Using fire to restore shortleaf pine (*Pinus echinata*) ecosystems severely impacted by southern pine beetle (*Dendroctonus frontalis*)

Oral presentation to Berry College, Rome, GA
April 2007

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Presentation Outline

- Background
  - Fire History
  - Coweeta's fire studies

- Restoration of shortleaf pine

  (Pinus echinata)

Was fire important in the history of the southern Appalachians?

- Native American history
- Early explorers
- Paleoecology
- Fire scars
- Plant & ecosystem traits

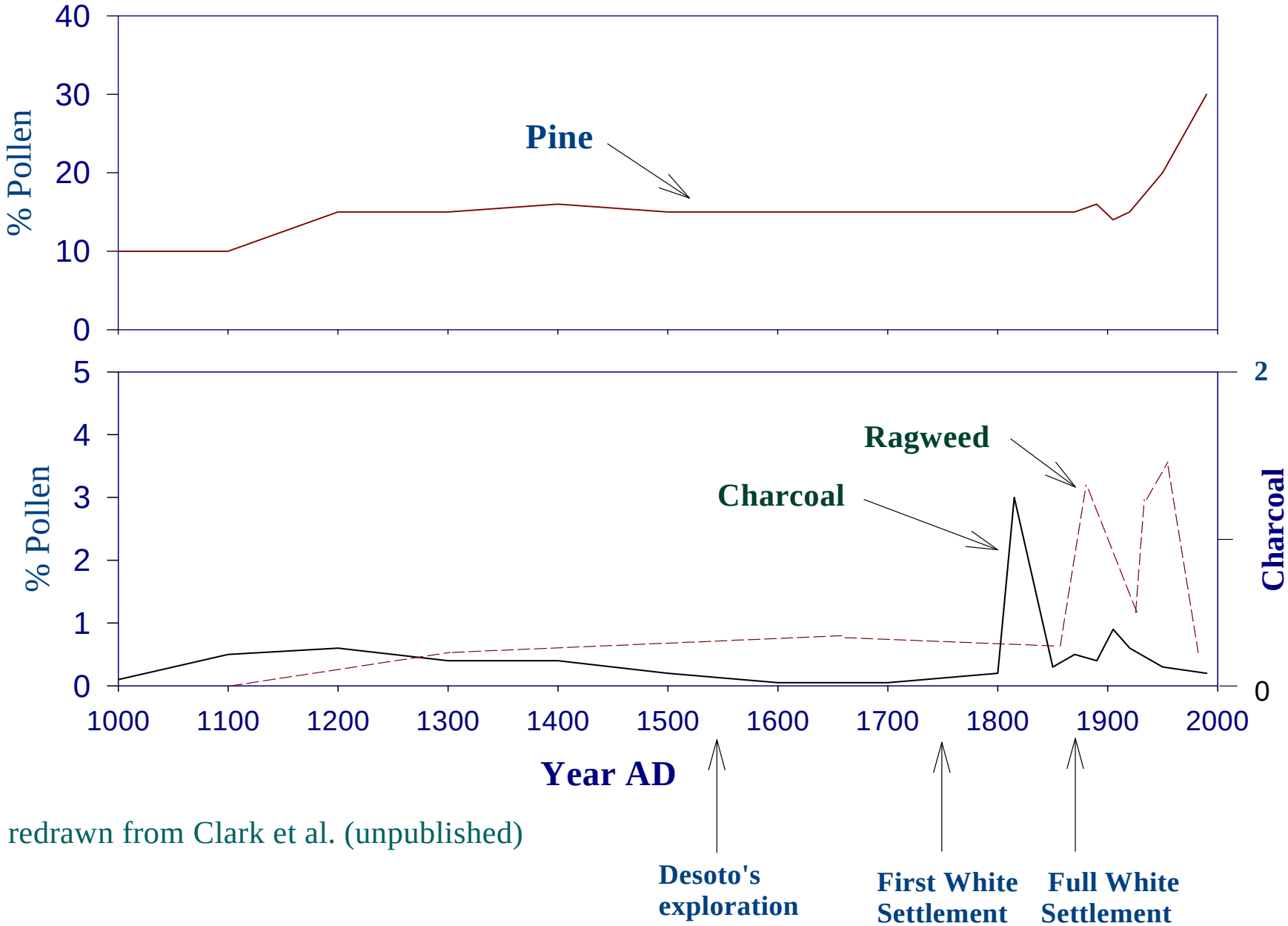
Native American History

"… in those days they said the mountains were like a park. Yeah. You could walk up in the mountains and there were huge trees everywhere and there was grass even in between the trees and not that much brush. And so it was like a walking park, you know, and now if you go up there there's just a lot of brush, a lot of different kinds of things." Cherokee elder (Cooley 2004, MS Thesis)

"Now, now that's the way the old people [built] a fire and they set fire all, all over .. in April. And sometimes in May when there ain't too much wind.." Cherokee elder (Cooley 2004)

