

Modeling Fire Behavior on the Landscape of the Southern Appalachians

A photograph of a person standing on a rocky mountain peak. The person is wearing a red jacket and dark pants. The landscape is vast and hazy, with rolling hills and mountains in the distance. The sky is a pale, hazy blue. The foreground shows the rocky and forested slopes of the mountain.

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Abstract

Fire is increasingly acknowledged as an important ingredient in natural ecosystems, and prescribed fire is increasingly used as a tool to restore the dynamics to fire dependent natural systems. The pattern of natural fire on the landscape of the Southern Appalachians is likely a complex mosaic of burned and unburned areas reflecting physical conditions (slope position, aspect, moisture, as well as long-term and recent weather patterns).

...This pattern of burns on the landscape would also both reflect and shape ecological communities. As prescribed fires are applied to the landscape the potential exists to both restore as well as harm ecological communities. In order to apply prescribed fire appropriately and to reestablish natural fire regimes requires knowledge of the pattern of burns under natural conditions on the landscape. A GIS model will be described and displayed that predicts fire behavior on the landscape based on physical conditions and ecological communities.

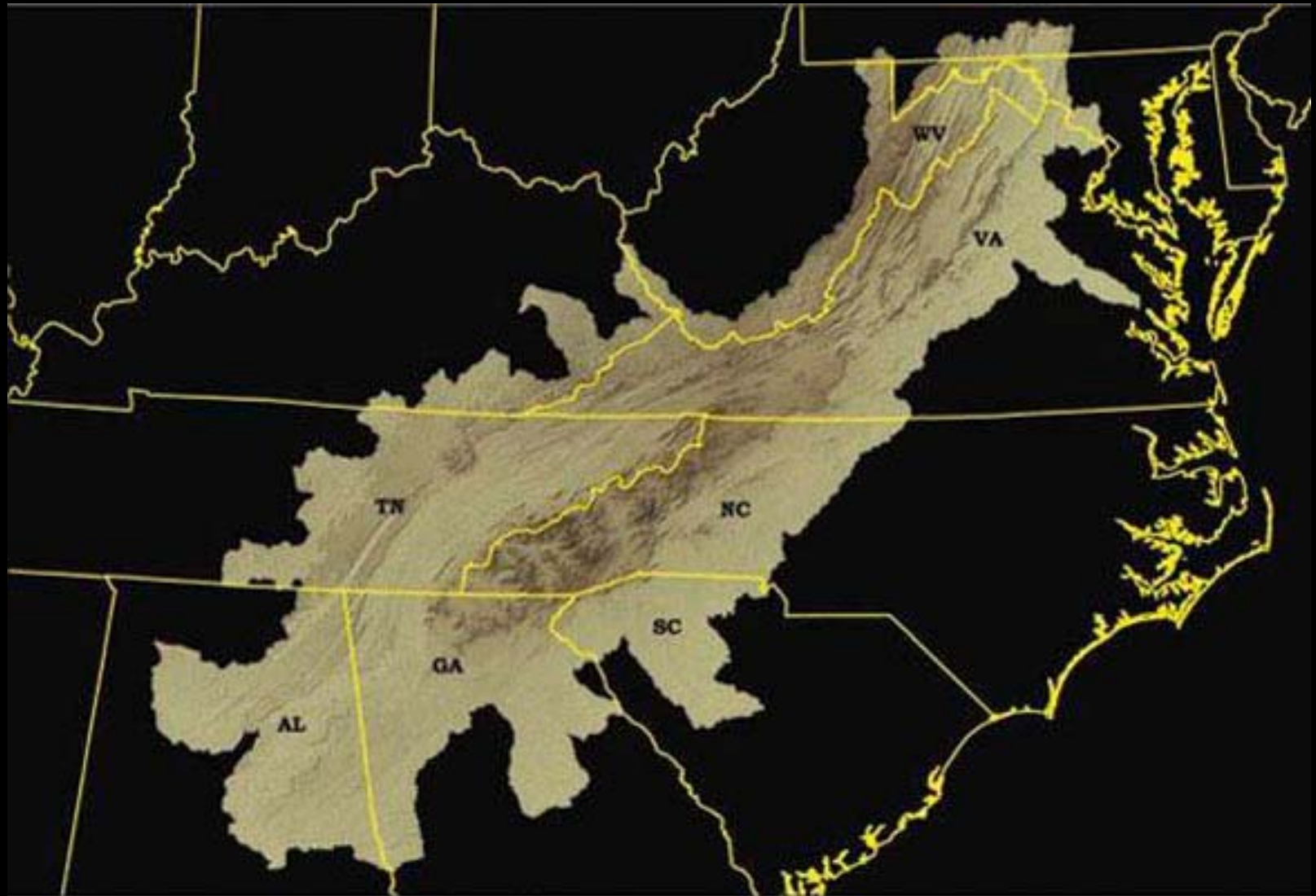
“This great and persistent selecting force has influenced ecosystem traits and characteristics since fuels and lightning first interacted. The result is a forest with diversity and flexibility that is well adapted to fire occurrence. Fire has no doubt been a major selection force in our forest ecosystems, both lightning and anthropogenic. Many of the communities and species require fire to sustain populations.”

- Jefferson Nation Forest DEIS

In the Southern Appalachian Mountains a cycle of succession is not the principal process that serves to regenerate the forest ecosystem and maintain it in a state of dynamic equilibrium. This is because fire is not a major natural disturbance event for the region. The Southern Appalachian Physiographic Province averages between 55 and 60 inches of rain a year, culminating in over 100 inches of annual rainfall in the area around Highlands, North Carolina (Southern Appalachian Assessment, Terrestrial Report, 1996; Wilson, 1901). Because of the high annual rainfall, the fuel load does not accumulate, but decays, and the ground generally stays moist, except on ridge crests, especially ones displaying southern or western aspects.

- Quentin Bass, "The Forest Ecosystem and the Effects of Land Use in the Southern Appalachian Physiographic Province"

Southern Appalachian Region



The mountains of the Southern Appalachians provide a variety of ecotypes and variations in fire dependence and fire susceptibility



Patchiness is evident even in dry forest systems that are more clearly and predominantly fire dependent than the forests of the Southern Appalachians

In the Biscuit fire that burned 500,000 acres of Oregon's Siskiyou National Forest

- Slightly over 15% was so severely burned that virtually all the trees died
- About 65% experienced fires of light and moderate severity
- About 20% of the area remained unburned



Diversity of Communities



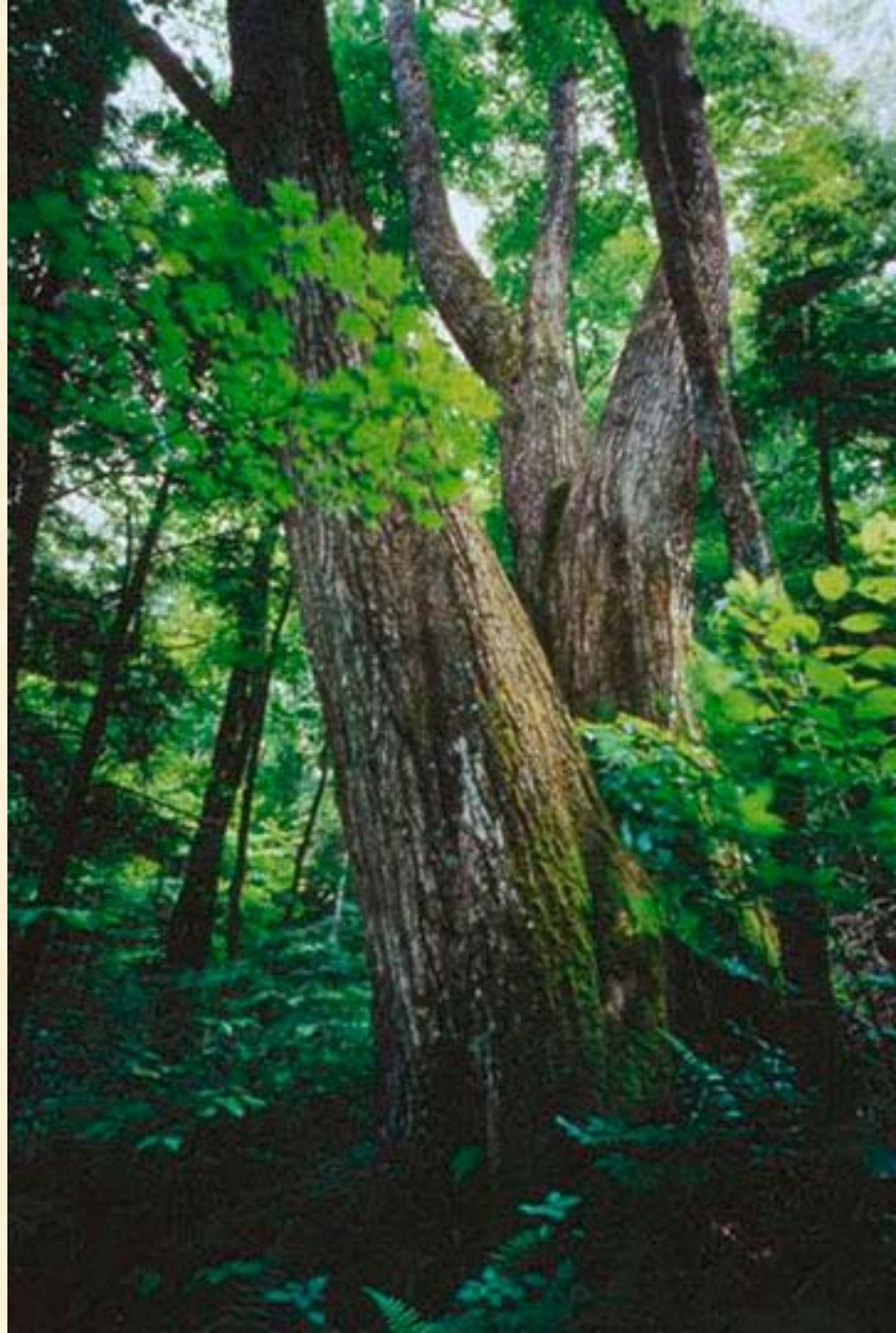
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Communities*



