest average slope and LFI relative to all other Zones. Less clear is the relationship between the Dry-Mesic Oak-Hickory Zone and precipitation, relief, elevation, and LFI. These 4 variables account for over one-half of the total model gain, however, reference plot values are not distinctively different from plot values of other Zones, in fact they reflect more average conditions.

The relationships between Ecological Zones and environmental variables can get confusing because many variables used in this analysis provide redundant information and are therefore correlated. Elevation, relative slope position, distance to streams or rivers, and landform index, for example, can all have a major influence on temperature and moisture regimes. Although MAXENT 'finds' the variable or combination of variables that contribute most to predicting each Zone, care must be taken in interpreting these relationships because of the complexity of variable interactions and the statistics used in 'fitting' models. The relationship between Ecological Zones and environmental variables is more fully explained in Table 8 (Interpretation of Maxent Results).

Table 7. Percent contribution of variables used in Ecological Zone models in the Southern Blue Ridge Escarpment.

Ecological Zone / DTM	Floodplain Forest	Alluvial Forest	Acidic Cove	Mixed Oak Rhodo.	Rich Slope	Rich Cove	Montane Oak Cove	Montane Oak Rich	High Elev. Red Oak	Montane Oak Slope	Dry-Mesic Oak	Dry Oak Deciduous	Dry Oak Evergreen	Pine Oak Heath	Shortleaf Pine-Oak	# of types [5/]	total contrib. [6/]
Aspect raw	2		-2	+3	+1	-9	3		-	1	6	3	+1	+4	-	1	36
Aspect cos.	-2	6	-	+1	+3	2	+1	-	-	-	-	1	2	-1	-1	1	20
Curve		-	-		-	-	-			-	-		-	-	1	0	1
Curpl			-	-		-	+1	-	-	-2	-		-1	-	-	0	4
Curpr			-	-	2	1	-			-	2		-		-1	0	6
Elevation	-10	-2	2	*-5*	4	-4	*-5*		***+69***	+9	*-11*	-2	5	*22*	*-21*	*9*	171
Mafic Geo.	-2	1	+1	+6	-4	-4	-2	7	3	+5	-6	+8	5	+3	+9	7	66
Silicic. Geo.	-3		-1	-1	-1	-2	-	-7	+3	-	-	-	+2	2	-	1	22
Mixed Geo.	-3	*-10*	-4	-2	1	-1	-4	***+29***	-	-2	--[4/]	-	-6	+3	--[4/]	3	65
LFI	-[3/]	+4	*+23*[1/]	+10	+10[2/]	***+31***	**+26**			-1	**+15**	-2	1	-3	-11	7	137
Precipitation	-	-	+4	+4	-	-7	+5	-	-	+10	+11	+5	+12	+12	+4	7	74
Relief	+4	+4	+5	+7	+3	+14	9		-	*+29*	+15	+1	*+20*	5	1	8	117
Riverdiff	**-28**	**-31**	-3	+1	-	2	-3	-	+9	**+30**	8	+25	**9**	3	+8	8	160
Riverdist	-9	9	4	-2	-1	-	1	+4	+2	1	+2	2	-	-	-	2	37
RSP1	-	-1	+4	-	+2	+4	+7	-9	-	-	2	-	-3	-4	**-18**	3	54
RSP2	-1		+1	+1		-1	-2	-7		-	+1	-20	2	1		2	37
Slope	*-29*	-8	-1	4	***+66***	-10	-1		-	-	-1	-1	-2	2	-2	4	127
SLength1	-1	-	-2	-1		-1	+1		+4	3	-2	-	-1	2	-	0	18
SLength2	2		-	-	-	+2	-2		+2	+1	1	2	+3	+2	+3	0	21
Solar Radiation			-1	**-47**		-1	4	-	+2	-1	+3		-3	-	+3	1	65
Streamdiff		-21	+1	+2	-1	-1	-14	+28	-	-1	5	-	-8	**+8**	1	6	91
Streamdist			**-41**[1/]	-	-	+1	5	-	1	-	+4	+1	+6	+13	+7	5	79
TSI		-		-	-1	-2	-1	+3		-		-	-		+6	1	13
Valley Position	+4	-2	-1	-1	**-**	2	-2	-5	-5	-1	-5	***-26***	-9	-11	-2	6	76
# of reference plots	32	18	338	157	29	105	183	11	28	106	458	56	231	177	313		
# of variables [5/]	4	6	3	5	2	5	7	7	3	5	8	5	9	6	7		

[1/] numbers in bold indicate the environmental variable that provides the highest gain when used in isolation and therefore appears to have the most useful information by itself to define a Zone, e.g., stream distance is the most important variable found to define Acidic Coves; numbers in italics indicate the environmental variable that decreases the gain the most when it is omitted, which therefore appears to have the most information that isn't present in the other variables, e.g., LFI is the most significant variable found to define Acidic Coves not found in other variables.

[2/] the + or – sign indicates the direction of each environmental variable's contribution (gain) in the model prediction, e.g., Rich Cove Forests are positively related to LFI (the higher the LFI value, which indicates site protection, the greater the gain). The interpretation of distance variables such as geology, rivers and streams are counter-intuitive and can be confusing to interpret; Table 8 provides some explanation of these and other interpretations of MAXENT results. No sign indicates either that the gain is not linear, that there is confusion in interpretation, or that the trend is not consistent but an obvious gain occurs in one segment of the variable range.

[3/] a variable that provides less than 1% gain that is included in the prediction equation; blank indicates a variable having no (0) significance in the prediction equation.

[4/] a variable not evaluated in this Zone because it resulted in a map with a 'sharp' geology boundary that was not evident in the field. The mixed geology variable was not included in the Dry-Mesic Oak-Hickory or Shortleaf Pine-Oak models for this reason and because geology appeared to 'mask' other important environmental variables.

[5/] number of variables used in the model that made at least a 5% contribution to model prediction.

[6/] the number of types where the variable made at least a 5% contribution to model prediction gain.

[7/] the cumulative percent contribution of this variable across all Zones.

Table 8. Interpretation of Maxent results

DTM name and range in value	Interpretation of the relationships between Ecological Zones and environmental variables; 'related' = variable provides ≥ 5% gain in model prediction
Elevation 644' to 5004'	Zones related to higher elevations (+ sign): High Elevation Red Oak (very strongly), and Montane Oak Slope. Zones related to lower elevations (- sign): Shortleaf Pine-Oak (strongly), Dry-Mesic Oak, Floodplain, Montane Oak Cove, Mixed Oak / Rhododendron.
Relief 0 to 2,149' Elev. contrast	Nearly all Zones were related (+ sign) to areas with high relief, i.e., they are within the escarpment, 'a steep slope that separates two slightly sloped areas'. Zones most related to high relief include Montane Oak Slope, Dry Oak Evergreen Heath, Dry-Mesic Oak, and Rich Cove Forest.
River difference 0 to 2,168' elev. above rivers	Zones related to elevations similar to rivers (- sign), i.e., they are not far above rivers, include: Floodplain Forest, and Alluvial Forest (both strongly related). Zones related to areas well-above rivers (+ sign), the greater the difference in elevation the greater the gain: Montane Oak Slope, and Dry Oak Deciduous Heath.
Mafic Geology 0 to 59,098' distance from	Zones related to mafic geology (- sign): Rich Cove Forest (weak), Dry Mesic Oak, and Montane Oak Cove (weak). Zones furthest away from mafic geology map units (+ sign, the greater the distance from, the greater the gain): Mixed Oak / Rhododendron, Dry Oak Deciduous Heath.
Precipitation 44" to 91" annual	Nearly all Zones were related (+ sign) to areas of high precipitation, a condition typical in the SBR Escarpment were precipitation in most places is the highest east of the Mississippi. Only Rich Coves showed a negative relationship (- sign) to precipitation.
Landform Index 0 to 769 index	The larger the value, the more 'protection' a site has, e.g., an exposed ridgetop has LFI values close to zero while a deep ravine has the highest values. All Zones associated with coves, Acidic Cove, Rich Cove, and Montane Oak Cove were strongly related to LFI (+ sign).
Valley Position 0 to 100% ridge vs valley	The larger the value, the closer to the valley floor. Only two Zones are positively related (+sign) to valley position, Floodplain Forest, and Shortleaf Pine-Oak. Most Zones are related to lower values (since this is the Escarpment with more upper valley positions) especially Dry Oak Deciduous Heath and Pine-Oak Heath.
Mixed Geology 0 to 52,137' distance from	Most Zones are negatively related (- sign), i.e, they are not far away from mixed geology map units due to plot selection and the wide extent of this geology group. Only the Montane Oak Rich Zone is positively related (+ sign), i.e., this Zone occurs far away from this geology type, however, this is a complex relationship because these gains are eliminated for plots > 10,000 feet from this geologic map unit.
Stream difference 0 to 1,200' elev. above strm.	Zones related to elevation similar to streams (- sign) include: Alluvial Forest (strongly related), Montane Oak Cove, and Dry Oak Evergreen Heath which is often associated with slopes just above streams in association with Mixed Oak / Rhododendron. Zones found well-above streams include: Montane Oak Rich Forests, and Pine Oak Heath.
Stream distance 0 to 1,200' distance from	Acidic Cove Forests are strongly related to stream distance (- sign), i.e., they are found in close proximity to streams. Zones that are related to areas furthest away from streams (+ sign) include: Pine-Oak Heath, Shortleaf Pine-Oak, and Dry Oak Evergreen Heath.
Slope 0 to 1,929%	Rich Slope Forest is the only Zone strongly related (+ sign) to slope steepness and this is likely due to the stronger influence of the Relief variable in the relatively steep Escarpment landscape. Most Zones are negatively related to slope, especially Floodplain Forests (strongly), Rich Cove Forest, and Alluvial Forest.
Relative slope position1 0 to 100 percent from minor ridge	Minor ridges are zero (0), toeslopes and streams are close to 100. Although relative slope position influences Ecological Zone prediction, few types are strongly related to this variable. Shortleaf Pine-Oak, and Montane Oak Rich Forests are the most negatively related (- sign), i.e., they are predicted in upper slope positions while Montane Oak Cove, Acidic Cove, and Rich Cove are the most positively related (+ sign), i.e, they are predicted at lower slopes positions.
Aspect raw 0 to 360 degrees	Although this variable had some influence on model prediction gain, e.g., in Rich Cove Forest, it is difficult to interpret except in narrow aspect ranges because of its non-linear values.
Aspect cosine -99 to 100 index	More north-facing slopes are positive values while south-facing slopes are negative. Although this is a linear and more relative representation of aspect (the direction of the maximum slope), no Zones had a strong relationship that added significantly to model gain although aspect did strongly influence Zone location.
River distance 0 to 8,216' distance from	This variable contributed somewhat to model gain in numerous Zones but was only significant in Floodplain Forest (- sign), i.e., negatively related to distance from rivers while the farther away from rivers (+ sign) resulted in a greater gain in model prediction for the Alluvial Forest Zone.
Relative slope position2 0 to 100 percent from major ridge	Major ridges are zero (0), toeslopes, streams, and rivers are close to 100. Dry Oak Deciduous Heath and Montane Oak Rich Forest are the only Zones that showed a relationship to this variable (- sign), i.e., they were predicted in upper slope positions.
Solar Radiation 53,968-1,764,913 ESRI units	This ESRI-generated variable approximates insolation received from the sun accounting for variation in elevation, slope, aspect, and shadows cast by topographic features. Larger values indicate greater incoming solar radiation. Only Mixed Oak /Rhododendron showed a significant relationship to this variable (- sign) indicating a very strong relationship with landscapes receiving the least amount of solar radiation.
Siliciclastic Geology 0 to 15,486 feet distance from	Although most Zones show a minor relationship to distance from siliclastic geology, only Montane Oak Rich Forest had a greater than 5% gain in model prediction value (- sign). Higher gains occurred closer to this geology type, a relationship that does not fit the concept for Zones supporting more 'rich site' species.

Table 8. Interpretation of Maxent results (continued)

DTM name and range in value	Interpretation of the relationships between Ecological Zones and environmental variables; 'related' = variable provides ≥ 5% gain in model prediction
Terrain shape index -211 to 175 index	Convex slopes have positive values, flats are zero (0), and concave slopes have negative values. Only Shortleaf Pine-Oak had a greater than 5% gain in model prediction value (+ sign), i.e., the Zone was predicted on more convex slopes.
Slope Length1 0 to 13,098 feet (close proximity)	This measurement of slope segment length did not contribute greater than 4% to any Zone model prediction gain.
Slope Length2 0 to 21,378 feet (mid-proximity)	This measurement of slope segment length did not contribute greater than 3% to any Zone model prediction gain.
Curvature **Curve planiform** **Curve profile**	Convex slopes have positive values, flats are zero (0), and concave slopes have negative values; measured across slope, up&down slope, and in all directions. These variables did not contribute greater than 2% to any Zone model prediction gain due likely to the small DEM pixel size (10x10')

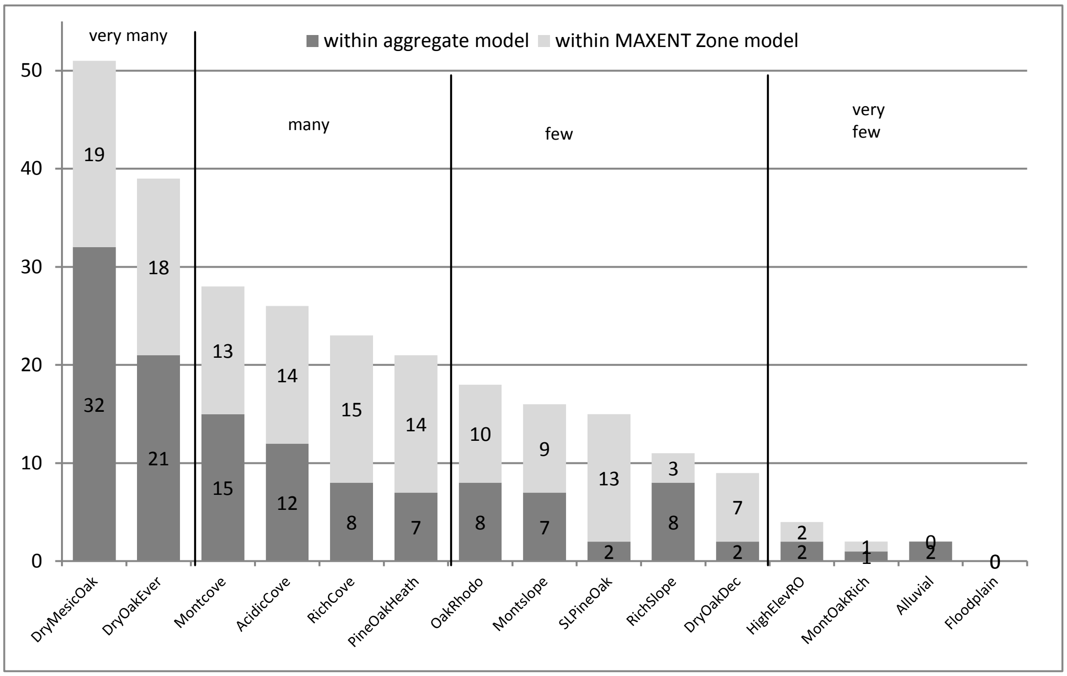
2) Influence of local environments on ecotones and model adjustments: Environments within the ecotones between Ecological Zones were analyzed to refine boundaries among similar and adjacent types, to better balance Zone model strengths, and to reduce confusion between Ecological Zones occurring in these transition conditions. This analysis identified the environmental variables (DTM values) where minor adjustments in MAXENT model probability values could result in increased accuracy among classes in the aggregate Ecological Zone models.

