Fire Restoration Needs in the Southern Appalachian Landscapes

Gary Kauffman, Botanist

National Forests in NC

Discussion

- **Identification of Fire Dependent or Fire-loving plant communities**
- **Identification of Fire Dependent or Fire-loving rare species**
- **Development of Fire Unit Ecological Ranking Model**
- **LiDAR/Landfire tools to identify existing and desired structural components**

Easier to assess Fire Needs by Ecological Communities

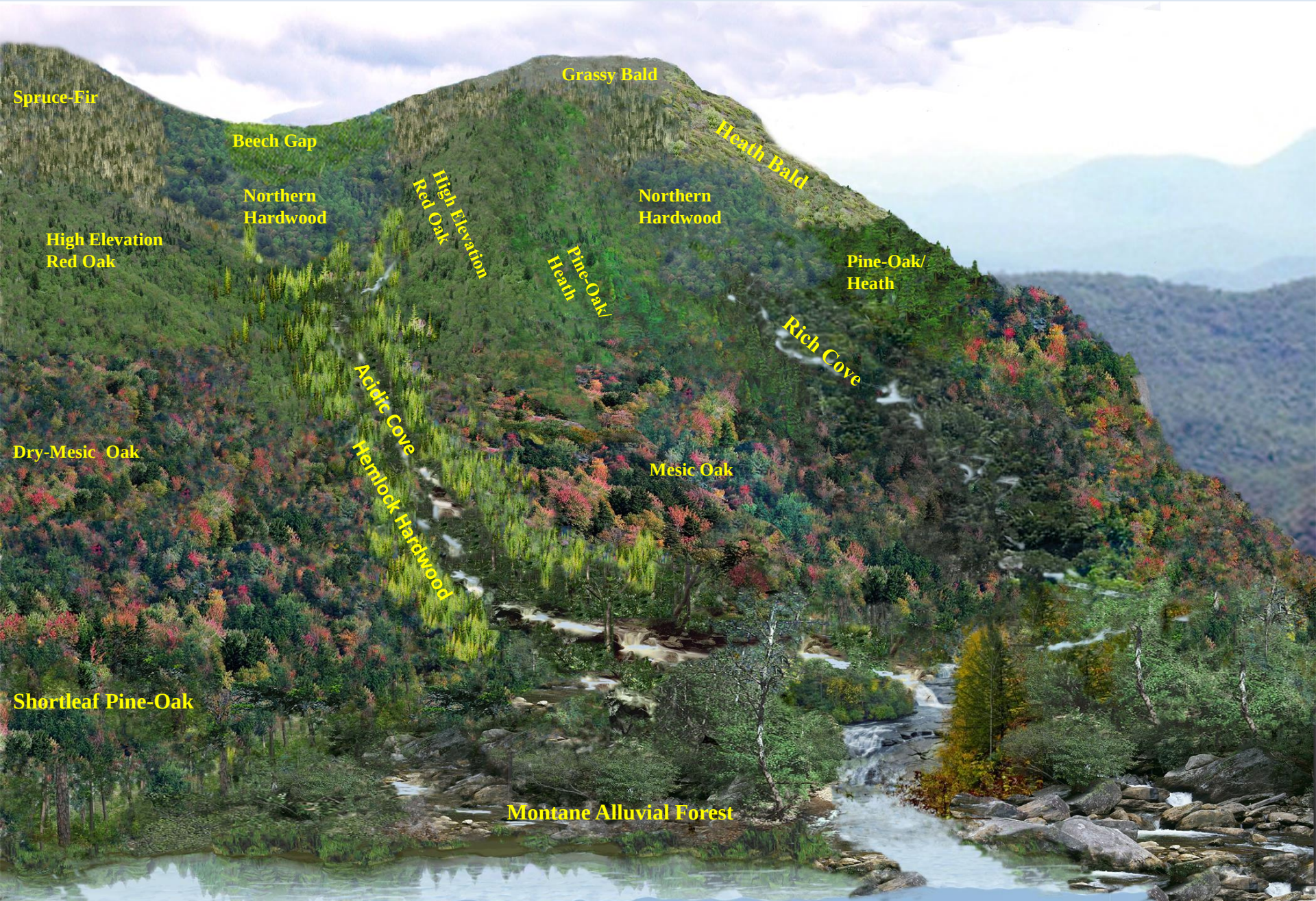
What is an Ecological Community ?

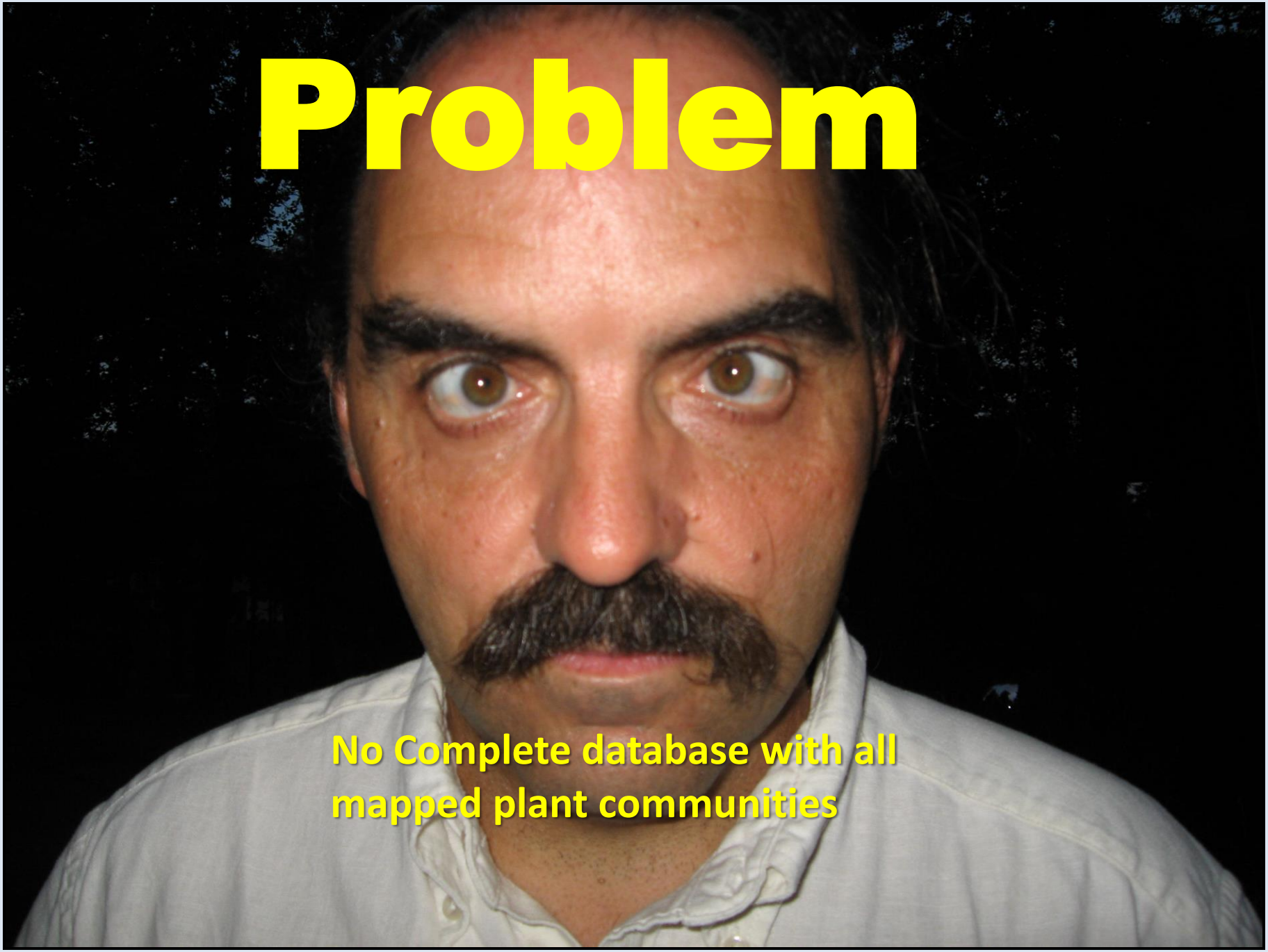
An assemblage of co-existing, interacting species, considered together with the physical environment and associated ecological processes, that typically recurs on the landscape.

Vegetation typically reflects biological and ecological landscape patterns, plants often faithful indicators of site conditions

Vegetation types are the standard for classification, element ranking, mapping, and conservation planning.

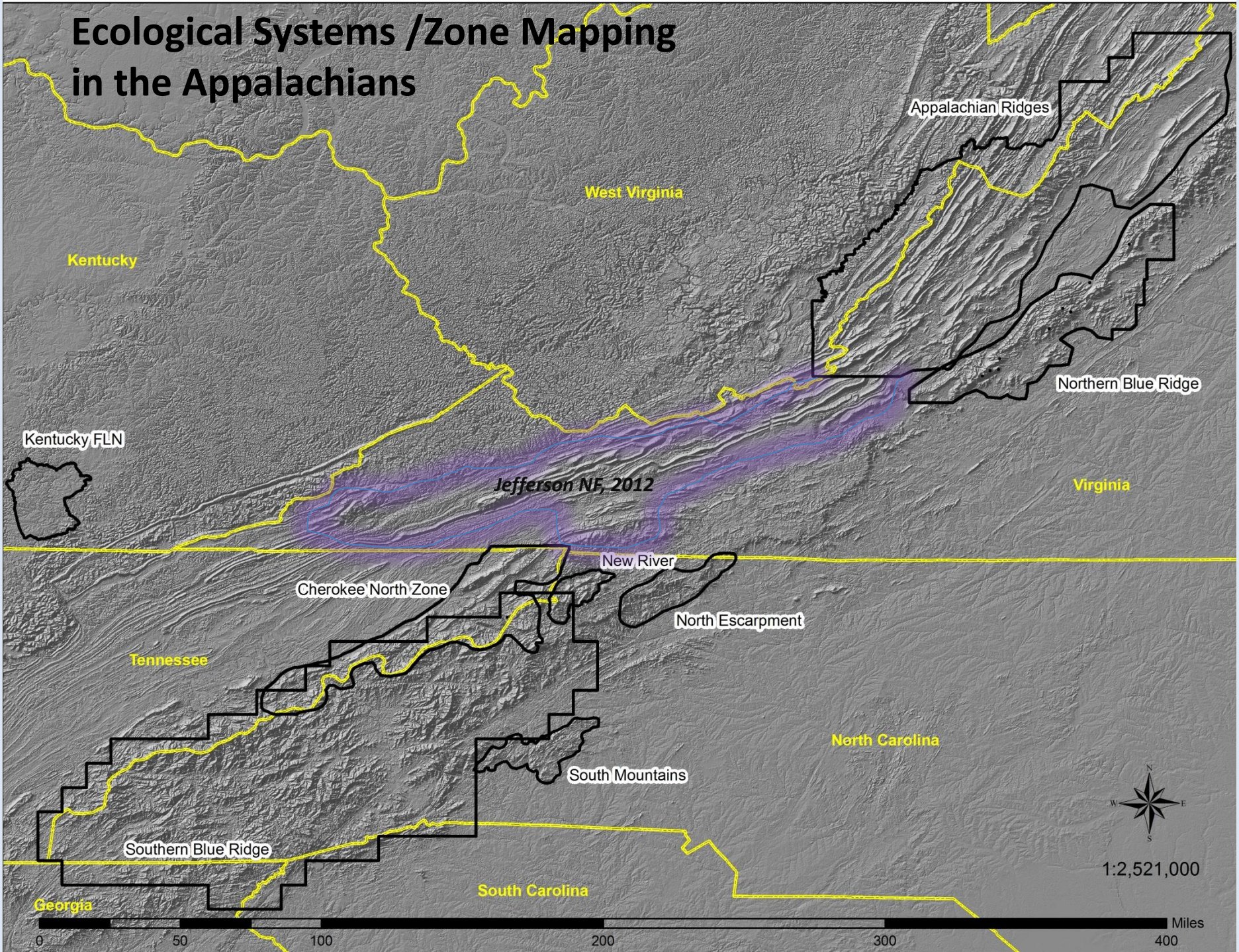
Plant Communities in Southern Appalachian Landscape




Problem
No Complete database with all mapped plant communities

Ecological Zones

Ecological Zones are units of land that can support a specific plant community or plant community group based upon environmental factors such as temperature, moisture, fertility, and solar radiation that control vegetation distribution. They may or may not represent existing vegetation, but instead, the vegetation that could occur on a site with historical disturbance regimes.


Ecological Systems /Zone Mapping in the Appalachians
Appalachian Ridges
West Virginia
Kentucky
Northern Blue Ridge
Kentucky FLN
Jefferson NF, 2012
Virginia
New River
Cherokee North Zone
North Escarpment
Tennessee
North Carolina
South Mountains
Southern Blue Ridge
South Carolina
Georgia
1:2,521,000
Miles
0
50
100
200
300
400

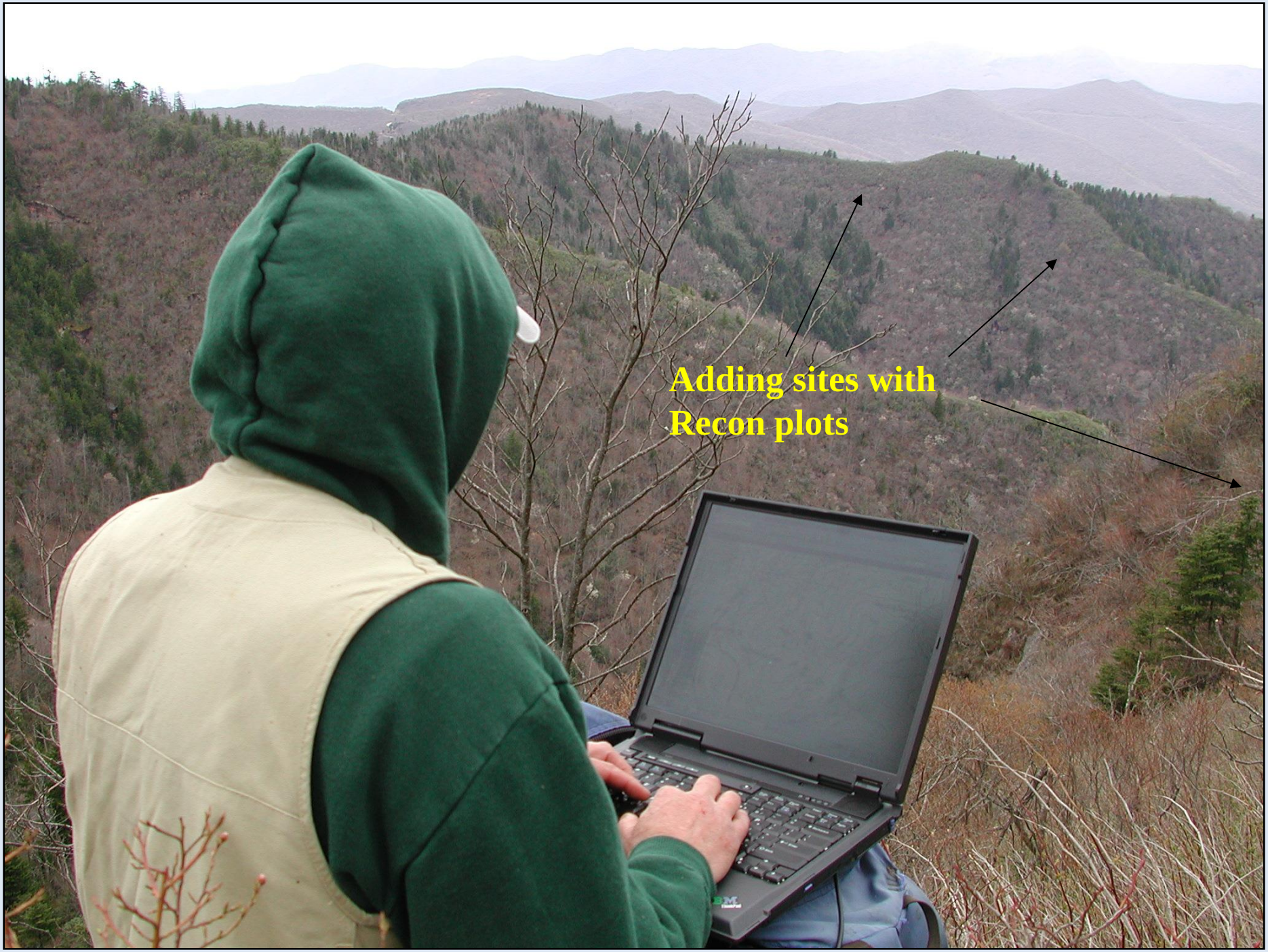
The Southern Appalachian Vegetation Dataset

(Ulrey, Peet, and others 1999)

