Fire in Longleaf Pine - Outside My Window

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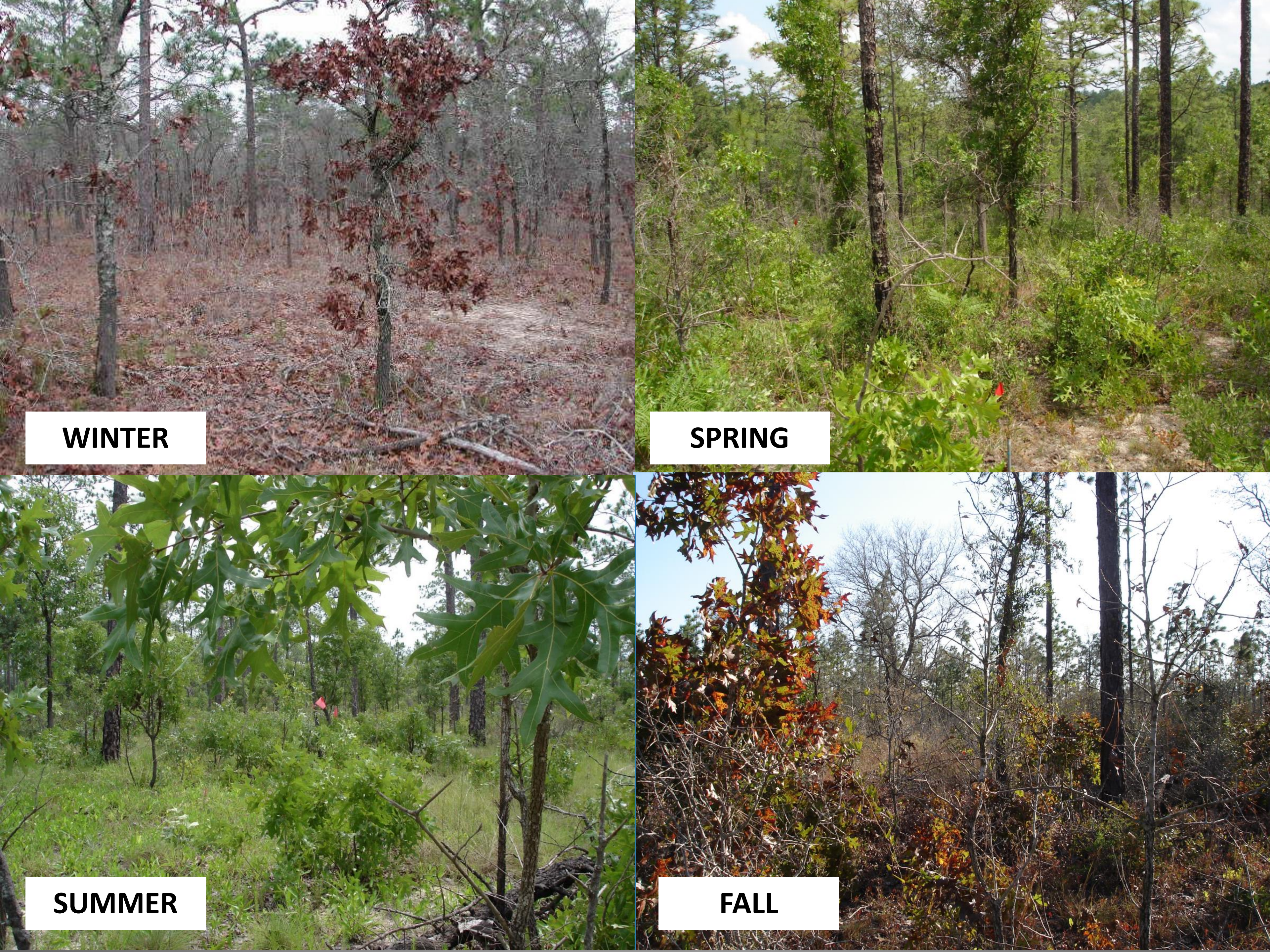
Which is a Better Burn Day?


WINTER
SPRING
SUMMER
FALL

Traditional Challenges to Burning

1) Weather
2) Capacity
3) Smoke/Air Quality
4) Liability
5) Public Perception
6) Resources
7) Permitting
8) Low Priority
9) WUI

What is the biggest challenge to burning in Longleaf?

"Ourselves?"

Burn Boss Paradox

Decision making process

+

Personal values / perceptions

+

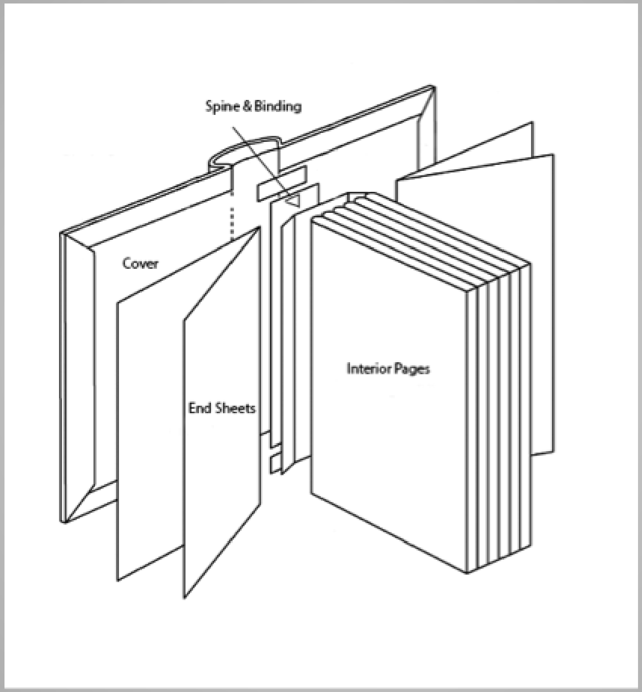
Conviction

=

Dogma!

Burn Plan as a surrogate…

Anatomy of a Burn Plan



Composed of 21 Elements that ultimately outline the “rules of engagement”

Prescription Element Rigidity

- Authorization
- Go/No Go Checklist
- Complexity Analysis
- Description of Unit
  - Physical, Fuels, Onsite Values
- Funding
- Briefing
- Organization and Equipment

- Communication
- Public and Firefighter Safety
- Test Fire
- Holding Plan
- Contingency Plan
- Wildfire Declaration
- Smoke management
  - Dispersion Index
  - Wind Speed and Direction

Prescription Element Flexibility

"Where we can get backed into a corner"

- Conflicting Management Objectives
  - Timber Management
  - Wildlife Management
  - Promotion of Specific Species
- Scheduling / Seasonality
- Pre-burn Considerations and Weather
  - Making Go/No Go based on a single parameter (RH, Temp)
- Ignition Plan

Why do we make these decisions?

- Institutional Habits
  - “This is the way we have always burned this unit”
- Conflicting Science
  - “Gotta burn in the growing season to get wire grass and long leaf regeneration”
  - “March 15th is the growing season and we can only burn this unit in the dormant season”
  - “Your never gonna kill hardwoods with a winter burn”
  - “Dormant season burning is only good for hazard fuel reduction”
  - “RCW’s need 40-60 ft^2 BA for colony expansion”
  - “To hammer the sweetgum ya gotta burn when the leaves are the size of a squirrels ear”
  - “If you scorch my pines it will reduce the growth rate”

