Longleaf and Lasers:

Improving Models for Wind Susceptibility in the Coastal Plain

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Introduction

Forests in the coastal plain of the Southeastern United States are particularly vulnerable to wind damage from increasingly frequent and powerful hurricanes. Understanding factors influencing wind risk to forests can improve predictions of hurricane impacts on forest ecosystem dynamics, structure, and function at large spatial and temporal scales. Models of wind damage susceptibility rely on coarse assumptions about crown shape that may overestimate crown size and therefore wind risk. We use a terrestrial lidar system (TLS) to assess how assumptions about crown shape can impact estimation of wind risk. Additionally, we investigate how stand basal area may affect crown growth and estimations of crown dimensions.

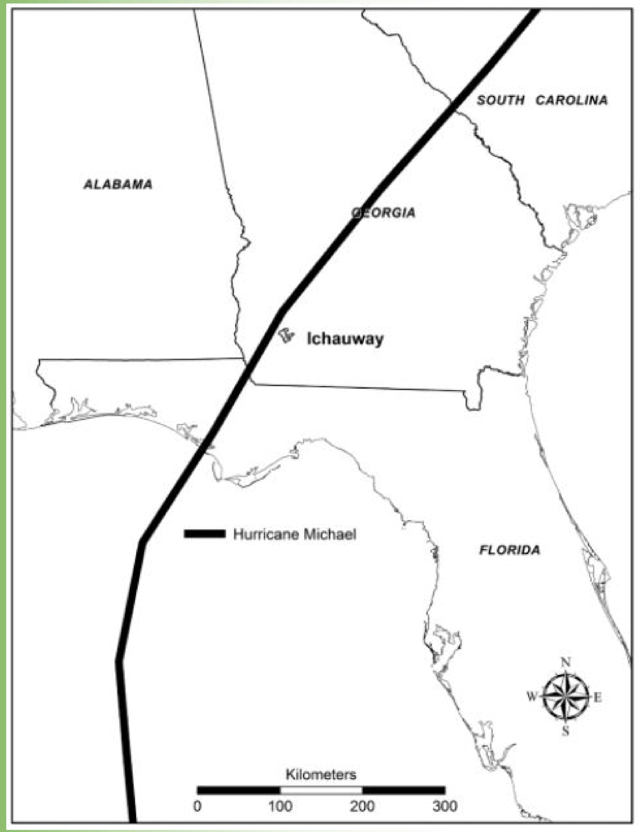


Fig 1 (Left): study location shown in Southwest Georgia along with Hurricane Michael path (B.T. Rutledge et al. 2020);
Fig 2 (Right): Tall Timbers' Hannah Redford and Riegl VZ series scanner collect data at Ichauway.

Methods

We used terrestrial lidar in second growth *Pinus palustris* stands with a range of ages and densities to analyze crown characteristics. Individual sample trees were selected from an existing forest inventory GIS to produce a stratified sample representative of forests at the study area. We calculated basal area index (m2/ha) within a neighborhood of 35m based on the tallest trees in the study (Table 1). We used R Package TreeLS to extract tree diameter and crown properties (Figure 3). Multiple linear regression was employed to test for a relationship between crown area with basal area and DBH . We compared crown area estimates using ellipse, diamond, convex polygon, concave polygon, and voxel methods to determine the benefit of more precise canopy estimates for input to wind models over simple geometries.

	Basal Area (m2/ha)						
DBH (cm)	**0-5**	**5-10**	**10-15**	**15-20**	**20-25**	**25-30**	
10-20	1	1	1	2	2	2	9
20-30	2	2	2	2	4	1	13
30-40	0	3	4	1	1	2	11
40-50	2	2	3	2	6	1	16
50-60	0	5	2	4	5	1	17
60-70	0	2	5	3	0	0	10
70-80	0	0	1	2	0	0	3
	5	15	18	16	18	7	**79**

Table 1: Sample trees were stratified to represent tree size and forest conditions at the site.

