Stand-level structural characteristics dictate hurricane resistance and resilience more than silvicultural regime in longleaf pine woodlands

Adam Polinko – John Willis – Ajay Sharma – Jim Guldin

MISSISSIPPI STATE UNIVERSITY
DEPARTMENT OF FORESTRY

UF IFAS
UNIVERSITY of FLORIDA

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Forestry paradigms

- Even-aged vs. uneven-aged silviculture
- Uneven-aged silviculture is hypothesized to be more resistant and more resilient to disturbances.

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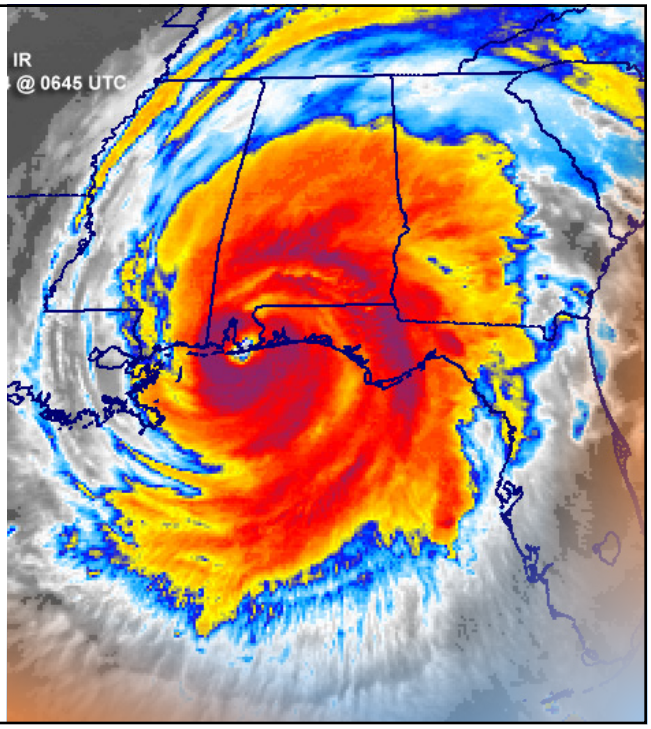
Hurricane Ivan

- September 16th, 2024
- Made landfall as category 3 hurricane
- Eye wall 24km west of Escambia Experimental Forest



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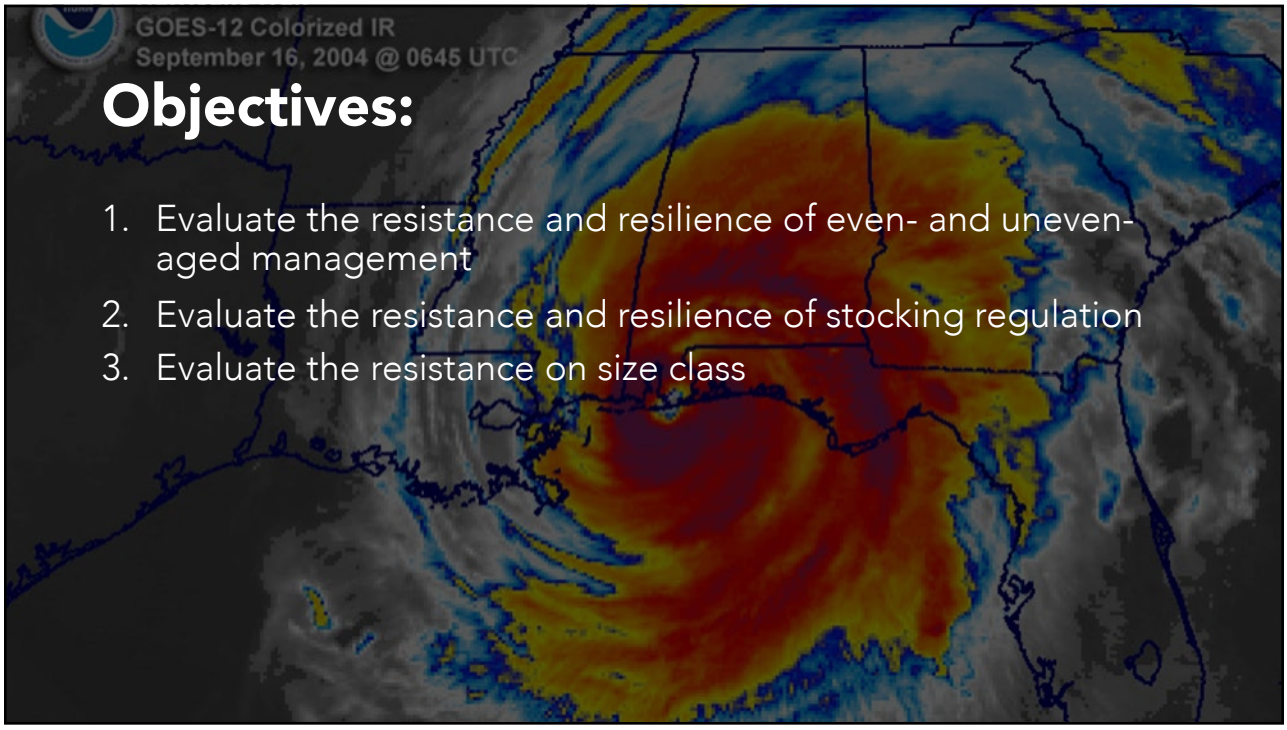

