Understanding duff fires and pine mortality

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Collaborators and Funding

Collaborators:

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Eamon Engber & Lenya Quinn-Davidson, Humboldt State University Fire Lab
Bob Mitchell, Jones Research Center at Ichauway
James Furman & Brett Williams, Eglin AFB
Steve Coates & Andy Rappe, Ordway-Swisher Biological Station
Roger Ottmar & Bob Vihnanek, Pacific Wildland Fire Sci. Lab (Seattle)
Many at **Eglin AFB** and **Ft. Gordon** (GA)
The Nature Conservancy of Florida & Georgia

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UF UNIVERSITY of FLORIDA

Contemporary Longleaf Pinelands

Restoring Fire to Long-Unburned *Pinus palustris* Ecosystems: Novel Fire Effects and Consequences for Long-Unburned Ecosystems

J. Morgan Varner, III,[1,2,3] Doria R. Gordon,[4,5] Francis E. Putz,[5] and J. Kevin Hiers[6]

Varner et al. 2005 *Restoration Ecology*

Fire exclusion across ½ of area
(Outcalt 2000)

Results of exclusion:

- ✓ Structural changes
- ✓ Compositional shifts
- ✓ Fauna extirpation
- ✓ Advent of forest floor

Reintroduction linked to:

- ✓ Heavy overstory mortality
- ✓ Long-duration soil heating
- ✓ Persistent noxious smoke

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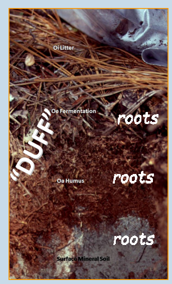
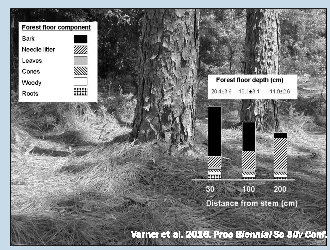
What changed?





Deep mounds, dominated by bark slough

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Management Conundrum:

How to reduce duff
while maintaining large, old pines

Retain large, old trees | **Reduce duff**

High survival = residual duff hazard | **Consume duff = high mortality**

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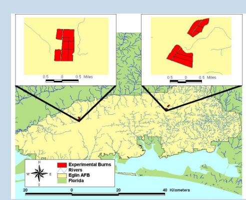
Operational scale Rx fire experiment:

Eglin Air Force Base, FL

4 treatments × 4 reps (>25 ac)
- No burn
- Wet duff (115% mc)
- Moist duff (85% mc)
- Dry duff (55% mc)



Injury surveyed within 3 wks
Mortality surveyed every 6 mo for 2 yrs

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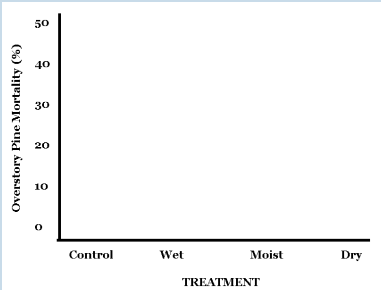
Post-fire pine mortality: Year 1



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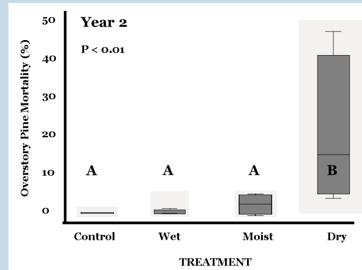
Post-fire pine mortality: Year 2



- Mortality **delayed** 18-24 months
- Mortality peaked in **dry** burns
- Mortality in unburned not different from moist & wet

Overstory tree mortality resulting from reintroducing fire to long-unburned longleaf pine forests: the importance of duff moisture

J. Morgan Varner III, J. Kevin Hiers, Roger D. Ottmar, Doria R. Gordon, Francis E. Putz, and Dale D. Wade

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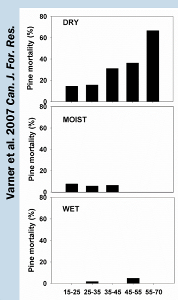
Which pines died?