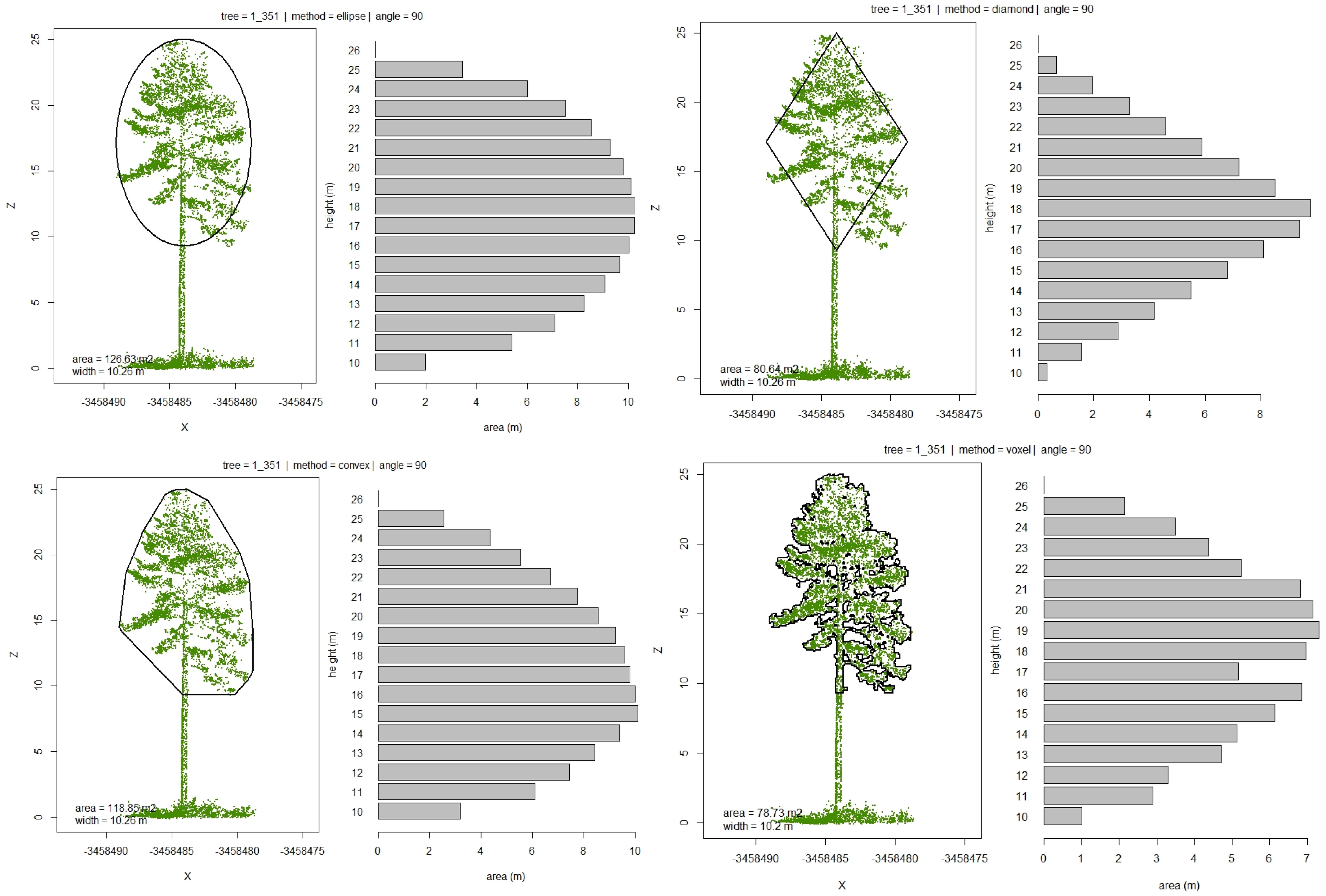
