Fire Weather, Fuels, and Other Fiery Things

Dr. Adam Coates

Virginia Tech

Thursday, May 10, 2018

Today's Objectives

Tom Yawkey Wildlife Center, Georgetown, SC
March 2015

- Personal introduction
- My fire story
- Fire triangles and fire behavior
- Prescribed fire ignition strategies
- Questions

Personal Introduction

- BS (2003), MS (2006), Ph.D. (2017) all in Forest Resources from Clemson University
- Married with three kids (Sam – 8, Kate – 5, Natalie – 3)
- Spent time working in research, production agriculture, and non-profits

“Only you…”

Image: www.nal.usda.gov/exhibits/speccoll/files/original/16d2c82620b322a1c57d4d18b3289ebe.jpg

Fire story

North Carolina SBR FLN, August 2017

- I was introduced to wildland fire ecology as a freshman at Clemson University
- A professor described a “fire planet”
- Table Mountain Pine communities

Image: slate.com

Pictures of Table Mountain Pine

Image: conifersociety.org

Image: National Park Service
Table Mt Pine post-fire

Unique features of Table Mountain Pine

- Fire aids the regeneration of Table Mountain pine in several ways. It:
  - opens the **serotinous** cones
  - consumes leaf litter
  - exposes mineral soil
  - eliminates competing vegetation (allowing more light and water for pine seedlings)

Reference: https://www.fs.fed.us/database/feis/plants/tree/pinpun/all.html

We aren’t talking about small fires, either!

a. Table Mountain Pine with SPB

b. Table Mountain Pine burning

Image: http://kelab.tamu.edu/standard/waldron/

The more I began to learn…

- Fire has been part of the historic landscape for centuries
- We live on a “fire planet”
- How can that be?

Image: NASA
Fires of October 2016

Mean Fire Interval Prior to 1850

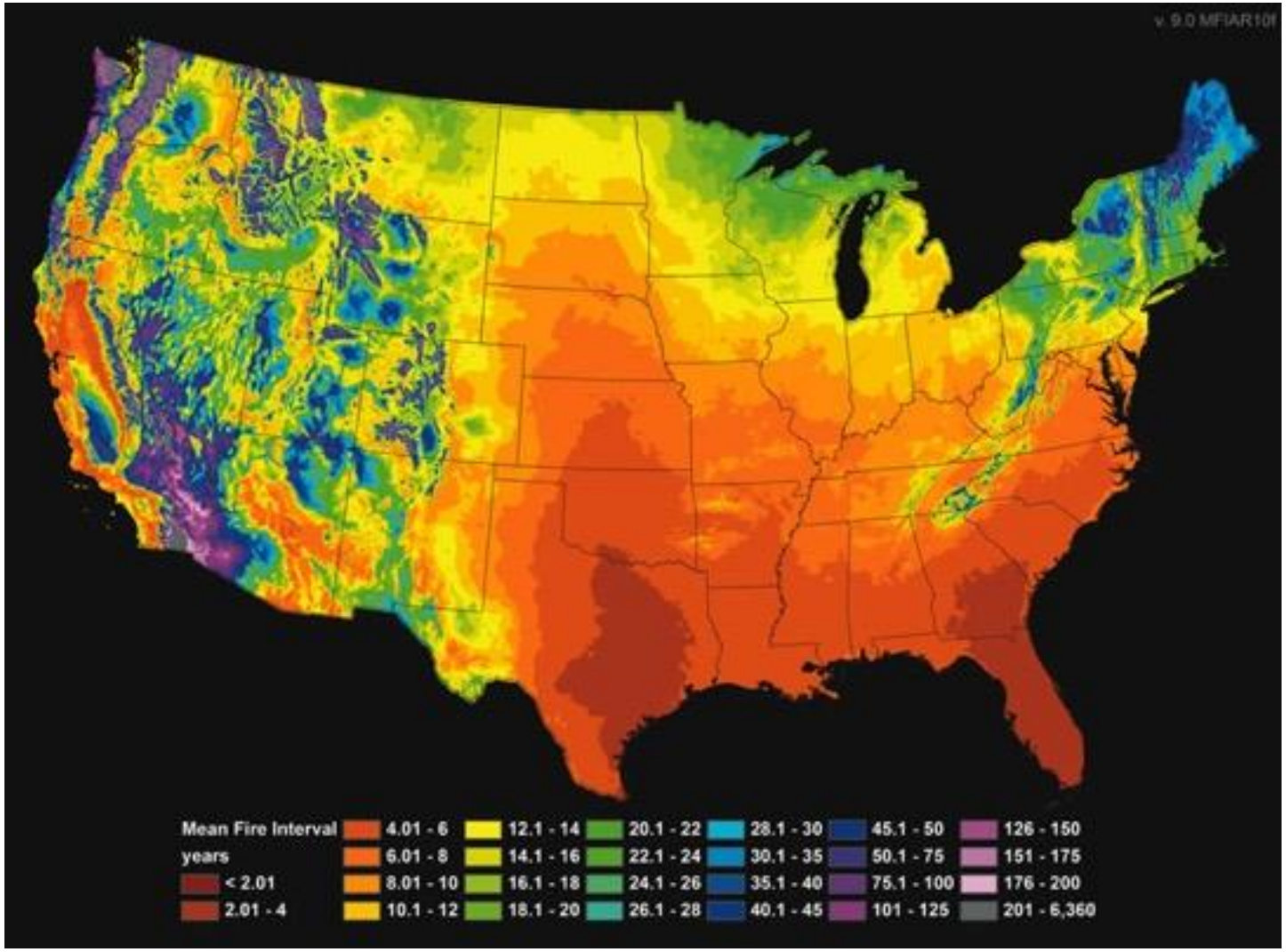
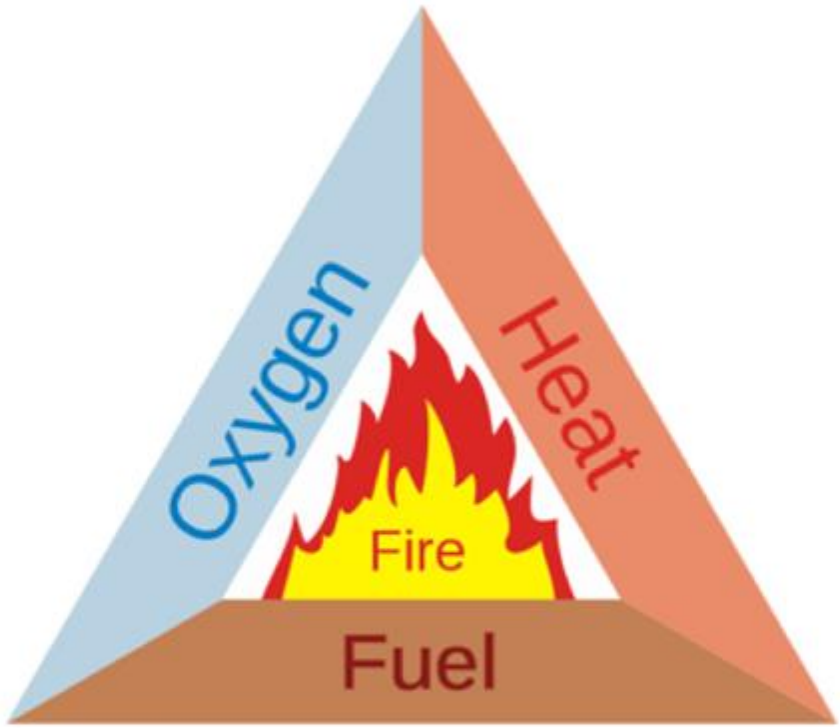


