appendixes to: **Ecological Zones on the Jefferson National Forest Study Area: First Approximation**

Ecological Zones on the Jefferson National Forest Study Area: First Approximation

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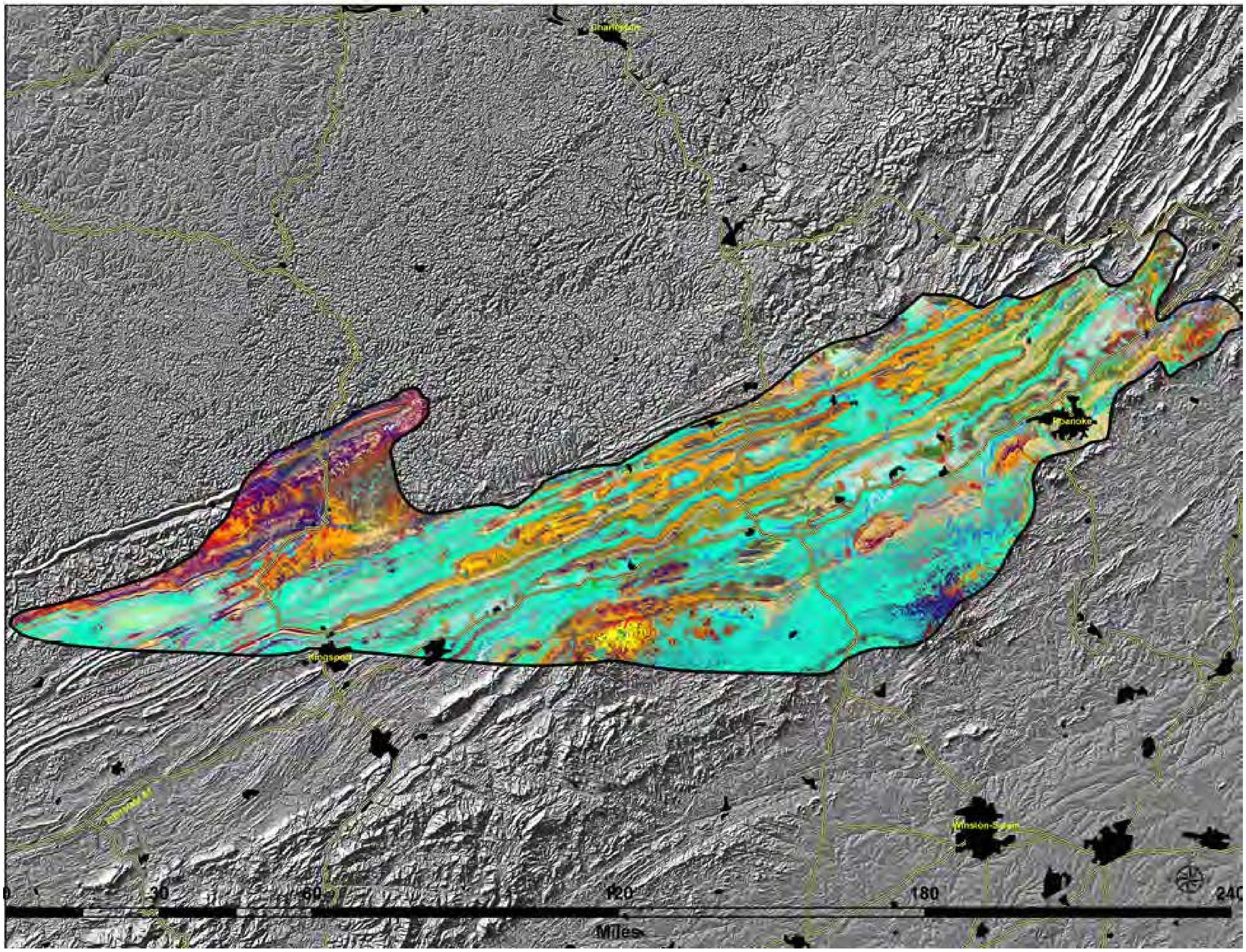


A 1st approximation of Ecological Zones centered on the Jefferson National Forest, Great Valley of Virginia, the Northern Ridge and Valley, and Central Blue Ridge Mountains was developed from 4,900 field reference sites, 34 computer-generated environmental variables, and analysis and adjustment of ecotone boundaries using local environmental relationships between types. Oak-dominated Ecological Zones, about equally distributed on carbonate- and non-carbonate-bearing rock, (mapped bluish green, orange, and dark gray respectively) accounted for about 68% of the nearly 6 million acre landscape, Cove Ecological Zones 19% (red & dark blue), and Pine-Oak Ecological Zones 5% (green). The remaining 8% of the landscape included Alluvial Forest, Floodplain, Barrens, Glades, Northern Hardwood, and Spruce-Fir.

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

Ecological Zones were cross-walked with LANDFIRE Biophysical Settings (BpS) / Nature Serve Ecological Systems by comparing field observations with descriptions of indicator species and species with high constancy or abundance identified in the "Ecological Zones in the Southern Appalachians: First Approximation" (Simon et. al. 2005), from descriptions of dominant species and site relationships in Nature Serve Ecological Systems (2010), from LANDFIRE BpS model descriptions (LANDFIRE, 2009), Schafale and Weakley (1990) and Fleming and Patterson (2010). **The following description were extracted from these sources and especially from the later two sources.**

Additional Ecological Zone site or vegetation indicators not included in the 1st approximation model but identified from local knowledge within the Appalachian study areas are indicated by *italics*. Shortleaf Pine-Oak Heath is **not** included in these descriptions; it is considered the lowest elevational extent of Pine-Oak Heath that occupies narrow ridges within the Shortleaf Pine-Oak Ecological zone and therefore shares compositional and structural characteristics between these two types.

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

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

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

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

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

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

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

Acidic Cove Ecological Zone
This zone includes hemlock and mixed hardwood-conifer forests typically dominated by an evergreen understory occurring in narrow coves and ravines and often extending up on adjacent protected, north-facing slopes where it merges with the Mixed Oak / Rhododendron Ecological Zone. 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 first included in the SBR 2nd approximation and labeled "Mixed Oak / Heath", but was not included in the GW project area because of its poor representation there. The Zone is confined to steep, mostly north-facing mid to upper slopes adjacent to the Acidic Cove Ecological Zone and therefore can be considered a refinement of this type, however, the overstory is dominated by oaks. Indicator species and species with high abundance include great rhododendron, northern red oak, chestnut oak, black birch, and tulip poplar.

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

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

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

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. It occurs primarily on private land (92% of modeled map units) and was observed predominantly on carbonate-bearing, and mixed geology over carbonate-bearing rocks outside of the Blue Ridge Mountains. Further work is needed to evaluate vegetation differences between this slope element and the cove element of 'Rich Coves'.

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

Alluvial Forest Ecological Zone
This zone 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).

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 in an unaltered condition.

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

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

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

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

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

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

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

- BpS / Nature Serve – 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).

Dry-Mesic Oak Ecological Zone

This zone was included in the Dry and Dry-Mesic Oak-Hickory type in the 1st approximation NC but separated into its components -- Dry Oak and Dry-Mesic Oak in the 2nd approximation both in the KY FLN 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-Mesic Calcareous Forest Ecological Zone

This group of montane, mixed hardwood forests occupies submesic slopes and crests with warm (southeast to southwest) aspects and fertile soils weathered from underlying limestone, dolomite, calcareous sandstone, and calcareous siltstone. Habitats in western Virginia include valley sideslopes, lower mountain slopes, gentle crests, and ravines up to about 1,150 m (3,800 ft.) elevation. Forests of this group are widely distributed in the Ridge and Valley province, more local in the Cumberland Mountains, and rare in the northern Piedmont Triassic Basin. Mixtures of sugar maple, black maple, white oak , northern red oak, black oak, and hickories (*Carya* spp.) are typical. Another variant features co-dominance by white oak, chinkapin oak, white ash, and hickories. Tulip-poplar is most abundant as an invader of logged stands. Understory and herbaceous vegetation varies from sparse to lush (especially on limestone sites), but is generally dominated by species characteristic of submesic soil moisture conditions, such as white snakeroot, hog-peanut, common eastern bromegrass, and black bugbane.

Dry-Mesic Calcareous Forests are readily distinguished from Rich Cove and Slopes Forests or Basic Mesic Forests by the absence of prominent mesophytic forbs such as blue cohosh, broad-leaved waterleaf, or wood nettle. Compared to Montane Dry Calcareous Forests and Woodlands, they occupy more mesic habitats and lack a strong component of xerophytic plants. Many stands of this group have been heavily cut over or destroyed for agriculture. In some cases, it appears that stands of this community result from the invasion of oak-hickory forests by more mesophytic species (especially sugar maple), perhaps as a result of long-term fire exclusion.

Includes:

Rich Low-Elevation Appalachian Oak-Hickory Forest (CEGL007233); dry-mesic to mesic, low-montane oak-hickory forests of the Ridge and Valley, Cumberland Mountains, and adjacent Southern Blue Ridge.
Central Appalachian Rich Red Oak - Sugar Maple Forest (CEGL008517); submesic slopes known from the Ridge and Valley region of west-central and northwestern Virginia and adjacent Maryland, with a few outliers in the Piedmont of both states.
Ridge and Valley Limestone Oak-Hickory Forest (CEGL004793); rich forests of moderately steep slopes in the Ridge and Valley and adjacent provinces over various limestone and dolomitic formations.

- BpS / NatureServe – Northeastern Interior Dry-Mesic Oak Forest: These oak-dominated forests are one of the matrix forest systems in the northeastern and north-central U.S. Occurring in dry-mesic settings, they are typically closed-canopy forests, though there may be areas of patchy-canopy woodlands. They cover large expanses at low to mid elevations, where the topography is flat to gently rolling, occasionally steep. Soils are mostly acidic and relatively infertile but not strongly xeric. Local areas of calcareous bedrock, or colluvial pockets, may support forests typical of richer soils. Oak species characteristic of dry-mesic conditions (e.g., northern red oak, white oak, black oak, and scarlet oak) and hickory spp. are dominant in mature stands. Chestnut oak may be present but is generally less important than the other oak species. American chestnut was a prominent tree before chestnut blight eradicated it as a canopy constituent. Red map, black birch, and yellow birch may be common associates; sugar maple is occasional. With a long history of human habitation, many of the forests are early- to mid-successional, where white pine, Virginia pine, or tulip poplar may be dominant or codominant. Within these forests, hillslope pockets with impeded drainage may support small isolated wetlands, including non-forested seeps or forested wetlands with red maple, swamp white oak, or black gum characteristic.

Basic Oak-Hickory Ecological Zone
This zone is currently known from a narrow range in the Northern Blue Ridge and adjacent inner Piedmont of Virginia, Maryland, and West Virginia. It is restricted to the western Piedmont foothills and lower- to middle-elevation slopes and spurs of the main Blue Ridge. Elevation ranges from 140 to 950 m (450-3100 feet). The type is generally associated with base-rich soils weathered from mafic igneous and metamorphic rocks, including metabasalt, amphibolite, pyroxene-bearing granulite, charnockite, and actinolite schist. It also occurs less frequently on granitic rocks and calcareous metasiltones and phyllites. Habitats are more-or-less rocky, gentle to steep, submesic to subxeric slopes with a wide range of aspects. Midslope topographic positions are typical, but stands occasionally occur on lower or upper slopes and crests. This association is a true oak-hickory forest with mixed canopy dominance by several oak spp. and hickory spp. Red hickory, red Oak and chestnut oak are consistent codominants and have the highest importance values based on standard forestry statistics generated from stem-diameter measurements. White oak, black oak, mockernut hickory, red hickory, white ash, and tulip poplar are less constant canopy species but achieve codominance in some stands. Hickories, oaks, maples, blackgum, ash, and sassafrass are well-represented in lower tree strata. Redbud (at lower elevations) and, to a lesser extent, dogwood dominate the shrub and lowest tree layers, while maple-leaf viburnum is a common low shrub. A large number of herbaceous species occur in the type. (taken directly from NatureServe's Community description for CEGL008514; Central Appalachian Basic Oak-Hickory Forest (Western Piedmont / Lower Blue Ridge Type)).

- BpS / NatureServe – Northeastern Interior Dry-Mesic Oak Forest: see description above

Montane Dry Calcareous Forest and Woodlands Ecological Zone
These deciduous or occasionally mixed forests and woodlands occur on subxeric to xeric, fertile habitats over carbonate formations of limestone and dolomite, or very rarely highly calcareous siltstone or shale. Habitats are steep, usually rocky, south- to west-facing slopes at elevations from < 300 to 900 m (< 1,000 to 2,900 ft). Soils vary from circumneutral to moderately alkaline and have high calcium levels. Confined in Virginia to the mountains, these communities are most frequent and extensive in the Ridge and Valley, but occur locally in both the Blue Ridge and Cumberland Mountains. Tree canopies vary from nearly closed to sparse and woodland-like. Overstory mixtures of chinkapin oak, sugar maple, black maple, northern red oak, white oak, Shumard oak, and white ash. These forests and woodlands share many understory and herbaceous plants with the Piedmont / Mountain Basic Woodlands group and are similarly species-rich. A few of the taxa that are confined to or most important in the limestone and dolomite communities include Carolina buckthorn, round-leaved ragwort, robin's-plantain, American beakgrain, slender muhly, black-fruited mountain ricegrass, purple sedge, in extreme southwestern Virginia only), stiff-haired sunflower, small-headed sunflower, northern leatherflower, common eastern shooting-star, hoary puccoon, and mountain death-camas. Considerable compositional variation is evident in these communities across western Virginia. A rare and distinctive community type in this group, confined to the largely dolomitic Elbrook formation in the southwestern Ridge and Valley, features an abundance of the magnesiophiles prairie ragwort, glade wild quinine, and tall larkspur, as well as populations of the federally listed smooth coneflower and the globally rare, Virginia endemic Addison's leatherflower.

Includes:

Appalachian Sugar Maple - Chinkapin Oak Limestone Forest (CEGL006017); calciphilic maple-oak forest is found in the Central Appalachians and adjacent regions of the eastern United States, ranging south and west to the Interior Low Plateau of Tennessee and the Cumberlands of Alabama.

Ridge and Valley Dolomite Glade (CEGL006030); dolomite woodland of the Ridge and Valley of Virginia. It is physiognomically variable, often containing patch-mosaics of semi-closed, forb-rich woodlands, shrub thickets, and small grassy openings.

Interior Low Plateau Chinkapin Oak - Mixed Oak Forest (CEGL007699); chinquapin oak - mixed oak forest association is found in the inner Nashville Basin of central Tennessee and related areas of the Interior Low Plateau of Kentucky, Illinois and Indiana, and in Virginia and marginally into the southern limestone/dolomite valleys of northwestern Georgia.

Limestone Chinkapin Oak Woodland (CEGL006231); open calcareous glade occurring in the Central Appalachians in the Ridge and Valley of northeastern West Virginia, western Virginia, and in central southeastern Pennsylvania.

Dry Calcareous Forest/Woodland (White Ash - Shagbark Hickory Type), (CEGL008458); This community type is currently known only from a narrow, midslope band of Greenbrier limestone on Little Stone Mountain in Wise County, Virginia, and a narrow band of limestone along the Virginia side of Cumberland Gap National Historical Park.