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Diversity of Communities



Diversity of Communities



Diversity of Species



Diversity of Species



Diversity of Species



Diversity of Species



Diversity of Species



Diversity of Species



Fire naturally played a role in Southern Appalachian forests, but it was a role limited in scale. Natural fire ignitions occurred from lightning strikes on ridges of Southern Appalachian mountains, primarily during the summer.



The Southern Appalachian Assessment documents that these lightning strike fires naturally occur at the rate of two to six fires per million acres per year

Limited Role of Fire

- *Between 1987 and 2001 George Washington-Jefferson National Forest averaged 44 wildfires per year covering 1,475 acres per year*

Between 1970 and 1999 the Chattahoochee-Oconee NF averaged 135 wildfires per year covering 1,428 acres per year

Sumter National Forest experiences an average of 30 wildfires per year covering 200 acres per year

Alabama National Forests average 92 wildfires per year covering an average of 1,963 acres per year

Wildfires are predominantly human caused

- *81% on George Washington-Jefferson NF*
76% on Chattahoochee-Oconee NF
90% on the Sumter NF
87.5% on Alabama National Forests

Lightning caused wildfires accounted for

- *19% on George Washington-Jefferson NF*
4% on Chattahoochee-Oconee NF
10% on the Sumter NF
12.5% on Alabama National Forests

Small Size of Wildfires

- On the George Washington-Jefferson National Forest between 1987 and 2001, 73% of all wildfires were less than 10 acres in size; Only 1% of fires were over 1,000 acres; fires averaged 33.5 acres*

Small Size of Wildfires

- *This pattern also held on the GW NF during the 79 year period between 1915 and 1993: 76% were less than 10 acres;
1% were over 1,000 acres*

Small Size of Wildfires

- *On Sumter National Forest 14% of fires were over 10 acres; ; fires averaged 6.7 acres*

Small Size of Wildfires

- *On Chattahoochee-Oconee National Forest only 0.4% of wildfires were over 10 acres ; fires averaged 13.2 acres*

Small Size of Wildfires

- *Wildfires averaged 21.6 acres on Alabama National Forests*

Our Largest Fires are of Limited Extent

Any fire is cause for concern and should be monitored and controlled if it enters the wildland-urban interface or threatens life and property.

However, it is important to put the wildfires in the Southern Appalachians in perspective.

Limited Role of Fire

- *On the George Washington-Jefferson National Forest between 1987 and 2001 the largest lightning ignited fire burned 382 acres*

The largest human-ignited fire burned 2,151 acres

Limited Role of Fire

- *The largest lightning fire on Alabama National Forest between 1989 and 2000 was 200 acres*

Limited Role of Fire

- *The largest lightning wildfire on the Chattahoochee-Oconee National Forest between 1970 and 1999 burned 1,050 acres*

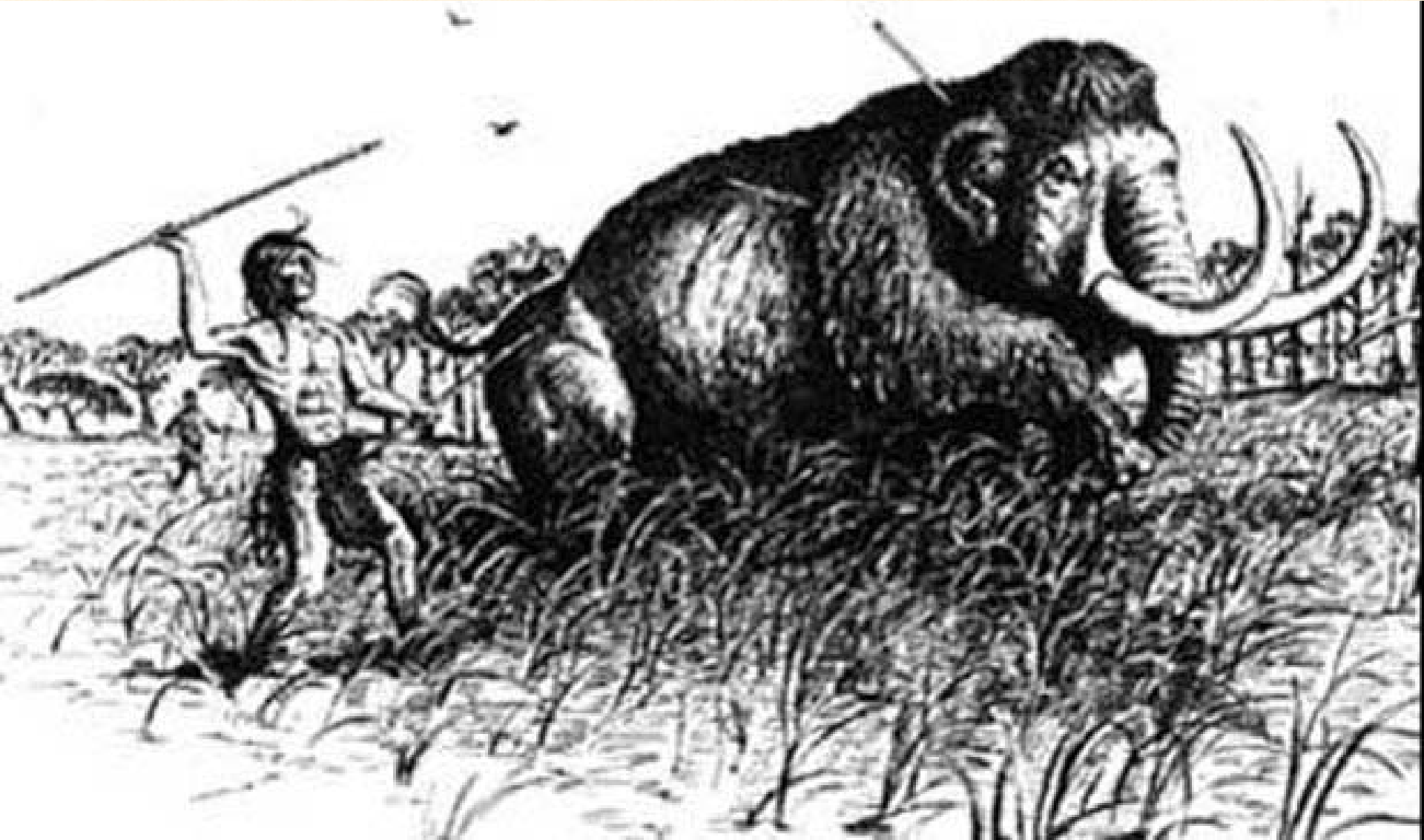
The largest human-ignited fire was a 2,570 acre arson fire

Limited Role of Fire

- *Human ignited fires are generally set on lower slopes and burn upslope while lightning fires almost always ignite on ridges and slopes and burn downslope*

The human-set wildfires are generally larger because they can gain momentum burning upslope

Native Americans have been present in the region for at least 12,000 years



An active debate is currently going on:

- What population levels did Native American populations reach?*
- How extensively did Native Americans use fire in the region?*

This Native American presence went through several distinct phases:

Paleoindian Period (12,000-8000 B.C.)

Archaic Period (8000 B.C.-1000 B.C.)

Woodland Period (1000 B.C.-900 A.D.)