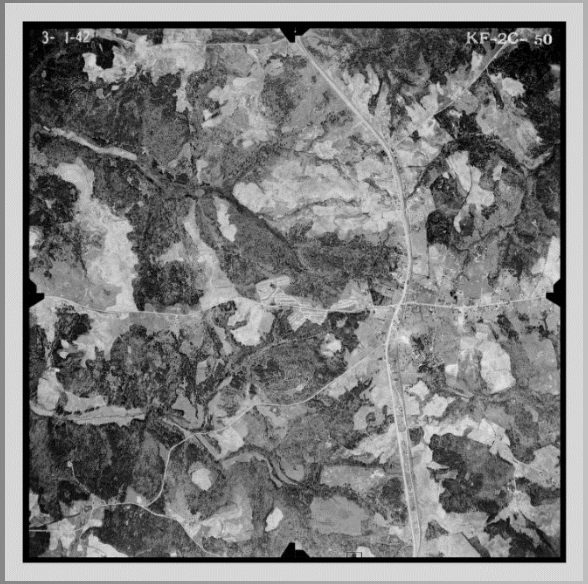
Tunnel Vision

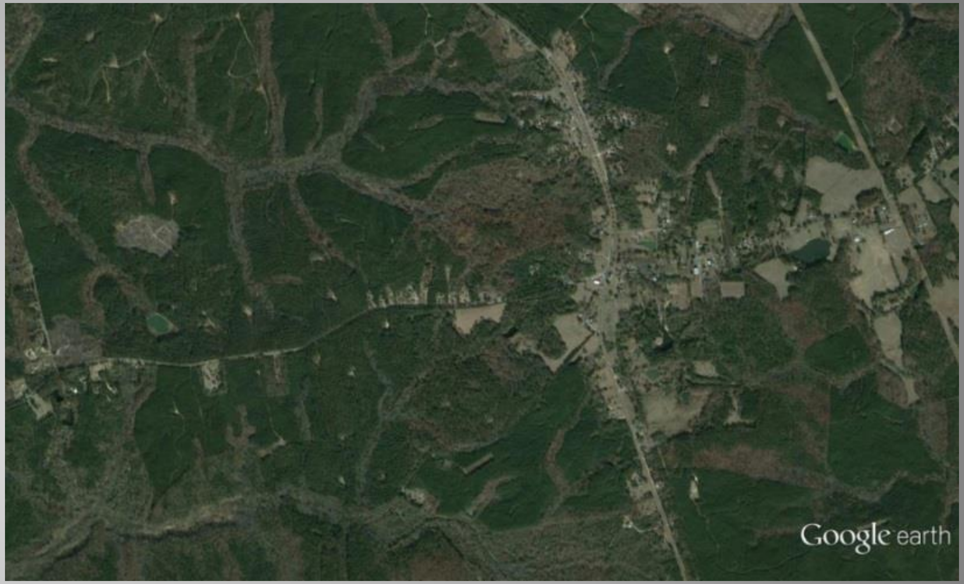
If we can learn to avoid this with regard to Firefighter Safety by practicing SA why don’t we use this to better understand resource objectives….

It gets more complicated!!

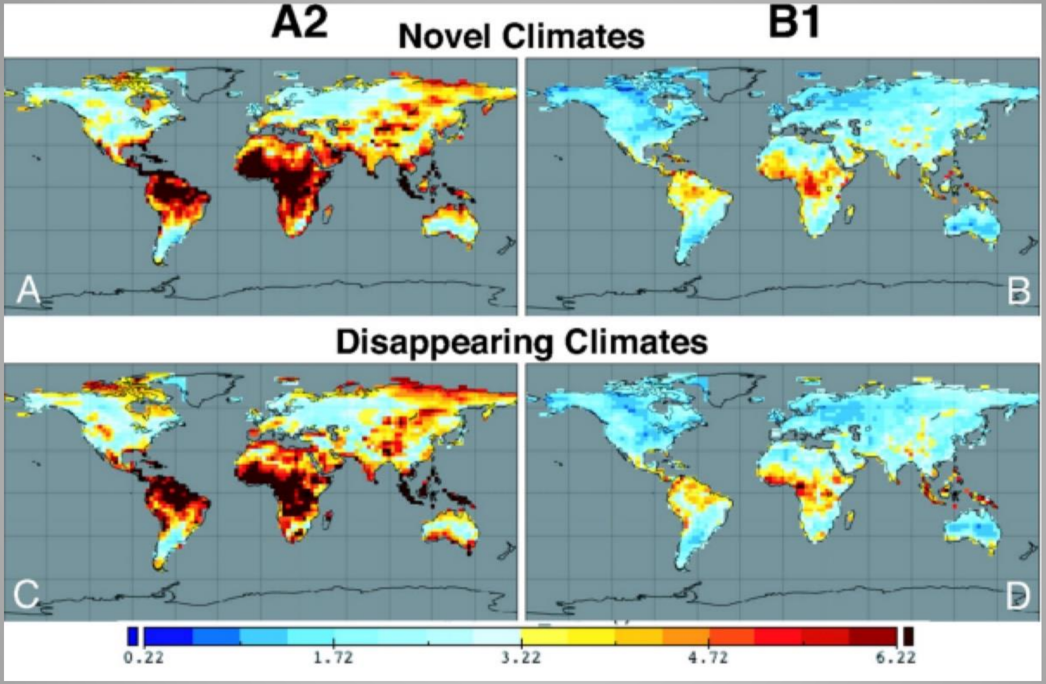
- Knowledge of fuels and fire regimes
- Weather patterns in flux
  - Annual rain fall is not changing but frequency and intensity are
  - Models predict more variability in climate moving into the future
- Invasive species
  - Insects
  - Plants that promote fire
  - Plants that create fire shadows
  - Interactions with native vegetation
- Wildland Urban Interface

Novel Ecosystems





No-analog Future

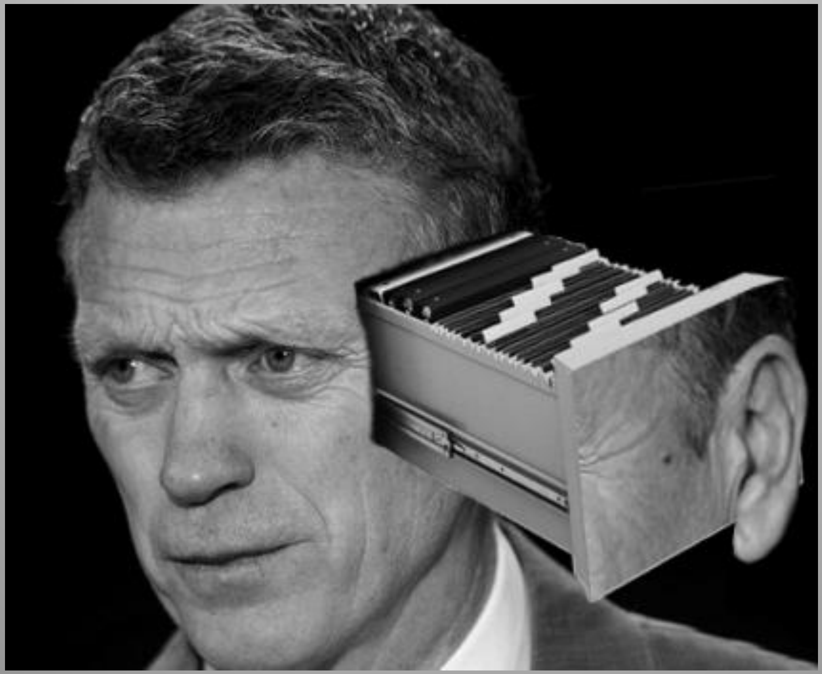


Williams, John W., and Stephen T. Jackson. "Novel climates, no-analog communities, and ecological surprises." Frontiers in Ecology and the Environment 5.9 (2007): 475-482.

2016 Fall Appalachian Fire season

No-analog Present

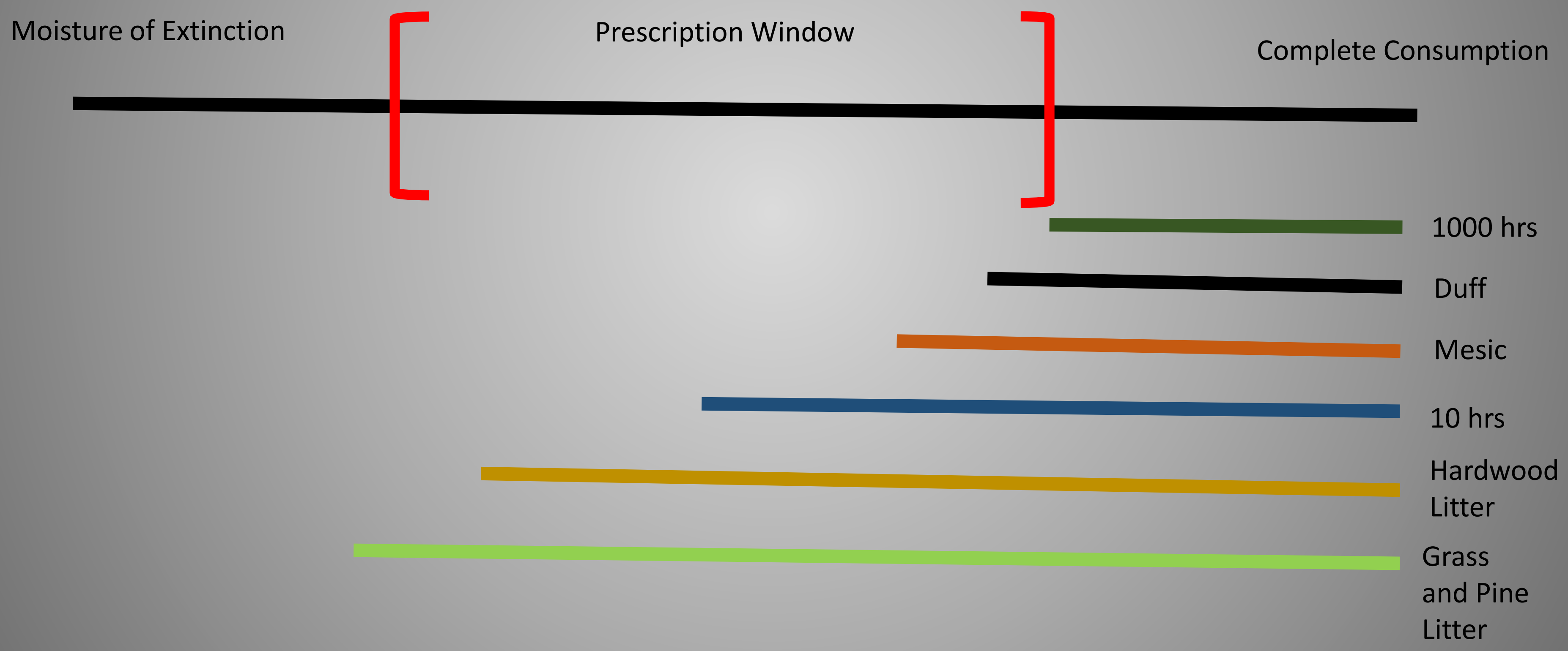
320 - 100+ acre fires totaling 325,000 forested acres burned from October to December