- BpS / Nature Serve – Central Appalachian Alkaline Glade and Woodland: This system occurs at low to moderate elevations from the Central Appalachians (with a few northward incursions into southernmost New York and New England possible) down into the Ridge and Valley. It consists of woodlands and open glades on thin soils over limestone, dolostone or similar calcareous rock. In some cases, the woodlands grade into closed-canopy forests. Eastern red cedar is a common tree, often increasing in the absence of fire, and chinkapin oak is indicative of the limestone substrate. Fragrant sumac, redbud, and hophornbeam may occur. Prairie grasses are the dominant herbs (big bluestem, little bluestem, blue grama grass spp.); forb richness is often high. Characteristic forbs include whorled milkweed, bee balm, lyreleaf sage, aromatic aster, and false boneset. Fire is sometimes an important natural disturbance factor, but open physiognomies may also be maintained by drought.
- BpS /NatureServe – Southern Ridge and Valley / Cumberland Dry Calcareous Forest: This system includes dry to dry-mesic calcareous forests of the Southern Ridge and Valley region of Alabama and Georgia, extending north into Tennessee, Kentucky, Virginia and adjacent West Virginia. It includes calcareous forests on lower escarpments of the Cumberland Plateau and other related areas. Examples occur on a variety of different landscape positions and occur on generally deeper soils than glade systems of the same regions. This system is distinguished from those farther north in the Ridge and Valley by its relatively southern location in the region, in an area which is transitional to the "Oak-Pine-Hickory" region. High-quality and historic examples are typically dominated by combinations of oak species and hickory species, sometimes with pine species and/or Eastern red cedar as a significant component in certain landscape positions and with particular successional histories. These forests occur in a variety of habitats and are the matrix vegetation type that covers portions of the landscape under natural conditions. Examples can occur on a variety of

topographic and landscape positions including valley floors, sideslopes, and lower to midslopes. Fire frequency and intensity are factors determining the relative mixture of deciduous hardwood versus evergreen trees in this system. Much of this system is currently composed of successional forests that have arisen after repeated cutting, clearing, and cultivation of the original forests. The range of this system is primarily composed of circumneutral substrates, which exert an expected influence on the composition of the vegetation.

Limestone and Dolomite Barrens Ecological System
Exposed, carbonate rock outcrops and associated xeric rocky slopes provide the requisite habitats for the herbaceous communities of this group. These calcareous barrens are scattered throughout the western Virginia Ridge and Valley region, usually occurring on steep, south- to west-facing slopes. In The Cedars region of Lee County, "flatrock" limestone barrens are present on gently rolling topography. The degree of exposed bedrock cover is variable, and many occurrences have considerable development of thin soils and gravel. Soils typically have high pH (> 7.0) and calcium levels; in addition, dolomitic soils have relatively high magnesium levels.

Warm-season prairie grasses, including big bluestem, little bluestem, Indian grass, side-oats grama, and rough dropseed characterize the largely herbaceous vegetation. Ebony sedge is also an abundant, sod-forming graminoid at some sites. Associated perennial forbs include western silky aster, = *Aster pratensis*), false boneset, eastern indian-paintbrush), Canada bluets, tall gay-feather, false aloe, southern obedient-plant, white blue-eyed-grass, hairy wild-petunia, and stiff goldenrod, Pitcher's stitchwort, wiry panic grass, sheathed dropseed, and other calciphilic annuals are characteristic of exposed, gravelly areas and rock crevices. Stunted trees and shrubs such as chinkapin oak, eastern red cedar, and Carolina buckthorn are scattered in the barrens. Communities in this group are highly localized, small-patch units that are considered state-rare and, in some cases, globally rare. Threats include quarrying, grazing, and invasive introduced weeds.

- BPS/NatureServe -- Southern Ridge and Valley Calcareous Glade and Woodland: This ecological system consists of open glades and surrounding woodlands on shallow, high pH soils of the Ridge and Valley region from southwestern Virginia southward. These glades occur in broad valley bottoms, rolling basins, and adjacent slopes where soils are shallow over flat-lying limestone strata. The flat to rolling terrain and locally xeric soils may have been especially susceptible to periodic fires that helped maintain the prairielike openings and savannalike woodlands. Today, much of the system is currently somewhat more closed and brushy, suggesting fire suppression. Chinkapin oak and post oak are typical where the canopy is present. Dominant or abundant Eastern red cedar is probably a result of the lack of fire.

Dry Oak Heath Ecological Zones (evergreen and deciduous heath types)
These zones, includes xeric to dry mixed-oak forests typically dominated by an ericaceous (evergreen or deciduous) understory and represents the driest zones where oaks are the dominant species. In general, 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, but varies considerably according to slope position (and the predominantly east or west-facing side of major ridges). Further work is needed to differentiate these two zones to discern if this is an environmental influence or 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.

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, post oak, blackjack oak, chestnut oak, scarlet oak, but also pignut hickory, red maple, and others. The shrub layer may be well-developed, with hillside blueberry, black huckleberry, or other acid-tolerant species most characteristic. Herbs are usually sparse but may include narrowleaf silkgrass and goat's rue.

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

Pine-Oak Shale Woodlands Ecological Zone
This Ecological Zone was modeled in the VA-WVA FLN to characterize the very distinctive, pine-dominated, xeric sites found predominately on acidic shales at lower elevations on south to west facing slopes; it was also found within the Jefferson NF study area. Virginia pine is most often the dominant tree and is stunted in size and widely spaced. Other characteristic trees include: chestnut oak, pitch pine, bear oak, blackjack oak, eastern red cedar (occasionally), and post oak. The understory is normally very sparsely vegetated; lichens often provide the dominant ground cover. Other characteristic species in the understory include Pennsylvania sedge, poverty oat grass, and little bluestem.

- VA Heritage – Central Appalachian Xeric Shale Woodland (Mountain / Piedmont Acidic Woodlands in the VA-WVA FLN 2009 report) (in part, but, more acidic): Most commonly exhibiting a patchy woodland cover, often with herbaceous openings, these barrens occasionally range from a closed canopy to open shrublands; most sites have less than 50% canopy cover of stunted trees. Shrubs are often sparse and usually less than 30% cover. Herbaceous cover varies widely but is typically less than 50%. Virginia pine and chestnut oak, in varying mixtures, are the dominant trees. Associates vary from site to site; the more frequent are pignut hickory, red oak, white ash, Eastern red cedar, white oak, white pine, black oak, and shagbark hickory. Downy serviceberry is a common small tree. Shrubs include bear oak, deerberry, hillside blueberry, Carolina rose, and fragrant sumac. The ground layer is dominated by the graminoids Pennsylvania sedge, poverty oatgrass, and occasionally little bluestem.
- BpS/Nature Serve – Central Appalachian Pine-Oak Rocky Woodland (in part): This system encompasses open or patchily wooded hilltops and outcrops or rocky slopes. It occurs mostly at lower elevations, but occasionally up to 1220 m (4000 feet) in West Virginia. The vegetation is patchy, with woodland as well as open portions. Pitch pine (and within its range Virginia pine) is diagnostic and often mixed with xerophytic oaks and sprouts of American chestnut. Conditions are dry and for the most part nutrient-poor, and at many, if not most, sites, a history of fire is evident.
- Nature Serve – Appalachian Shale Barrens (in part): This system encompasses the distinctive shale barrens of the central and southern Appalachians at low to mid elevations. The exposure and lack of soil create extreme conditions for plant growth. Vegetation is mostly classified as woodland, overall, but may include large open areas of sparse vegetation. Dominant trees are primarily chestnut oak and Virginia pine. The substrate includes areas of solid rock as well as unstable areas of shale scree, usually steeply sloped. The fully exposed areas are extremely dry.

Shale Barren Ecological Zone
This Ecological Zone was first modeled in the VA-WVA FLN to characterize the very distinctive barrens found on acidic shales primarily at lower elevations and lower slopes above larger streams and rivers. Characteristic species include Virginia pine, eastern red cedar, chestnut oak, shagbark hickory, little bluestem, and Pennsylvania sedge.

- VA Heritage – Central Appalachian Shale Barrens: This is variable group of sparse woodland, shrublands, and open herbaceous rock outcrops occurring on Ridge and Valley shales and Blue Ridge metashales of the central Appalachian Mountains. Habitats generally occur on steep slopes with south to west aspects. The steep xeric slopes and friable nature of the shale create poorly vegetated hillsides of bare bedrock and loose channery visible from afar. Continual undercutting of thick but relatively weak shale strata by streams maintain most shale barrens. Less common, densely graminoid dominated variants occurring on steep spur ridge crests and mountain summits are sometimes referred to as "shale ridge balds". Although stunted trees of several species – e.g., chestnut oak and pignut hickory are common, shale barrens are strongly characterized by their open physiognomy and by a suite of uncommon and rare plants found almost exclusively in these habitats.

- Bps / Nature Serve – Appalachian Shale Barrens: This system encompasses the distinctive shale barrens of the central and southern Appalachians at low to mid elevations. The exposure and lack of soil create extreme conditions for plant growth. Vegetation is mostly classified as woodland, overall, but may include large open areas of sparse vegetation. Dominant trees are primarily chestnut oak and Virginia pine; although on higher-pH substrates the common trees include eastern red cedar and white ash. Shale barren endemics are diagnostic in the herb layer. The substrate includes areas of solid rock as well as unstable areas of shale scree, usually steeply sloped. The fully exposed areas are extremely dry.

Xeric Pine-Oak Ecological Zone & Acidic Glade Ecological Zone
Coniferous , mixed (**Xeric Pine-Oak**), or less commonly deciduous woodlands (**Acidic Glade**) of xeric, edaphically stressful habitats constitute this ecological zone. These woodlands are not common but are found in the Piedmont of the southeastern United States, as well as in the southern Appalachians and westward in the Ozark and Ouachita Mountains. Stands are scattered throughout the Virginia mountains and inner Piedmont, occupying somewhat heterogeneous habitats that are characterized by rock outcrops and shallow, drought-prone, highly

oligotrophic soils. Included are outcrops and pavements of sandstone and other acidic rocks in the northern Blue Ridge, Ridge and Valley and Cumberland Mountains; xeric, low-elevation terrain formed on massive alluvial fans along the western foot of the Blue Ridge; and massive bedrock terraces flanking the Potomac River in the fall zone west of Washington, D.C. Most expressions of the group in Virginia could be characterized as pine-oak woodlands. Virginia pine, pitch pine, and shortleaf pine are each co-dominant in one or more classified types. Chestnut oak, post, and blackjack oak are representative oak components. In some cases, this zone is floristically similar to Pine-Oak/ Heath Woodlands, but may be maintained primarily by drought stresses associated with outcrop environments or extremely dry soils rather than by fire. This zone also tends to have a sparser representation of heath shrubs and a more diverse herb layer, with a larger component of graminoids such as little bluestem, Pennsylvania sedge, poverty oat-grass, and starved panic grass. Most of the community types in this group are considered state- or globally rare, but their relationships to vegetation on a regional scale needs further investigation. (Further work is needed to better characterize this type).

- BpS / NatureServeCentral Appalachian Chestnut Oak - Virginia Pine Woodland
  This community is a mixed oak-pine woodland with a canopy of stunted, often gnarled trees, varying from semi-open to very open. It occurs on steep convex slopes, ridge spurs, and clifftops which have high solar exposure. Most are on moderate to steep slopes with much exposed mineral soil. Sites are confined to lower elevations 2500 feet, are distinctly xeric, and usually have southeast to southwest aspects. **Within the project area, they were observed primarily at Sinking Creek Mountain which exceeds this elevation limit.** Underlying bedrock includes quartzite, metasandstone and sandstone, granite, shale, and other acidic rocks. Surface cover of outcrops and loose stones is relatively high. Soils are extremely acidic. The canopy is typically codominated by chestnut oak and Virginia Pine in variable proportions; in some slightly more mesic occurrences, red oak may occur with or in place of chestnut oak. Table mountain pine is an important, even dominant, associate in a minority of stands. Minor but relatively constant tree associates include pignut hickory, downy serviceberry, and sassafras. Minor, inconstant tree associates include scarlet oak, black oak, post oak, blackjack oak, white oak, mockernut hickory, shagbark hickory, Eastern red cedar, white pine, and white ash. The shrub layer varies from moderately dense to sparse, with hillside blueberry and deerberry the most constant and abundant species. Graminoid-rich openings dominated by little bluestem, starved panic grass, Pennsylvania sedge, poverty oat grass, and variable panicgrass are frequent.

APPENDIX II: photos of plant communities in selected Ecological Zones

Grassy Bald (Whitetop Mountain, Jefferson NF, VA – 5,400' elevation)

Spruce-Fir (Balsam Mountain, Jefferson NF, VA -- 4,825' elevation)

Acidic Glade (Sinking Creek Mountain., Jefferson NF, VA -- 3,202' elevation)

Pine-Oak Heath (Little Walker Mountain, Jefferson NF, VA -- 2,674' elevation)

Mixed Oak / Rhododendron (Rocky Knob Recreation Area, Blue Ridge Parkway, VA -- 3,318' elevation)

Mixed Oak / Rhododendron (Breaks Interstate Park above Russell Fork, VA – 1,605' elevation)

Floodplain Forest (Cripple Creek near Pierce Mill, VA -- 1,980' elevation)

Alluvial Forest (Russell Fork near Bartlick, VA – 1,170' elevation)

Dry Oak / Evergreen Heath (Johns Creek Mountain, Jefferson NF, VA – 2,860' elevation)

Dry Oak / Deciduous Heath (Foster Falls Mountain, New River Trail State Park, VA – Elev. 2,092)

Montane Oak Cove (Sand Mountain, The Big Survey WLMA, VA – 2,691' elevation)

Montane Oak Slope (Brushy Mountain, Jefferson NF, VA – 2,900' elevation)

Dry Calcareous Oak-Hickory (Powell Mountain, Jefferson NF, VA – 2,655' elevation)

Dry-Mesic Calcareous Oak-Hickory (Copper Ridge, Pinnacle State Natural Area Preserve, VA – 2,024' elevation)

Northern Hardwood Slope (High Knob, Stone Mountain, Jefferson NF, VA – 4,145' elevation)

Northern Hardwood Cove (Garden Mountain, Jefferson NF, VA – 3,714' elevation)

Acidic Cove (Stony Creek, Jefferson NF, VA – 2,578' elevation)

Rich Cove (Breaks Interstate Park, VA – 1,833' elevation)

High Elevation Red Oak (Peters Mountain, Jefferson NF, VA – 3,359' elevation)

Montane Oak Rich (Walker Mountain, Jefferson National Forest, VA – 3,220' elevation)

Dry-Mesic Oak (valley between Garden Mt. and Brushy Mt., Jefferson NF, VA – 2,917' elevation)

Rich Slope and Rich Cove (Pine Mountain near Jesse Gap, VA – 2,489' elevation)

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

The following DTMs were developed to characterize broad, mid, and small-scale terrain, climate, geology, and solar radiation influences that control temperature, moisture, fertility, and solar inputs on landscapes in the Ridge and Valley, Blue Ridge Mountains, and Cumberland Mountains within the Jefferson National Forest study area. These environmental factors affect the distribution of Ecological Zones and their component plant communities in different landscapes. They were used to develop site specific probability values for each Ecological Zone based upon their correlation to reference field sample locations for each type. All processing of 2nd derivative grids (slope, aspect, etc.) used 10 meter DEM except Valley position, Relief, and Solar Radiation, which were evaluated with 30 meter grid size. All DTMS were processed using the NAD_1983_UTM_Zone_17N projected coordinated system and D_North_American_1983 datum with x,y,z units in meters.