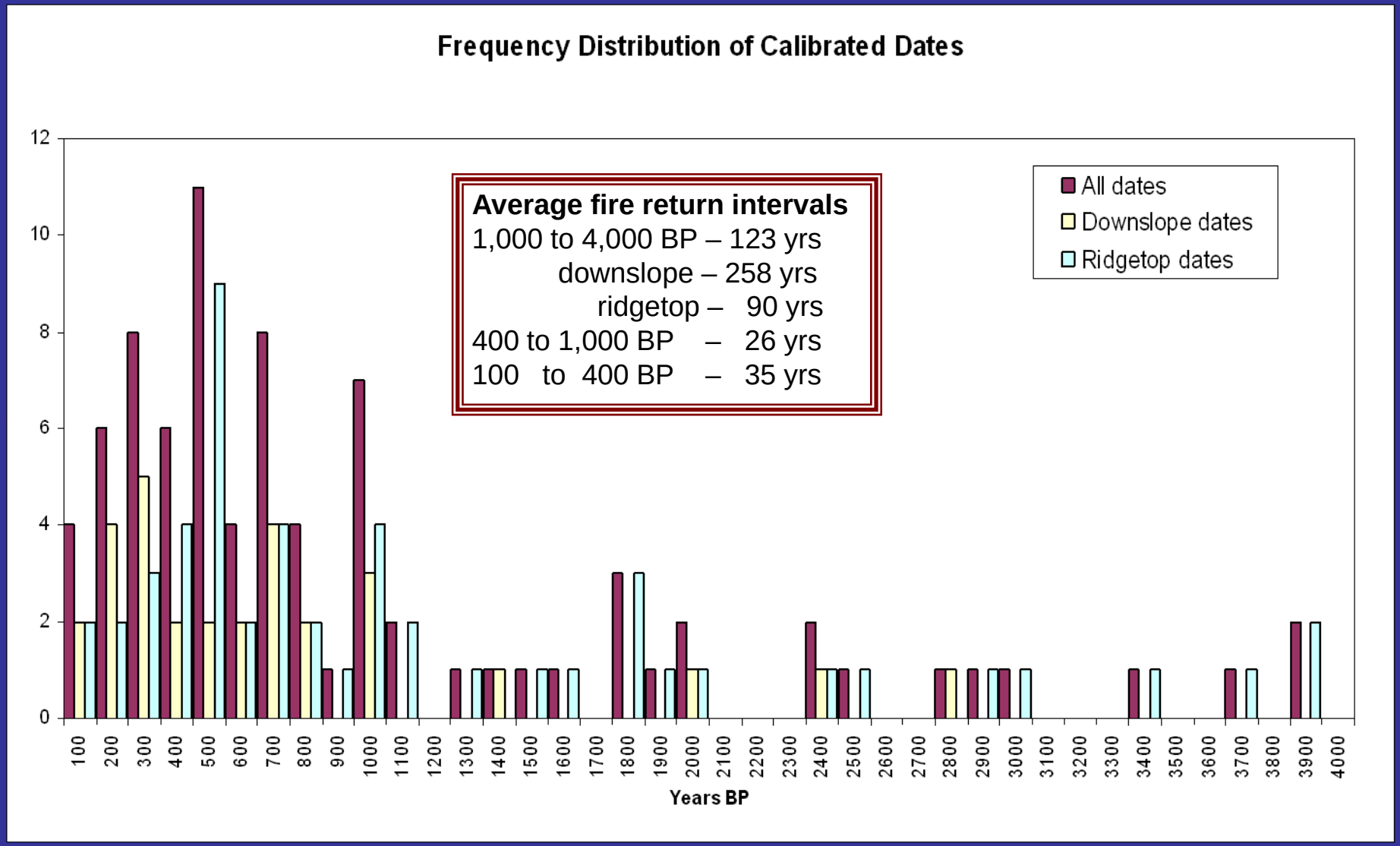
Early explorer's accounts

- William Bartram's journey through the Little Tennessee River valley of Georgia and North Carolina in the 1770s
- Andrew Ellicott's similar route in 1812
- Robert Love's survey of Macon and Swain counties, North Carolina in 1820



redrawn from Clark et al. (unpublished)

Soil charcoal and carbon dating



"Fire History Among Southern Appalachian Forest Types." Norman L. Christensen, Principal Investigator

Post-logging and land clearing slash fires expose mineral soil

"….in 1908…86% of the acreage in the southern Appalachians was cleared…."

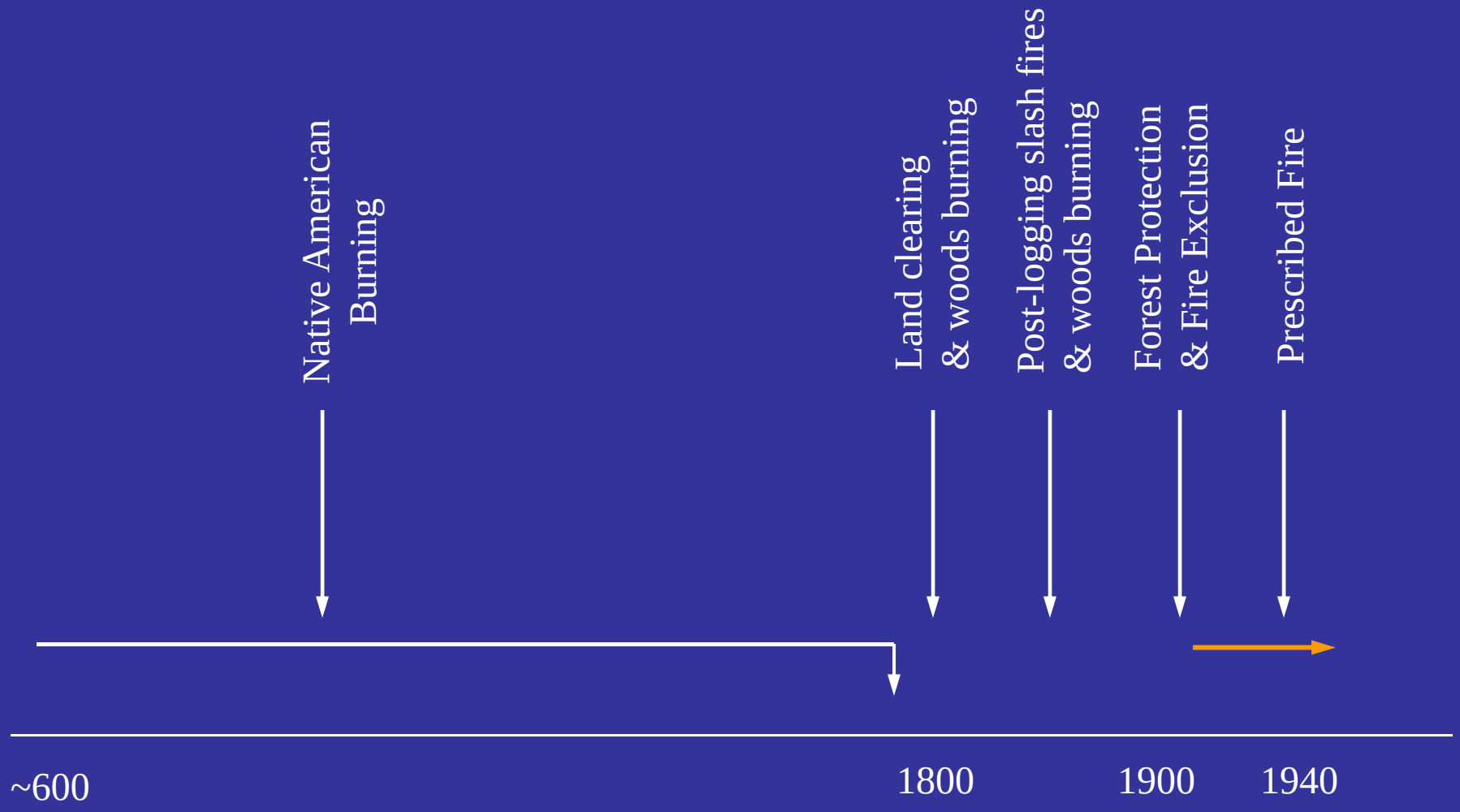
"….practically all of it, whether cut or not had been burned….."