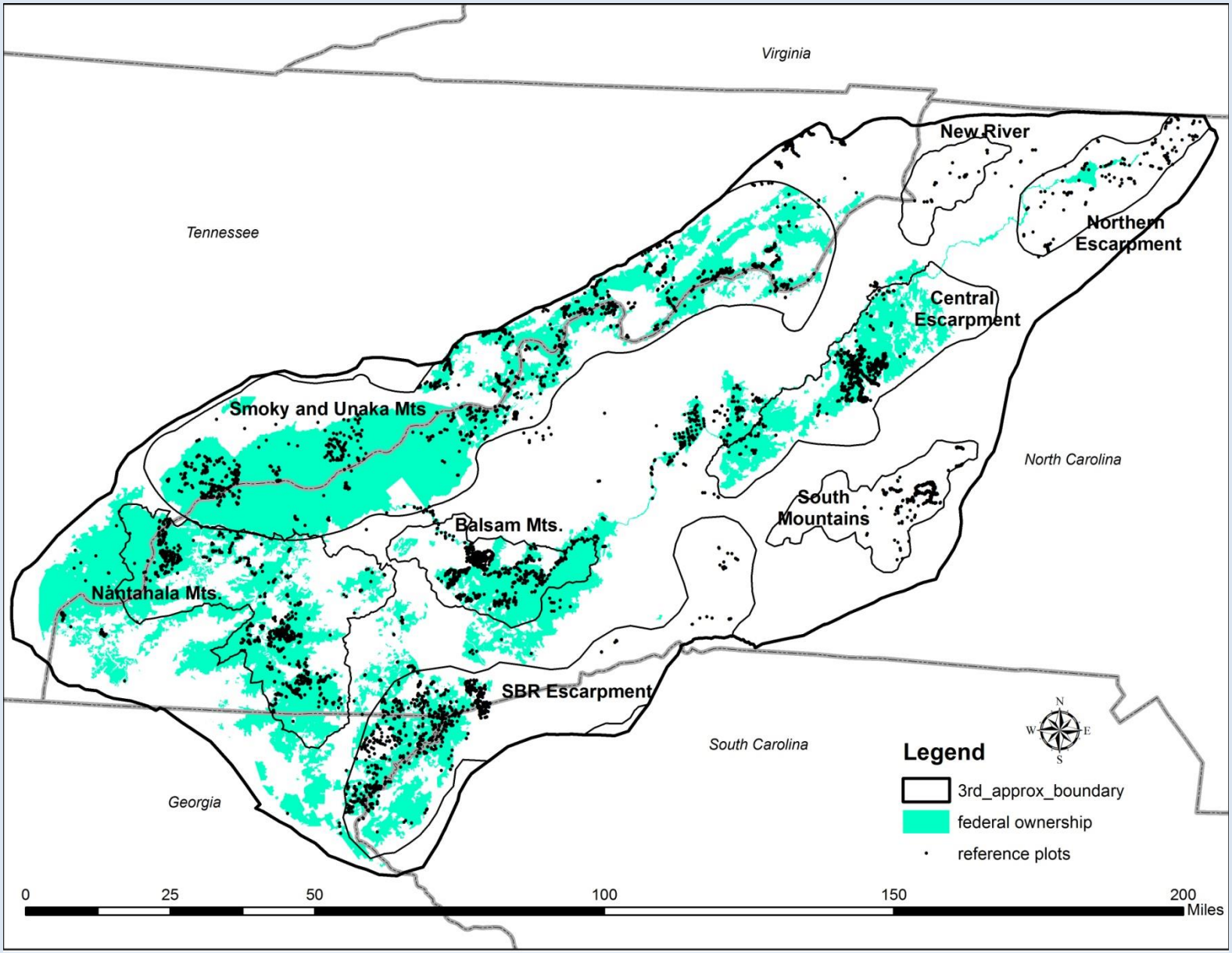
- *2,332 plots, mostly permanent, .05 - .1 ha. in size*
- *plant species presence, abundance*

- **Thompson River** (1976-78. T. Wentworth)
- **High Elevation Red Oak** (1978. J.Delapp & T. Wentworth)
- **Great Smoky Mts.** (1980. P.White)
- **Black and Craggy Mts** (1984. D. Mcleod)
- **Ellicot Rock** (1990-91. K. Patterson)
- **Craggy Mountains** (1991. C.Ulrey)
- **Steels Creek** (1992. C. Ulrey)
- **Grandfather-Roan** (1995. B. Peet)
- **Chattooga Basin** (1995. S. Simon)
- **Linville Gorge** (1995. C. Newell)
- **Nantahala Mountains** (1995-96. B. Peet)
- **Montane Cedar Hardwoods** (1996 C. Small)
- **Kelsey Tract** (1996. S. Roberts)
- **Shining Rock** (1996. Claire Newell)
- **Winesprings** (1996, McNab & Simon)
- **Joyce Kilmer-Slickrock** (1997. Claire Newell)
- **Great Smoky Mts. TNC** (1997-98. K. Patterson & C. Ulrey)
- **Highlands Area - PULSE** (1997. B. Peet)
- **Chimney Rock & Hot Springs PULSE** (1998. B. Peet)

Black Mts. NC

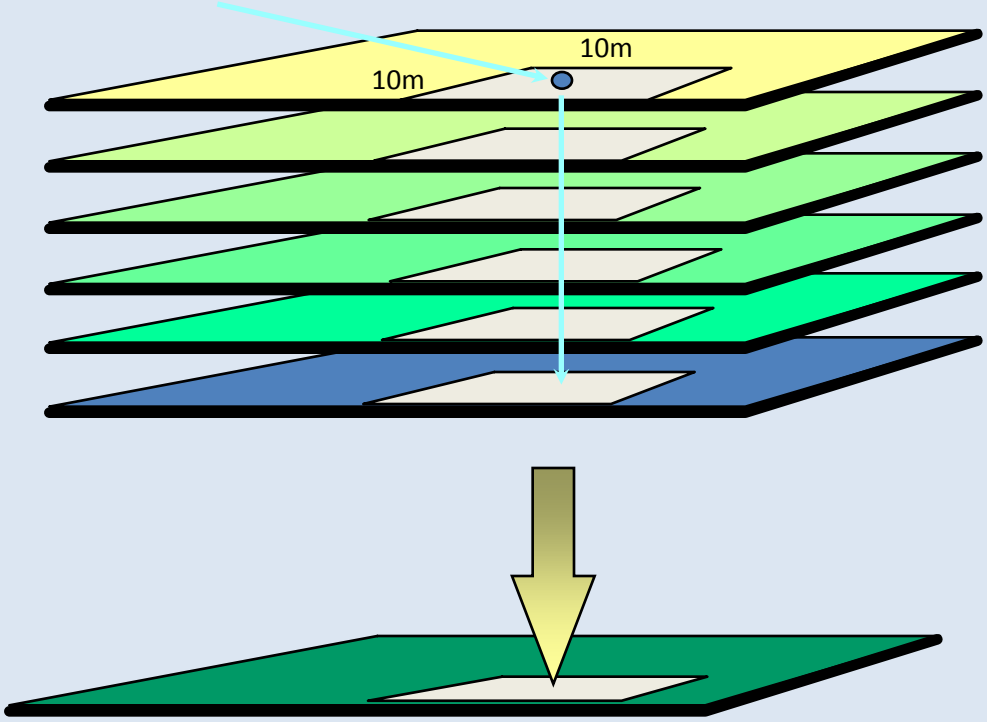

Adding sites with
Recon plots

Plot Distribution (5000 plus)



Ecological Systems / Zone modeling

Known Location (point)



Spatial Data Layers (DTMs)

- **Elevation**
- **Aspect**
- **Slope**
- **Ave. annual precipitation**
- **Relative slope position**
- **Geology (+ 24 others)**

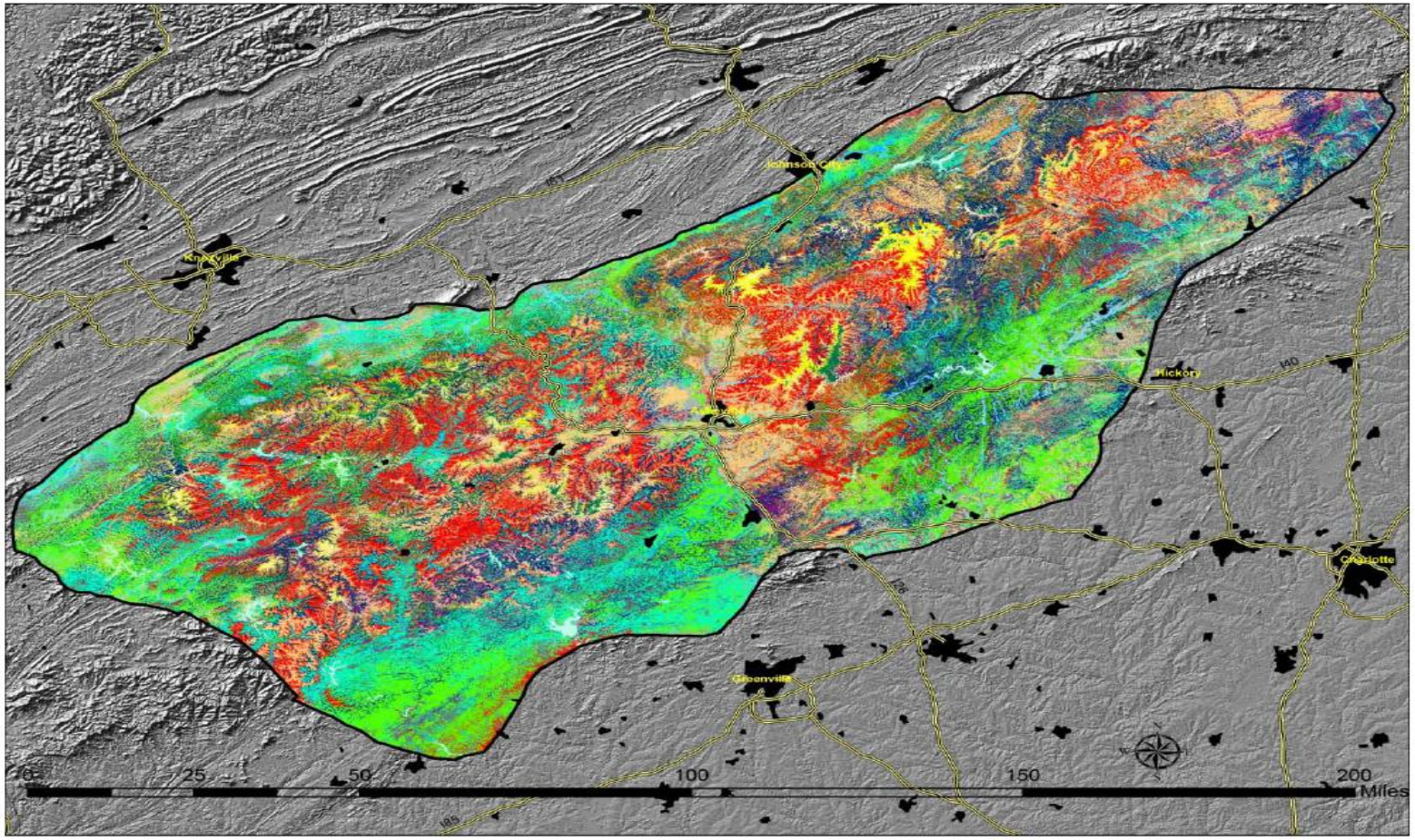
Maxent

= Predicted distribution map from 700+ points

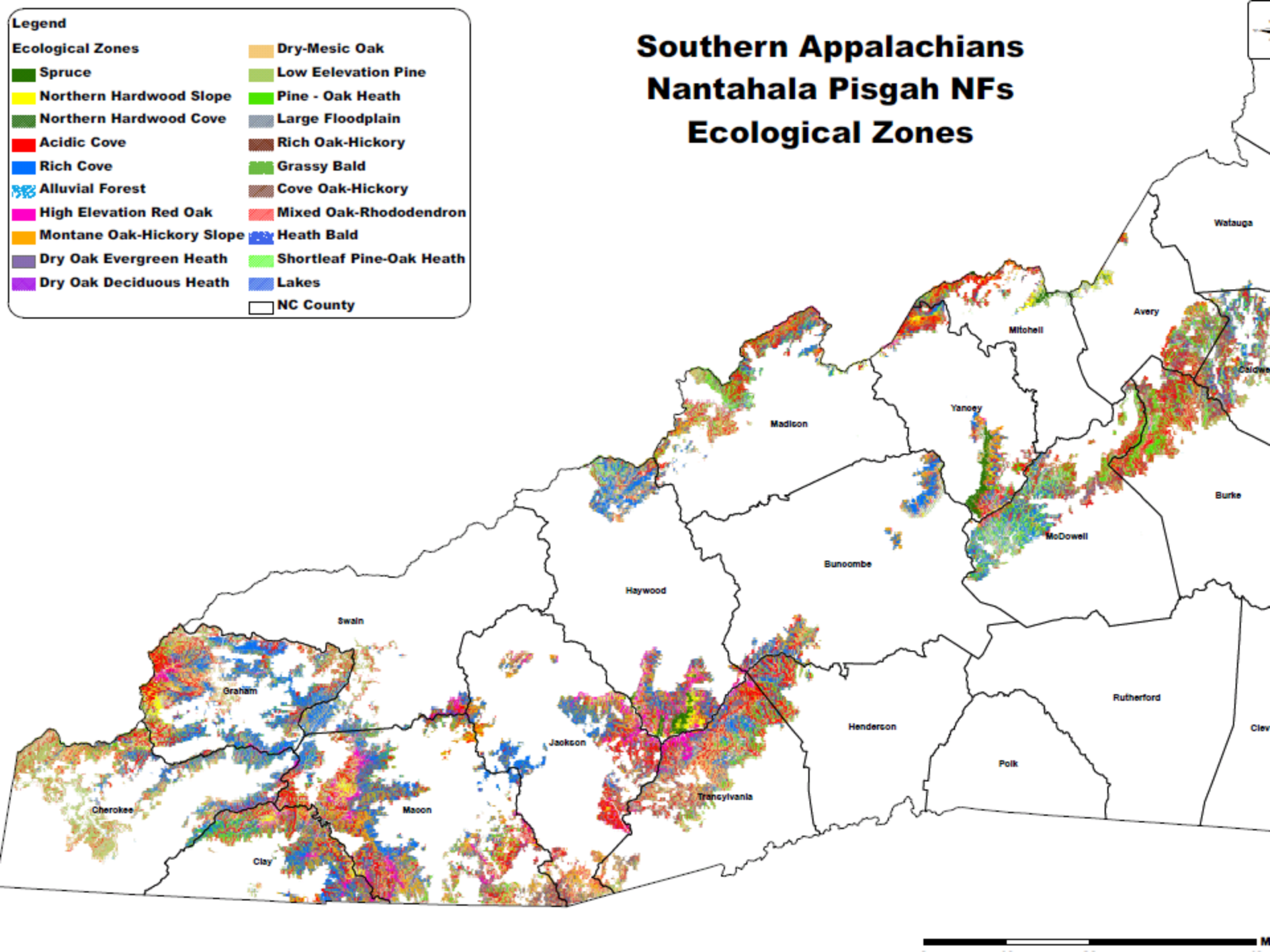
Ecological Zones in the Southern Blue Ridge: 3rd Approximation

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

12/31/2011



Southern Appalachians
Nantahala Pisgah NFs
Ecological Zones



High Elevation > 4200 Feet

10% of Nantahala & Pisgah NFs


Spruce - Fir
Forest

Windy & Cold Often in Clouds


Spruce-Fir Forest
Red Spruce – Fraser Fir
Typically above 5000 feet
Dense to open midstory
Diverse bryophyte layer
Low herb diversity
16,600 ac (1.6%)

Northern Hardwood Forest

Northern Hardwood Cove

Generally above 4200 feet elevation
Protected concave slope
Yellow Birch-Sugar Maple- Yellow Buckeye
Open diverse herb layer – wood nettle, blue cohosh, ramps

34,500 ac 3.3%

Northern Hardwood Slope Forest

Generally above 4200 feet elevation
Drier Convex or steep slope
Yellow Birch-Beech- Northern Red Oak
Typically mixed to open understory
Herb layer sparse – Pennsylvania sedge often dominant
19,500 ac 2%

High Elevation Red Oak Forest

High Elevation --- above 4000 feet, along ridges and exposed sites and steep convex slopes with high growing season rainfall

Community primarily derived from former oak - American chestnut forest

High Elevation Red Oak

Northern Red Oak Dominance
Often Stunted or wind-swept

Ridge tops, primary, secondary, tertiary
Generally above 4000 feet elevation

Variable shrub layer dense to open
Deciduous to evergreen

Low to moderate herb diversity

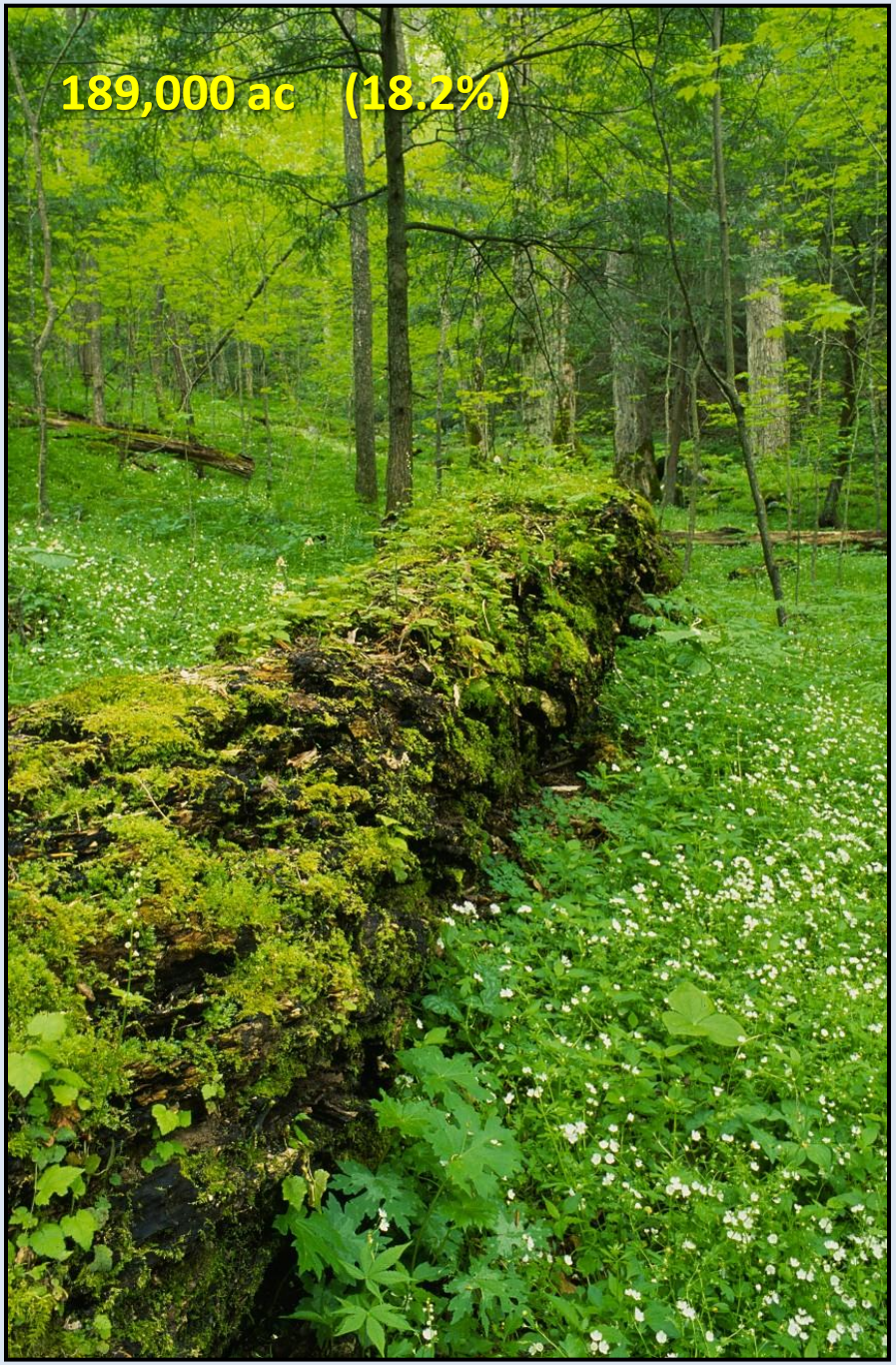
39,000 ac (4%)

