Weather Variability and its Impacts on Forest Health

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USDA United States Department of Agriculture
Southeast Regional Climate Hub

What is forest health? Depends on your objective…

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Forest health in the Southeast

- Historical land use

Factors impacting forest health

Factors impacting forest health

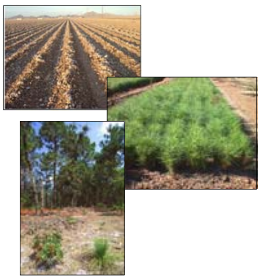
Forest health in the Southeast

- Historical land use
- Commercial forestry
  - Loss of resistance?

Commercial forestry
=
Intensive management

Forest health in the Southeast

- Historical land use
- Commercial forestry
  - Loss of resistance?
- Management



Factors impacting forest health

Right species, right site

Factors impacting forest health

Competition control

Factors impacting forest health

Thinning

http://www.forestryforum.com/board/index.php?topic=39179.0

Factors impacting forest health

Not thinning/neglect

Factors impacting forest health

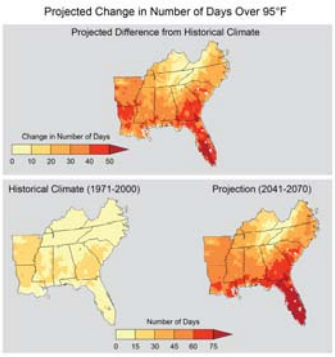
Fire (lack thereof, or too hot)

Forest health in the Southeast

- Historical land use
- Commercial forestry
  - Loss of resistance?
- Management
- Weather

Weather & Climate

Heat Waves



Source: National Climate Assessment 2014

Streak On

- "Hottest month on record"

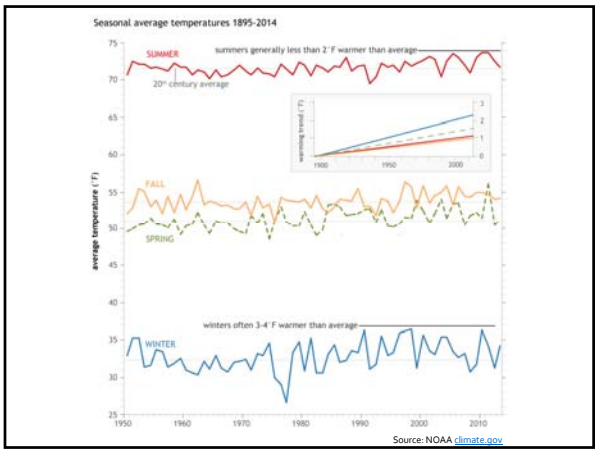
Contiguous U.S. (CONUS) Temperature for five periods ending in March 2017

Length	Period	Average Temperature	Departure from 20th century average	Rank (since 1895)
12-month	Apr 2016 - Mar 2017	55.05°F	+3.02°F	Warmest to Date
24-month	Apr 2015 - Mar 2017	55.05°F	+3.03°F	Warmest to Date
36-month	Apr 2014 - Mar 2017	54.44°F	+2.44°F	Warmest to Date
48-month	Apr 2013 - Mar 2017	53.84°F	+1.85°F	Warmest to Date
60-month	Apr 2012 - Mar 2017	53.86°F	+1.88°F	Warmest to Date

Source: NOAA climate.gov

Cold Things Warm Faster

- Cooler places and cooler times
  - Arctic Amplification
  - Winter season
  - Overnight lows (minimum)