Total adjustments: Adjustments of individual pixel probability values in the Ecological Zone models developed from Maxent can be evaluated from two perspectives; the total number of adjustments made within the preliminary aggregate Ecological Zone model(s), and the total number of times each MAXENT Zone model was adjusted within the aggregate Ecological Zone model during these iterations. There were 3 iterations of the aggregate Zone model which account for the multiple adjustments described below. These adjustments are referred to as 'within aggregate model' and 'within MAXENT zone model' adjustments respectively (Figure 3). For example, "within the preliminary aggregate Dry-Mesic Oak Hickory model, add .089 to all Montane Oak Cove model pixels having a probability value > .593 and a relative slope position (RSP1) value > 63", was an adjustment within pixels in the MAXENT Montane Oak Cove model that were misclassified within the preliminary aggregate model for the Dry-Mesic Oak Hickory type. This specific adjustment was made based upon Montane Oak Cove field reference plot environments within lower slope positions (RSP1) that the aggregate model did not accurately predict; this logic was used for all other type adjustments, i.e., adjust probability values in environments that were incorrectly predicted to support a specific type in the aggregate Zone model. These adjustments were referred to as 'within type' and 'outside type' in previous Ecological Zone / Ecological Systems reports.

When both ‘within aggregate model’ and ‘within type model’ adjustments are considered, Zones can be grouped into the following categories (arranged from most to least adjustments):

Very Many (39-51 adjustments	Many (21-28 adjustments)	Few (9-18 adjustments)	Very few (0-4 adjustments)
Dry-Mesic Oak Hickory Forest	Montane Oak Cove Forest	Mixed Oak / Rhododendron Forest	High Elevation Red Oak
Dry Oak Evergreen Heath	Acidic Cove Forest	Montane Oak Slope Forest	Montane Oak Rich Forest
	Rich Cove Forest	Shortleaf Pine-Oak Woodland	Alluvial Forest
	Pine-Oak Heath Woodland	Rich Slope Forest	Floodplain Forest
		Dry Oak Deciduous Forest&Wdlnd.	

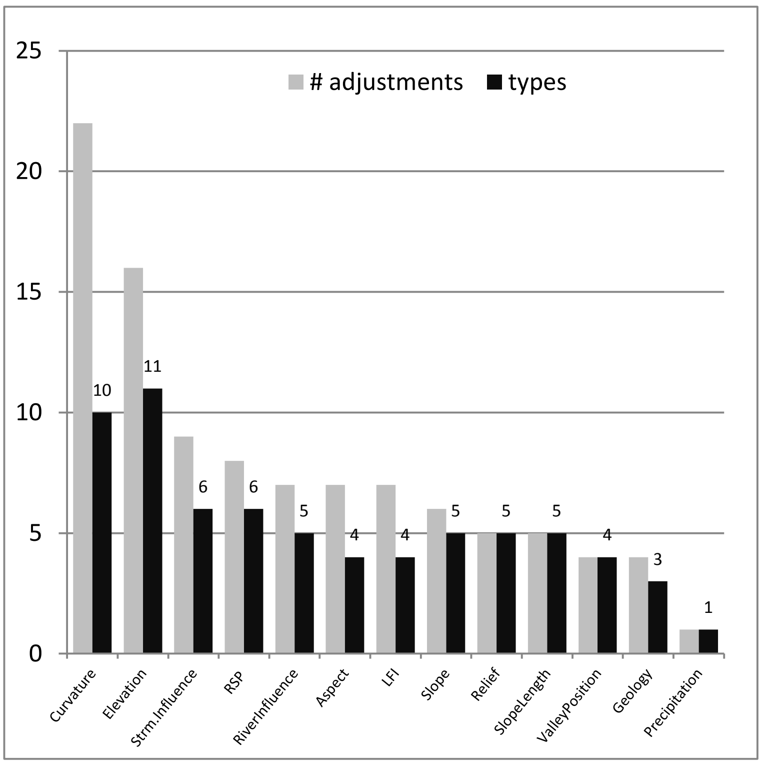
Figure 3. Number of ecotone adjustments within the aggregate Ecological Zone model and the number of adjustments within the MAXENT Zone models in the Southern Blue Ridge Escarpment 4th Approximation.



There were 136 total ecotone adjustments made in the initial models. This is far fewer than were made in the SBR 3rd Approximation where 100 adjustments were used just in the Dry-Mesic Oak-Hickory Zone model. However, model accuracy (79%) was the same for both studies. Fewer adjustments were needed in the SBR Escarpment 4th Approximation due (most likely) to the higher resolution liDAR-generated DEM used to develop the initial MAXENT models in this more current study.

Variables used in Ecotone Adjustments: Topographic /environmental variables used most frequently to describe local environments and refine ecotone boundaries between types were predominantly fine-scale and included: curvature (curve, curpl, curpr), elevation (a fine- to broad-scale variable), stream influence (distance to stream or elevation above stream), and LFI (Figure 4). Three of the least-frequently used variables were broader scale. They included valley position, geology, and precipitation and these variables were also used in the fewest number of Zones. Slope length, a fine-scale variable, was used in only 4 ecotone adjustments and not at all in MAXENT models. This may reflect its limited effect on environments at the Ecological Zone level or that other variables were better correlated. Elevation was the most important variable used by both MAXENT and for ecotone adjustments which reflects its importance in affecting many environments in the steep and varied landscape of the SBR Escarpment.

Figure 4. Environmental variables[1/] used in ecotone adjustments



[1/] Curvature = planiform curvature, profile curvature, curvature; Strm. Influence = distance from streams, elevation above stream; RSP = relative slope position, River Influence = distance from rivers, elevation above river; LFI = landform index.

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

Variable[2/]	Ecotone adjustments	Maxent models [1/]	% difference in variable use
	% of types with variable used		
Elevation	80	73	-7
Curvature	60	13	-47
Strm.Influence	60	46	-14
LFI	53	53	0
River Influence	47	53	6
RSP	53	40	-13
Relief	40	80	40
Aspect	53	20	-33
Slope	40	33	-7
Geology	33	53	20
Valley Position	27	53	26
Slope Length	20	0	-20
Precipitation	1	67	66

[1/] where variable made at least a 5% contribution to model prediction gain.
[2/] Curvature = planiform curvature, profile curvature, curvature, TSI; Strm. Influence = distance from streams, elevation above stream; RSP = relative slope position, River Influence = distance from rivers, elevation above river; LFI = landform index; aspect = aspect raw, cosine, and solar radiation.

3) <u>Map unit accuracy</u>: Accuracy assessments are essential parts of all vegetation mapping projects. They provide the basis to compare different map production methods, and information regarding the reliability and usefulness of the maps for particular applications (Story and Congalton. 1986). For this and other Ecological Zone studies, an 'accuracy evaluation' was completed to compare reference field data to the classified (modeled) Zones from the same sites. Although this is not a true 'accuracy assessment' (see Appendix V), this is a reasonable means of objectively comparing how well map composition reflects field data across different modeling at regional landscapes (Figure 1) and is necessary for evaluating ecotones to improve map unit accuracy among Ecological Zones within specific landscapes.

The following discussion is based on intersecting 2,236 reference plots with the 4th Approximation Ecological Zone map for the Southern Blue Ridge Escarpment. Details of this accuracy evaluation are included in Appendix V. Overall accuracy within the study area is equal to the SBR 3rd Approximation but slightly less than in other Appalachian landscapes where Zone models were evaluated (Table 10). If Ecological Zone map units are 'collapsed' to Ecological Systems described by NatureServe (2013), e.g., combining Cove Forests (Acidic Cove, Rich Cove, Rich Slope, Mixed Oak / Rhododendron), combining

Montane Oak (slope, cove, and rich), and combining Dry Oak (deciduous and evergreen) overall map unit accuracy would increase to 82% (Appendix V, Table 2) because of the similarity between the collapsed Zones and the fewer categories (types) being evaluated.

Table 10. Ecological Zone accuracy within the Appalachian Mountains study areas

Ecological Zone	Southern Blue Ridge Escarpment (2015)	3rd Approx. Southern Blue Ridge (2011)[1/]	Jefferson NF Project Area (2013)		George Washington NF Project Area (2011)	
			Ridge & Valley	Blue Ridge	Ridge & Valley	Blue Ridge
Size of area (acres-rounded)	864,765	783,440	3,733,290	1,940,220	3,761,700	1,026,200
Number of Zones	15	14	23	22	23	15
OVERALL accuracy	**79**	**76**	**83**	**80**	**77**	**80**
Most fire-adapted types	96	95	98	96	97	98
Grassy Bald	-[2/]	-	-	83	-	-
Heath Bald	-	-	-	-	-	-
Spruce-Fir Forest	-	-	-	83	89	-
Northern Hardwood Slope Forest	-	100	90	85	86	81
Northern Hardwood Cove Forest	-	-	94	89	89	100
Acidic Cove Forest	79	76	86	84	83	90
Spicebush Cove Forest	-	-	-	-	-	71
Rich Cove Forest	73	63	81	76	82	82
Rich Slope Forest	77	-	89	-	67	94
Alluvial Forest	100	40	92	93	78	-
Floodplain Forest	91	100	97	85	86	84
High Elevation Red Oak Forest & Wdls.	97	68	82	74	77	68
Montane Oak-Hickory Rich Forest	91	-	76	80	79	-
Montane Oak-Hickory Cove Forest	77	58	86	89	72	80
Montane Oak-Hickory Slope Forest	79	80	83	76	70	-
Colluvial Forest	-	-	-	-	84	90
Dry-Mesic Oak-Hickory Forest	80	78	84	82	81	-
Dry-Mesic Calcareous Forest	-	-	-	-	66	73
Dry Oak Evergreen Heath Forest & Wdls.	73	70	74	81	65	71
Dry Oak Deciduous Heath Forest & Wdls.	69	50	72	74	-	-
Mixed Oak / Rhododendron Forest	77	63	83	74	90	91
Shortleaf Pine-Oak Woodlands	87	90	86	80	-	-
Shortleaf Pine-Oak Heath Woodlands	-	-	-	-	82	-
Pine-Oak Heath Woodlands (eastside)	-	-	-	-	77	83
Pine-Oak Heath Woodlands (westside)	77	63	80	79	59	-
Pine-Oak Heath Woodlands (ridges)	-	-	-	-	89	-
Pine-Oak Shale Woodland	-	-	92	-	83	-
Shale Barren	-	-	90	-	92	-
Alkaline Woodland	-	-	-	-	-	91
Mafic Glade and Barren	-	-	-	-	-	-

[1/] from Table 9 in Appendix X: FLN Landscape Area Analysis: 3rd Approximation Ecological Zones, for the Southern Blue Ridge Escarpment

[2/] Zone does not occur or was not modeled in the project area

In the SBR 4th Approximation, Alluvial Forest, Floodplain Forest, High Elevation Red Oak Forest and Woodlands, and Montane Oak-Hickory Rich Forest Zones have the highest accuracy (greater than 90%); Shortleaf Pine-Oak Woodlands and Dry-Mesic Oak Hickory Forest Zones have the next highest accuracy (greater than 80%). Just three Zones have accuracies well below average; they include Dry Oak Deciduous Heath Forest and Woodland (the lowest accuracy at 69%), Dry Oak Evergreen Heath Forest and

Woodland, and Rich Cove Forest. The remaining 6 Zones are slightly below or equal to the overall average accuracy of 79% (Table 10 and Appendix V, Table 1). The Dry Oak Deciduous Heath Forest and Woodlands, Rich Slope Forest, and Rich Cove Forest Zones have the highest percentage of reference plots from other types 'confused' with these Zones (commission error). This may be due to the overall combined extent of these three Zones (less than 7% of the total landscape, Table 11), or more likely to the small size of individual map units comprising these Zones and their adjacency to more extensive types.

Accuracy of Ecological Zones within the SBR Escarpment was increased considerably in the 4th Approximation compared to the SBR 3rd Approximation models specific to the Escarpment area (79% vs 76%; this 3 percentage point difference represents about 26,000 acres). Although these overall accuracy percentages appear very similar, nearly one-half of the Zones in the 4th Approximation exceed model accuracy by 10 percentage points or greater than the earlier 3rd Approximation and 10 of 15 models exceed accuracy by 2 percentage points or greater. These 10 models represent over 70% of the Escarpment landscape (Table 11). Only Shortleaf Pine-Oak Woodlands and Floodplain Forests more accurately reflected by reference plots in the SBR 3rd Approximation (3% and 9% greater accuracy respectively). These Zones represent about 21% of the total Escarpment landscape. In addition, 2 new Ecological Zones (Montane Oak Rich Forest and Rich Slope Forest) were modeled in the 4th Approximation. There was no real change in model accuracy in the remaining type, Montane Oak-Hickory Slope Forest which represents about 1.2% of the total acres.

