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Functional morphology of shortleaf pine (Pinus echinata Mill) fire-adapted traits

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Introduction

- Shortleaf pine (SLP) is valued in the Southeast for lumber, plywood, and pulpwood production
- Frequent fire has led to the development of fire-adapted traits in SLP, specifically sprouting from the basal crook after top-kill (**figure 1a**) and thick bark (**figure 1b**)
- We aim to determine what fire-adapted traits are responsible for protecting SLP throughout its life, from seedling to mature tree

Objective

- To characterize SLP sprouting after top-kill and the increase of bark thickness in relation to stem size

Methods

- We top-killed SLP in the Ouachita National Forest (ONF), AR
- Diameter and bark thickness were measured along each stem at 0, 30, and 140 cm above the groundline
- Live/dead status for each stump was determined by the presence of sprouts one growing season following top-kill
- A logistic regression model with a logit link was developed to predict probability of survival (live/dead status) for a given stump as a function of diam.
- Diameter, age, and the interaction were used as predictors for bark thickness in a linear regression
- All analyses were conducted in R version 3.5.2 (Eggshell Igloo)

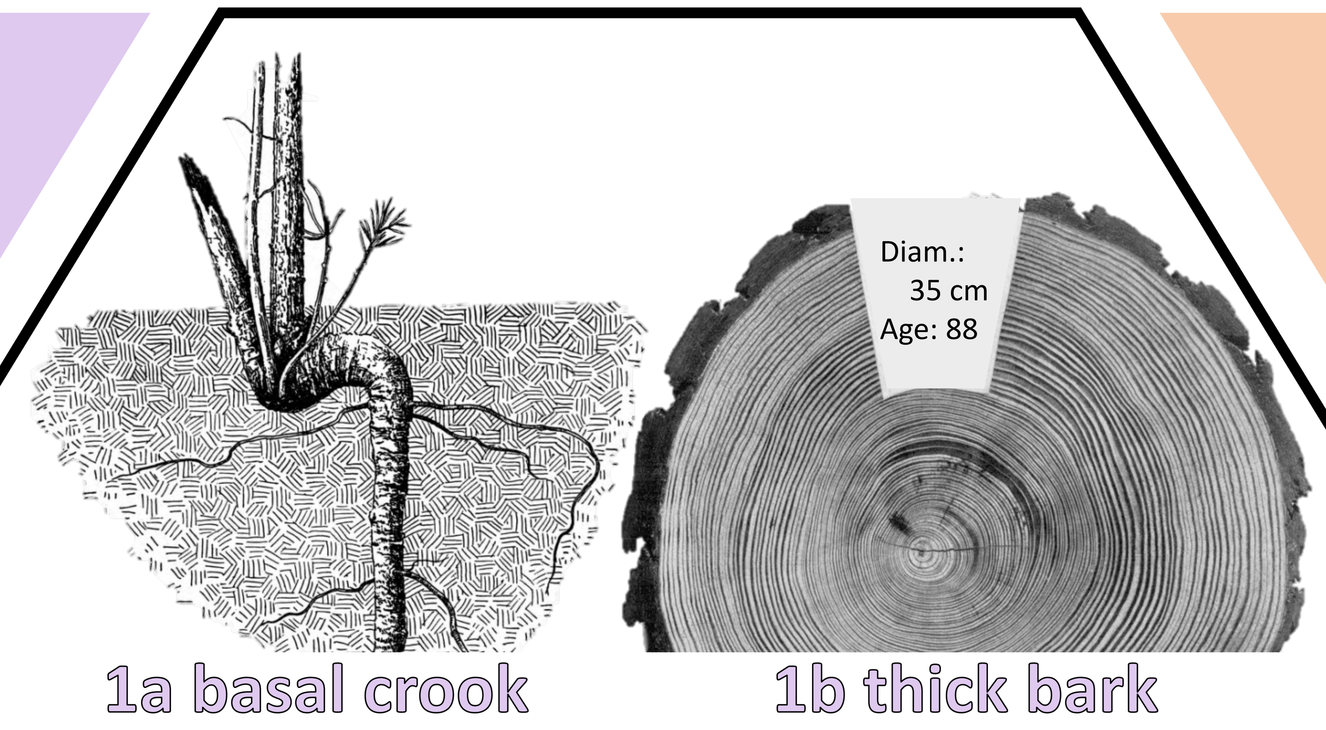

Figure 1. The basal crook (**1a**), a horizontal section of the stem, is insulated from fire in the soil, protecting auxiliary buds that can initiate sprouts after top-kill; the thick bark (**1b**) of shortleaf pine acts as a protective barrier for the cambium layer during a fire (Images: USDA FS)