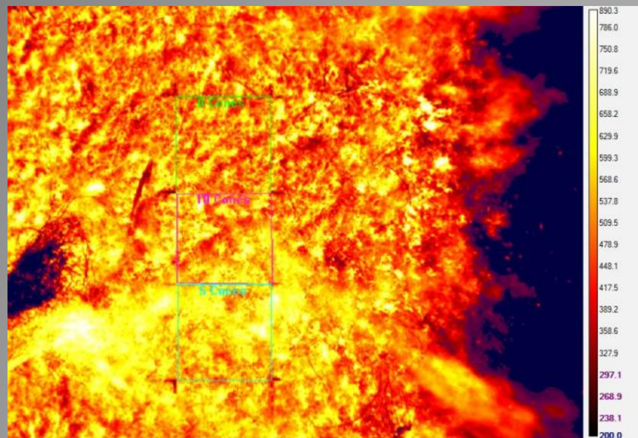
What Drives our Fire Effects?

“Fire effects are the result of an interaction between the heat regime created by the fire and the properties of ecosystem components present on the site.” (NWCG - Fire Effects Guide)

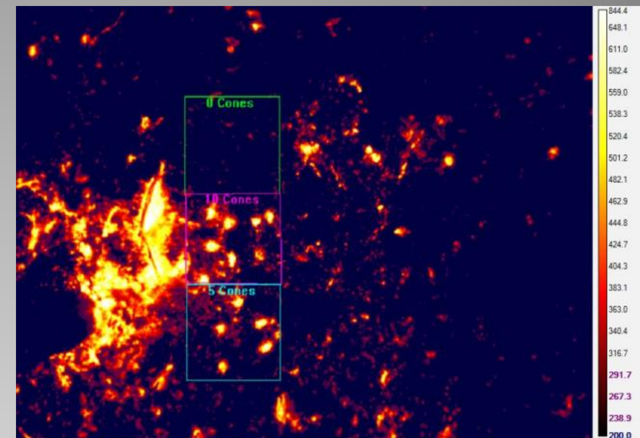
Fuels Driving Fire Effects



Fuels, Energy, and Community Assembly

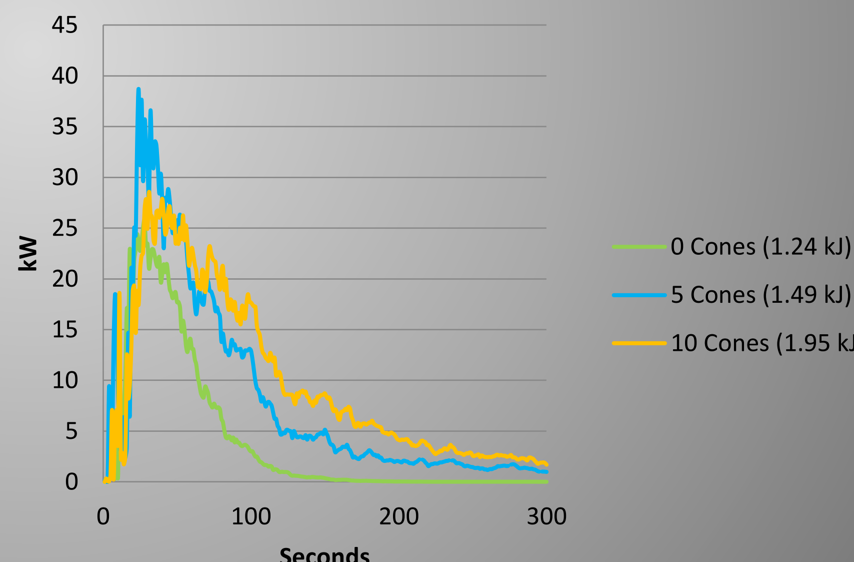


25 Seconds



3 Minutes

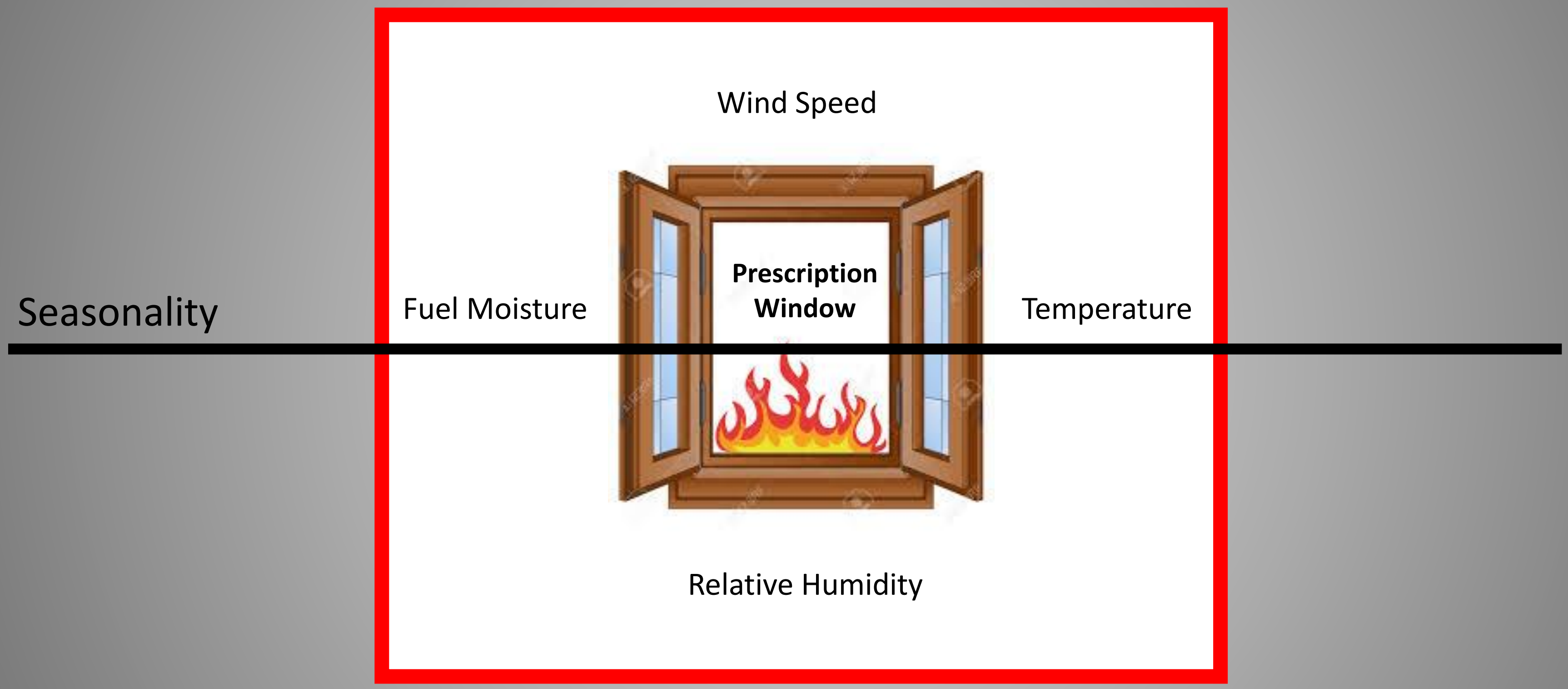
- Plants as fuel alter fire behavior
- Fire behavior and energy transfer drives post fire effects
- Recovering vegetation is the fuel to drive future fire