4) <u>Ecological Zone location and extent</u>: The Southern Blue Ridge Escarpment models based on MAXENT, with only moderate ecotone adjustments relative to the number used for the SBR 3rd Approximation, appear to represent both the location and extent of Ecological Zones observed in the field and the pattern of elevational gradients within the more-refined Escarpment boundary provided by TNC (Figures 5-12, Tables 11-16). Ecological Zones that support dry-mesic oak-hickory, shortleaf pine-oak, and acidic cove dominated plant associations (in decreasing order of extent) form the potential forest matrix (nearly two-thirds of the total acres) in the SBR Escarpment but vary in extent across elevational gradients (Tables 12-13). The Shortleaf Pine-Oak Zone is part of the predominant forest matrix below 2,500 feet elevation (medium green color on maps) and is modeled along broader ridges in the study area. The Acidic Cove Forest Zone is extensive throughout the entire SBR Escarpment (darkest blue on maps) and modeled in the more protected (higher LFi) areas that are closer to streams. The Dry-Mesic Oak-Hickory Forest Zone (lightest green on maps) is the most extensive type below 4,000'. These elevational and Zone relationships were very apparent in the field.

Table 11. Extent of Ecological Zones within the Southern Blue Ridge Escarpment by ownership (acres rounded)

Ecological Zone	Map Code	Study Area		Federal and State			Private		
		acres	percent	acres	% area	%type[1/]	acres	% area	%type[1/]
Total		864,765	100.0	356,130	100.0	41.2	508,635	100.0	58.8
Floodplain Forest	23	14,390	1.7	1,370	0.4	9.5	13,020	2.6	90.5
Alluvial Forest	6	5,880	0.7	800	0.2	13.6	5,080	1.0	86.4
Acidic Cove Forest	4	130,735	15.1	49,250	13.8	37.7	81,485	16.0	62.3
Mixed Oak / Rhododendron Forest	29	39,070	4.5	20,150	5.7	51.6	18,920	3.7	48.4
Rich Slope Forest	55	13,285	1.5	6,620	1.9	49.8	6,665	1.3	50.2
Rich Cove Forest	5	14,820	1.7	6,445	1.8	43.5	8,375	1.6	56.5
Montane Oak-Hickory Cove Forest	28	52,375	6.1	24,290	6.8	46.4	28,085	5.5	53.6
Montane Oak-Hickory Rich Forest	24	5,735	0.7	1,030	0.3	17.9	4,705	0.9	82.1
High Elevation Red Oak Forest&Wdl.	8	5,110	0.6	1,990	0.6	38.9	3,120	0.6	61.1
Montane Oak-Hickory Slope Forest	9	10,500	1.2	6,240	1.8	59.4	4,260	0.8	40.6
Dry-Mesic Oak-Hickory Forest	13	260,665	30.1	113,800	32.0	43.7	146,865	28.9	56.3
Dry Oak Deciduous Heath	11	29,695	3.4	14,565	4.1	49.1	15,130	3.0	50.9
Dry Oak Evergreen Heath	10	70,645	8.2	40,795	11.5	57.8	29,850	5.9	42.2
Pine Oak Heath Woodland	18	35,900	4.2	17,915	5.0	49.9	17,985	3.5	50.1
Shortleaf Pine-Oak Woodland	16	163,790	18.9	49,330	13.9	30.1	114,460	22.5	69.9
Reservoirs_Lakes	999	12,170	1.4	1,540	0.4	12.6	10,630	2.1	87.4

[1/] percent of the total Ecological Zone in the project area

How well the predicted / mapped Ecological Zone distribution fits the observation of elevational gradients in the field can be assessed by examining both the proportion of different Zone map units within elevation classes relative to the elevation class size (Table 12) and the proportion of Zone map units within elevation classes relative to the entire Ecological Zone extent (Table 13). 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 through the models.

Within the forest matrix, the Dry Oak Evergreen Heath Forest and Woodland Zone (occurring on more exposed landscapes) and the Montane Oak-Hickory Cove Forest Zone (occurring on protected, but wider concave sites than Acidic and Rich Coves) are the 2nd most common types, and in combination potentially occupy > 14% of the total landscape (Table 11) but nearly 25% of landscapes between 2,500' and 3,500' in elevation. Distinctive types dominating the highest elevations (> 4,000') but having less than 5% total coverage within the forest matrix, include (in order of extent), High Elevation Red Oak Forest and Woodlands (occupying the most exposed landscapes), and Montane Oak-Hickory Slopes. The Floodplain Forest Ecological Zone (along with reservoirs) is the most distinctive type that occurs at elevations below 1,500' within the forest matrix.

Table 12. Percent of landscape within elevation classes in the Southern Blue Ridge Escarpment, e.g. the Shortleaf Pine-Oak Woodland Ecological Zone is comprises 31% of landscapes between 1501-2000' in elevation.

Ecological System	Elevation in feet								# Elev. classes 1/	% Land 3/
	< 1001	1001-1500	1501-2000	2001-2500	2501-3000	3001-3500	3501-4000	GT 4000		
Reservoir	5	4	-	-					1	1.4
Floodplain Forest	13	2	1	1					1	1.7
Shortleaf Pine-Oak Woodlands	20	29	31	16	2				4	18.9
Alluvial Forest	1	1	-	1	-	-	- 2/		0	0.7
Rich Slope Forest	-	1	3	3	2	1	-		0	1.5
Rich Cove Forest	1	1	3	2	2	1	1	-	0	1.7
Montane Oak-Hickory Cove Forest	7	5	6	6	8	8	7	3	7	6.1
Acidic Cove Forest	17	13	15	18	16	14	21	15	8	15.1
Mixed Oak / Rhododendron Forest	6	3	4	5	6	5	7	5	6	4.5
Dry-Mesic Oak Hickory Forest	29	37	26	28	29	28	24	6	8	30.1
Dry Oak Evergreen Heath Forest and Woodland	1	4	7	10	15	15	12	16	6	8.2
Dry Oak Deciduous Heath Forest and Woodland	-	1	3	4	6	11	4	2	2	3.4
Pine-Oak Heath Woodland			1	6	13	11	5	7	5	4.2
Montane Oak-Hickory Rich Forest		-	-	1	1	2	3	2	0	0.7
Montane Oak-Hickory Slope Forest			-	1	1	4	13	13	2	1.2
High Elevation Red Oak Forest and Woodland					-	1	6	31	2	0.6
(a) % of landscape	6.7	29.9	19.3	16.8	15.1	7.8	3.5	1.0		
(b) # of Zones (at least 3% extent)	7	7	9	9	7	8	10	8		
(b) /(a) = relative diversity	0.96	0.23	0.47	0.54	0.46	1.03	2.86	8.00		

1/ number of elevation classes where the type represents at least 5% of the landscape. 2/ present, but less than 1% of the landscape. 3/ Ecological System extent

Table 13. Percent of Ecological Zones within elevation classes, e.g. 51% of High Elevation Red Oak Forests and Woodlands are predicted > 4000' in elevation and less than 10% of Rich Cove Forests area predicted below 1000'.

Ecological System	Elevation in feet								elevation range with ≥ 80% of type extent
	< 1001	1001-1500	1501-2000	2001-2500	2501-3000	3001-3500	3501-4000	GT 4000	
Reservoir	22	75	1	2					< 1500'
Floodplain Forest	53	32	9	7					< 1500'
Shortleaf Pine-Oak Woodlands	7	45	32	14	2				1000-2500'
Alluvial Forest	12	47	12	21	6	3	1		1000-2500'
Rich Slope Forest	1	11	36	34	17	2	-		1500-3000'
Rich Cove Forest	6	24	28	20	16	5	1	-	1000-3000'
Montane Oak-Hickory Cove Forest	8	24	18	16	20	10	4	1	1000-3500'
Acidic Cove Forest	7	25	19	20	16	7	5	1	1000-3500'
Mixed Oak / Rhododendron Forest	8	22	18	18	19	8	5	1	1000-3500'
Dry-Mesic Oak Hickory Forest	7	37	17	16	14	7	3	-	1000-3000'
Dry Oak Evergreen Heath Forest and Woodland	1	13	17	21	28	14	5	2	1000-3500'
Dry Oak Deciduous Heath Forest and Woodland	-	10	14	19	27	25	4	1	1500-3500'
Pine-Oak Heath Woodland			4	23	46	21	4	2	2000-3500'
Montane Oak-Hickory Rich Forest		5	7	22	22	28	14	3	2500-4000'
Montane Oak-Hickory Slope Forest		-	5	9	13	26	37	10	> 3000'
High Elevation Red Oak Forest and Woodland			-	1	7	8	33	51	> 3500'

The influence of elevation on Ecological Zone location is also evident when the total extent of Zones is evaluated within elevation classes (Table 13). For example, 80% of the total extent of the following Ecological Zones occur in distinct elevation ranges: Floodplain Forest (< 1,500'), Shortleaf Pine-Oak Woodland, and Alluvial Forest (1,000' to 2,500'), Rich Cove (1,000' to 3,000'), Montane Oak-Hickory Cove Forest, Acidic Cove Forest, and Mixed Oak / Rhododendron Forest (1,000 to 3,500'), Dry-Mesic Oak-Hickory (1,000' to 3,000'), Montane Oak Hickory Slope Forest (> 3,000'), Pine-Oak Heath Woodland (2,000' -3,500'), and High Elevation Red Oak Forest and Woodland (> 3,500').

4b) <u>Comparison of Ecological Zone extent and location between the 4th and 3rd Approximation models</u>: Accuracy of Ecological Zones was not only improved in the SBR Escarpment 4th Approximation, but there was also a noticeable improvement in map unit detail (Figures 5-8) and the predicted extent of Zones (based upon 2014 field observations). This is very apparent by comparing 4th and 3rd Approximation maps for the same areas. The most notable improvements in the central portion of the study area (Figures 5-6) is the detail and extent of Shortleaf Pine-Oak Zones south of Highway 11, the greater coverage of Pine-Oak Heath Zones closer to Brevard, NC (Standing Stone Mt. and Brevard Quads), and the reduced extent of Rich Coves south of Jocassee Lake; for landscapes centered on USFS ownership (Figures 7-8), the most notable improvements again include the detail and extent of Shortleaf Pine-Oak Zones but also the greater extent and refinement of the Dry-Oak Evergreen Heath and Mixed Oak / Rhododendron Zones.

The three Ecological Zones that appear to have been the most 'over-mapped' in the SBR 3rd Approximation models include Montane Oak-Hickory Slope, Shortleaf Pine-Oak Woodland, and Rich Cove Forest. Even if the acreage for the Rich Slope Forest Zone is included with Rich Coves and the Montane Oak-Hickory Rich Forest Zone is included with Montane Oak Slope Forests (both of which were not modeled in the 3rd Approximation but would be the best match for these Zones respectively), this still represents over 50,000 acres (Table 14). The three Ecological Zones that appear to have been the most 'under-mapped' in the SBR 3rd Approximation models in comparison to the 4th Approximation include Acidic Cove (19,670 acres), Dry Oak Deciduous Heath Forest and Woodland (6,280 acres), Mixed Oak / Rhododendron Forest (5,020 acres), and Floodplain Forest (4,615). Interestingly, Dry-Mesic Oak-Hickory Forest, the most extensive Zone within the study area, showed the least difference, except for Pine-Oak Heath Woodlands, and Reservoirs, between the two Ecological Zone modeling attempts (Table 14).

Table 14. Comparison of predicted Ecological Zone Extent in the SBR 4rd vs. 3rd Approximations calculated within the smaller 3rd Approximation boundary (acres rounded).

Ecological Zone	Map Code	SBR Escarpment 4th Approximation		SBR Escarpment 3rd Approximation		Change in Ecological Zone prediction extent 4th – 3rd Approximation	
		acres	% area	acres	% area	acres	% area
Total		781,600	100.0	783,440	100.0	1,840 [1/]	
Floodplain Forest	23	13,135	1.7	8,520	1.1	4,615	0.6
Alluvial Forest	6	5,380	0.7	2,920	0.4	2,460	0.3
Acidic Cove Forest	4	122,090	15.6	102,420	13.1	19,670	2.5
Mixed Oak / Rhododendron Forest	29	36,470	4.7	31,450	4.0	5,020	0.7
Rich Slope Forest	55	12,320	1.6	not modeled		12,230	1.6
Rich Cove Forest	5	13,480	1.7	38,510	4.9	-25,030	-3.2
Montane Oak-Hickory Cove Forest	28	50,100	6.4	47,50	6.1	2,600	0.3
Montane Oak-Hickory Rich Forest	24	5,670	0.7	not modeled		5,670	0.7
High Elevation Red Oak Forest and Woodland	8	5,110	0.7	1,610	0.2	3,500	0.4
Montane Oak-Hickory Slope Forest	9	10,370	1.3	34,080	4.4	-23,710	-3.0
Dry-Mesic Oak-Hickory Forest	13	223,715	28.6	222,400	28.4	1,315	0.2
Dry Oak Deciduous Heath Forest and Woodland	11	27,490	3.5	21,210	2.7	6,280	0.8
Dry Oak Evergreen Heath Forest and Woodland	10	66,900	8.6	65,040	8.3	1,860	0.3
Pine Oak Heath Woodland	18	33,810	4.3	32,880	4.2	930	0.1
Shortleaf Pine-Oak Woodland	16	145,570	18.6	163,880	20.9	-18,315	-2.3
Reservoirs_Lakes	999	10,000	1.3	10,780	1.4	-780	-0.1

[1/] **this 1,840 acre discrepancy between the total acre figures is due to different cell sizes used in the models, rounding errors, and to errant fairies**

Figure 5: Ecological Zones in the central portion of the Southern Blue Ridge Escarpment 4th Approximation