Mid Elevation: 2300- 4200 Feet

85% of Nantahala & Pisgah NFs


Rich Cove Forest
Diverse Tree species or potential
Often dominated by tulip poplar due to
past land use history
Open mid-story and shrub layer


Diverse Herb layer
Many spring flowering


189,000 ac (18.2%)


Streamside Acidic Cove Forest

Acidic Cove Forest - Rhodo Hell

Often stream side forests
Protected concave slopes
Tulip poplar- Black Birch – Fraser Magnolia
Moderate to extremely dense shrub layer – typically Great Rhododendron
Herb layer sparse , Bryophyte diversity

240,000 ac (23%)


Dry-Mesic Oak
White Oak – Black Oak-
Chestnut Oak
Moderately closed
understory – huckleberry,
low bush blueberry
Low herb diversity
106,000 ac 10%


"Dry-Mesic" Oak-Hickory Forest

Mesic Oak Forest

White Oak/Red Oak typically dominant
Hickories often present , can be sparse

Generally open midstory
Moderate – Diverse herb diversity

190,000 acres (18%)

Mesic Oak Slope

Mesic Oak Cove


Dry-Mesic Oak
White Oak – Black Oak-
Chestnut Oak
Moderately closed
understory – huckleberry,
low bush blueberry
Low herb diversity
106,000 ac 10%

Dry Oak Forest

Steep south or west-facing slopes
Rocky thin soils

Chestnut Oak

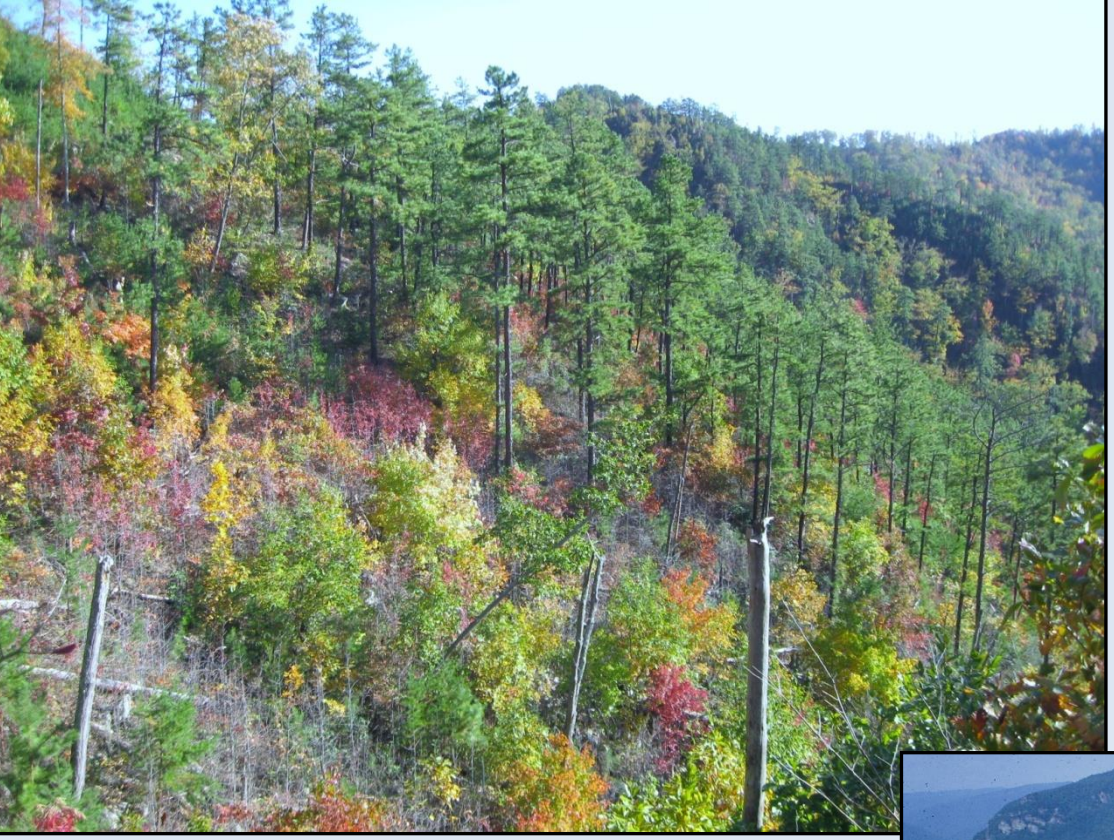
Quercus prinus

Dry Oak

Open to closed evergreen or deciduous shrub layer
Low herb diversity
60,000 acres (6%)

Pine- Oak Heath

101,000 ac (10%)



Closed to open Forest
Pitch Pine- Table Mt Pine- Chestnut Oak

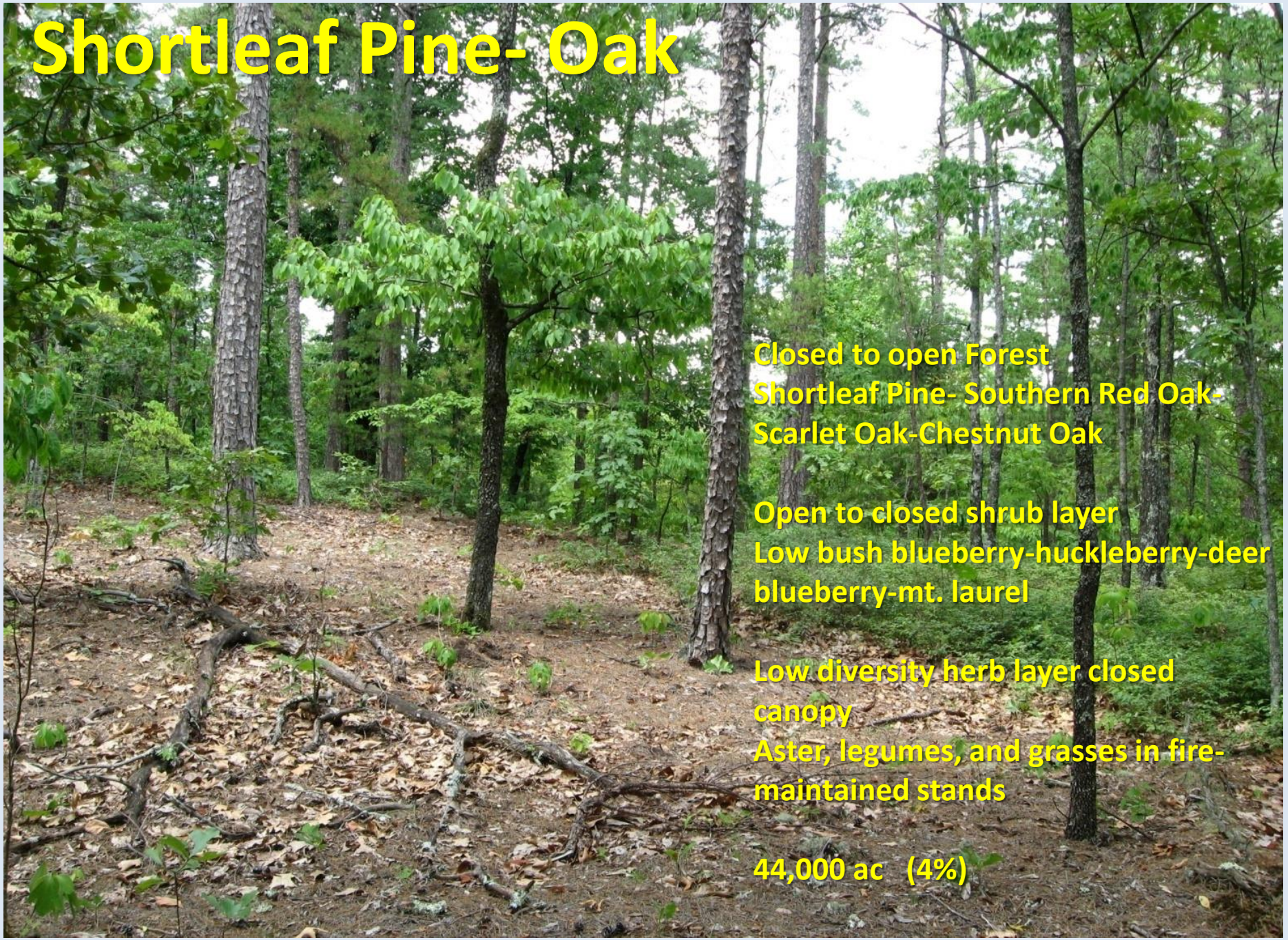
Open to closed shrub layer
Low bush blueberry-huckleberry-deer blueberry-Mt. laurel

Low diversity herb layer closed canopy
Aster, legumes, and grasses in fire-maintained stands – turkey beard

Low Elevation < 2300 Feet

5% of Nantahala & Pisgah NFs

Shortleaf Pine- Oak



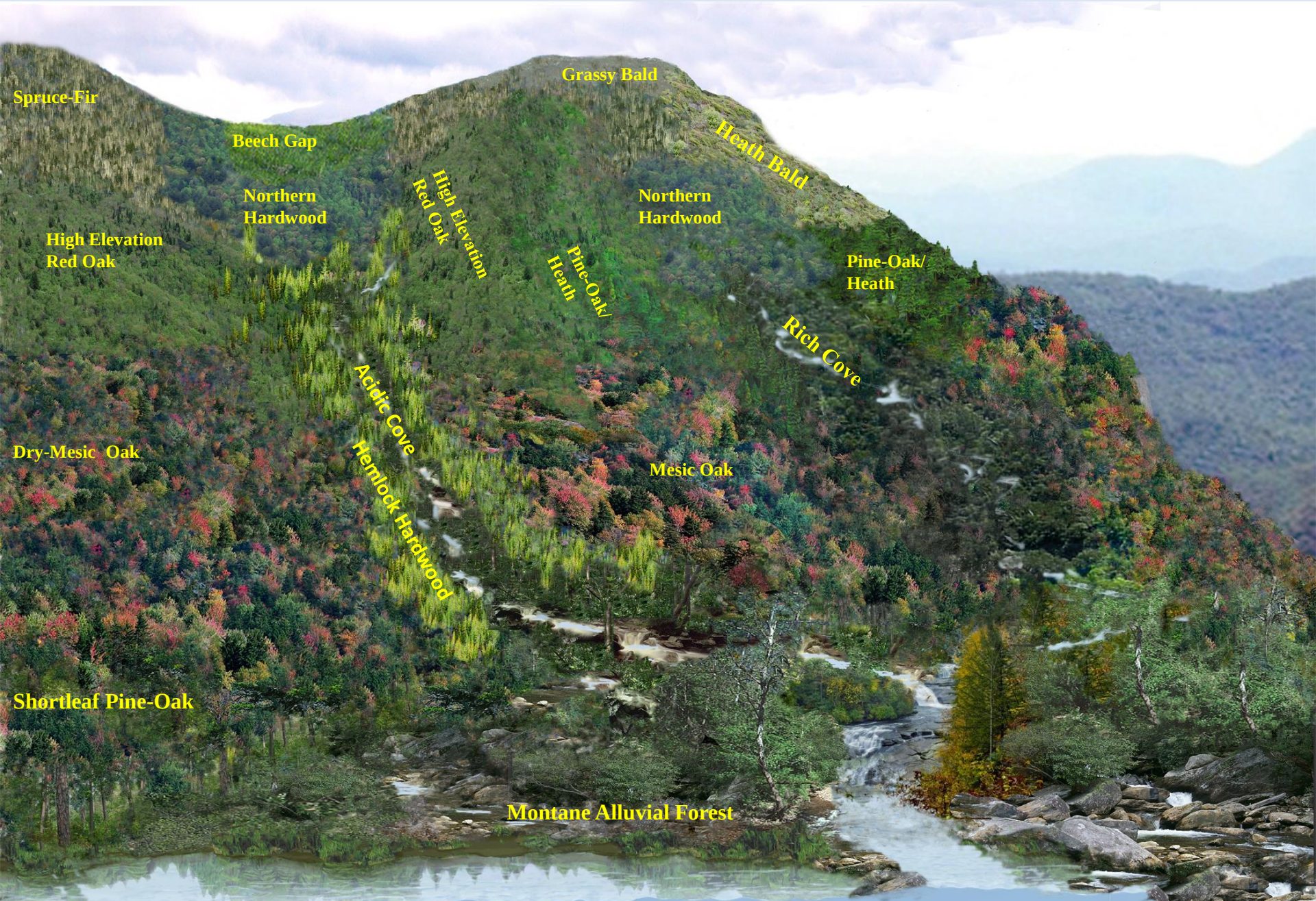
Closed to open Forest
Shortleaf Pine- Southern Red Oak-Scarlet Oak-Chestnut Oak

Open to closed shrub layer
Low bush blueberry-huckleberry-deer blueberry-mt. laurel

Low diversity herb layer closed canopy
Aster, legumes, and grasses in fire-maintained stands

44,000 ac (4%)

Plant Communities in Southern Appalachian Landscape



Fire Adapted Ecological Zones
Grandfather RD

Type	Acres
Pine	53541
Oak	79800
Total	133341

Legend

Ecological Zone

- High Elevation Red Oak
- Mesic Oak-Hickory
- Chestnut Oak/Heath
- Pine-Oak/Heath
- Dry-Mesic Oak-Hickory
- Shortleaf Pine-Oak
- Shortleaf Pine-Oak/Heath
- Grandfather Ranger District
- Blue Ridge Parkway

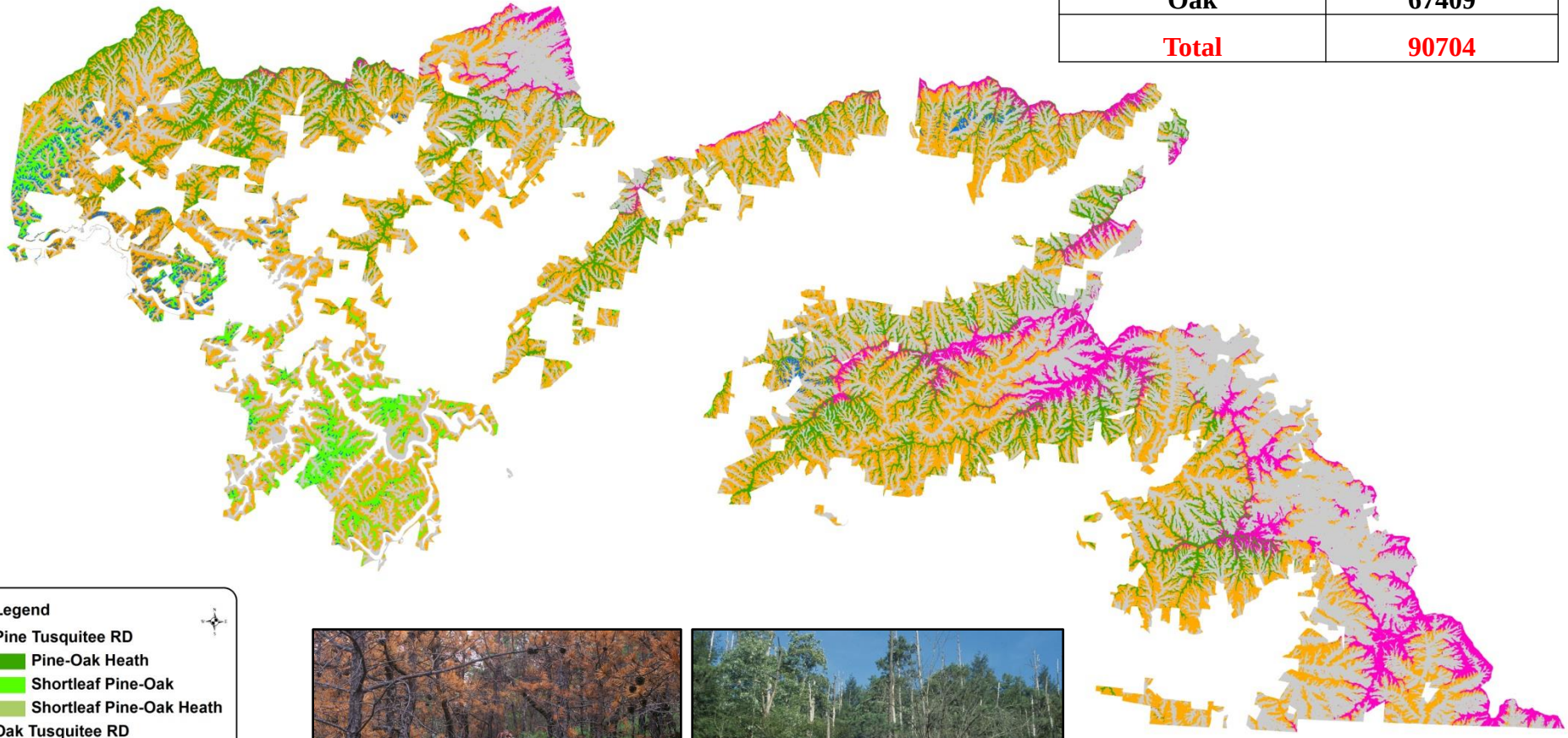
0 3.75 7.5 15 Miles

Fire Adapted Ecological Zones
Cheoah RD

Type	Acres
Pine	20647
Oak	51252
Total	71899

Fire Adapted Ecological Zones
Tusquitee RD

Type	Acres
Pine	23295
Oak	67409
Total	90704



Legend

Pine Tusquitee RD
- Pine-Oak Heath
- Shortleaf Pine-Oak
- Shortleaf Pine-Oak Heath