Mississippian Period (900 A.D.-1550 A.D.)



*Estimates of Pre-European Indian Population
ranges from 40,000 to 250,000 in the Southern
Appalachians*



Evidence indicates that Indians used fire in their agriculture along alluvial plains in river valleys



Evidence is less clear that they systematically set fire to forests for hunting and to shape the forests in the Southern Appalachians



Many Southern Appalachian Forest ecotypes are not fire dependent or fire maintained and would indeed be harmed by fire



Mesic forests would not
have naturally or easily
burned

By definition these
forests are moist – many
of the trees in mesic
forest have thin bark and
many herbaceous
species in mesic forests
are not fire adapted



But some forest ecotypes are fire adapted



What is the appropriate scale and extent of fire in the Southern Appalachians?

*The answer to
this questions
is vitally
important in
returning an
appropriate
type and scale
of fire regime
to the native
forests*



Large-scale destructive logging a century ago created conditions



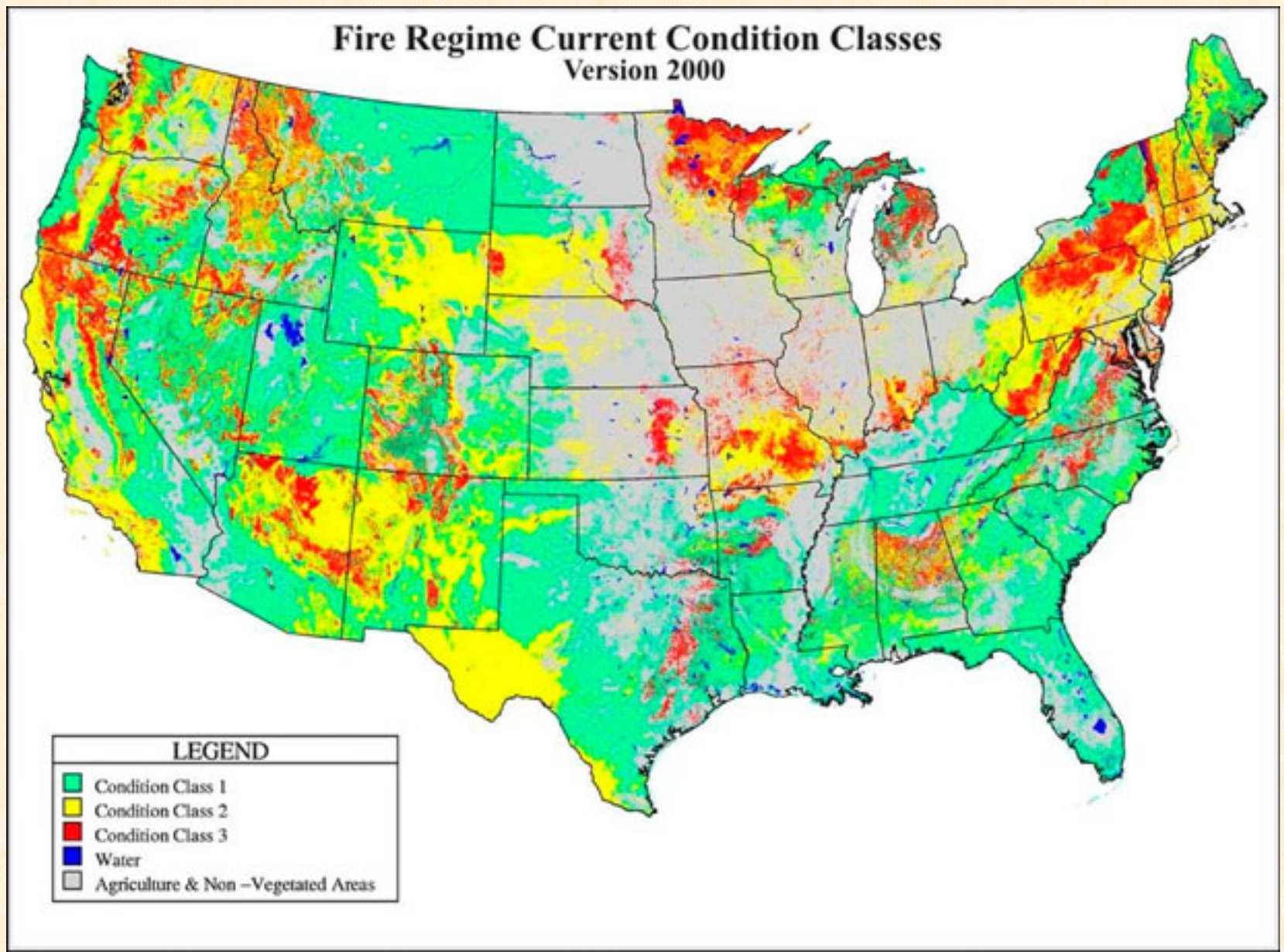
at the turn of the 20th century that lead to destructive wildfires and flooding



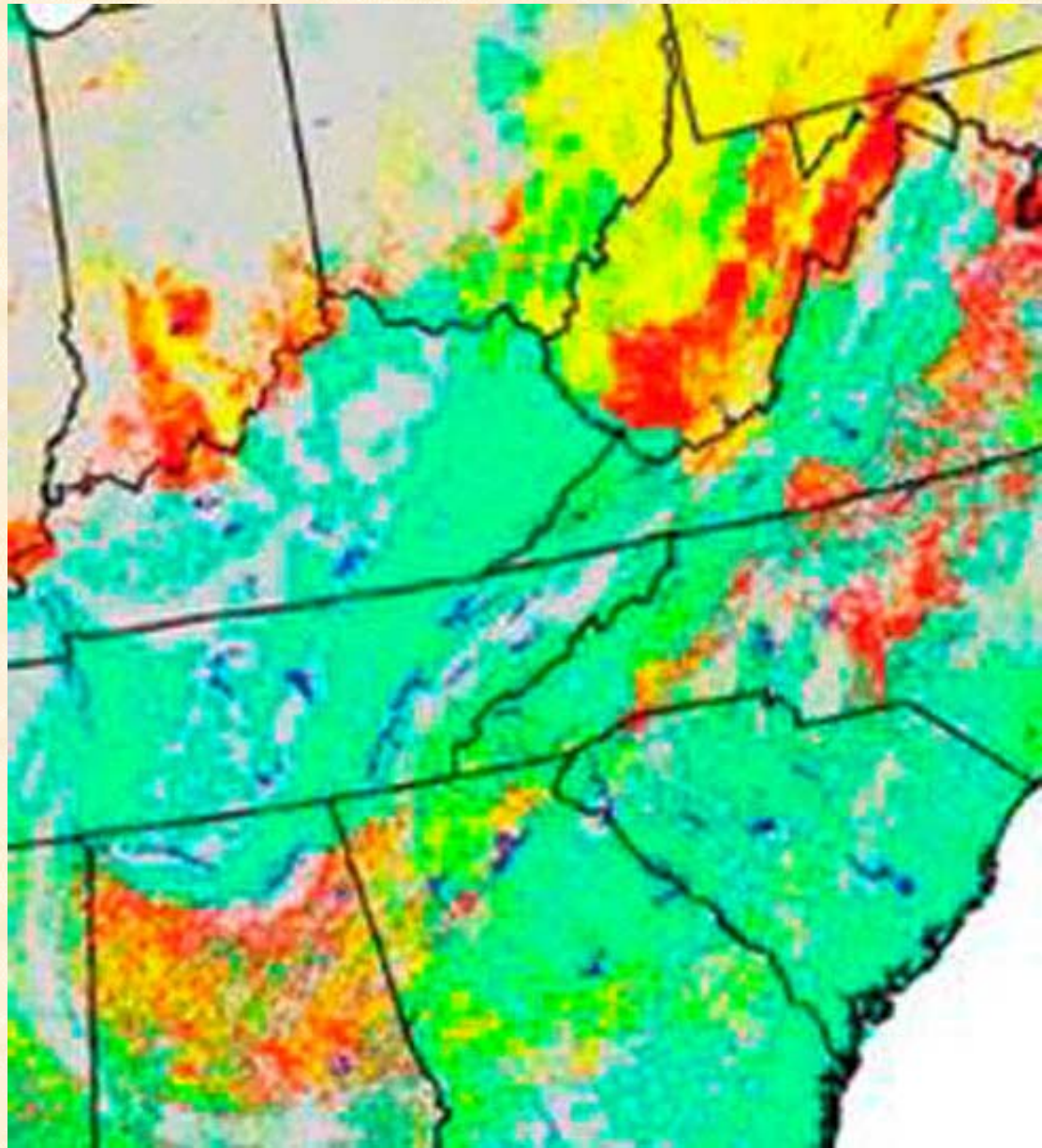
The reaction to these conditions and the creation of a Smoky the Bear philosophy from the misreading of forest ecology in the Western States led to almost a century of fire suppression and a failure to acknowledge fire ecology.