- Dead DBH > Live DBH*
- Pines < 16” DBH= 19% mortality
- Pines > 16” DBH= **53% mortality**

- Crown scorch also important

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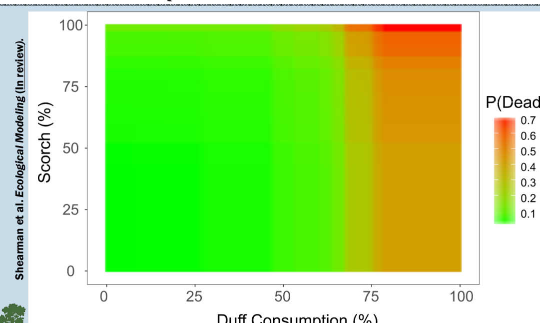
Which more important: *duff or scorch?*



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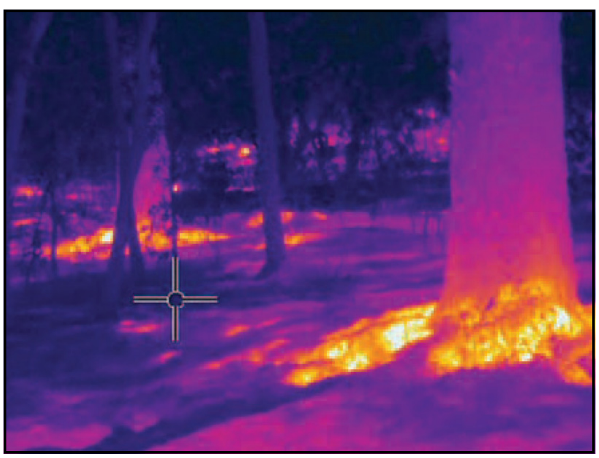
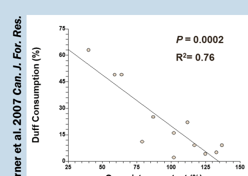


What drives duff consumption?



- **Lower duff moisture drives consumption.**

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What makes these pines die?

Ordway-Swisher Biological Station, FL

- Long-unburned (37 yrs)
- *Pinus palustris-Aristida-Quercus*
- Deep forest floor

Experiment: 4 treatments×20 trees

– "injury" treatments
  - ROOT
  - STEM
  - ROOT + STEM
  - CONTROL (×2)

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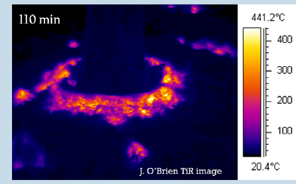
Patterns of heating during fires

25% of all burns recorded lethal temperatures (<140F) at <u>8" depths</u>

At 4" deep, averaged 6 *minutes* of lethal heating



Durations of lethal heating (i.e. temperatures >60 °C) to basal bark, duff, and mineral soil during individual tree burns at the Ordway-Swisher Biological Station in northern Florida, USA.

Treatment[a]	Duration of temperatures >60 °C (min)				
	Basal bark	Basal duff	5 cm soil	10 cm soil	20 cm soil
STEM ($n=6$)	44.3 ± 77.1	42.9 ± 47.3	7.9 ± 14.1	7.3 ± 17.9	–
ROOT ($n=6$)	10.1 ± 7.0	145.6 ± 283.7	41.0 ± 90.5	4.6 ± 9.9	0.7 ± 0.8
ROOT + STEM ($n=6$)	82.2 ± 121.8	95.7 ± 187.3	56.1 ± 122.2	12.8 ± 20.9	2.1 ± 4.8
CONTROL ($n=6$)	9.4 ± 2.6	10.6 ± 24.6	2.7 ± 5.9	1.4 ± 3.5	0.2 ± 0.5
Means	36.5 ± 73.9	73.7 ± 168.8	26.9 ± 74.8	6.5 ± 14.4	0.8 ± 2.5