Oak Tusquitee RD
- High Elevation Red Oak
- Mesic Oak-Hickory
- Chestnut Oak Heath
- Dry-Mesic Oak-Hickory
- Tusquitee RD

Miles
0 3 6 12

Fire Adapted Ecological Zones
Appalachian RD

Type	Acres
Pine	41595
Oak	42083
Total	83678

Miles
0 4.5 9 18

Legend
Pine Appalachian RD
Pine-Oak Heath
Shortleaf Pine-Oak
Shortleaf Pine-Oak Heath
Oak Appalachian RD
High Elevation Red Oak
Mesic Oak-Hickory
Chestnut Oak Heath
Dry-Mesic Oak-Hickory
Appalachian RD
Blue Ridge Parkway

Fire Adapted Ecological Zones Nantahala RD

Type	Acres
Pine	8993
Oak	90720
Total	99713

Fire Adapted Modeled Ecological Zones Pisgah RD

Type	Acres
Pine	1190
Oak	61696
Total	62886

Legend
Oak Pisgah RD
High Elevation Red Oak
Mesic Oak-Hickory
Chestnut Oak Heath
Dry-Mesic Oak-Hickory
Pine Pisgah RD
Pine-Oak Heath
Shortleaf Pine-Oak
Shortleaf Pine-Oak Heath
Pisgah RD
Blue Ridge Parkway

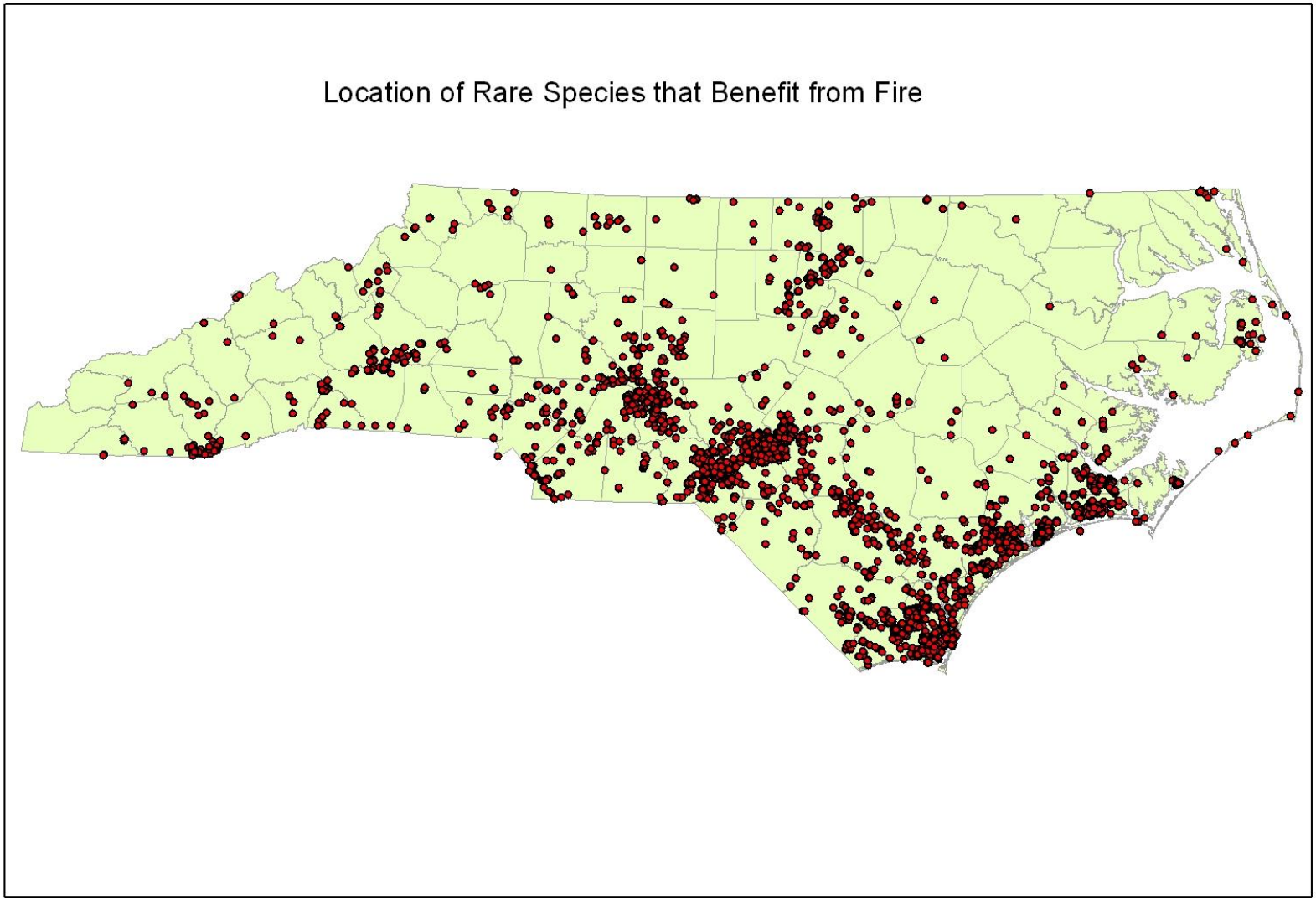
0 2.5 5 10 Miles

Comparison of NFsNC Districts by % Fire Adapted Acreage

District	Pine Ac	Oak Ac	Pocosin Ac	Total Acres	District Fire Adapted
Uwharrie	7743	39916	0	47659	95%
Croatan	66955	6080	73943	146978	94%
Grandfather	53541	79800	0	133341	70%
Cheoah	20647	51252	0	71899	59%
Tusquitee	23295	67409	0	90704	57%
Appalachian	41595	42083	0	83678	52%
Nantahala	8993	90720	0	99713	40%
Pisgah	1190	61696	0	62886	40%

Fire Adapted Rare Species

- **Life cycle of Species**
- **Rare species occurring in fire adapted habitats**
- **Consultation with other land managers**
- **Grey literature**

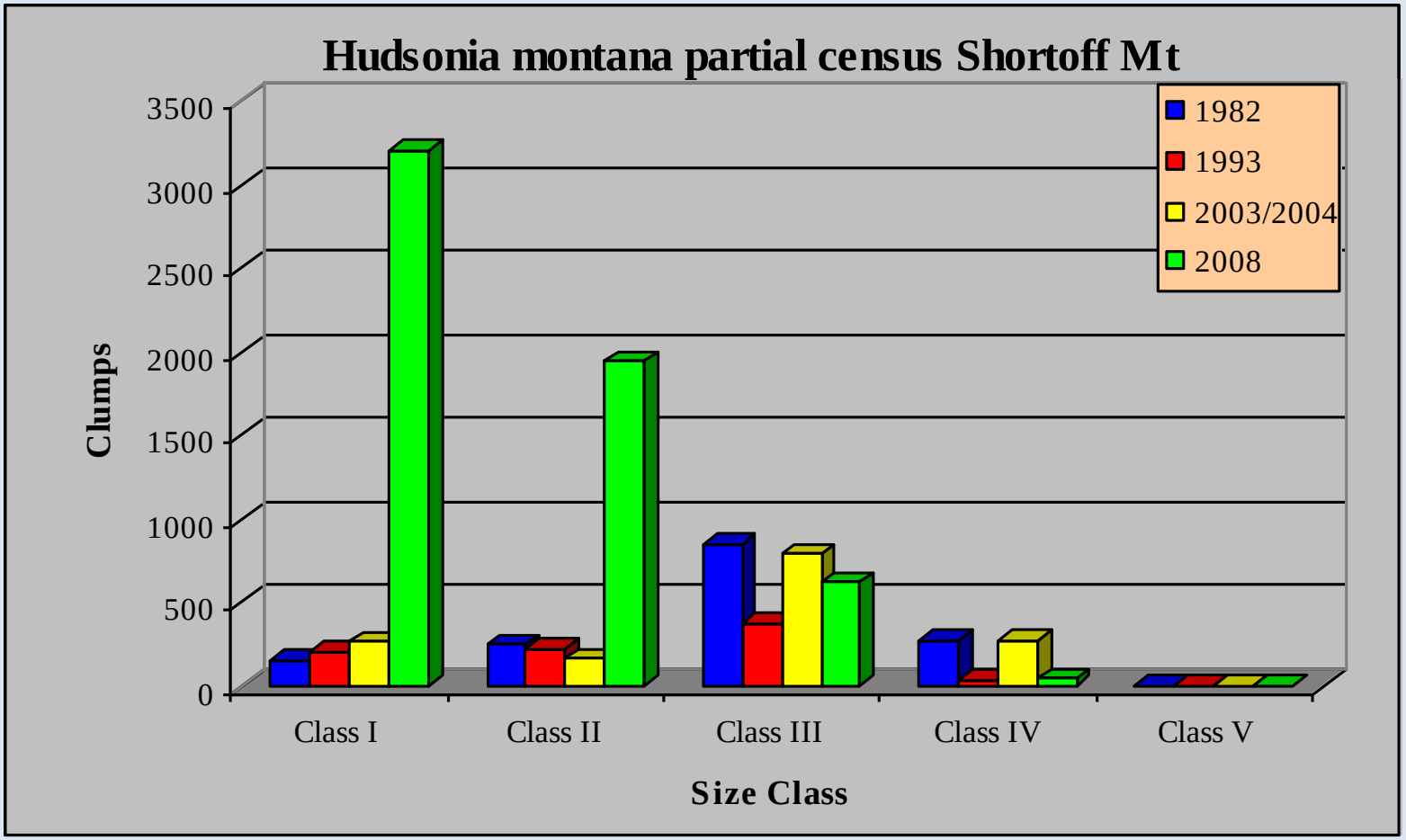


On a broad scale, fire adapted species are more frequent in the Coastal Plain, then in the Piedmont, or in the Southern Appalachian Mountains…

Mountain Golden Heather

Hudsonia montana

The fire caused mortality in the larger size classes but also huge increase in smaller size classes. Total numbers of plants increased five-fold after fire and aerial extent of suitable habitat was increased.

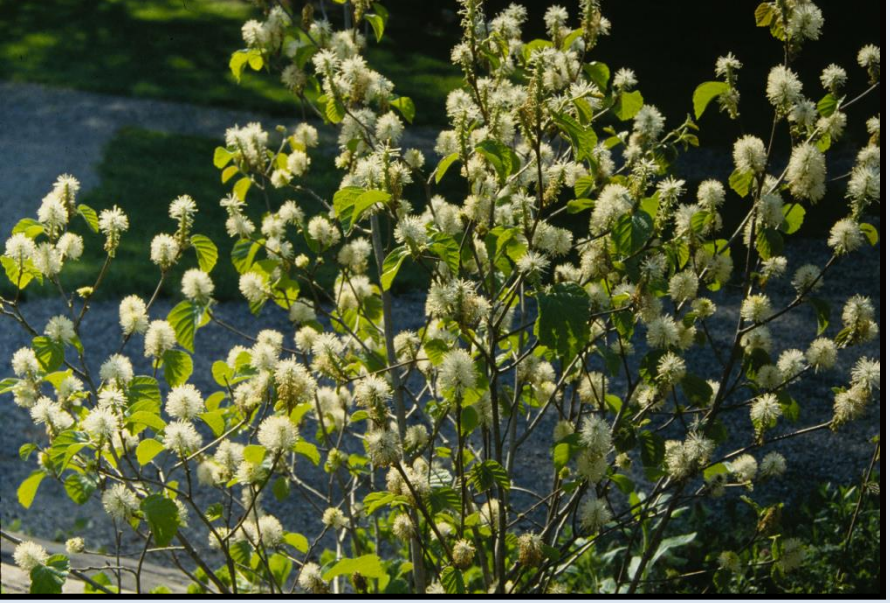


Heller’s Blazing Star

Liatris helleri

Sarracenia oreophila

Green Pitcherplant



Witch Alder **Fothergilla major**

Pygmy Pipes **Monotropsis odorata**

Prairie Dropseed
Sporobolus heterolepis

Species that flower and fruit more abundantly following burn

Porter’s Reed Grass

Calamagrostis porteri

Fraser’s Loosestrife

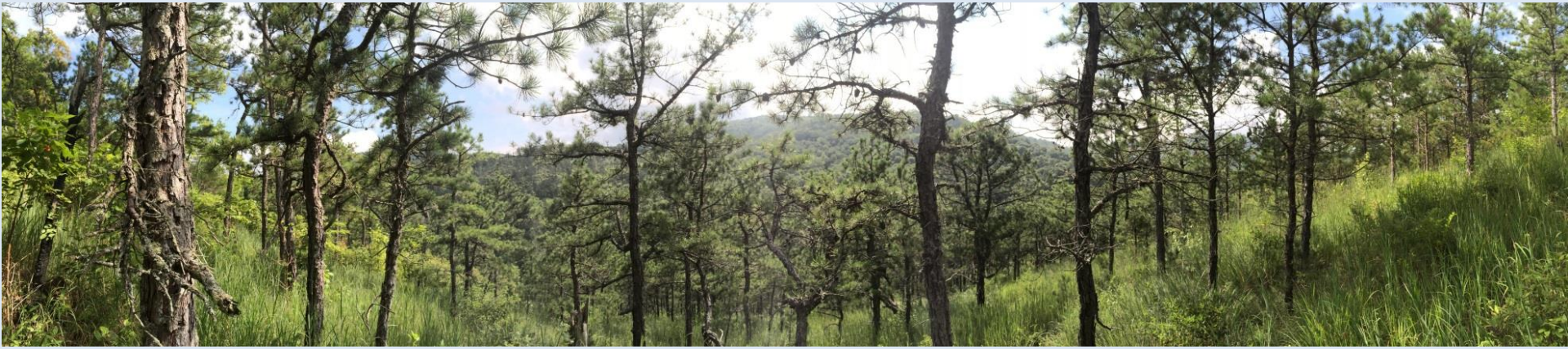
Lysimachia fraseri

Rare Thermopsis Species

Golden-banners

Thermopsis mollis, fraxinifolia, & villosa

Rare Invertebrates Habitat Improvement



Serpentine Barren/Woodland

Southern Appalachian Bog

Pitcher Plants

Swamp Pink

Bog turtles

Ecological Criteria Considered:

- Distribution on Landscape
- Current Condition (Good, Fair, Poor)
- Burn History
- Return Interval
- Presence of fire adapted rare species
- Presence of fire sensitive species
- Invasive species threats
- Percentage of site that is fire prone
- Acreage of Fire Adapted Vegetation
- Presence of Fire Adapted Significant Natural Heritage Areas

Common Factors in National Forest in NC Ecological Prioritization Schemes

- Scaling and weighting vegetation types that benefit from fire; either based on acreage or % fire adapted and fire return interval; more frequent interval = greater weight
- Scaling and weighting rare plants and wildlife that benefit from fire; global rarity weighted more than local rarity
- Attention to special habitats, rare communities, and existing high-quality vegetation

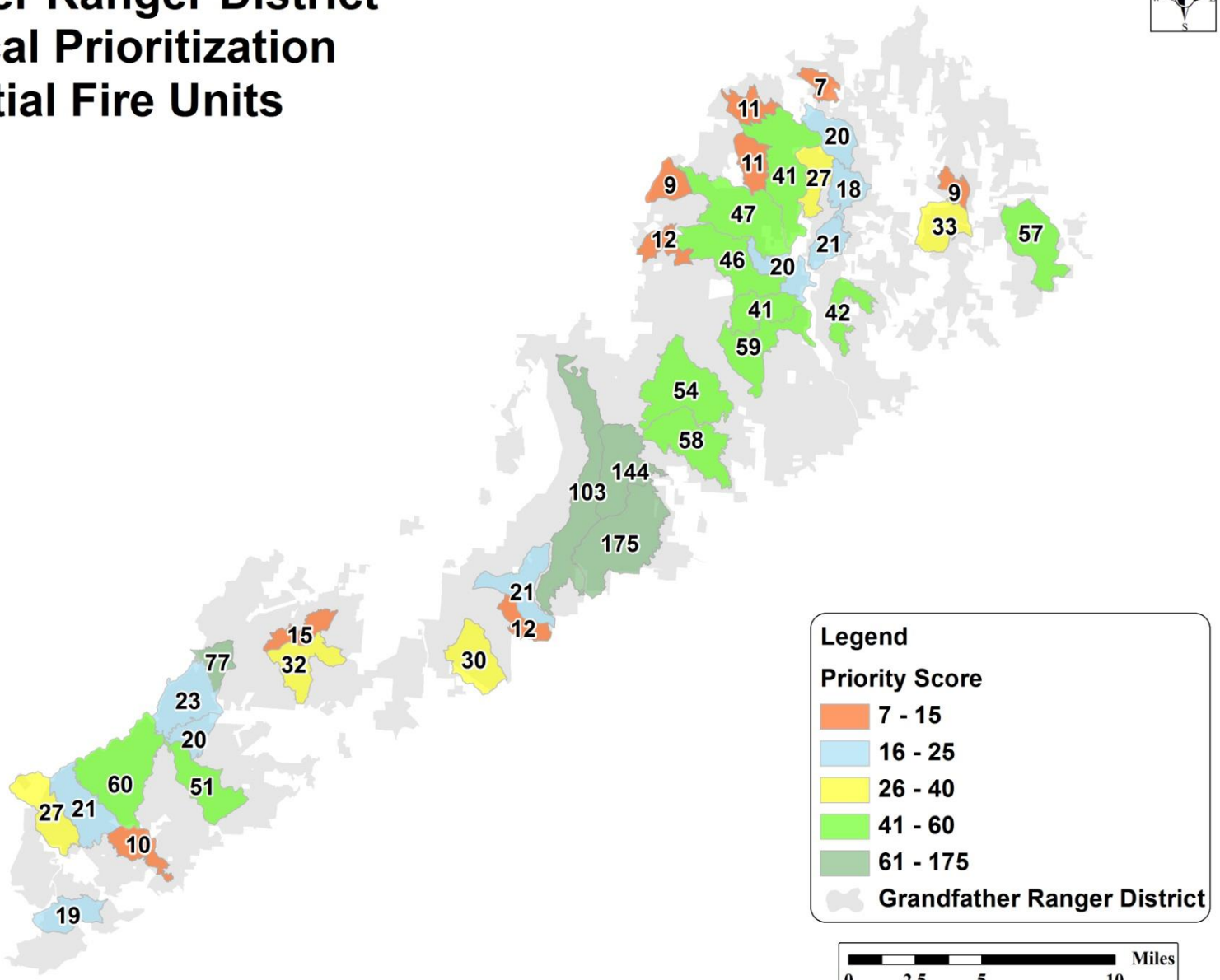

Pontential Burn Units with Ecological Score

Working Ecological Prioritization Model for the Grandfather Ranger District

- **Pine Acres (PA)**
- **Oak Acres (OA)**
- **Rare Plants and Animals Dependent on Fire; Globaly Rare & State Rare; special weight given to *Hudsonia montana***
- **SNHA s with fire adapted vegetation**
- **Acres of wildlife opening**

