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Protecting our mountains, rivers, and forests

Assessment of Landscape Scale Forest Structure and Ecological Departure in Western North Carolina

Josh Kelly

Outline of Presentation

- Overview of “Maps, Models, and Metrics” eCAP methodology sensu Low et al. (2010)
- Review of Ecological Zone Models (Maps)
- Review of Landfire Biophysical Settings (Models)
- Review LiDAR data products available for vegetation analysis (Measurements)
- Ecological Departure (Metrics)

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Low, Greg, Susan L. Abele, and Louis Provencher. 2010. Enhanced conservation action planning: assessing landscape conditions and predicting benefits of restoration strategies. *Journal of Conservation Planning* Vol 6 36-60.

The Study Area

- Study area is the overlap of the Proclamation Boundary of Nantahala-Pisgah National Forest and 2005 LiDAR data totaling 2,020,851 acres
- 844,831 acres of Nantahala-Pisgah NF
- 1,176,060 acres of other lands, mostly private ownership
- Approximately1,767,150 acres of forest

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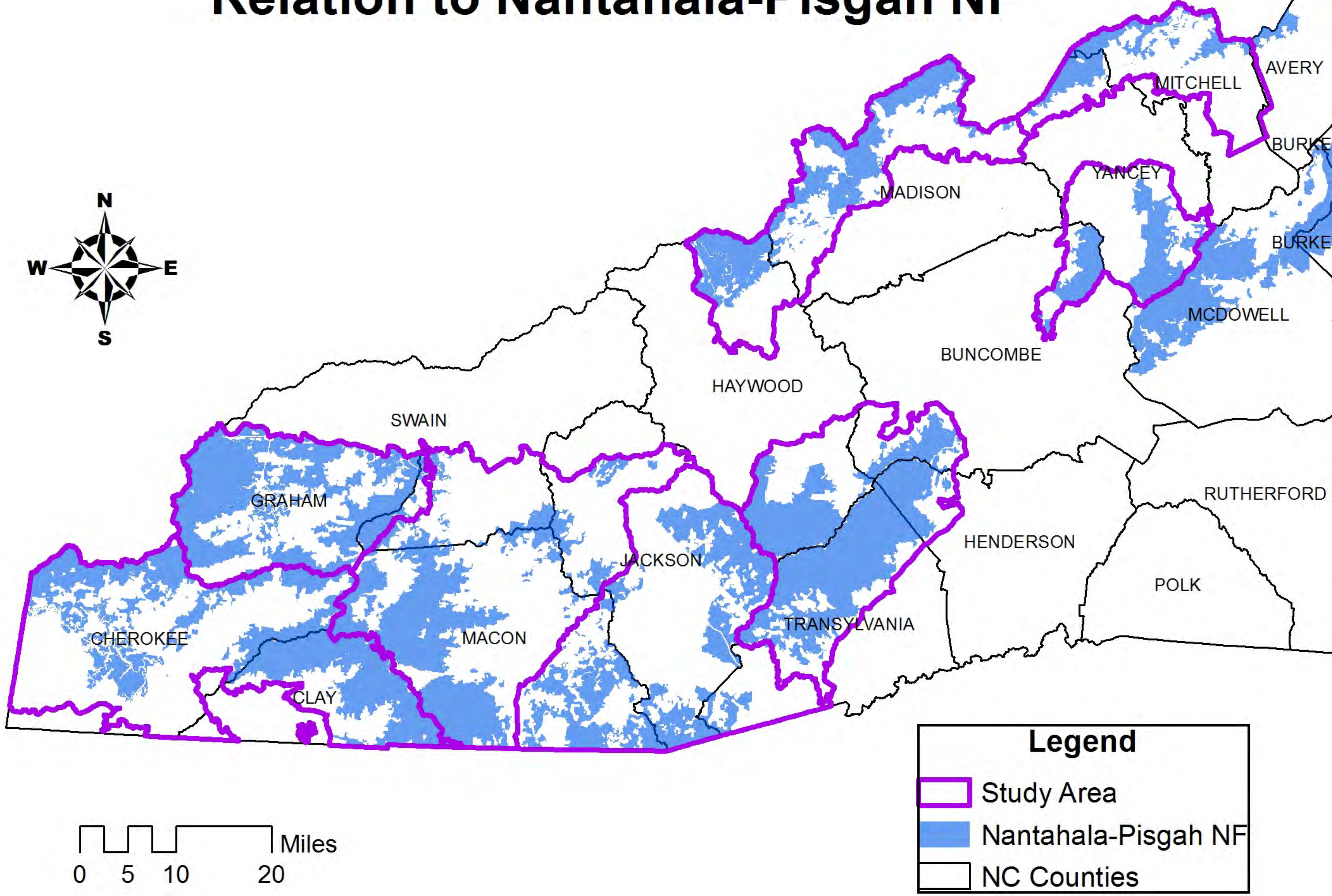
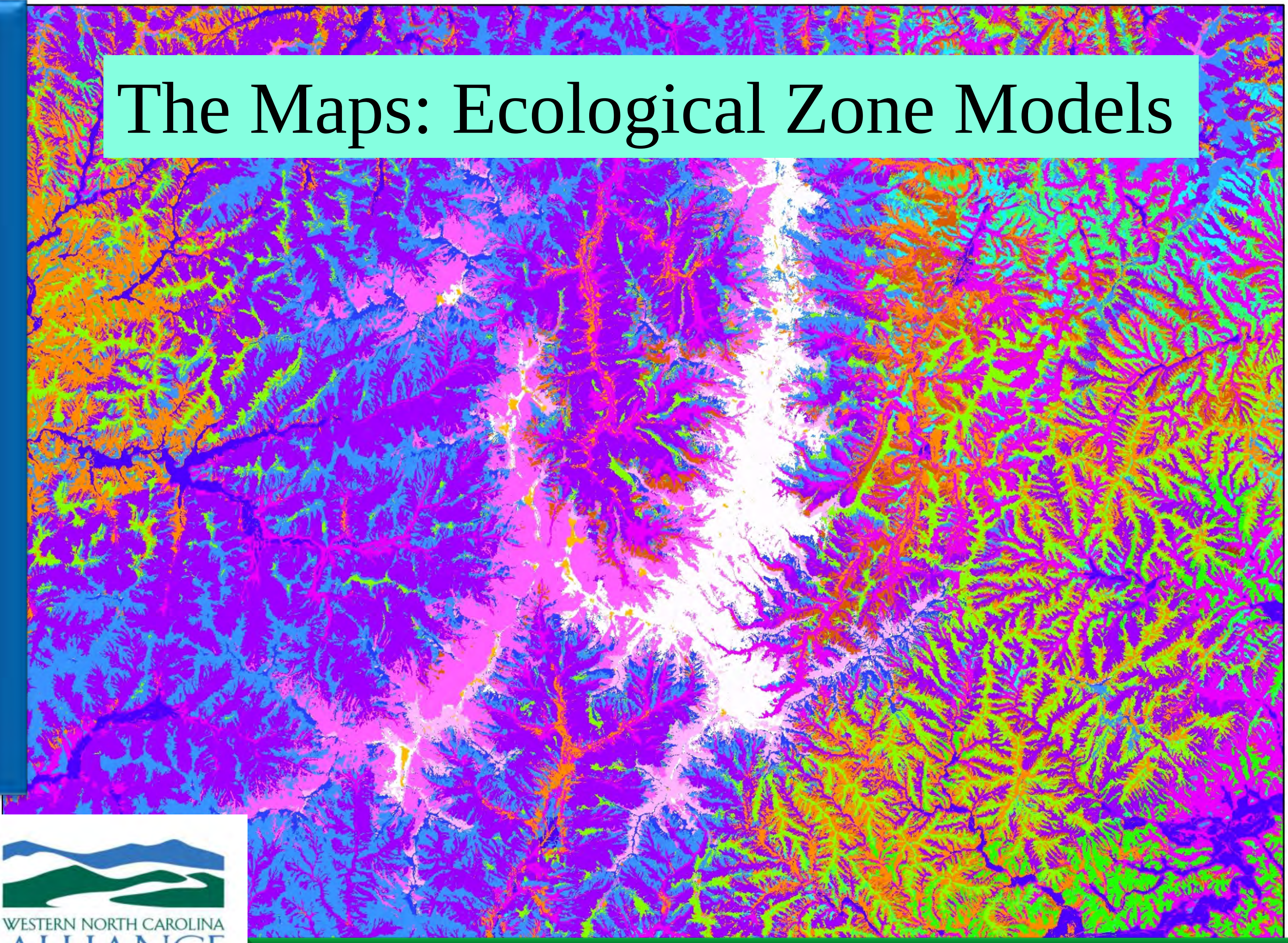
Boundary of Ecosystem Analysis in Relation to Nantahala-Pisgah NF



The Maps: Ecological Zone Models



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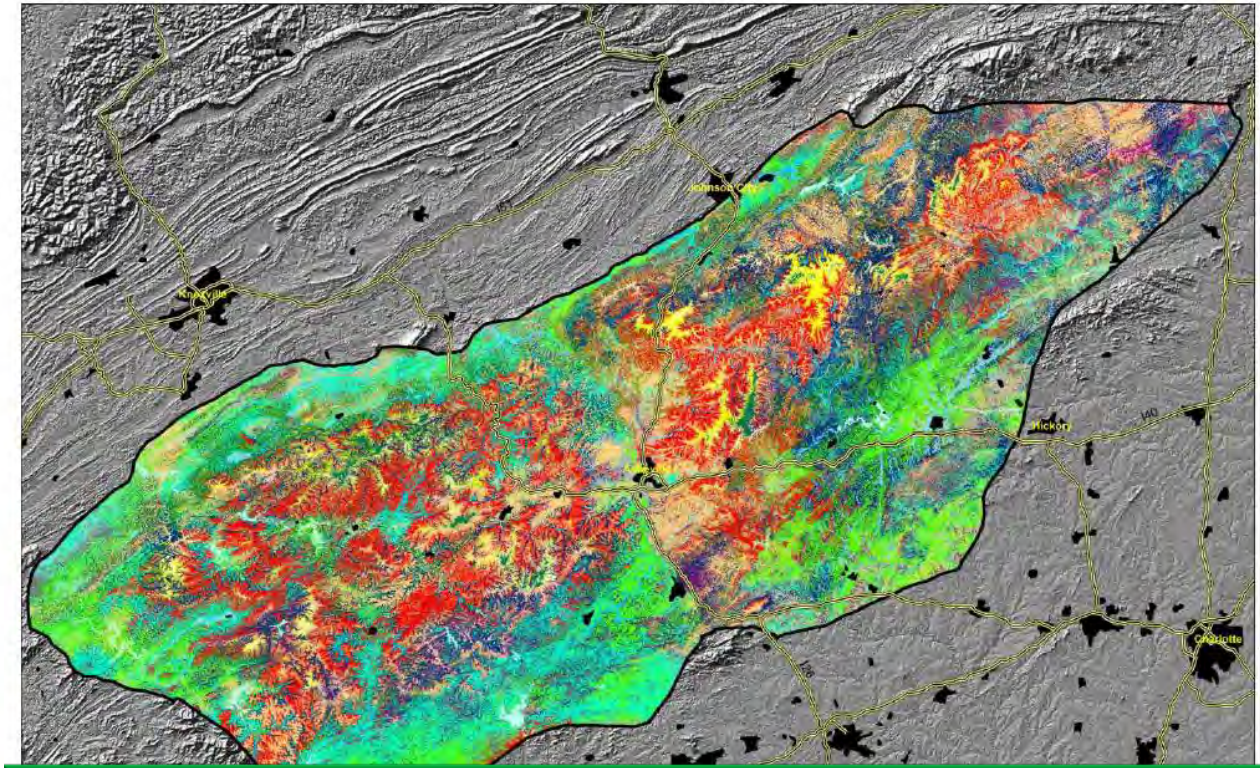
Ecological Zones in the Southern Blue Ridge: 3rd Approximation