Objectives:

1. Evaluate the resistance and resilience of even- and uneven-aged management
2. Evaluate the resistance and resilience of stocking regulation
3. Evaluate the resistance on size class

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Methods

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BDq

Based on three parameters:

- Residual basal area (B)
- Maximum leave tree diameter (D)
- The ratio of trees in successively smaller diameter classes (q)

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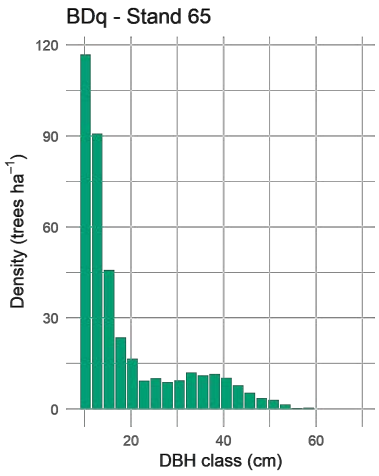
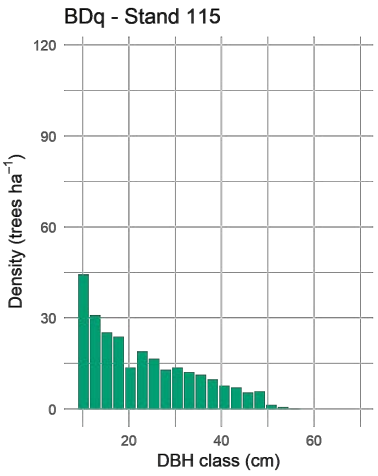
BDq

Entries
1982
1992

B – 11.5 m^2ha^{-1}
D – 50.8 cm
q – 1.2





Entries
1996

B – 13.8 m^2ha^{-1}
D – 50.8 cm
q – 1.2

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Diameter limit

Based on two parameters:

- Set a residual basal area
- Cut everything above a maximum leave tree diameter

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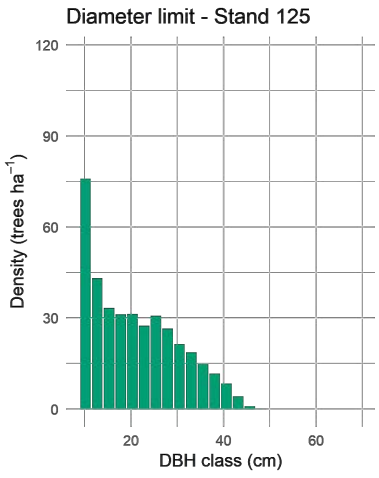
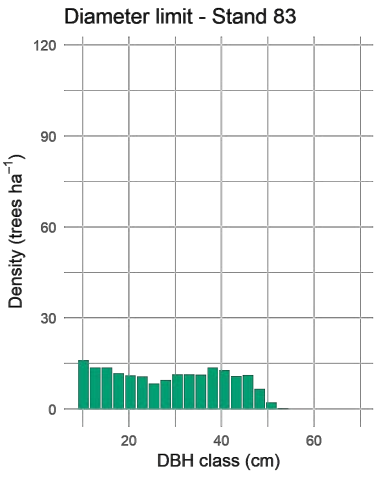
Diameter-limit