Results

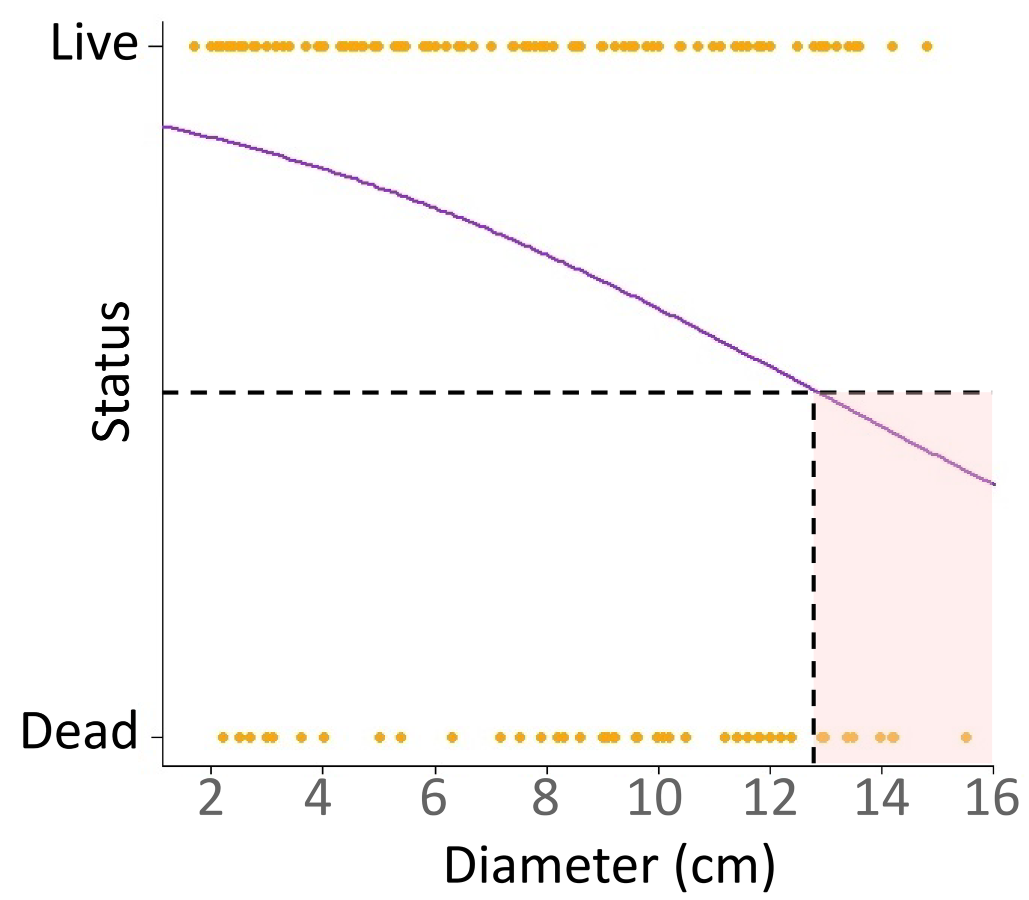

Figure 3. Probability of sprouting for a stump by diameter. Horizontal dashed line shows a 50% chance of survival after top-kill; right of vertical dashed line (in pink) shows the diameter when a stump is more likely to die after top-kill