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

12/31/2011



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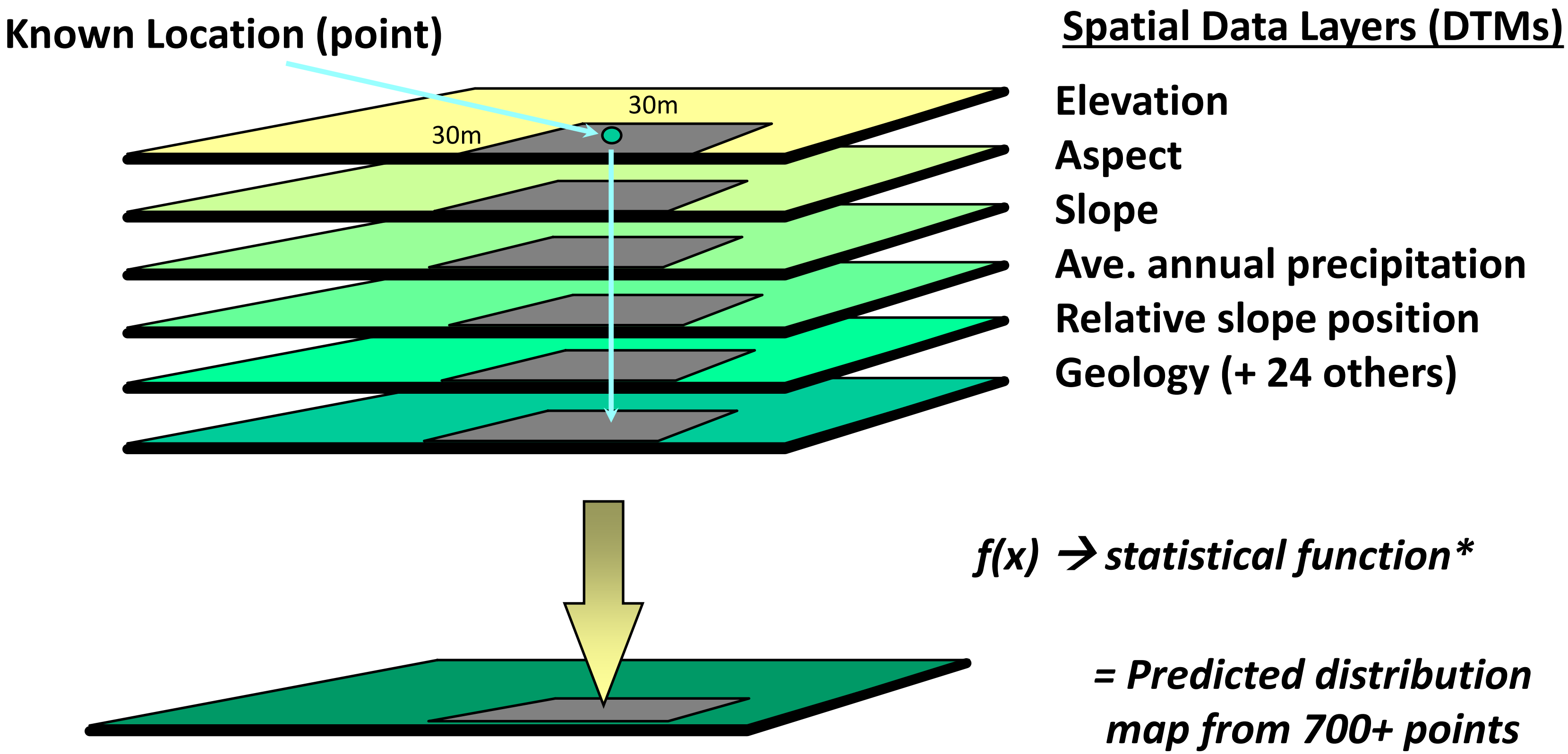
Heath Bald

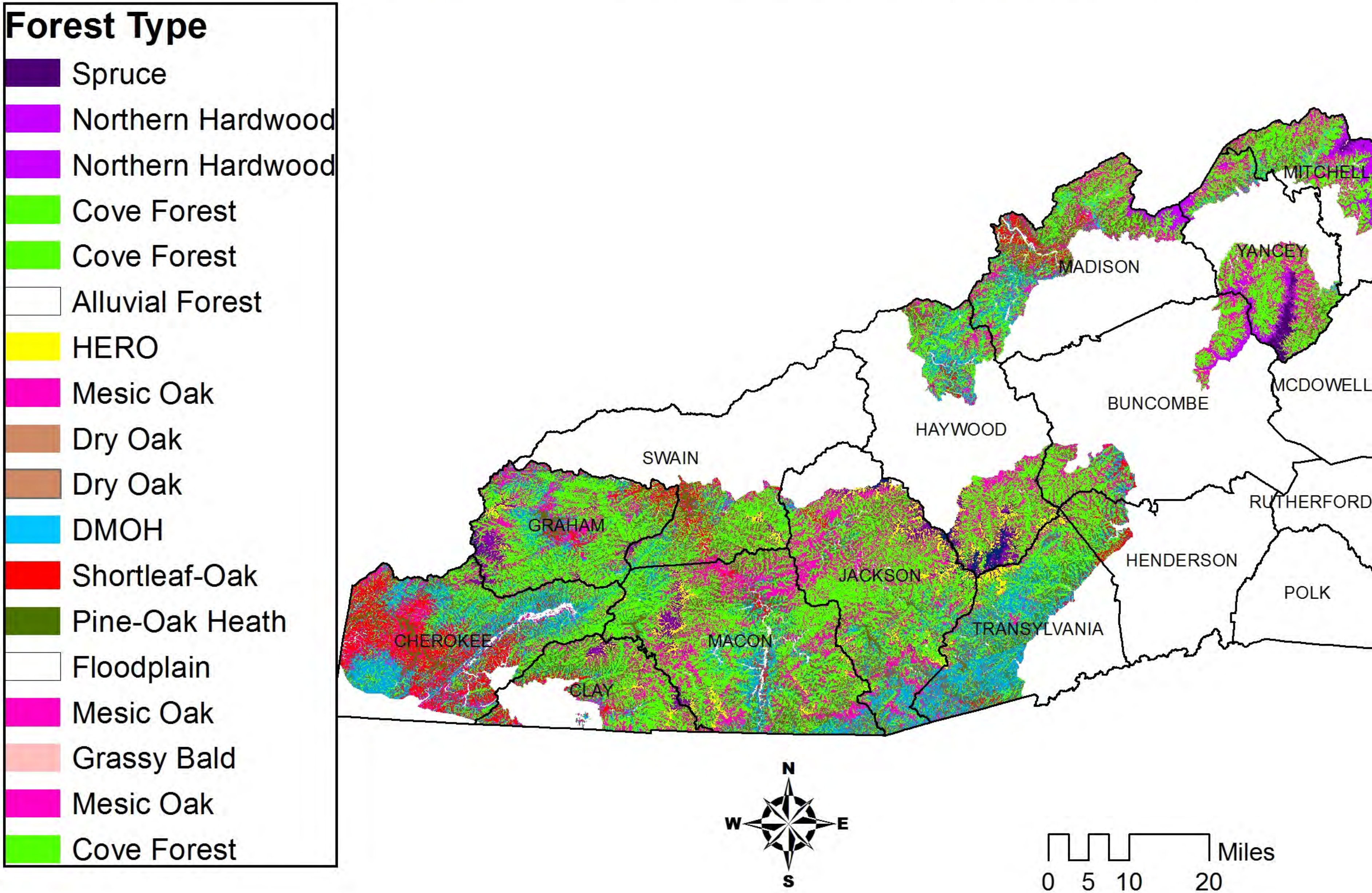
Ecological Systems / Zone modeling



* e.g. Maximum entropy, Logistic regression, Discriminant analysis

From "Assessment and Mapping of Vegetation Communities in the Shenandoah National Park," John Young, USGS

Ecological Zones in Study Area



Models: LANDFIRE Biophysical Settings

LANDFIRE developed reference condition models for every ecological system in the United States

"All Models Are Wrong But Some Are Useful"

George E.P. Box

LANDFIRE Biophysical Setting Model

Biophysical Setting 5713180 Southern and Central Appalachian Cove Forest

General Information

Contributors | Date
Modeler 1 | Reviewer
Modeler 2 | Reviewer
Modeler 3 | Reviewer

Vegetation Type: Forest and Woodland

Map Zone: 57

Dominant Species*: FAGR, AEFL, LITU, ACSA3, TIAMH

General Model Sources: ☑ Literature ☐ Local Data ☑ Expert Estimate

Model Zone: ☐ Alaska ☐ California ☐ Northeast ☐ N-Cent.Rockies ☐ Pacific Northwest ☐ South Central ☐ Southeast ☑ S. Appalachians ☐ Southwest

Geographic Range

Biophysical Site Description

LANDFIRE Biophysical Setting Model

Biophysical Setting 5713520 Southern Appalachian Montane Pine Forest and Woodland

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

General Information

Contributors (also see the Comments field **Date** 8/15/2007

Modeler 1	Steve Croy		**Reviewer**	Wanda SanJule	wsanjule@tnc.org
Modeler 2	Margit Bucher	mbucher@tnc.org	**Reviewer**	Charles Lafon	clafon@geog.tamu.edu
Modeler 3	Sam Lindblom	slindblom@tnc.org	**Reviewer**		

Vegetation Type

Forest and Woodland

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

Dominant Species*

PIPU5 GAYLU
PIRI VACCI
QUPR2 QUIL
QUCO2

General Model Sources

☑ Literature
☑ Local Data
☑ Expert Estimate

Geographic Range

Blue Ridge Mountains of TN, NC, and VA (including extreme northeast GA and northwest SC). Mountains of the Ridge and Valley in VA and WV. Western extent is along the KY-VA border on Pine Mtn.

There may also be isolated examples occurring on ridges or monadnocks like Pine Mountain (MZ54 GA), Kings Mountain (MZ59 NC), Pilot Mountain and Hanging Rock in NC.

Disturbance Probabilities for Montane Pine Forest & Woodland

Disturbances

Fire Regime Group:** I

Historical Fire Size (acres)

Avg 1000
Min 100
Max 10000

Sources of Fire Regime Data

- ☑ Literature
- ☑ Local Data
- ☑ Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	88.43			0.01131	5
Mixed	100.9			0.00991	5
Surface	5.422			0.18443	90
All Fires	5			0.20565	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☑ Insects/Disease
- ☑ Wind/Weather/Stress
- ☐ Native Grazing
- ☐ Competition
- ☑ Other (optional 1) Ice storm
- ☐ Other (optional 2)

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Class A **12 %**

Early Development 1 All Structure

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model

Indicator Species* and Canopy Position

PIRI	Mid-Upper
PIPU5	Mid-Upper
QUCO2	Mid-Upper
QUPR2	Mid-Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	51 %	100 %
Height	Tree 0m	Tree 5m
Tree Size Class	Sapling >4.5ft; <5"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform.

Class C **25 %**

Mid Development 1 Open

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 9

Indicator Species* and Canopy Position

PIRI	Mid-Upper
PIPU5	Mid-Upper
QUCO2	Mid-Upper
QUPR2	Mid-Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	21 %	70 %
Height	Tree 5.1m	Tree 10m
Tree Size Class	Medium 9-21"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform.

Class D **55 %**

Late Development 1 Open

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 2

Indicator Species* and Canopy Position

PIRI	Upper
PIPU5	Upper
QUCO2	Mid-Upper
QUPR2	Mid-Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	21 %	70 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform.