1-2) <u>aspect (raw and transformed)</u> Aspect is a measure of aspect at each cell location derived from the elevation DEM. The following steps were used to produce aspect:

a. GRID function ASPECT (in degrees) from the elevation DEM (not filled for sinks). = **aspraw**
b. Convert degrees to radians (1 degrees = 0.0174532925 radian), in raster calculator: (**aspraw** * 0.017432925). Calculate cosine using ARC TOOLBOX Spatial Analyst Tools, Math, Trigometric, Cos. Value varies from -1 to 1 == **aspcos**

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

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

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

6) <u>elevation (meters & feet)</u> Use the National Map Seamless Server http://seamless.usgs.gov/website/seamless/viewer.htm or the National Map Viewer http://viewer.nationalmap.gov/viewer/ to download 1/3" NED DEMs for the following counties in VA: Lee, Wise, Scott, Dickenson, Buchanan, Russell, Washington, Tazewell, Smyth, Grayson, Wythe, Bland, Giles, Pulaski, Carroll, Patrick, Floyd, Montgomery, Craig, Roanoke, Franklin, Bedford, Botetourt, Alleghany, Rockbridge, Amherst. In KY: Bell, Harlan, Letcher, Pike. WVA: McDowell, Mercer, Summers, Monroe. TN: Claiborne, Hancock, Hawkins, Sullivan, Washington, Johnson, NC: Alleghany, Ashe, Watauga. Counties were determined by all HUCS that have at least a portion of their extent within the study area.

7-16) Geology (distance to rock type)

The following steps were used to create geology DTMs:
1. Download VA, WVA, KY, TN, NC state geology coverages from USGS site.
2. Draw a boundary well outside the project area and clip all state geology coverages by this layer (about 9 million acres).
3. Append all state geology coverages**.**
4. Clip out area where USFS geology mapping exists and append USFS geology mapping.
5. Add item "group" and label map units in the following categories:

    1 = CARBONATE-BEARING ROCKS
    2 = FELSIC IGNEOUS AND METAMORPHIC ROCKS
    3 = SILICICLASTIC ROCKS
    4 = MIXED over CARBONATE-BEARING ROCKS
    5 = CARBONACEOUS-SULFIDIC ROCKS AND VERY ACID SHALE
    6 = MAFIC AND ULTRAMAFIC ROCKS
    7 = TUFF (Lappili Tuff [Zmwtt], Mt Rogers welded tuff [Zmw, Zmwp]); used only in the Blue Ridge Mts. to help differentiate Spruce, Northern Hardwood, and Balds.
    8 = LAVA (Zmwt); used only in the Blue Ridge Mts. to help differentiate Spruce, Northern Hardwood, and Balds
    9 = Conglomerate_Phyllite_Siltstone, Quartzite_Conglomerate, Sandstone_Phyllite_Quartzite, Sandstone_Quartz_Phyllite (primary_secondary_tertiary rock types); used only in the Blue Ridge Mts. to help differentiate Pine-Oak Heath and Dry Oak Heath types.
    10 = Quartzite_Sandstone (primary = quartzite and secondary = sandstone), map symbols Ca, Cer; used only in the Blue Ridge Mts. to help differentiate between Pine-Oak Heath and Dry Oak Heath types.

6. Create separate grids for each of the geology groups.
7. Calculate Euclidean distance to each of the grids to help 'smooth' the differences in scales and mapping resolution.

Geology grouping and map unit details (geology units included in the different groups) are listed in Appendix VIII.

17-18) Landform10 and Landform30 These two metrics estimate landform surface shape within a 10x10 and 30x30 pixel neighborhood respectively. It is used to characterize narrow and broader ridges observed in the study area that may differentiate between High-Elevation Red Oak Forests seen on more narrow ridges from Montane Oak (rich type) seen on slightly broader ridges, and to better characterize the broad landforms at lower elevations that may support Low Elevation Pine. They are calculated by averaging the profile curvature within a moving 10x10 and 30x30 pixel, circular window.

c:\1_jeff\dtms\lfm10 = focalmean (c:\1_jeff\dtms\curvepr, circle, 10)
c:\1_jeff\dtms\lfm30 = focalmean (c:\1_jeff\dtms\curvepr, circle, 30)

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

Processing lfi from topometrix requires the following steps:

a) clip DEM (demstrm2) to reasonable-sized area using 12-digit HUC boundaries, this ranges from 1 to 4 HUCS
b) convert the clipped elevation to .asc file
c) run lfi in topometrix and save as .asc file
d) in ArcMap, convert .asc grid to floating point grid
e) define projection (projections get dropped between steps 2 and 4)
f) set null for all grid values < - 100
g) mosaic these grids together and 'fill' the boundary areas to ensure all "nodata" values are corrected; use the typical method to accomplish this, i.e., fill null values with the average values based upon the adjacent grid cells with values
h) multiply the mosaicked grid by 0.001 because raw topometrix values do not match McNab's definition of LFI values.

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

Data was downloaded from: ftp://Prism.oregonstate.edu/pub/Prism/Maps/precipitation/total/Regional/. Files were converted from shapefile to grid after clipping to the study area boundary. Average precipitation ranges from 35" to 63". Use the 'Range' value, which is the midpoint in the legend.

<u>21) Local Relief</u> Local relief is a measure of the difference in elevation between the watershed divide and the valley floor relative to a cell's location; calculated with a 30 meter DEM.

c:\1_jeff\dtms\maxelev = focalmax(g:\1_jeff\dtms\elev_30m, circle, 60)
c:\1_jeff\dtms\minelev = focalmin(g:\1_jeff\dtms\elev_30m, circle, 60)
c:\1_jeff\dtms\relieftemp = g:\1_jeff\dtms\maxelev – g:\1_jeff\dtms\minelev
If this results in some areas have "negative" or zero relief, then set all values < 1 to "1" (they did not for the Jeff.)
c:\1_jeff\dtms\relieftemp2 = con(g:\1_jeff\dtms\relieftemp < 1, 1, g:\1_jeff\dtms\relieftemp)

Resample to 10 meters, extract to project area boundary (min, max, and relieftemp result in a larger coverage)

22-23) <u>(rsp1, rsp2)</u> RSP (relative slope position) is an estimate of the slope position at each cell location relative to the nearest ridge and drainage (Wilds 1996). A value of 100 represents the bottom of the slope and 0 the top of the slope (the ridge). Relative slope position uses (1) a threshold level of flow accumulation to represent slope bottom, (2) the difference between mean elevation and highest elevation in a moving window to represent ridges, and (3) flow-length to calculate distance to the top or bottom. RSP1 uses 7 acres as minimum catchment area, RSP2 uses 20 acres. Steps to produce RSP performed with the raster calculator:

a) GRID commands: note* create flowdirection and flowaccumulation (floating point) coverages from the elevationgrid first
b) c:\1_jeff\dtms\streams7temp = con(c:\1_jeff\dtms\flowacc < 284, 1)
or
c:\1_jeff\rsp2_calc\streams20temp = con(c:\1_jeff\streamrivercalcs\flowacc2 < 811, 1)

(7 acres x 43,560 sqft/ac = 304,920 sqft; 10x10 meter cell = 1076 sq ft; 304,920/1076 = 283)
(20 acres x 43,560 sqft/ac = 871,200 sqft; 10x10 meter cell = 1076 sq ft; 871,200/1076 = 810)

c) c:\1_jeff\rsp2_calc\streams_flip2 = con(isnull(c:\1_jeff\rsp2_calc\streams20temp), 1, 0)
d) c:\1_jeff\rsp2_calc\streams_thin2 = thin(c:\1_jeff\rsp2_calc\streams_flip2)
e) c:\1_jeff\rsp2_calc\streams2 = setnull(c:\1_jeff\rsp2_calc\streams_thin2 > 0, 1)
f) setmask streams2 (do in spatial analysis, options)
g) c:\1_jeff\rsp2_calc\flow_dir2 = c:\1_jeff\rsp2_calc\flowdir2
h) setmask off (do in spatial analysis, options)
i) c:\1_jeff\rsp2_calc\flow_down = flowlength(c:\1_jeff\rsp2_calc\flow_dir2, #, downstream)
j) c:\1_jeff\rsp2_calc\mean = focalmean (c:\1_jeff\dtms\elev_m, rectangle, 30, 30)
… 10x10 for 2.75 acres, 20x20 for 7.4 acres, and 30 x 30 for 20 acres.
k) c:\1_jeff\rsp2_calc\differ = c:\1_jeff\rsp2_calc\mean - c:\1_jeff\dtms\elev_m
l) c:\1_jeff\rsp2_calc\ridges = con(c:\1_jeff\rsp2_calc\differ < -20, 1, 0)
… < -10 for 2.75 acres, < -20 for 7.4 acres, and < -20 for 20 acres (this produces more extensive ridges than 7.4 ac.,20 & 20ac, 20)
m) c:\1_jeff\rsp2_calc\thin_ridges = thin(c:\1_jeff\rsp2_calc\ridges, #, #, #, 15)
n) c:\1_jeff\rsp2_calc\top = setnull(c:\1_jeff\rsp2_calc\thin_ridges > 0, 1)
o) setmask top
p) c:\1_jeff\rsp2_calc\flow_dir3 = c:\1_jeff\rsp2_calc\flow_dir2
q) setmask off
r) c:\1_jeff\rsp2_calc\flow_up = flowlength(c:\1_jeff\rsp2_calc\flow_dir3, #, upstream)
s) c:\1_jeff\rsp2_calc\rsp_float = c:\1_jeff\rsp2_calc\flow_up / (c:\1_jeff\rsp2_calc\flow_up + c:\1_jeff\rsp2_calc\flow_down) (this puts large number on btm)
t) c:\1_jeff\rsp2_calc\rspa = int(c:\1_jeff\rsp2_calc\rsp_float * 100)
u) c:\1_jeff\rsp2_calc\rspb = con(c:\1_jeff\rsp2_calc\thin_ridges == 1, 0, c:\1_jeff\rsp2_calc\rspa)
v) c:\1_jeff\rsp2_calc\rspc= con(c:\1_jeff\rsp2_calc\streams_thin2 == 1, 100, c:\1_jeff\rsp2_calc\rspb)
w) c:\1_jeff\rsp2_calc\rsp2a = focalmean (c:\1_jeff\rsp2_calc\rspc, rectangle, 3, 3)

24) <u>Slopelength</u> Slope length is an estimate of the cell position along a slope segment, from the ridges (major and tertiary) to the bottom of the slope. Ridges and the slope bottom are estimated using similar procedures as the RSP calculation (Wilds 1996) and equals the sum of 'flowup' and 'flowdown' from rsp1 (uses 7 acres to start stream).

Steps to produce slopelength performed with the raster calculator:

Same as RSP1 steps a) through r), then

a) c:\1_jeff\dtms\slopelength1 = c:\1_jeff\dtms\flow_up + c:\1_jeff\dtms\flow_down
<u>Fill in null values at streams for flow_up and flow_down before adding together</u>
b) c:\1_jeff\dtms\slopelength2 = con(isnull(c:\1_jeff\dtms\slopelength1), focalmean(c:\1_jeff\dtms\slopelength1, rectangle, 3, 3), c:\1_jeff\dtms\slopelength1)

25) Flowup Flowup is an estimate of the influence (moisture, nutrient input) from land upslope from a cell and is calculated from flow accumulation and slope position. Cells with low flowup are ridges, while those with high flowup are lower slopes. The pattern, however, is not as well stream-oriented as Flowdown. See RSP for steps.
26) Flowdown Flowdown is an estimate of the amount of moisture, nutrients that are 'shed', 'leaving' a cell and is calculated from flow accumulation and slope position. Cells with low flowdown are lower slopes and drainages (moisture and nutrients are accumulating in these areas) while high flowdown values are along ridges where drainage is away from these areas. See RSP for steps.

27) slope The rate of maximum change in z value (elevation_ft) from each cell derived from the DEM: GRID function slope with percentrise. Calculated from **elev** (x,y,z = meters).

28) solar The yearly solar radiation per cell derived from the DEM. See "Area Solar Radiation" in ARC TOOLBOX, Spatial Analyst Tools, Radiation. Processing was performed on the 30 meter elevation grid. This elevation grid must be converted to a floating point, environmental settings need to be at default levels, and then resampled to 10 meters.

29-32) Stream and River influence

29) DSTRM (distance to stream A measure of each cell's distance to the nearest stream, regardless of stream order. Streams are modeled from the elevation DEM using ESRI hydrology tools. The following steps were used to produce distance to streams:

a) model streams from a 10 x 10 meter, **filled** large DEM that extends beyond the project area. The large DEM boundary includes all entire HUCs that have at least a portion of their extent within the study area; only streams are derived from this coverage. Set 13 acres to accumulate water (526 10 x 10 meter cells). (1076 sq ft per pixel, 566,280 sq ft in 13 acre, 566,280/1076.4 = 526 pixels); in raster calculator = streamgrid = setnull(flowaccumulation < 527, 1).
b) Calculate Euclidean distance to stream (GRID command, Dstrm = eucdistance stream) = **dstrm**.
f) Clip to smaller project area boundary = **dstream**

30) Stream_diff (sdiff) A measure of the difference in elevation of an individual cell and the closest stream (above stream = positive number, below stream = negative number). The following process was used to develop Sdiff:

a) create a coverage of elevation at stream cells: streamelev = con(streamgrid > 0, 'filled' elevation grid)
b) 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. Use a 3x3, and 6x6 rectangular neighborhood; this extends a stream's elevation from its location to the adjacent cells: temp = con(isnull(streamelev, focalmin (streamelev, rectangle, 3, 3), streamelev)
c) 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 include man-made structures (ponds, mines), natural ponds, small areas due to rounding, and some areas that are actually on the other side of the watershed that result from the constant filling in of nodata areas with the focalmin of elevation.

d) Fix results of streamfill. Set all values less than 0 (below stream) to null.
e) To take care of areas nearest streams with emphasis on the distance from stream:
c:\1_jeff\dtms\temp2 = con((c:\1_jeff\dtms\dstream < 100 & c:\1_jeff\dtms\strmdiff2 < 0), focalmean(c:\1_jeff\dtms\temp1,circle,3), c:\1_jeff\dtms\temp1).
f) Fill in remaining nodata values with focal MINIMUM from adjacent cells.
g) –OR- live with values below stream and evaluate (these were filled for Jeff. NF)

River influence

31) Distance to rivers (Rivdist) Same process as distance to streams but using 4th order and greater streams only.