Image: wildfiretoday.com/wp-content/uploads/2015/06/map-fire-freq.jpg

Fire requires heat (ignition source), oxygen, & fuel

- At any point in time, generally two of these are readily available

- **Which portion of the fire triangle is most under our control?**



Fire Triangle

Image: idahofirewise.org/wildfire-ignition-behavior-and-effects/

Fire

- Fire is a chemical reaction
- In a sense, fire breaks down what photosynthesis puts together
- It speeds up decomposition, a natural process

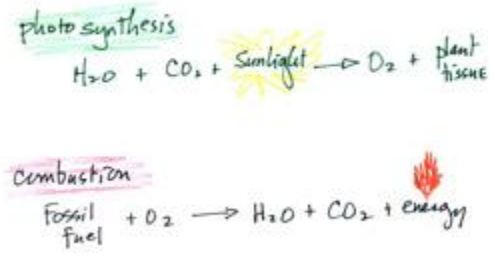


Image: Arizona.edu

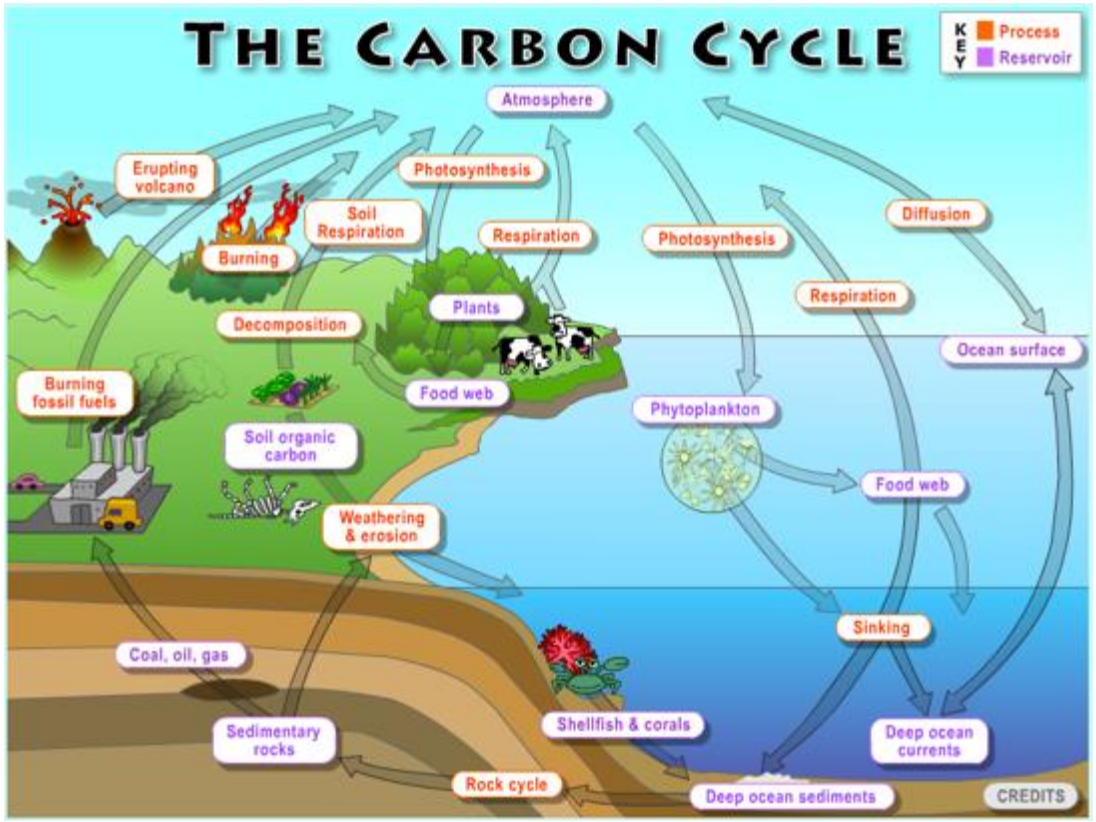
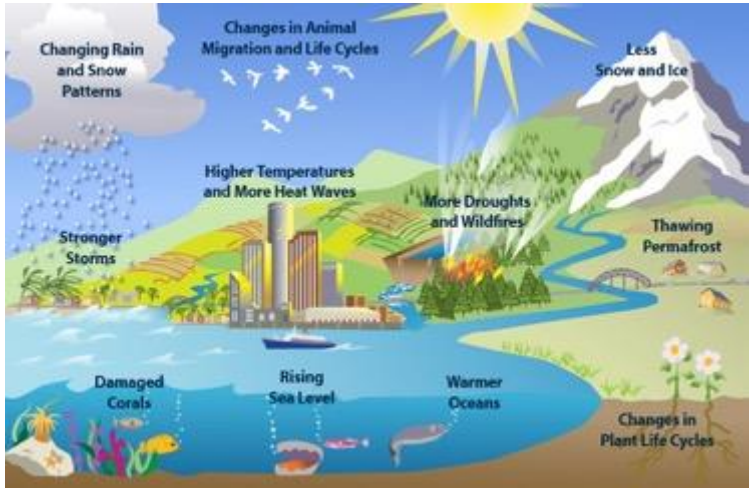


Image: carleton.edu

Natural process

Image: Daily Mail

- Do not forget that combustion is simply an acceleration of decomposition
  - Decomposition may take years/decades/centuries
  - Fire can accelerate that, decrease turnover time to minutes/hours