Class E **5 %**

Late Development 1 Closed

Upper Layer Lifeform

- [ ] Herbaceous

Indicator Species* and Canopy Position

PIRI	Upper
PIPU5	Upper
QUCO2	Mid-Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	71 %	100 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

A Word about S-Classes

- S-Classes refer to Successional (age) and Structural (open vs. closed) characteristics of forest
- A tenet of conservation is that if S-Classes are in their proper proportions and orientations, ecosystems are healthy
- Open and early s-classes can be used to evaluate disturbance rates & processes

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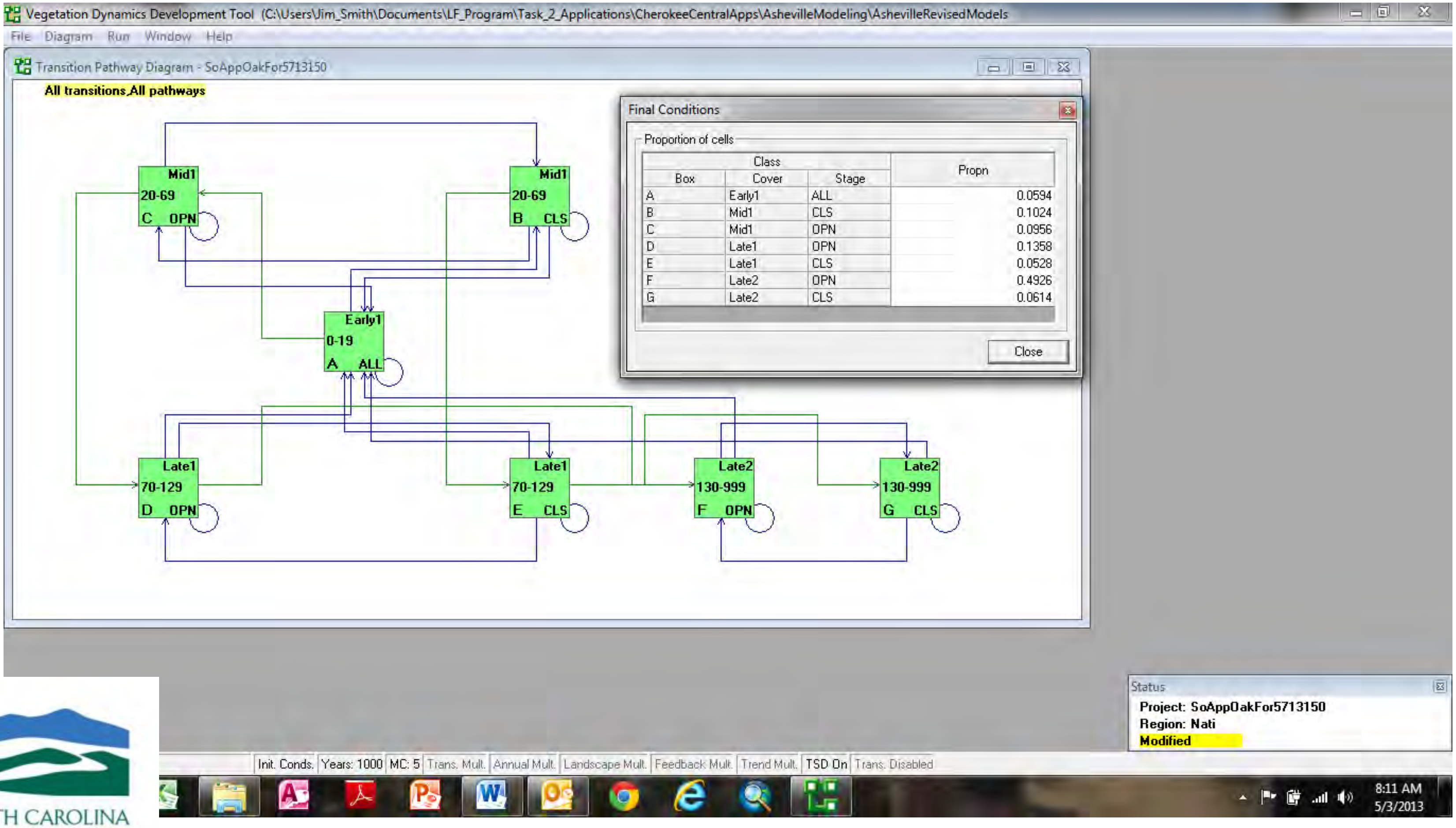
A Schematic of a the Southern Appalachian Oak Forest BPS



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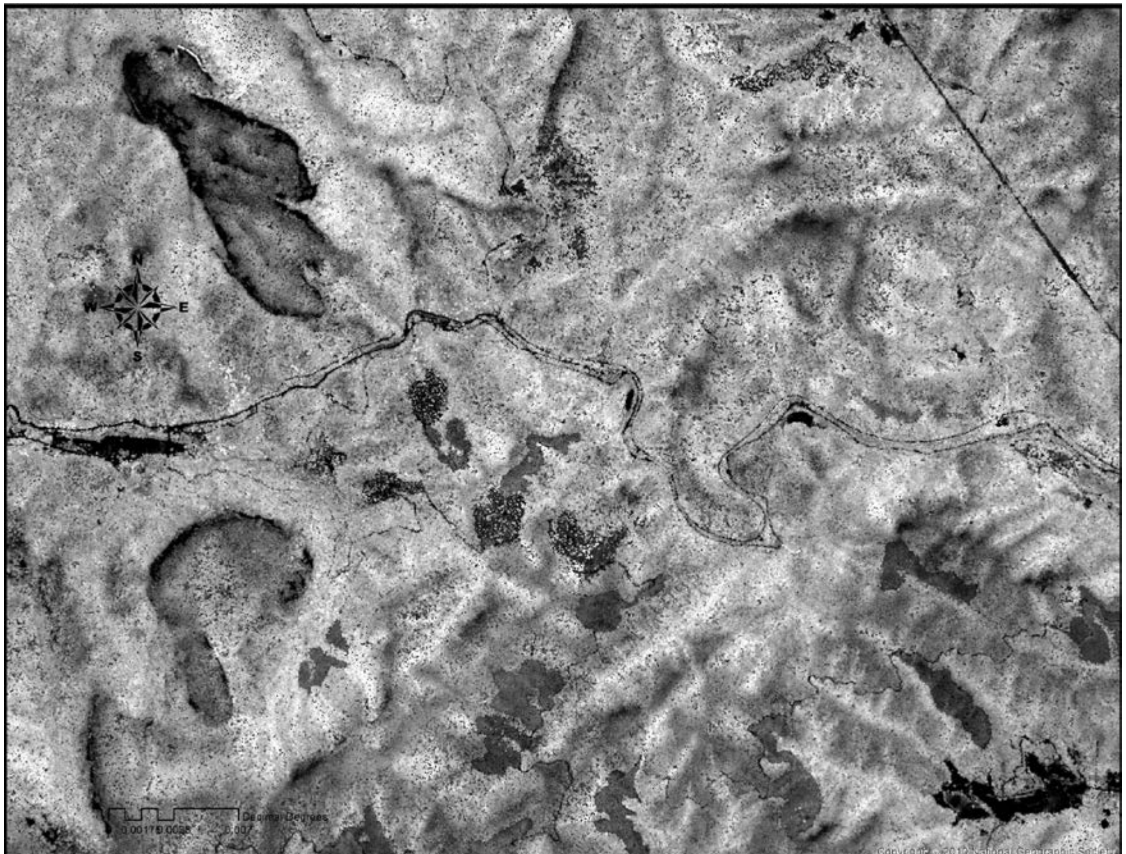
Using Lasers to *Measure* Vegetation and Analyze Ecosystems



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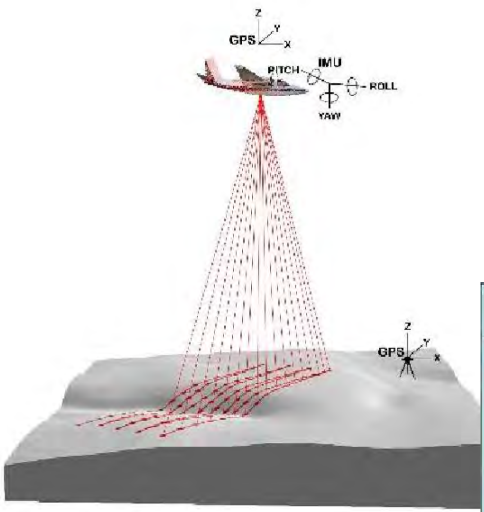
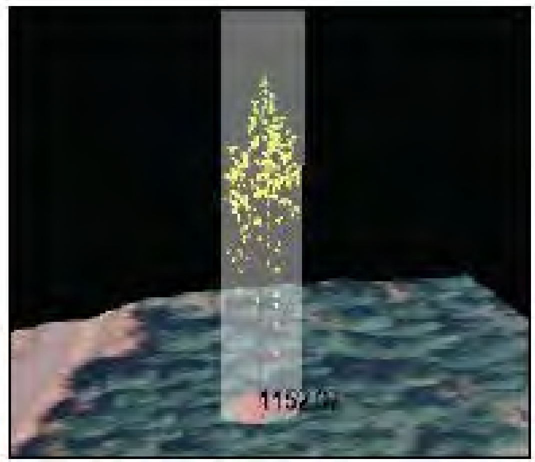
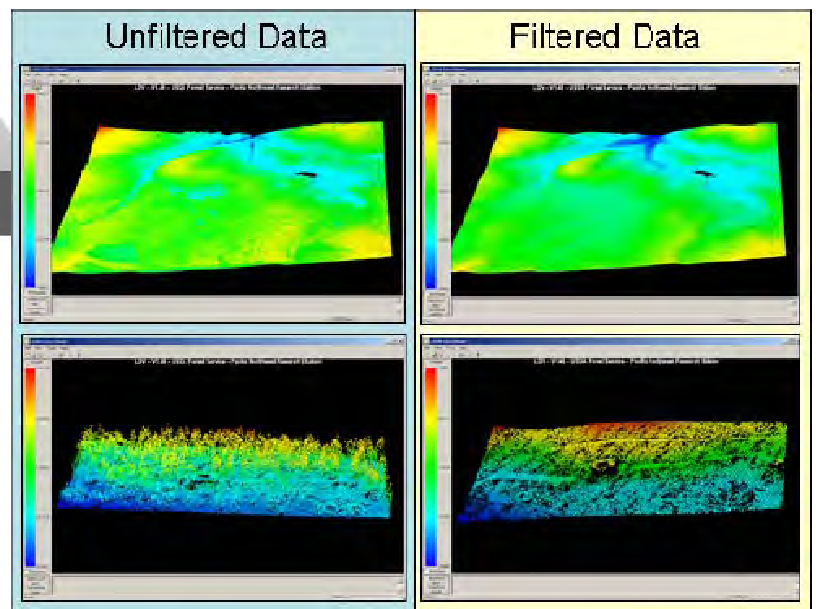
What is LiDAR?