National Fire Plan: Fire Condition Class



This scheme
and other
“one size fits
all plans” do
not deal with
the ecology or
conditions of
our forests at
the proper
scale or
texture



Working toward a regional model of fire susceptibility based on

- Complex Topographic Index – measure of inherent moisture
- Topographic Aspect – Measure of exposure

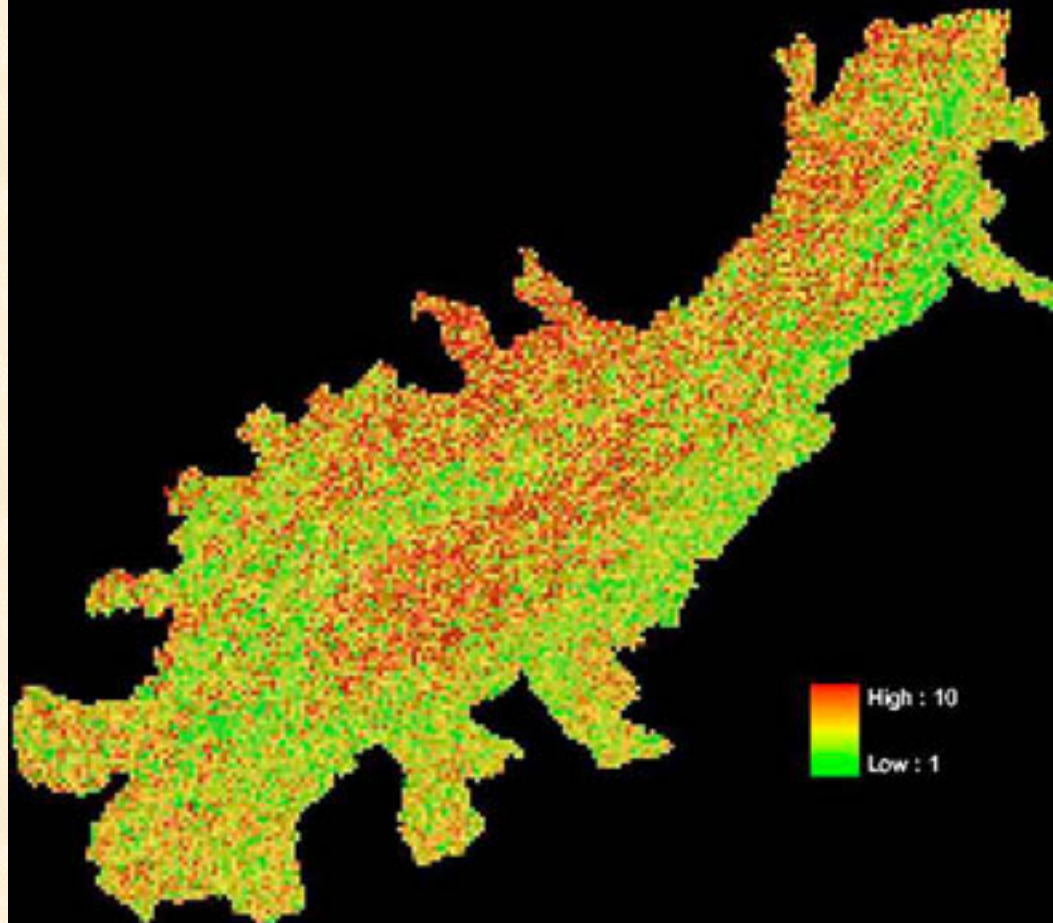
Complex Topographic Index

- GIS Grid based
- Steady state wetness index
- CTI is a function of both the slope and the upstream contributing area per unit width orthogonal to the flow direction
- CTI is highly correlated with several soil attributes such as horizon depth ($r=0.55$), silt percentage ($r=0.61$), organic matter content ($r=0.57$), and phosphorus ($r=0.53$)

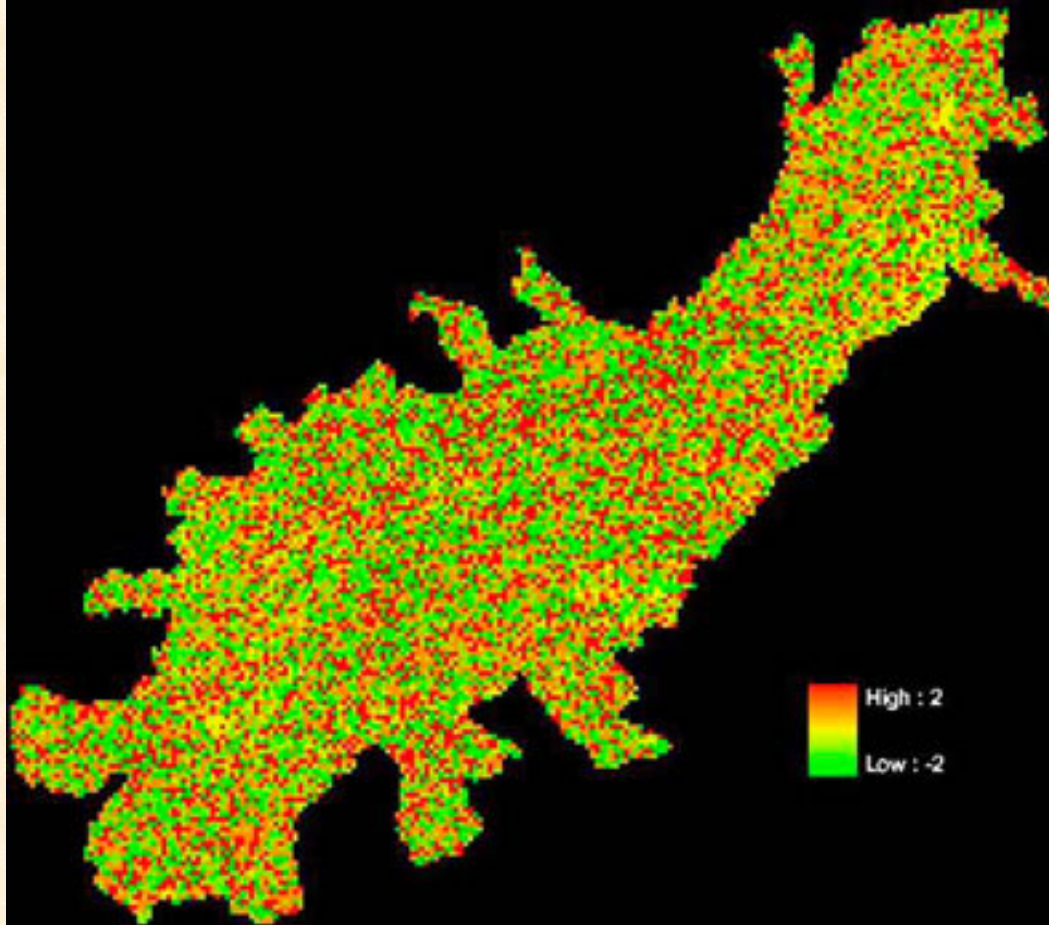
Aspect

- South aspect associated with drying effects from sun exposure
- North aspect associated with protected mesic sites