- Disturbances are part of our natural systems

Pioneer, intermediate, climax

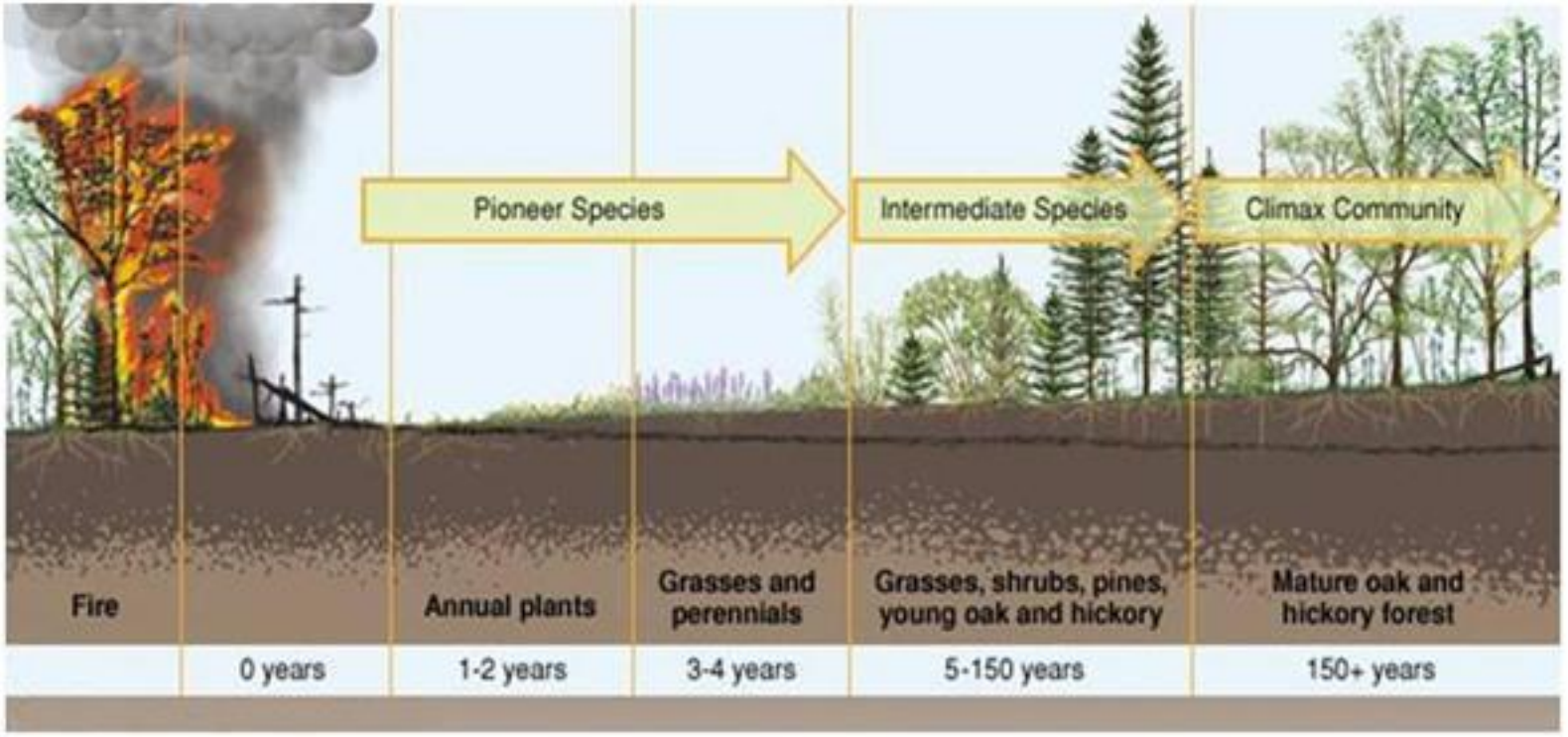


Image: vle.du.ac.in/mod/book/print.php?id=11170#ch21085

What is the typical trajectory of succession?

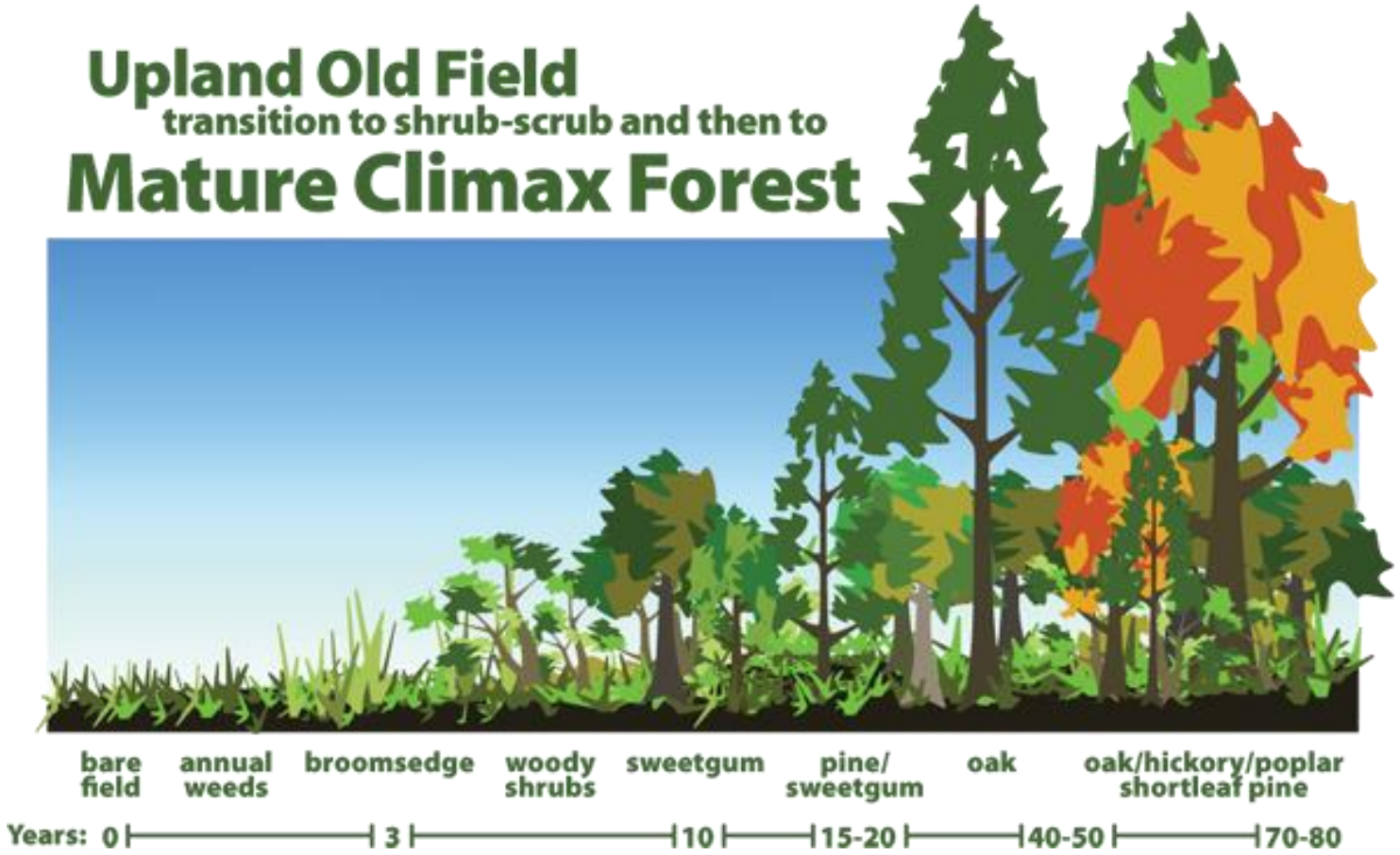
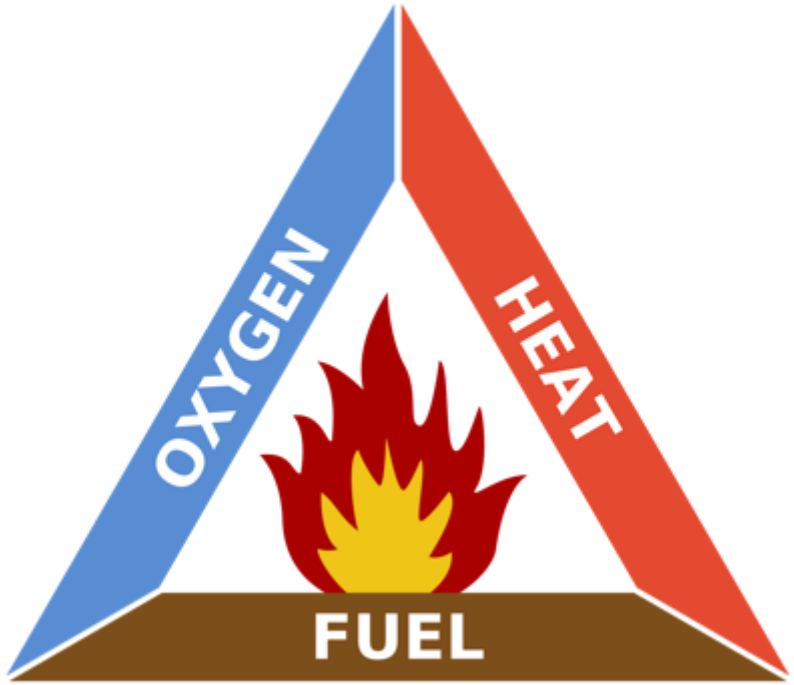