32) Distance above rivers (i.e., streams 4th order and greater) (Rivdiff)
The following process was used:
a) Create stream order coverage (see streams above)
b) Create elevation of Rivers using 10 meter elevation DEM
c:\1_jeff\dtms\river_elev = con(c:\1_jeff\streamrivercalcs\river4 == 1, c:\1_jeff\dtms\elev_m, 0)

c) Create a mask for analysis area:
- Convert HUCS12 poly to grid with Fid as ID
- Use focal analysis (range) to locate grid cells representing HUC boundaries (where range > 0)
- Create new coverage where range > 0 = 99999
- Use con(isnull (gridcoverage, focalmean, rectangle, 3, 3) until the boundary is 11 cells in width
- Setnull all values not = 99999 (this will be the interior cells) == **masktest1**

d) Expand this elevation to the landscape; this process fills in the non-river landscape with the closest river elevation to allow easy subtraction with grid algebra using the following commands in the raster calculator, i.e., Fill in areas that are not rivers through a series of focalmin commands WITH MASK SET TO MASKTEST1:

c:\1_jeff\dtms\temp1 = con(isnull(c:\1_jeff\dtms\river_elev), focalmin (c:\1_jeff\dtms\river_elev, circle, 3), c:\1_jeff\dtms\river_elev)
c:\1_jeff\dtms\temp2 = con(isnull(c:\1_jeff\dtms\temp1), focalmin (c:\1_jeff\dtms\temp1, circle, 3), c:\1_jeff\dtms\temp1)

Used 3x3 for 50 iterations, 6x6 for 50 iterations, 10x10 rectangle instead of circle which is faster, 3x3 rectangle for 75 iterations, finish with 10 x 10 rectangle – 28 iterations == **rivelevfill1**

e) setmask OFF
f) fill in watershed boundaries with series of con(isnull statements like above) == rivelevfill2
g) recheck stream difference
c:\1_jeff\rivdiff2 = c:\1_jeff\dtms\elev_m – c:\1_jeff\rivelevfill2, and rerun steps above:
j) still some negative (below stream values) – fix by creating a coverage of these areas and expanding it by 4 cells, use this to assign nodata values for these areas within strmdiff, then filling with streamdiff2 (instead of streamfill)
c:\1_jeff\temp1 = con(c:\1_jeff\rivdiff2 < 0, 9)
c:\1_jeff\temp2b = con(isnull(c:\1_jeff\temp1), focalmean(c:\1_jeff\temp1, rectangle, 4, 4), c:\1_jeff\temp1)
set all nodata values to 0 (this needs to be done for SETNULL to work), and other values to 9
c:\1_jeff\tempnodata1 = con(isnull(c:\1_jeff\temp2b), 0, 9)
setnul l values within rivdiff2 based on this area
c:\1_jeff\temp4 = setnull(c:\1_jeff\tempnodata1 == 9, c:\1_jeff\rivdiff2)
fill with focalmax
c:\1_jeff\temp5 = con(isnull(c:\1_jeff\temp4), focalmax(c:\1_jeff\temp4, rectangle, 3, 3), c:\1_jeff\temp4)
- 20+ iterations
k) focalmean for entire coverage (3 iterations) and clip to project area.

33) <u>Terrain shape index</u> Terrain shape index is an estimate of local land surface convexity or concavity slightly broader than curvature and is calculated by subtracting elevation value of the center neighborhood cell from the value of each of 8 neighbors.

a) F:\1_jeff\dtms\tsi = f:\1_jeff\dtms\elev_m – focalmean (f:\1_jeff\dtms\elev_m, circle, 5)

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

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

34) <u>Valley position</u> Valley position is a measure of the elevational position of a cell relative to the <u>watershed divide</u> and the <u>valley floor</u>. The old method of calculating this DTM used the original DEM to model streams with a 13 acre accumulation area and stream order, to identify valley floor and the same DEM to identify watershed divide. This resulted in many areas with negative numbers due to the closest stream (and its elevation) and required extensive and questionable methods to fill these areas. The new method determines the watershed divide as the maximum elevation within a 3/4 mile x 3/4 mile window, i.e., it is an estimate (model) of where major ridges occur and the elevation of grid cells at those locations and the minimum elevation in a similar manor. It uses 30 meter DEM (resampled from the original 10 meter DEM) because this is a mesoscale indicator meant to evaluate environments at a broader scale than Relative Slope Position that does not require micro-scale data.

GRID commands:

c:\1_jeff\dtms\maxelev = focalmax(c:\1_jeff\dtms\elev_30m, rectangle, 60,60)
c:\1_jeff\dtms\minelev = focalmin(c:\1_jeff\dtms\elev_30m, rectangle, 60,60)
c:\1_jeff\dtms\relief = c:\1_jeff\dtms\maxelev – c:\1_jeff\dtms\minelev
(same steps for relief)

c:\1_jeff\dtms\down = c:\1_jeff\dtms\elev_30m - c:\1_jeff\dtms\minelev
c:\1_jeff\dtms\vpostemp = 1 – (c:\1_jeff\dtms\downfloat / c:\1_jeff\dtms\relief2float)

Check for nodata values: c:\1_jeff\dtms\nodata = con(isnull(c:\1_jeff\dtms\vpostemp), 99999, c:\1_jeff\dtms\vpostemp)
Fill all nodata values with mean of adjacent cells ***<u>(none in Jeff. Project area)</u>***
c:\1_jeff\dtms\vpostemp2 = con(isnull(c:\1_jeff\dtms\vpostemp1), focalmean(c:\1_jeff\dtms\vpostemp1, rectangle, 3, 3), c:\1_jeff\dtms\vpostemp1)

Used focalmean 3x3 three times to eliminate values below 0
c:\1_jeff\dtms\vpostemp2 = con(c:\1_jeff\dtms\vpostemp1 < 0, focalmean(c:\1_jeff\dtms\vpostemp1, rectangle, 3, 3), c:\1_jeff\dtms\vpostemp1)
OR .. just change all values less than 0 to 0

Resample to 10 meters

APPENDIX IV: 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.
Create CSV file with the following variables: **TYPE, Xcoordinate, Ycoodinate, DTM values**.
Use Hawth tools to attach X, Y to original plot coverage
Use Hawth tools to attach DTM data to points: Hawth Analysis, point intersection.
Export table and strip all but TYPE, X, Y and DTM from file, save as CSV file.
i.e., (open an .xl file and select 'open as dbf', edit if necessary and SAVE AS [MSDOS] CSV file), i.e., (Comma delimited)

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

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

```
c:\1_jeff\models2\max1 = max ~
(c:\1_jeff\models2\gbald, ~
c:\1_jeff\models2\poshale, c:\1_jeff\models2\sf, ~
c:\1_jeff\models2\floodplain, c:\1_jeff\models2\nhcove,c:\1_jeff\models2\alluvial, c:\1_jeff\models2\oakrhodo, ~
c:\1_jeff\models2\montoakcove,c:\1_jeff\models2\montoakrich, c:\1_jeff\models2\drycalc, c:\1_jeff\models2\sloak, ~
c:\1_jeff\models2\nhslope,c:\1_jeff\models2\dmcalc, c:\1_jeff\models2\hero, c:\1_jeff\models2\rcove, ~
c:\1_jeff\models2\dryoakdecid,c:\1_jeff\models2\poh, c:\1_jeff\models2\dryoakever, c:\1_jeff\models2\dmoak, ~
c:\1_jeff\models2\acove, c:\1_jeff\models2\montoakslp, c:\1_jeff\models2\basicOH)
```

Reads each model Grid and compares to the maximum probability for that grid cell; if a match occurs, inserts Ecological Zone model code.

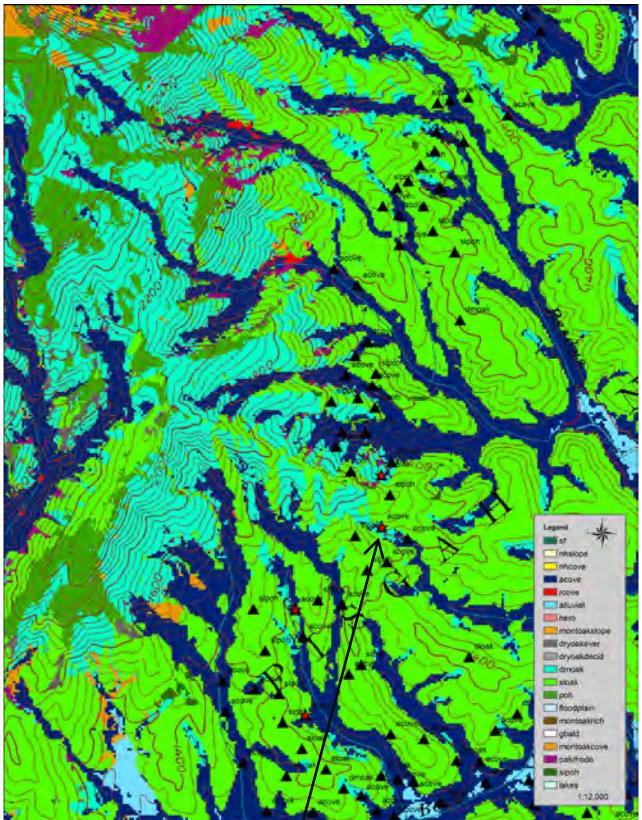
```
c:\1_jeff\models2\zone1  = con(c:\1_jeff\models2\max1 == \1_jeff\models2\sf, 1, ~
c:\1_jeff\models2\max1 == c:\1_jeff\models2\gbald, 30, ~
c:\1_jeff\models2\max1 == c:\1_jeff\models2\poshale, 22, ~
c:\1_jeff\models2\max1 == c:\1_jeff\models2\floodplain, 23, ~
c:\1_jeff\models2\max1 == c:\1_jeff\models2\nhcove, 3, ~
c:\1_jeff\models2\max1 == c:\1_jeff\models2\alluvial, 6, ~
c:\1_jeff\models2\max1 == c:\1_jeff\models2\oakrhodo, 44, ~
c:\1_jeff\models2\max1 == c:\1_jeff\models2\montoakcove, 15, ~
c:\1_jeff\models2\max1 == c:\1_jeff\models2\montoakrich, 24, ~
c:\1_jeff\models2\max1 == c:\1_jeff\models2\drycalc, 17, ~
c:\1_jeff\models2\max1 == c:\1_jeff\models2\sloak, 16, ~
c:\1_jeff\models2\max1 == c:\1_jeff\models2\nhslope, 2, ~
c:\1_jeff\models2\max1 == c:\1_jeff\models2\dmcalc, 14, ~
c:\1_jeff\models2\max1 == c:\1_jeff\models2\hero, 8, ~
c:\1_jeff\models2\max1 == c:\1_jeff\models2\rcove, 5, ~
c:\1_jeff\models2\max1 == c:\1_jeff\models2\dryoakdecid, 11, ~
c:\1_jeff\models2\max1 == c:\1_jeff\models2\poh, 18, ~
c:\1_jeff\models2\max1 == c:\1_jeff\models2\dryoakever, 10, ~
c:\1_jeff\models2\max1 == c:\1_jeff\models2\dmoak, 13, ~
c:\1_jeff\models2\max1 == c:\1_jeff\models2\acove, 4, ~
c:\1_jeff\models2\max1 == c:\1_jeff\models2\basicOH, 31, ~
c:\1_jeff\models2\max1 == c:\1_jeff\models2\montoakslp, 9, 0)
```

APPENDIX V: Ecotone evaluation and Ecological Zone model adjustments.

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

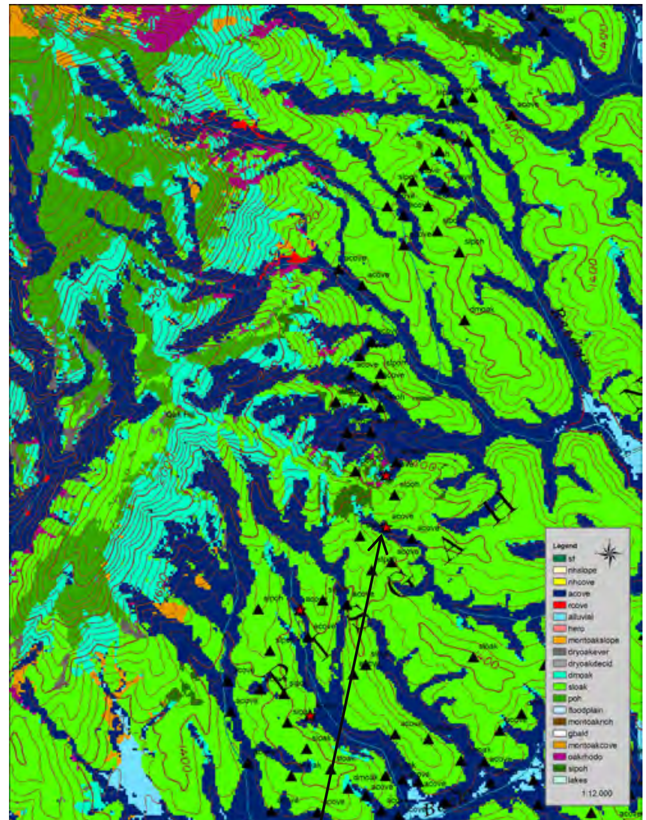
1. Examine the accuracy assessment matrix to identify an Ecological Zone (Zone) were large omission errors occur, i.e., numerous field reference plots are incorrectly classified into another type. Reference plot data is known information of high accuracy and therefore we assume that the omission errors indicate areas that were incorrectly over-mapped. The focus here is on adjusting pixel values **only** within these areas.
2. Intersect all field plots with the preliminary model and extract only those plots that occur in the Zone assumed to have been over-mapped along with all environmental variables associated with **all** field plots that fall within this zone.
3. Calculate the difference between the reference type probability and the maximum probability at the plot location for that same pixel. This difference is the value that if added to the original Zone in question would result in a correct classification of the 'incorrectly classified' reference plot(s), and theoretically other pixels away from these plots. In other words, by adding this difference to the pixels that constitute the omission error, the highest probability is transferred to the correct type.
4. Sort the 'difference' data from low to high and choose a realistic threshold value (around .10) to highlight those omission error plots having the least difference between the modeled type and the reference type. Disregard values greater than the threshold but maintain data from all plots within the Zones being analyzed (the reference Zone and the omission Zone).
5. Add the 'difference' threshold value only to plots within the Zone under question that are within the omission error model. Examine how this adjustment might affect relationships with other Zones. The purpose here is to find the value that when added will result in the greatest number of gains and least number of additional errors.
6. The final step for adjusting the ecotone includes a close examination of each environmental variable within the threshold limit to see which is most associated with the greatest number of 'least different' reference vs. model values and results in the greatest gain for the Zone in question. The point here is not only to adjust pixels that decrease the omission error to improve the accuracy assessment matrix. The point is to consider what environmental variables make sense in separating the Zones being questioned because any adjustment made at plot locations also occurs in pixels away from plot areas within these specified environmental conditions. It is assumed that, because reference plots are used to 'train' habitat suitability models using MAXENT, the environmental relationships observed at these locations should also 'train' adjustments elsewhere. An example of the result of this analysis might be to: **"add .115 to all Acidic Cove probabilities greater than .42 within the Dry-Mesic Oak modeled area (omission model area) where Relative Slope Position values are > 16**, i.e., slope positions lower on the hill".
7. Re-evaluate additional omission errors and threshold limits within the Zone under question and cycle through steps 2-6 to get the greatest gain to create a new version of the Zone.
8. Rerun the maximum probability model (combining all Zones again) using the new version of the Zone. Display the 'before and after' combined models to evaluate if they make any sense at all, e.g., does the ecotone adjustment reflect a true environmental difference between the types under question and do the new type distributions (mapping) fit local knowledge. If they don't make sense, drop this analysis. If they do, build from this point by going back to step 1 for another Zone. Figures 1-3 display the results of multiple adjustments in an example area within the Southern Blue Ridge project area.

Figure 1: Zones based on maximum probability method.



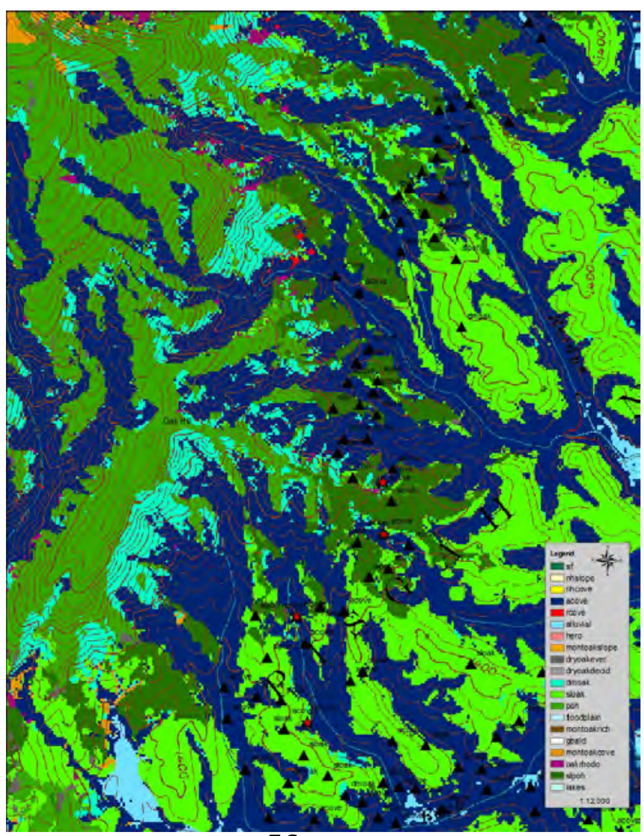
Plot data used for adjustment (stars)

Figure 2: Zones with one ecotone adjustment.