3PA/100 + OA/100 50 Hm + 10Gr + 5 Sr + SNHA + WO = Eco score

Grandfather Ranger District
Ecological Prioritization
Potential Fire Units



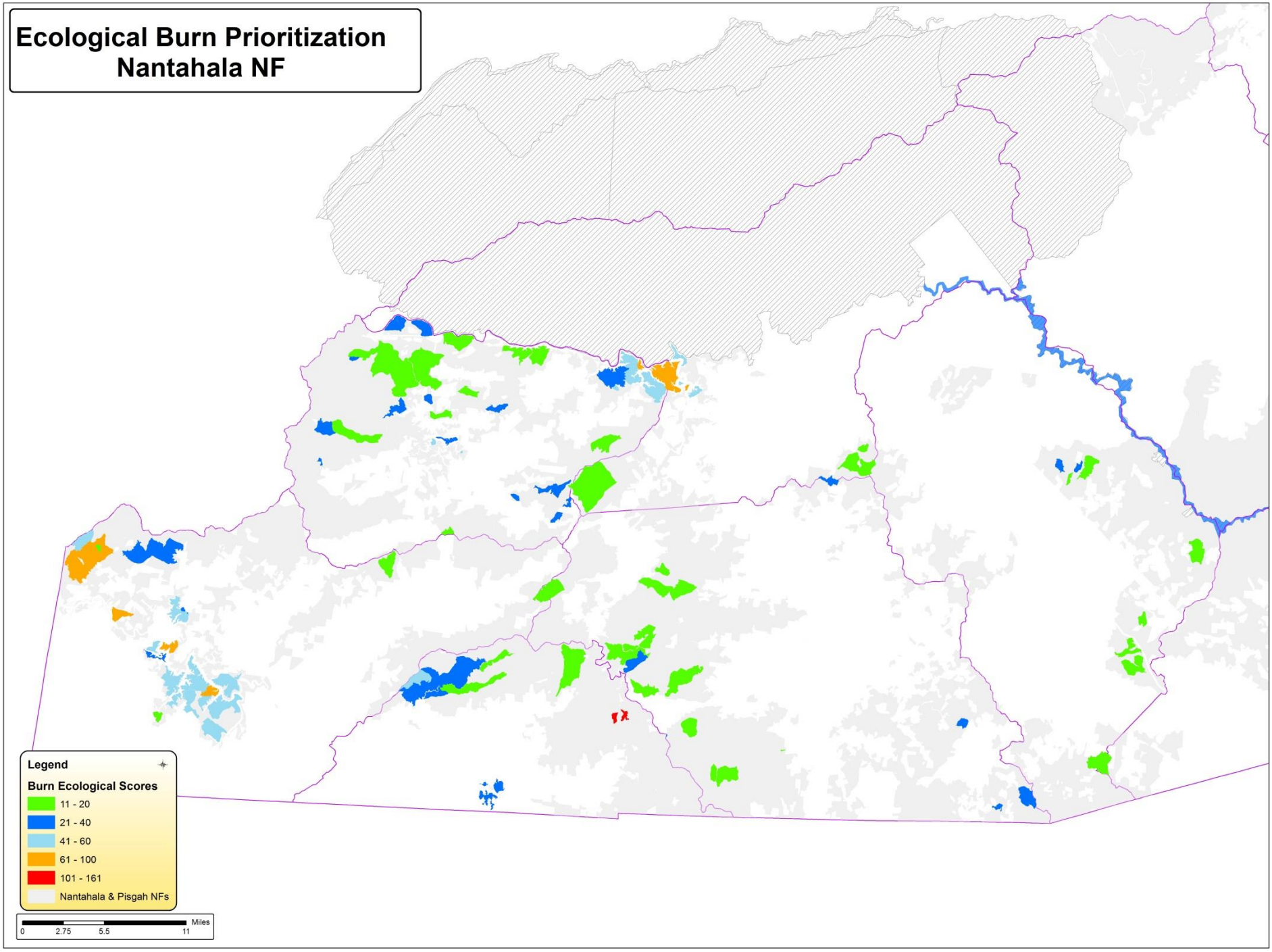
Criteria Used in Draft of Cheoah, Nantahala & Tusquitee RDs
Eco-Math

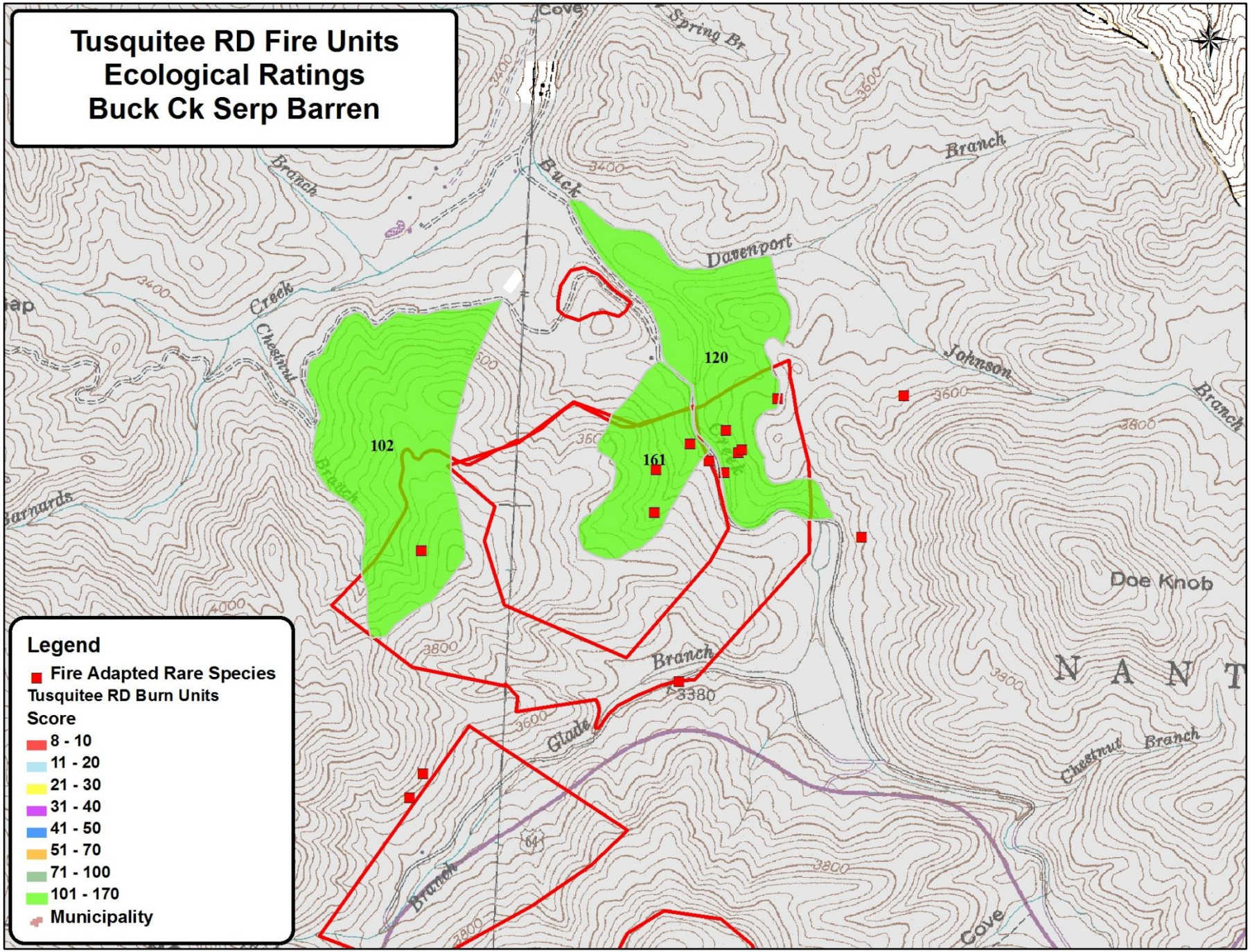
- **Pine acres (acres x 3)**
- **Xeric Oak acres (acres x 1)**
- **Mesic Oak acres (acres x 0.5)**
- **Percentage of Fire Adapted Vegetation within each fire unit**
- **Globally Rare Fire Dependent Species (x10 for each species)**
- **State Rare Fire Dependent Species (x5 for each species)**
- **State Natural Heritage Areas with fire dependent elements (10 for National, 5 for State and 3 for Regional significance)**

(3PA + XOA + 0.5MOA) /fire unit + 10Gr + 5 SR + SNHA (10,5, or 3) + =

Draft Ecological Score

Ecological Burn Prioritization
Nantahala NF

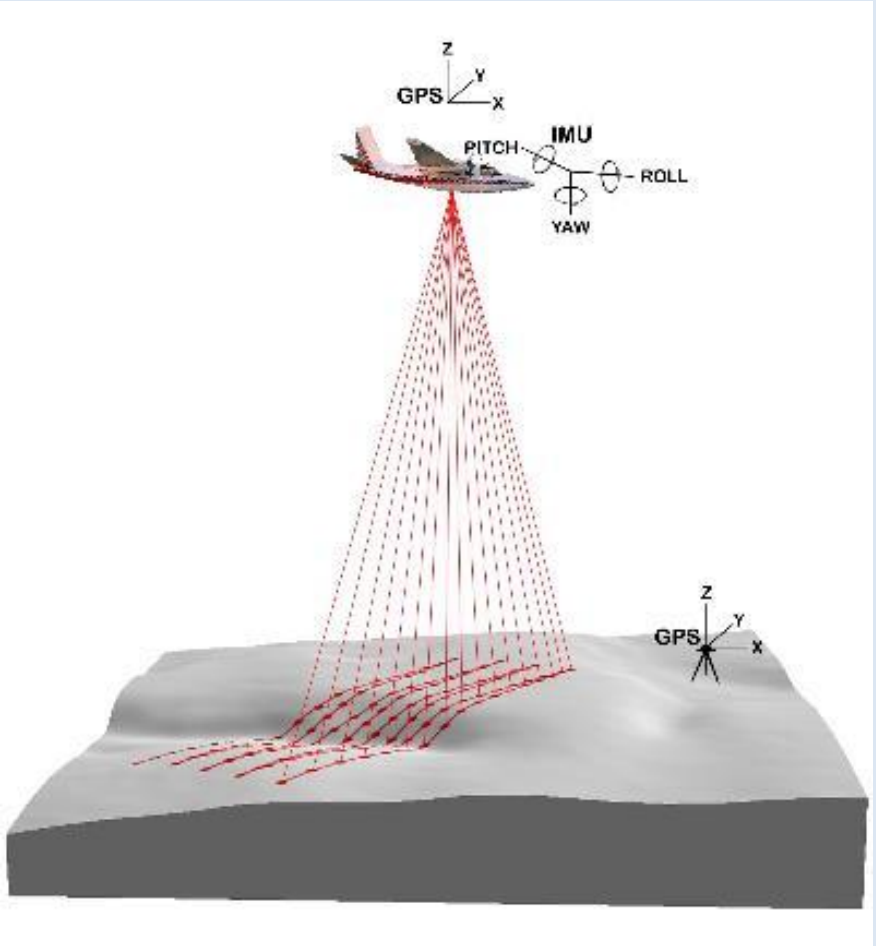



Tusquitee RD Fire Units
Ecological Ratings
Buck Ck Serp Barren
Legend
Fire Adapted Rare Species
Tusquitee RD Burn Units
Score
8 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 70
71 - 100
101 - 170
Municipality
102
120
161
Davenport
Johnson
Doe Knob
Buck
Glade
Cove
Spring Br
Chestnut Branch
Barnards

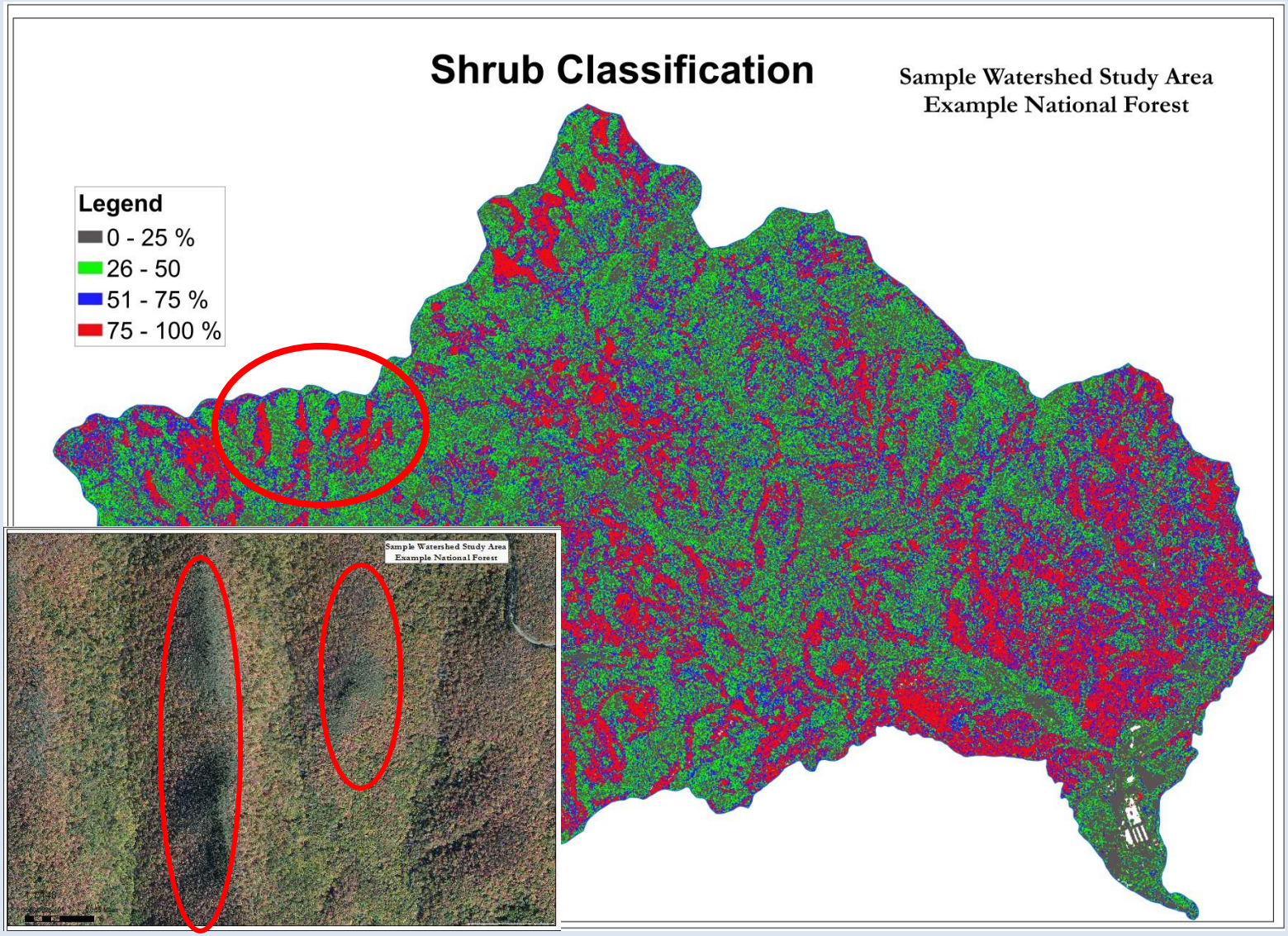
LiDAR – Light Detection and Ranging

- LiDAR uses laser light to measure distances – most frequently translated as heights

- Devices are generally mounted in airplanes and data is collected as the airplane flies across a landscape in lines that overlap the scanned areas