Canopy-Derived Fuels Drive Patterns of In-Fire Energy Release and Understory Plant Mortality in a Longleaf Pine Sandhill in Northwest Florida, USA. Canadian Journal of Remote Sensing. 2016

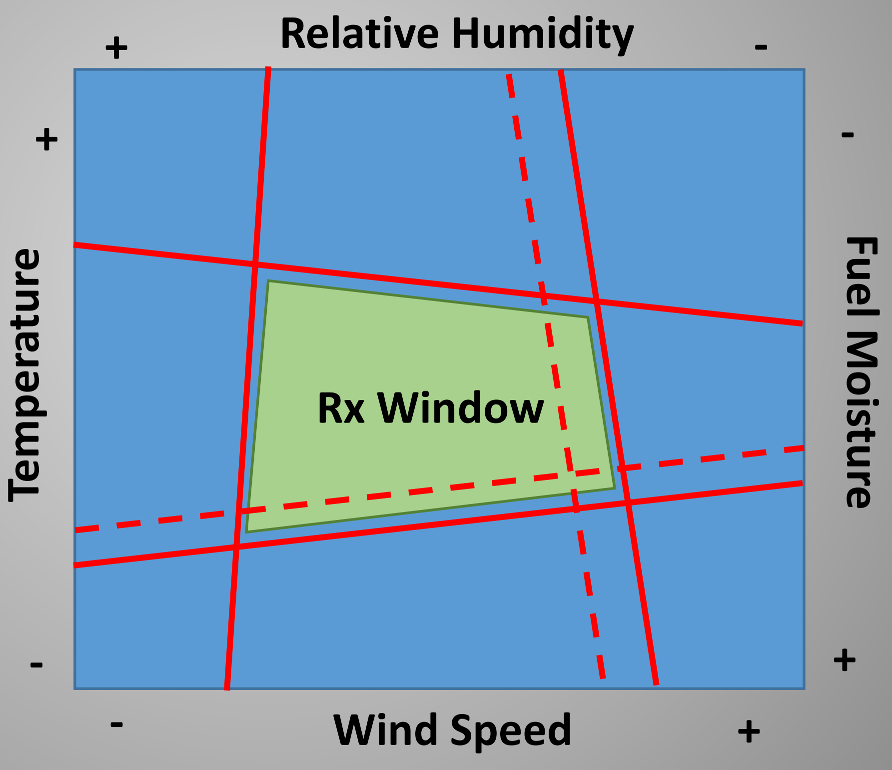
JJ O'Brien , EL Loudermilk, JK Hiers, SM Pokswinski, BS Hornsby, AT Hudak, D Strother, E Rowell, BC Bright

The Realm of Fire



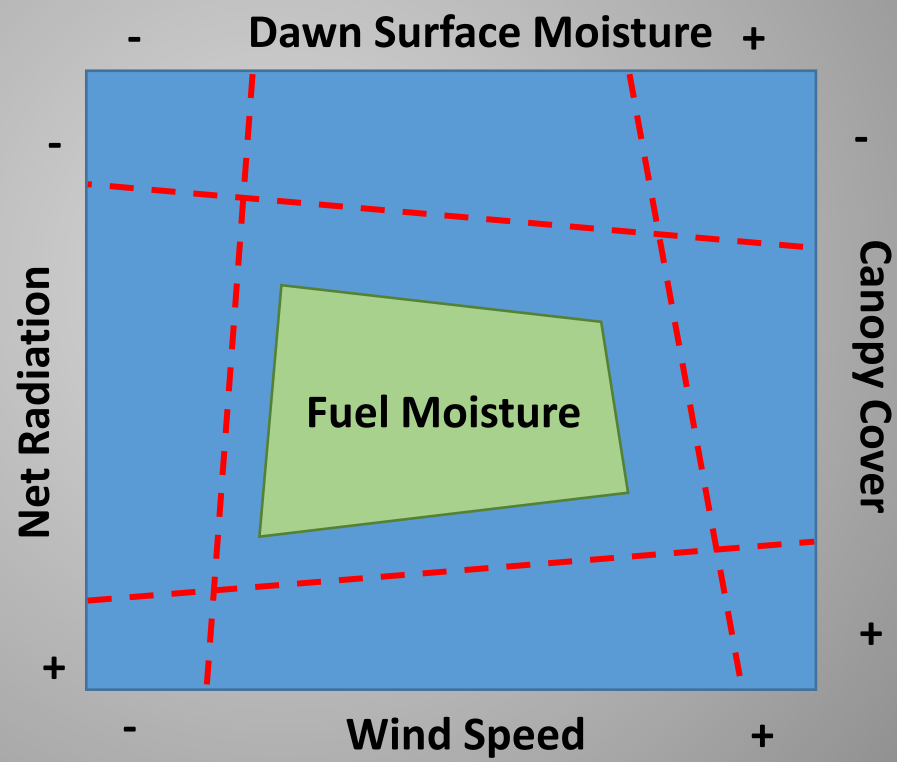
Prescription Precisionism

- Prescriptions are either developed from Fire Behavior Prediction System…. OR
- Past experiences
- They are LEGAL documents with little science
- Fuel moisture and wind drives fire behavior in FBPS
- Rx mostly denotes RH and Temp to define windows for fuel moisture



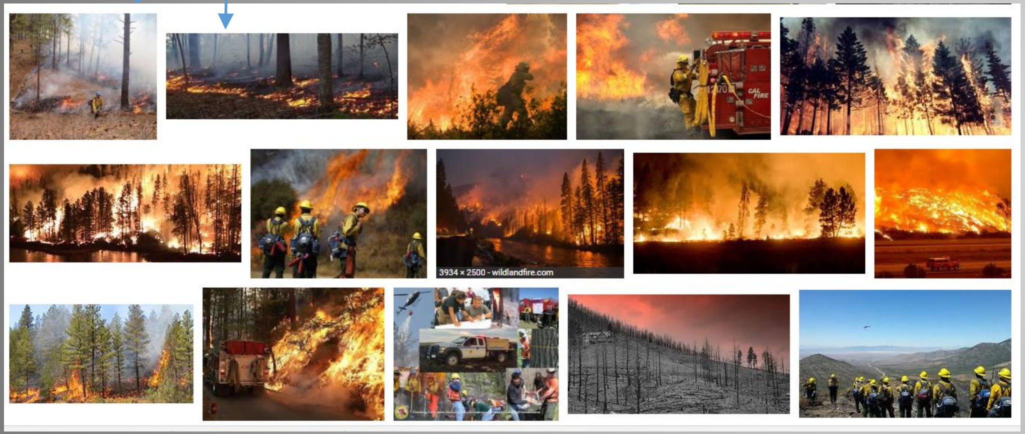
Prescription Precisionism

- What if Fuel Moisture is more complicated?
- How does dew or rain or soil moisture affect diurnal drying
- What if prescriptions are wider than we allow?
- Too many artificial constraints on fire managers already…



National Systems for Fire are Problematic

Rx fire?



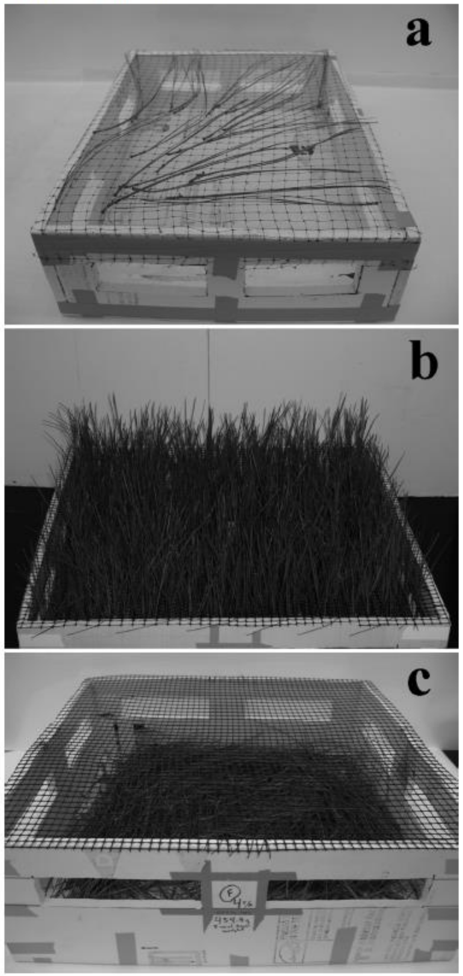
Google: “Wildland Fire”

- NFDRS based on a half-inch pine dowel (Nelson 2010)
- Built on “worst case fire scenario”
- Are equilibrium moisture assumptions safe for the real world?
- Not practical for diurnal moisture cycles or forest types
- RAWS network hasn’t been evaluated for local adaptation

Understanding Characteristics Within a Fuel is Important

Fuel Particles vs. Fuel Beds

Fig. 3. Longleaf pine needle beds during drying with needles arranged as (*a*) individual needles loaded at 0.044 kg·m^{-2} (0.2 ton/acre), (*b*) vertical needles at 0.896 kg·m^{-2} (4 tons/acre), (*c*) flat needles at 0.896 kg·m^{-2} (4 tons/acre).