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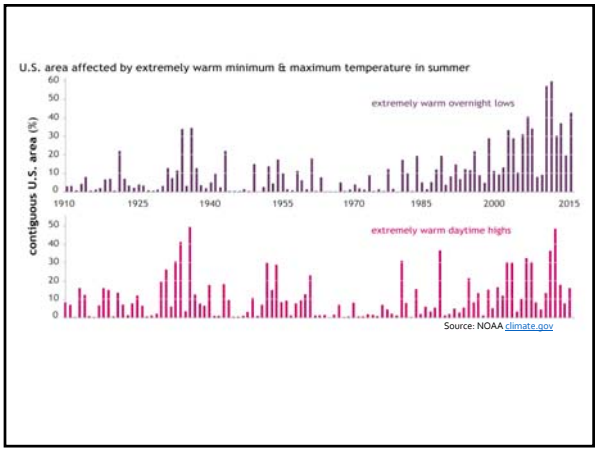

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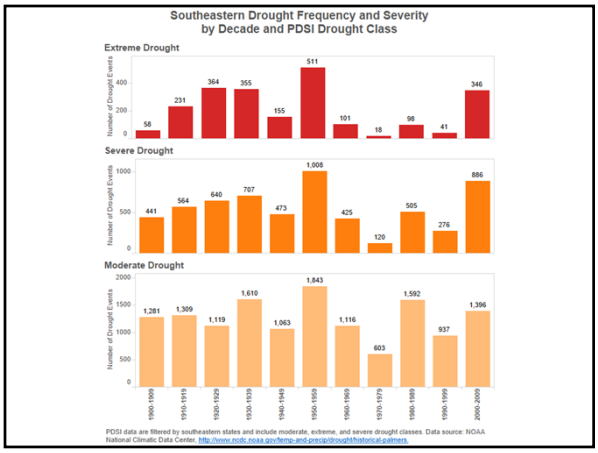
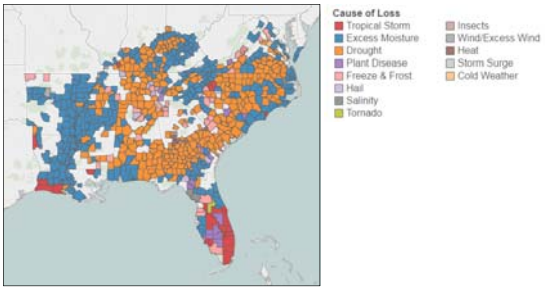


PDSI data are filtered by southeastern states and include moderate, extreme, and severe drought classes. Data source: NOAA National Climatic Data Center, http://www.ncdc.noaa.gov/temp-and-precip/drought/historical-palmers.

Southeast Crop Loss



Source: USDA RMA, SERCH Tableau data viz

Big Droughts End in Big Floods

Dry Brazos River in Knox Co, TX, Summer 2011

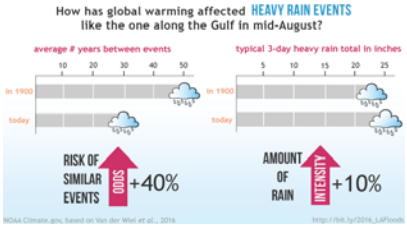
Flash flooding on I-45 in Houston, May 2015

Source: NOAA climate.gov

Heavy Precipitation Trends
(Five-Year Events)

Source: National Climate Assessment 2014

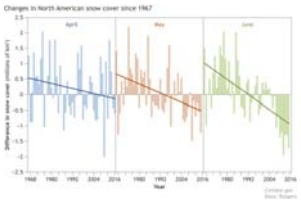
Flooding



- Climate interactions:
  - Warmer air → more water vapor → more heavy rain events

Spring Snow

- Across North America, spring snow extent is shrinking
- Climate interactions:
  - Warmer winters → more insects → more mortality → more fuel
- Impacts on fire season



Extreme Weather Events

- Annual averages:
  - 1980-2016: 5.5 events
  - 2012-2016: 10.6 events
  - 2016: 15 events
  - 2017: 5 to date, more than $1 billion in damage already

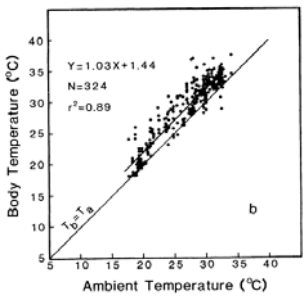
Source: NOAA NCEI

Coming Soon!