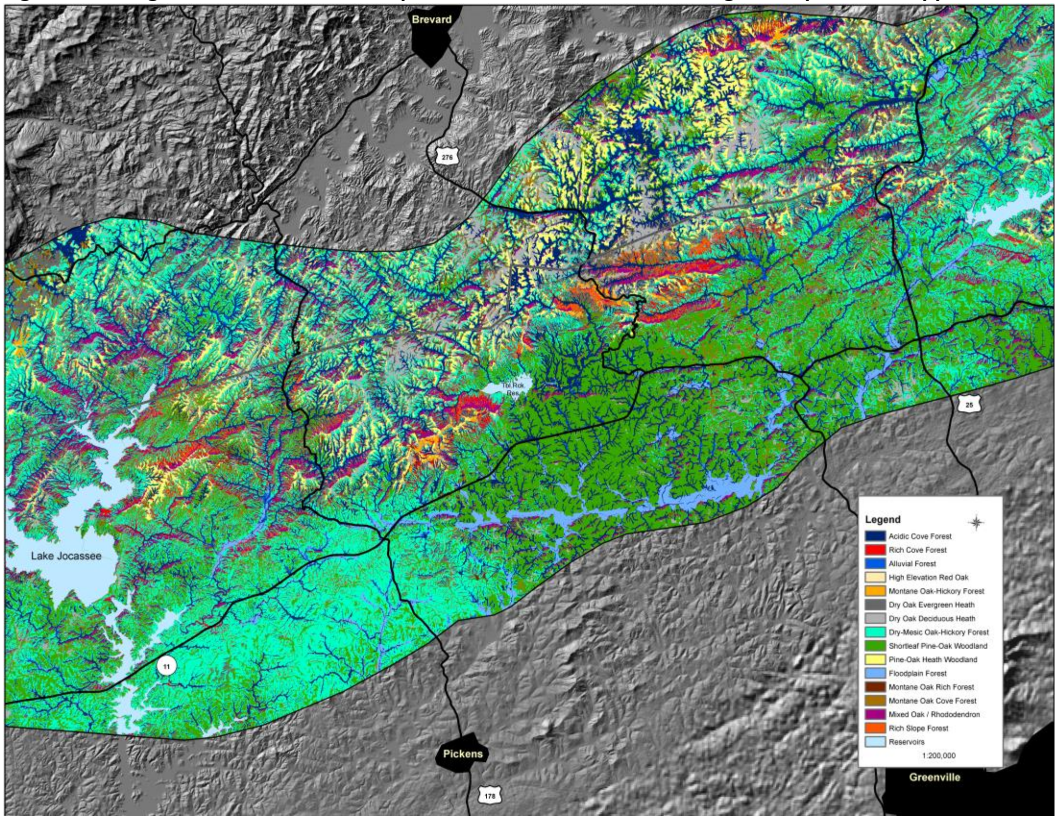


Figure 6: Ecological Zones in the central portion of the Southern Blue Ridge Escarpment 3rd Approximation

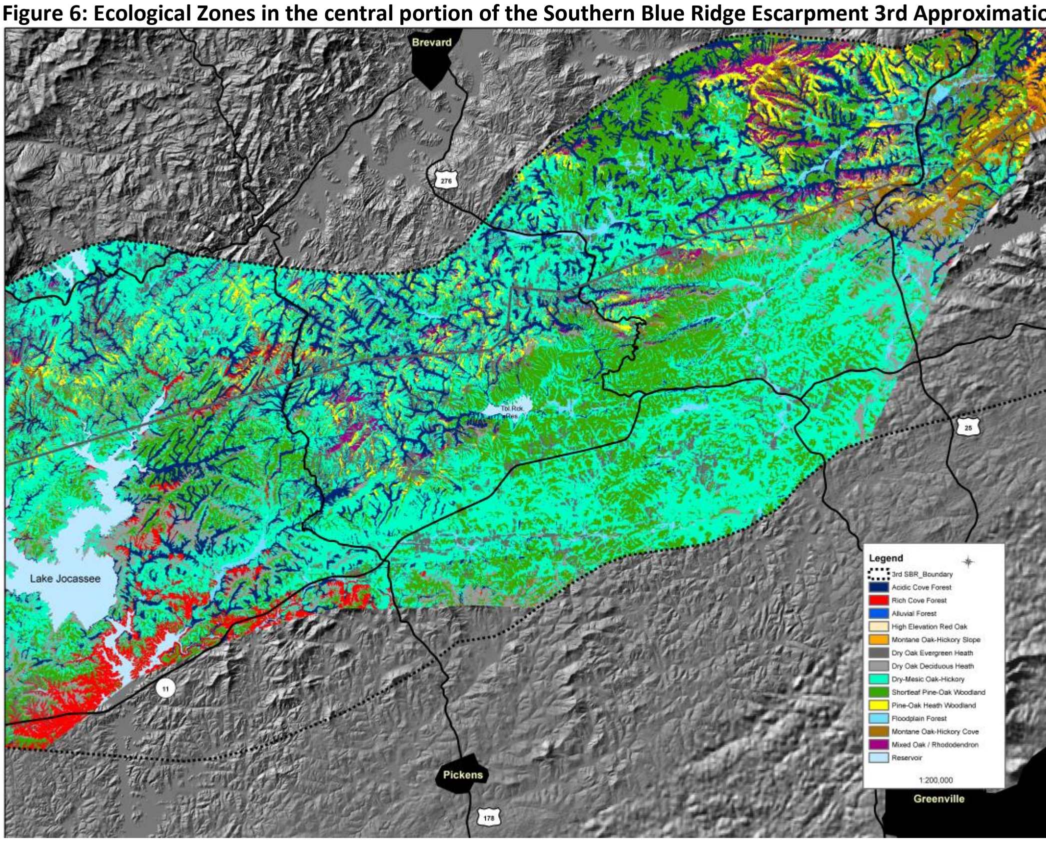


Figure 7: Ecological Zones centered on the Andrew Pickens and Chattooga Districts (USFS) 4th Approximation

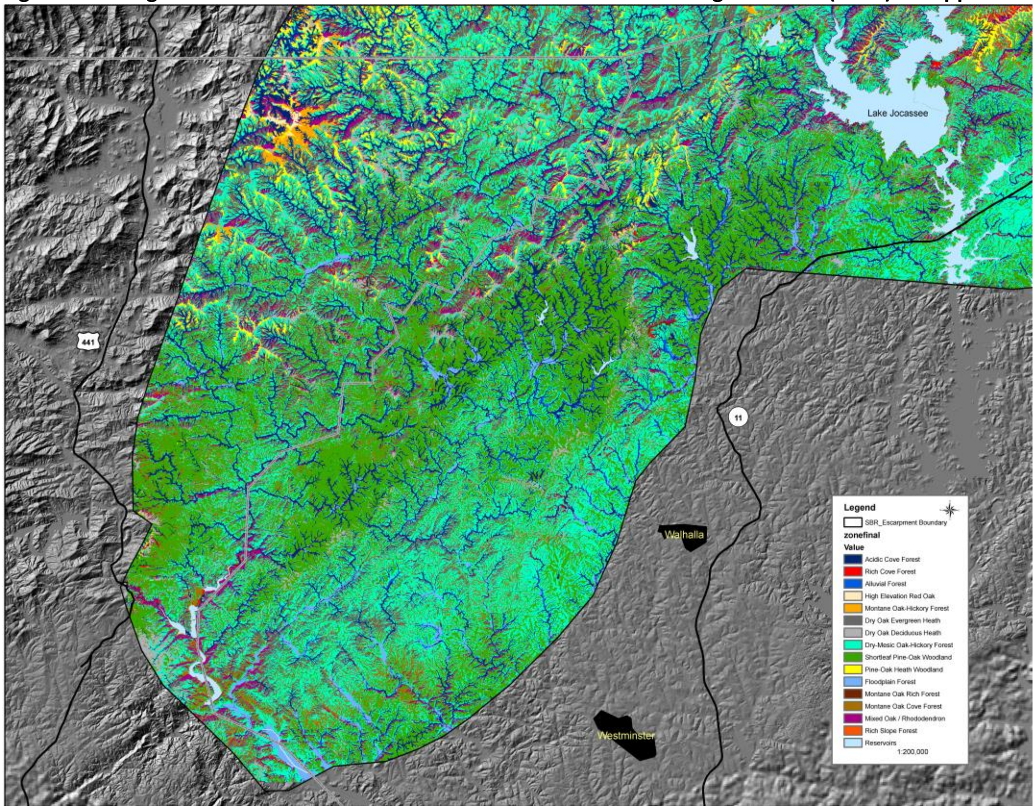
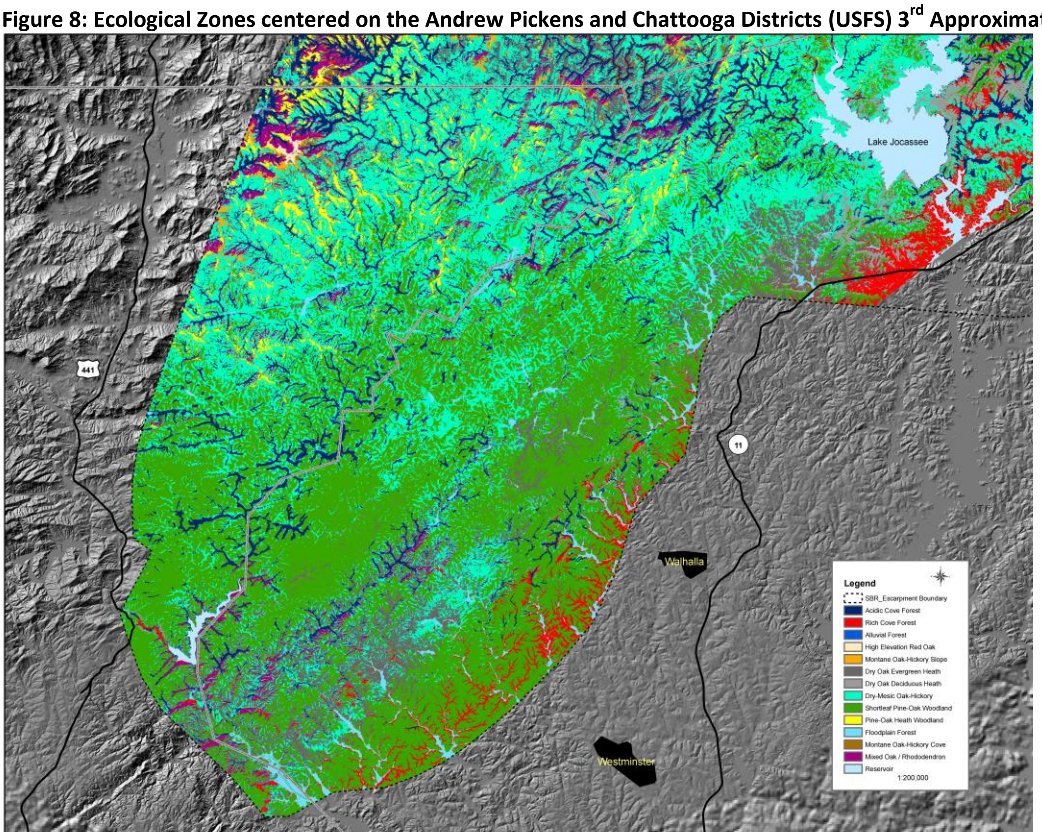


Figure 8: Ecological Zones centered on the Andrew Pickens and Chattooga Districts (USFS) 3rd Approximation



4c) Ecological Zone extent across ownerships: Landscapes within the 864,765 acre Southern Blue Ridge Escarpment intersect 3 States and include multiple private, State, and Federal ownerships. The following is a broad analysis of only the major ownership components, Federal, State, and Private protected, and Private non-protected lands. Nearly 60% (508,635 acres) of the study area is in private, non-protected land (Table 11). More than 80% of the total extent of 4 Ecological Zones modeled within the SBR Escarpment occurs within these landscapes. They include Floodplain Forest, Alluvial Forest, Montane Oak-Hickory Rich Forests, and Reservoirs. Only two Zones, Montane Oak Hickory Slope Forest, and Dry Oak Evergreen Heath Forest and Woodlands are more extensive on Federal and State lands, while Rich Slope Forest, Dry Oak Deciduous Heath Forest, and Pine-Oak Heath Woodland Zones are about equally distributed across private and Federal and State lands. In Georgia, however, over 80% of the Escarpment landscape is in Federal and State ownership (Table 15).

The pattern of Ecological Zone extent among States follows an elevational gradient. North Carolina occupies much of the higher elevations within the Escarpment and therefore includes 95% of the total High Elevation Red Oak Forest and Woodland extent; 60% on Private land, 35% on Federal and State land (Table 15). Similarly, 80% of the total extent of the Montane Oak Slope Forest Zone is in North Carolina (38% on Private land, 42% on Federal and State land), about 65% of the total extent of Pine-Oak Heath is in North Carolina (44% Private, 21% Federal and State), and about three quarters of the Montane Oak Rich Forest Zone occurs in North Carolina (Private land). South Carolina occupies much of the lower elevations within the Escarpment and therefore includes 83% of the total extent of Reservoirs (Private land), 66% of the total extent of Floodplains (61% Private, 6% Federal and State), and 70% of the total extent of the Shortleaf Pine-Oak Ecological Zone (50% Private, 20% Federal and State)

Table 15. Extent of Ecological Zones within the SBR Escarpment by State and ownership (acres rounded)