Entries
1992



Residual BA – 13.8 m^2ha^{-1}



Maximum DBH – 40.6 cm

Entries
1996

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Volume guiding diameter-limit

Based on two parameters:

- Residual sawtimber volume determined by periodic annual growth (in Mbf/acre)
- Cut everything above a maximum leave tree diameter

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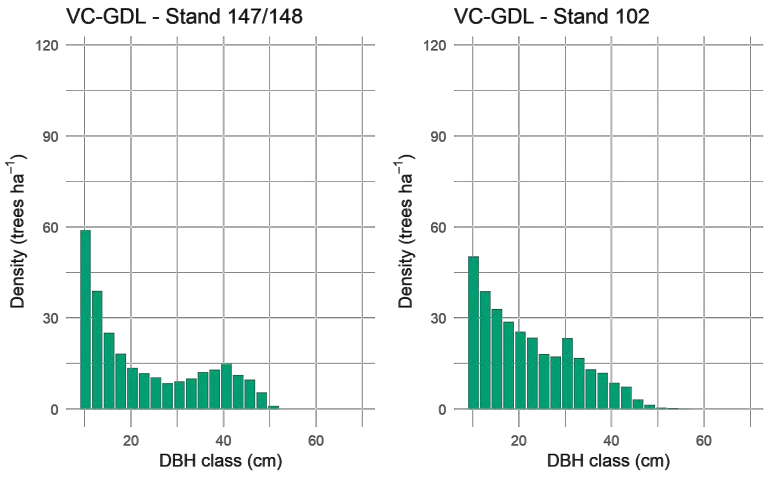
Volume guiding diameter-limit

Entries
1978
1988
1998



Entries
1996

Residual sawtimber – 7.5 – 8 Mbf/acre (international)
Maximum DBH – 40.6 cm

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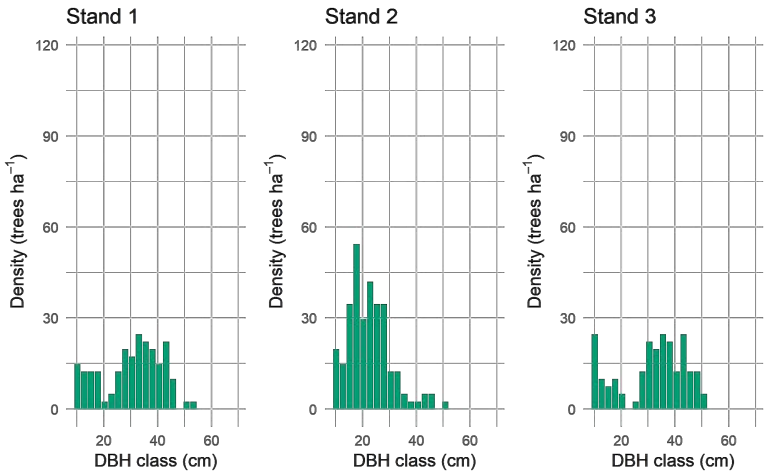
Even aged Stands



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Available data

Diameter distributions – 100% stand inventory

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Inventory years

Method	Pre-Ivan	Post-Ivan	Follow up
Evenaged stands	2003	2005	2010
BDq – Stand 65	2002	2007	2012
BDq – Stand 115	2000	2005	2010
Diameter limit	2000	2006	2011
VC-GDL – 147/148	2003	2008	2013
VC-GDL - 102	2004	2009	