Loading	Timelag
0.2 tons/acre	3.3 – 5.5 hours
4 tons/acre	4.4 to 8.6 hours
4 tons/acre	6.5 to **31.6** hours

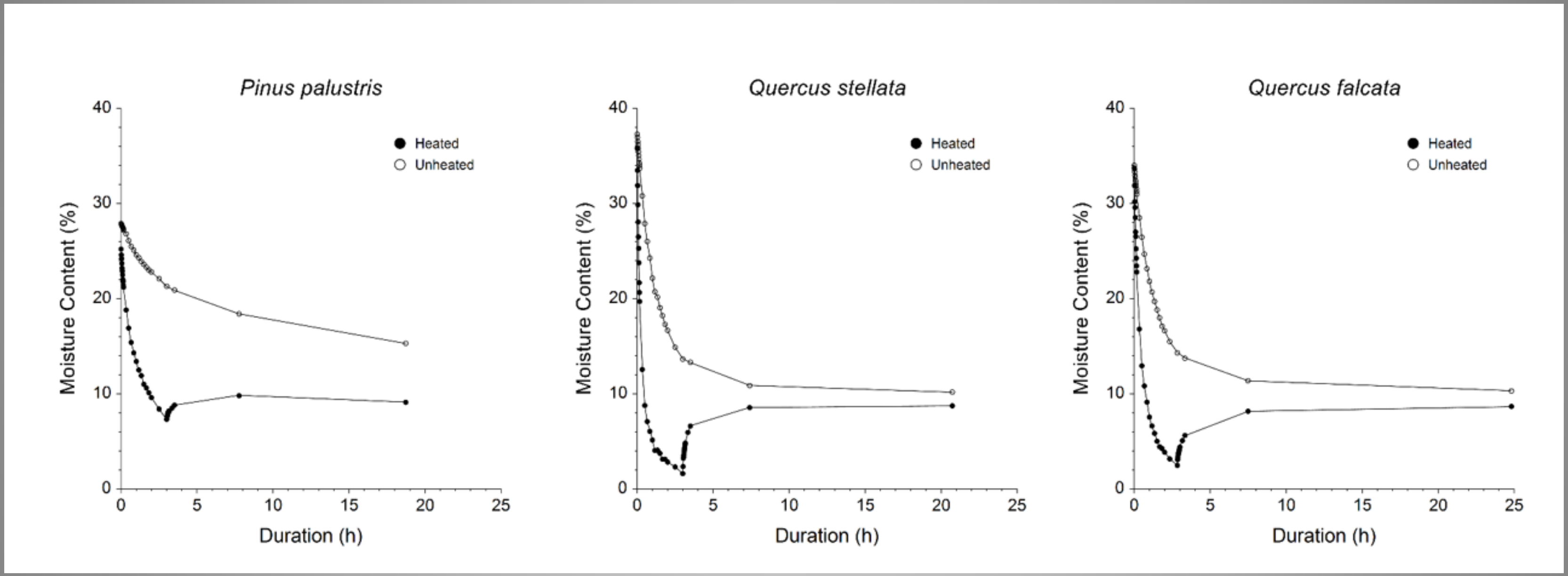
Nelson, R. M., and J. K. Hiers. 2008. Fuel moisture in longleaf pine litter: the influence of fuel bed properties on timelags and drying rates. *Canadian Journal of Forest Research* 38:2394-2404.

Drying with Solar Exposure

				Exposed					Unexposed				Lab Conditions	
Litter Species	Initial mass‡	Drying time		Dry Mass	Initial FMC	End FMC	Fuel Temp		Dry mass	Initial FMC	End FMC		Air Temp	Relative Humidity
	g	h		g	%	%	°C		g	%	%		°C	%
P. palustris	131	1		103	27.0	13.6	44		101	29.8	25.7		24	50
P. palustris	107	3		85.5	25.2	7.3	52		84.0	27.9	21.3		24	45
P. palustris	88	3		69.1	27.0	7.3	48		68.5	27.7	19.6		26	43
Q. stellata	37	3		27.3	35.8	1.6	47		26.5	37.3	13.6		24	41
Q. falcata	42	3		31.1	33.7	2.5	45		31.4	34.0	14.3		23	39

Table 1. Longleaf pine (*Pinus palustris*) and oak (*Quercus stellata*, and *Q. falcata*) litterbeds used in indoor laboratory experiments conducted to observe the influence of radiative energy input, simulating solar heating, on litter drying. End moisture contents are following one or three hours of drying under laboratory conditions of litter unexposed or exposed to infrared lamps producing 600 W m^{-2}. Fuel temperatures are given for litterbeds that were exposed to infrared radiation quantified from thermal infrared imagery. ‡Initial mass of litterbeds (exposed and unexposed) were following 24 h incubation in a moisture chamber.

Influence of Solar Radiation



Effects of solar exposure and litter position on forest floor moisture dynamics: influence of overstory structure and litter type. ***2018 Canadian Journal of Forest Research***
Jesse K. Kreye, J. Kevin Hiers, J. Morgan Varner, Ben Hornsby, Saunders Drukker, and Joseph J. O'Brien

Pine Litter and Palmetto

- Fine dead duel moisture lags are species-specific
- Stand-level fuel moisture estimates are inadequate
- Minimum daily fine dead fuel moistures of palmetto and pine litter were significantly different (17% mid-day difference on average)
- Palmetto litter displayed consistently lower moisture content than pine litter

Fine dead fuel moisture shows complex lagged responses to environmental conditions in a palmetto (*Serenoa repens*) dominated understory. 2018. Agricultural and Forest Meterology

J. Kevin Hiers[1*], Christina L. Stauhammer[2], Joseph J. O'Brien[3], Henry L. Gholz[4], Timothy A. Martin[5], John Hom[6], and Gregory Starr[2]

Pine Litter and Palmetto

- Palmetto FDFM showed little/no response to rain events
  - live palmetto fronds shield palmetto litter from short-term rain events
  - waxy cuticle and vertical orientation of dead fronds shed water (Abrahamson 2007)

- Pine litter slow to respond to precipitation with as much as a day lag time

- Helps explain why southeastern fuels can burn intensely in high relative humidities and cloudy conditions.

Fine dead fuel moisture shows complex lagged responses to environmental conditions in a palmetto (*Serenoa repens*) dominated understory. ***In Press***

J. Kevin Hiers[1*], Christina L. Stauhammer[2], Joseph J. O'Brien[3], Henry L. Gholz[4], Timothy A. Martin[5], John Hom[6], and Gregory Starr[2]