Changed to acove model

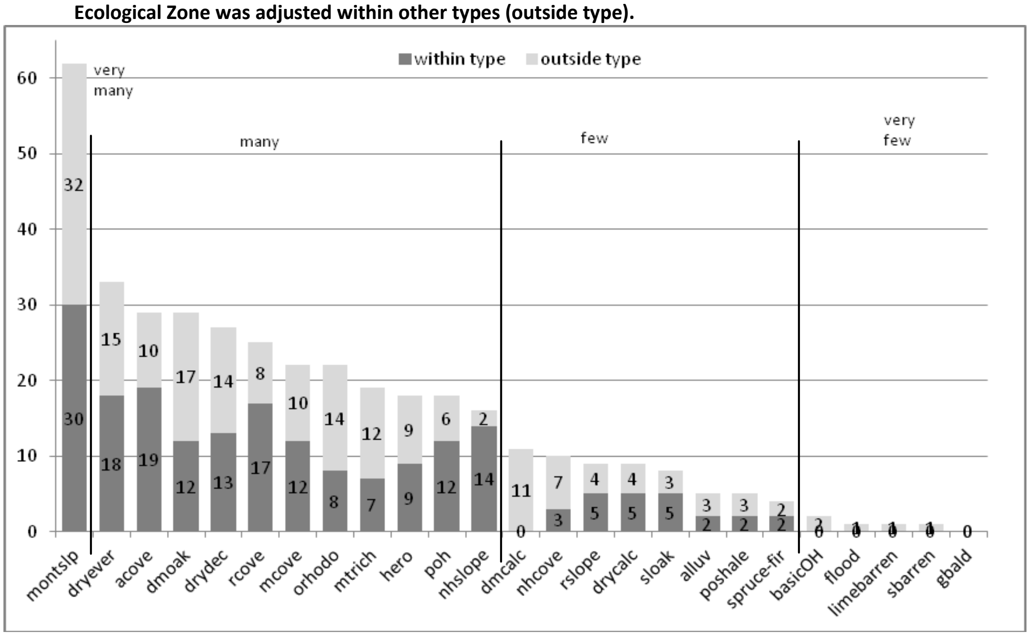
Figure 3: Ecological Zones with all ecotone adjustments.



APPENDIX VI: Results and discussion: ecotone evaluation and Ecological Zone model adjustments

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

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



Very many	Many	Few	Very few
Montane Oak (Slope)	Dry-Oak/Evergreen Heath	Dry-Mesic Calcareous Forest	Basic Oak-Hickory
	Acidic Cove	Northern Hardwood Cove	Floodplain
	Dry-Mesic Oak	Rich Slope	Lime-Dolomite Barren
	Dry-Oak/Deciduous Heath	Dry Calcareous Forest	Shale Barren
	Montane Oak (Cove)	Shortleaf Pine-Oak	Grass Bald
	Rich Cove	Alluvial Forest	
	Mixed Oak/Rhododendron	Pine-Oak Shale	
	Montane Oak (Rich)	Spruce-Fir	
	High Elevation Red Oak		
	Pine-Oak Heath		
	Northern Hardwood Slope		

There were 60 adjustments made to create the final Montane Oak Slope model, 30 'within type' and 30 'outside type' (Figure 1), the most of all types. This type accounts for about 9% of the total acres in the 5.6 million+ project area and therefore has an extensive ecotone with other types, but this only partially explains the reason for needing such a large number of adjustments. These 'matrix' forests are highly variable, include numerous Plant Associations, and, in the authors' opinion, are not adequately defined in the NatureServe Ecological System structure, a structure followed closely in developing all Ecological Zone models. Furthermore, extensive logging and loss of American chestnut and other type indicators make accurate Zone identification difficult in this area, which could have resulted in greater confusion between types.

The second category 'many' accounts for about 45% of the landscape and includes the remainder of the more-extensive Ecological Zones that support 'matrix' forests. However, this category also includes the High Elevation Red Oak type that occurs in only 1% of the area but because of its landscape position on ridges and upper slopes, forms an extensive ecotone with Montane Oak Slopes and Northern Hardwood Slopes. The remainder of the Ecological Zones (15 total) represent nearly half of the area and needed few, very few ecotone, or no adjustments of the original Maxent models to reduce type confusion. This is primarily due to their occurrence in more distinct environments, e.g., the highest elevations (Spruce-Fir or Grass Balds), the lowest elevations in flats near rivers (Floodplains), or on distinct geologic substrates (Shale Barrens and Pine-Oak Shale on shale rock only), and the numerous types that, by definition, occur only on carbonate-bearing rock, e.g., Dry-Mesic and Dry Calcareous Forest, Basic Oak-Hickory, and Lime-Dolomite Barren.

Fewer (50% less) ecotone adjustments were used in the Jefferson study area 1st Approximation Ecological Zone models than were needed in the Southern Blue Ridge 3rd Approximation to produce models of roughly equal (≈80%) Zone accuracy.

Adjustments within and between types: The greatest number of model adjustments (8) was made to differentiate between Montane Oak Slope and Dry Oak/Evergreen Heath. Seven environmental variables were used in the adjustments: slope, elevation, mafic and ultramafic rock, landform30, distance to streams, felsic igneous & metamorphic rocks, and the difference in elevation relative to rivers. The next most frequent adjustments were made between Montane Oak Slope and Rich Cove or Acidic Cove (6 each), Acidic Cove and Montane Oak Cove (6), and High Elevation Red Oak and Montane Oak Rich (6). Five adjustments were made between Montane Oak Slope and the following types: High Elevation Red Oak, Montane Oak Rich, and Montane Oak Cove (Table 1).

Table 1: Most frequent ecotone adjustments in the Jefferson NF project area.

Total Adjustments	Ecological Zones where confusion occurred
8	Montane Oak Slope & Dry Oak/Evergreen Heath
6	Montane Oak Slope & Rich Cove
6	Montane Oak Slope & Acidic Cove
6	Acidic Cove & Montane Oak Cove
6	High Elevation Red Oak & Montane Oak Rich
5	Montane Oak Slope & High Elevation Red Oak
5	Montane Oak Slope & Montane Oak Rich
5	Montane Oak Slope & Montane Oak Cove
5	Dry Oak/Deciduous Heath & Montane Oak Slope
4	Dry Oak/Deciduous Heath & Dry Oak Evergreen Heath
4	Dry Oak/Evergreen Heath & Dry-Mesic Oak
4	Dry Oak/Evergreen Heath & Pine-Oak Heath
4	Pine-Oak Heath & Montane Oak Slope
4	High Elevation Red Oak & Northern Hardwood Slope
4	Rich Cove and Acidic Cove

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

Most frequent (>22)	Frequent (9-18)	Less Frequent (5-7)	Least Frequent (<4)
Curvature (curve, curpl, curpr, tsi)	Landform shape (lf10, lf30, lfi)	Carbonate-bearing rock	Siliclastic rock
Elevation	Slope percent	Relief	Shale rock
Stream influence (dstream, sdiff)	River influence (driver, rdiff)	Felsic igneous, metamorphic rock	Mixed geology
	Relative Slope Position (rsp1, rsp2)	Mafic and ultramafic rock	Precipitation
	Valley Position		
	Aspect (aspr, aspc)		
	Slope length (slength, flowup, flowdown)		

Topographic/environmental variables used most frequently to describe local environments that might refine ecotone boundaries between types were clearly fine-scale and included: surface curvature, elevation, and stream influence (Figure 2). These variables were used over 20 times each in the nearly 200 adjustments made between the preliminary and final Ecological Zone models (Table 3). A combination of fine- and mid-scale variables that included landform shape, slope percent, river influence, relative slope position, were frequently used. Less and least frequently used were mid-scale to broader-scale variables. This contrasts greatly from variables used in the original Maxent models for each type. While curvature and landform shape were used frequently to adjust ecotone boundaries (nearly ½ of the models used these variables), they had at least a 5% contribution to prediction gain in less than 12% of the Maxent models (Table 2). Similarly, slope length, provided only a 2% gain in one Maxent model (Table 7, report), but was used in 22% of the models for ecotone adjustments. Conversely, relief, and siliclastic geology which had significant contributions in Maxent models were among the least frequently used variables in the ecotone adjustments.

Variables used within Ecological Zones: The most variables were used (at least 9) for ecotone adjustments in Montane Oak Slope, Dry Oak/Evergreen Heath, Rich Cove, Acidic Cove, and Pine-Oak Heath (Table 3). Curvature, elevation, stream influence, landform shape, slope and valley position were the most frequently used variables for adjusting these models.

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

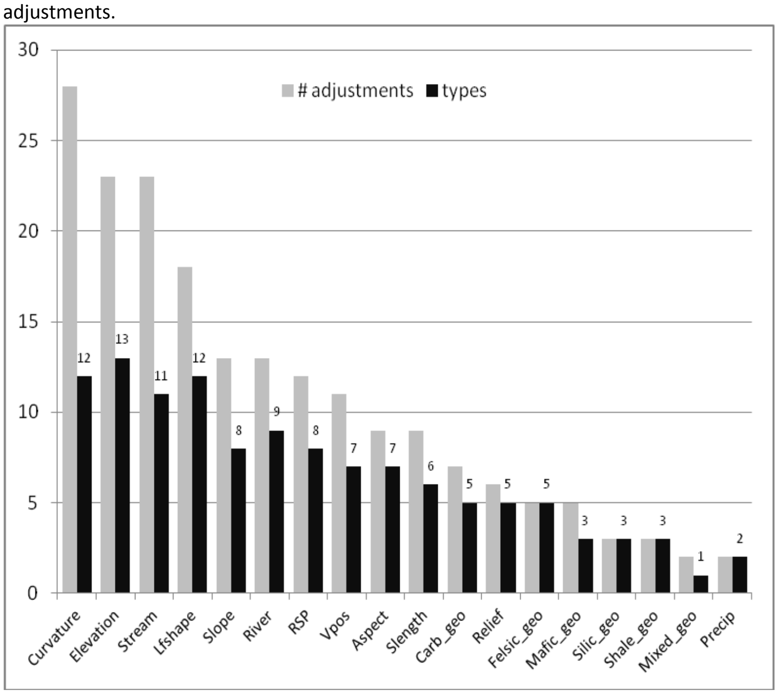


Table 2: Comparison of environmental variable use in ecotone adjustments vs. Maxent models

Variable[1/]	Ecotone adjustments	Maxent models [1/]	% difference in variable use
	% of types variable used		
Curvature	44	9	35
LFshape	44	11	33
Slength	22	0	22
Slope	30	20	10
Stream	41	33	8
RSP	30	22	8
Aspect	26	20	6
Vpos	26	20	6
Elevation	48	47	1
Carb_geo	10	24	-14
Mafic_geo	11	29	-18
Felsic_geo	19	38	-19
Precip	7	27	-20
Shale_geo	11	31	-20
River	33	60	-27
Relief	19	47	-28
Mixed_geo	3	37	-34
Silic_geo	11	51	-40

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

Table 3: Environmental variables used for ecotone adjustments within Ecological Zones

Variable[1/]	# adj.	# types	MTslp	Dryeve	Rcove	NHslp	Acove	Drydec	MTcov	Dmoak	Poh	Hero	Orhodo	Alluv	MTrich	Rslope	Drycal	Sloak	NHcov	SF	POsha	[2/]
			number of within type adjustments																			
Curvature	28	12	5			2	1	4	3	1	3	1	3		3	1	1					
Elevation	23	13	5	1	1	4	2	1		1		1	1	2					1	2	1	
Stream	23	11	2	3	2	4	2		2	2		1	2	2				1				
LFshape	18	12	1	2	1		2	2	1	1	2			1	2	1		2				
Slope	13	8	3	2	1			1			1	2	1			2						
River	13	9	1	3		1	1		1			2		2				1			1	
RSP	12	8	2	2		1		3	1		1				1				1			
Vpos	11	7	3		2		2	1								1	1		1			
Aspect	9	7		1	1			1	2	2					1		1					
Slength	9	6	1				2			2	1						1	2				
Carb_geo	7	5			2		2		1		1	1										
Relief	6	5	1		1					2	1		1									
Felsic_geo	5	5	1	1	1		1					1										
Mafic_geo	5	3	2						1	2												
Silic_geo	3	3	1			1					1											
Shale_geo	3	3	1		1	1																
Mixed_geo	2	1			2																	
Precip	2	2		1													1					
Total adj.	192	19	29	16	15	14	15	13	12	13	11	9	8	7	7	5	5	6	3	2	2	0
Total var.			14	9	11	7	9	7	8	8	9	7	5	4	4	4	4	4	3	1	2	

[1/] Rsp = rsp1, rsp2; Aspect = aspr, aspc, solar; Curvature = curve, curpl, curpr, tsi; Stream = dstream, sdiff; River = driver, rivdiff; LFshape = lfm10, lfm30, lfi; Slength = slength, flowup, flowdown.
[2/] No adjustments made within Balds, Basic Oak-Hickory, Floodplain, Dry-mesic Calcareous Oak-Hickory, Shale Barren, Cedar Barren, Xeric Pine-Oak, Acid Glade

Table 4: Number of times variable was used in local environment / ecotone adjustment, model area1 (NW I-81).

