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THE JONES CENTER AT ICHAUWAY
Natural Resource Research & Management

Windfirmness of *Pinus elliottii (slash pine)*: Measuring effects of soil moisture using static winching

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Introduction

Large scale wind disturbance effects on slash pine forests in the Southeastern US are one of the primary causes of natural timber loss. Relative to studies of tree adaptation to other types of disturbance, very little is known about wind resistance of southern pine species. More specifically, there are no published studies of the effect of soil moisture on pine windfirmness. We measured the wind resistance of 60 *Pinus elliottii (*slash pine*)* across a gradient of soil moisture to determine whether soil moisture reduces critical turning moment for individual trees.

We hypothesize that:

1. Windfirmness increases with tree size.
2. Windfirmness decreases with soil moisture.
3. Probability of uprooting increases (relative to trunk breakage) with soil moisture.

Methods

Wetting

To simulate rainfall associated with a large storm, approximately 500 gallons of water are applied within the dripline of the target tree the afternoon before winching to create a moisture gradient in the soils. Soil samples are collected just before winching of each tree. Samples are weighed, dried, and weighed again to determine their moisture content at the time of winching.

We separate trees into three classes based on soil moisture content (dry, moderate, wet). We determine classes based on soil moisture ranges (3.9-6.3% dry) (6.4-9.0% moderate) (9.01-12.4% wet).

Winching

An illustration of the setup for static winching is shown in **Figure 1** below.

1. A winch is strapped to the base of the 'anchor tree' in two locations and connected to a pulley.
2. Another series of straps are secured from the pulley to a location below the lowest main limb on the 'target tree'.
3. A load cell is secured between the pulley and the target tree to record/transmit the force applied while winching.
4. Inclinometers are attached at two locations (base and near strap attachment) to record angles throughout the winching process.

The peak tension is determined after winching and matched with inclinometer readings at the corresponding time.

A multiple linear regression is run on our preliminary data to determine if there is an effect on turning moment based on soil moisture content and tree size.

Results

-Confirming other studies' results, windfirmness increases with tree size (P<0.001) (**Figure 2**).

-Contrary to our expectations, wetter soils are not significant related to windfirmness (p=0.47), but the interaction of moisture and tree size is significant (P=0.039)

-The size x moisture interaction suggests that trees on wetter soils are more windfirm, but the effect is limited to large trees. (**Figure 3**).

-Trees with higher soil moisture are more likely to uproot relative to drier soils, but fates in moderate soils are more unpredictable (**Figure 4**).

The picture above shows a target tree being winched to failure. This illustrates the straps attachment to the target tree (what we commonly refer to as strap height). The anchor tree is to the far back right in the picture (not clearly shown).
The picture below illustrates the winch's attachment to the anchor tree.