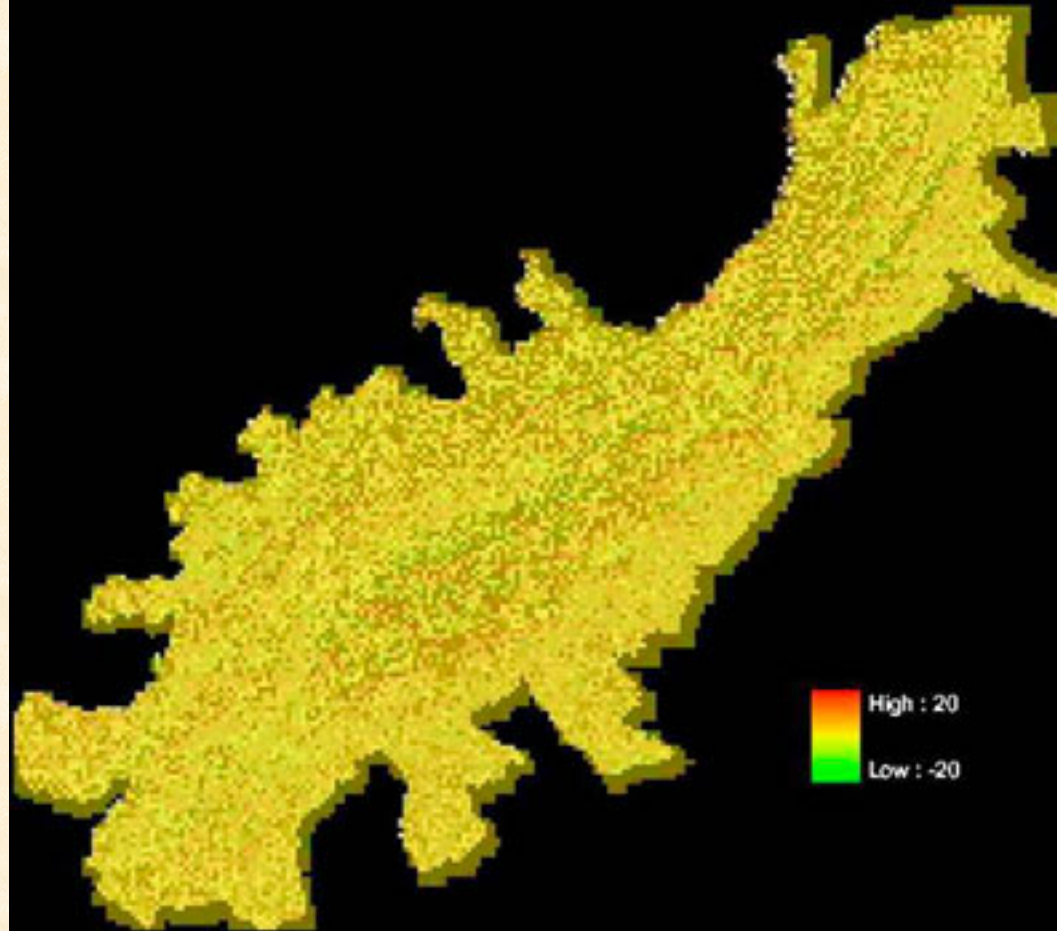
Complex Topographic Index



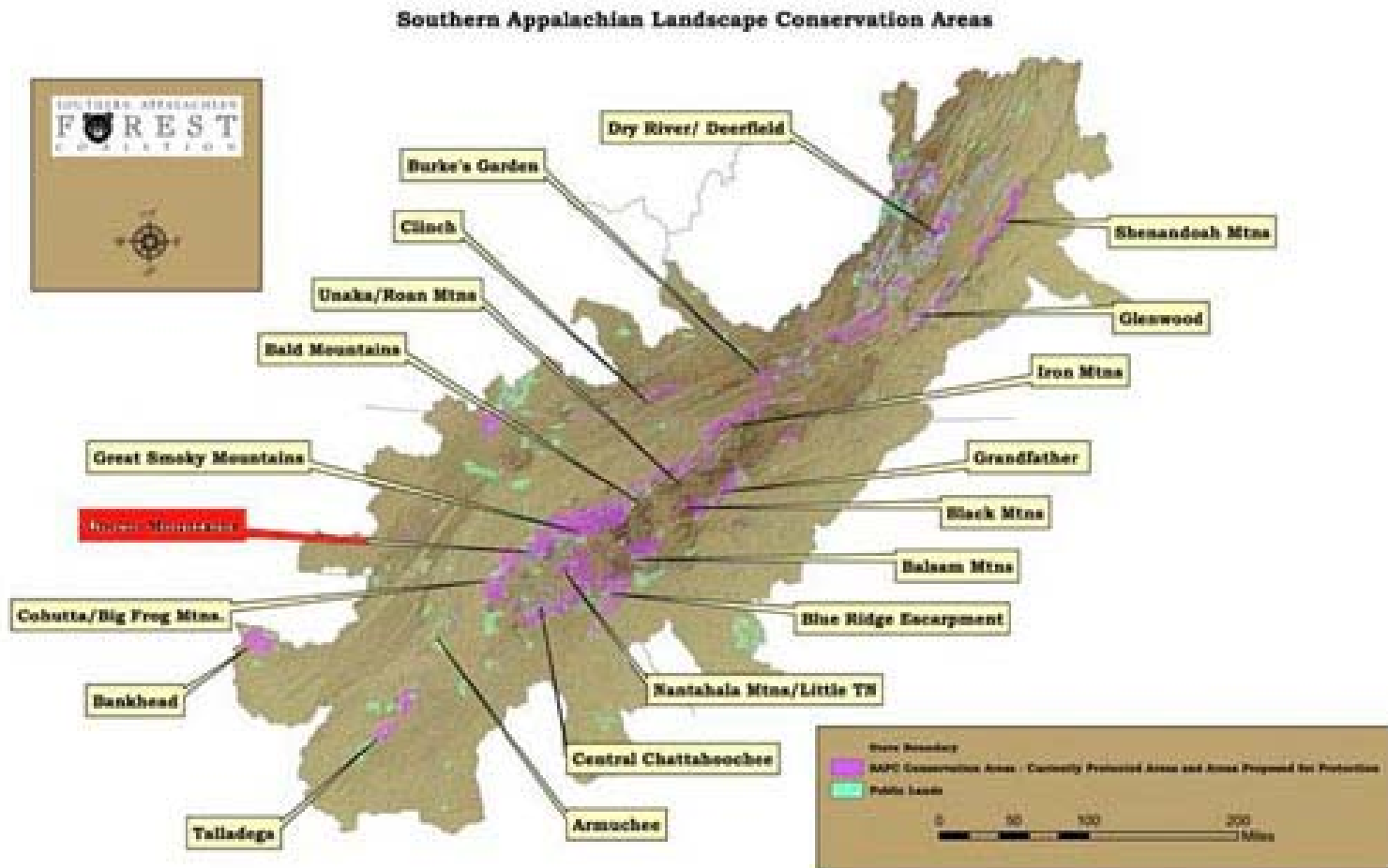
Topographic Aspect



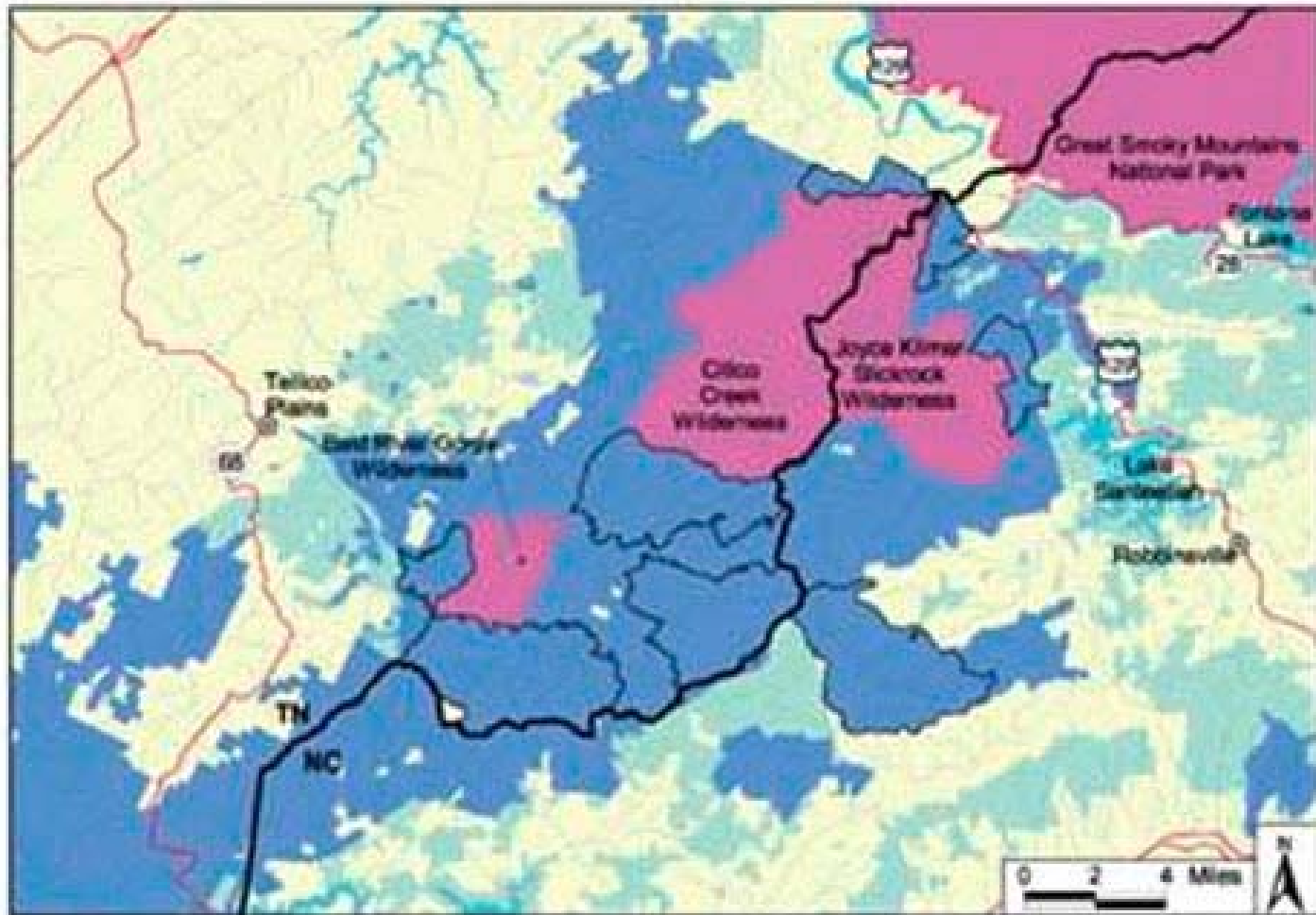
Fire Susceptibility Model



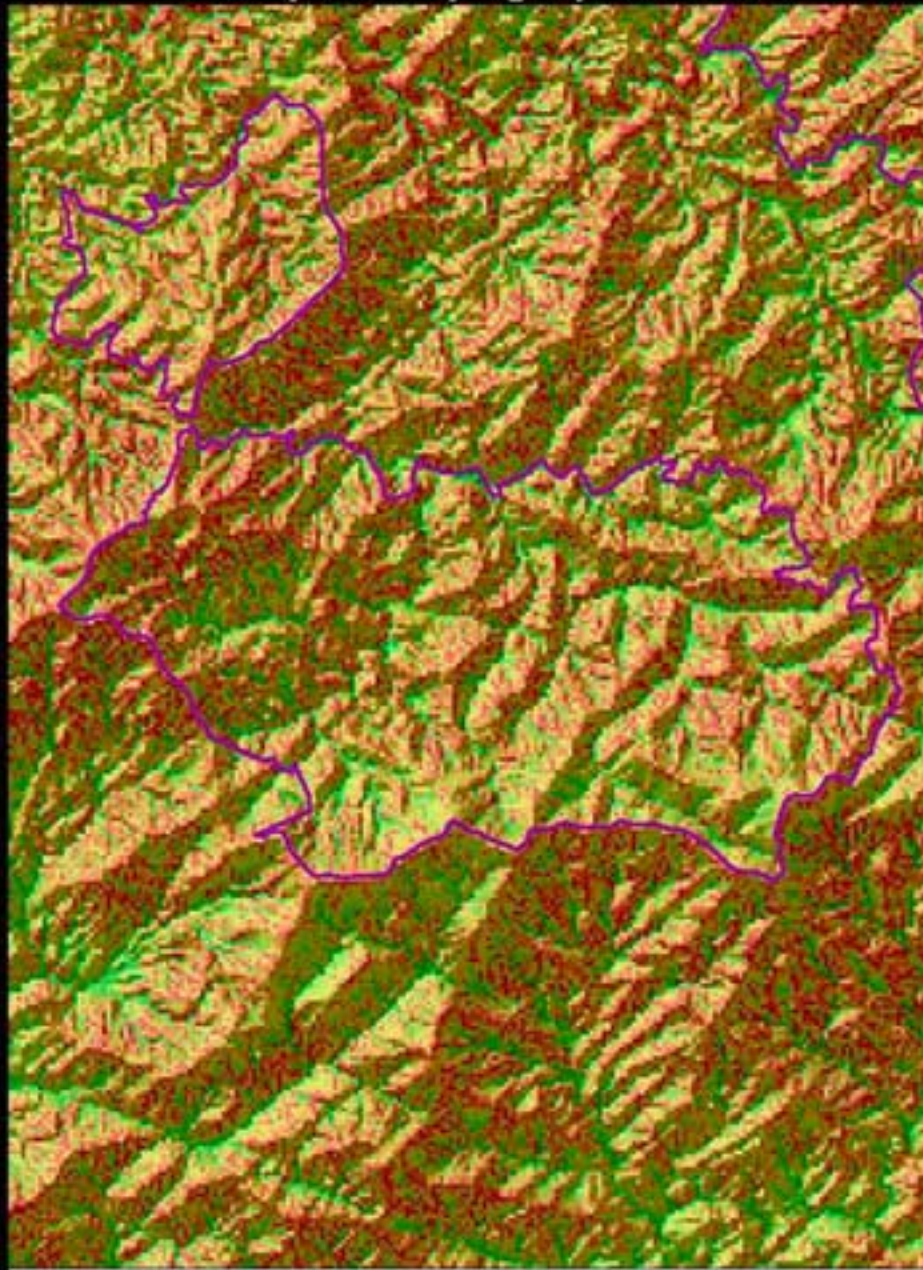
Unicoi Mtns Landscape Conservation Area