U.S. Secretary of State, Wilson

Plant & Ecosystem Traits

- Serotinous cones
- Sprouting
- Thick bark
- Buried seed dormancy
- Basal meristems
- Flammability (pyrogenic)
- Nutrient conservation

Wildland fire



HUMAN FIRE REGIME TIMELINE

(see Brose et al. 2001)

Ecological Consequences of Fire Exclusion

- Changes in species composition
- Changes in nutrient pool sizes and cycling rates - productivity
- Increased probability of severe and intense disturbances

Changes in species composition

- **Loss of fire dependent (or enhanced) species**
  - e.g., pitch pine, table mountain pine, oaks
- **Expansion of fire sensitive species**
  - e.g., white pine, red maple

Nutrient Pools and Cycling

- Decrease in biological fixation
- Decrease in N-cycling rates
- Shift in the amount and distribution of nutrients among pools
  - re-calcitrant shrub layer

Increased Probability of Severe & Intense Disturbance

- Fuel build-up
- Fuel ladders
- Interactions with insects & disease

  southern pine beetle

Coweeta Fire Studies

- **Fire History** (Clark and Lynch 2002, Jurgelski 2003, Cooley 2004, Gragson 2005, Christensen 2006)

- **Xeric mixed pine/hardwood** (5 CJFR 1993; 22 others) pitch pine, hardwoods; mountain laurel understory

- **Dry mixed pine/hardwood** (Hubbard et al. 2004; Elliott and Vose 2005a, 2005b, Clinton and Vose 2006) shortleaf pine, Virginia pine, hardwoods; white pine understory

- **Mesic, mixed-hardwoods** (Elliott et al. 2004, Clinton et al. 1998) mixed hardwoods, herbaceous understory

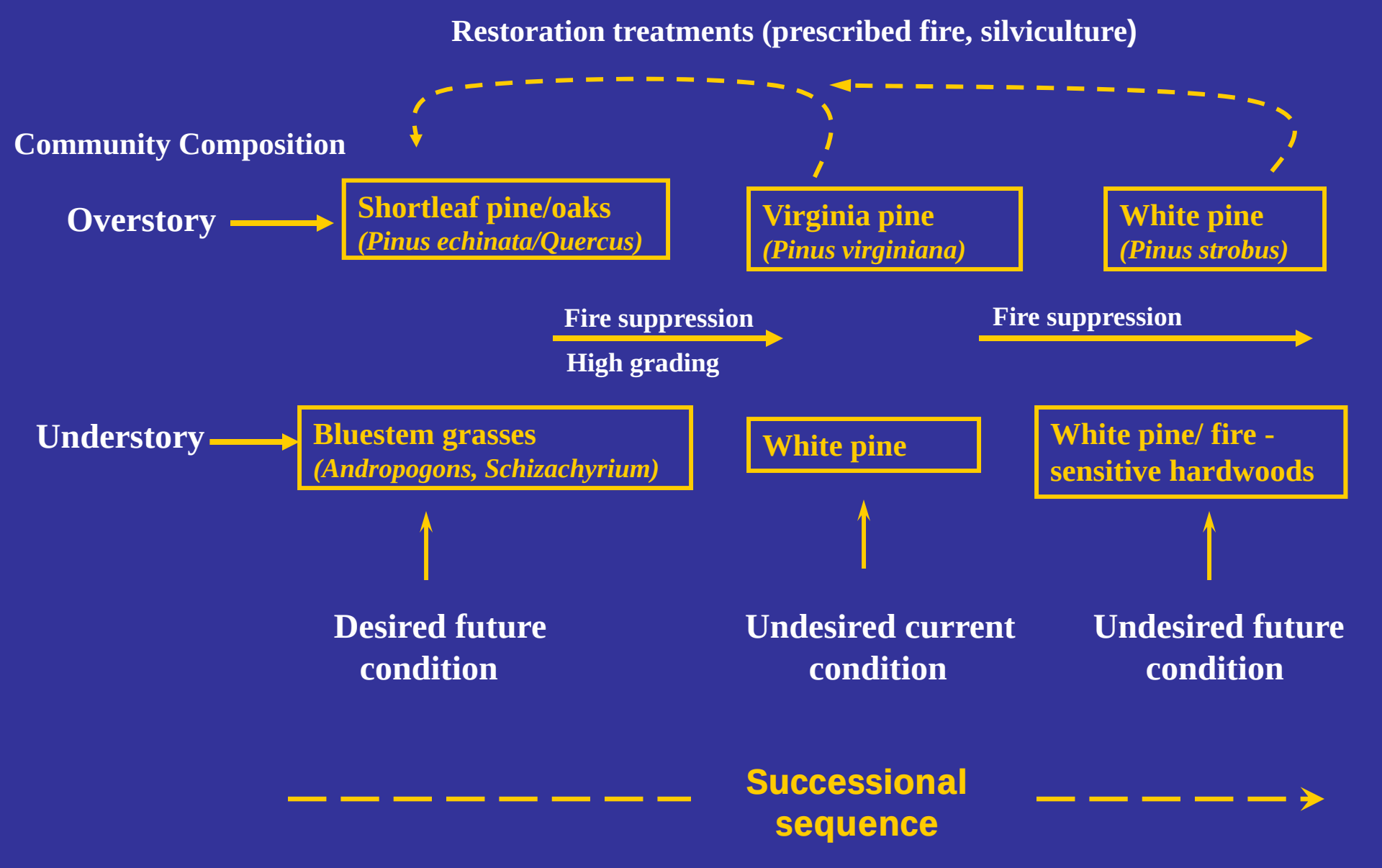
- **Mesic, mixed-oak** (in progress JFSP)