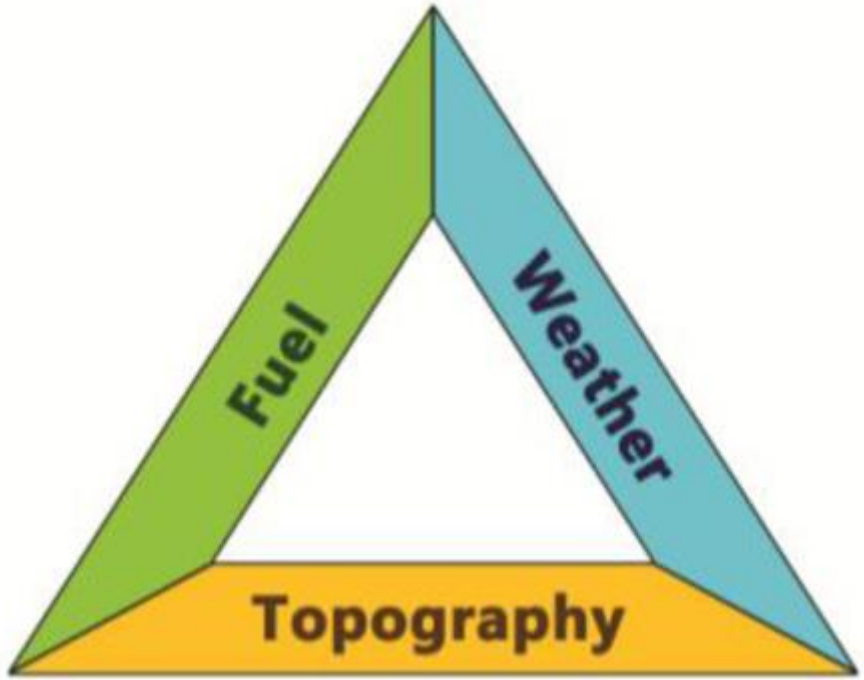
Image: Lake Conestee Nature Park

Fire Behavior: more specific to each location

Fire (Fundamentals) Triangle



Fire Environment (Behavior) Triangle



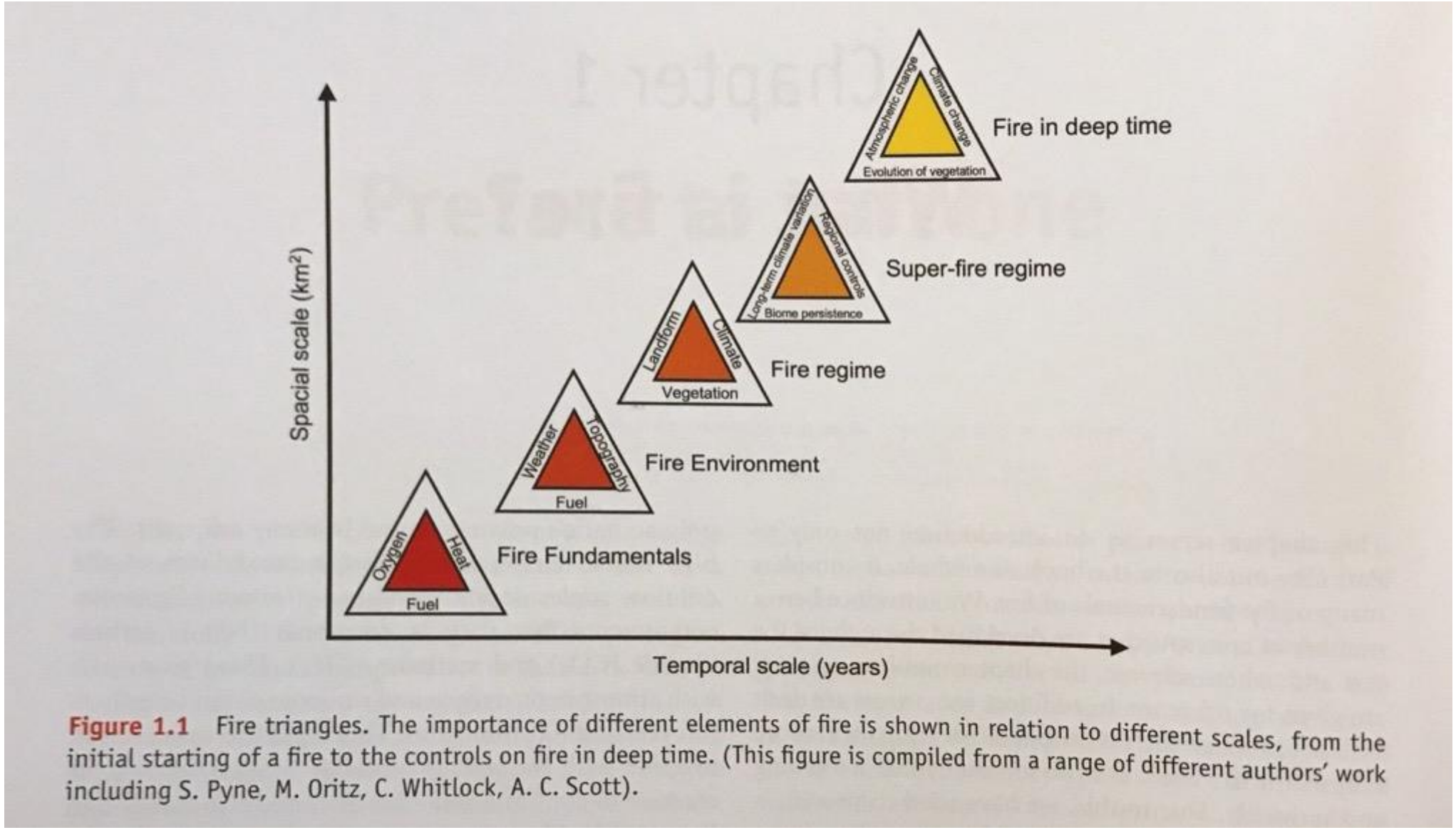


Figure 1.1 Fire triangles. The importance of different elements of fire is shown in relation to different scales, from the initial starting of a fire to the controls on fire in deep time. (This figure is compiled from a range of different authors' work including S. Pyne, M. Oritz, C. Whitlock, A. C. Scott).