Ecological Zone	South Carolina				North Carolina				Georgia				% of Ecological Zones State and Fed. Land 2/		
	Federal and State		Private		Federal and State		Private		Federal and State		Private				
	Ac	% 1/	Ac	% 2/	Ac	%	Ac	% 1/	Ac	%	Ac	% 1/	SC	NC	GA
Floodplain	795	0.5	8,720	60.6	435	0.4	3,640	25.3	140	0.2	675	4.7	5.5	3.0	1.0
Alluvial	575	0.3	2,560	43.5	193	0.2	2,490	42.4	30	0.0	35	0.6	***9.8***	3.3	0.5
Acidic Cove	22,750	12.9	30,970	23.6	15,990	16.3	47,595	36.4	10,510	12.8	3,020	2.3	17.4	12.2	8.0
Mixed Oak/Rhodo	9,120	5.2	8,240	21.1	6,170	6.3	9,600	24.6	4,860	5.9	1,090	2.8	5.2	15.8	12.4
Rich Slope	4,250	2.4	1,190	8.9	2,030	2.1	5,445	41.0	345	0.4	30	0.2	2.4	***15.3***	2.6
Rich Cove	3,470	2.0	1,884	12.7	2,130	2.2	6,245	42.1	845	1.0	250	1.7	***23.4***	14.4	5.7
Montane Oak Cove	11,430	6.5	9,070	17.3	5,730	5.8	17,265	33.0	7,130	8.7	1,755	3.3	6.5	10.9	***13.6***
Montane Oak Rich	625	0.4	365	6.4	370	0.4	4,340	75.7	35	0.0	1	0.0	10.9	6.4	0.6
High Elevation Red Oak	6	0.0	1	0.0	1,785	1.8	3,070	60.0	200	0.2	50	1.0	0.1	***34.9***	3.9
Montane Oak Slope	770	0.4	225	2.1	4,410	4.5	4,030	38.4	1,060	1.3	5	0.1	7.4	***42.0***	10.1
Dry-Mesic Oak	57,635	32.8	66,360	25.5	30,235	30.8	75,420	28.9	25,995	31.6	5,045	1.9	***32.8***	11.6	10.0
Dry Oak Deciduous Heath	6,895	3.9	4,375	14.7	3,840	3.9	10,105	34.0	3,835	4.7	650	2.2	***23.2***	12.9	12.9
Dry Oak Evergreen Heath	17,175	9.8	6,090	8.6	13,660	13.9	22,610	32.0	9,965	12.1	1,150	1.6	9.8	19.3	14.1
Pine Oak Heath	6,900	3.9	1,790	5.0	7,450	7.6	15,830	44.1	3,570	4.3	370	1.0	19.2	20.8	9.9
Shortleaf Pine-Oak	32,030	18.2	81,530	49.8	3,600	3.7	28,660	17.5	13,700	16.7	4,315	2.6	***19.5***	2.2	8.4
Reservoirs_Lakes	1,510	0.9	10,105	83.0	20	0.0	110	0.9	5	0.0	420	3.5	***12.4***	0.2	0.0
TOTAL	175,925		233,360		98,040		256,450		82,210		18,850				
% of project area	20.3		27.0		11.3		29.7		9.5		2.2				

1/ percent of Ecological Zone within the ownership 2/ percent of total Ecological Zone extent in the project area

Sixty percent of land within the Sumter National Forest, Andrew Pickens District proclamation boundary is federally owned. Four Ecological Zones are 'over-represented' on federal land, i.e., their extent on National Forests is at least 10 percentage points higher than the 60.2% average USFS ownership within the proclamation boundary. They include (in order of over-representation): Pine Oak Heath Woodland, Dry Oak Evergreen Heath Forest and Woodland, Montane Oak-Hickory Slope Forest, and Montane Oak-Hickory Cove Forest (Table 16). Conversely, six Zones that are 'under-represented' on federal land include: Reservoirs_Lakes, Floodplain Forest, Montane Oak-Hickory Rich Forest, Alluvial Forest, Rich Slope Forest, and Rich Cove Forest. US Forest Service ownership on the Sumter National Forest accounts for just 9.7% of the total acres within the SBR Escarpment but a disproportionately higher amount of the total extent of Montane Oak-Hickory Cove (13.9%), Dry Oak Evergreen Heath Forest and Woodland (13.4%), Shortleaf Pine-Oak Woodland (12.0%), and Dry-Mesic Oak-Hickory Forest (11.2 %).

Table 16. Extent of Ecological Zones on the Andrew Pickens District (acres rounded)

Ecological Zone	Map Code	Proclamation Boundary			USFS Ownership			Percent USFS Ownership within proc. boundary
		acres	percent	%Type[1/]	acres	% area	%Type[1/]	
Total		139,700	100.0	16.1	84,110	100.0	9.7	60.2
Floodplain Forest	23	1,805	1.3	12.5	490	0.6	3.4	27.1
Alluvial Forest	6	675	0.5	11.5	210	0.2	3.5	31.1
Acidic Cove Forest	4	17,785	12.7	13.6	9,725	11.6	7.4	54.6
Mixed Oak / Rhododendron Forest	29	5,610	4.0	14.3	3,310	3.9	8.5	59.0
Rich Slope Forest	55	550	0.4	4.1	265	0.3	2.0	48.0
Rich Cove Forest	5	960	0.7	6.5	485	0.6	3.3	50.1
Montane Oak-Hickory Cove Forest	28	9,695	6.9	18.5	7,270	8.6	13.9	74.9
Montane Oak-Hickory Rich Forest	24	330	0.2	3.9	95	0.1	1.6	28.8
High Elevation Red Oak Forest and Woodland	8	-	-	-	-	-	-	-
Montane Oak-Hickory Slope Forest	9	8	0.0	0.1	6	0.0	0.1	75.0
Dry-Mesic Oak-Hickory Forest	13	41,680	29.8	16.0	29,140	34.6	11.2	69.9
Dry Oak Deciduous Heath Forest and Woodland	11	4,235	30	14.2	2,855	3.4	9.6	67.4
Dry Oak Evergreen Heath Forest and Woodland	10	11,940	8.5	16.9	9,470	11.3	13.4	79.3
Pine Oak Heath Woodland	18	1,425	1.0	4.0	1,150	1.4	3.2	80.7
Shortleaf Pine-Oak Woodland	16	37,455	26.8	22.8	19,640	23.3	12.0	52.5
Reservoirs_Lakes	999	5,650	4.0	46.4	-	-	-	-

[1/] **percent of the total Ecological Zone across the SBR Escarpment area**

At larger map scales (1:12,000), the relationships between environmental factors and Ecological Zones are more evident as is the association among Ecological Zones (Figures 9-12). The distribution of types relative to site exposure, slope position, elevation, and surface shape can be seen in the Table Rock State Park in SC (Figure 9). The Pine-Oak Heath Woodland Zone is modeled along the highest ridges and more-exposed midslope ridges with southerly exposure. The north-facing slopes along the highest ridges from Panther Gap to Pinnacle Mountain are dominated by Mixed Oak / Rhododendron or Dry Oak Evergreen Heath Forest while most mid to upper southerly facing slopes are dominated by Montane Oak Slope Forest. The most concave slopes in narrow to wider draws are dominated by Cove Ecological Zones while the Shortleaf Pine-Oak Zone only occurs at lower elevations along convex tertiary, south-facing ridges.

The distribution of types relative to site exposure, elevation, and surface shape can also be seen at Tryon Peak and White Oak Mountain, North Carolina (Figure 10). Like Table Rock, this in one of the areas of highest relief in the Southern Blue Ridge Escarpment. Some of the most extensive High Elevation Red Oak Forest and Woodlands and Montane Oak Slope Forests found in the Escarpment occur in this area. The highest elevations are dominated by High Elevation Red Oak and this Zone transitions to Montane Oak Slopes at upper slopes on all aspects but especially south-facing exposures. Again, drainages are dominated by Acidic Cove and Rich Cove Forests while the higher north-facing slopes are dominated by Mixed Oak / Rhododendron. Dry-Mesic Oak-Hickory is extensive below these Zones.

The more typical pattern of Ecological Zones across the SBR Escarpment can be seen on the Sumter National Forest near Morton and Dodge Mountains (Figure 11). In this mid-elevation area, the 3-Zone forest-matrix is prominent; Dry-Mesic Oak-Hickory Forest (occurring on slightly convex side slopes), Shortleaf Pine-Oak Woodland (occurring on the broader, low ridges), and Acidic Cove Forest (in drainages). The Dry Oak Deciduous Heath Forest and Woodland Zone is fairly extensive in this area occurring on mid to upper slope positions while Dry Oak Evergreen Heath Forest and Woodlands and Mixed Oak / Rhododendron occur on the steeper north-facing slopes. At lower elevations near Brasstown Creek and Pine Mountain, SC, the Dry-Mesic Oak Hickory Zone is the dominant member of the typical 3-Zone matrix due to less extensive broad, low ridges in this area where Shortleaf Pine-Oak Woodlands would be more typical. In addition, Montane Oak Cove Zones are more extensive in drainages usually dominated by Acidic Cove Forest. This is likely due to Mafic geology in the area and this may also explain the presence of the small Rich Coves along upper Longnose Creek (adjacent the southern-most Floodplain Forests).

Figure 9. Ecological Zone detail at Table Rock State Park, South Carolina

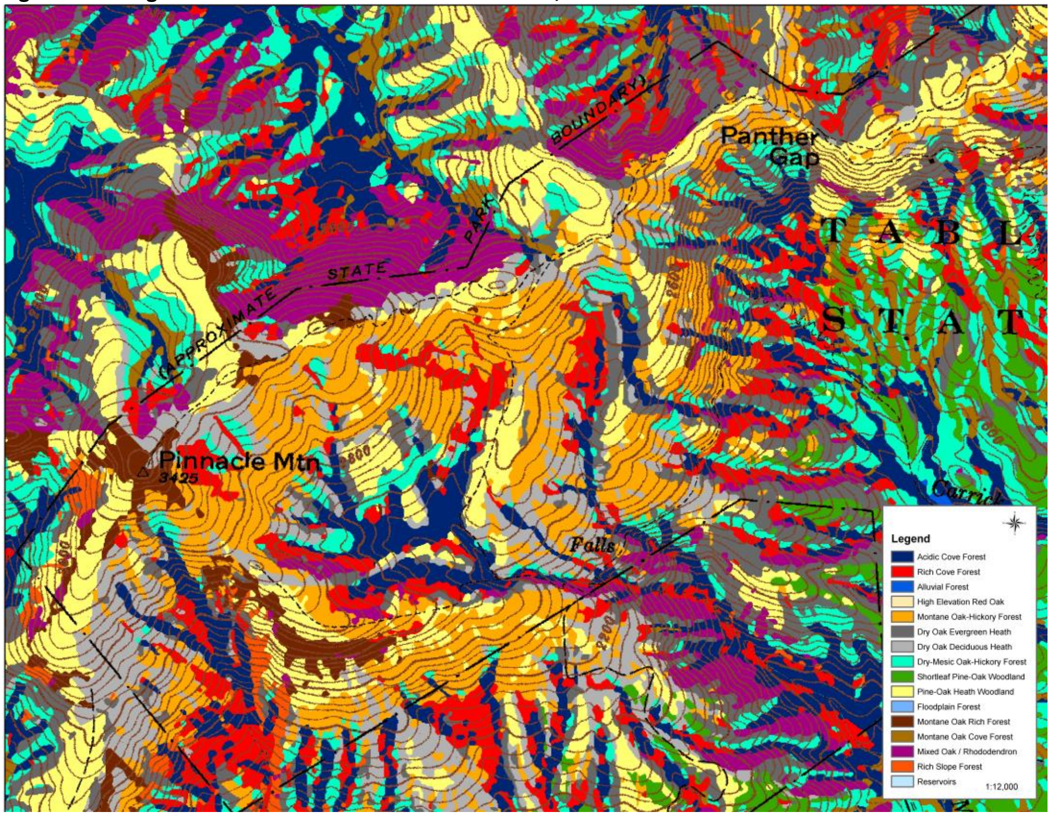


Figure 10. Ecological Zone detail, High Elevation Red Oak and Montane Oak Slope at Tryon Peak, NC

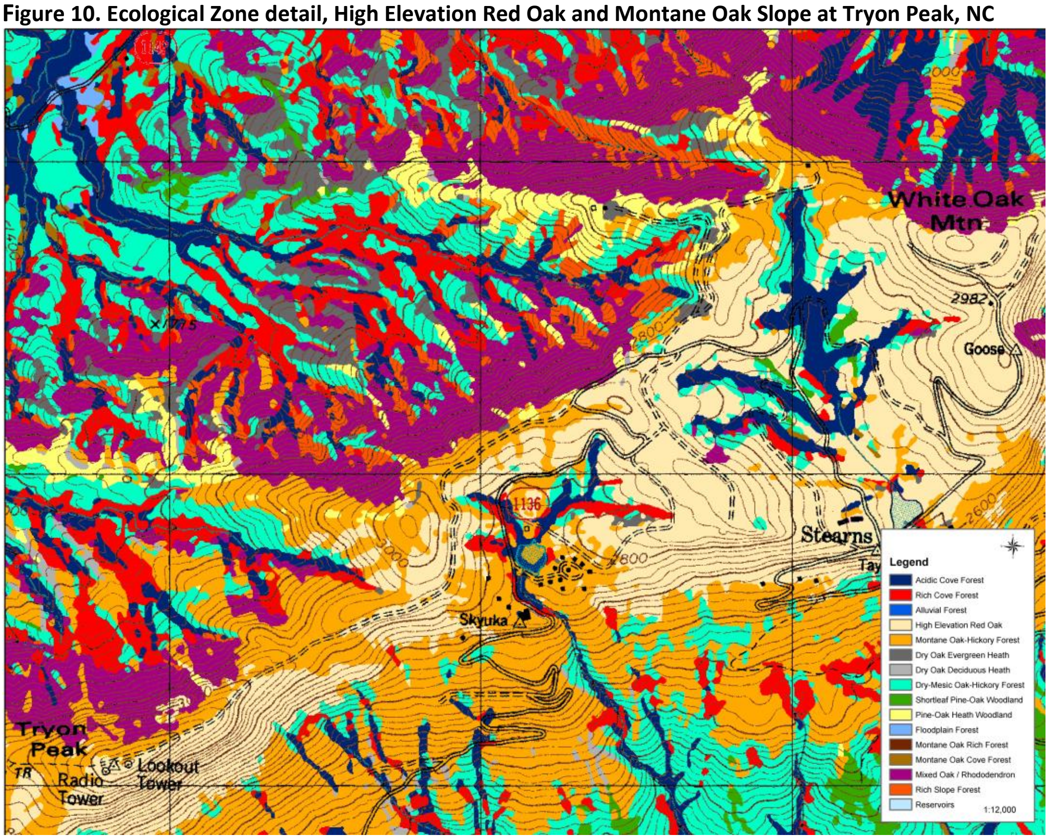


Figure 11. Ecological Zone detail near Dodge and Morton Mtns, South Carolina (USFS, Andrew Pickens)