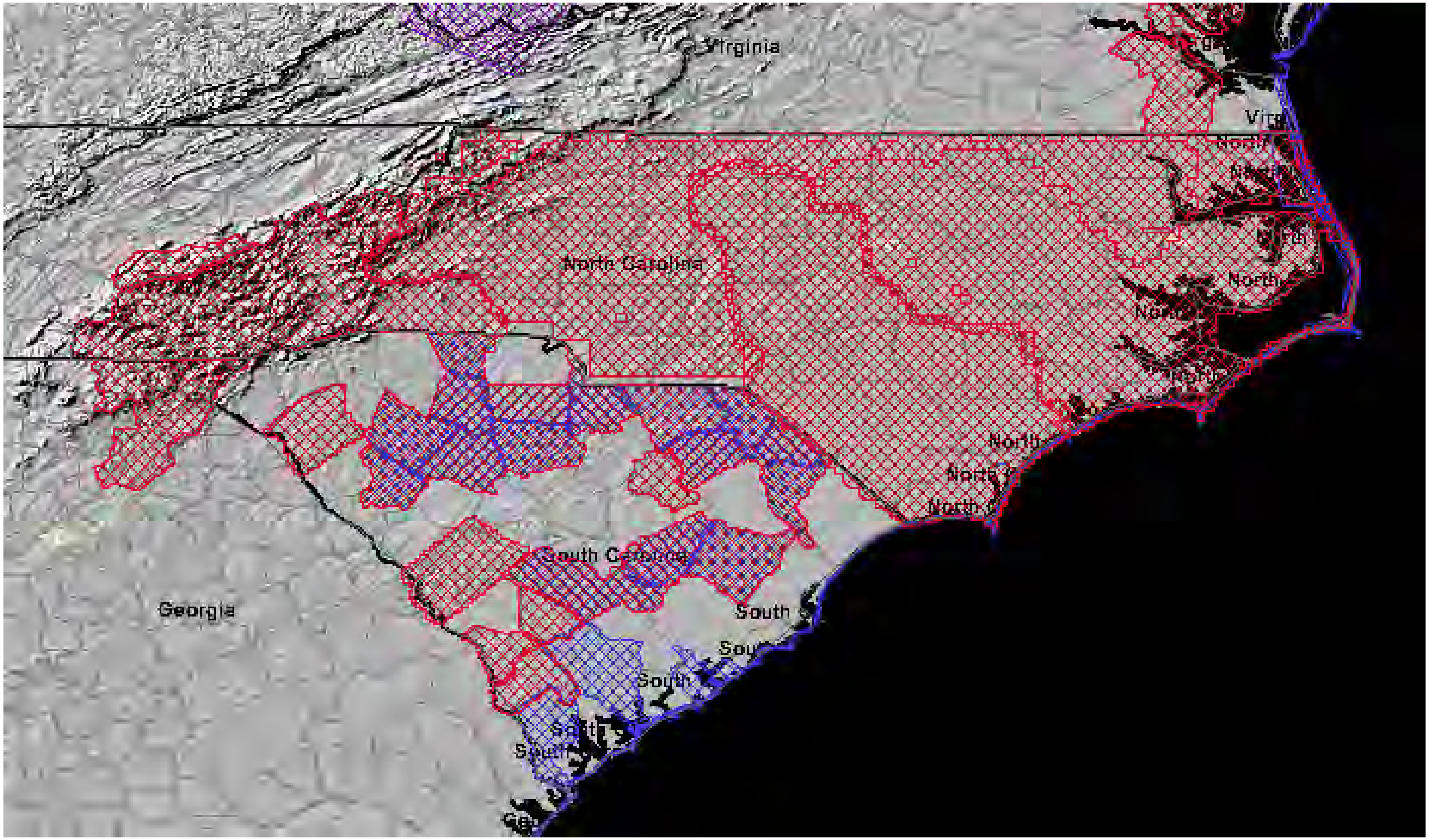


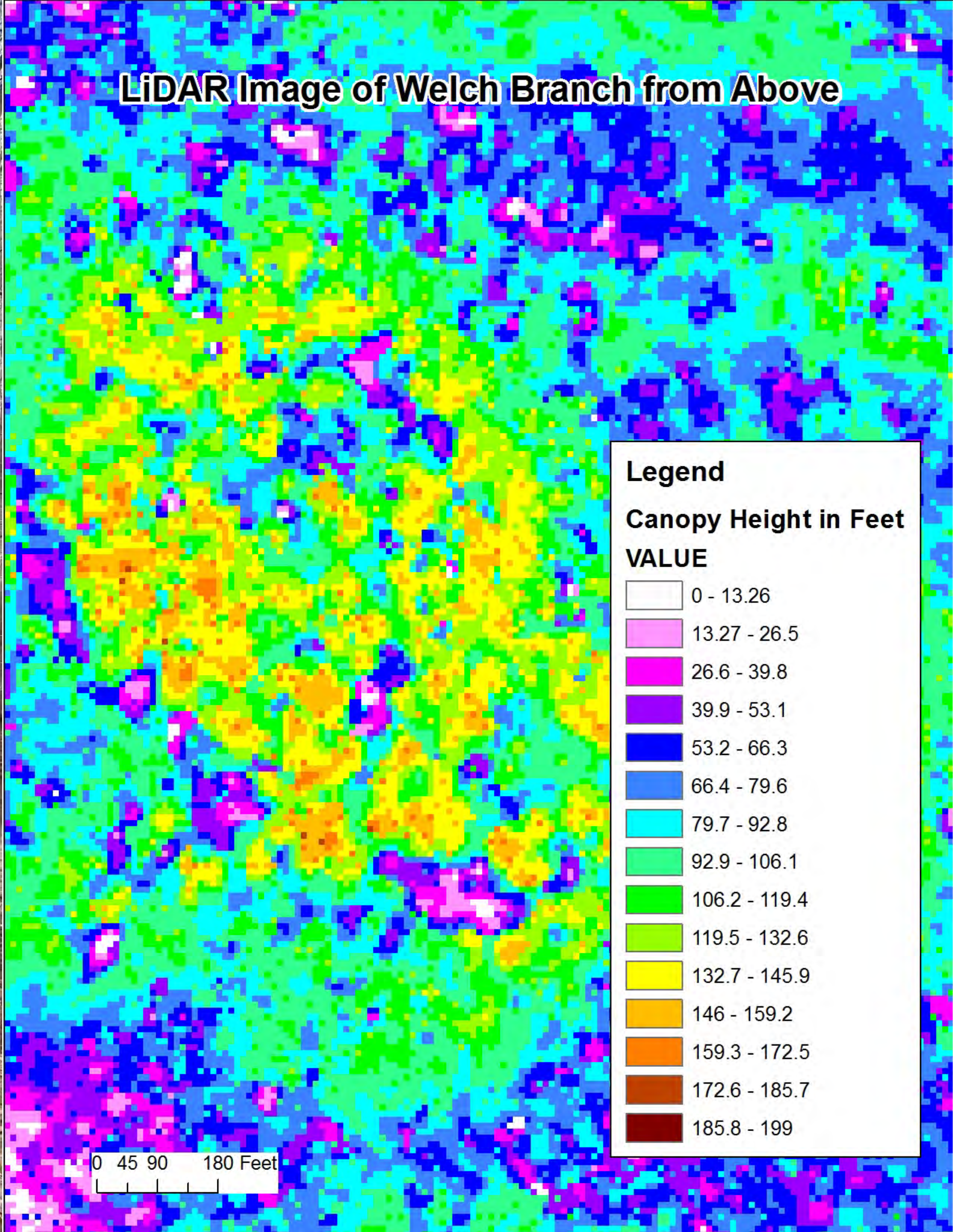


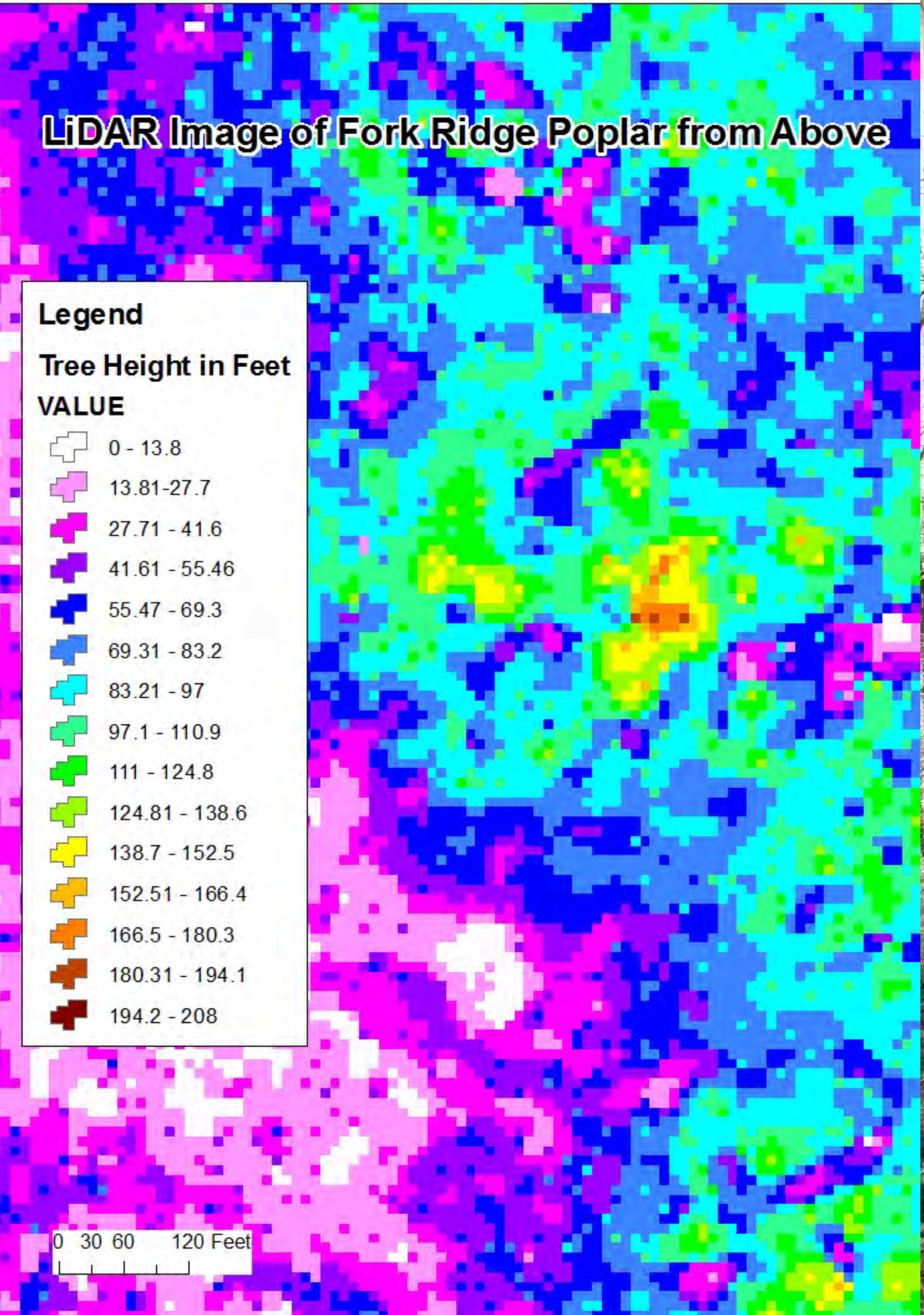


Where can I get LiDAR data?