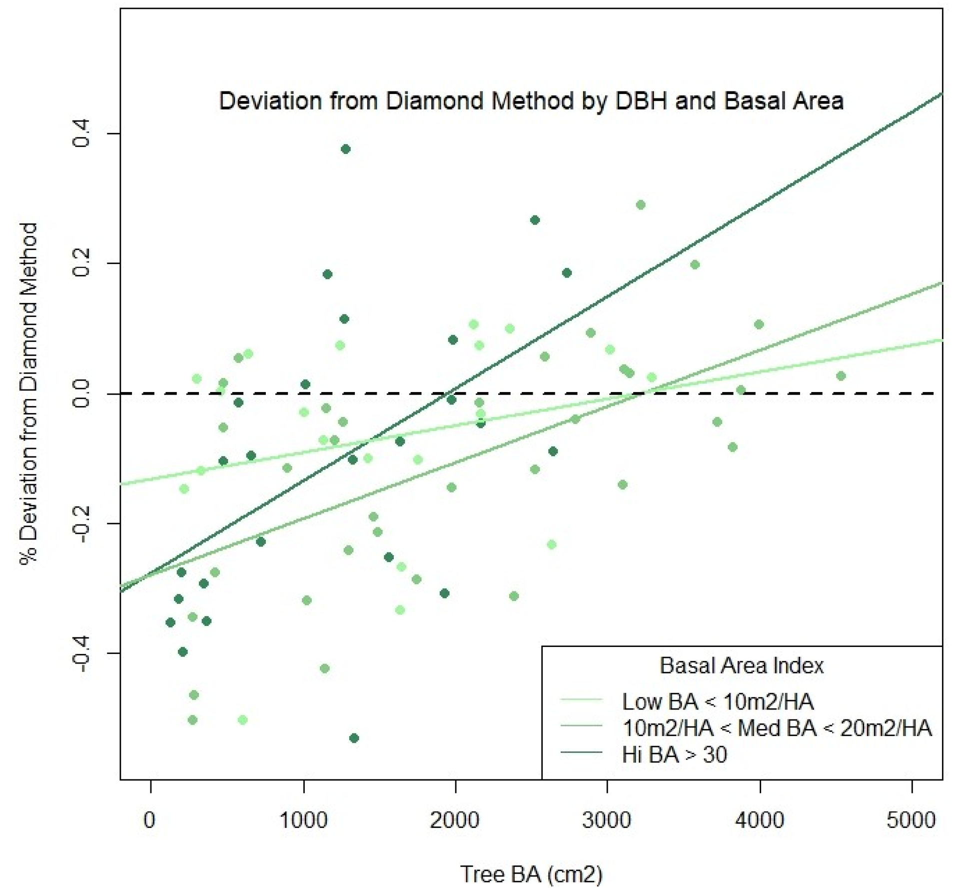