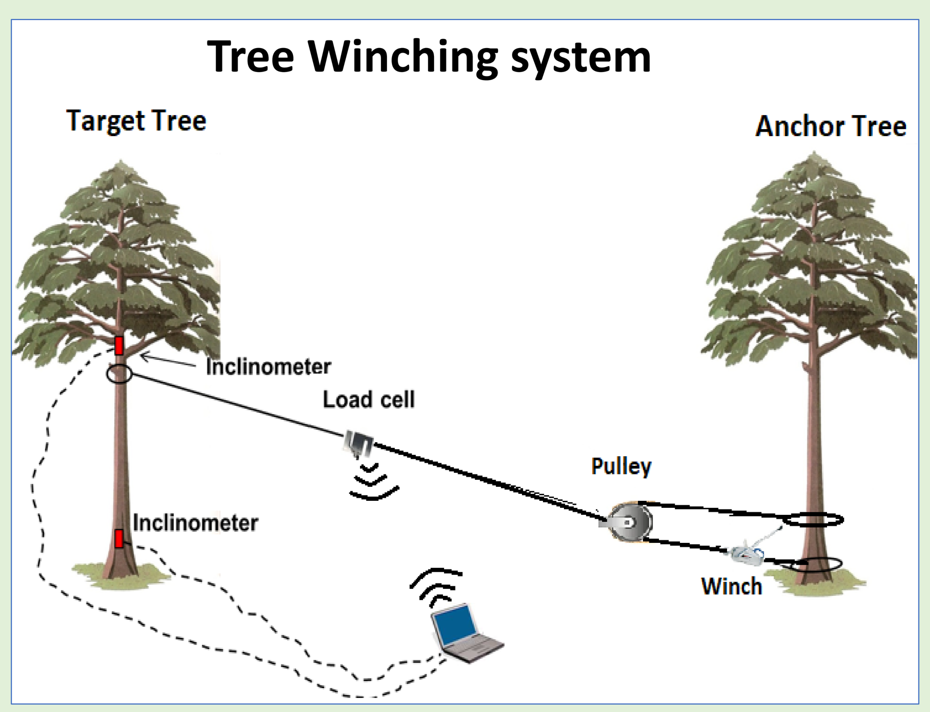

Figure 1: Visual representation of the winching setup we use to measure force to induce stem failure. Readings of measured force and the trees angle throughout winching are sent to a field laptop while the winch pulls the target tree from a measured distance away (from an anchor tree).

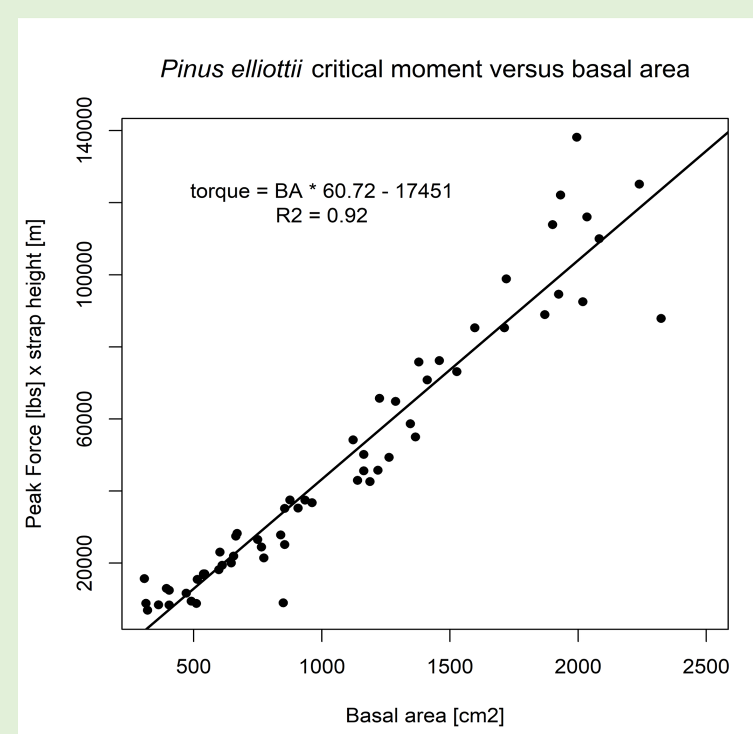

Figure 2: Torque necessary for tree failure increases with tree size (R2=0.92).

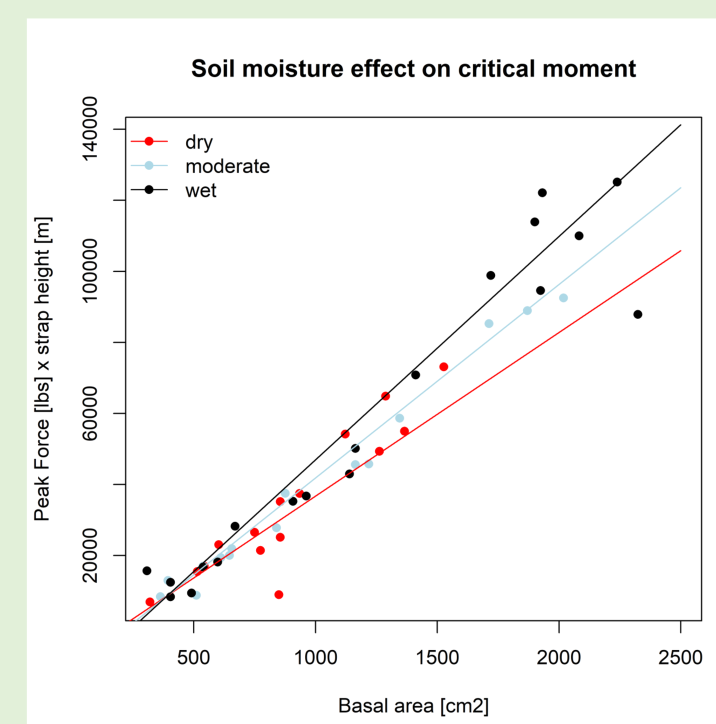

Figure 3: A linear regression is used to determine the separate and combined effects of tree size and soil moisture on the proxy for turning moment. The interaction between soil moisture and tree size is significant, but only in larger individuals.