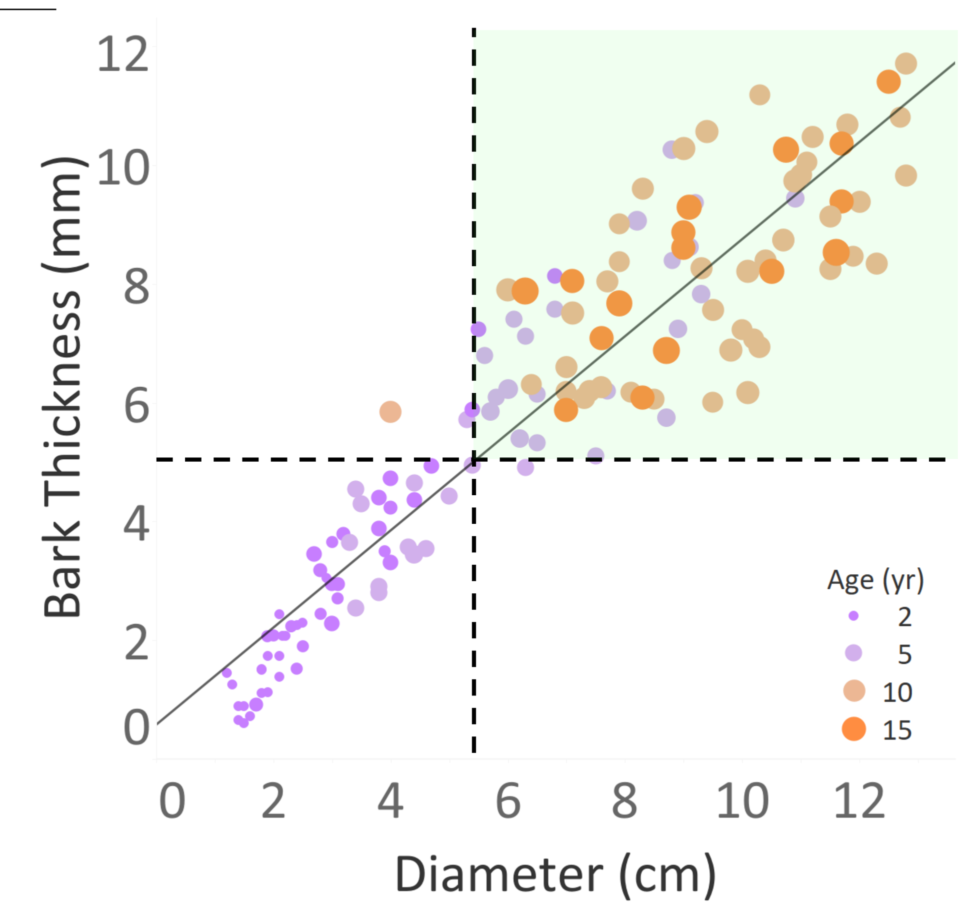

Figure 4. Diam. and age as predictors for bark thickness (BT). Horizontal dashed line shows the min. BT necessary to insulate cambium during fire[1]; right of vertical dashed line (in green) shows the diam. when a stump is more likely to survive fire

- Large trees are less likely to sprout (survive) after being top-killed (**figure 3**; $p = 0.005$)
- Age is not a significant predictor of stump survival (sprouting) following top-kill
- Diameter, age, and the interaction effect are all significant predictors for bark thickness (**figure 4**, $p < 0.001$)

Discussion

- We found the defense mechanism may depend on tree size: smaller trees sprouted after top-kill, while larger trees were less likely to survive (**figure 3**)
- Decreased survival of large top-killed trees may be the result of those trees having bark thick enough (> 5mm) to survive a low-intensity surface fire[1] and thus the larger trees are less likely to "rely" on sprouting to survive a fire (**figure 4**)
- We hypothesize that the larger trees did not sprout as readily because the thicker bark would have protected the cambium layer resulting in a decrease in the probability of mortality, ultimately demonstrating a shift in fire-defense mechanisms throughout the life of the shortleaf pine

Future Directions

- Examine morphology of the basal crook and determine how sprouting is affected as the tree grows larger and the prominence of the basal crook decreases
- Compare shortleaf pine response to top-kill in two distinct locations within the range of shortleaf pine with different fire regimes
- Determine non-structural carbohydrates in different portions of the tree (roots, basal crook, stem) across a range of stem sizes

References

[1] Harmon ME (1984). Ecology 65:796–802.

Acknowledgments

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