Image: Scott et al. *Fire on Earth*, 2014

Terminology: Intensity & Severity

Fire Intensity

- Related to energy release
- Most common metric is **flame length** at **the flaming front** of a fire
- May or may not be related to peak burning temperature
  - All flames approximate 1100 – 1300^{o}C at their tips

Fire Severity

- Related to degree of charring
- Most common metric is organic matter loss (i.e. duff consumption – exposure of mineral soil)

Forest soils are unique

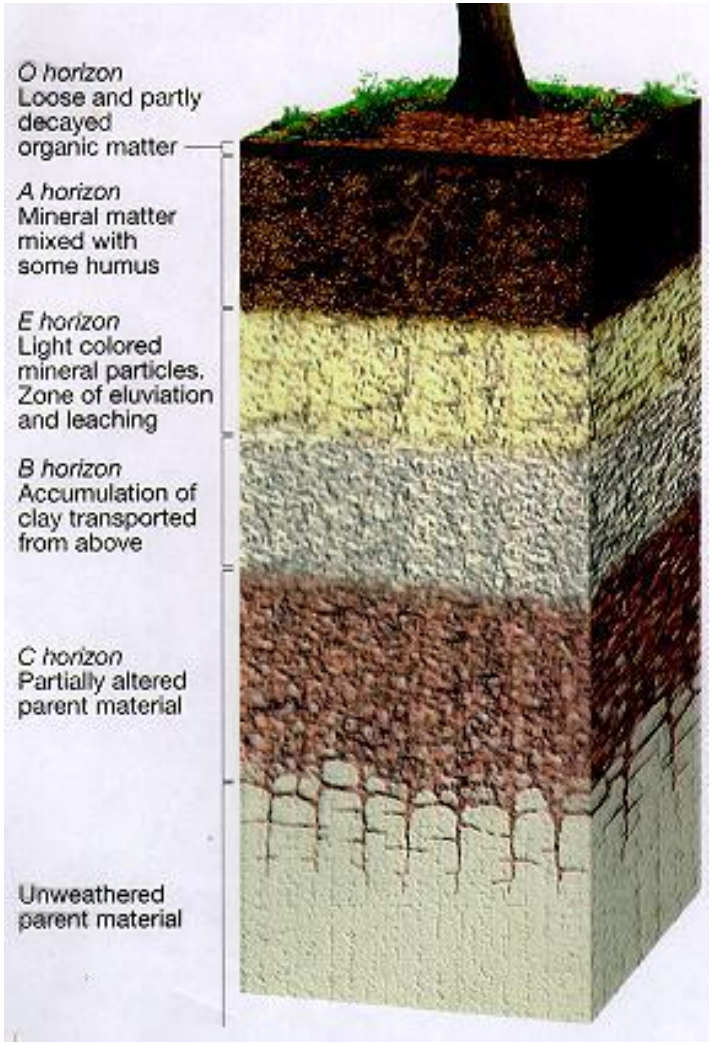
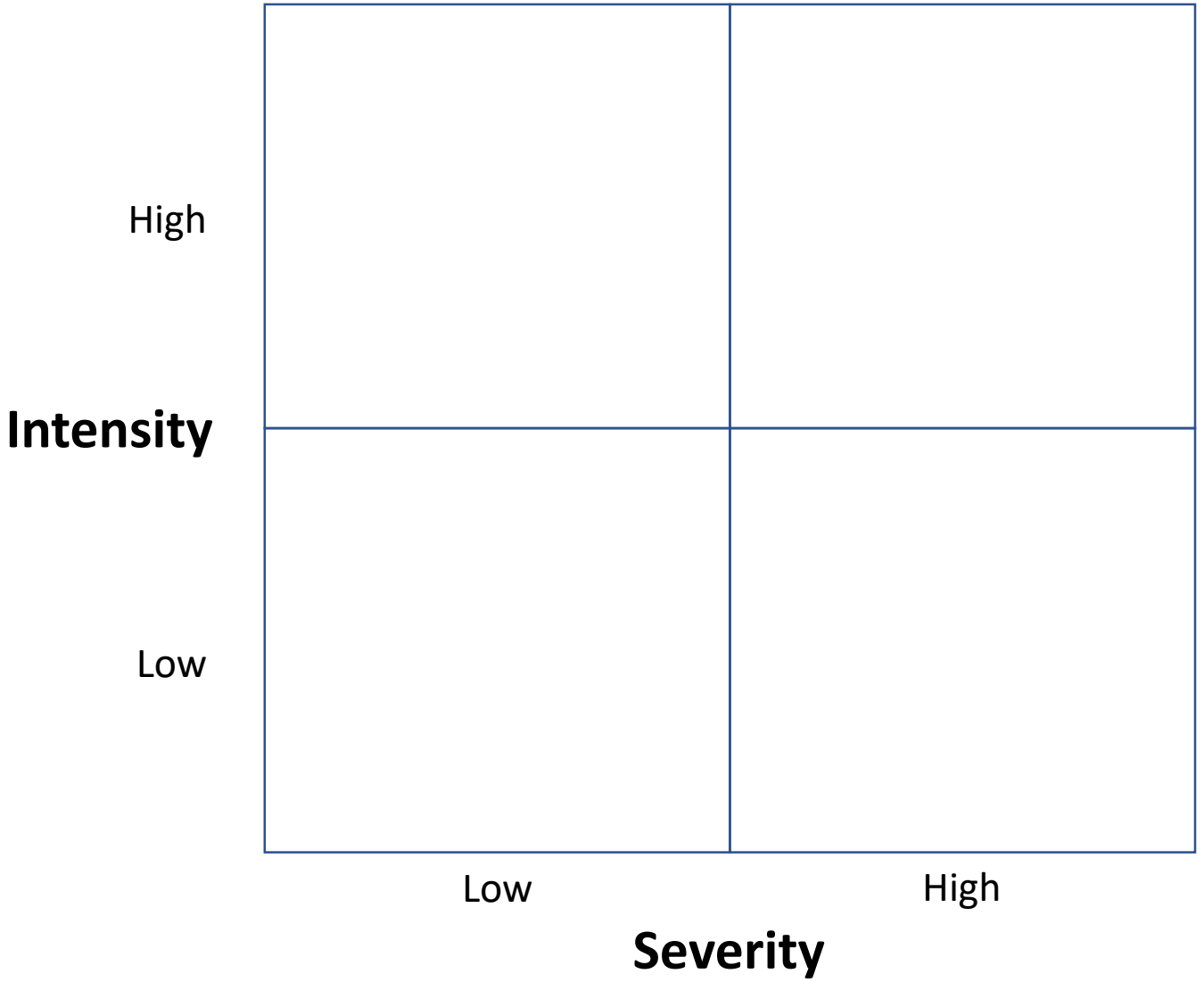