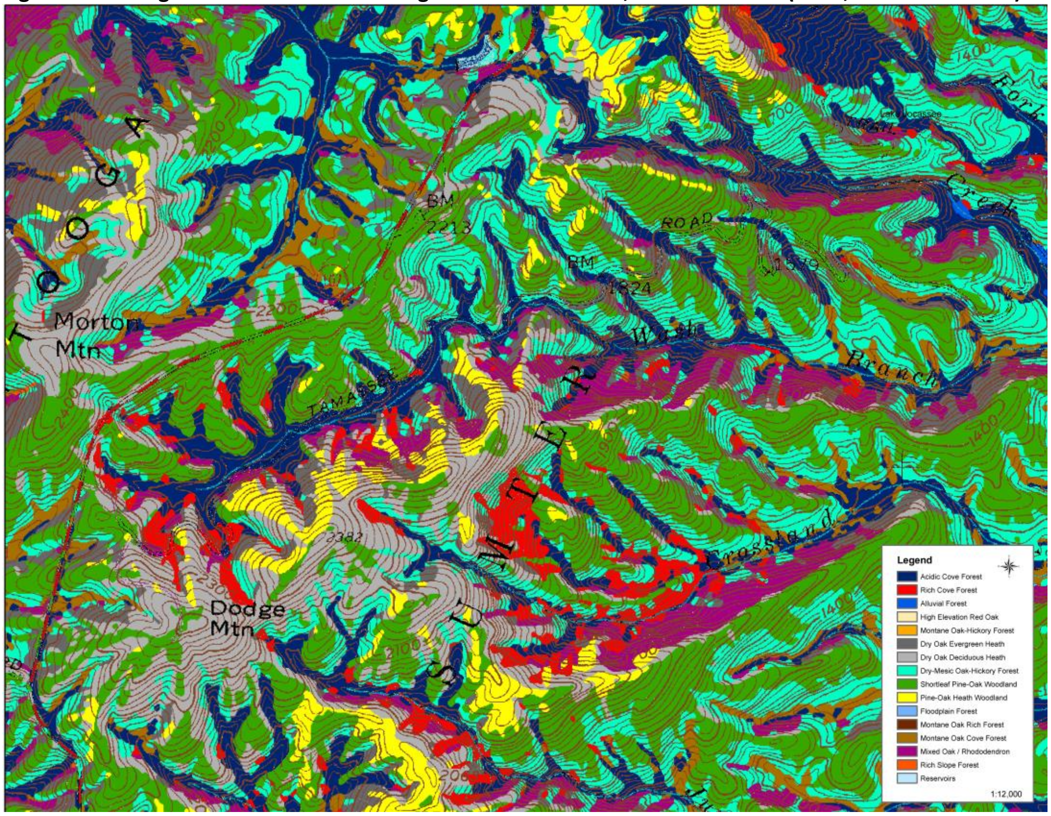
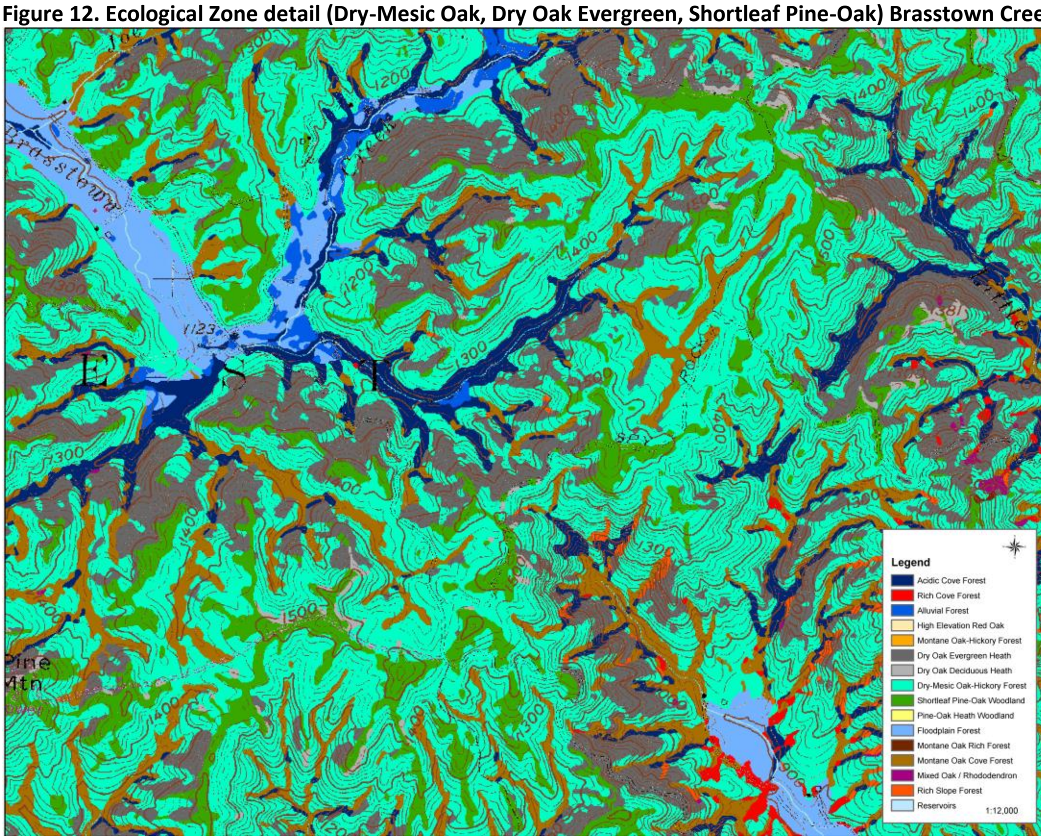


Figure 12. Ecological Zone detail (Dry-Mesic Oak, Dry Oak Evergreen, Shortleaf Pine-Oak) Brasstown Creek, SC



Improving Map Unit Accuracy

The accuracy of the 4th Approximation Ecological Zone map for the Southern Blue Ridge Escarpment is better than the 3rd Approximation and comparable to other similar Ecological Zone / System 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 in the field, 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. Choosing reference plots on 'postage stamp' sites or near ecotones can also affect model accuracy. This was evident when comparing plot accuracy before and after performing just one majority filter (an ESRI post-processing step used to reduce "data noise" that replaced individual pixel Zone assignments based upon the majority of Zones found in their 8 contiguous neighbors, page 7). Plot accuracy was reduced 6 percentage points, i.e., "raw models' = 85% accuracy and after one majority filter = 79% accuracy. Although difficult to capture in GIS modeling, this variability in environmental conditions over short distances is common in the SBR Escarpment 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 have a major impact on the outcome of map unit extent and accuracy. It should also be noted that these field identification 'errors' may at times be accounted for by the MAXENT statistical procedure that evaluates environmental conditions at multiple plots (often in the hundreds), and therefore the models **could** better represent Ecological Zones than the field evaluation, i.e, the models may be more objective and more accurate than the field investigators. This is something to consider when reviewing the accuracy evaluation matrix (Appendix V).

3) DTM accuracy: The accuracy of DTMs used to reflect temperature, moisture, and fertility gradients in the study area has a significant impact on Ecological Zone map unit accuracy. Second derivative DTMs developed from the highly accurate LiDAR generated digital elevation model are assumed to be the most accurate of all environmental variables, although DTM methodology (Appendix III) could be improved. Geologic type / parent material and soils influence soil fertility (and soil drainage) and could therefore have a major influence on the distribution of Ecological Zones across the complex background of temperature and moisture regimes described by other DTMs. Geology map units in the SBR Escarpment are currently at a much coarser resolution than the LiDAR DEM, therefore their use in this modeling effort could actually have a negative effect on model accuracy especially at finer scales.

4) Modeling methods: The 4th Approximation Ecological Zones were based on merging 15 individual Zone models into one map based upon the Zone having the highest probability of occurrence and some minor adjustments along ecotones. Although this seems to be a reasonable approach, other techniques might be better. 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 Descriptions

The following are brief descriptions excerpted from 'NatureServe. 2013. International Ecological Classification Standard: Terrestrial Ecological Classifications. NatureServe Central Databases. Arlington, VA. U.S.A. Data current as of 12 July 2013', and the 'Guide to the Natural Communities of North Carolina, Fourth Approximation (Schafale 2012), unless otherwise noted.

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.

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 – Central Appalachian River Floodplain: 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.

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).

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 3rd 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 can therefore be considered a refinement 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 / NatureServe – Southern and Central Appalachian Cove Forest: See description above.

Rich Slope Ecological Zone
This zone is a refinement of the Rich Cove type and modeled to improve map unit accuracy at steeper slope locations within this type. Further work is needed to evaluate vegetation differences between this slope element and the cove element of 'Rich Coves'.

- BpS / NatureServe – 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 / NatureServe – 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.

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 -- Central and Southern Appalachian Montane Oak Forest: 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.

- BpS / Nature Serve – Southern and Central Appalachian Northern Red Oak-Chestnut Oak Forest (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).

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 -- Central and Southern Appalachian Montane Oak Forest: 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.

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 – 3rd approximations, 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 -- Southern Appalachian Oak Forest: 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, this varies considerably according to slope position (and the predominantly east or west-facing side of major ridges in VA). 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 -- Allegheny-Cumberland Dry Oak Forest and Woodland: 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.

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. In NC)*, and wintergreen.

- Bps / Nature Serve – Southern Appalachian Montane Pine Forest: 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.

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 -- Southern Appalachian Low-Elevation Pine: 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, 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.

Appendix II: photos of selected Ecological Zones

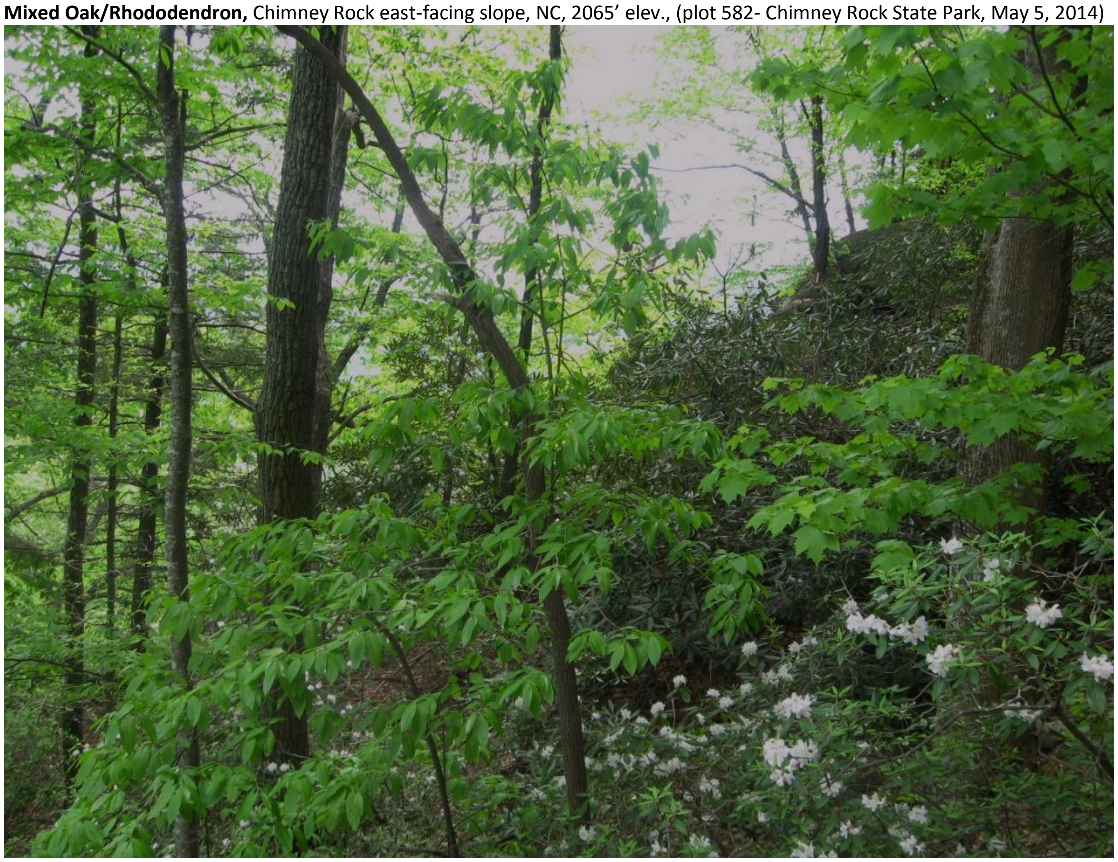
Floodplain Forest, Green River, NC, 1050' elev., (plot 727 – Green River Game Land, NW of Brushy Mtn., May 9, 2014)

Alluvial Forest, Pulliam Crk. upper right fork, NC, 2000' elev., (plot 778, Green River Game Land, NW of Long Ridge, May 9, 2014)

Acidic Cove Forest, Oolenoy River east of Sharp Top Mtn, SC, 1150' elev., (plot 104–Jocassee Gorges State Park, April 4, 2014)

Acidic Cove Forest, Green River tributary, NC, 1400' elev., (plot 724 – PVT Land, Green River Cove Road near Saluda, May 9, 2014)

Mixed Oak/Rhododendron, Chimney Rock east-facing slope, NC, 2065' elev., (plot 582- Chimney Rock State Park, May 5, 2014)



Mixed Oak/Rhododendron, Slope above Tugaloo Lake, SC, 920' elevation, (plot 277- PVT land in USFS Proc. Boundary, April 7, 2014)

Rich Slope Forest, Slope above Eastatoe Crk. trib. near state line, SC, 2160' elev., (plot 115 –Jocassee Gorges St. Park, April 4, 2014)