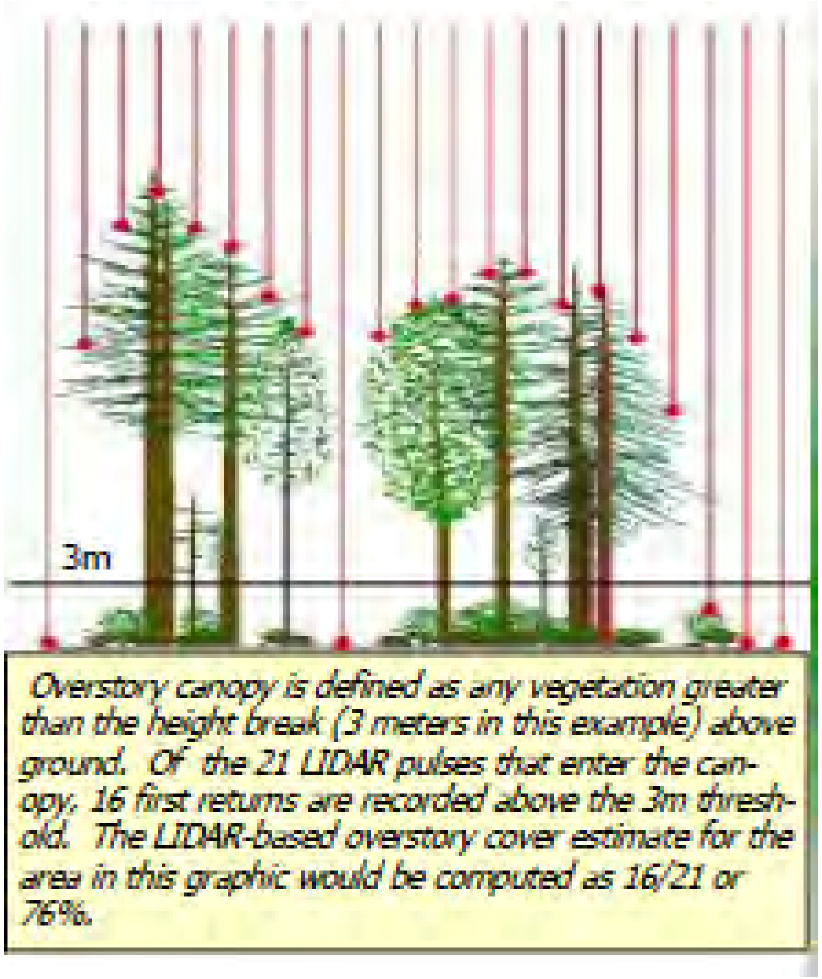
http://lidar.cr.usgs.gov/LIDAR_Viewer/viewer.php




LiDAR Image of Welch Branch from Above
Legend
Canopy Height in Feet
VALUE
0 - 13.26
13.27 - 26.5
26.6 - 39.8
39.9 - 53.1
53.2 - 66.3
66.4 - 79.6
79.7 - 92.8
92.9 - 106.1
106.2 - 119.4
119.5 - 132.6
132.7 - 145.9
146 - 159.2
159.3 - 172.5
172.6 - 185.7
185.8 - 199
0 45 90 180 Feet

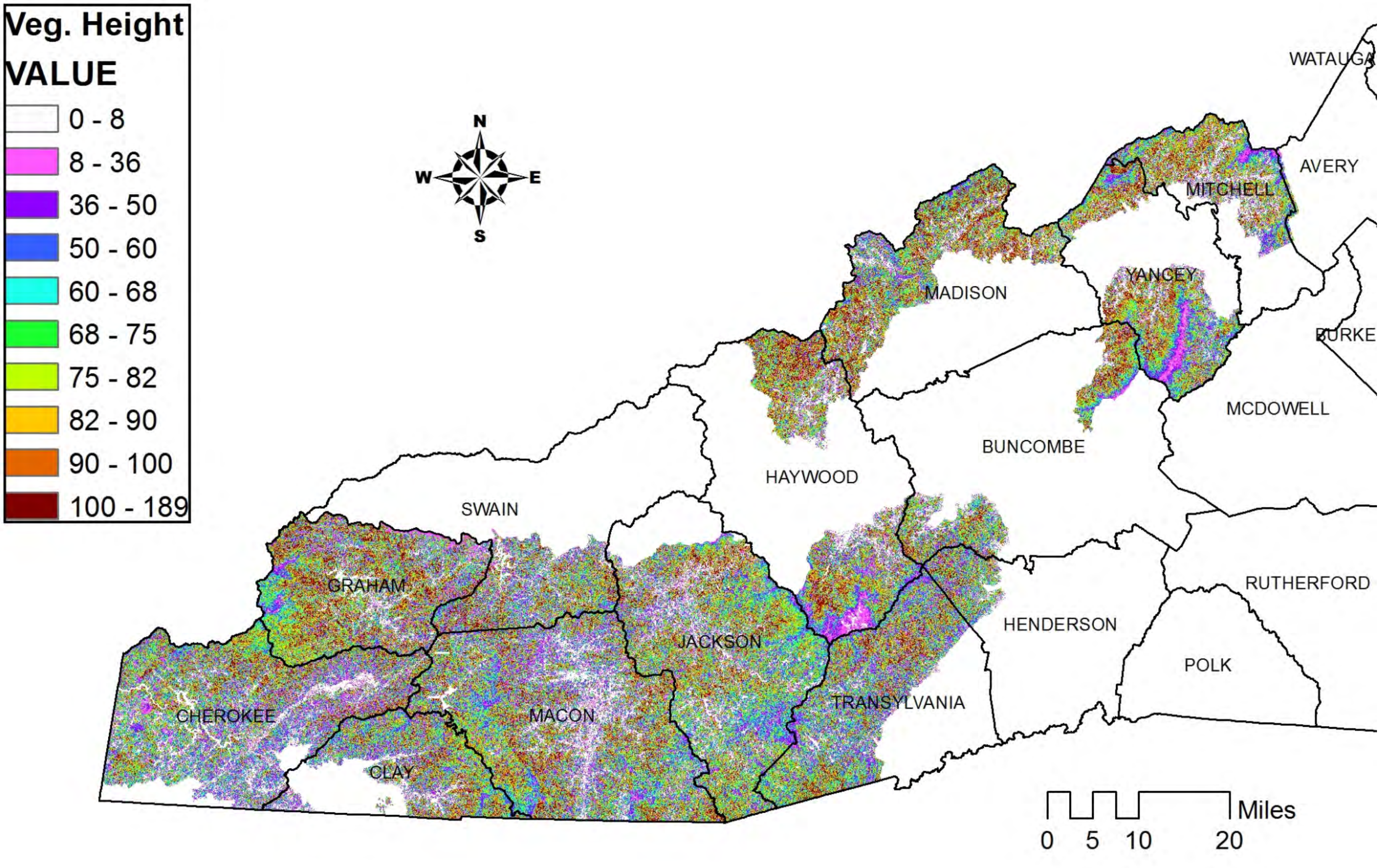

LiDAR Image of Fork Ridge Poplar from Above
Legend
Tree Height in Feet
VALUE
0 - 13.8
13.81-27.7
27.71 - 41.6
41.61 - 55.46
55.47 - 69.3
69.31 - 83.2
83.21 - 97
97.1 - 110.9
111 - 124.8
124.81 - 138.6
138.7 - 152.5
152.51 - 166.4
166.5 - 180.3
180.31 - 194.1
194.2 - 208
0 30 60 120 Feet

Canopy Height, Canopy Cover, & Shrub Density, Processed with Fusion Software

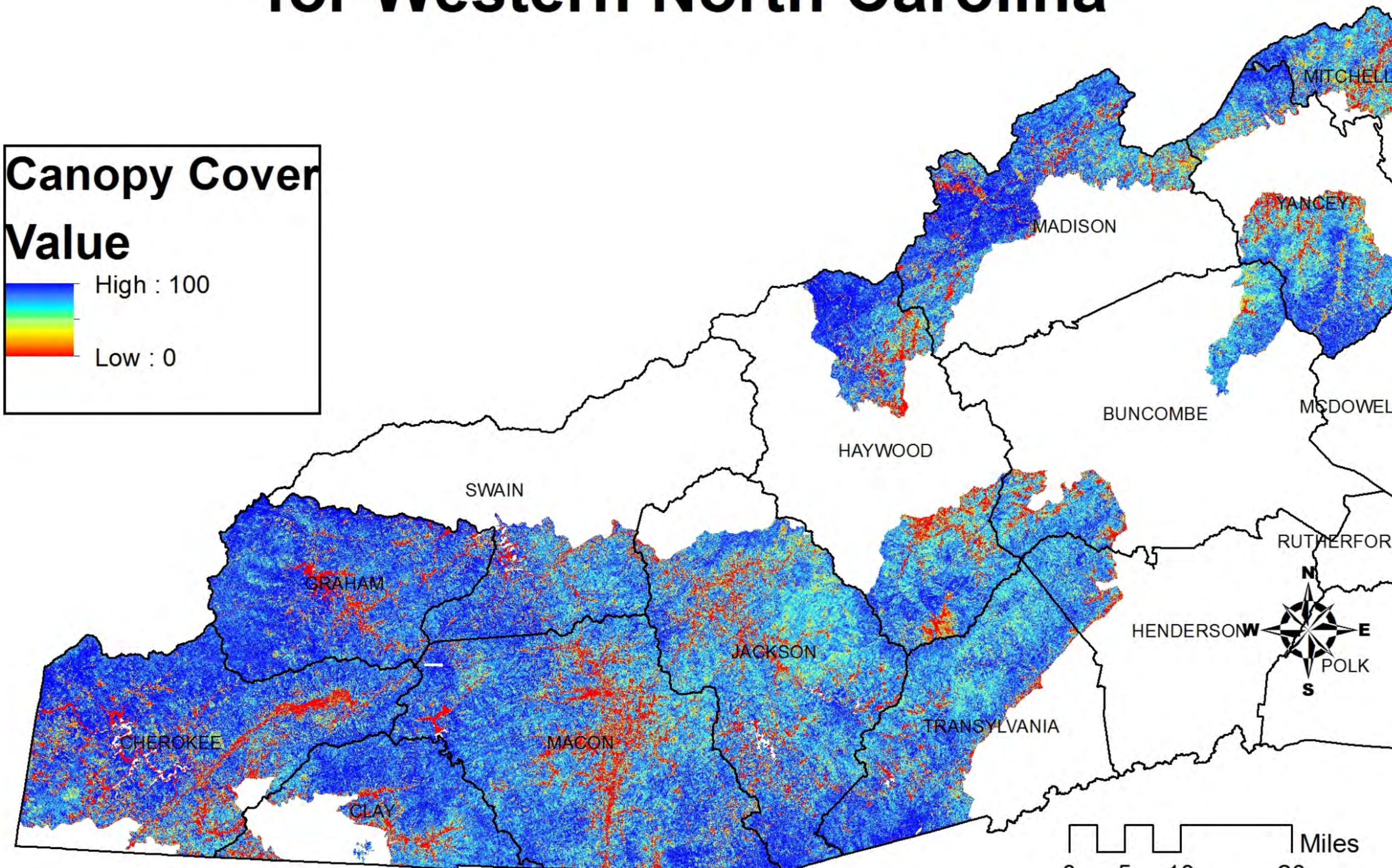


Images from Fusion tutorials

Vegetation Height in Study Area



LiDAR Derived Canopy Cover for Western North Carolina



Strengths & Limitations of LiDAR for Vegetation Analysis

Strengths

- High Resolution
- Great for Forest Structure; best available technology for capturing vertical structure
- Allows analysis across ownerships
- Captures Natural Disturbances

Limitations

- These data do not include species composition
- Collected in 2003 (Phase II) & 2005 (Phase III)
- Can be trained to plots, but plots must be .1 Ha or larger, and concerns exist about re-projection of original data