Image: ISU.edu

- O Horizon material in a forest soil is unique
- It contains leaves and needles at varying stages of decomposition
- The consumption of this O Horizon material is monitored to determine more of what a specific fire does to ecosystem properties and processes

Highs & Lows

- You can also have:
  - High intensity/high severity
    - Wildfires in California grasslands in Autumn 2003
  - Low intensity/low severity
    - Burning biennially in longleaf pine in dormant season



High Variability

- What will “most likely happen” in a given fire is subject to change – no fire is exactly like another
- In fact, no one area that burns is exactly like another area that burns in the **SAME BURN**
- What affects these “micro-site” differences?

Highs & Lows

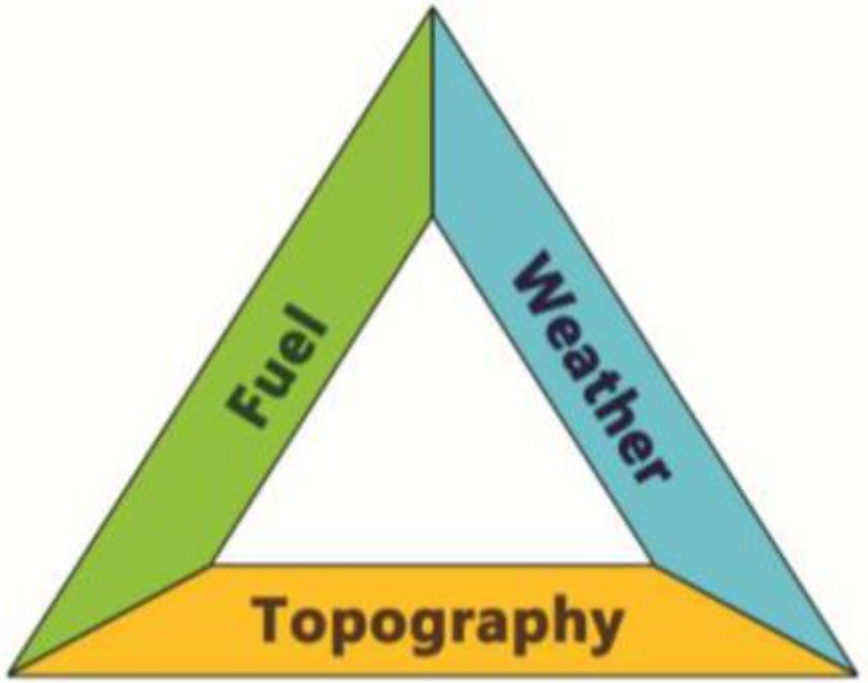
- You can have high severity with low intensity
- Vice versa, you can have high intensity with low severity

- Let’s think about those scenarios:
  - What about burning in a longleaf pine – wiregrass stand burned every 5 years with wind at its back?
  - What about burning in a dried out swamp with peat accumulation?

Fire behavior

- Fire is unique in the sense that each fire is different
- Just because I tell you I have a fire, that doesn't mean all of the fire effects will be the same
- In fact, one location within a given fire can be burning differently than another location within the same fire

Fire Environment (Behavior) Triangle



FUEL

- Fuel has to be present for fire to happen

- But what else matters about fuel?
  - Type
  - Amount
  - Composition

Image: EPA

Fuels

Santee Experimental Forest
Cordesville, SC - 2015

- What might we consider to be fuel for a fire?
  - Smaller, live vegetation
  - Leaf litter and needles
  - Woody debris (stick, twigs, logs)

Fuel measurements

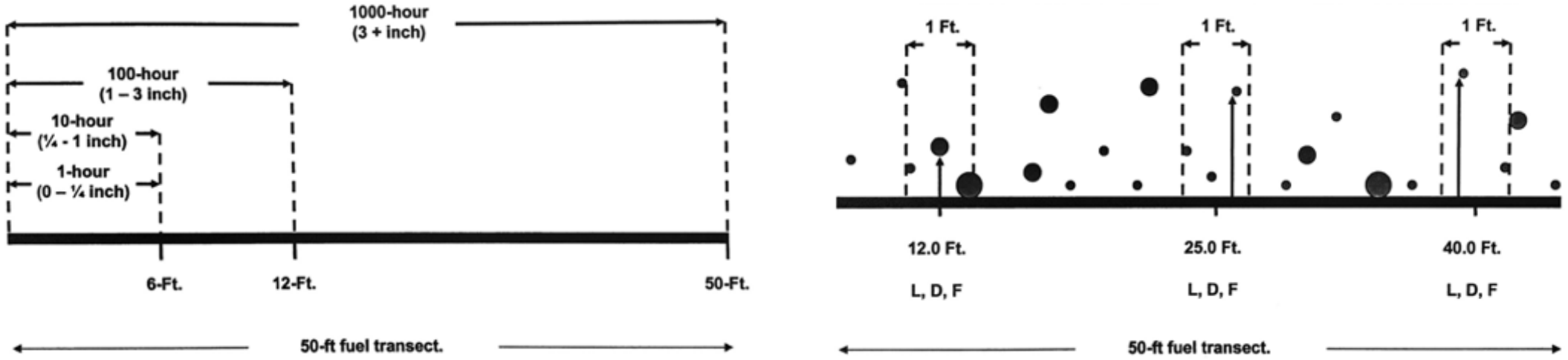


Image: Stottlemyer, 2004

- This is where landform, terrain shape, and ecology come into play
- Fuel type makes a difference
- “Just because it’s leaves mean it burns the same”
  - Example: Pine needles vs. oak leaves
  - What properties separate these two?