  Quercus (rubra, prinus, alba); herbaceous understory

Summary of responses

Parameter	Response	References
Diversity	+	Elliott et al. 1999, 2004, 2005
Nitrogen cycling	+	Knoepp & Swank 1993, 1995; Vose et al. 1999; Knoepp et al. 2004
Water quality	0	Clinton et al. 2003, Vose et al. 2005; Elliott & Vose 2005
Erosion	0	Vose et al. 2005, Elliott & Vose 2005
Small mammals & insects	+/0	Ford et al. 1999, Crossley et al 1999, Love et al. 2007

Conceptual Model of Forest Succession & Management Options in the Upper Conasauga River Basin



Problem

- In the southern Appalachians and Cumberland Plateau, over one million acres (with a timber value loss of 1.5 billion dollars) have been impacted by the most recent southern pine beetle (SPB) (*Dendroctonus frontalis*) outbreak from 1999-2003

Objectives

1. to compare fuel load reduction methods in pine/hardwood forests heavily impacted by southern pine beetle induced tree mortality
   - overstory felling →material left on site → Rx fire
   - Rx fire only
   - no treatment
2. to evaluate the effects of further restoration treatments including planting shortleaf pine and seeding native grasses on ecosystem structure and function

All sites had standing dead and down trees due to the SPB

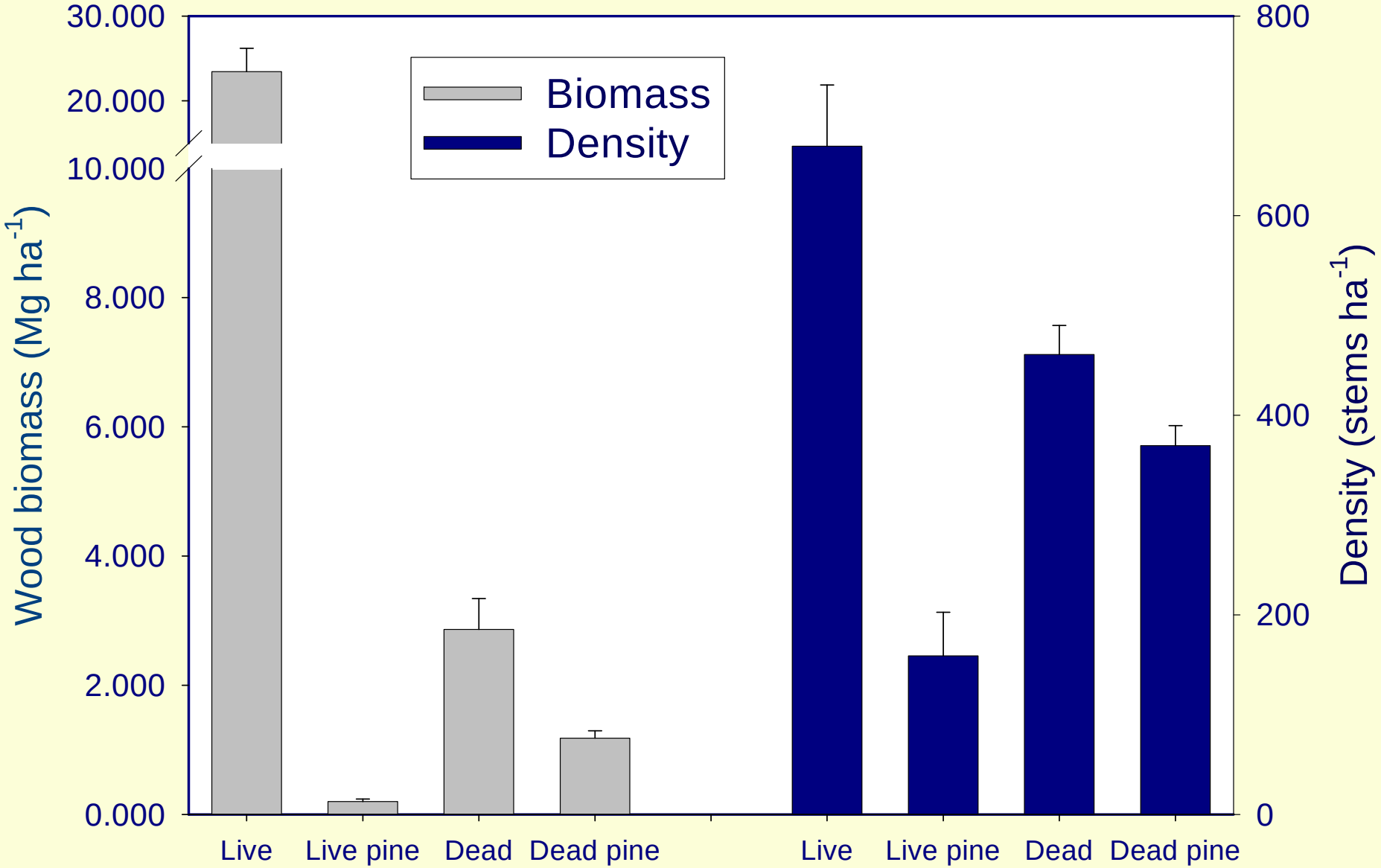


Fig. 1. Pre-treatment (2005) aboveground biomass and density of live and dead trees (branch + bole). Biomass was estimated from species specific allometric equations.