Fig 3: Crown geometries for a single tree produce a wide range of corresponding crown areas. This example ranges from a minimum of 71 m2 crown area from the voxel method to a maximum of 120 m2 using the ellipse method. The diamond method produced a crown area of 80 m2.



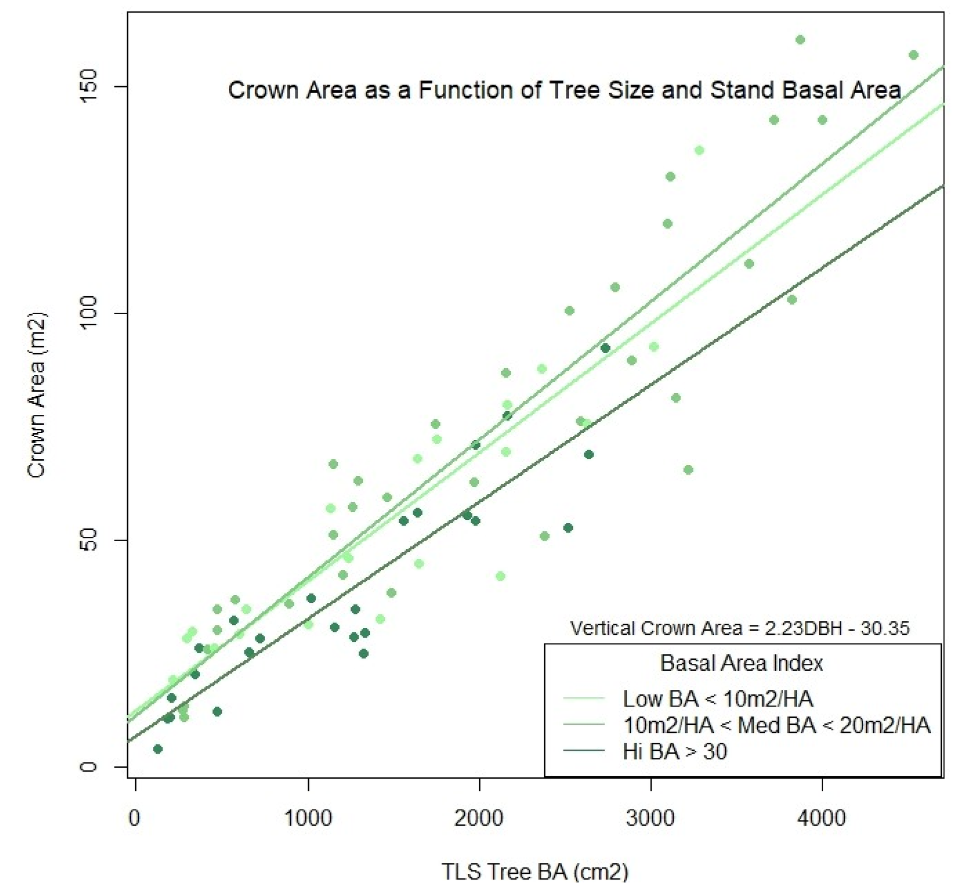


Fig 4 (Left): Tree size and stand basal area showed marginally significant interactive effects (p=0.067) in predicting crown area deviation from the diamond method. Voxel-derived crown area deviation diverges from estimates using a diamond assumption in medium-high basal area stands.

Fig 5 (Right): Crown area increases with tree size (p < 0.001) but suggests little difference based on stand basal area (p=0.512). Additionally, no strong interaction is seen between tree size and basal area (p=0.616). Vertical Crown Area = 2.23DBH – 30.35.

Results

- TLS estimations of DBH field validated with strong agreement (R2 = 0.97)
- Estimation of crown area increased predictably with tree diameter but differed depending on assumptions of crown shape (Figure 4, Figure 5).
- Local stand basal area does not strongly predict crown area (Figure 5).
- The high resolution voxel method predicted 10% less vertical crown area than the standard diamond method employed for conifer species. (Figure 4)
- Ellipse geometries overpredicted crown area by nearly 60%. (Figure 6)
- The voxel method is most useful where canopy deviates greatest from the diamond method in med-high density stands (Figure 5)