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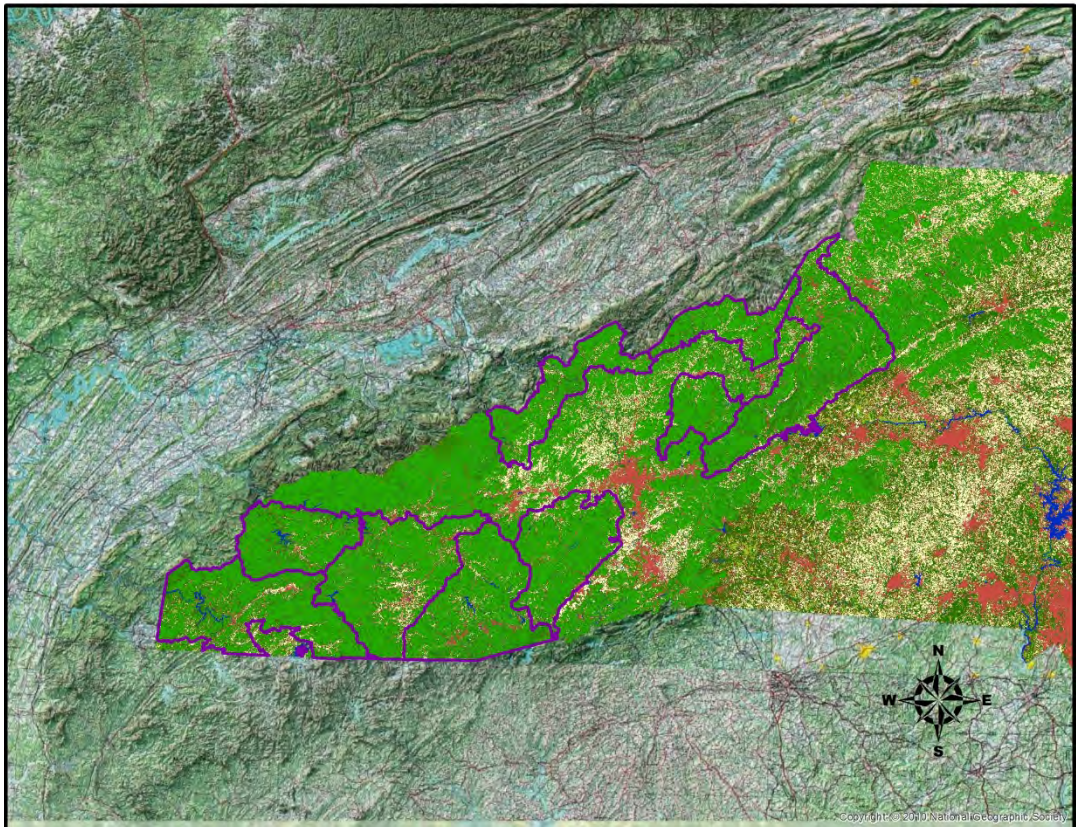
Assumptions used in this study

1. GAP data is a sufficiently skilled tool for discerning forest from non-forest



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Assumptions used in this study of Ecological Departure

2. Tree height can be correlated with tree age

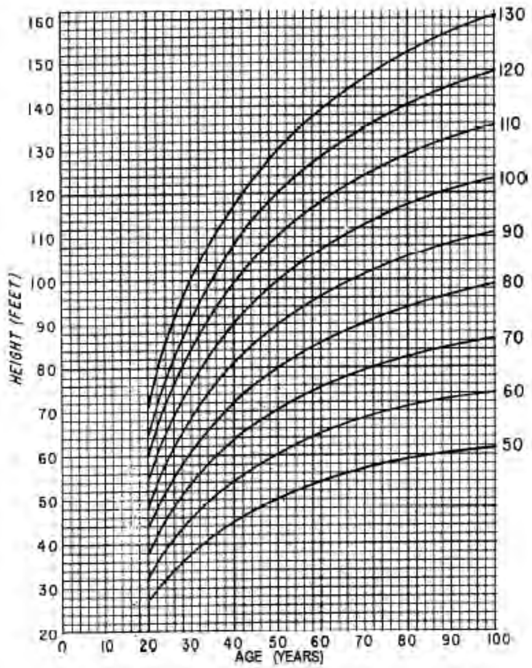

Figure 2. --Site index curves at an index age of 50 years for yellow-poplar in the southern Appalachian Mountains.

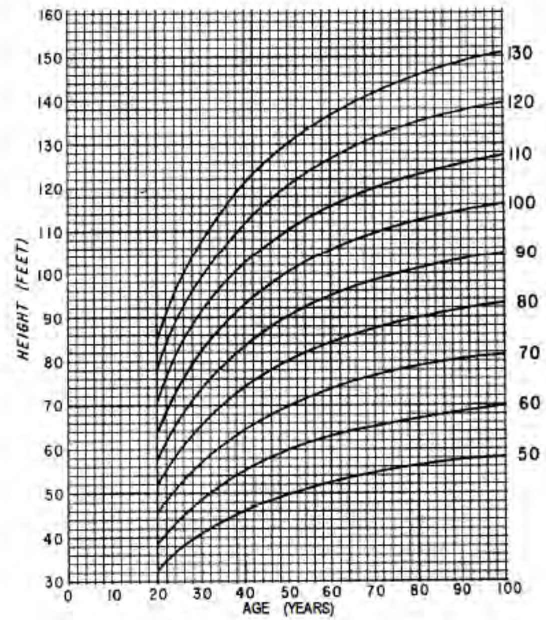

Figure 3. --Site index curves at index age of 50 years for yellow-poplar in the Piedmont of Virginia and the Carolinas.

Donald E. Beck
Asheville Research Center

Reasons why Site Index Underestimates Tall (Old) Forest

- Not every point in a tree's crown reaches max height
- Not every species grows as fast as the site index for the characteristic species
- Not all forests measured are even aged; large areas have been high-graded

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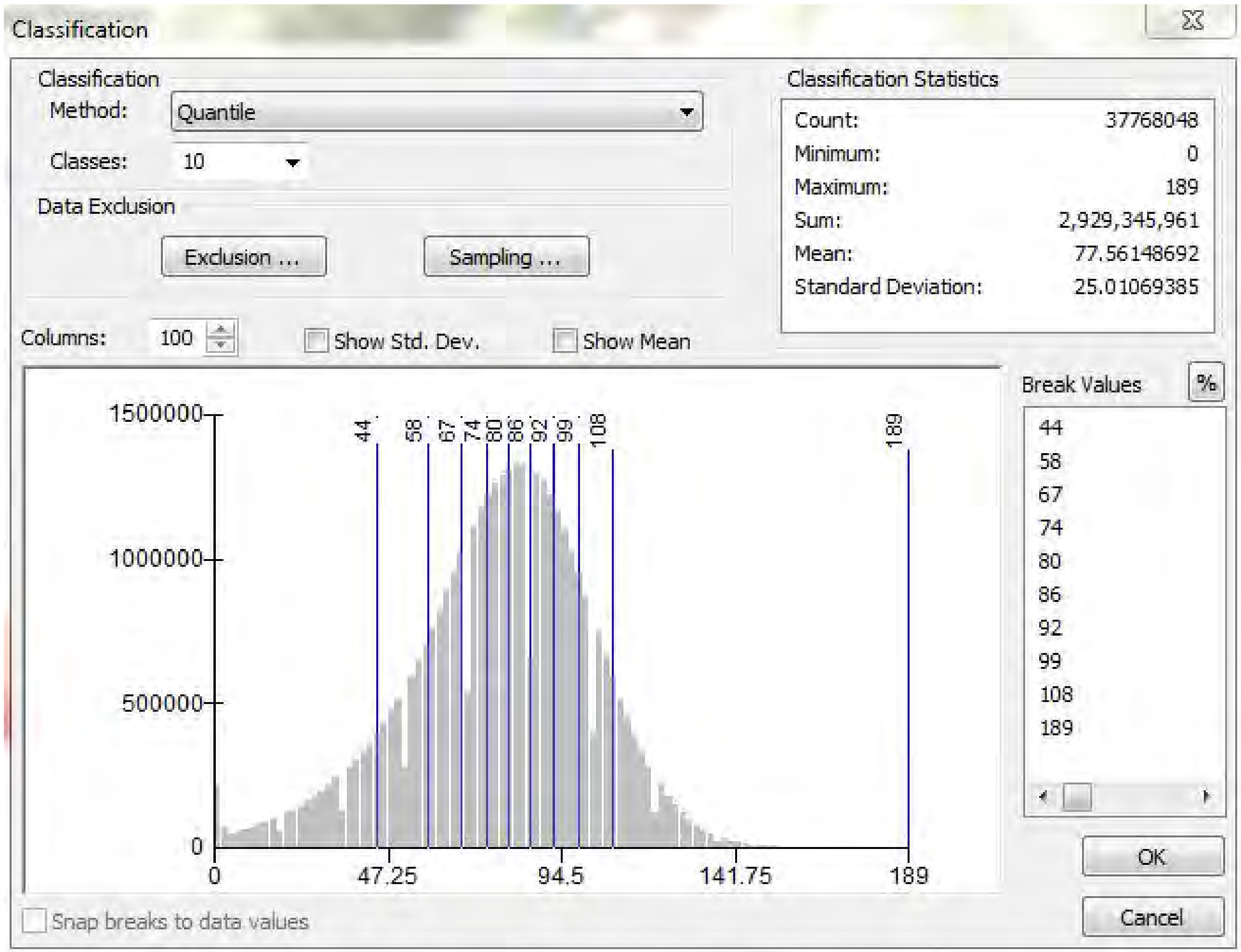
My Solution: use Forest Service Age Data and analyze the distribution of heights in an ecosystem to define the height break between mid and late-succession



Assumptions used in this study

3. LiDAR vegetation models are the most accurate tool available for capturing vegetation structure
4. The metrics chosen are for height (age), canopy closure, and shrub density are ecologically meaningful but broad enough to mostly right, most of the time.
5. Potential Natural Vegetation Mapping is the most accurate ecosystem mapping tool available

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Biggest Assumption

- Structural & successional classes reflect the processes that have shaped and are shaping forests
- A comprehensive analysis of structural & succesional classes provides a method for evaluating the operation of ecosystem processes, the potential habitat of species of concern, and other conservation issues

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Metric: Ecological Departure

- Measures each ecological system's condition *across a landscape*
- Integrated measure based upon vegetation *composition*, *structure* and *disturbance* regimes
- *Departure* of current vegetation from its natural range of variability (NRV) -- i.e., dissimilarity between expected and current vegetation classes

$$\text{Ecological Departure} = 100\% - \sum_{i=1}^{n} \min\{Current_i, NRV_i\}$$

Low ⟷ High

0-33%	34-66%	67-100%

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SOUTHERN APPALACHIAN MONTANE PINE ECOLOGY

Class A

<16 years
Early Development

NRV: 12%

Current: 4.7%

With Fire

No Fire

Class B

16-70 years
Mid Dev.
Closed

NRV: 3%

Current: 14.8%

Class C

16-70 years
Mid Dev.
Open

NRV: 25%

Current: 1%

Class D

>70 years
Late Dev.
Open

NRV: 55%

Current: 3%

Stand Replacement Fire with Pine seed source

- OR –
"Harvest" & Plant

Uncharacteristic Oak Dominated

NRV: 0%

Current: ?