A cut + burn site after cutting

Sampling Methods

Forest floor sample

In situ soil nitrogen mineralization

Vegetation (herbs, shrubs & trees)

Diameter (dbh) of shortleaf pine (20 m x 20 m plot)

Coarse wood & fuel load

Soil solution lysimeter

Prescribed fires were hand-lit March 2006

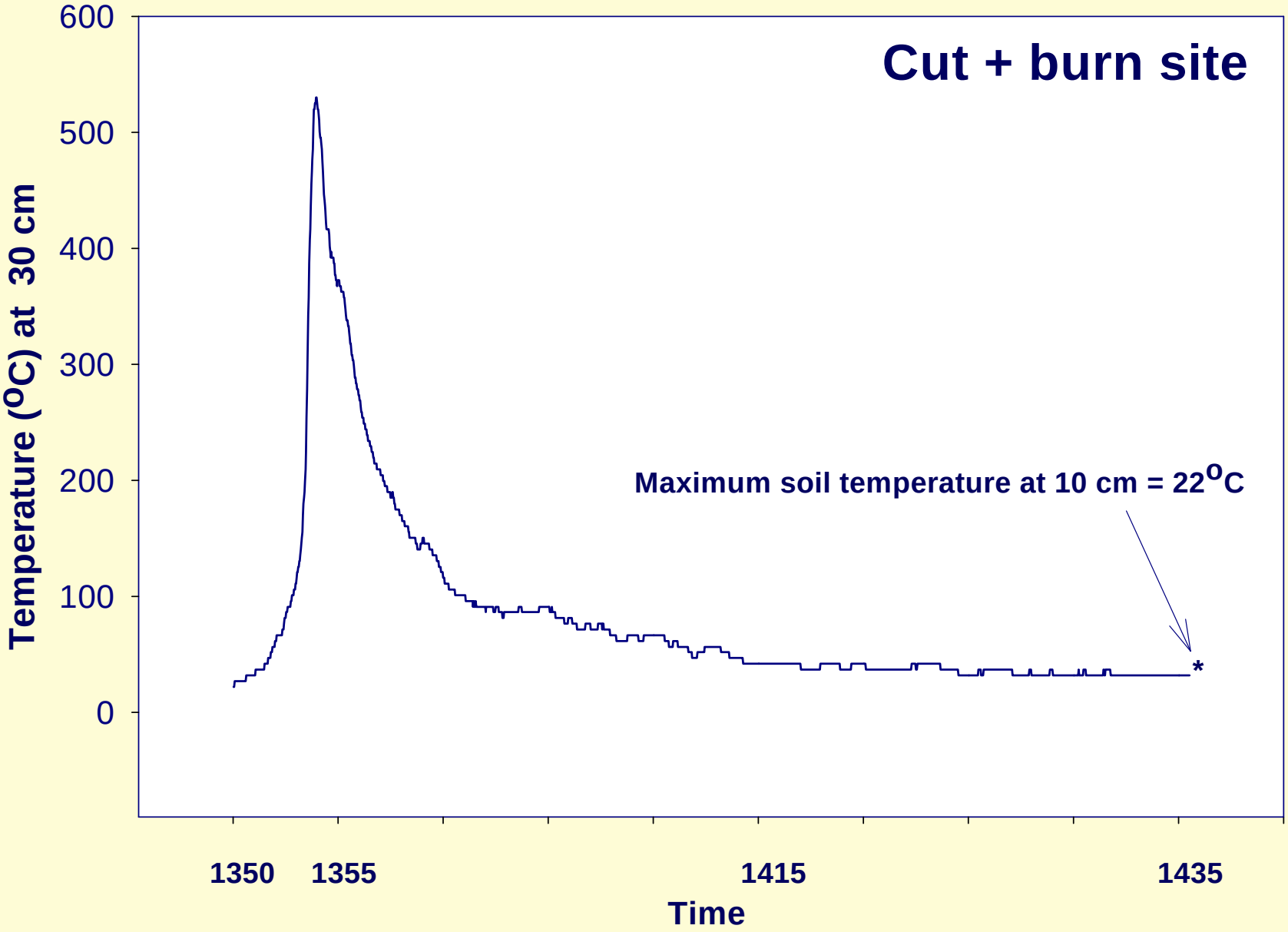


Fig. 2. Flame temperature response curve.

High intensity, moderate severity fire

Consumption of fine fuels (small wood < 7.5 cm diameter, and forest floor litter layer)

Burn only site -- smoldering at base of tree leads to input of large wood to forest floor