How Does Weather Impact Forest Health?

Insect Biology 101

Insects are ectotherms



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Insect Biology 101

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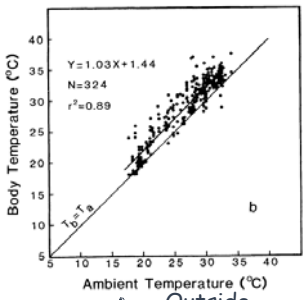

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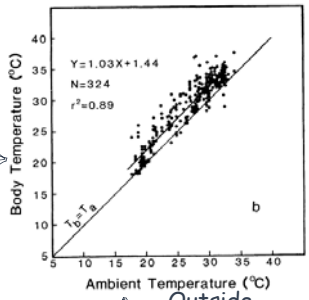
Insects are ectotherms

Insect body temperature



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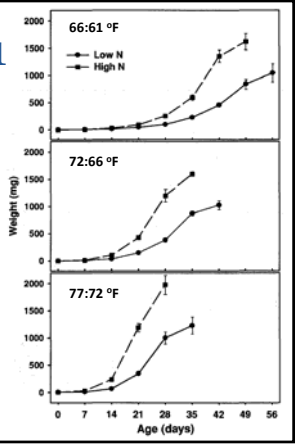
Insect Biology 101

Warmer body temp

=

Grow faster

Grow bigger



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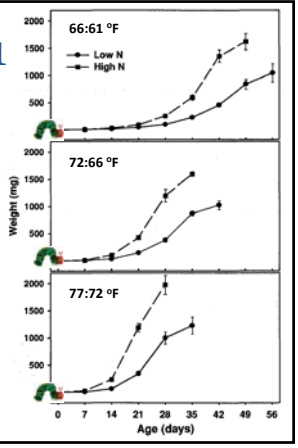

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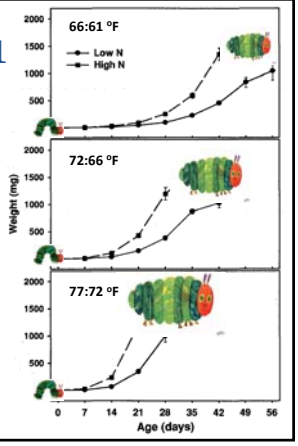

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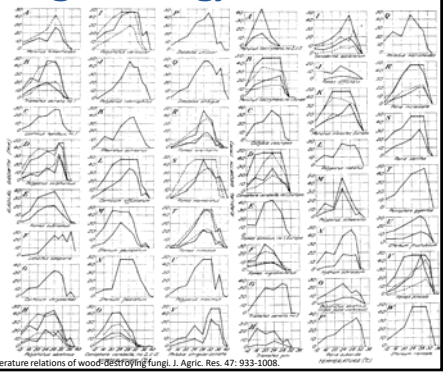
Fungal Biology 101



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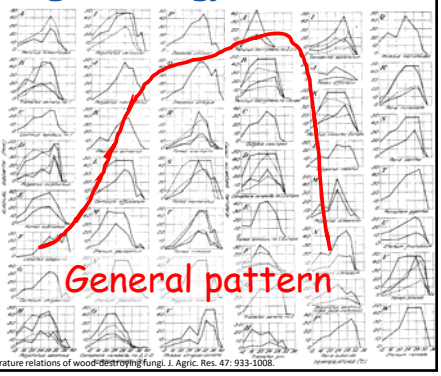

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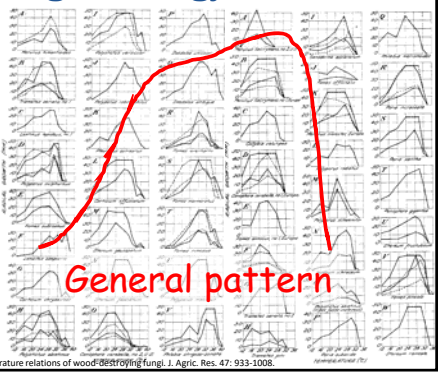
Fungal Biology 101