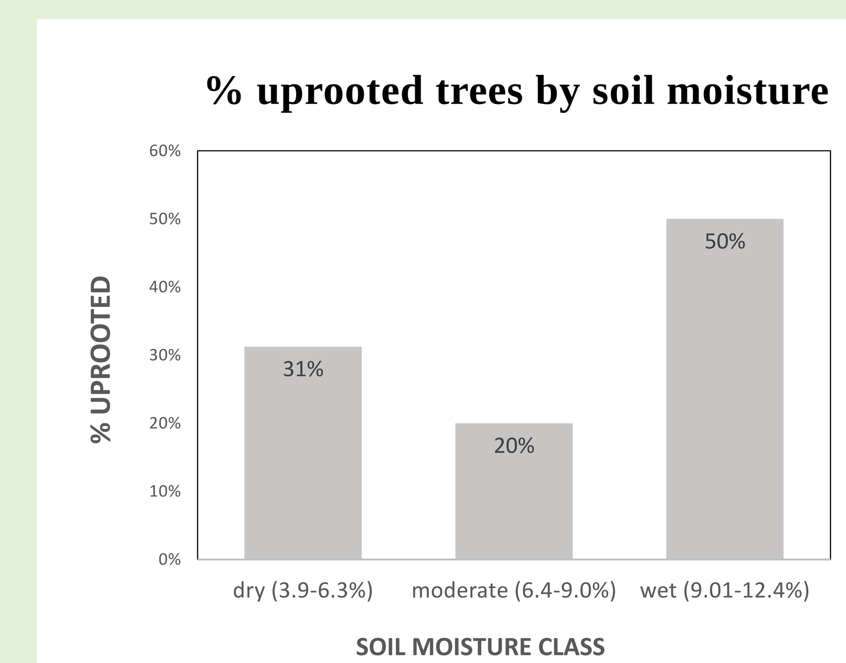

Figure 4: We separate trees into three classes based on soil moisture content (dry, moderate, wet). Classes are determined based on soil moisture ranges (3.9-6.3% dry) (6.4-9.0% moderate) (9.01-12.4% wet). The results are then plotted against the observed uprooting percentage.

This is a picture of a tree during a wetting treatment. A water tank is driven to the target tree and approximately 500 gallons are applied across the area within drip line of the tree. While we have delineated wetted/not wetted, trees are measured and sorted into classes based on the soil moisture at the time of winching.

The above picture illustrates a general idea of the strap's locations and angles from anchor tree to target tree.

Study Site

Our winched trees and soil are sampled across three research areas within the 12,000 ha property at the Jones Center at Ichauway in Baker County, GA (**Figure 5).** The three locations are illustrated with red stars.

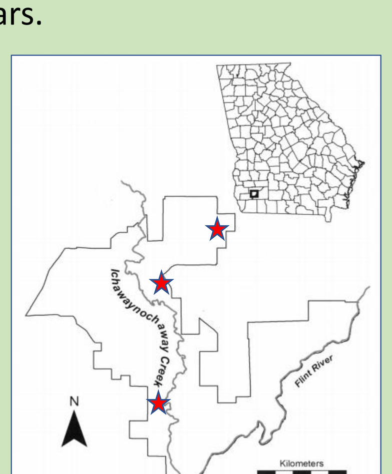

Figure 5: Our study site is The Jones Center at Ichauway: located in Southwest Georgia

Discussion

Windfirmness increases with basal area and is not significantly related to moisture, but there is a significant interaction between moisture and tree size which indicates that soil moisture increases windfirmness only in larger trees.

While there have been wind resistance studies in other species, little experimental work on windfirmness has been done to date on slash pine, and none focusing on moisture content as it relates to windfirmness. Further analysis on slash pine data available may reveal a stronger correlation between soil moisture and critical turning moment.

Future studies that incorporate multiple species and soil types will deepen our understanding of tree-soil interactions related to windfirmness.

Continuing work includes running the same winching experiment on longleaf pine (*Pinus palustris*) in Summer 2021 along with running analysis on soil particle size and their effects on the critical turning moment before stem failure.

This work will be helpful to both planted and natural pine stand owners and professionals in the SE United States when incorporated into wind risk models to predict damage or to mitigate potential loss.

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