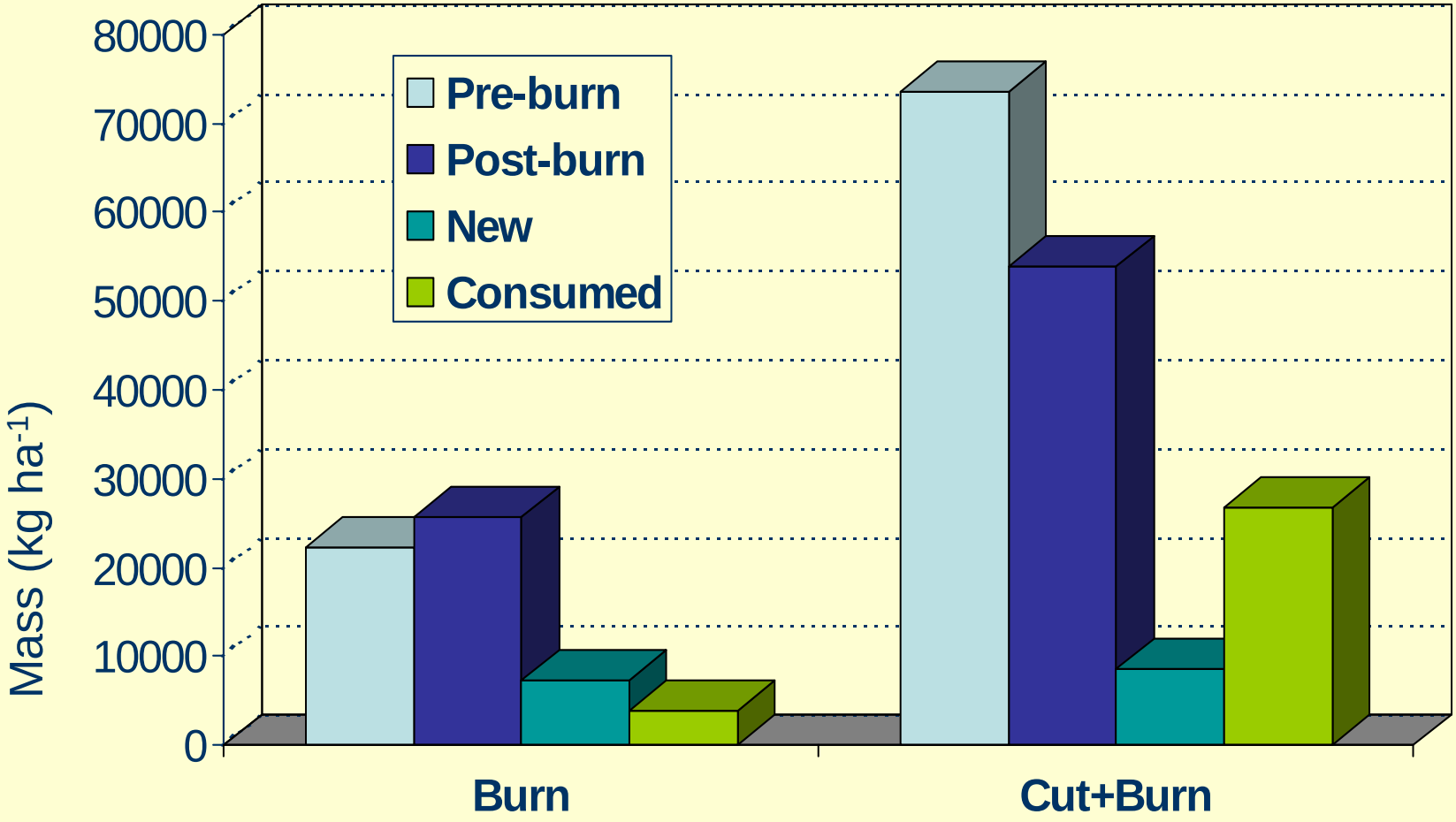
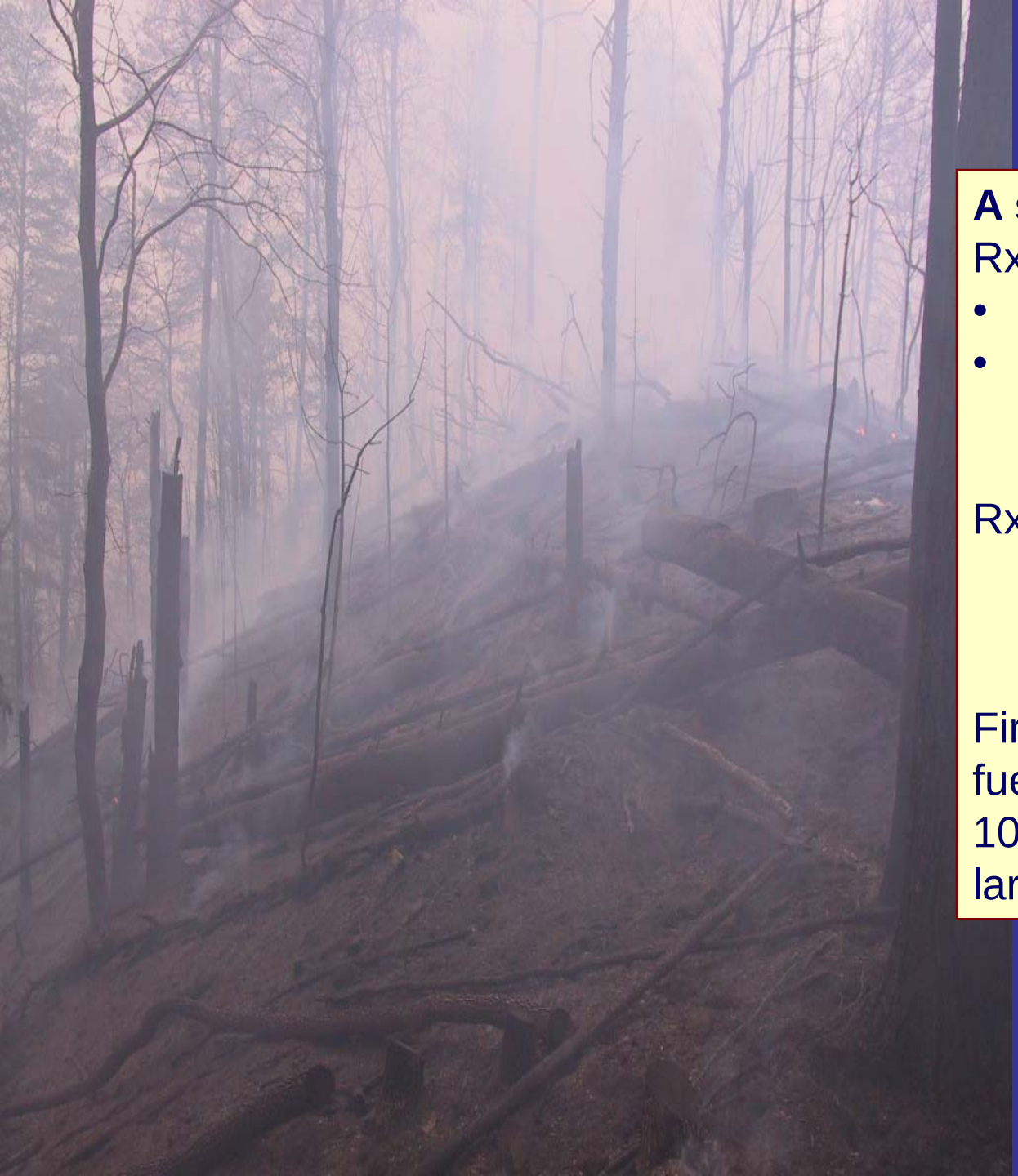