Too cold = no growth

Too hot = dead



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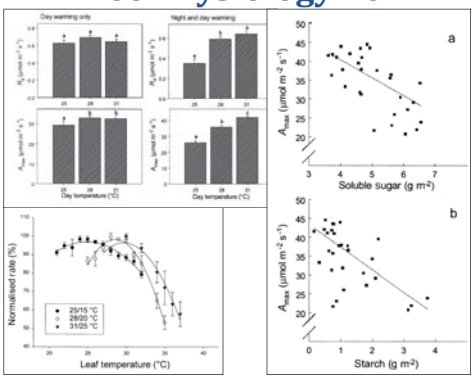

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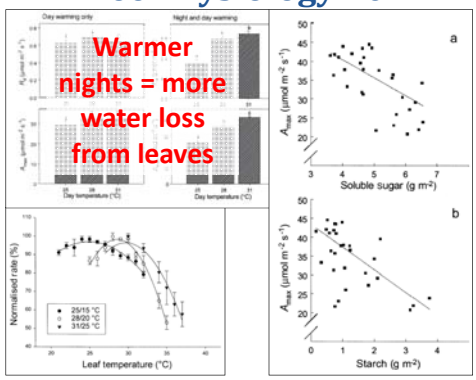

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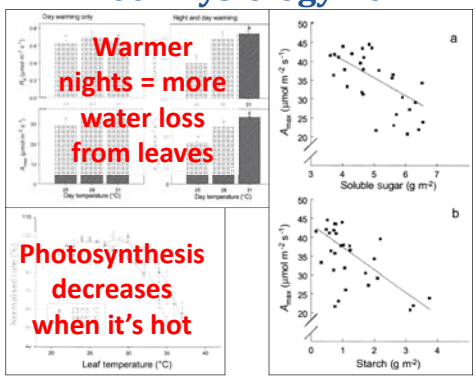

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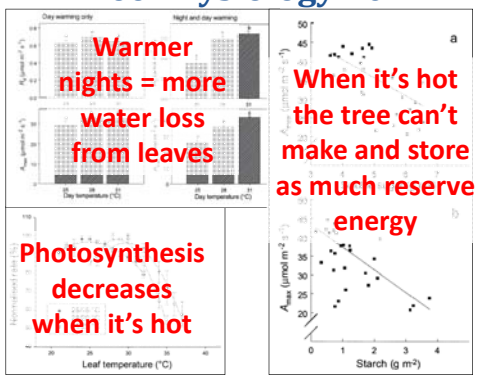

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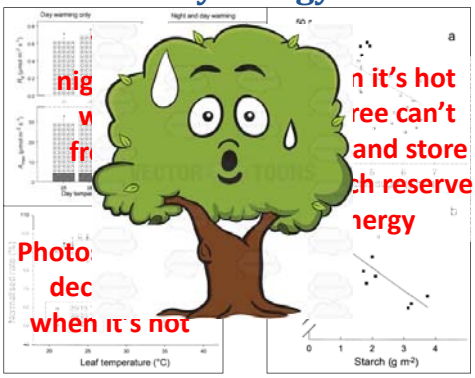