No fire.
Insects / disease likely

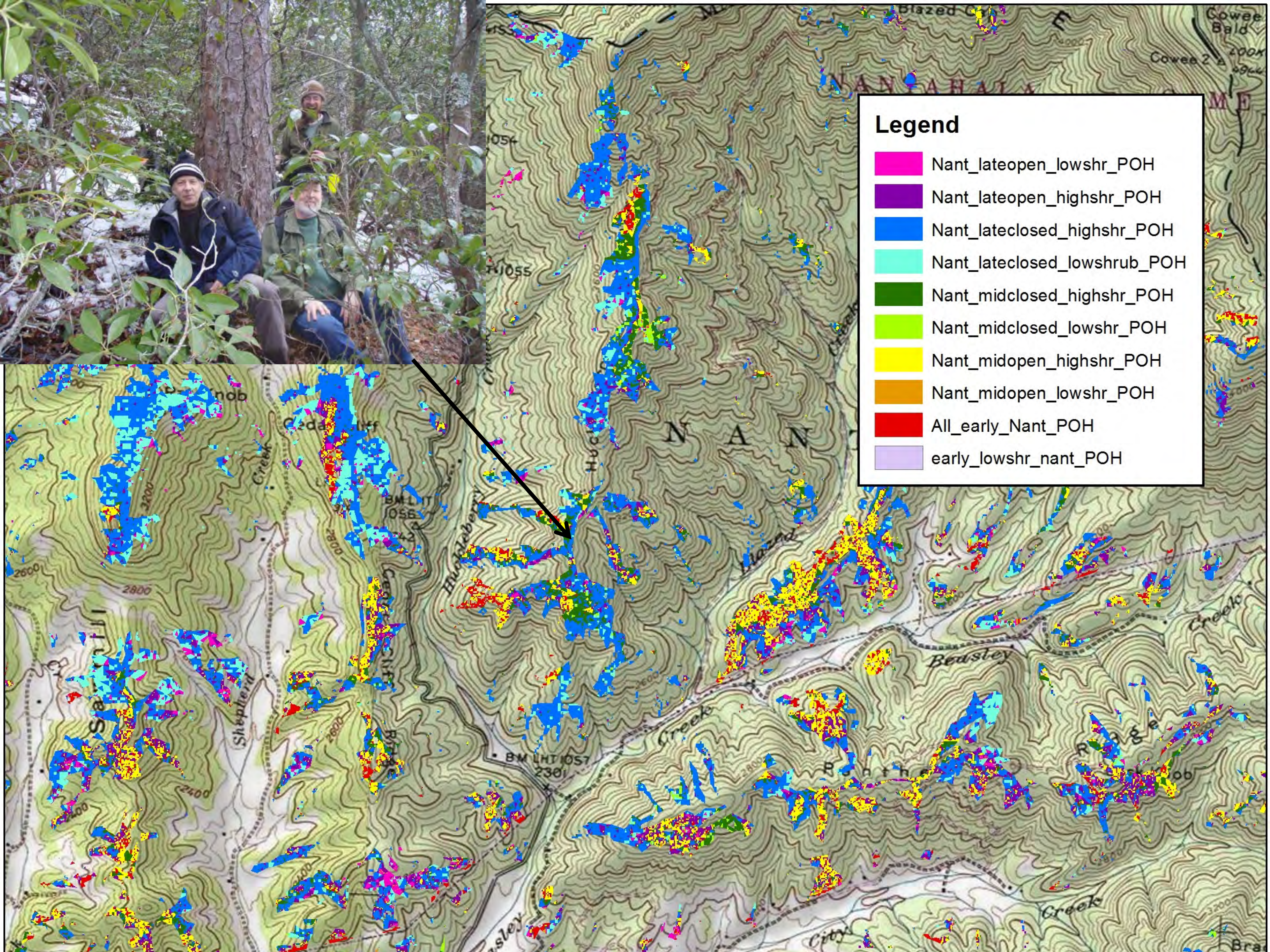
Class E

>70 years
Late Dev. Closed

NRV: 5%

Current: 76.6%

83% departure


Legend
Nant_lateopen_lowshr_POH
Nant_lateopen_highshr_POH
Nant_lateclosed_highshr_POH
Nant_lateclosed_lowshrub_POH
Nant_midclosed_highshr_POH
Nant_midclosed_lowshr_POH
Nant_midopen_highshr_POH
Nant_midopen_lowshr_POH
All_early_Nant_POH
early_lowshr_nant_POH
N A N
Beasley
Creek
BM LHT 1057
2301

Comparison of Ecological Departure across Ecosystems

Ecosystem	National Forest	Other Lands	All Lands	Driver
Dry Oak	84	80	80	Too much closed canopy, lacks old-growth
POH*	83	74	79	Too much closed canopy
Shortleaf-Oak*	83	63	71	Too much closed canopy, lacks early
DMOH	70	71	71	Too much closed canopy, lacks old-growth
Mesic Oak	70	74	72	Too much closed canopy, lacks old-growth
HERO	64	75	65	Too much closed canopy, lacks old-growth
Acidic Cove	55	57	56	Lacks old-growth
Rich Cove	54	56	56	Lacks old-growth, too much mid-seral forest (<100 years)
Spruce-Fir*	34	43	39	Too young, species composition?
N Hardwoods*	6	14	10	* = old-growth not modeled

New Products Produced Nantahala-Pisgah National Forest

- Shapefiles of 13 s-classes for 10 ecosystems
- Separate shapefiles for Forest Service and All Lands
- These shapefiles allow for the identification and management of over-abundant s-classes on a site-specific basis
- Most ecosystems in the study area are very departed from our reference

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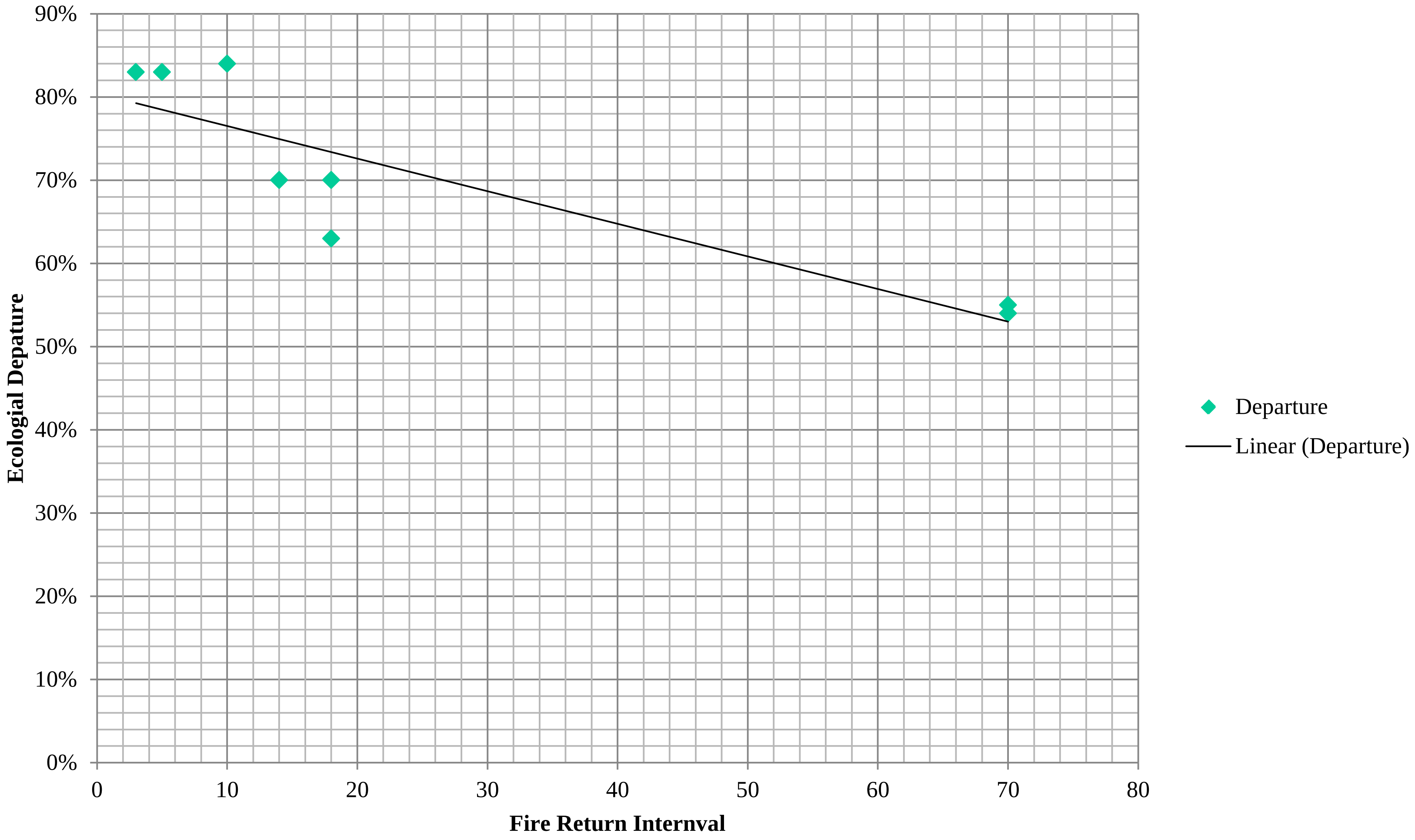
Ecological Departure Compared to Historical Fire Return Interval

Ecosystsem	National Forest Rank	Other Lands Rank	All Lands Rank	FRI
Dry Oak	1	1	1	10 years
POH	2	4	2	5 years
Shortleaf-Oak	3	8	5	5 years
DMOH	4	5	3	14 years
Mesic Oak	5	3	4	18 years
Acid Cove	6	6	6	70 years
HERO	7	2	7	18 years?
Rich Cove	8	7	8	70 years
Spruce-Fir	9	9	9	1000 years
Northern Hardwoods	10	10	10	500 years

Ecosystem Departure Plotted vs. FRI



% High Shrub Density by Ecosystem

Ecosystem	National Forest	Other Lands	All Lands
Dry Oak	54.3%	43.4%	48.4%
Pine-Oak/Heath	55.5%	46%	50.8%
Shortleaf-Oak	34.4%	43.2%	39.2%
DMOH	48.4%	40%	43.1%
Mesic Oak	40.8%	22.3%	36.1%
Acidic Cove	100%	100%	100%
HERO	44.4%	36.7%	42.5%
Rich Cove	NA	NA	NA
Spruce-Fir	NA	NA	NA
Northern Hardwoods	NA	NA	NA

% Closed Canopy by Ecosystem vs. NRV

Ecosystem	National Forest	Other Lands	All Lands	NRV
Shortleaf Pine – Oak	85%	65%	74%	3%
Pine-Oak – Heath	92%	82%	87%	8%
Dry-Oak Forest	88%	84%	86%	10%
Dry-Mesic Oak-Hickory	88%	78%	82%	22%
Mesic Oak-Hickory	88%	75%	86%	42%
High Elevation Red Oak	91%	84%	89%	42%
Spruce-Fir	73%	73%	73%	72%
Northern Hardwoods	89%	77%	84%	89%
Rich Cove	84%	68%	75%	96%
Acidic Cove	94%	88%	91%	96%

% Late Seral & Old-Growth by Ecosystem

Ecosystem	National Forest	Other Lands	All Lands	NRV
Acidic Cove Forest	11%	9%	10%	79%
Rich Cove Forest	26%	16%	20%	79%
Mesic Oak-Hickory Forest	69%	62%	66%	81%
High Elevation Red Oak	77%	73%	76%	81%
Dry-Mesic Oak-Hickory	74%	67%	70%	74%
Dry Oak Forest	77%	77%	77%	80%
Northern Hardwoods	70%	64%	67%	77%
Spruce-Fir Forest	41%	18%	35%	58%
Pine-Oak/Heath	80%	78%	79%	60%
Shortleaf-Oak	60%	44%	51%	34%

General Trends for the Nantahala-Pisgah

- Most forests have a canopy cover and shrub layer that is more dense than predicted by our reference; the exception being the economically valuable Rich Cove Forest and Spruce-Fir Forest
- There has been insufficient fire prior to 2005 to create and maintain open forest canopies
- All forests in the study area, with the exception of Pine-Oak/Heath, have below reference levels of old-growth forest
- Private land is more disturbed in every ecosystem than Forest Service Land and has a lower proportion of old (tall) forest.