Santee Experimental Forest
Cordesville, SC - 2015


Control
Burn-only
Mechanical-only
Mechanical & Burn

Four fire treatments

Long-term, unburned
One replication
6.5 ha (16 acres)

Annual dormant
Three replications
1-2 ha/replication

Annual growing
Three replications
1-2 ha/replication

Biennial dormant
Three replications
1-2 ha/replication

Unmanaged watershed
46.35 m^2 ha^{-1}
41% loblolly pine BA
59% hardwood BA

Managed watershed
33.72 m^2 ha^{-1}
84% loblolly pine BA
16% hardwood BA

Common hardwood species on both watersheds: multiple oak species, sweetgum, maple

Fuel Models (Anderson 1982)

Fuel Model

Anderson, Hal E. 1982. Aids to determining fuel models for estimating fire behavior. USDA Forest Service General Technical Report INT-122. 22 p.

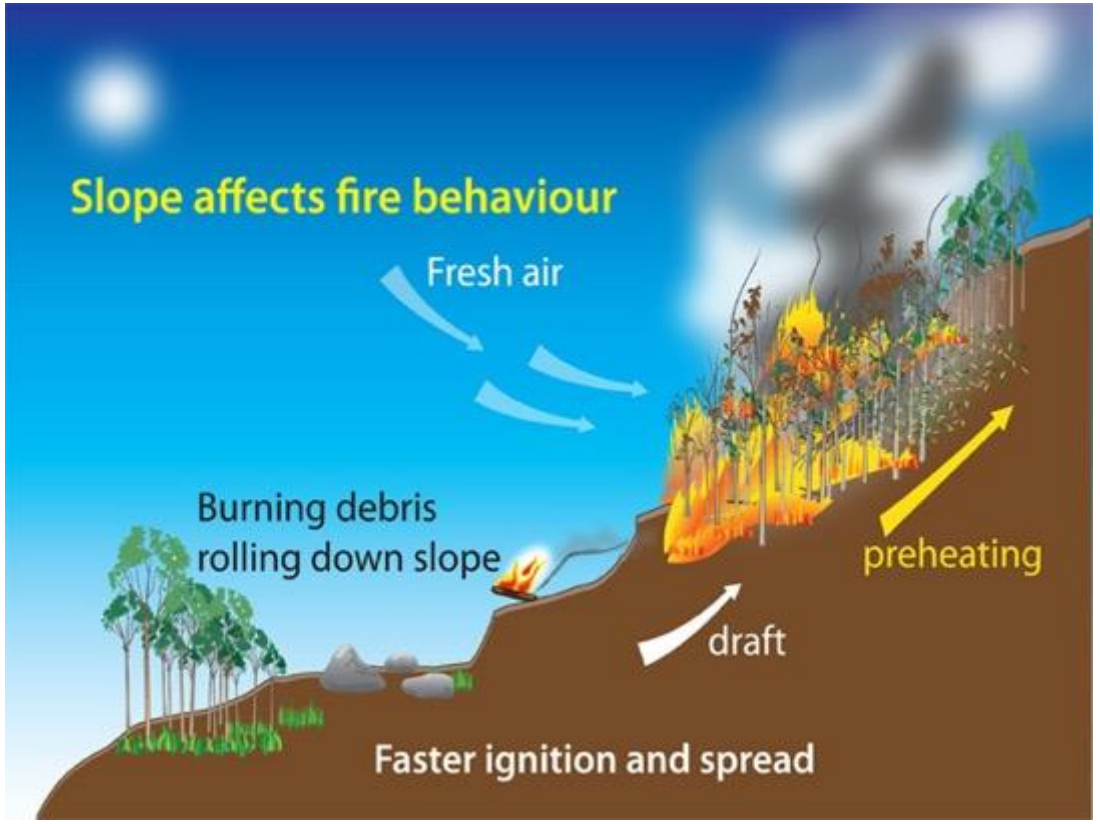
	Description
1	Grass
2	Pine/Grass
3	Tall Grass
4	Tall Chaparral
5	Brush
6	Dormant Brush
7	Rough
8	Hardwood/Lodgepole Pine
9	Mixed Conifer Light
10	Mixed Conifer Medium
11	Light Slash
12	Medium Slash
13	Heavy Slash
14	Plantation/Burned last 15 years
15	Desert
28	Urban
97	Agricultural Lands
98	Water
99	Barren/Rock/Other

- Tallies of fuels over time in the same geographic area have been utilized to create fuel models
- Picture models were developed in the 1980s and 1990s
- GIS has advanced that a step further

Fire Behavior/Environment

TOPOGRAPHY

- Did you know fire travels faster up a hillside?
- Why is that?
- This is because the flames can easily reach more unburnt fuel in front of the fire. Radiant heat ***pre-heats*** the fuel in front of the fire, making the fuel even more flammable



- Wildland firefighters get in trouble when a fire gets behind them on a slope
- Generally 20% of annual firefighter deaths occur because of “fire behavior changes”
- Ex. South Canyon Fire, 1994