Season of Burn, Oak Kill and Fuel Moisture

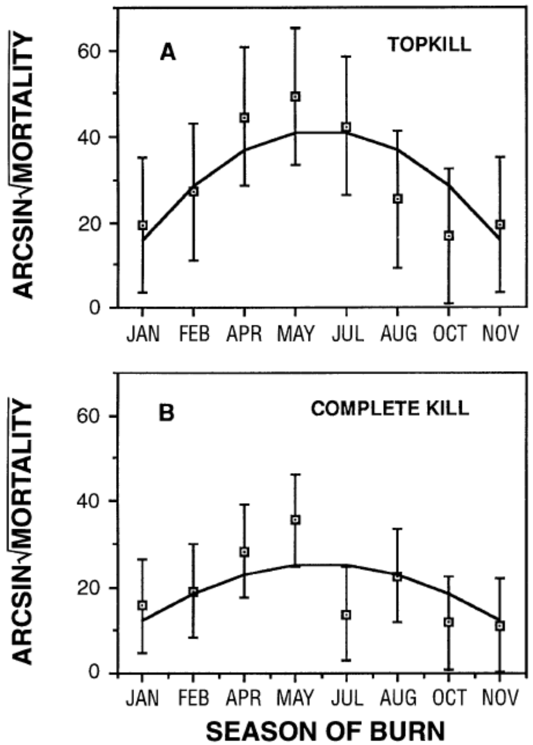


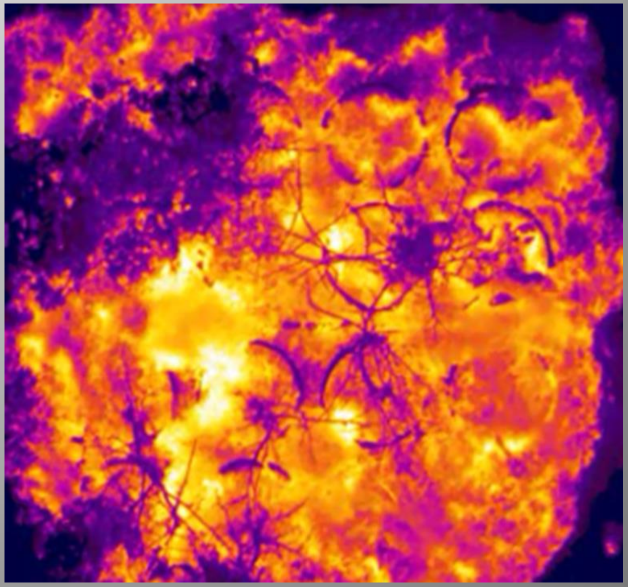
FIG. 14. Effect of season of burn on topkill (A) and complete kill (B) of oaks in sandhills over the fourth treatment cycle. Means, confidence intervals, and curves are as described in Fig. 1 legend.

Differences in oak kill related to:

- ✓ Ambient air temp differences?
- ✓ Live fuel moisture?
- ✓ Live:dead fuel ratio?
- ✓ Weather factors?
- ✓ Physiological status of oaks?
- ✓ Fire behavior not accounted for in study?

Effects of Fire Regime and Habitat on Tree Dynamics in North Florida Longleaf Pine Savannas. 1995. Glitzenstein, J.S., W.J. Platt, and D.R. Streng. Ecological Monographs, Vol. 65 (4), 441-476.

Season of Burn and Sweetgum



Season of Burn and Sweetgum Results

No Acute Starvation:

- Mortality not related to carbon deficit
- NSC was not different

No Chronic Starvation:

- Burned trees replenished NSC by end of growing season
- Root mass increased in fire treatments

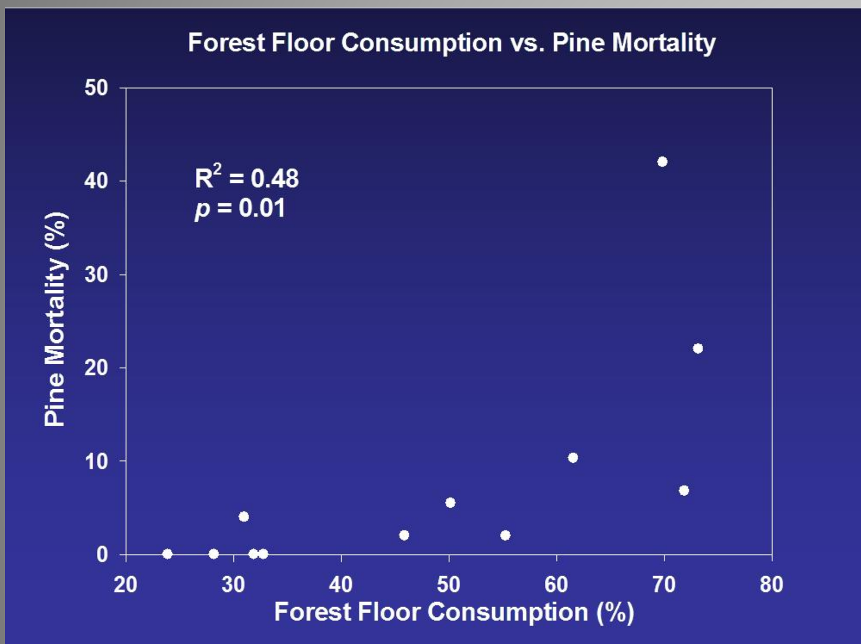
Top-killing impacts trees regardless of season:

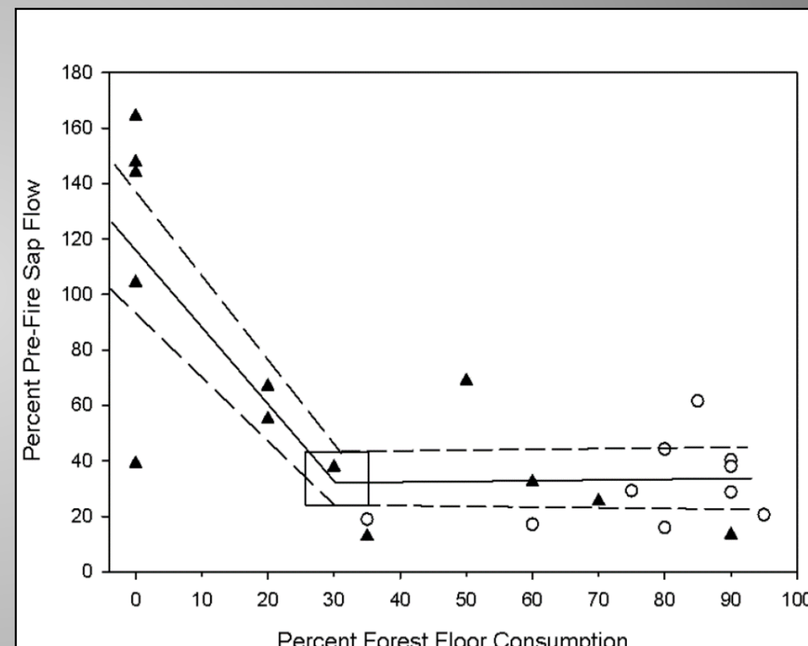
- Unburned trees has 2× biomass and stem diameters

Cold temperatures could kill resprouting dormant stems:

- season × damage interactions

Duff Consumption and Southern Pine Mortality





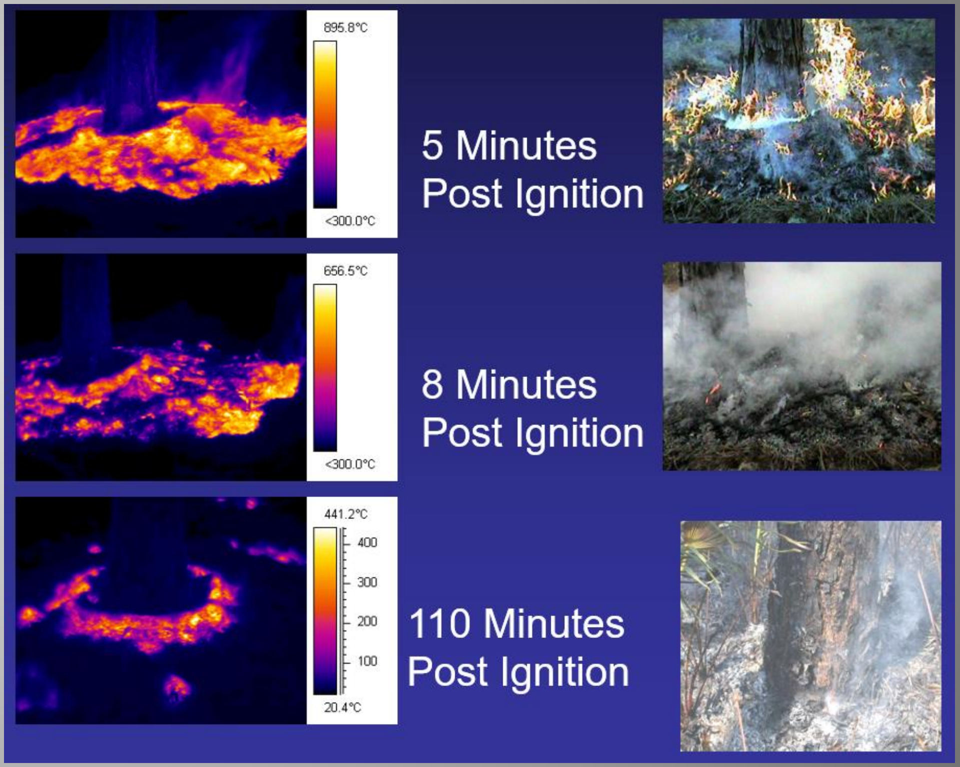
40% duff consumption breakpoint for increased pine mortality (Varner et al. 2009. *Forest Ecology and Management*)