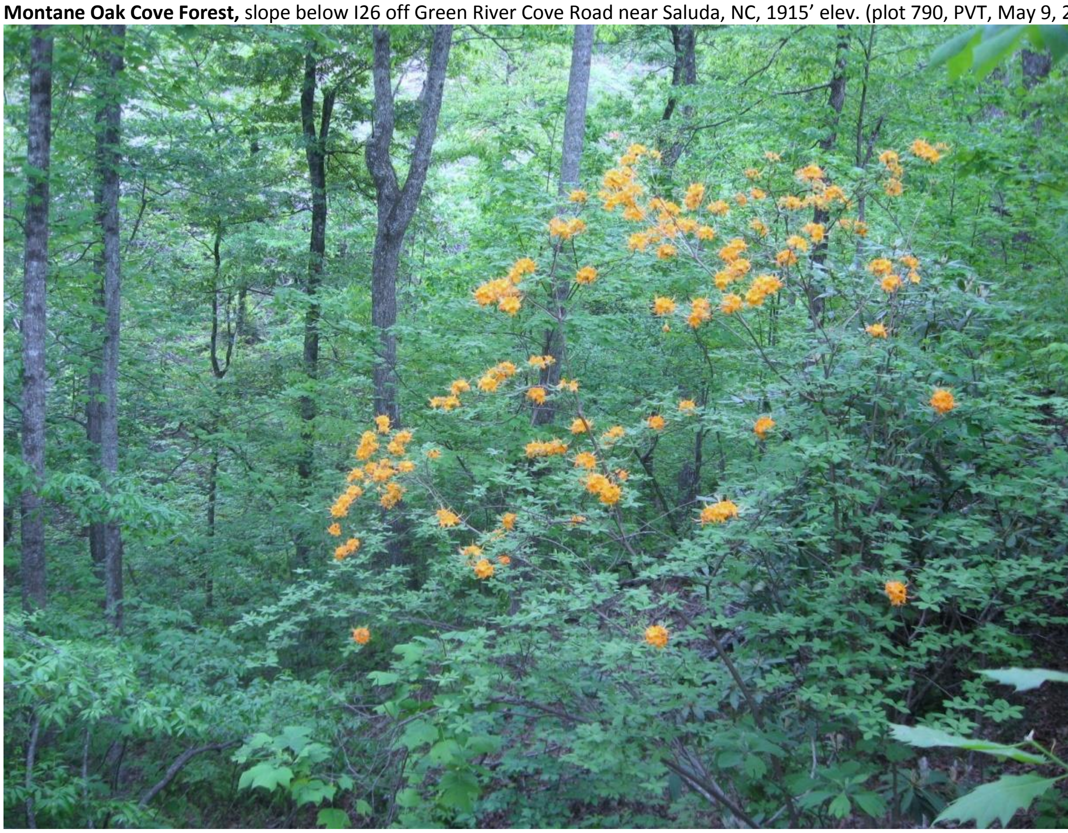
Rich Slope Forest, Slope above Eastatoe Crk. below Hog Crk., SC, 1840' elev., (plot 122- Jocassee Gorges State Park, April 4, 2014)

Rich Cove Forest, Cove below Panther Gap, SC, 2515' elevation, (plot 9133, Table Rock State Park, April 5, 2014)

Rich Cove Forest, Cove below Pulpit Rock, NC, 1790' elevation, (plot 577- Chimney Rock State Park, May 5, 2014)

Montane Oak Cove Forest, Side of Mtn. Creek-north of Laurel Fork Gap, SC, 2010' elev., (plot 143, Jocassee Gorges St. Park, April 4, 2014)

Montane Oak Cove Forest, slope below I26 off Green River Cove Road near Saluda, NC, 1915' elev. (plot 790, PVT, May 9, 2014)



Montane Oak Slope Forest, upper slopes Saluda River, Caesars Head, SC, 3065' elev., (plot 827, Jocassee Gorges St. Park, May 8, 2014)

Montane Oak Slope Forest, slope at Green River Cove Road near Saluda, NC, 1925' elev., (plot 718, PVT land, May 9, 2014)

High Elevation Red Oak, Caesars Head, SC, 3180' elev., (plot 87, Jocassee Gorges State Park, April 3, 2014)

High Elevation Red Oak, Shenandoah Mt., VA, 3,700' elev. (GW National Forest, 2001)

Dry Mesic Oak Forest, slopes of Side Mt. Crk., NC, 2000' elevation, (plot 154, Jocassee Gorges State Park, April 4, 2014)

Dry Mesic Oak Forest, Hwy. 1142 near Piney Mtn., NC, 1720' elev., (plot 748, PVT land adjacent Green River Gameland, May 9, 2014)

Dry-Oak Deciduous Heath, Cane Mt., SC, 2300’ elevation, (plot 434 Jocassee Gorges State Park, April 16, 2014)

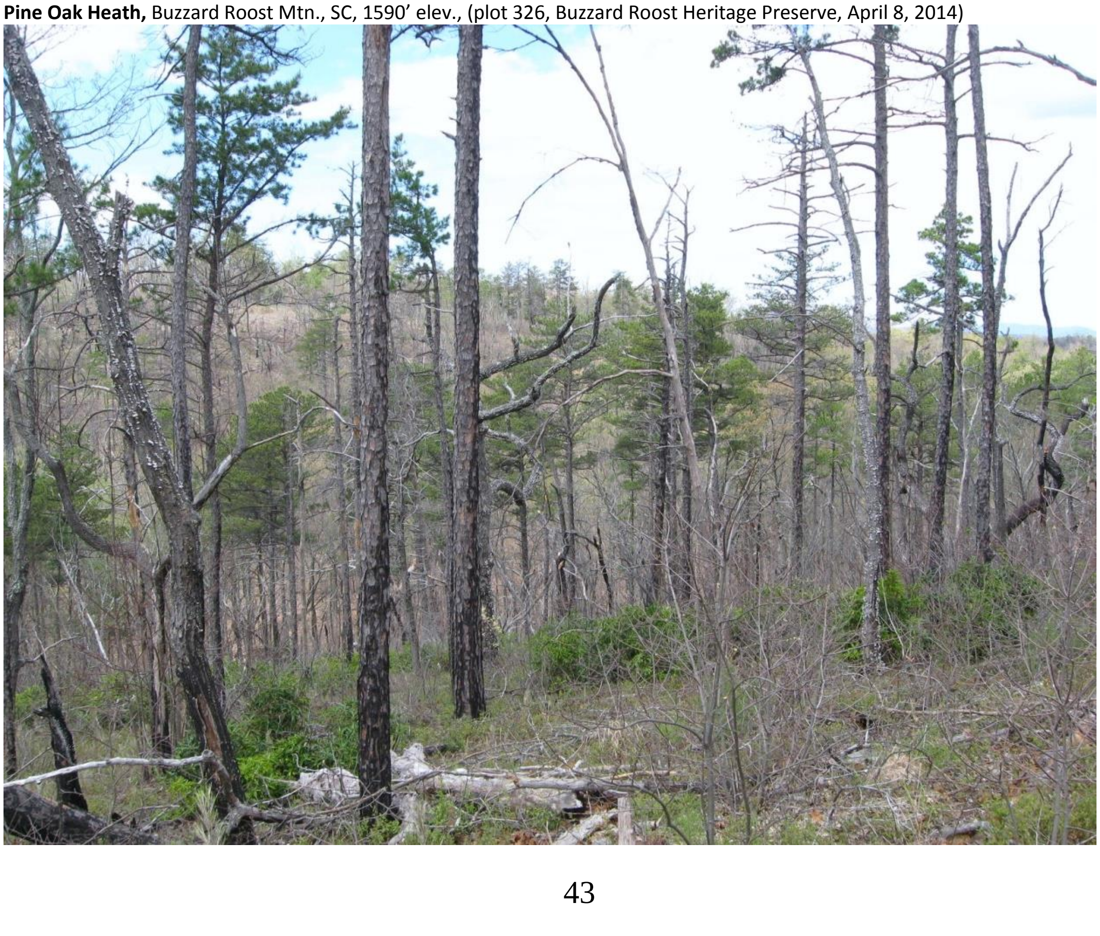
Dry-Oak Deciduous Heath, Cold Spring Branch near Caesars Head, SC , 2380’ elev., (plot 808, Jocassee Gorges St. Park, May 8, 2014)

Dry Oak Evergreen Heath, Near Laurel Fork Gap, SC, 2160' elevation, (plot 141, Jocassee Gorges State Park, April 4, 2014)

Dry Oak Evergreen Heath, Chimney Rock Mtn., NC, 2590' elevation, (plot 584, Chimney Rock State Park, May 5, 2014)

Pine Oak Heath (prominent mid-range view), Cane Creek Mt., NC, 2290' elev., (plot 5830, Chimney Rock State Park, May 5, 2014)

Pine Oak Heath, Buzzard Roost Mtn., SC, 1590' elev., (plot 326, Buzzard Roost Heritage Preserve, April 8, 2014)



Pine Oak Heath, Bully Mt., SC, 2040’ elevation., (general location, Gorges State Park, April 16, 2014)

Pine Oak Heath, Near Long Ridge, NC, 2170’ elevation, (plot 782, Green River Game Land, May 9, 2014)

Shortleaf Pine-Oak, Ridge above Otter Creek, SC, 1730’ elevation, (plot 304, Sumter NF, April 8, 2014)

Shortleaf Pine-Oak, Persimmon Ridge, SC, 1430’ elevation, (plot 58, Ashmore Heritage Preserve, April 3, 2014)

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

The following DTMs were developed to characterize fine to broad-scale terrain, climate, and geology that control temperature, moisture, fertility, disturbance, and solar inputs in the Southern Blue Ridge Escarpment. These environmental factors affect the distribution of Ecological Zones and their component Plant Associations in different landscapes within this area. DTMs are used to develop site specific probability values for Ecological Zones based upon their correlation to reference field locations for each Zone. All processing of 2nd derivative grids (i.e., DTMS; slope, aspect, elevation above streams, etc.,) used the 'filled' DEM developed for modeling streams; processing and final grid cell size was 10 feet except where noted below; all final DTMS have a NAD_1983_HARN_ Stateplane_South_Carolina coordinate system and D_North_American_1983 datum with x,y,z units in feet. The name of the DTM grid coverages are in parenthesis.

1) Aspect (aspraw)
Aspect is a measure of slope direction (exposure) at each cell location (ESRI); values range from -1 to 360; 16 bit signed integer.

2) Aspcos (aspcos)
Aspcos is the cosine of aspect; values range from -100 to 100; 8 bit signed integer. Aspcos was developed using the following steps:

a) convert degrees to radians in raster calculator: (aspraw * 0.017432925); cosine measurements for a continuous aspect variable are derived from radians.
b) calculate cosine using ARC TOOLBOX Spatial Analyst Tools, Math, Trigometric, Cos.
c) multiply product by 100, convert to integer

3) Curvature (curve)
Curve is the curvature of a surface at each cell center in a 3x3 neighborhood (ESRI); 16 bit signed integer (multiplied by 100 and converted from original format).

4) Curvature planiform (curpl)
Curpl is the curvature of a surface in a 3x3 neighborhood perpendicular to the slope direction (ESRI tools GRID curvature function with {out_plan_curve} an optional output grid referred to as the planiform curvature); 16 bit signed integer (multiplied by 100 and converted from original format).

5) Curvature profile (curpr)
Curpr is the curvature of surface in a 3x3 neighborhood in the direction of slope (ESRI tools GRID curvature function with {out_profile_curve} an optional output grid showing the rate of change of slope for each cell); 16 bit signed integer (multiplied by 100 and converted from original format).

6) Elevation (elev)
Elev is LiDAR derived elevation in feet (digital elevation model - DEM); 32 bit floating point, sinks filled; from the following DEM sources:

- Francis Marion-Sumter National Forest GIS staff; resampled original 5'x5' DEM to 10'x10' (160,502 acres; 18.5 % of area),
- The National Map Viewer; 1/9 second , i.e., 10'x10' DEMs (684,743 acres; 78.9% of area),
- The National Map Viewer; 20'x20' DEMs at the NC-SC boundary (22,281 acres; 2.6% of area; 2,392 acres NC_protected, multiple owners, predominantly USFS).

7) Landform index (lfi)
Landform index is an index of landform shape (site protection) and macro-scale landform (*McNab, W.H. 1996. Classification of local- and landscape-scale ecological types in the Southern Appalachian Mountains. Environmental Monitoring and Assessment 39:215-229.*); values range from 0 – 768 (larger number is more protected); 16 bit signed integer.

TopoMetrix software was used to calculate LFI which requires very large RAM and caching capability and therefore will not perform except on relatively small areas. Processing lfi from TopoMetrix required the following steps:

a) clip 'filled DEM' to reasonably-sized areas using 12-digit modeled HUC boundaries subdivisions of these sub-watersheds.
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 and define projection.
e) set null for all grid values < 0 or > 800 (outside poly boundary).
f) mosaic grids and fill through focalmean all nodata values.

8-10) Parent material / geology (geo2, geo3, geo6)
The influence of parent material /geology was estimated from the distance to mapped bedrock units grouped within categories having similar chemical composition. Bedrock geology was derived by combining state geology coverages from Georgia, South Carolina, North Carolina, and finer resolution R. D. Hatcher mapping and quad mapping in North Carolina. The following steps were used to create the final geology 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:
   - 2 = MAFIC SILICATE ROCKS
   - 3 = SILICICLASTIC ROCKS
   - 6 = MIXED SILICICLASTIC -MAFIC ROCKS
2. Create a separate grid 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. Geology groupings and rock types are documented in Appendix VIII, Ecological Zones in the Southern Blue Ridge: 3rd Approximation.

11) Precipitation (precip)
Average annual precipitation in inches based on average annual precipitation for the climatological period 1981-2010. 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 that explain extreme, complex variations in climate that occur in mountainous regions i.e., (orographic effects are included in the PRISM model). The precipitation data were distributed at a resolution of approximately 800m which is a considerably finer scale than the 4km data previously used in Ecological Zone models for the Southern Blue Ridge Mountains and other areas in the Appalachians and Cumberland Plateau.

Data was downloaded from: PRISM Climate Group, Oregon State University. Files were converted from shapefile to grid after clipping to the study area boundary; 25 ESRI focalmean calculations were done to smooth the coarse boundary relative to other DTMs. Average precipitation with the study area ranges from 44" to 91".

12) Relief (rel)
Relief is a measure of the difference in elevation between the watershed divide and the valley floor relative to a cell's location (see procedure below for valley position). Calculated using 20x20' cell resolution, then resampled to 10x10' cell resolution.

13) River elevation difference (rdiff)
Rdiff is a measure of the difference in elevation of an individual cell and the closest modeled "river"; 32 bit floating point. Rivdiff calculations follow the same procedure as strmdist (see below) using only streams 4th order and larger.

14) River distance (rdist)
Rivdist is the distance to the nearest modeled 4th order and larger streams; 32 bit floating point.