Fig. 3. Down fuel load (≥7.5 cm diameter) and consumption.



A site preparation burn

Rx Ignition hand-lit

- backing fire along ridges,
- head fire from the lower slopes

Rx result - high intensity
short duration
moderate severity

Fires consumed nearly all fine fuels (litter and small wood [1-100 hr]) and 23-31% of the larger fuels (1000 hr)

Results

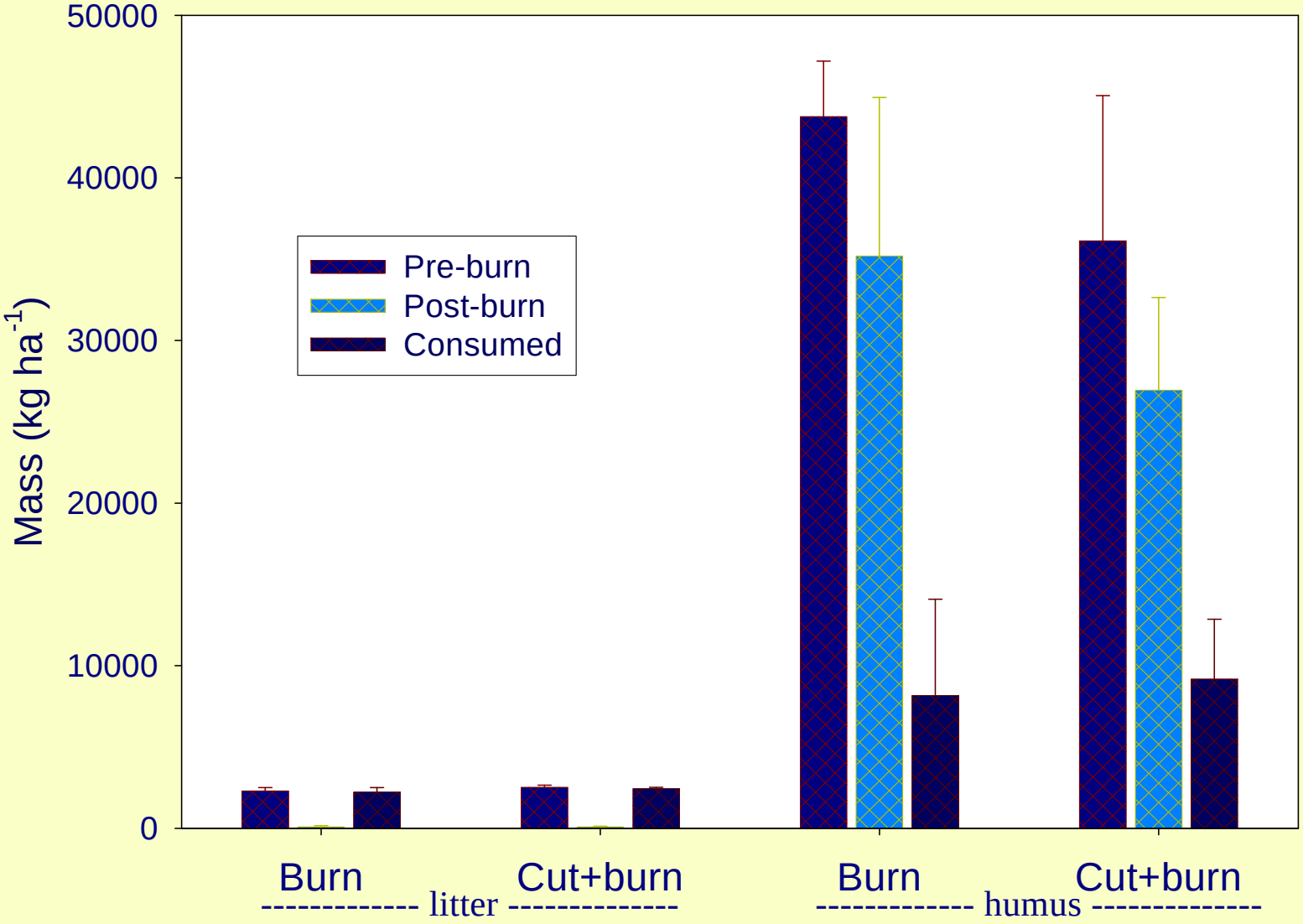


Fig. 4. Forest floor litter (Oi) and humus (Oe+Oa) mass pre- and post-burn.