31.3% duff consumption breakpoint for significant decrease in % pre-fire sap flow (O'Brien et al. 2010. *Fire Ecology*)

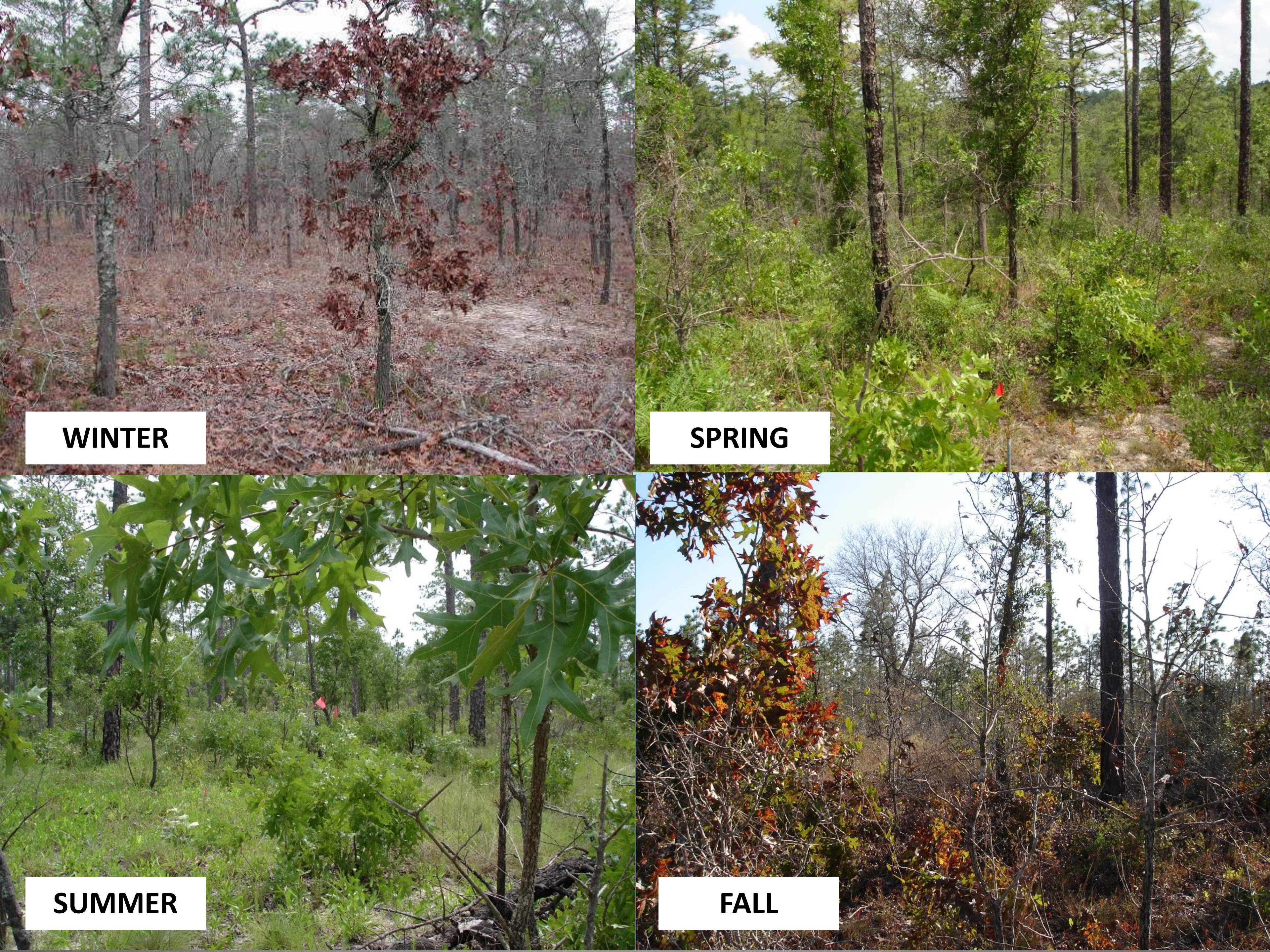
Rule of Thumb: > 40% duff consumption = increased pine mortality

Duff Consumption and Southern Pine Mortality

- **<u>Rules of Thumb for Safe Burning with Duff:</u>**
- **Low ET conditions (winter) :**
- 0.5” to 1.0” rain event >12 hour duration
- **High ET conditions (spring/summer):**
- 1.0” to 1.5” rain event > 12 hour period
- **Dry conditions:**
- extreme rain events may not be enough



Which is a Better Burn Day?


WINTER
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Synergy of Rx Parameters

- Parameter interaction can’t be ignored!
  - Predicted low RH but only 2 days since rain
  - Max temp for dormant season burning
  - Cloudy day following a few warm sunny days in pine
- Little science to relate time since rain to burn conditions
- Is the fire accomplishing the desired goals?
  - Decentralize the go/no go decision point

Take Home Messages

- Precisionism all too common in S.M.A.R.T. objectives and prescriptions!
- Tools cannot relate weather, fuels and fire behavior
- Get to know your fuels and how their moisture varies daily, weekly, and seasonally by species
- The time it takes for a fuel to dry is dependent on arrangement and loading
- Solar radiation significantly influences drying rates
- Once a fuel dries out, it is resistant to gaining fuel moisture from increases in humidity alone
- <u>Appendix B Fuel Moisture tables</u> don’t adequately account for effects of precipitation nor solar radiation and may be more useful as an index within one burn period.

Take Home Messages

- Season of burn had minimal impact on sweetgum physiology – Every Day is a Burn Day
- Timing doesn’t matter but top killing does
- Large “fireproof” stems subsidize smaller ones with root grafts
- Fire effects are dose dependent – fire energy is the dose

Applications

- Plumes and cloud cover can rapidly alter FDFM and fire behavior
- Solar drying of surface fuels create the largest difference in FDFM prediction in the morning and late PM.
- Sun exposure drives FDFM at fine scales in the SE
- On high RH days, fuel moistures can be ½ of predicted “empirical values”
- “gravimetric” measurement techniques cannot capture solar driven FDFM unless done in the field

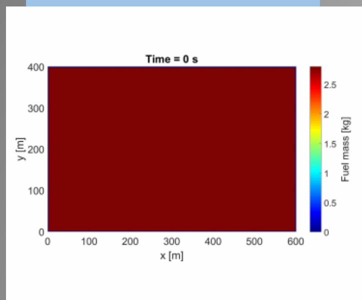
The Power is in Your Hands!

Prescribed Fire Planning Evolution

- Need better planning tools to inform decisions!
  - Fuel Types
    - A homogeneous fuel bed doesn’t cut it
    - What time lag class is a pine cone?
      - Flame length vs involvement
  - Fuel Moisture
    - 10 fuel stick
    - Solar Radiation/Sun Angle
    - Fuel Orientation
- Smoke models tailored to ignition patterns
- Realistic fire behavior models that inform fire effects

Fire Behavior Modeling: QUICFire

5%



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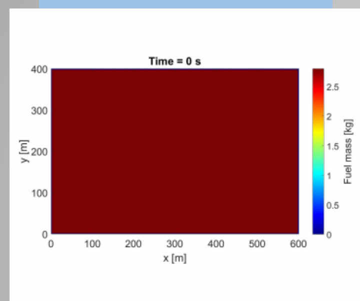
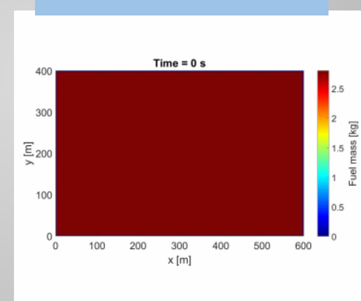
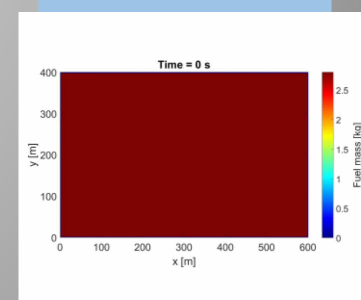