Unicoi Mtns Landscape Conservation Area



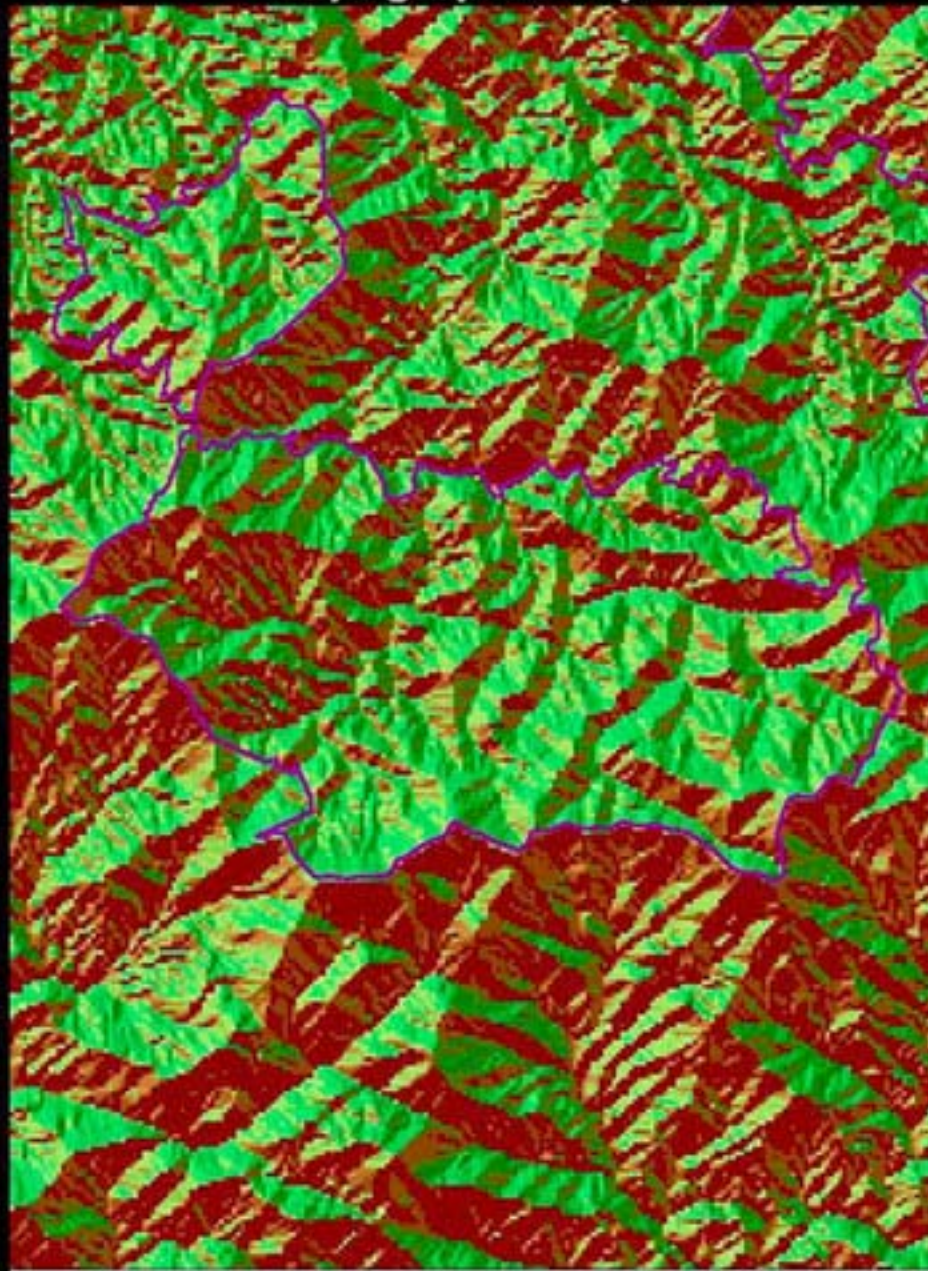
Complex Topographic Index



0 0.5 1 2 Miles

High : 10
Low : 1

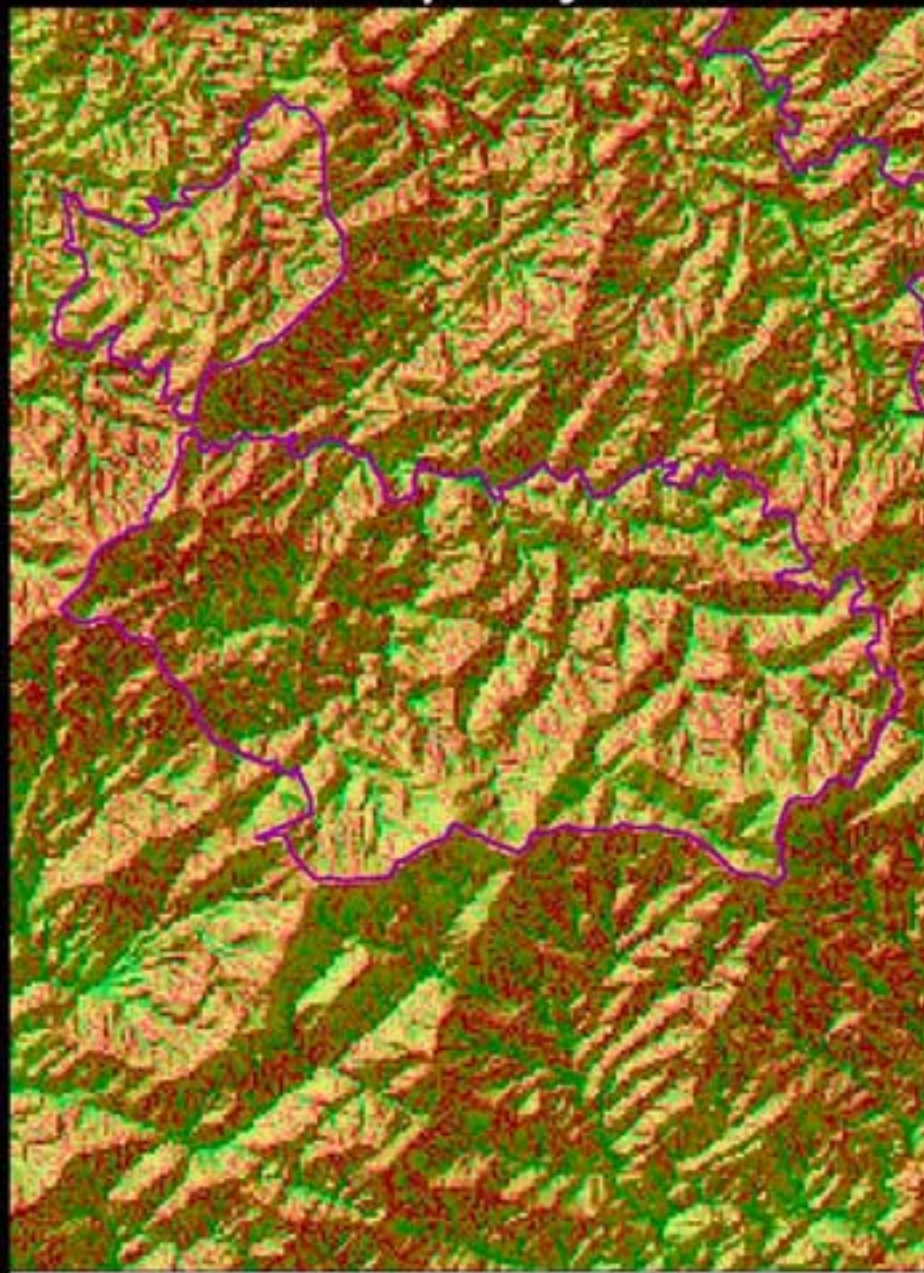
Topographic Aspect



0 0.5 1 2 Miles

High : 2
Low : -2

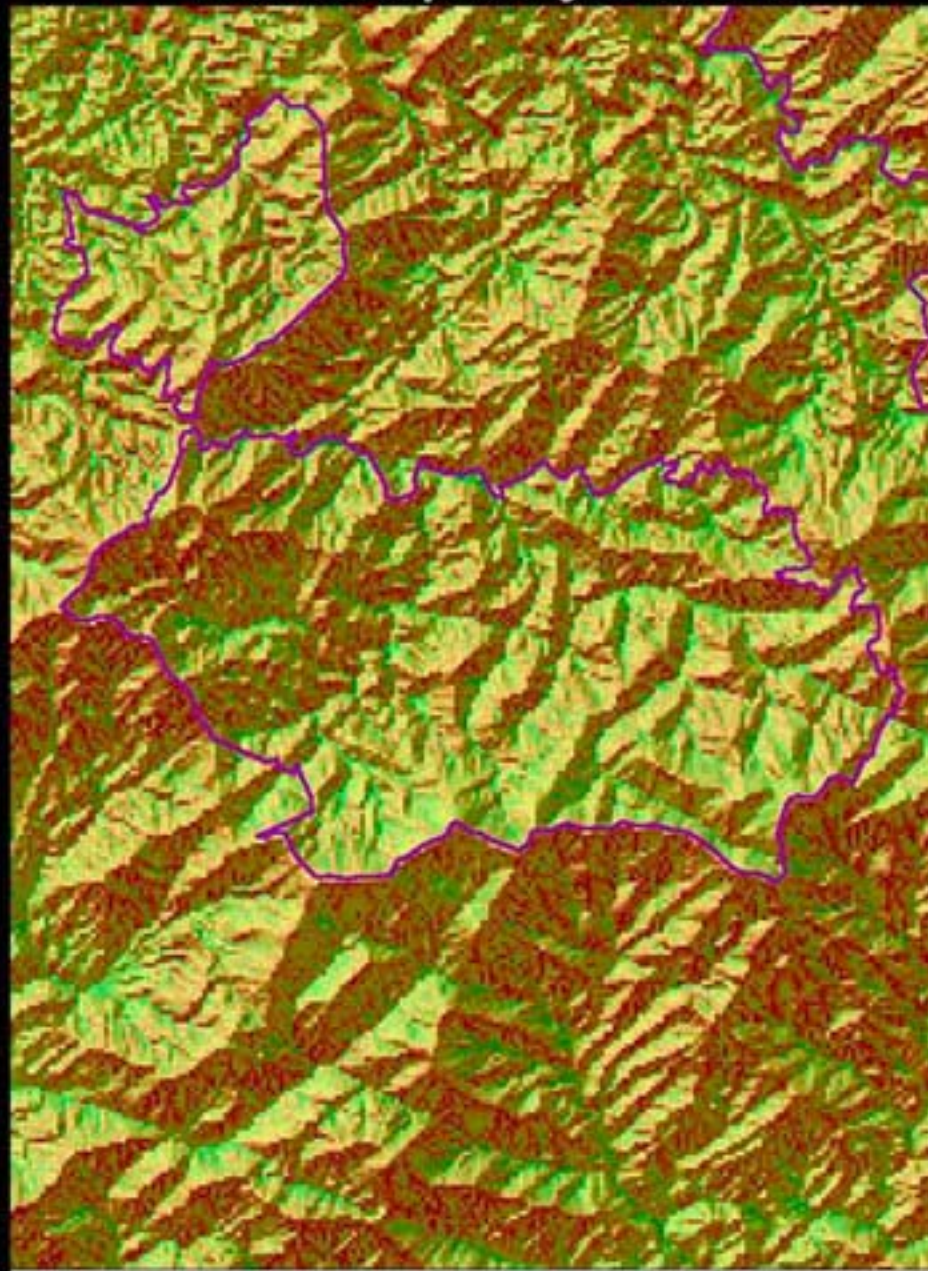
Fire Susceptibility Model - 1



0 0.5 1 2 Miles

High : 10
Low : 1

Fire Susceptibility Model - 2



0 0.5 1 2 Miles

High : 12
Low : -1

Calibration or Regression Analysis of Model

- Ideally data from prescribed burn projects could be used in Regression analysis of model
- No monitoring data available