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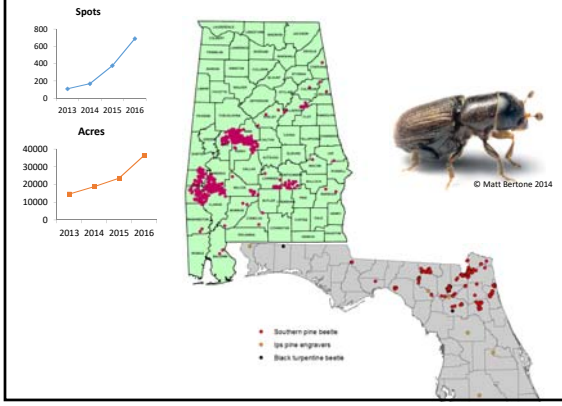
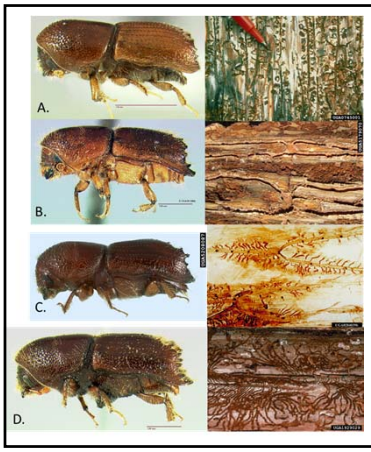
Case Studies

- Bark beetles in the Southeast
- Southeastern wildfires (fall 2016)
- Southern pine beetles & red spruce

Southern bark beetles



© Matt Bertone 2014

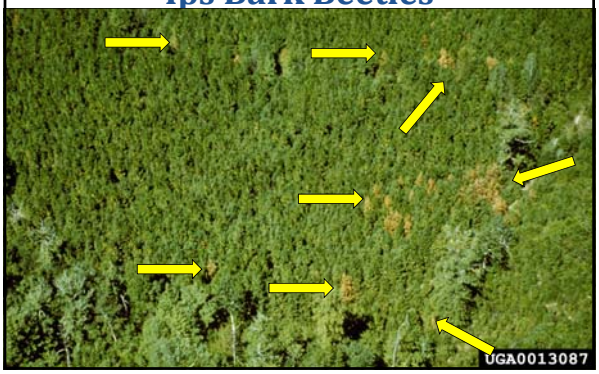


Ips Bark Beetles

- Common in SE US
- Generally attack weakened or stressed trees
- Male starts gallery, calls female using odors (pheromones)
- Can cause mortality during droughts

Ips Bark Beetles

Ips Bark Beetles



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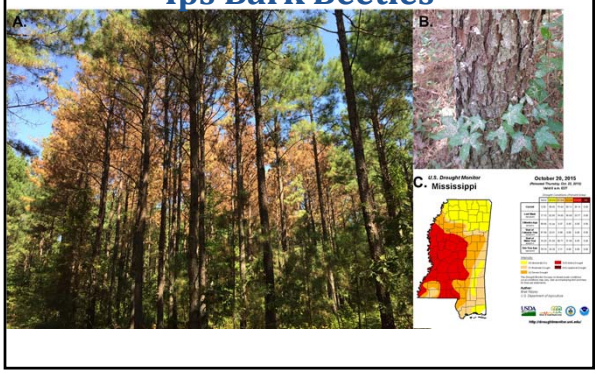
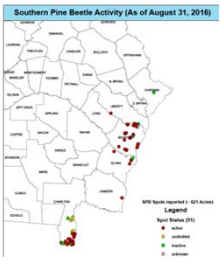
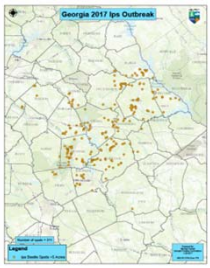


Bark Beetle Issues in Georgia





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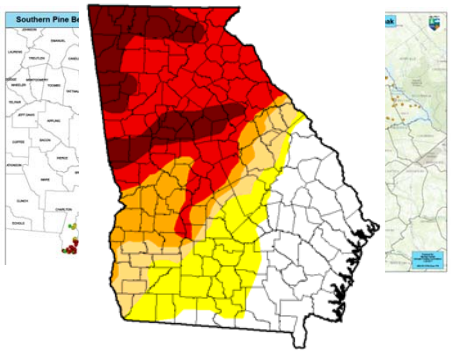
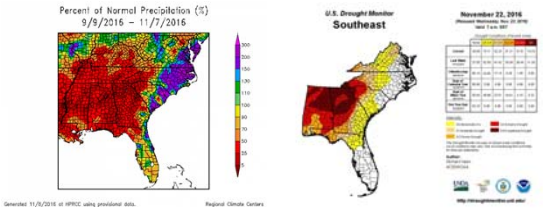