Table 1. Understory woody species richness (number of species per plot), density (stems ha^{-1}), and basal area (m^2 ha^{-1}) for the prescribed burn treatments

	Richness		Density		Basal area	
Treatment	Pre	Post	Pre	Post	Pre	Post
Burn	6.4	6.5	16,500	32,250 a	2.78	1.87
	(0.9)	(0.7)	(3466)	(5870)	(0.65)	(0.43)
Cut + burn	8.6	7.4	27,375	33,875 ab	4.99	2.04
	(1.0)	(0.7)	(4160)	(4480)	(0.79)	(0.30)
Reference	7.6	8.5	12,450	14,550 b	1.94	2.56
	(0.9)	(0.7)	(2330)	(2757)	(0.42)	(0.64)

Woody stems < 5.0 cm dbh, >0.5 m height. Standard errors are in parentheses.

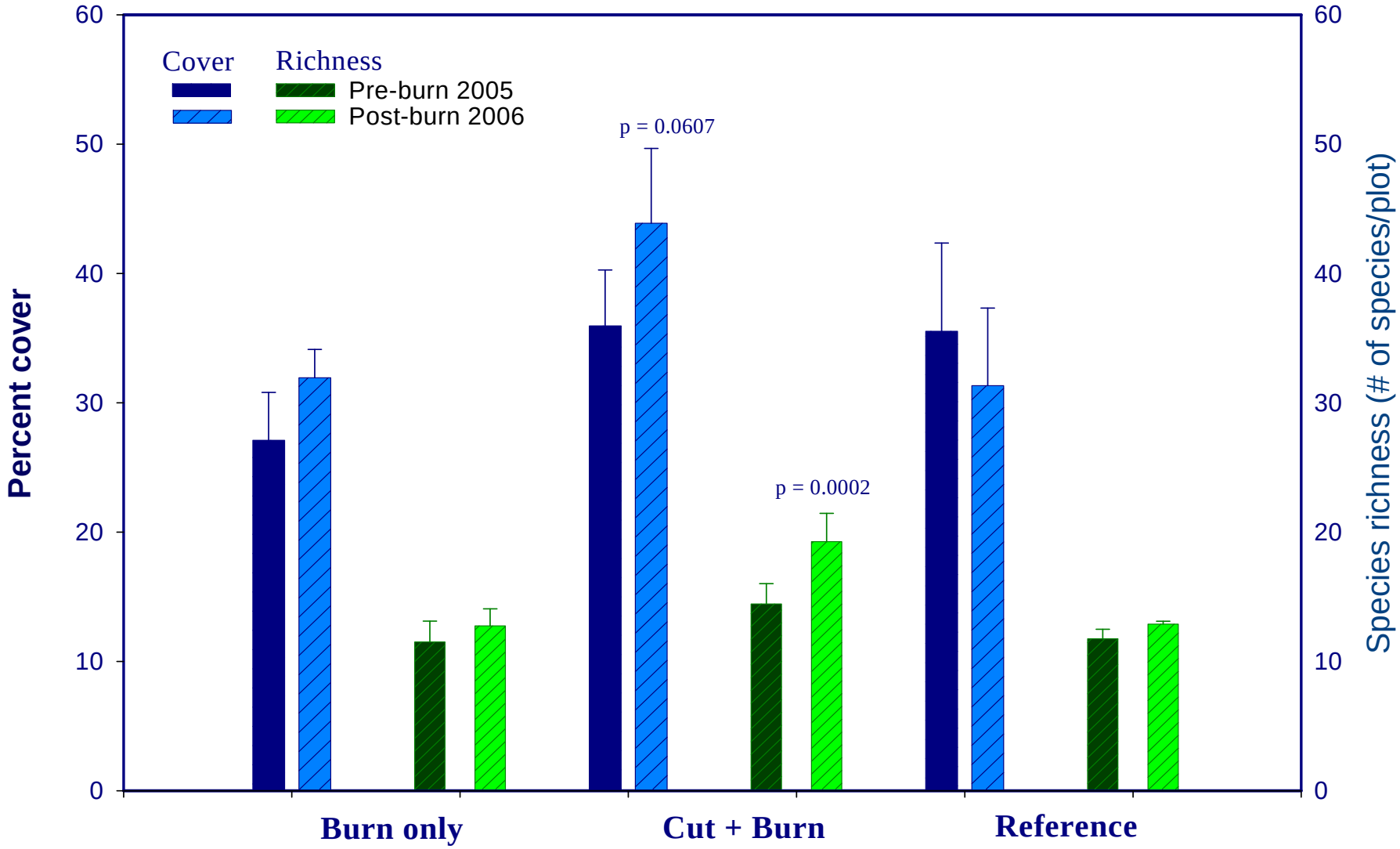


Fig. 5. Percent cover and species richness of herbaceous layer species before and the first growing season after the prescribed fires at Ocoee, TN. Significant differences were evaluated by repeated measures anaysis of variance (Proc Mixed, SAS 2002).

Summary

- Before the prescribed fires, all sites had a large amount of dead wood (Fig 1) due to tree mortality from the southern pine beetle.
- Even though fire intensity was high (Fig 2, flame temperature), fire duration was short resulting in moderate severity burns.
- In the burn only treatment, the fire burned the base of standing dead trees, which contributed large wood mass to the forest floor. More new wood was contributed to down material than consumed (Fig 3).
- The cut+burn treatment reduced down wood mass (Fig 3).

Summary (cont.)

- The forest floor litter layer was consumed, but a large proportion of the humus layer remained intact (Fig 4).
- Understory wood density was high before the treatments due to increased number of saplings following the pine mortality. Density increased again after treatments (Table 1).
- Herbaceous layer percent cover and species richness increased after the cut+burn treatment, but no significant change with burn only (Fig 5).
- **We are continuing sampling and analyses to evaluate changes in vegetation composition and diversity, carbon and nitrogen pools, soil and soil water chemistry, and success of planted pine and bluestem grasses.**

Acknowledgements

- Cherokee National Forest for conducting the prescribed burns.
- Field Staff: Patsy Clinton, Neal Muldoon, Chris Sobek, Jim Gruhala, Duane Foster
- Funding provided in part from Joint Fire Science Program, Co-PIs James M. Vose and Katherine J. Elliott.