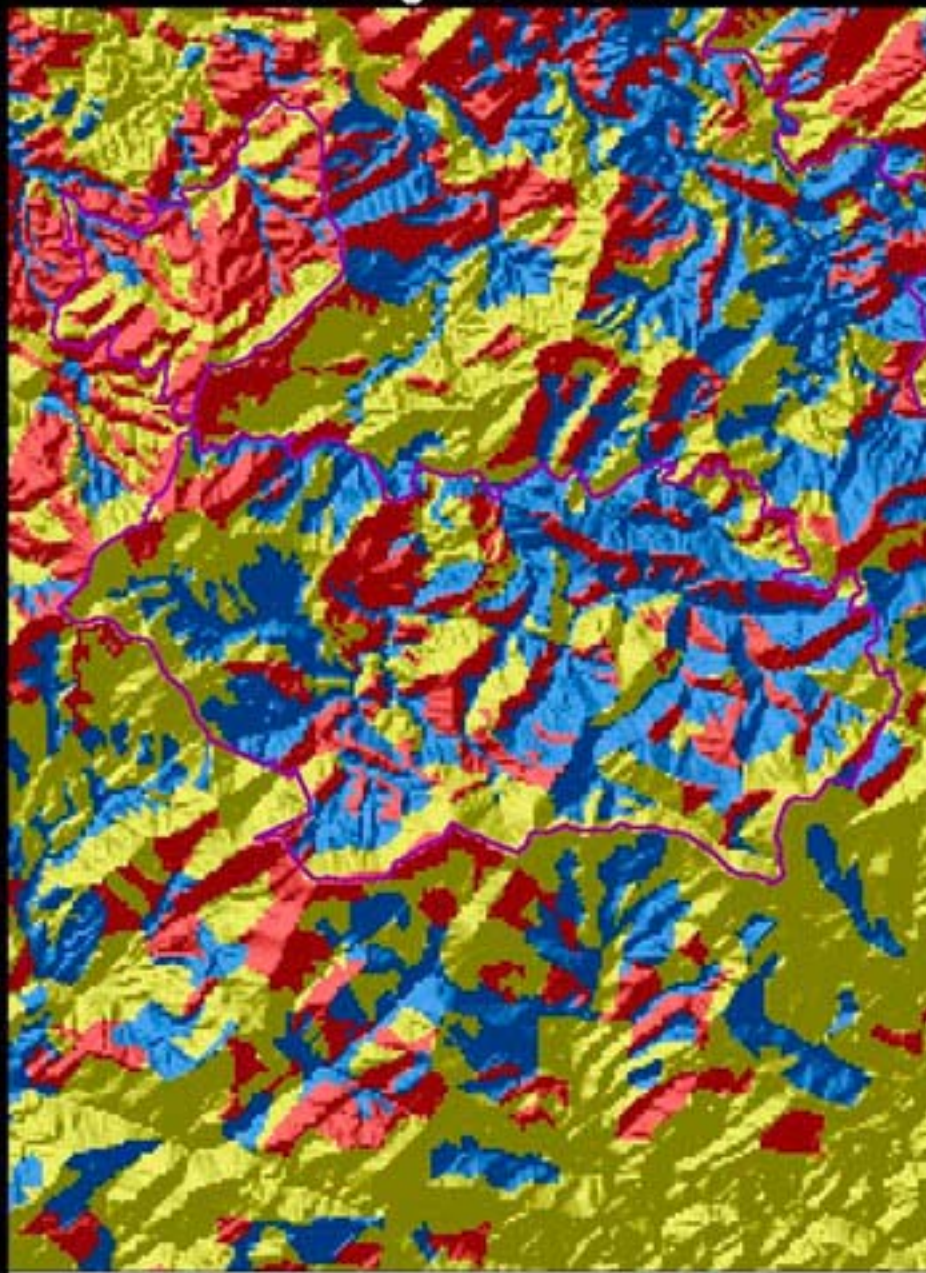
Ecological Screen by Forest Community Types

- CISC Forest Stand Type to Old Growth Forest Community Type
- OG Community Type into Mesic, Fire Dependent, and Intermediate classes
- Grid of values used to screen Fire Susceptibility Grid

OG Community Types

- Mesic: northern hardwood, conifer-northern hardwood, mixed mesophytic,
- Fire Dependent: dry and xeric oak, xeric pine and pine-oak
- Intermediate: dry-mesic oak, dry and dry-mesic oak-pine,

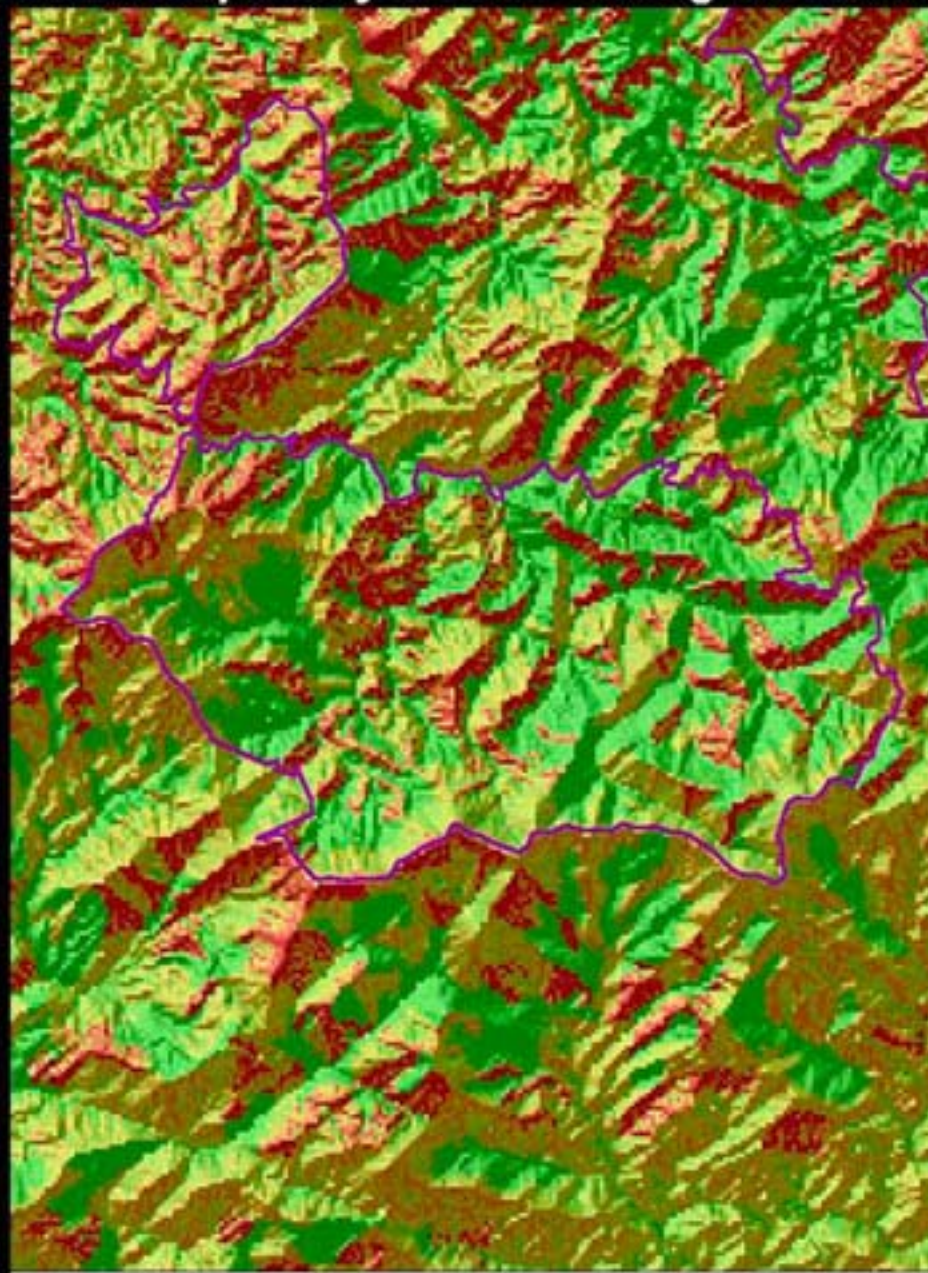
Ecological Screen



0 0.5 1 2 Miles



Fire Susceptibility Model - Ecological Screen



0 0.5 1 2 Miles





The appropriate role of fire in the Southern Appalachians

- *The interspersion of fire intolerant forest communities throughout the Southern Appalachians with fire tolerant communities illustrates the fine texture of the landscape in relation to fire*

*Fire **does not** gain the momentum to burn across the landscape, jumping streams and moving from watershed to watershed to burn most of the forest in its path.*



The appropriate role of fire in the Southern Appalachians

- *Fire in the Southern Appalachians is fine textured, burning primarily on ridges and south slopes and being limited by the mesic habitat interspersed with more fire adapted habitat.*

In moist years these fires go out quickly as they burn down slope and encounter moist conditions.

Rarely, during drought or dry conditions, fire could burn further down the slope. However, even in dry years fire would be extinguished as it encountered the moist conditions of the coves.



The appropriate role of fire in the Southern Appalachians

- This appropriate and limited role should be returned through natural fire occurrence and some prescribed burns in areas (primarily ridges and south slopes) where it would naturally occur*



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