EZONE	NhS	NhC	Acove	Orhodo	Rslope	Rcove	Alluvial	Flood	Hero	MonR	MonS	MonC	Dmoak	Dmcalc	Drycalc	LimeB	DryE	DryD	SLoak	Poh	POshale	ShaleB	Total
total	8	1	14	8	5	12	2	0	8	5	17	8	12	0	4	0	12	7	5	9	0	0	137
Asp_r													dmcalc					mtslp					2
Asp_c										hero		rcove	poh		Dmcalc		dmoak						5
Curve					dmcalc					mtslp										drydec			3
Curpl												mtslp			Rslope		orhodo	dmoak					4
Curpr	mtcove										mtcove rslope												3
Dstrm						Rslope orhodo			nhslope		hero	acove					drydec mtslp						7
Driver	mtslp		mtcove				dmoak		mtrich		dmoak								poshale				6
Elev	nhcove hero		dmoak shaleB	dmoak					mtrich		dryever		mtslp										9
Flowup													sloak						dryever				2
Flowdw			alluvial																				1
Geo1			mtcove rcove			Mtslp acove			mtslp			acove											6
Geo2			mtslp								dmcalc						mtslp						3
Geo3	acove																			sloak			2
Geo4						dmcalc dmoak																	2
Geo5	nhcove					mtcove					poh												3
Geo6											dryever drydec	dmoak	drydec mtslp										5
Lfi										dryever hero							poh	mtrich	poh	mtslp			6
Lfm10													oakrhodo										1
Lfm30			dmcalc flood		dmoak	mtslp											drydec		dmoak				6
Precip															cedarB		dmcalc						2
Relief				rcove		dmcalc							dryever acove							mtslp			5
Rivdiff									dryever								aglade mtrich						3
Rsp1	mtslp									mtslp	nhslope	dmoak											4
Rsp2																	mtcove dmoak	dryever		dmoak			4
Slength																							0
Slope				poh	orhodo dmcalc	mtcove			drydec mtrich		drydec acove mtrich							hero		dryever			11
Solyr																							0
Stmdiff	hero		orhodo nhcove	dryever mtslp			acove				rcove	dryever	poshale rslope						drydec				11
Tsi			mtslp	mtrich drydec drycalc					mtslp		aglade drycalc	mtslp	aglade					sloak		mtrich drydec			12
Vpos		acove	rcove mtslp		mtslp	nhcove alluvial					nhcove				Dryever			oakrhodo					9
total	2-hero 2-mtslp 2-nhcove 1-acove 1-mtcove	1-acove	3-mtslp 2-mtcove 2-rcove 1-dmcalc 1-flood 1-orhodo 1-nhcove 1-alluvial 1-dmoak 1-Sbarren	1-dmoak 1-rcove 1-poh 1-dryever 1-mtslp 1-mtrich 1-drydec 1-drycalc	2-dmcalc 1-dmoak 1-orhodo 1-mtslp	2-mtslp 2-dmcalc 2-mtcove 1-rslope 1-orhodo 1-acove 1-dmoak 1-nhcove 1-alluvial	1-dmoak 1-acove		3-mtrich 2-mtslp 1-nhslope 1-dryever 1-drydec	2-mtslp 2-hero 1-dryever	2-drydec 2-dryever 2-drycalc 1-dmcalc 1-mtcove 1-rslope 1-hero 1-dmoak 1-nhslope 1-acove 1-mtrich 1-rcove 1-aglade 1-nhcove	2-acove 2-dmoak 2-mtslp 1-dryever 1-rcove	2-mtslp 1-dmcalc 1-poh 1-aglade 1-rslope 1-poshale 1-acove 1-dryever 1-drydec 1-orhodo 1-sloak		1-dmcalc 1-rslope 1-limeB 1-dryever		2-dmoak 2-mtslp 2-drydec 1-mtcove 1-mtrich 1-aglade 1-dmcalc 1-orhodo 1-poh	1-mtslp 1-dmoak 1-mtrich 1-dryever 1-hero 1-sloak 1-orhodo	1-dryever 1-poshale 1-poh 1-dmoak 1-drydec	2-mtslp 2-drydec 1-sloak 1-dmoak 1-dryever 1-mtrich			22-mtslope 13-dmoak 11-dryever 10-drydec 9-dmcalc 8-mtrich 8-acove 7-orhodo 7-mtcove 6-hero 5-rcove 5-nhcove 4-poh 4-rslope 3-drycalc 3-sloak 3-aglade 2-alluvial 2-poshale 2-nhslope 1-flood 1-Sbarren 1-limeB

Table 5: Number of times variable was used in local environment / ecotone adjustment, model area2.

EZONE	Gbald	SF	NhS	NhC	Acove	Orhodo	Rcove	Alluvial	Flood	Hero	MonR	MonS	MonC	Dmoak	Dmcalc	Drycalc	BasicOH	DryE	DryD	SLoak	Poh	POshale	Total
total	0	2	6	2	5	0	5	0	0	1	2	13	4	0	0	1	0	6	6	0	3	2	58
Asp_r																							0
Asp_c							dmoak						acove										2
Curve																			mtrich				1
Curpl							mtslp orhodo						drydec					dmoak					4
Curpr											mtslp												1
Dstrm			mtrich rcove															drydec					3
Driver					alluvial								mtslp									dryever	3
Elev		nhcove mtrich	basicOH hero	mtslp	orhodo mtcove		mtslp					orhodo hero drydec basicOH poshale						orhodo	drycalc			mtcove	16
Flowup																							0
Flowdw																							0
Geo1																					orhodo		1
Geo2							orhodo			mtslp													2
Geo3												poh											1
Geo4																							0
Geo5																							0
Geo6																							0
Lfi					mtslp														dmoak		drydec		3
Lfm10													dmoak										1
Lfm30												dryever											1
Precip																							0
Relief												mtrich											1
Rivdiff																		mtslp					1
Rsp1				sf								orhodo							orhodo dmcalc				4
Rsp2																							0
Slength												dryever				dmcalc					dryever		3
Slope																		mtslp poh					2
Solyr																							0
Stmdiff			nhcove		rcove																		2
Tsi			sf								hero	mtcove							mtslp				4
Vpos												acove rcove											2
total		1-nhcove 1-mtrich	1-mtrich 1-rcove 1-basicOH 1-hero 1-nhcove 1-sf	1-mtslp 1-sf	1-alluvial 1-orhodo 1-mtcove 1-mtslope 1-rcove		1-dmoak 2-orhodo 2-mtslp			1-mtslp	1-mtslp 1-hero	2-orhodo 1-hero 1-drydec 1-basicO 1-poshale 1-poh 2-dryever 1-mtrich 1-mtcove 1-acove 1-rcove	1-acove 1-drydec 1-mtslp 1-dmoak			1-dmcalc		1-dmoak 1-drydec 1-orhodo 2-mtslp 1-poh	1-mtrich 1-drycalc 1-dmoak 1-orhodo 1-dmcalc 1-mtslope		1-orhodo 1-drydec 1-dryever	1-dryever 1-mtcove	8-mtslope 8-orhodo 4-dmoak 4-dryever 4-drydec 4-mtrich 3-hero 3-mtcove 3-rcove 2-acove 2-basicOH 2-dmcalc 2-nhcove 2-poh 2-sf 1-drycalc 1-alluvial 1-poshale

APPENDIX VII: Accuracy Evaluation

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

A true accuracy assessment was not completed for this project, hence the title "Accuracy Evaluation". However, the same procedure was followed, i.e., a comparison was made of reference data for a site to categorized (classified, modeled) data (map units) on the same site. A quantitative accuracy assessment depends on the collection of reference data. Reference data is known information of high accuracy (theoretically 100% accuracy) about a specific area on the ground (the accuracy assessment site). The assumed-true reference data can be obtained from ground visits, photo interpretation, video interpretations, or some combination of these methods. In a map unit accuracy assessment, sites are generally the same type of modeling unit used to create the map. In a true field accuracy assessment, the evaluation would be made around randomly generated points on the ground or more realistically within a 'stand' or other reasonable-size area (ground truthing).

Error Matrix

The error matrix (Tables 1, 2) below are a square array in which accuracy assessment sites are tallied by both their classified category and their actual category according to the reference data. For this study, the columns in the matrix represent the classified Ecological Zone map units, while the rows represent the reference data; this is a non-traditional approach in arranging the error matrix. The major diagonal, highlighted in the following table, contains those sites where the classified data agree with the reference data. The nature of errors in the classified map can also be derived from the error matrix. In the matrix, errors (the off-diagonal elements) are shown to be either errors of inclusion (commission errors) or errors of exclusion (omission errors). High errors of omission/commission between two or more classes indicate spectral confusion between these classes.

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

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

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

> Overall Accuracy, a common measure of accuracy, is computed by dividing the total correct samples (the diagonal elements) by the total number of assessment sites found in the bottom right cell of the matrix.
>
> **Producer's Accuracy**, which is based on omission error, is the probability of a reference site being correctly classified. It is calculated by dividing the total number of correct accuracy sites for a class (diagonal elements) by the total number of reference sites for that class found in the right-hand cell of each row (Story and Congalton 1968). Producer's accuracy indicates how many times an Ecological Zone on the ground was identified as that Ecological Zone on the map.
>
> **User's Accuracy**: the total number of correct pixels in a category divided by the total number of pixels that were classified in that category (commission error). This is the probability that a pixel classified on the map actually represents that category on the ground; also called reliability.

Table 1: Ecological Zone accuracy in the Jefferson NF Model Area 1 from 3,148 field plots

#		2	3	4	44	55	5	6	23	8	24	9	15	13	14	17	29	10	11	16	18	22	21	27	Total	% corr.
2	Nhslope	43		1							1	2	1												48	**90%**
3	Nhcove	1	17																						18	**94%**
4	Acove			275	1	2	11	1	1			3	16	9	2										321	**86%**
44	Oakrhodo				53	1						3		1				5	1						64	**83%**
55	Rslope					80	2					4			3	1									90	**89%**
5	Rcove			7	1	1	158					3	5	1	17	1									194	**81%**
6	Alluvial			2			1	45	1																49	**92%**
23	Floodplain			1					31																32	**97%**
8	Hero									121	5	18						2	2						148	**82%**
24	Mont_rich									8	42	4						1							55	**76%**
9	Mont_slope	4	1	5	2	4	2			4		377	2	4	4			19	23		1				452	**83%**
15	Mont_cove			1			1					2	66	7											77	**86%**
13	Dmoak			3	5							7	1	303	2			19	8	5	3	3			359	**84%**
14	DM-Calc.					4	2					4	1	3	152	4	1	2							173	**87%**
17	Dry-Calc				2	2									10	91	3								108	**84%**
29	Lime Barren														1	3	27								31	**87%**
10	Dryoak_ever				4					1		25	1	10		2		200	22		5				270	**74%**
11	Dryoak_dec.				3							19		14	1	3		17	164	1	5				227	**72%**
16	SL-Oak													12						86	2				100	**86%**
18	POheath										1	6	1	3	4			27	11	2	224	1			280	**80%**
22	POshale																				2	24			26	**92%**
21	Shalebarren													1									9		10	**90%**
27	Acidglade																	1						15	16	**94%**
	Total column	48	18	295	71	94	177	46	33	134	49	477	94	368	195	105	31	293	231	94	242	28	9	15	3148	
	TOTAL correct	43	17	275	53	80	158	45	31	121	42	377	66	303	152	91	27	200	164	86	224	24	9	15	2603	**83%**

Most fire-adapted **group** (below double line) = 98% correct in category, Less fire-adapted **group** (above double line) = 90% correct in category

Table 2: Ecological Zone accuracy in the Jefferson National Forest Model Area 2 from 1,427 field plots

#		1	30	2	3	4	44	5	6	23	8	24	9	15	13	14	17	31	10	11	16	18	222	total	% corr.
1	Spruce	**29**	1	5																				35	**83%**
30	GrassBald	1	**10**	1																				12	**83%**
2	Nhslope	4		**74**	5		1					2	1											87	**85%**
3	Nhcove	1		3	**40**			1																45	**89%**
4	Acove				2	**129**	1	11	1	1			4	2				1	2					154	**84%**
44	Oakrhodo						**26**	1					6	1									1	35	**74%**
5	Rcove					4	1	**89**	1	1			10		4	3		3	1	2				119	**75%**
6	Alluvial								**13**	1														14	**93%**
23	Floodplain							2		**11**														13	**85%**
8	Hero			1			2				**54**	6	9						1					73	**74%**
24	Mont_rich										2	**36**	5							2				45	**80%**
9	Mont_slope					1	5	2			5	5	**172**	2	1	4		2	17	8		2	3	229	**75%**
15	Mont_cove					1							1	**25**	1									28	**89%**
13	Dmoak						1		1				2	2	**64**		1	3	1	2	1	1		79	**81%**
14	DM-Calc.								1							**16**	2							19	**84%**
17	Dry-Calc															2	**16**			1				19	**84%**
31	BasicOH						1	1					1					**18**						21	**86%**
10	Dryoak_ever						2				1		13		2				**123**	5		6	1	153	**80%**
11	Dryoak_dec.						1						7		8		1		4	**77**	1	6		105	**73%**
16	SL-Oak														2					1	**12**			15	**80%**
18	POheath						2						3		1				8	7		**87**	2	110	**79%**
222	Xeric PO																		1			1	**15**	17	**88%**
	Total column	35	11	84	47	135	43	107	17	14	62	49	234	32	83	25	20	27	158	105	14	103	22	1427	
	TOTAL correct	29	10	74	40	129	26	89	13	11	54	36	172	25	64	16	16	18	123	77	12	87	15	1136	**80%**

Most fire-adapted **group** (below double line) = 98% correct in category, Less fire-adapted **group** (above double line) = 93% correct in category

Table 3: Biophysical Settings / Ecological Systems accuracy in the Jefferson NF study area from 4,531 field sites [1/]

#	Map code #	30	1	2	4	6	23	8	9	13	31	17	29	10	16	18	27	21	total plots	correct class.
30	Southern Appalachian Grass and Shrub Bald	1	10	1															12	83%
1	Central and Southern Appalachian Spruce-Fir Forest	1	29	5															35	83%
2	Southern Appalachian Northern Hardwood		5	183	3				7										198	92%
4	Southern and Central Appalachian Cove Forest			2	854	3	3		57	15	29	2		11			1		977	87%
6	Central Appalachian Stream and Riparian Systems				3	58	2												63	92%
23	Central Appalachian Floodplain Systems				3		42												45	93%
8	Central and Southern Appalachian Montane-Oak			1	2			175	38					5					221	79%
9	Southern and Central Appalachian N. Red Oak-Chestnut Oak			5	24			19	739	13	10			70		3	3		886	83%
13	Southern Appalachian Oak Forest				9	1			12	367	5	1		30		3	3		438	84%
31	Northeastern Interior Dry-Mesic Oak Forest				8	1			6	3	186	6	1	2					213	87%
17	Central Appalachian Alkaline Glade and Wdl.; Southern Ridge & Valley/Cumberland Dry Calc.				4						12	107	3	1					127	84%
29	Southern Ridge and Valley Calcareous Glade and Woodland										1	3	27						31	87%
10	Central Appalachian Dry Oak-Pine Forest				9			2	65	34	1	6		612	2	22	1		754	81%
16	Central Appalachian Low-Elevation Pine									14				1	98	2			115	85%
18	Southern Appalachian Montane Pine Forest and Woodland				2				11	4	4			53	2	311	3		390	80%
27	Central Appalachian Pine-Oak Rocky Woodland													1			15		16	94%
21	Appalachian Shale Barren									1								9	10	90%
		TOTAL Correct [2/] Most fire-adapted **group** = 98% correct in category, Less fire-adapted **group** = 91% correct in category																	4,531	84%

[1/] rows are reference (field plot) data, columns are classified (modeled) data, [2/] Total Correct percent = 3,822 (correctly modeled field plots = highlighted) / 4,531 (total plots)

APPENDIX VIII: Geology grouping and map unit details.