Structure - Shrub Layer Density



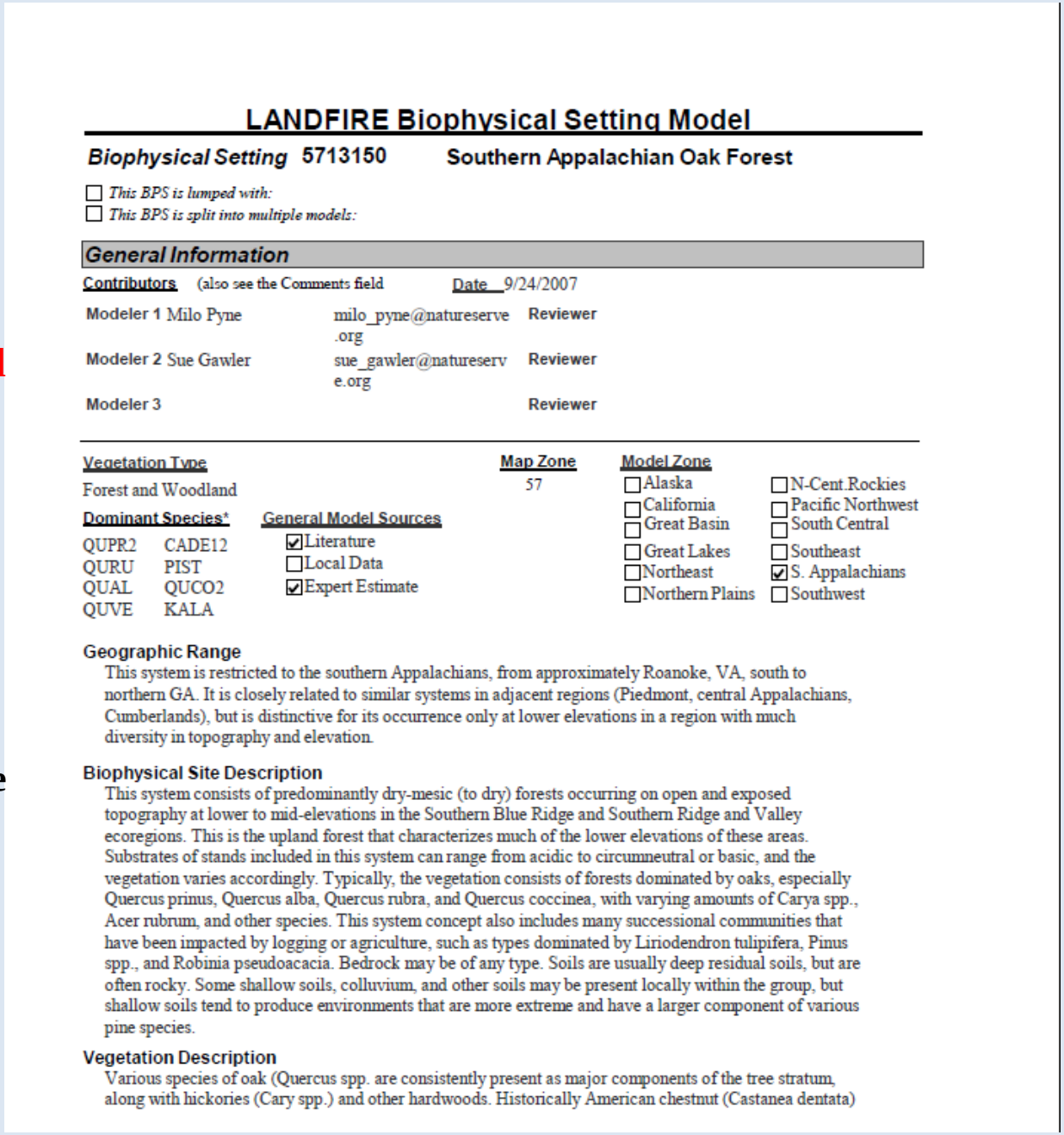
Natural Range of Variation components:

1) Ecozones

2) Correlate Ecozones with Biophysical Settings (BPS)

- **Biophysical Settings (BpS) represents vegetation that may have been dominant on the landscape prior to Euro-American settlement and are based on both the current biophysical environment and an approximation of the historical disturbance regime.**

- **Map units are defined by Nature Serve (NatureServe.org) Ecological Systems, a nationally consistent set of mid-scale ecological units.**



LANDFIRE Biophysical Setting Model

Biophysical Setting **5713150** **Southern Appalachian Oak Forest**

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field) **Date** 9/24/2007

Modeler 1 Milo Pyne	milo_pyne@natureserve.org	Reviewer
Modeler 2 Sue Gawler	sue_gawler@natureserve.org	Reviewer
Modeler 3		Reviewer

Vegetation Type
Forest and Woodland

Dominant Species*

QUPR2	CADE12
QURU	PIST
QUAL	QUCO2
QUVE	KALA

General Model Sources
☑ Literature
☐ Local Data
☑ Expert Estimate

Map Zone
57

Model Zone
☐ Alaska
☐ California
☐ Great Basin
☐ Great Lakes
☐ Northeast
☐ Northern Plains
☐ N-Cent.Rockies
☐ Pacific Northwest
☐ South Central
☐ Southeast
☑ S. Appalachians
☐ Southwest

Geographic Range
This system is restricted to the southern Appalachians, from approximately Roanoke, VA, south to northern GA. It is closely related to similar systems in adjacent regions (Piedmont, central Appalachians, Cumberlands), but is distinctive for its occurrence only at lower elevations in a region with much diversity in topography and elevation.

Biophysical Site Description
This system consists of predominantly dry-mesic (to dry) forests occurring on open and exposed topography at lower to mid-elevations in the Southern Blue Ridge and Southern Ridge and Valley ecoregions. This is the upland forest that characterizes much of the lower elevations of these areas. Substrates of stands included in this system can range from acidic to circumneutral or basic, and the vegetation varies accordingly. Typically, the vegetation consists of forests dominated by oaks, especially Quercus prinus, Quercus alba, Quercus rubra, and Quercus coccinea, with varying amounts of Carya spp., Acer rubrum, and other species. This system concept also includes many successional communities that have been impacted by logging or agriculture, such as types dominated by Liriodendron tulipifera, Pinus spp., and Robinia pseudoacacia. Bedrock may be of any type. Soils are usually deep residual soils, but are often rocky. Some shallow soils, colluvium, and other soils may be present locally within the group, but shallow soils tend to produce environments that are more extreme and have a larger component of various pine species.

Vegetation Description
Various species of oak (Quercus spp. are consistently present as major components of the tree stratum, along with hickories (Cary spp.) and other hardwoods. Historically American chestnut (Castanea dentata)

Southern Appalachian Montane Pine disturbance parameters used in computer simulations

	Succession stage (Age and Structure)				
	Class A 0-15 yrs	Class B (closed) 16-70 yrs	Class C (open) 16-70 yrs	Class D (open) 71 yrs+	Class E (closed) 71 yrs+
Disturbance type	---------- return interval (years) ----------				
surface fire	5	5	5	5	25
mixed fire		50	75	100	75
replacement fire	20	75	150	200	500
major wind event		500	1000	1000	1000
ice damage		250			250
insects / disease		50	100	75	75

Natural Range of Variation components:

1) Ecozones

2) Correlate Ecozones with Biophysical Settings (BPS)

3) Review and modify Ecological Systems descriptions (type and rate of disturbance, structural diversity) for appropriate area

4) Run Computer simulations: VDDT (vegetation dynamics development tool), quantifies rate and effects of vegetation change

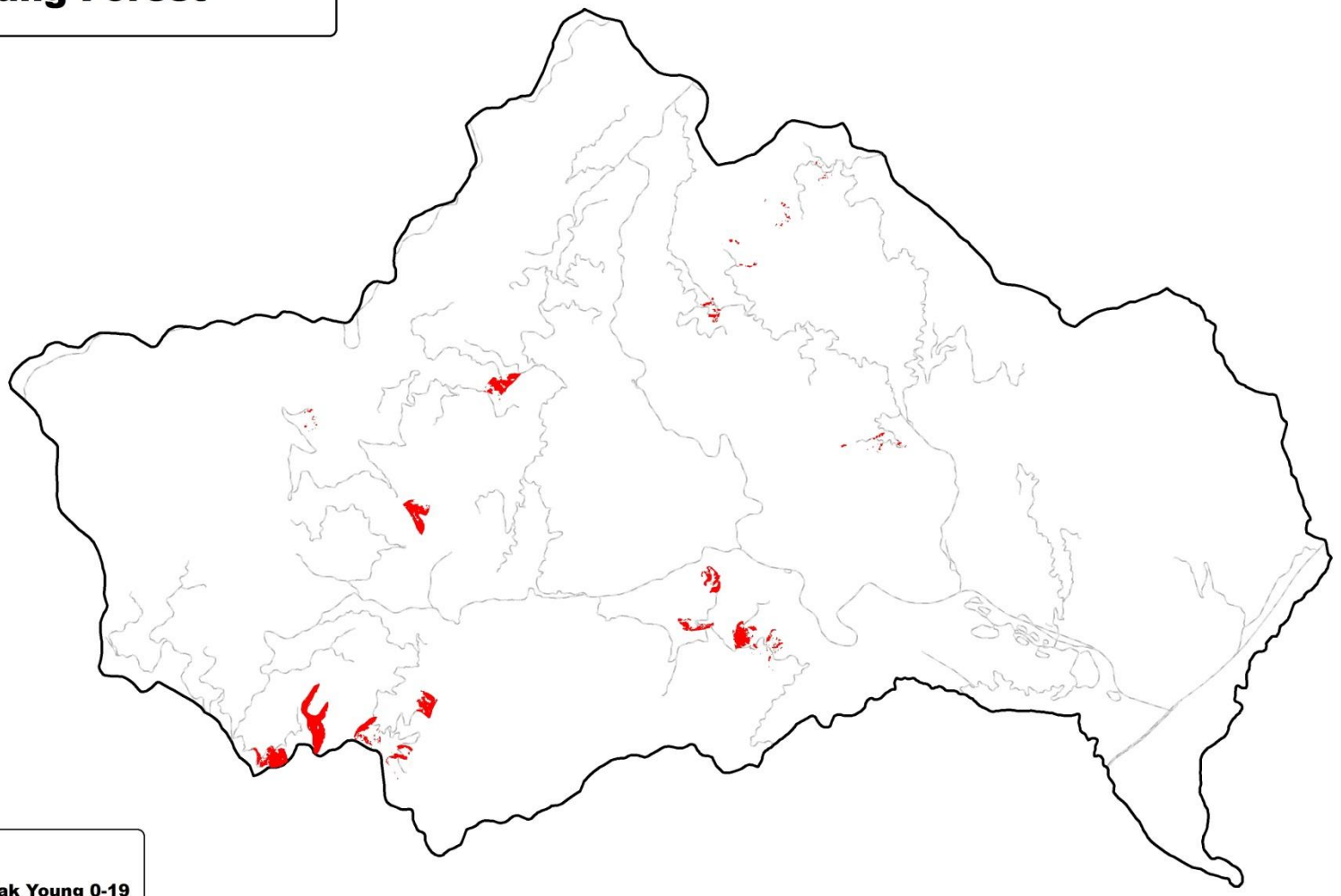
Natural Range of Variation

Dry-Mesic Oak				
	Age	Chattahoochee NF	Cherokee NF	So. Apps
Early	0-19	7%	7%	6%
Mid-Closed	20-70	6%	15%	10%
Mid-Open	20-70	13%	25%	10%
Late -Open	71-130	14%	23%	14%
Late- Closed	71-130	5%	13%	5%
Old Growth Open	> 130	42%	11%	49%
Old Growth Closed	> 130	12%	6%	6%
Total Closed		23%	34%	21%
Total Open		76%	66%	79%

Natural Range of Variation

Dry-Mesic Oak			
	Age	So. App	Existing in Watershed
Early	0-19	6%	2%
Mid-Closed	20-70	10%	8%
Mid-Open	20-70	10%	2%
Late -Open	71-130	14%	8%
Late- Closed	71-130	5%	78%
Old Growth Open	> 130	49%	.5%
Old Growth Closed	> 130	6%	1.5%
Total Closed		21%	87%
Total Open		79%	13%

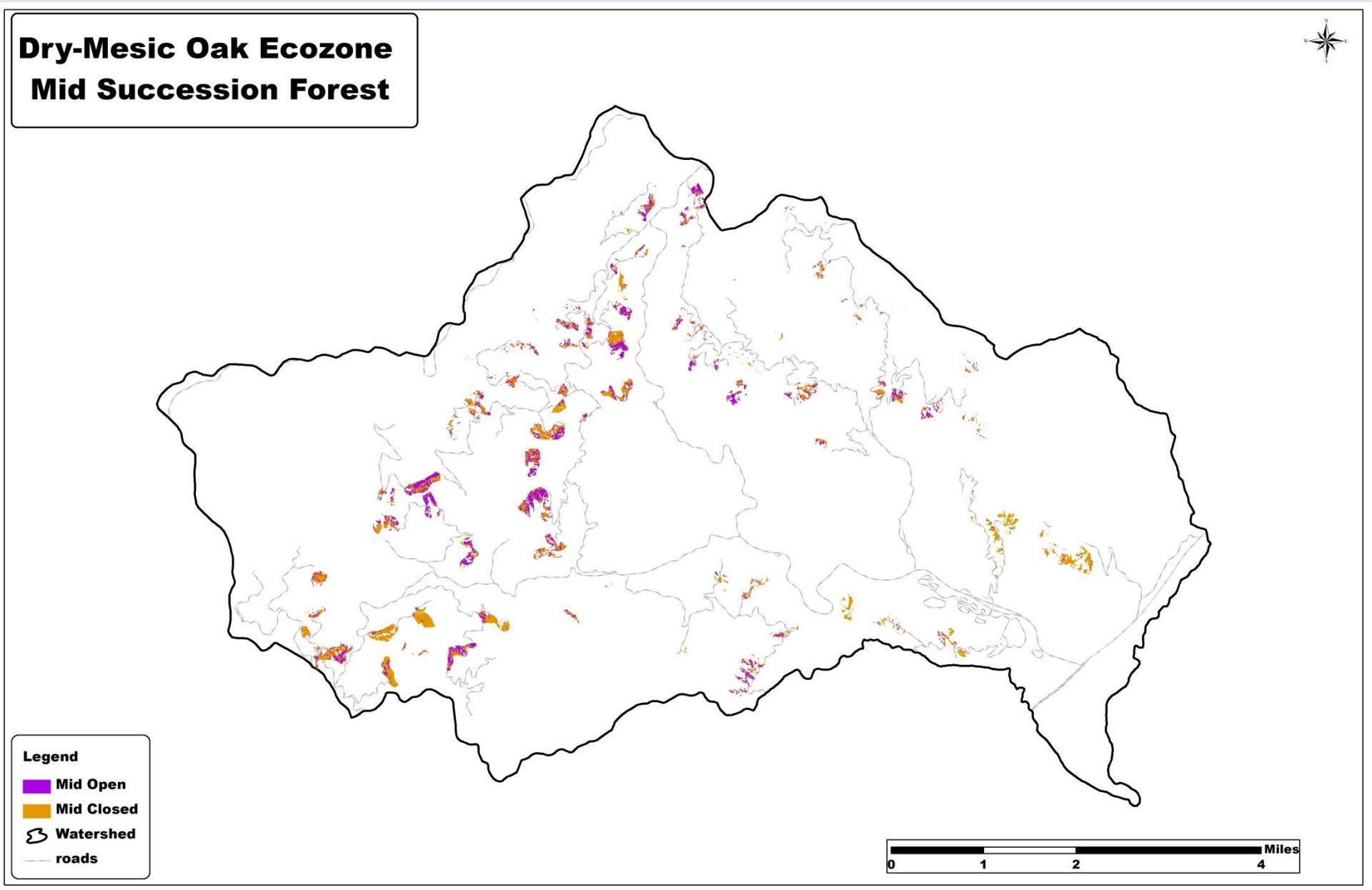
Dry-Mesic Oak Ecozone
Young Forest



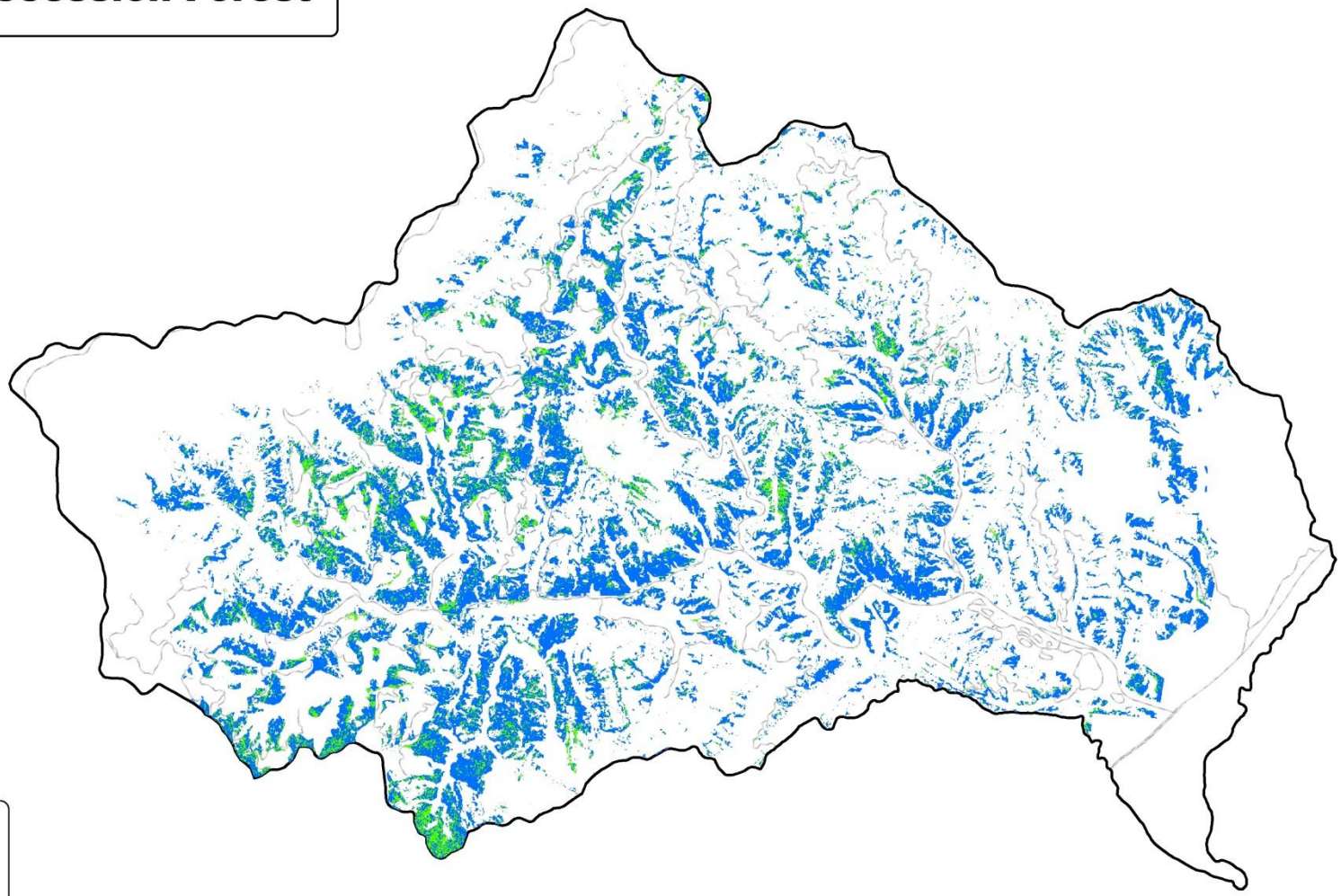
Legend

- Dry Mesic Oak Young 0-19
- Watershed
- roads

0 1 2 4 Miles


Dry-Mesic Oak Ecozone
Mid Succession Forest
Legend
Mid Open
Mid Closed
Watershed
roads
Miles
0
1
2
4