Ips bark beetles, Georgia, ongoing…

Case Study: SE Wildfires

- Severe drought
- Warmest fall season on record (Sep-Nov)



SE Wildfires, Fall 2016

- High winds
- After leaf fall

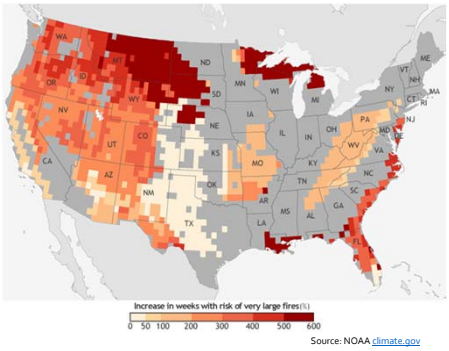
Source: Marshall Shepherd, Forbes

SE Wildfires, Fall 2016

- Fire suppression
- Rhododendron & mountain laurel
- Climate interactions:
  Warmer winters → more insects → more mortality → more fuels

Source: Climate Nexus / Climate Signals

Wildfire Risk



The Curious Case of the Mt. Mitchell Dying Spruce

Mt. Mitchell Study Area

- Peak elevation of 2030 m
- much of the area in mountain farming until 1920's
- Forest cover is a mix of coniferous and deciduous species
- Subject to acid deposition from Midwest states
- There were pockets of dead and live red spruce within the study area

Background

The mountainous area of Western North Carolina (NC) experienced a moderate three year drought from 1999-2002.

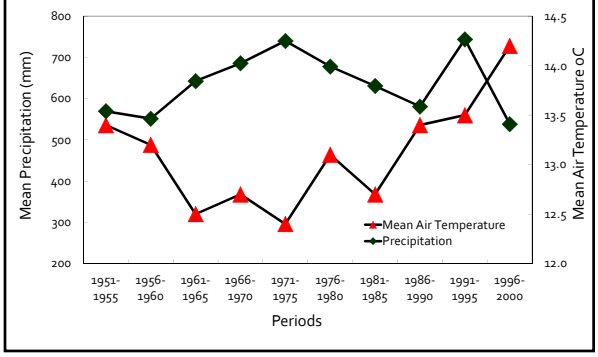
In 2001, red spruce (*Picea rubens*) trees began to die in large numbers in and around Mt. Mitchell NC, USA.

The initial sampling suggested that the trees were killed by the southern pine beetle (SPB). This insect species is not normally successful in colonizing these tree species.

Subsequent investigations revealed an interesting pattern in which trees died or survived the SPB attack.

Southern Pine Beetle Damage in Southern Appalachian Red Spruce Stand

Five Year Averaged Climate (1951–2001), Mt. Mitchell, NC, USA



What we thought we would observe….
A very high rate of mortality in the stands with poor crown form, and generally stressed looking trees.

What we actually observed…
A very high rate of mortality in the area with the largest, most fully formed crowned trees (dead foliage was still present on the stands when we first observed the stands).

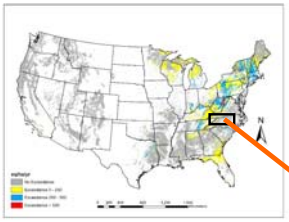
Question:

Why was the area with the trees that would be considered most healthy prior to the drought be the ones to die, while the areas with less healthy looking trees have almost no mortality?