FM. SYMBOL	Ridge and Valley SOURCE	FMNAME	PRIMARY ROCK	SECONDARY	TERTIARY	acres
CARBONATE-BEARING ROCKS – group 1						
[co	VA003		limestone	dolostone		18,602
[e	VA003	no_name	dolostone	limestone		58,050
Cco	GWJeff 1:24,000	Conococheague	Limestone	Dolomite	Sandstone	10,705
Ccr	GWJeff 1:24,000	Copper Ridge	Dolomite	Sandstone		17,467
Ccr	TN001	no_name	dolostone	chert		9,710
Ccu	TN001	no_name	dolostone	shale		1,210
Ce	GWJeff 1:100,000	Elbrook	Limestone	Dolomite	Shale	5,461
Ce	GWJeff 1:24,000	Elbrook	Dolomite	Limestone	Shale	203,770
Chk	TN001		dolostone	limestone		1,121
Chon	GWJeff 1:24,000	Honaker	Dolomite	Limestone	Shale	18,719
Clim	GWJeff 1:24,000	various	Limestone	Shale	Dolomite	17,043
Cmn	TN001		limestone	dolostone		1,716
Cmr	TN001		limestone	shale		755
Cs	GWJeff 1:24,000	Shady	Dolomite	Limestone		56
Dhl	GWJeff 1:24,000	Helderberg	Limestone			6,116
DlS	GWJeff 1:100,000		Limestone	Shale	Sandstone	6,150
DlS	GWJeff 1:24,000		Limestone	Shale	Sandstone	5,330
DS	GWJeff 1:100,000		Limestone	Shale	Sandstone	13,189
DS	GWJeff 1:24,000		Limestone	Mudstone	Sandstone	554
DSs	TN001		limestone	dolostone		453
Mccf	VA003		limestone	sandstone		22,689
Mg	GWJeff 1:24,000	Greenbrier	Limestone			13,832
Mg	TN001		shale	siltstone		21,006
Mg	VA003		limestone	shale		45,895
Mn	TN001		limestone	shale		4,457
Mnl	GWJeff 1:24,000	Newman	Limestone	Shale		1,969
mOu	GWJeff 1:100,000	undivided	Limestone	Shale	Chert	2,793
O[cc	VA003		dolostone	limestone		46,355
O[co	VA003		limestone	dolostone		11,371
O[k	VA003		dolostone	limestone		196,357
O[z	VA003		limestone	dolostone		6,274
Ob	GWJeff 1:100,000	Beekmantown	Dolomite	Limestone	Chert	10,920
Ob	GWJeff 1:24,000	Beekmantown	Dolomite	Limestone		170,119
Ob	GWJeff 1:24,000	Edinburg Beekmantown	Limestone	Shale		2,848
Ob	VA003		dolostone	limestone		4,608
Oc	GWJeff 1:24,000	Chepultipec	Dolomite	Chert		2,486
Oc	TN001		dolostone	limestone		899
Och	TN001		limestone	shale		15,807
OCk	GWJeff 1:24,000	Knox Group	Dolomite	Limestone	Sandstone	47,648
OCk	TN001		dolostone	limestone		4,128
OClim	GWJeff 1:24,000	Various	Limestones			8,231
Od	GWJeff 1:24,000	Dot	Limestone			12
Oe	GWJeff 1:24,000	Edinburg	Limestone	Shale		8,854
Oh	GWJeff 1:24,000	Hardy Creek	Limestone			531
Oj	TN001		claystone	siltstone		330
Oj	TN001		claystone	siltstone		328
Ol	GWJeff 1:100,000	Lowville	Limestone	Shale	Sandstone	135
Olc	TN001		dolostone	limestone		3,319
Olim	GWJeff 1:24,000	various	Limestone			18,559
Olm	GWJeff 1:24,000	Lenoir and Mosheim	Limestone			412
Ols	VA003		shale	mudstone		5,255
Olv	TN001		dolostone	limestone		442
Omk	VA003		dolostone	chert		34,317
Oml	VA003		limestone	shale		54,288
On	TN001		dolostone	limestone		3,049
Onc	TN001		dolostone	limestone		17,235
Os	TN001		limestone	shale		45
Osp	WV002		limestone	chert		2,981
Ot	GWJeff 1:24,000	Trenton	Limestone	Shale	Mudstone	6,258
Otbr	WV002		limestone	bentonite		1,751
Ou	GWJeff 1:100,000	Undivided	Limestone	Shale		190
Ow	GWJeff 1:24,000	Woodway	Limestone			728
PADpg	KY001		limestone	sandstone		3,195
Sh	GWJeff 1:24,000	Hancock	Limestone			3,422

TOTAL						1,202,505
SILICICLASTIC ROCKS – group 3						
@h	VA003		sandstone	siltstone		1,133
@l	VA003		arenite	sandstone		4,778
@Ml	VA003		arenite	sandstone		820
@n	VA003		shale	siltstone		84,367
@nr	VA003		sandstone	siltstone		3
@w	VA003		sandstone	siltstone		45,322
@wg	VA003		sandstone	siltstone		4,743
@z	VA003		sandstone	siltstone		2,717
Ca	GWJeff 1:100,000	Antietam	Quartzite	Sandstone	Phyllite	966
Ch	GWJeff 1:24,000	Harpers	Sandstone	Phyllite	Quartzite	59
Dbc	GWJeff 1:24,000	Becraft	Sandstone			77
Dch	GWJeff 1:24,000	Chemung	Sandstone	Shale	Conglomerate	42,115
Dch	WV002		siltstone	sandstone		3,595
Dcm	GWJeff 1:24,000	Chattanooga	Siltstone	Shale		5
Dcml	GWJeff 1:24,000	Chattanooga	Siltstone	Shale		1,610
Df	GWJeff 1:24,000	Foreknobs	Sandstone	Siltstone	Shale	3,398
Dhun	GWJeff 1:24,000		Chert			259
Do	GWJeff 1:24,000	Oriskany	Sandstone			7,852
Drg	GWJeff 1:24,000	Rocky Gap	Sandstone			5,807
DSOz	VA003		sandstone	shale		1,086
DSz	VA003		sandstone	limestone		8,760
Dwv	GWJeff 1:24,000	Wildcat Valley	Sandstone			291
Mb	GWJeff 1:24,000	Bluestone	Siltstone	Sandstone	Shale	912
Mb	GWJeff 1:24,000	Bluestone	Siltstone	Sandstone	Shale	14,099
Mbf	WV002		shale	sandstone		38,994
Mbp	WV002		shale	sandstone		4,628
Mfp	TN001		chert	shale		42
Mgr	GWJeff 1:24,000	Greenbrier	Siltstone	Shale		1,548
Mhm	GWJeff 1:24,000	Hinton	Siltstone	Shale	Sandstone	5,362
Mhs	GWJeff 1:24,000	Hinton	Sandstone	Shale		2,986
Mht	GWJeff 1:24,000	Hinton	Sandstone			1,934
Mmcc	WV002		shale	sandstone		424
Mmp	GWJeff 1:24,000	Maccrady and Pocono	Sandstone	Shale		8,641
Mmp	WV002		shale	sandstone		3,847
Mmpr	GWJeff 1:24,000	Maccrady and Price	Mudstone	Siltstone	Sandstone	2,318
Mmpr	VA003		sandstone	shale		23,863
Mmprc	GWJeff 1:24,000	Maccrady and Price	Mudstone	Siltstone	Shale	780
Mp	GWJeff 1:24,000	Pocono Group	Sandstone	Conglomerate	Shale	27
Mpps	GWJeff 1:24,000	Pennington	Sandstone	Siltstone		661
Mpr	GWJeff 1:24,000	Price	Sandstone	Siltsone	Conglomerate	102,690
Mpr	VA003		sandstone	shale		1,670
Oj	GWJeff 1:100,000	Juniata	Sandstone	Shale	Conglomerate	434
Oj	TN001		claystone	siltstone		268
Ojo	GWJeff 1:24,000	Juniata and Oswego	Sandstone	Shale	Conglomerate	1,725
Ojo	WV002		sandstone	shale		1,079
Om	GWJeff 1:24,000	Martinsburg	Sandstone	Shale	Siltsone	10
PAbl	KY001		shale	siltstone		59,997
PAbm	KY001		sandstone	shale		17,729
PAMl	KY001		conglomerate	sandstone		29,158
Pb	GWJeff 1:24,000	Breathitt - lower	Sandstone	Shale	Coal	30,632
Pbea	GWJeff 1:24,000	Breathitt	Sandstone	Shale	Coal	6,207
Pg	GWJeff 1:24,000	Gladeville	Sandstone			379
Ph	GWJeff 1:24,000	Harlan	Sandstone	Siltstone	Coal	878
Pha	GWJeff 1:24,000	Hance and Mingo	Siltsone	Sandstone	Coal	3,254
Pl	GWJeff 1:24,000	Lee - undivided	Sandstone	Siltstone	Coal	1,520
Plbr	GWJeff 1:24,000	Lee - Bee Rock Member	Quartzarenite	Sandstone		4,833
Plh	GWJeff 1:24,000	Lee - Hensley Member	Siltstone	Sandstone	Coal	6,260
Plls	GWJeff 1:24,000	Lee	Quartzarenite			10,642
Plm	GWJeff 1:24,000	Lee – Middlesboro interbed	Siltstone	Sandstone	Coal	28,013
Plml	GWJeff 1:24,000	Lee - Middlesboro lower	Quartzarenite	Sandstone		13,944
Plmu	GWJeff 1:24,000	Lee - Middlesboro upper	Quartzarenite	Conglomerate		19,167
Pln	GWJeff 1:24,000	Norton Naese	Sandstone			234
Plss	GWJeff 1:24,000	Lee	Sandstone			511
Plus	GWJeff 1:24,000	Lee	Quartzarenite	Sandstone		3,421
Pn	GWJeff 1:24,000	Norton	Siltsone	Sandstone	Coal	106,343
Pp	GWJeff 1:24,000	Pocahontas	Siltsone	Sandstone	Coal	1,044
Pw	GWJeff 1:24,000	Wise - interbedded	Siltsone	Sandstone	Coal	111,599
Pwws	GWJeff 1:24,000	Wise sandstone	Sandstone			1,396
Qa	KY001		sand	silt		10

Qal	GWJeff 1:24,000	Alluvium	Gravel			436
Qg	GWJeff 1:24,000	terrace deposit	Gravel			412
Ql	GWJeff 1:24,000	Landslide	Sandstone			3,474
Sc	GWJeff 1:24,000	Clinch	Sandstone	Shale	Siltstone	1,398
Sc	TN001		sandstone	siltstone		1,111
Scp	GWJeff 1:24,000	Clinch-Poor Valley Member	Sandstone	Shale		6,538
Sk	GWJeff 1:100,000	Keefer Sandstone	Sandstone			83
Sk	GWJeff 1:24,000	Keefer	Sandstone			8,330
Skrh	GWJeff 1:100,000	Keefer and Rose Hill	Sandstone	Shale		1,650
Skrh	GWJeff 1:24,000	Keefer and Rose Hill	Sandstone	Shale		206
Skrt	GWJeff 1:100,000	Keffer, Rose Hill & Tuscorora	Sandstone			18,988
Skrt	GWJeff 1:100,000	Keefer, Rose Hill & Tuscarora	Sandstone	Shale	Conglomerate	10,942
Skrt	GWJeff 1:24,000	Keefer, Rose Hill and Tuscarora	Sandstone	Shale		40
Skrt	GWJeff 1:24,000	Keffer, Rose Hill and Tuscorora	Sandstone	Shale	Conglomerate	170,697
Skrt	VA003		arenite	shale		555
Smc	WV002		shale	sandstone		3
SOz	VA003		sandstone	shale		1,576
Src	TN001		sandstone	shale		4,545
Srh	GWJeff 1:100,000	Rose Hill	Sandstone	Shale	Siltstone	229
St	WV002		sandstone			1,424
Stu	GWJeff 1:100,000	Tuscarora	Sandstone	Conglomerate	Quartzite	1,491
Sz	VA003		sandstone	shale		54,545
	Total					1,184,550
MIXED CARBONATE-BEARING ROCKS – group 4						
[c	VA003		shale	limestone		1,444
[nhk	VA003		shale	dolostone		101,156
[nmrr	VA003		shale	limestone		15,044
[r	VA003		shale	siltstone		61,644
Cc	TN001		shale	limestone		4,035
Ccl	TN001		shale	limestone		9,015
Cn	TN001		shale	limestone		1
Cr	GWJeff 1:24,000	Rome	Shale	Limestone		13,753
Cr	TN001		shale	siltstone		5,190
Dch	GWJeff 1:24,000	Chemung	Sandstone	Shale	Conglomerate	10,596
Dch	VA003		shale	sandstone		7,393
Dh	GWJeff 1:24,000	Helderberg Sandstone	Sandstone	limestone		10
Dh	GWJeff 1:24,000	Helderberg Sandstone	Sandstone	limestone		609
DIS	GWJeff 1:24,000	Devonian-Silurian	Sandstone	Limestone	Conglomerate	98
Dl	GWJeff 1:24,000	lower Devonian	Sandstone	Limestone		1,321
Dmn	GWJeff 1:100,000	Millboro Shale, Needmore	Shale	Mudstone	Limestone	14,781
Dohl	WV002		sandstone	limestone		205
DS	GWJeff 1:24,000		Sandstone	Limestone		4,692
DSu	GWJeff 1:24,000	Devonian-Silurian	Siltstone	Limestone	Sandstone	718
DSu	GWJeff 1:24,000	Devonian-Silurian	Sandstone	Limestone	Conglomerate	10,518
DSz	GWJeff 1:24,000		Sandstone	Limestone		922
DSz	VA003		sandstone	limestone		6,565
M	GWJeff 1:24,000	Chester series	Sandstone	Shale	Mudrock	1,418
Mbf	GWJeff 1:24,000	Bluefield	Shale	Limestone	Siltstone	5,326
Mbf	VA003		shale	limestone		1,270
Mh	GWJeff 1:24,000	Hinton - middle red Member	Shale	Siltstone	Limestone	5,413
Mhl	GWJeff 1:24,000	Hinton- Little Stn. Gap Member	Mudstone	Limestone		147
Mmu	GWJeff 1:24,000	Newman - upper member	Siltstone	Limestone	Shale	15
Mppu	GWJeff 1:24,000	Pennington – Stn. Gap Member	Siltstone	Sandstone	Limestone	1,198
Mz	VA003		shale	limestone		12,353
Oa	GWJeff 1:24,000	Athens	Shale	Limestone		2,217
Oj	GWJeff 1:24,000	Juniata	Sandstone	Shale	Limestone	7,409
Okpl	VA003		sandstone	conglomerate		514
Ols	GWJeff 1:24,000	Moccasin and Bays	Mudstone	Limestone	Siltstone	47,581
Ols	VA003		shale	mudstone		8,288
Om	GWJeff 1:100,000	Martinsburg	Shale	Sandstone	Calcitic Shale	12,068
Om	GWJeff 1:24,000	Martinsburg	Shale	Limestone		133,865
Om	WV002		shale	limestone		136,426
Omb	TN001		shale	limestone		1,136
Omlc	TN001		shale	limestone		762
Or	GWJeff 1:24,000	Reedsville Shale	Shale	Limestone		1,185
Ordr	GWJeff 1:100,000	Reedsville and Dolly Ridge	Shale	Sandstone	Limestone	4,291
Os	GWJeff 1:24,000	Sequatchie	Mudstone	Siltstone	Limestone	1,514
Osr	GWJeff 1:24,000	Sequatchie and Reedsville	Shale	Mudstone	Limestone	1,853
Osv	TN001		shale	limestone		1,007
Ous	VA003		shale	mudstone		164
P	GWJeff 1:100,000	Perioditite	Peridotite			17