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Solution

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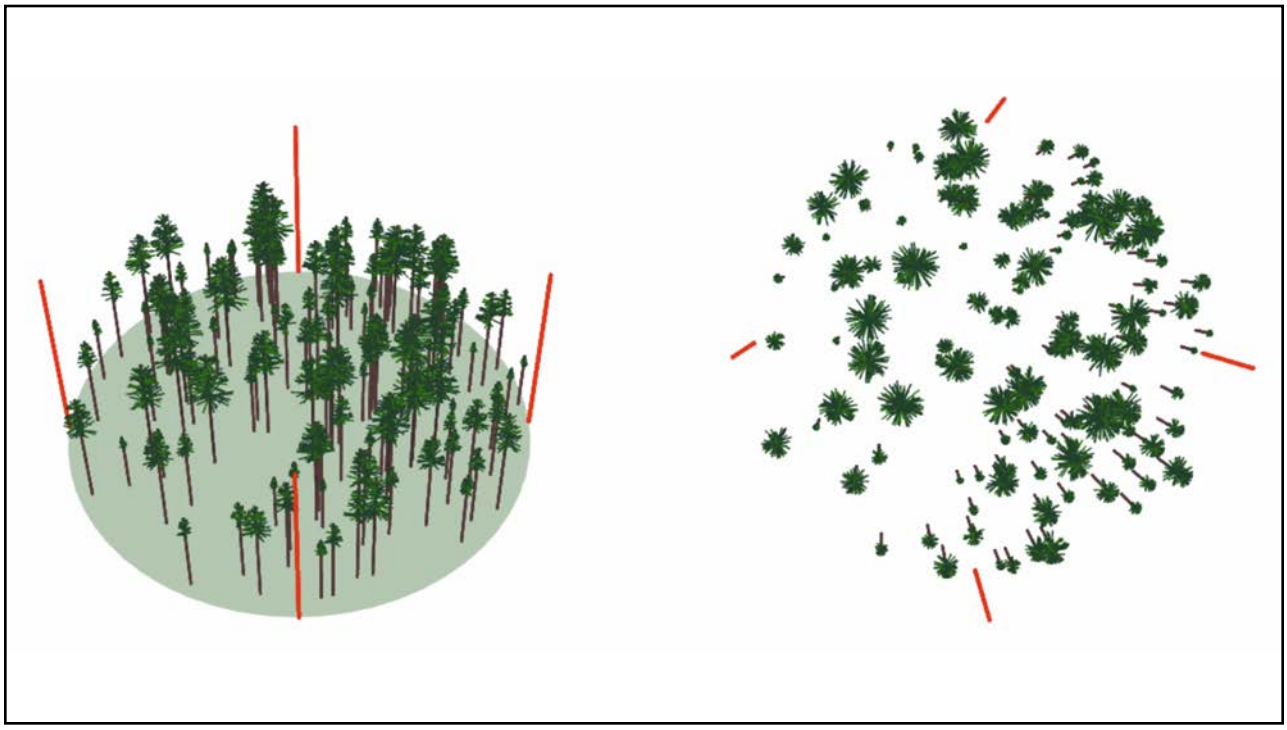

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FVS projections

- Start stands at first inventory and grow until the latest inventory
- Provides estimate of basal area increment without disturbance

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Resistance to hurricane Ivan

$$1 - \frac{(BA_m - BA_e) - (BAI_{pre} \times n_{year})}{BA_m}$$

BA_m = predicted basal area post Ivan
BA_e = measured basal area post Ivan
BAI_{pre} = predicted basal area increment pre Ivan
n_{year} = number of years between measurement periods

Adapted from D'Amato et al. 2013

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Resilience (recovery) to hurricane Ivan

$$\frac{BAI_{post}}{BAI_{pre}}$$

BAI_{post} = basal area increment following Ivan
BAI_{pre} = predicted basal area increment for the same period

Adapted from D'Amato et al. 2013

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Change in distributions

Menning's departure index (Menning et al. 2007)