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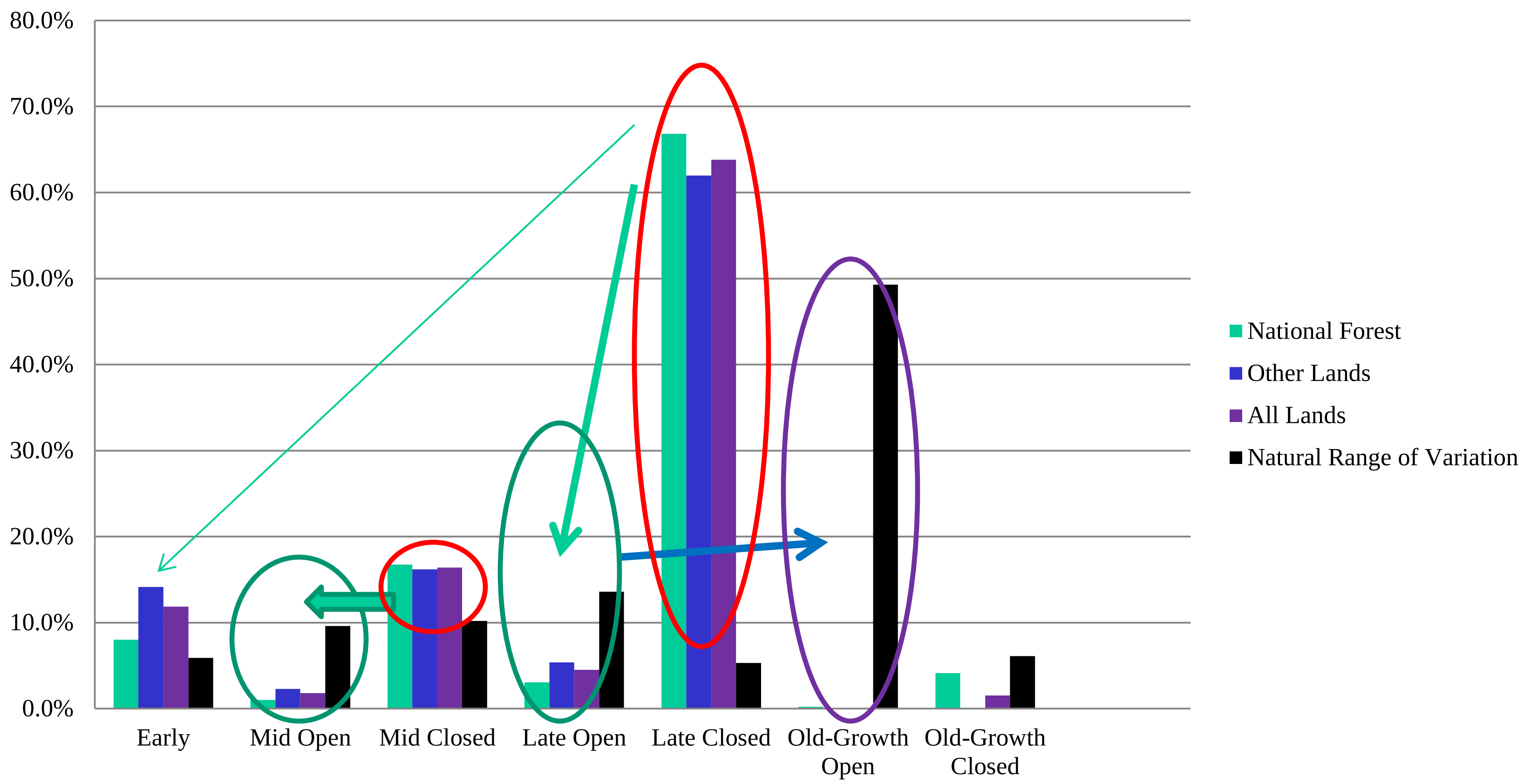
Current Condition of Dry-Mesic Oak-Hickory Forest vs. NRV



Management Implications

- Oak and Pine Forests need more frequent fire than they have experienced in the past five decades
- Increasing the amount of open-canopied forest in Oak and Pine-Forests will benefit those ecosystems and their attendant wildlife.
- Continuing to manage for old-growth in both the unsuitable and suitable timber base will benefit hardwood ecosystems. The majority of old-growth in the region is on public land.

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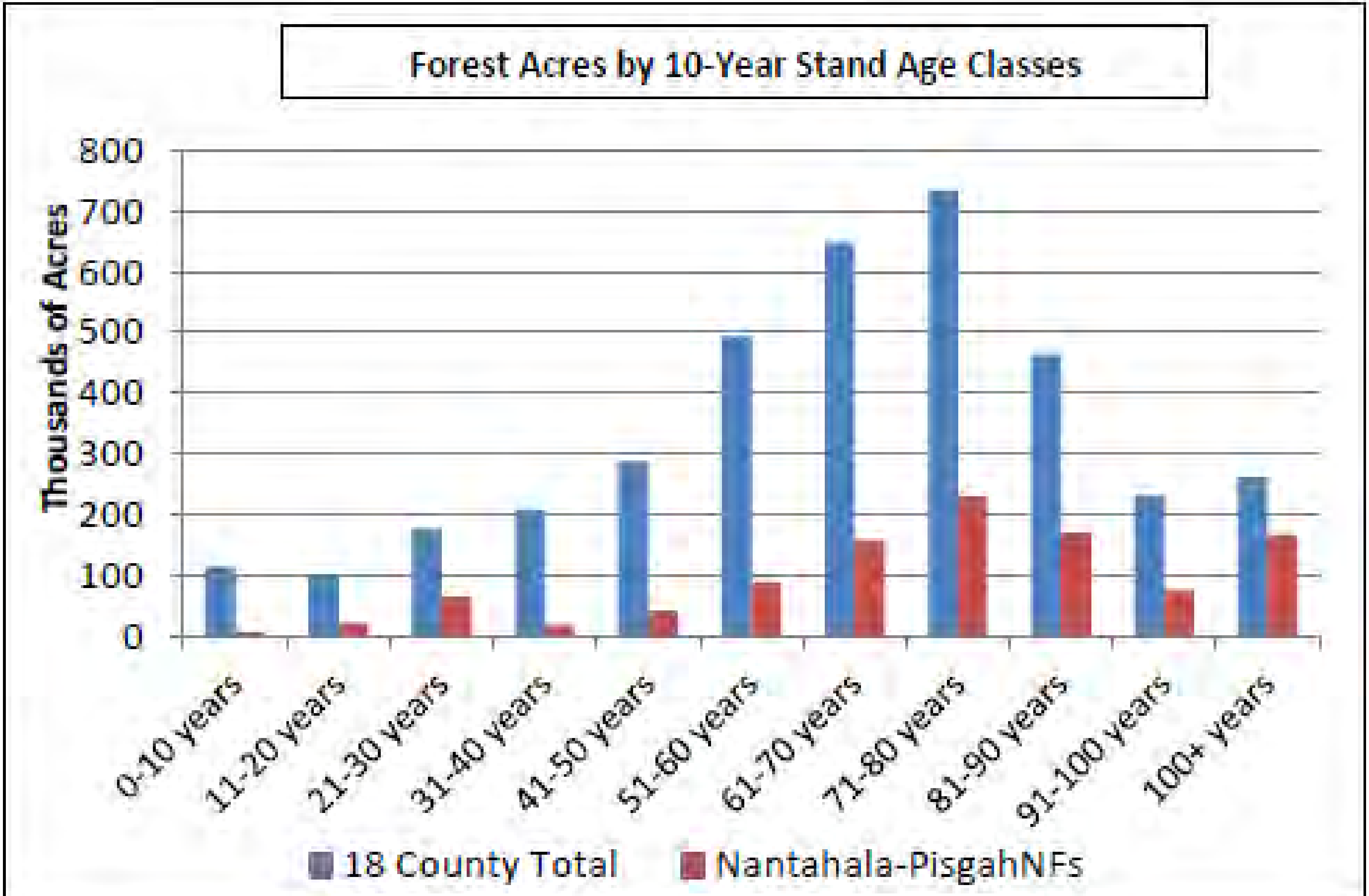

Forest Acres by 10-Year Stand Age Classes
Thousands of Acres
800
700
600
500
400
300
200
100
0
0-10 years
11-20 years
21-30 years
31-40 years
41-50 years
51-60 years
61-70 years
71-80 years
81-90 years
91-100 years
100+ years
18 County Total
Nantahala-PisgahNFs

Opportunities for Restoration

- Some ecosystems, e.g. Pine-Oak/Heath and Dry Oak, are in high departure and offer little economic return on management
- Other ecosystems, e.g. shortleaf pine, dry-mesic oak, mesic oak, and (with caution) high-elevation red oak, are significantly departed and offer economic return on management

My Proposal: Mechanically Open Up to 51,719 Acres in Operable Pine and Oak Ecosystems in Next Forest Plan Using Mechanical Techniques and Fire

- Up to 18,707 acres in Shortleaf Pine/Oak (42%) cutting mostly white pine and hardwoods. Regenerating and planting in most departed areas, moving to woodlands in others
- Up to10,599 acres in Dry Mesic Oak-Hickory (10%) cutting white pine, poplar, red maple & oak
- Up to18,613 acres in Mesic Oak-Hickory (10%) " "
- Up to 4,250 acres in HERO (5%) cutting mostly oak and other hardwoods
- Keep regeneration harvest at current levels; fire-only management in SNHA's, Core Interior Forests, etc.
- Use the proceeds of harvest to fund other restoration work

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Estimated Acreage of the Most Departed Ecosystems on Nantahala-Pisgah National Forest

Ecosystem	Potential Acres on NF	% of Acres Convert to Open	Increase in Early Acres Needed for NRV
Shortleaf Pine/Oak	44,541	20% - 8,908	9,799
Pine-Oak/Heath	101,275	20% - 20,250	3,118
High Elevation Red Oak	38,637	10% - 3,864	386
Mesic Oak-Hickory	186,131	10% -18,613	NA
Dry-Mesic Oak	105,991	10% -10,599	NA
Dry Oak	59,677	20% - 11,934	596
Total		74,168 Acres	13,899

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Some Cautions!!!

- To be successful, areas appropriate for restoration will need to be carefully sited. Much of the Nantahala-Pisgah is not appropriate for timber harvest.
- Let’s not lose sight of Dry Oak and Pine-Oak/Heath Forest despite their lack of commercial viability
- The current sustainable harvest of the Nantahala-Pisgah in the 1994 Plan Amendment is around 3,000 acres/year
- This is an ambitious goal. There is currently not the capacity to accomplish it with either the Forest Service or with partner organizations.
- Increasing restoration harvest to 2,500 acres annually would represent a 200% increase in management

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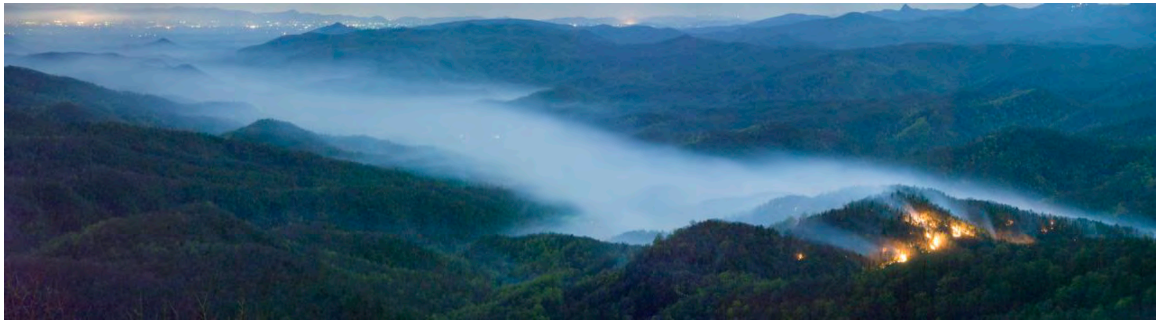

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