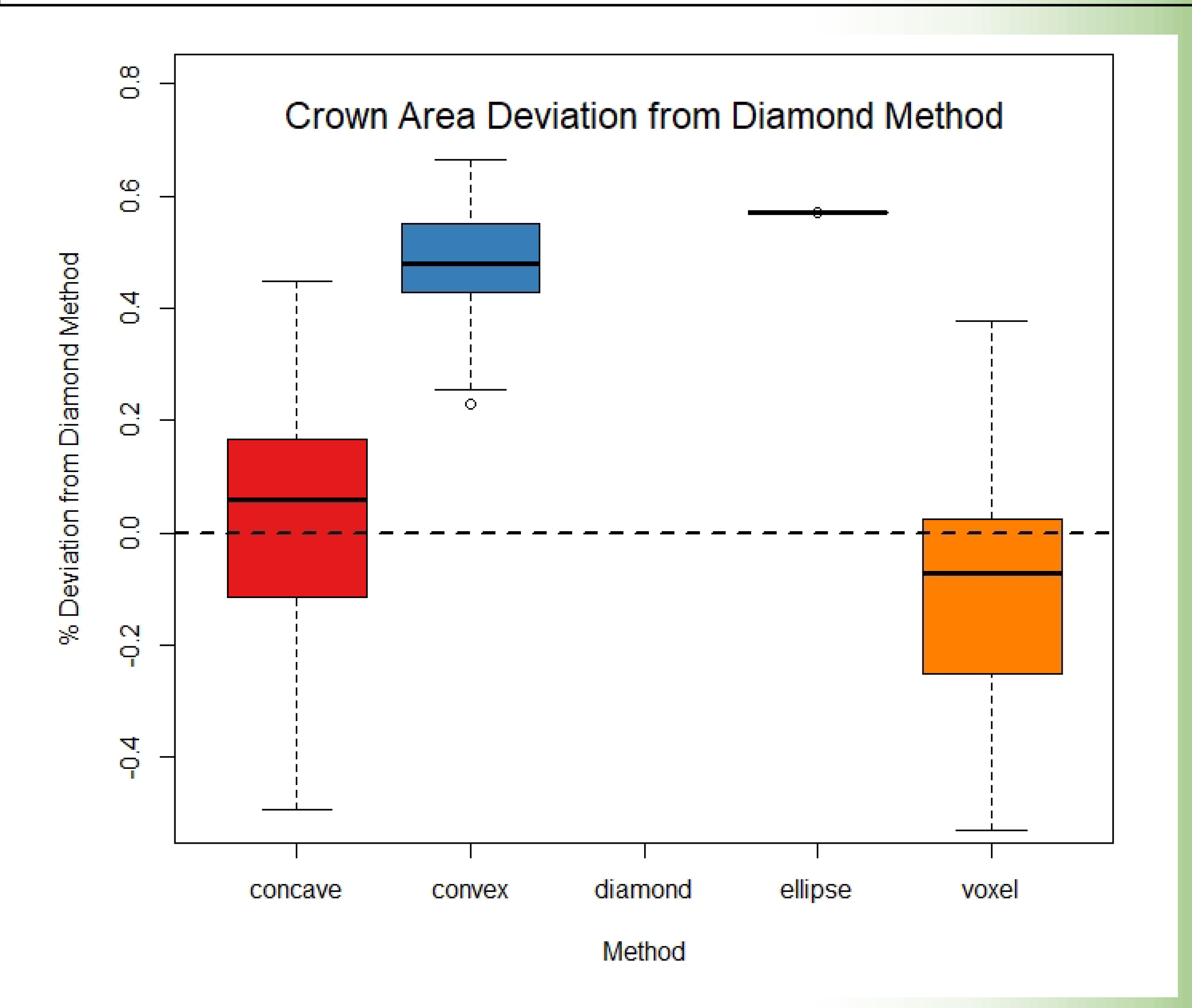


Fig 6: Percent deviation from standard diamond method for concave (+2%), convex (+48%), ellipse (57%), and voxel methods (-10%).

Discussion

•Stand density affects wind susceptibility indirectly by modifying crown shape beyond direct mitigation of windspeed.

•Current mechanistic models of wind damage that use coarse approximation of crown shape may be overestimating wind susceptibility, particularly for trees in medium-high density stands where actual crown area deviates from simpler geometries as we found in longleaf.

•Greater competition for light resources may lead to more complex, dispersed, and irregular crown growth in denser stands which can complicate estimation of wind susceptibility.

•Additional consideration should be given to crown growth when modeling disturbances, particularly in smaller trees in med-high density stands.

Next Steps

•Explore range of wind-affected coastal plain species and impacts of broader stand densities/management types on individual tree susceptibility to wind disturbance

•Evaluate how differences in crown measurements and vertical distribution translate into differences in wind-derived torque on individual trees.