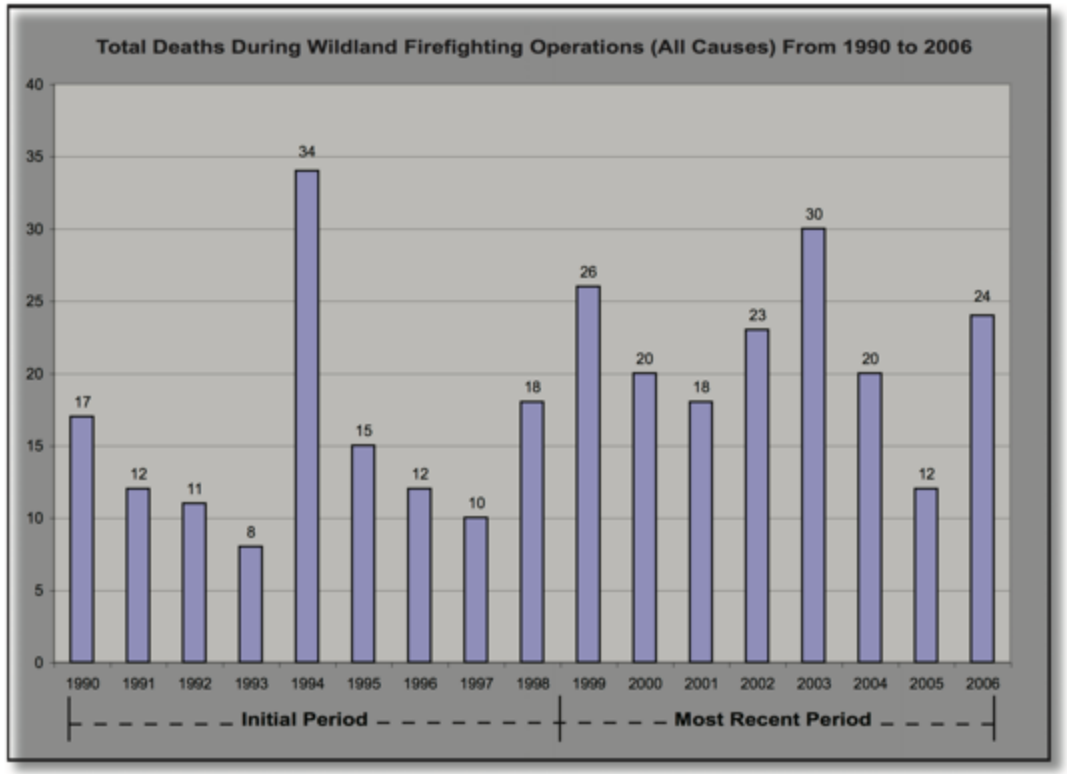


Figure 2—The annual death toll for persons who died during wildland fire operations from 1990 to 2006 (310 total deaths).

Fire Behavior/Environment

Weather

- Relative humidity
- Wind speed
- Wind direction
- Moisture
  - Fuel moisture
  - Soil moisture
- Season
- Dew point
- Ambient temperature

Preferred Rx Fire Conditions

- 1-3 mph winds
- 30-55 relative humidity
- Winter temperature < 60F
- Soil moisture: damp
- Fine fuel moisture: 10-20%
- Atmosphere slightly unstable or neutral
- Mixing ht.: 1700-6500 ft.
- Transport windspeed: 9-20 mph

High fuel moistures produce lots of smoke

Stable conditions or a low mixing height keep smoke near the ground

Unstable conditions and/or a high mixing height provide for rapid smoke dispersion

Image: Wade 1989

- Smoke management is the main concern that will delay prescribed burns
- Ex. Charleston/Santee Experimental Forest, 2015
- Weather has a huge impact on smoke

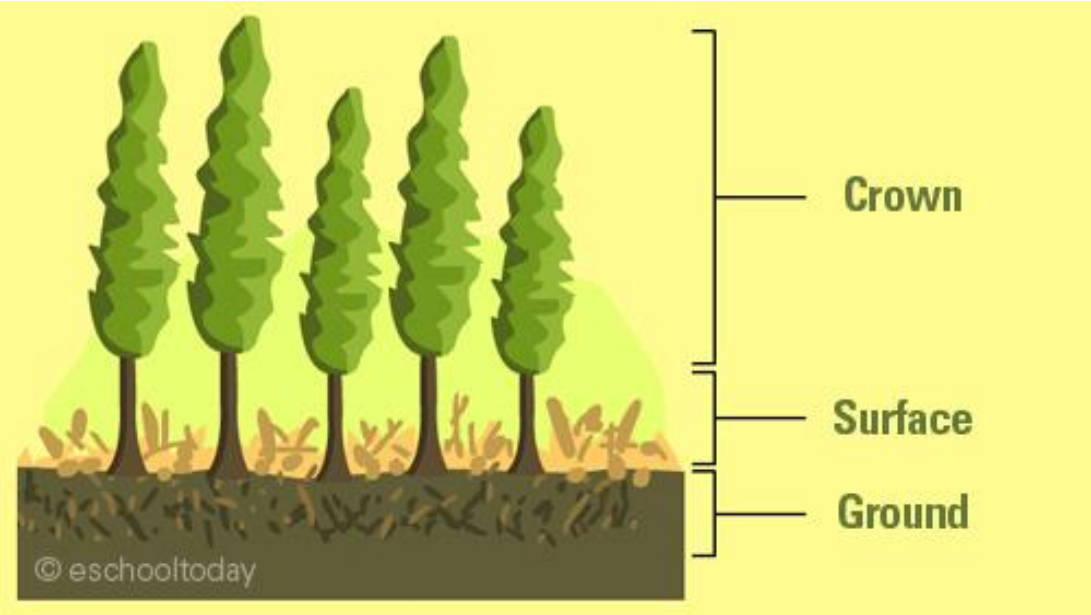
Florida wildfire, 1998

Red Flag Conditions in VA

- 10-hr fuel moisture: 7% or less
- Wind speed: 20 mph or greater
- Relative humidity: 30% or less

Image: WGBA

Common Fire Descriptions



- **Surface fire**: fire that burns only surface fuels such as litter, other loose debris on the soil surface, and small vegetation
- **Ground fire**: fire that burns the organic matter in the soil layer that supports glowing combustion
- **Crown fire**: fire that advances from top to top of trees/shrubs more or less independently of the surface fire
- **Stand replacing fire**: fire that kills all or most living overstory trees in a forest and initiates secondary succession or regrowth
  - Usually a combination of all of the above (surface, ground, and crown)

Fuel structure plays a role

In a forest where fires rarely happen, fuel builds up: There's **surface fuel** (grass, logs, woody debris, brush); **ladder fuel** (shrubs, small trees, snags); and **tree crowns**.

1. Surface fires spread quickly through brush and woody debris.
2. Ladder fuels allow the fire to move up toward the forest canopy.
3. Tree crown fires are so intense, they're difficult to control.

Examples: Surface fires

Examples: Ground fire

Examples: Crown fire

Examples: Stand replacement fire

What has fire accomplished here?

Burned multiple times in 12 years

Unburned

Image: Coates, 2017

414
Annual Growing
Replication 1

Burning along the coastal plain

Less than one month post-fire at Tom Yawkey Wildlife Center, April 2016

Stand has been burned 4 times in 5 years

Ignition techniques

- Drip torch introduction
- Prescribed fire introduction
- Flank fire
- Ring fire
- Aerial ignition
- Aerial ignition 2
- How to use multiple ignition types
- Excellent boundary video

Image: inciweb.mwcg.gov

Image: ammlcc.myblog.arts.ac.uk

Contact information

Dr. Adam Coates
228F Cheatham Hall
310 West Campus Dr.
(540) 231-5676
acoates4@vt.edu