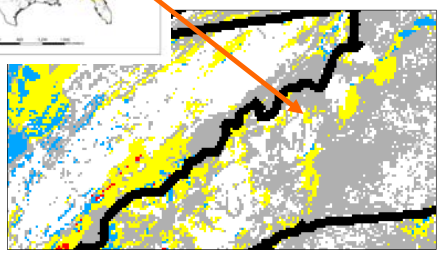
Two Important Components to Consider

- Consider the stresses and stress interactions
- Consider how chronically stressed and non-stressed forest trees and stands would uniquely react to these interactive stresses

First Stressor -
Exceedence of forest soil critical acid load



Critical Acid Load In Forest Soil in Western North Carolina, USA



First Stressor -
Exceedence of forest soil critical acid load

Second Stressor -
Southern pine beetle

Southern Pine Beetle

Southern Pine Beetle

Galleries of southern pine beetle under the bark of loblolly pine

James R. Baker & S. Bambara

First Stressor -
Exceedence of forest soil critical acid load

Second Stressor -
Southern pine beetle

Third Stressor -
Drought and high air temperature

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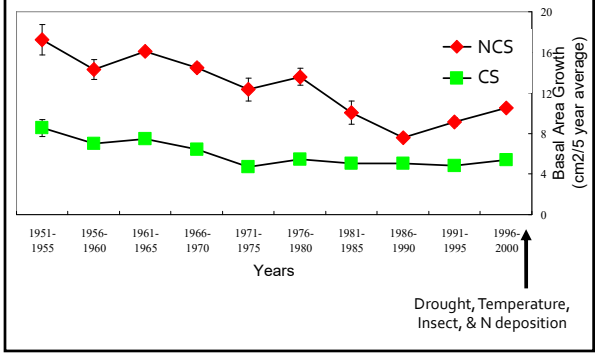
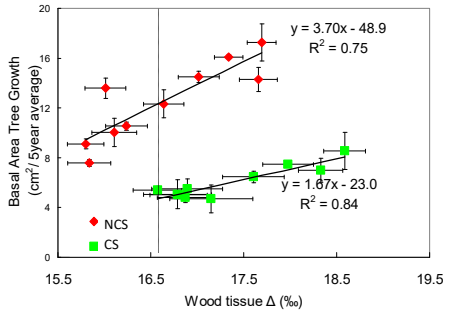
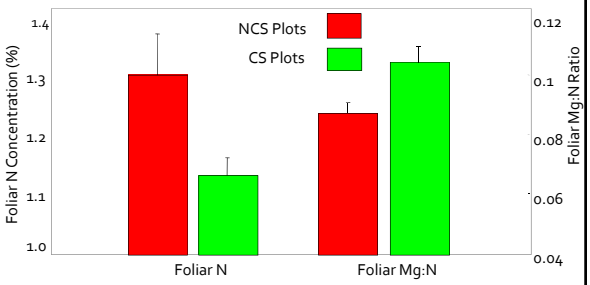
Historic Differences in Basal Area Growth



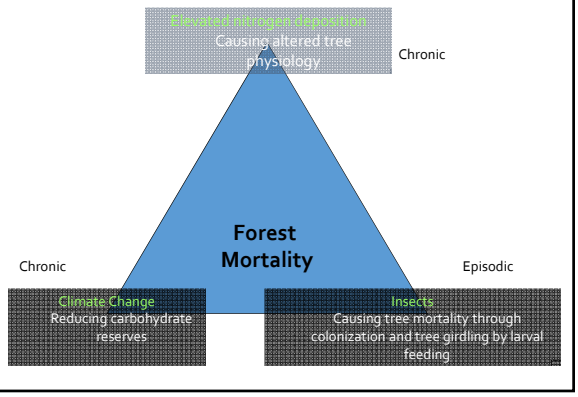
Basal Area Growth as a Tree Water Stress



Residual Tree Foliar Chemistry



Stress Interactions



What will the future hold?