25%



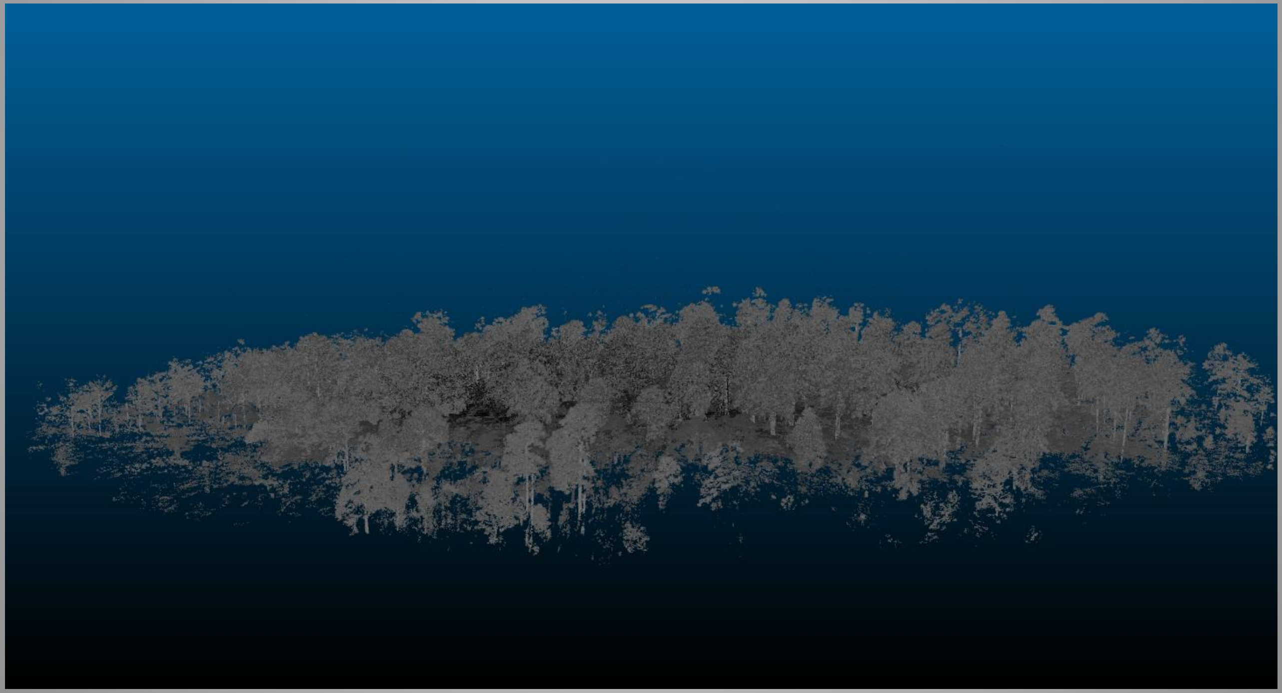
35%



Wind 13.5 MPH

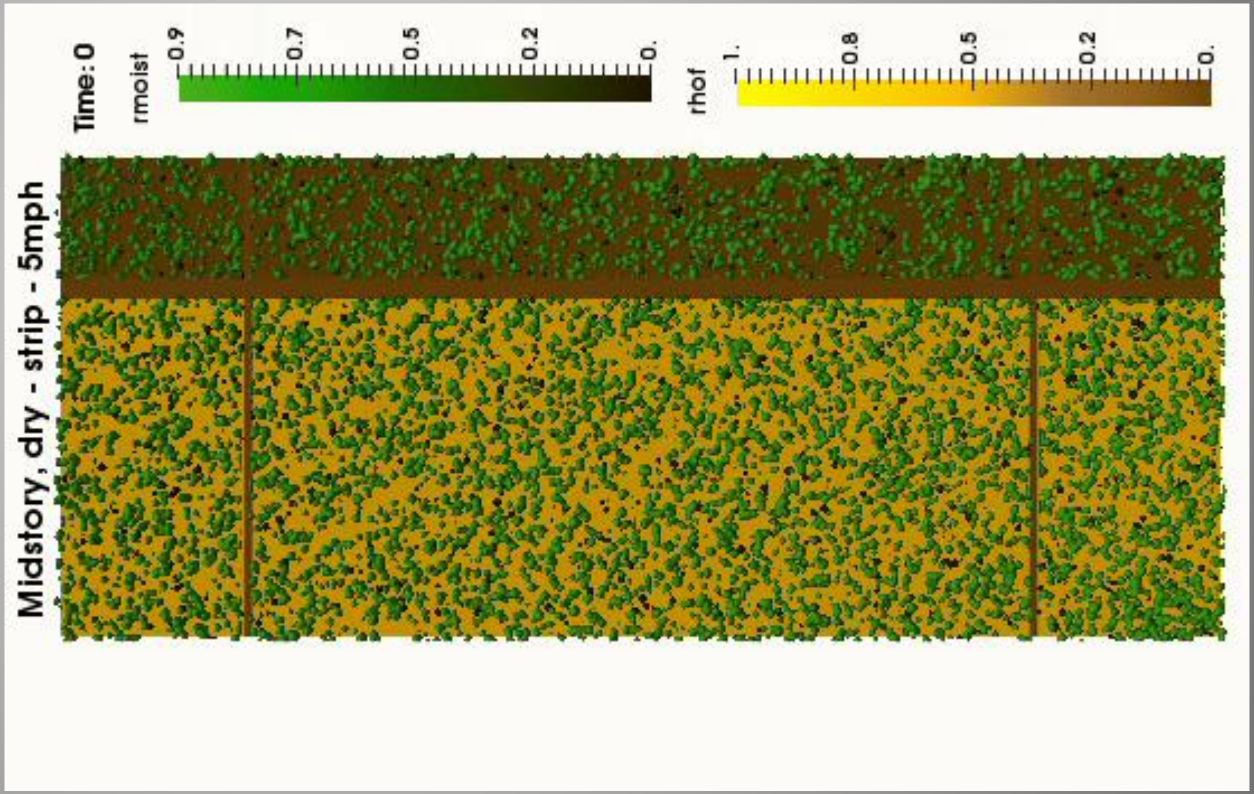
% Fuel moisture and affect on fire spread

LIDAR Derived Fuels



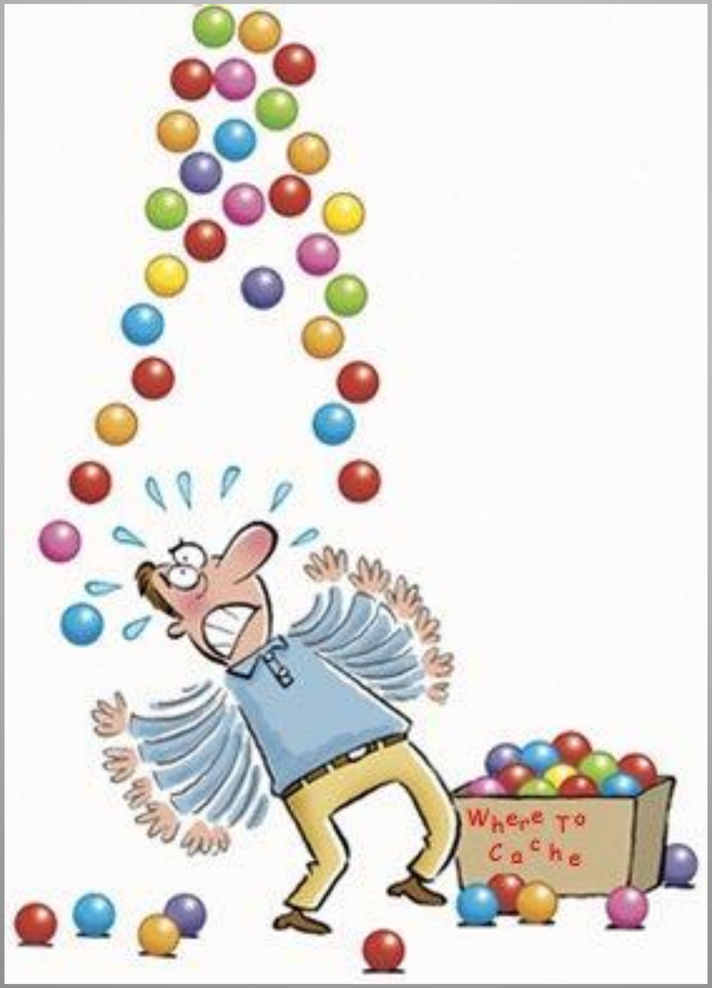
Next Generation Modeling Tools

- Fire Behavior Modeling continues to be dominated by 1970s science
- CFD tools like FIRETEC and WFDS have not had operational investment for use in prescribed fire



Burn Prioritization Model

The Burn Boss




Thank you.
Questions?