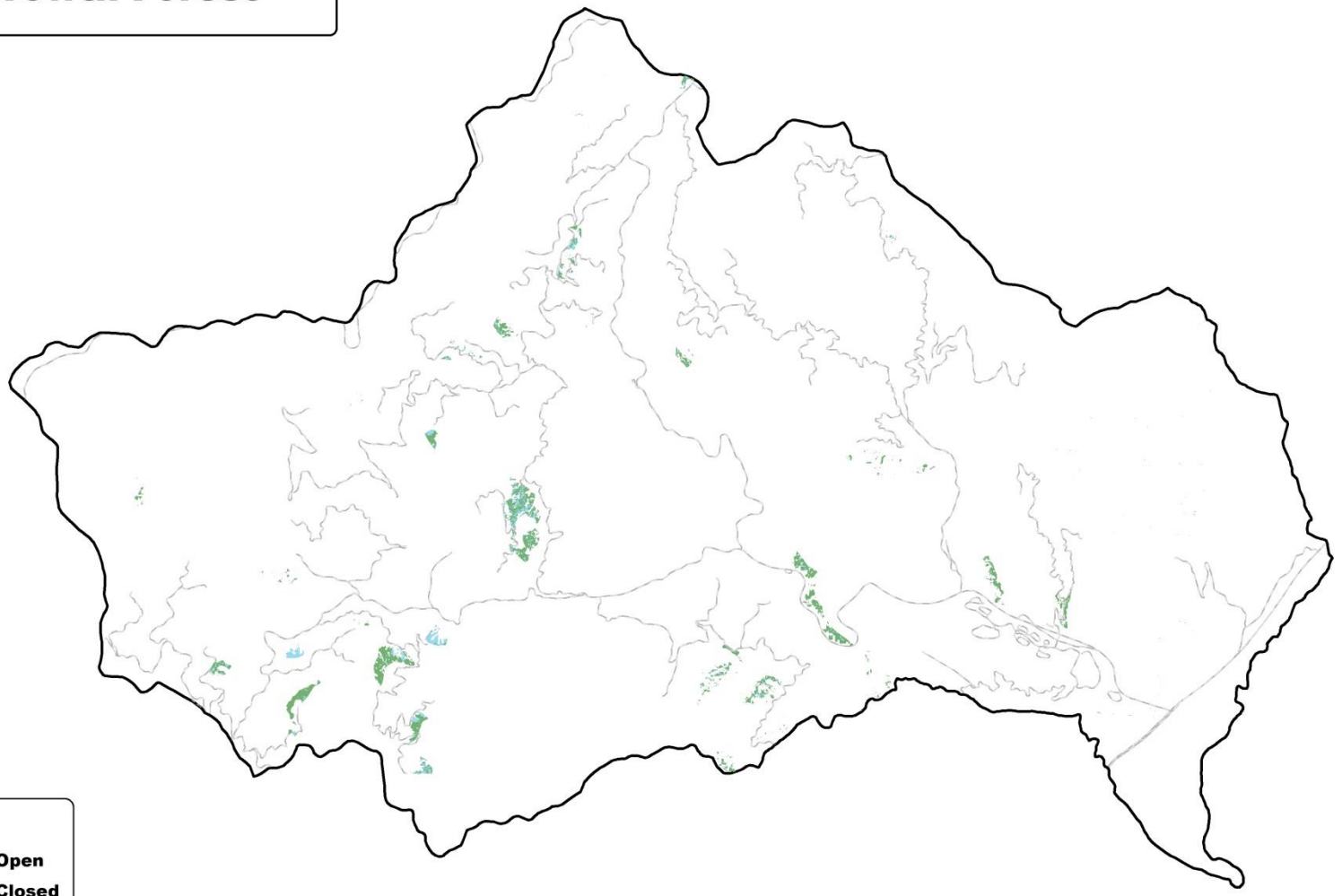
Dry-Mesic Oak Ecozone
Late Succession Forest



Legend
- Late Open
- Late Closed
- Watershed
- roads

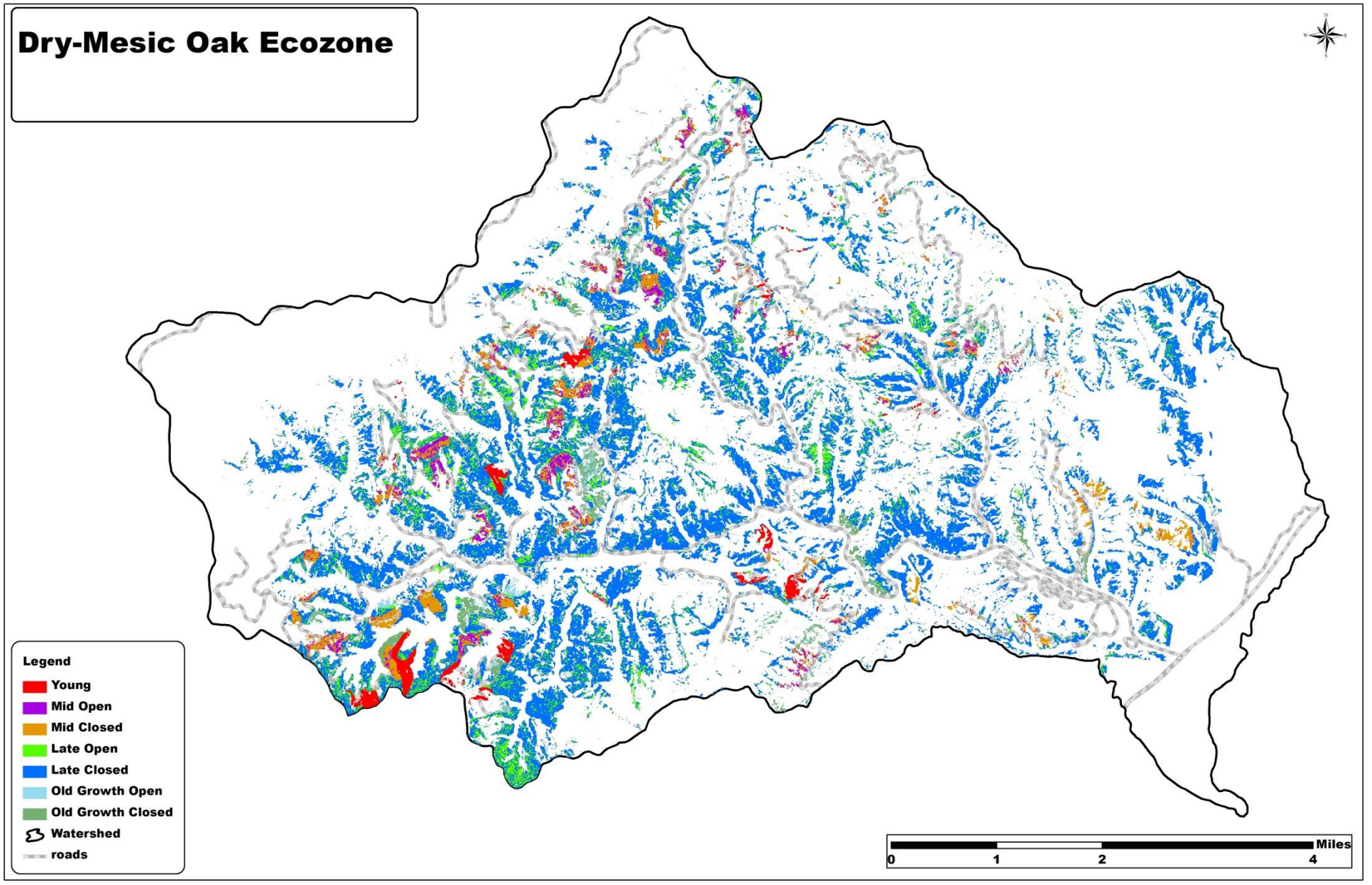
0 1 2 4 Miles

Dry-Mesic Oak Ecozone
Old Growth Forest



Legend
- Old Growth Open
- Old Growth Closed
- Watershed
- roads

0 1 2 4 Miles


Dry-Mesic Oak Ecozone
Legend
Young
Mid Open
Mid Closed
Late Open
Late Closed
Old Growth Open
Old Growth Closed
Watershed
roads
0
1
2
4
Miles