Contents lists available at ScienceDirect
Forest Ecology and Management
journal homepage: www.elsevier.com/locate/foreco

Post-fire tree stress and growth following smoldering duff fires

J. Morgan Varner[a,*], Francis E. Putz[b], Joseph J. O'Brien[c], J. Kevin Hiers[d], Robert J. Mitchell[d], Doria R. Gordon[b,e]

Varner et al. 2009 Forest Ecol & Management

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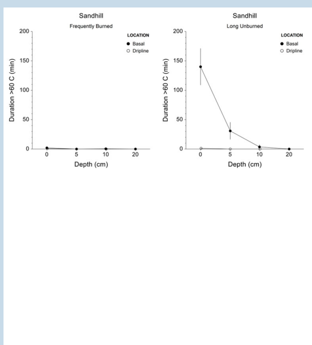
Heating during fires: what about flatwoods?

Sandhills:

~2 minutes of lethal heating at 4"

Flatwoods:

~**6 HOURS** of lethal heating at 4"



Kreye et al. Forest Science (In review)

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Trees get stressed via root injury

Varner et al. 2009 Forest Ecol. & Mgmt

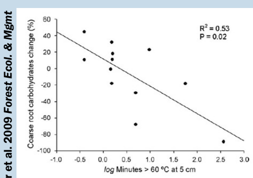
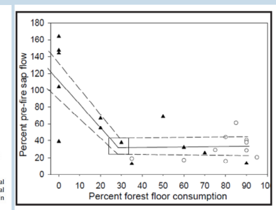


Fig. 3. Relationship between the change (2003–2004) in coarse root non-structural carbohydrates (sugar + starch) in mature *Pinus palustris* and duration of lethal heating (temperatures >60 °C) at 5 cm below the surface of the mineral soil in experimental fires in northern Florida, USA.



O'Brien et al. 2010 Fire Ecology

Pines sensitive to duff consumption & soil heating

- ✓Declines in root starch
- ✓Reductions in sap flow
- ✓Reductions in leaf N
- ✓Reductions in latewood growth

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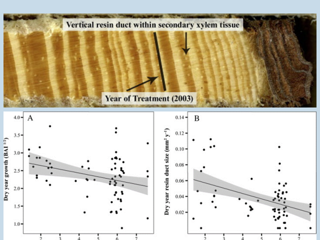
Stress endures for a decade

Slack et al. 2016 Forest Ecol. & Mgmt



Pines had reduced resin defense

Pines had slower growth during droughts as many as <u>10 years</u> post-burn

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How to manage duff consumption?

Duff consumption a function of MOISTURE, but…

Utility of an Instantaneous Moisture Meter for Duff Moisture Prediction in Long-Unburned Longleaf Pine Forests

Eamon A. Engber, J. Morgan Varner, Christopher J. Dugaw, Lenya N. Quinn-Davidson, and J. Kevin Hiers

Pine cones facilitate ignition of forest floor duff

Jesse K. Kreye, J. Morgan Varner, Christopher J. Dugaw, Jing Cao, Jonathan Szecsei, and Eamon A. Engber

NRC Research Press ARTICLE

Spatial and temporal variability of forest floor duff characteristics in long-unburned *Pinus palustris* forests

Jesse K. Kreye, J. Morgan Varner, and Christopher J. Dugaw

- ✓ **Burning following rainfall**
- ✓ **Small and large scale approaches**
- ✓ **"Peeling the onion"**

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- **Advent of forest floor is a major threat**
- **Duff-fire caused mortality a serious issue**
  - Pine stress & mortality
- **Duff consumption is key**
  - Linked to moisture
- **Much to learn…**

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What are the patterns in large pine mortality?

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