Smc	1:250,000	McKenzie-Clinton Gp	Shale	Limestone	Sandstone	2,882
Su	GWJeff 1:24,000	upper Silurian	Sandstone	Limestone		2,097
	Total					662,128
SHALE ROCK – group 5						
Cpv	TN001		shale	siltstone		136
Db	GWJeff 1:100,000	Brallier Shale	Shale			2,746
Db	GWJeff 1:24,000	Brallier Fm	Shale	Siltstone	Sandstone	335,631
Db	WV002		shale	siltstone		31,700
Dch	VA003		shale	sandstone		8,837
Dcl	GWJeff 1:24,000	Chattanooga S- Lower Member	Shale			189
Dcw	GWJeff 1:24,000	Chattanooga & Wildcat Valley	Shale	Siltstone	Sandstone	18,593
Dg	GWJeff 1:24,000	Genesee	Shale			53
Dm	GWJeff 1:24,000	Brallier and Millboro	Shale			149
Dm	GWJeff 1:24,000	Millboro Shale	Shale			7,588
Dmb	WV002		shale	black shale		325
Dmn	GWJeff 1:100,000	Millboro Shale	Shale			282
Dmn	GWJeff 1:24,000	Millboro Shale, Needmore	Shale			2,691
Dmn	VA003		black shale	shale		5,074
Dmu	WV002		shale			6,465
Doh	GWJeff 1:24,000	Ohio	Shale			2,465
Dx	VA003		black shale	chert		20,943
MDc	TN001		black shale			4,101
MDcw	VA003		black shale	siltstone		13,329
MDsb	GWJeff 1:24,000	Chattanooga –Sunburury, Berea	Shale	Siltstone	Sandstone	379
Mh	WV002		shale	sandstone		50,866
Mm	GWJeff 1:24,000	Maccrady	Shale	Siltstone		87
Mp	TN001		shale	siltstone		6,010
Mp	VA003		shale	sandstone		34,907
Ob	TN001		claystone	siltstone		207
Ols	VA003		shale	mudstone		111,569
Ou	VA003		shale	siltstone		25,130
Ous	VA003		shale	mudstone		88,767
Oz	VA003		shale	sandstone		2,718
Plsh	GWJeff 1:24,000	Lee	Shale			55
Sch	GWJeff 1:24,000	Clinch, Hagan Shale Member	Shale	Siltstone		93
Sct	WV002		shale	sandstone		8,328
Shrc	VA003		shale	siltstone		24,303
Skrt	GWJeff 1:24,000	Keffer, Rose Hill and Tuscorora	Sandstone	Shale	Conglomerate	11
Sr	TN001		shale	siltstone		141
Total						814,868
water	VA003		water			2,954
FM. SYMBOL	Blue Ridge SOURCE	FMNAME	PRIMARY ROCK	SECONDARY	TERTIARY	acres
CARBONATE-BEARING ROCKS – group 1						
[co	VA003		limestone	dolostone		23,491
[s	VA003		dolostone	limestone		53,500
Cco	GWJeff 1:24,000	Conococheague	Limestone	Dolomite	Sandstone	17,526
Ccr	GWJeff 1:24,000	Copper Ridge	Dolomite	Sandstone		3,360
Ccu	TN001		dolostone	shale		1,189
Ce	GWJeff 1:24,000	Elbrook	Dolomite	Limestone	Shale	71,386
Ce	TN001		quartzite	shale		2,910
Chk	TN001		dolostone	limestone		1,165
Cs	TN001		dolostone	limestone		92,102
O[co	VA003		limestone	dolostone		9,354
O[z	VA003		limestone	dolostone		8,055
Ob	VA003		dolostone	limestone		32,882
OCco	GWJeff 1:100,000	Conococheague	Limestone	Dolomite	Sandstone	49
OCk	TN001		dolostone	limestone		11,915
Oe	GWJeff 1:24,000	Edinburg	Limestone	Shale		370
Ojb	TN001		limestone	dolostone		160
TOTAL						329,414
FELSIC IGNEOUS AND METAMORPHIC ROCKS – group 2						
[Zas	VA003		schist			10,288
[Zmy	VA003		meta-argillite	schist		121,560
my	VA003		mylonite	gneiss		1,978
pCcgg	GWJeff 1:24,000	mylonite gneiss	Gneiss			269
pCmc	GWJeff 1:24,000	massive charnokite	Charnokite	Granite		379
pCmcm	GWJeff 1:24,000	mylonite gneiss	Gneiss			0

pCmy	GWJeff 1:24,000	mylonite gneiss	Gneiss	Mylonite		7,753
pCsgg	GWJeff 1:24,000	gneiss	Gneiss			5,053
pCv	GWJeff 1:24,000	Pedlar Marshall	Granite	Diorite	Unakite	34,387
pCZgd	GWJeff 1:24,000	biotite granite	Granite			865
Ybg	VA003		augen gneiss			25,224
Ybgg	NC002		granitic gneiss	amphibolite		9,648
Yc	VA003		granitic gneiss			9,981
Yec	VA003		quartz monzonite			167,929
Yep	VA003		augen gneiss	Qrtz. monzonite		12,596
Ygb	VA003		gneiss	granulite		23,797
Ygn	VA003		granulite	gneiss		12,182
Yma	VA003		felsic gneiss	flaser gneiss		7,958
Ypc	VA003		granite			5,805
Ypg	1:250,000	Gneiss	pyrox. granulite			1,058
Ypg	VA003		granulite			14,682
Ypp	VA003		granulite			15,732
Zabg	NC002		gneiss	conglomerate		3,524
Zabs	NC002		mica schist	phyllite		566
Zam	VA003		biotite gneiss			347,047
Zas	VA003		mica schist	phyllite		30,034
Zatm	NC002		gneiss	mica schist		9,396
Zgds	VA003		granite	syenite		417
Zmb	GWJeff 1:24,000	Mt Rogers - Buzzard Rock	Rhyolite			2,443
Zmf	GWJeff 1:24,000	Mt Rogers - Free Rhyolite	Rhyolite			8,011
Zmg	GWJeff 1:24,000	Mt Rogers - granophyre	Granite			58
Zmr	VA003		rhyolite			1
Zmwb	GWJeff 1:24,000	Mt Rogers breccia	Breccia	Rhyolite		546
TOTAL						891,166
[eh	VA003		sandstone	quartzite		50,450
[u	VA003		sandstone	quartzite		639
Ca	GWJeff 1:100,000	Antietam	Quartzite			4,784
Cch	1:250,000	Chilhowee Group	Sandstone	Quartz	Phyllite	2,059
Ceh	GWJeff 1:24,000	Erwin and Hampton Fms	Sandstone	Quartzite	Shale	29,561
Cu	TN001		sandstone	arkose		3,459
Cul	GWJeff 1:24,000	Lower Unicoi	Sandstone	Phyllite	Conglomerate	1,769
Cw	GWJeff 1:100,000	Weverton Fm	Sandstone Conglomerate	Phyllite	Mixed Conglomerate	1
DSOz	VA003		sandstone	shale		1,630
Qal	GWJeff 1:24,000	alluvium	Gravel			956
Qf	GWJeff 1:24,000	fan deposit	Gravel			6,089
Qt	GWJeff 1:24,000	terrace deposit	Gravel			194
Zk	GWJeff 1:24,000	Konnarock Fm - undivided	Diamictite	Rhythmite	Argillite	8,204
Zkd	GWJeff 1:24,000	Konnarock Fm	Diamictite			3,017
Zml	GWJeff 1:24,000	Mt Roger lower undivided	Conglomerate	Graywacke	Siltstone	10,946
TOTAL						123,758
SILICICLASTIC ROCKS – group 3						
[eh	VA003		sandstone	quartzite		50,450
[u	VA003		sandstone	quartzite		639
Ca	GWJeff 1:100,000	Antietam	Quartzite			4,784
Cch	1:250,000	Chilhowee Group	Sandstone	Quartz	Phyllite	2,059
Ceh	GWJeff 1:24,000	Erwin and Hampton Fms	Sandstone	Quartzite	Shale	29,561
Cu	TN001		sandstone	arkose		3,459
Cul	GWJeff 1:24,000	Lower Unicoi	Sandstone	Phyllite	Conglomerate	1,769
Cuu	GWJeff 1:24,000	Upper Unicoi	Conglomerate	Phyllite	Siltstone	1,422
Cw	GWJeff 1:100,000	Weverton Fm	Sandstone	Phyllite	Mixed	1
DSOz	VA003		sandstone	shale		1,630
Qal	GWJeff 1:24,000	alluvium	Gravel			956
Qf	GWJeff 1:24,000	fan deposit	Gravel			6,089
Qt	GWJeff 1:24,000	terrace deposit	Gravel			194
Zk	GWJeff 1:24,000	Konnarock Fm - undivided	Diamictite	Rhythmite	Argillite	8,204
Zkd	GWJeff 1:24,000	Konnarock Fm	Diamictite			3,017
Zml	GWJeff 1:24,000	Mt Roger lower undivided	Conglomerate	Graywacke	Siltstone	10,946
TOTAL						125,180
SHALE ROCK – group 5						
[r	VA003		shale	siltstone		120,550
Ch	TN001		shale	sandstone		2,402
Cham	GWJeff 1:24,000	Hampton	Shale	Sandstone		12,188
Cr	TN001		shale	siltstone		119,078
Cwbs	GWJeff 1:24,000	Waynesboro and Shady	Shale	Dolomite	Limestone	8,415

Db	VA003		shale	siltstone		5
Dch	VA003		shale	sandstone		158
Dm	GWJeff 1:24,000	Millboro Shale	Shale			23
Dmn	VA003		black shale	shale		1,181
DS	GWJeff 1:24,000		Sandstone	Limestone		28
Oa	GWJeff 1:24,000	Athens	Shale	Limestone		1,490
Okpl	GWJeff 1:24,000	Knobs, Paperville, Lenoir +	Sandstone	Limestone	Shale	23,295
Okpl	VA003		sandstone	conglomerate		20,705
Ols	VA003		shale	mudstone		5,205
Om	GWJeff 1:24,000	Martinsburg	Shale	Limestone		3,418
Osv	TN001		shale	limestone		13,586
Ous	VA003		shale	mudstone		1,472
TOTAL						333,200

MAFIC AND ULTRAMAFIC ROCKS – group 6

[Zum	VA003		ultramafic rock	schist		4,817
Zaa	VA003		amphibolite			45,220
Zata	NC002		amphibolite	metasedimentary		1,199
[Zum	VA003		ultramafic rock	schist		4,817
Zaa	VA003		amphibolite			45,220
Zata	NC002		amphibolite	metasedimentary		1,199
[Zum	VA003		ultramafic rock	schist		4,817
Zaa	VA003		amphibolite			45,220
Zata	NC002		amphibolite	metasedimentary		1,199
[Zum	VA003		ultramafic rock	schist		4,817
Zaa	VA003		amphibolite			45,220
Zata	NC002		amphibolite	metasedimentary		1,199
[Zum	VA003		ultramafic rock	schist		4,817
Zaa	VA003		amphibolite			45,220
Zata	NC002		amphibolite	metasedimentary		1,199
[Zum	VA003		ultramafic rock	schist		4,817
Zaa	VA003		amphibolite			45,220
Zata	NC002		amphibolite	metasedimentary		1,199
[Zum	VA003		ultramafic rock	schist		4,817
Zaa	VA003		amphibolite			45,220
Zata	NC002		amphibolite	metasedimentary		1,199
[Zum	VA003		ultramafic rock	schist		4,817
Zaa	VA003		amphibolite			45,220
Zata	NC002		amphibolite	metasedimentary		1,199
[Zum	VA003		ultramafic rock	schist		4,817
Zaa	VA003		amphibolite			45,220
Zata	NC002		amphibolite	metasedimentary		1,199
[Zum	VA003		ultramafic rock	schist		4,817
Zaa	VA003		amphibolite			45,220
TOTAL						51,236

VOCANIC TUFFS – group 7

Zm	GWJeff 1:24,000	Mt Rogers volcanics - undivided	Rhyolite	Tuff		24,556
Zmw	GWJeff 1:24,000	Mt Rogers welded tuff	Tuff			9,105
Zmwp	GWJeff 1:24,000	Mt Rogers welded tuff	Tuff			478
Zmwtt	GWJeff 1:24,000	Mt Rogers Whitetop Rhyolite	Lappili Tuff			186
TOTAL						34,325

VOCANIC LAVAS – group 8

Zmwt	GWJeff 1:24,000	Mt Rogers Whitetop Rhyolite	Lava			10,029

CONTACT ZONE ROCKS1 – group 9

[ch	VA003		quartzite	conglomerate		34,344
Ch	GWJeff 1:100,000	Harpers Fm	Sandstone	Phyllite	Quartzite	4,315
Ch	GWJeff 1:24,000	Honaker Fm	Sandstone	Phyllite	Quartzite	19,314
Cu	GWJeff 1:100,000	Unicoi Fm	Sandstone	Quartizite	Phyllite	101
Cu	GWJeff 1:24,000	Unicoi Fm	Sandstone	Quartzite	Phyllite	54,248
TOTAL						112,322

CONTACT ZONE ROCKS2 – group 10

Ca	GWJeff 1:24,000	Antietam Fm	Quartzite	Sandstone	Phyllite	112
Cer	GWJeff 1:24,000	Erwin Fm	Quartzite	Sandstone		46,480
TOTAL						46,592
water	VA003		water			5,405

Apendix IX: Use of Ecological Zones

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

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

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

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

From 2008 to 2011, Ecological Zones were mapped in the Cumberland Plateau of Kentucky, in the South Mountains, Northern Escarpment, and New River Fire FLN landscapes within the Southern Blue Ridge (SBR) in North Carolina to evaluate the location and extent of fire-adapted plant communities. From 2009 to 2010, Ecological Zones were mapped in the Virginia-West Virginia Fire Learning Network study area and for the George Washington National Forest to evaluate fire-adapted plant communities and to provide vegetation mapping for the Forest Plan revision. In 2011, Ecological Zones were mapped in Tennessee on the Cherokee National Forest – northend as part of a landscape restoration initiative, and a 3rd Approximation of Ecological Zones in the Southern Blue Ridge was completed. Work on developing Ecological Zone maps for the Jefferson National Forest study area in Virginia began in early 2012 and was completed in late 2013. Mapping of Ecological Zones on South Carolina's coast in the Francis Marion National Forest was also started in 2012 as part of the US Forest Service Plan Revision process and is scheduled for completion in 2013. Future work is planned for the Sumter National Forest in South Carolina.

Appendix VIII: Codes for Ecological Zones and NatureServe Ecological Systems

Code	Ecological Zone name
1	Spruce
2	Northern Hardwood Slope
3	Northern Hardwood Cove
4	Acidic Cove
5	Rich Cove
6	Alluvial Forest
8	High Elevation Red Oak
9	Montane Oak (slope type)
10	Dry Oak/Evergreen Heath (Mt. Laurel)
11	Dry Oak/Deciduous Heath (Huckleberry-Vaccinium)
13	Dry Mesic Oak
14	Dry Mesic Calcareous Forest
15	Montane Oak (cove type)
16	Shortleaf Pine-Oak
17	Dry Calcareous Forest
18	Pine-Oak Heath
21	Shale Barren
22	Pine-Oak Shale Woodland
23	Floodplain Forest
24	Montane Oak (rich type)
27	Acid Glade
29	Limestone-Dolomite Barren
30	Grass Bald
31	Basic Oak-Hickory
44	Mixed Oak/Rhododendron
55	Rich Slope
99	Lakes
222	Xeric Pine-Oak

Code	NatureServe Ecological System
1	Central and Southern Appalachian Spruce-Fir Forest
2	Southern Appalachian Northern Hardwood
4	Southern and Central Appalachian Cove Forest
6	Central Appalachian Stream and Riparian
8	Central and Southern Appalachian Montane Oak
9	Southern and Central Appalachian Northern Red Oak-Chestnut Oak Forest
10	Allegheny-Cumberland Dry Oak Forest and Woodland
13	Southern Appalachian Oak Forest
16	Southern Appalachian Low-Elevation Pine
17	Southern Ridge and Valley / Cumberland Dry Calcareous Forest
18	Southern Appalachian Montane Pine Forest and Woodland
21	Central Appalachian Shale Barren
23	Central Appalachian River Floodplain
27	Central Appalachian Pine-Oak Rocky Woodland
29	Southern Ridge and Valley Calcareous Glade and Woodland
30	Southern Appalachian Grass and Shrub Bald
31	Northeastern Interior Dry-Mesic Oak Forest
99	Lakes