SOUTHERN APPALACHIAN MONTANE OAK ECOLOGY – Dry-Mesic Oak

<19 years
Early
Development

NRV: 6%
Current: 2%

20-70 years
Mid Dev.
Closed

NRV: 10 %
Current: 8 %

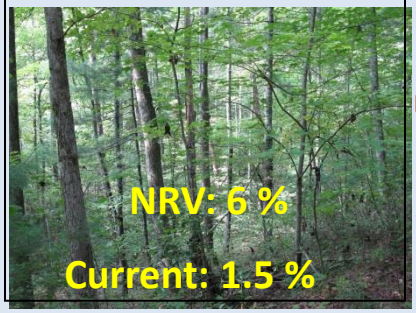
20-70 years
Mid Dev.
Open

NRV: 10
Current: 2%

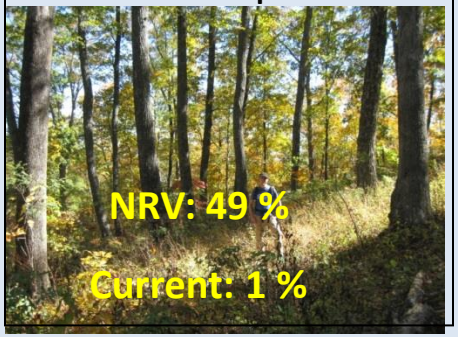
71- 130 years
Late Dev.
Open

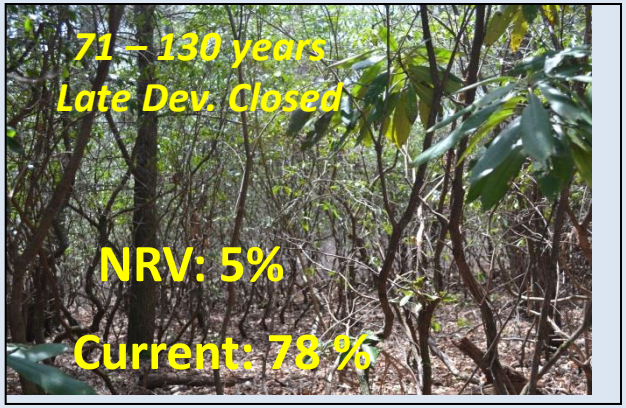
NRV: 14 %
Current: 8 %

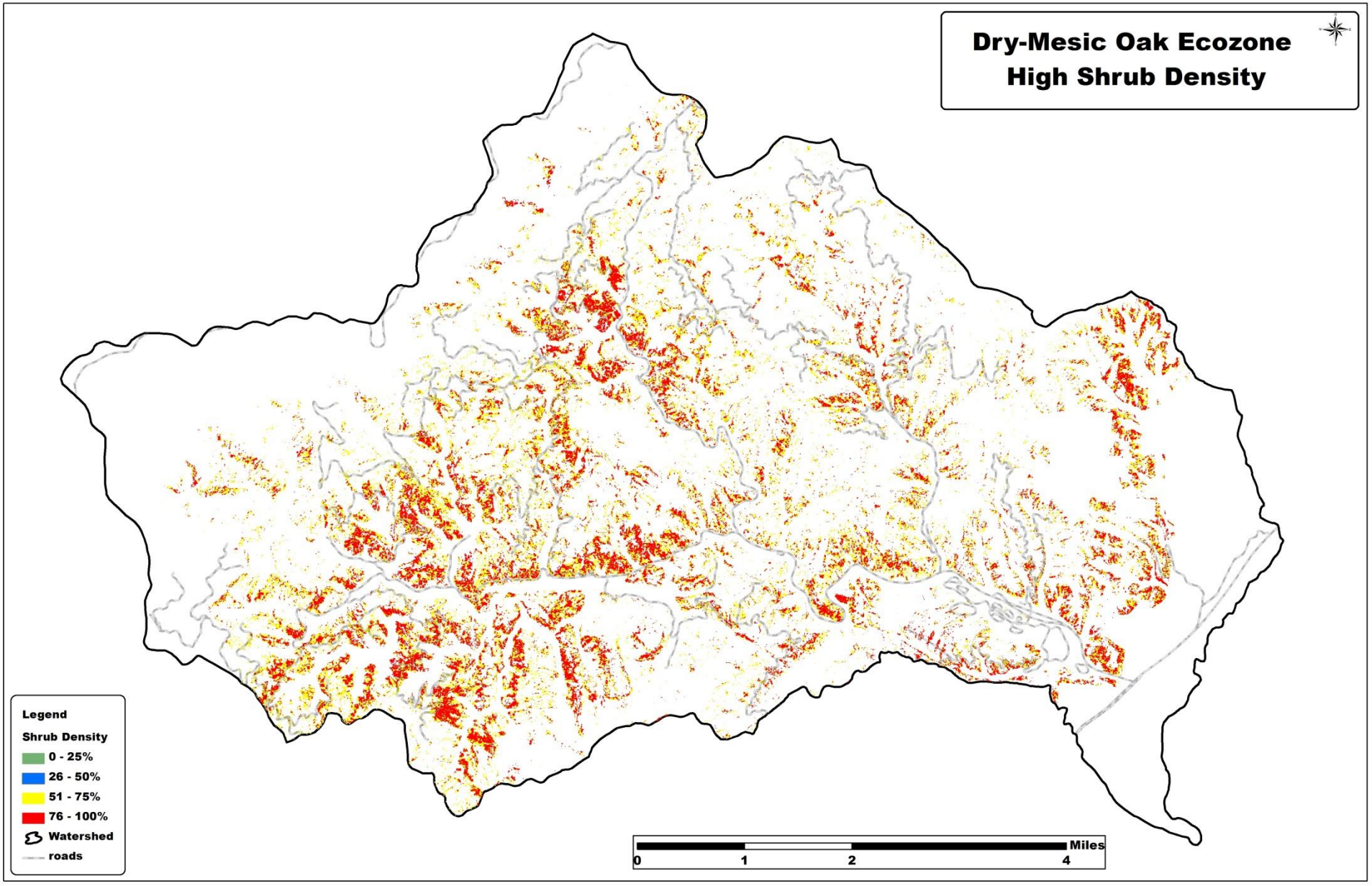
> 130 years
Old Growth Closed



> 130 years
Old Growth Open

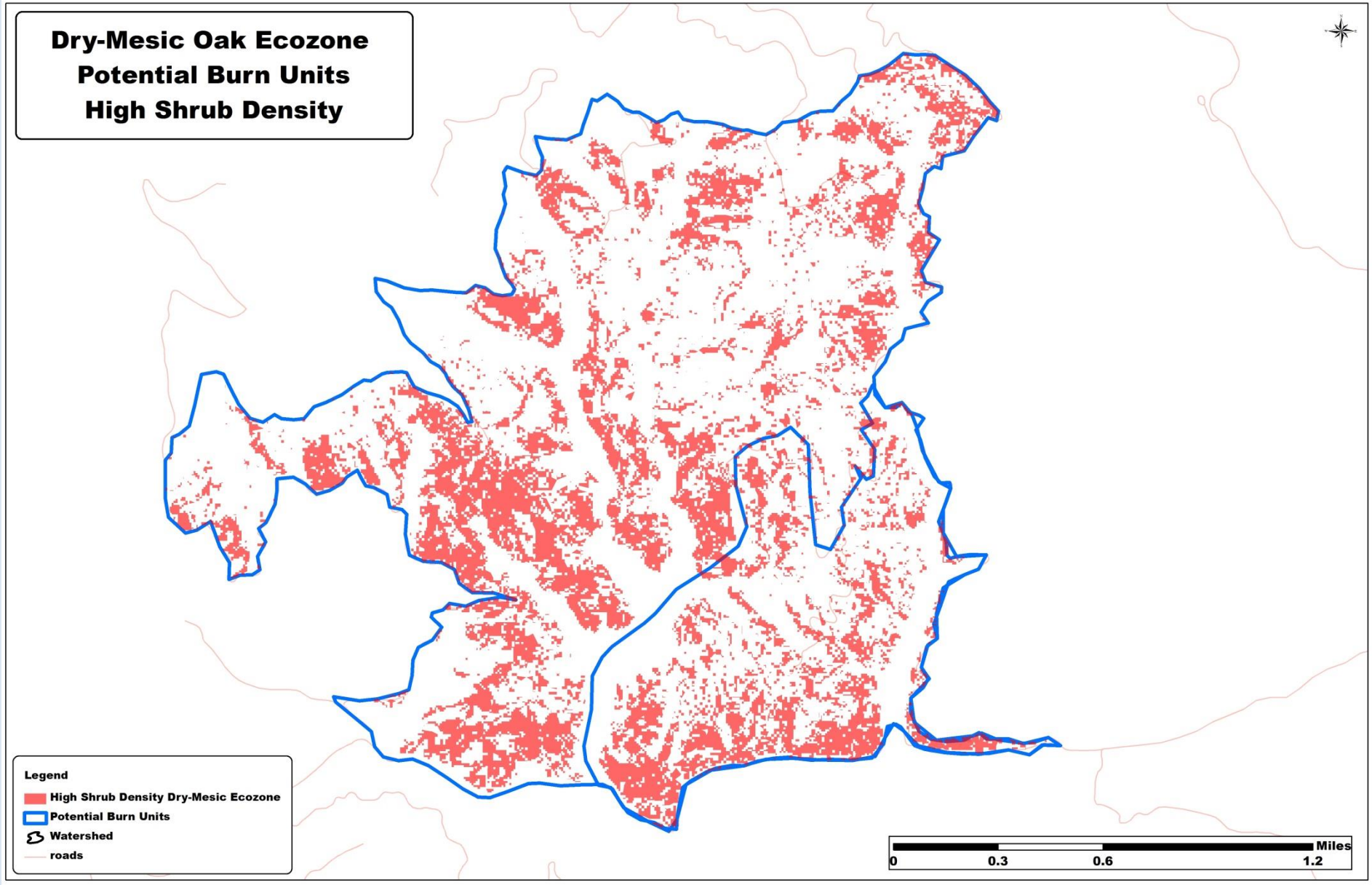




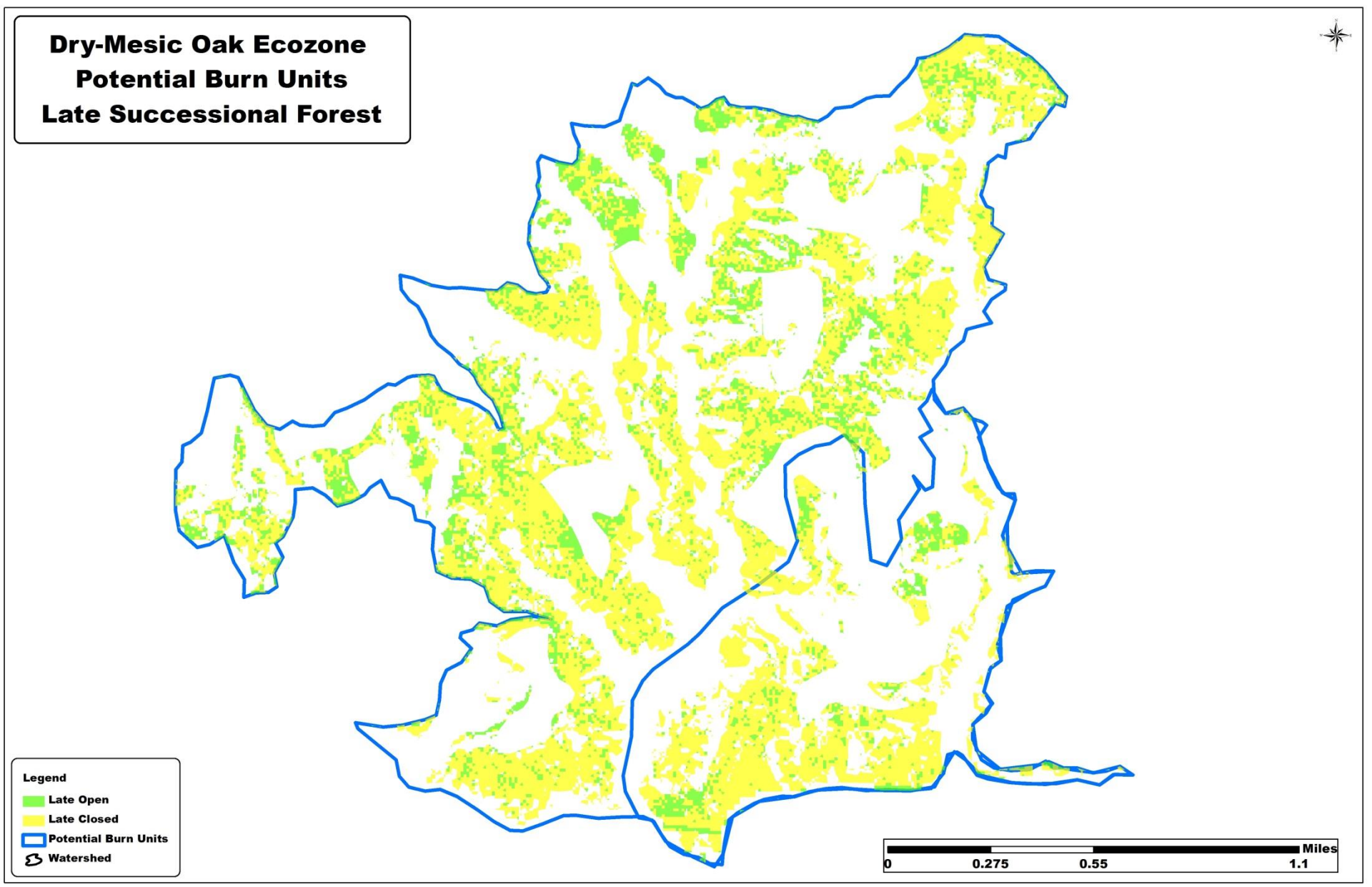


3717 acres with > 50% shrub density, mostly heath, mountain laurel, huckleberry, rhododendron

Two potential burn units identified with primary use of roads as firelines. Units - 467 acres, 1405 acres, or combined 1872 acres



631 acres dominated by dense shrubs - 132 acres in small unit, 499 acres in larger unit



932 acres from 71-130 year old forest - 725 acres in closed forest condition


Questions

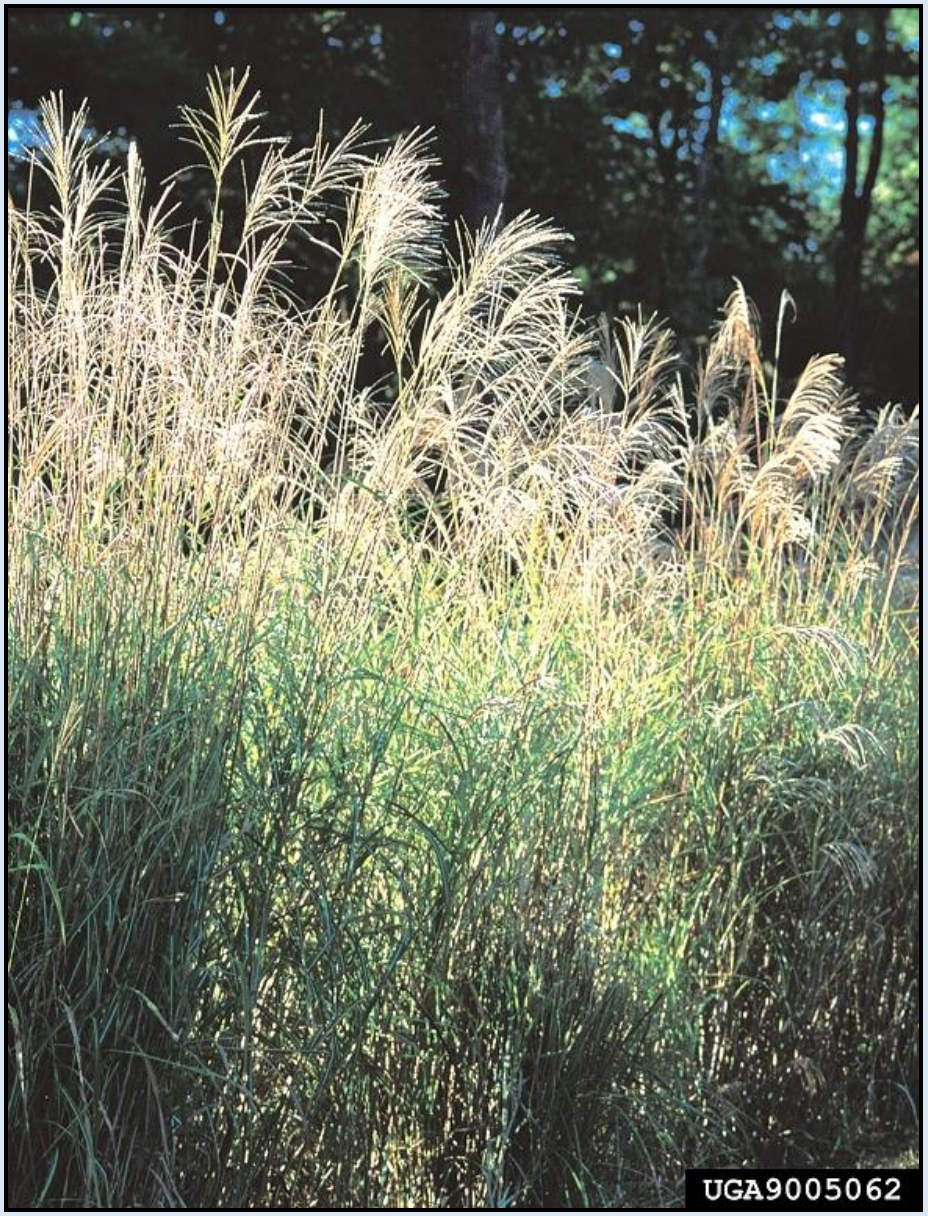
Habitat Restoration

Spot Fire Application

Controlling both native and non-native invasive species

- Increase from 10% cover to greater than 90% following timber harvest and prescribed burn

Princess Tree more competitive in sites with more open canopy and mineral soils



Chinese Silvergrass

Miscanthus sinensis

Changes fire intensity if present within prescribed burn, increases with fire activity

Kudzu (*Pueraria montana* var. *lobata*)

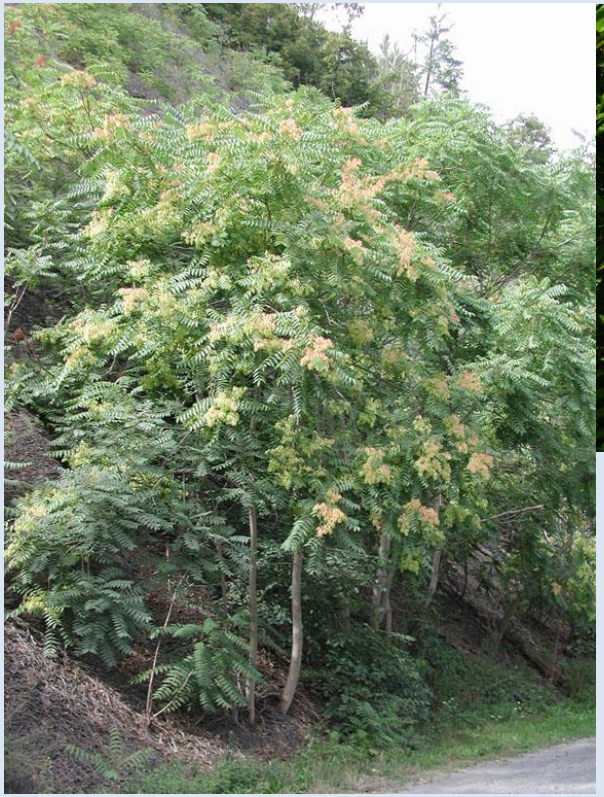
Burning when plants are dormant reduces above-ground biomass which in turn reduces the amounts of herbicide needed for control.

Escapes fire damage through deep roots and root crowns beneath the soil surface.

Stems and foliage resist fire damage during the growing season because they typically maintain high water content.

Soil heating as a result of fire may promote seed germination by scarifying the seed coat.

Dry litter can provide substantial fuel for dormant-season surface fires and dormant vines can provide ladder fuels that enhance the likelihood of crown fires.



Tree of heaven (*Ailanthus altissima*)

May be top-killed but rapidly re-sprouts after fire from roots, root crown, and damaged tree boles..

Numerous wind-borne seeds enables rapid spread into disturbed areas.

Several studies (VA, WVA, OH) document increases in abundance after fire.

Rapid growth and allelopathy allows tree-of-heaven to outcompete native woody species for the open spaces and flush of nutrients that often occur after fire.

Sericea lespedeza (*Lespedeza cuneata*)

Fire may kill seedlings but established plants likely only top-killed and rapidly re-sprout after fire from caudex.

Seed production is prolific and seed bank may remain viable for decades.

Research suggests that fall burning has a slightly better result on mortality than spring or summer burning however neither are good options for control.

Some evidence suggests that heat from fire may scarify dormant seed, increasing germination rates in recently burned areas.

Nepalese browntop (*Microstegium vimineum*)

Spring and summer burns only top-kill the species and plants that have not yet flowered may sprout from tillers and stolons following fire.

Fall burns will significantly reduce biomass however the species rapidly recovers through banked seed in the soil.

Because it is an annual, this grass must establish from soil-stored seed and/or off-site seed transported onto burned sites.

Mineral soils exposed by fire provide a favorable seedbed for Japanese stiltgrass germination and establishment.

Multiflora rose (*Rosa multiflora*)

Little information on this species in the literature however native *Rosa* spp. are typically top-killed by fire, and with increasing fire severity, may be subject to root crown and rhizome damage sufficient to inhibit sprouting.

One study in east-central Illinois documented a significant reduction in multiflora rose frequency following two consecutive early-spring burns at a prairie restoration site.

Japanese honeysuckle (*Lonicera japonica*)

Top-killed by fire but prolific post-fire sprouting may result in more biomass than pre-fire conditions. Sprouts from roots, root crowns, and trailing stems after fire.

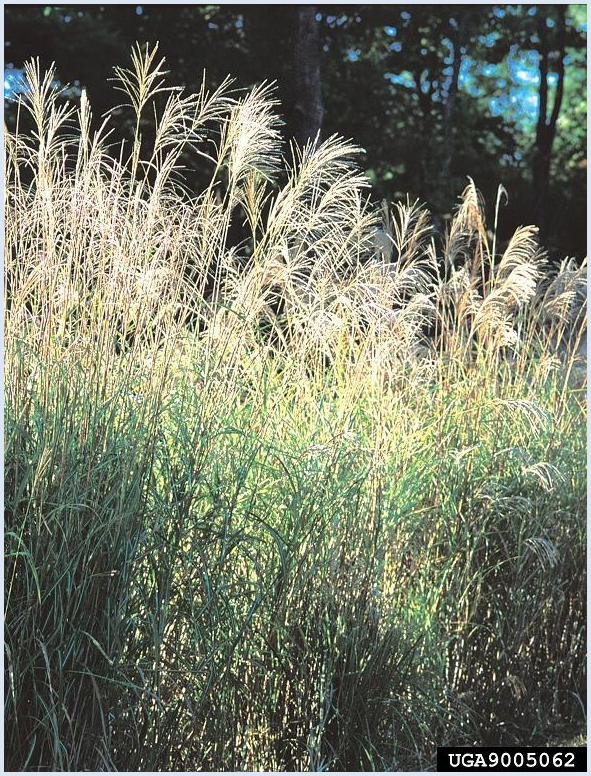
Can serve as a significant ladder fuel leading to crown fires.

Autumn olive (*Eleagnus umbellata*)

Fire can be useful in removing above-ground biomass, especially in dense thickets.

Top-killed by fire but rapid post-fire sprouting from roots and root crowns.

Has very rapid growth and prolific fruiting making post-fire colonization very likely.



Chinese silvergrass (*Miscanthus sinensis*)

Generally top-killed by fire but able to re-sprout rapidly due to extensive rhizomes.

Forms dense, tall clumps that are highly flammable and can create hazardous burn conditions.

Numerous studies suggest Chinese silvergrass responds favorably to fire. Studies from Japan suggest that fire may increase tillering , accelerate leaf emergence, and increase photosynthetic rates.

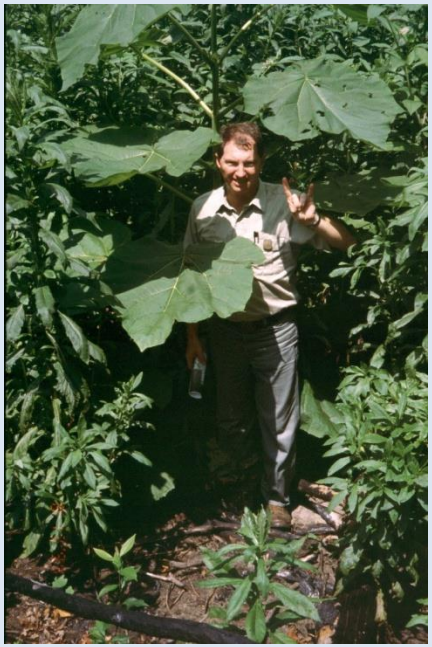
Oriental bittersweet (*Celastrus orbiculatus*)

Fire may reduce above-ground biomass but able to re-sprout rapidly from roots and root crowns.

Fruits are highly dispersed by birds and other animals which add to it's ability to colonize disturbed areas rapidly after fire.

High-climbing vines can serve as a significant ladder-fuel leading to crown fires.

Several studies have shown post-fire flushes due to increased light and nutrient availability



Princess tree (*Paulownia tomentosa*)

Above-ground parts are easily killed by fire however the species is capable of epicormic sprouting if only damaged. If top-killed, sprouts readily from root crown and root suckers.

Produces over 20 million wind-borne seeds per tree that germinate almost exclusively on open sites with exposed mineral soil.

Highly shade-intolerant, princess tree requires large-scale disturbances such as fire, landslides, flood scour, or other land scarification for optimal stand establishment. Thus, prescribed fire meant to restore native, fire-dependent forest communities (Table Mountain pine forests) may also create conditions suitable for princesstree regeneration.

Princess Tree more competitive in sites with more open canopy and mineral soils

Paulownia tomentosa colonizing an area in the Lineville Gorge Wilderness after a severe fire in 2007