Earth has been around for a while

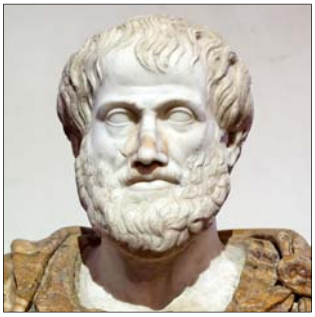
There has been a lot of change at the regional scale

And change at the global scale

Our experience is MUCH shorter

Sumerians (Edith and Howard) Approximately 3300 BC

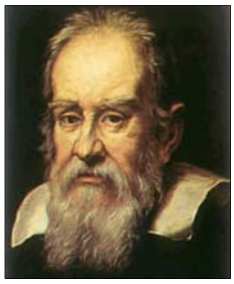
Aristotle
natural philosophy



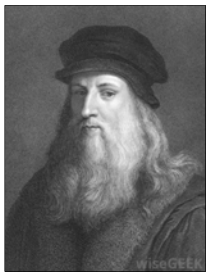
4th Century BC

The Dark Ages

Beginning of modern study (and great beards) 15th Century

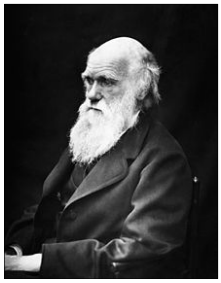


Galileo



Da Vinci

Darwin
19th Century



So…

That gives us less than 200 years of real environmental study

That could be

A really big problem

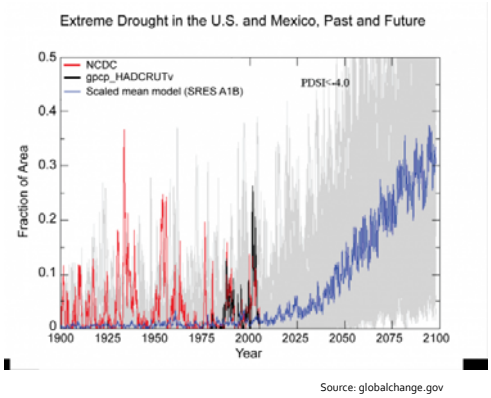
Because….

"As we know, there are known knowns. There are things we know we know. We also know. There are known unknowns. That is to say we know there are some things we do not know. But there are also unknown unknowns, the ones we don't know we don't know."

Donald Rumsfeld Feb. 12, 2002
Department of Defense news briefing

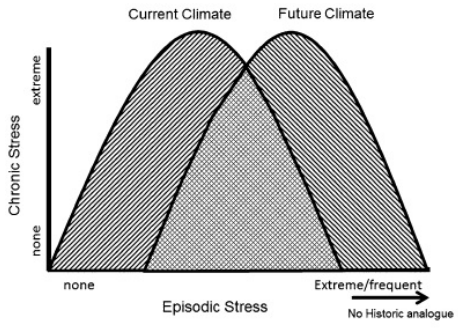
This may be not be unusual, just unusual in human experience

This may be not be unusual, just unusual in human experience

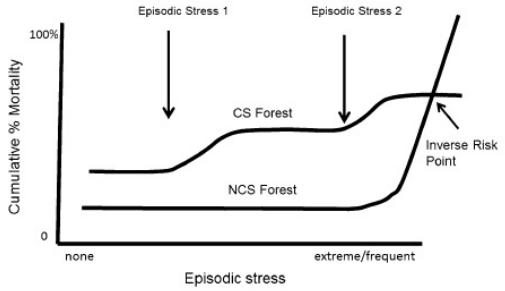


Source: globalchange.gov

Stable chronic stress, but increasing episodic stress?



Potential changes in forest response to stress



CS Chronically stressed NCS Non-chronically stressed

Moving Forward: Managing Forests in Changing Times

- Promote health through good silviculture
- Prevent water stress!
  - Stocking density
  - Thinning
  - Match tree species to site
  - Improved genetic stock
  - Controlled burning (when appropriate)
- Be vigilant in pest (esp. invasive species) detection and management

Questions?

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https://www.climatehubs.oce.usda.gov/southeast