15, 16) Relative slope position (rsp1, rsp2)
Relative slope position is an estimate of the slope position at each cell location relative to the nearest ridge and drainage (Wilds 1996); values range from 0 to 100; 8 bit signed integer. A value of 100 represents the bottom of the slope (the drainage) and 0 the top of the ridge. RSP1 uses a 23 acre moving neighborhood to determine mean elevation; RSP2 uses a 52 acre moving neighborhood to determine mean elevation. RSP2 also uses a larger cut level to define ridges. In combination, this results in a finer resolution of slope position using RSP1 parameters.

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 slope bottom or a ridge. Steps to produce RSP performed with the raster calculator include:

a) convert the modeled streams (cleaned and smoothed) line coverage to raster
b) stream_flip = con(isnull(streamraster), 1)
c) setmask stream_flip
d) flow_dir2 = flowdirection
e) setmask off
f) flow_down = flowlength (flow_dir2, #, downstream)
g) mean = focalmean (filled DEM resampled to 20', rectangle, 50, 50) (about a 23 acre neighborhood) (75x75 for rsp2 = about a 52 acre neighborhood)
h) differ = mean – 'altered' DEM
i) ridges = con (differ < -10, 1, 0) (for rsp2 = differ < 75, 1, 0)
j) thin_ridges = thin(ridges, #, #, #, 15)
k) top = setnull (thin_ridges > 0, 1)
l) setmask top
m) flow_dir3 = flowdirection (see above)
n) setmask off
o) flow_up = flowlength (flow_dir3, #, upstream)
p) rsp_float = flowup / (flow_up + flowdown)
q) rspa = int (rsp_float * 100)
r) rspb = con(thin_ridges == 1, 0, rspa)
s) rspc = con(isnull(stream_flip), 100, rspb)
t) rsp = focalmean (rspc, rectangle, 3, 3)

17) slope (slp)
Slope is the rate of maximum change in z value (elevation_feet) for each cell derived from the DEM and expressed in percent: ESRI percentrise; 16 bit signed integer.

18, 19) Slope length (slplen1, slplen2)
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 using the same procedure for developing Relative Slope Position. Slope length is merely the sum of 'flowup' and 'flowdown'. Slope length was calculated to determine relative slope position; slplen1 was derived from RSP1 calculations while slplen2 was derived from RSP2 calculations. Slplen1 is a finer-resolution estimate of slope length.

20) solar radiation (solar)
Solar radiation is the yearly solar radiation per cell derived from the DEM (ESRI); 32 bit unsigned integer. Processing was performed on a 10x10 foot grid cell for 5 subdivisions of the project area with the subdivisions merged back for the final coverage.

21) stream elevation difference (sdiff)
Sdiff is a measure of the difference in elevation of an individual cell and the closest stream; 32 bit floating point. Sdiff uses an ESRI filled version of the raw dem. Streams were modeled from the elevation DEM using ESRI hydrology tools. The following process was used to develop strmdiff:

- Fill raw DEM
- Flowdirection
- Flowaccumulation (integer)
- define stream threshold at 13 acres (5,700 – 10'x10'cells resolution).
- Streamorder (in grid); for use in developing rivdist and rivdiff
- create a coverage of elevation at stream cells: streamelev = con(streamgrid > 0, elevation grid)
- use a series of focalmin commands to fill in the non-stream landscape with the closest stream elevation to allow easy subtraction with grid algebra. This included 100's of 3x3 rectangular neighborhood iterations.
- calculate difference in elevation between each cell and the closest stream:
  strmdiff = elevation grid – stream elevation fill grid

  This creates some cells that are negative (BELOW the stream with which they are associated). These areas were replaced with 'nodata' and then filled with focal averages from the adjacent cells.

22) stream distance (sdist)
Strmdist is a measure of each cell's distance to the nearest stream, regardless of stream order. 32 bit floating point. Calculate ESRI Euclidean distance to streams

23) terrain shape index (tsi)
Terrain shape index is an estimate of local land surface shape slightly broader than ESRI curvature and is calculated by subtracting cell elevation from elevation of the 10-cell neighborhood; elevation – focalmean (elevation , rectangle, 10, 10). Modified 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.

24) valley position (vpos)
Valley position is an approximation of the position of a cell's elevation relative to the watershed divide and the valley floor. The watershed divide is defined as the maximum elevation within a ¾ mile by ¾ mile window and therefore an estimate of where major ridges occur. The valley floor is defined as the minimum elevation within the same size area. Both ridges and valley floor were derived from a 20' DEM resampled from the original 10' DEM. GRID commands:

- max_elevation = focalmax (20' DEM, rectangle, 200, 200)
  3/4 mile = 3960', 3960' x 3960' = 15,681,600 sq.ft., 1-20'x20' cell = 400 sq.ft; so 39,204 cells, i.e., a 198x198 cell window: ≈ 200
- min_elevation = focalmin (20' DEM, rectangle, 200, 200)
- relief = max_elevation + min_elevation
- downslope = DEM elevation – min_elevation
- vpos1 = 1 – (downslope / relief)
- vpos2 = int (vpos1 * 100)
- set values < 0 or > 1 to null and fill null with focalmean
- resample to 10'x10' cell size

Appendix IV: Maxent Analysis Process

Maximum Entropy (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, Ycoordinate, DTM values**.

- Use ESRI Tools, Spatial Analyst Tools, Extract Values to Points; then use ET Geo Wizard to change field names; Basic, Redefine Fields; this is done for each variable, changing coverage names at each step; a real pain in the ass.
  (on smaller data sets: Use Hawth tools to attach X, Y to original plot coverage)
- In Excel, open dBase Files, save as CSV (comma delimited) file.
  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)
  Save output as .asc
  Export all the resulting .asc files with floating point to create a Grid for each Ecological Zone using ESRI Tools (export as a raster grid). **For very large .asc files that will not export with this method, save Maxent output as a .bil image, open an ArcMap session, add the .bil file, then export as raster grid.**

Maximum probability Grid
Uses all Ecological Zone models produced in MAXENT to determine the maximum value on a cell-by-cell basis within the Analysis window, for example in the Southern Blue Ridge Escarpment:

```
c:\sc\mountains\models3\max5 = max ~
(c:\sc\mountains\models3\acovetemp15, c:\sc\mountains\models3\alluvial2, c:\sc\mountains\models3\dmoaktest20,~
c:\sc\mountains\models3\drydecidtemp7, c:\sc\mountains\models3\dryevertemp18, c:\sc\mountains\models3\floodtemp3, ~
c:\sc\mountains\models3\herotemp2, c:\sc\mountains\models3\mtcovetemp13, c:\sc\mountains\models3\mtrichtemp1, ~
c:\sc\mountains\models3\montslptemp10, c:\sc\mountains\models3\orhodotemp11, c:\sc\mountains\models3\pohtemp13, ~
c:\sc\mountains\models3\rcovetest5, c:\sc\mountains\models3\rslopetemp2, c:\sc\mountains\models3\sloaktest13)
```

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, for example in the Southern Blue Ridge Escarpment:

```
c:\sc\mountains\models3\zone5 = con(c:\sc\mountains\models3\max5 == c:\sc\mountains\models3\acovetemp15, 4, ~
c:\sc\mountains\models3\max5 == c:\sc\mountains\models3\alluvial2, 6, ~
c:\sc\mountains\models3\max5 == c:\sc\mountains\models3\dmoaktest20, 13, ~
c:\sc\mountains\models3\max5 == c:\sc\mountains\models3\drydecidtemp7, 11, ~
c:\sc\mountains\models3\max5 == c:\sc\mountains\models3\dryevertemp18, 10, ~
c:\sc\mountains\models3\max5 == c:\sc\mountains\models3\floodtemp3, 23, ~
c:\sc\mountains\models3\max5 == c:\sc\mountains\models3\herotemp2, 8, ~
c:\sc\mountains\models3\max5 == c:\sc\mountains\models3\mtcovetemp13, 28, ~
c:\sc\mountains\models3\max5 == c:\sc\mountains\models3\mtrichtemp1, 24, ~
c:\sc\mountains\models3\max5 == c:\sc\mountains\models3\montslptemp10, 9, ~
c:\sc\mountains\models3\max5 == c:\sc\mountains\models3\orhodotemp11, 29, ~
c:\sc\mountains\models3\max5 == c:\sc\mountains\models3\pohtemp13, 18, ~
c:\sc\mountains\models3\max5 == c:\sc\mountains\models3\rcovetest5, 5, ~
c:\sc\mountains\models3\max5 == c:\sc\mountains\models3\rslopetemp2, 55, ~
c:\sc\mountains\models3\max5 == c:\sc\mountains\models3\sloaktest13, 16, 0)
```

Appendix V: 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 (Table 1) below is a square array in which accuracy assessment sites are tallied by both their classified category and their actual category according to the reference data. 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 environmental 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 4th Approximation Ecological Zones in the Blue Ridge Escarpment study area from 2,236 reference plots

Ecological Zone[1/]	Map Code	23	6	4	29	55	5	28	8	24	9	13	11	10	18	16	total plots	% correct producers accuracy
Floodplain Forest	23	29	1	1				1									32	**91%**
Alluvial Forest	6		17														17	**100%**
Acidic Cove Forest	4			242	2	3	13	23			1	19	1	1	1		306	**79%**
Mixed Oak / Rhododendron Forest	29			3	116	3	2	3				4	2	14	1	2	150	**77%**
Rich Slope Forest	55			1	2	23		3				1					30	**77%**
Rich Cove Forest	5			7	1	1	75	6			1	9	1	2			103	**73%**
Montane Oak Cove Forest	28		2	13	3		4	140				19					181	**77%**
High Elevation Red Oak Forest and Woodland	8								29	1							30	**97%**
Montane Oak-Hickory Rich Forest	24									10		1					11	**91%**
Montane Oak-Hickory Slope Forest	9				1	1	2			1	85	6	3	6	2	1	108	**79%**
Dry-Mesic Oak Hickory Forest	13			16	1	1	10	18	1		2	396	8	22	8	13	496	**80%**
Dry Oak Deciduous Heath Forest and Woodland	11			1								7	38	4	1	4	55	**69%**
Dry Oak Evergreen Heath Forest and Woodland	10			2	5	1	2	1		1	2	30	6	163	6	5	224	**73%**
Pine-Oak Heath Woodland	18				1	1			1		4	5	6	14	139	9	180	**77%**
Shortleaf Pine-Oak Forest and Woodland	16				2			1				14	7	4	12	273	313	**87%**
User's Accuracy[2/]	% correct	100	85	85	87	68	69	71	94	83	89	77	53	71	82	89	2236	**79%**
	total column	29	20	286	134	34	108	196	31	12	96	511	72	230	170	307		
	total correct	29	17	242	116	23	75	140	29	10	85	396	38	163	139	273		

[1/] Most fire-adapted (Zones 23,6,4,29,55,5) = 96% correct, Least fire-adapted (Zones 28,8,24,9,13,11,10,18,16) = 85% correct
[2/] Total correct divided by total column: average User's Accuracy = **80.2%**

Ecological Zones can be cross-walked to Ecological Systems that 'represent recurring groups of biological communities found in similar physical environments and are influenced by similar dynamic ecological processes, such as fire or flooding. They are intended to provide a classification unit that is readily mappable, often from remote imagery, and readily identifiable by conservation and resource managers in the field': http://www.natureserve.org. This concept of Ecological systems recognizes that ecosystems 'do grade more-or-less continually across the landscape', 'rely on a combination of diagnostic classifiers of both abiotic and biotic factors to create reasonable classes of units', and 'incorporate plant community types already defined in the National Vegetation Classification (http://usnvc.org/) to help place boundaries on the system units' (Comer and others). This "bio-ecosystem" approach is based on "habitats" that are small to meso-scale ecosystem units, defined as "a limited geographic area with a particular environment and set of flora and fauna" (Devillers et al. 1991) and are similar to the "biogeocene complex" unit (Walter 1985). This NatureServe approach defines the boundaries of a system in part based on the combination of component plant communities and abiotic factors (Comer et al. 2003).

Table 2: Evaluation of 4th Approximation Ecological Zones in the Blue Ridge Escarpment study from 2,236 field reference plots

Ecological Zone[1/]	Map Code	23	6	44	99	8	13	100	18	16	total plots	% correct producers accuracy
Floodplain Forest	23	29	1		1						32	**91%**
Alluvial Forest	6		17								17	**100%**
Cove Forest	44			494	38		33	21	2	2	590	**84%**
Montane Oak Forest	99		2	24	235	1	26	9	2	1	300	**78%**
High Elevation Red Oak Forest and Woodland	8				1	29					30	**97%**
Dry-Mesic Oak Hickory Forest	13			28	21		396	30	8	13	496	**80%**
Dry Oak Forest and Woodland	100			11	3		37	211	7	9	278	**76%**
Pine-Oak Heath Woodland	18			2	5		5	20	139	9	180	**77%**
Shortleaf Pine-Oak Forest and Woodland	16			2	1		14	11	12	273	313	**87%**
User's Accuracy [2/]	% correct	100	85	88	77	97	77	70	82	89	2236	**82%**
	total column	29	20	561	305	30	511	302	170	307		
	total correct	29	17	494	235	29	396	211	139	273		

[1/] Most fire-adapted (Zones 23,6,4,29,55,5) = 96% correct, Least fire-adapted (Zones 28,8,24,9,13,11,10,18,16) = 85% correct

[2/] Total correct divided by total column: average User's Accuracy = **85%**

Appendix VI: Codes for Ecological Zones in Southern Blue Ridge Escarpment

Code	Ecological Zone
4	Acidic Cove Forest
5	Rich Cove Forest
55	Rich Slope Forest
6	Alluvial Forest
8	High Elevation Red Oak Forest and Woodland
9	Montane Oak-Hickory Forest
10	Dry Oak Evergreen Heath Forest and Woodland
11	Dry Oak Deciduous Heath Forest and Woodland
13	Dry-Mesic Oak Hickory Forest
16	Shortleaf Pine-Oak Forest and Woodland
18	Pine-Oak Heath Woodland
23	Floodplain Forest
28	Montane Oak-Hickory Cove Forest
29	Mixed Oak / Rhododendron Forest
999	Lakes and Reservoirs