- Estimates magnitude and direction in change of distributions
- Statistical significance – 999 iterations of 95% confidence intervals from test distribution (randomly removed trees across distribution)

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Stand structure

- Quadratic mean diameter
- Trees per hectare
- Stand basal area

Stand structural diversity:

- Ratio of stand density index (summation method) to Reineke's (1933) index (Ducey 2009)
- Shannon's Index (H) – stand density and basal area

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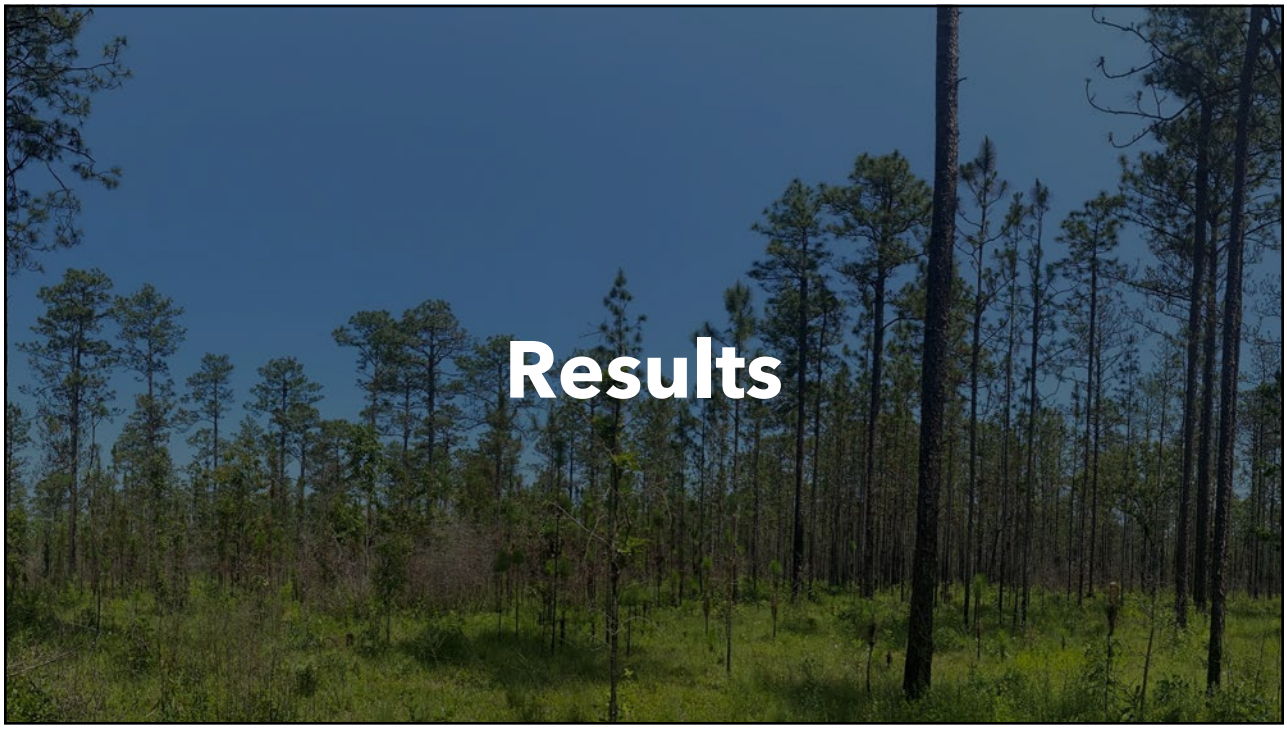

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Stand description

Uneven-aged stands:

- Trees per hectare: 461 – 983 trees ha^{-1}
- Basal area: 13.42 – 15.68 m^2ha^{-1}
- QMD: 21.7 – 30.9 cm

Even-aged stands:

- Trees per hectare: 560 – 768 trees ha^{-1}
- Basal area: 13.98 – 20.57 m^2ha^{-1}
- QMD: 23.9 – 33.9 cm

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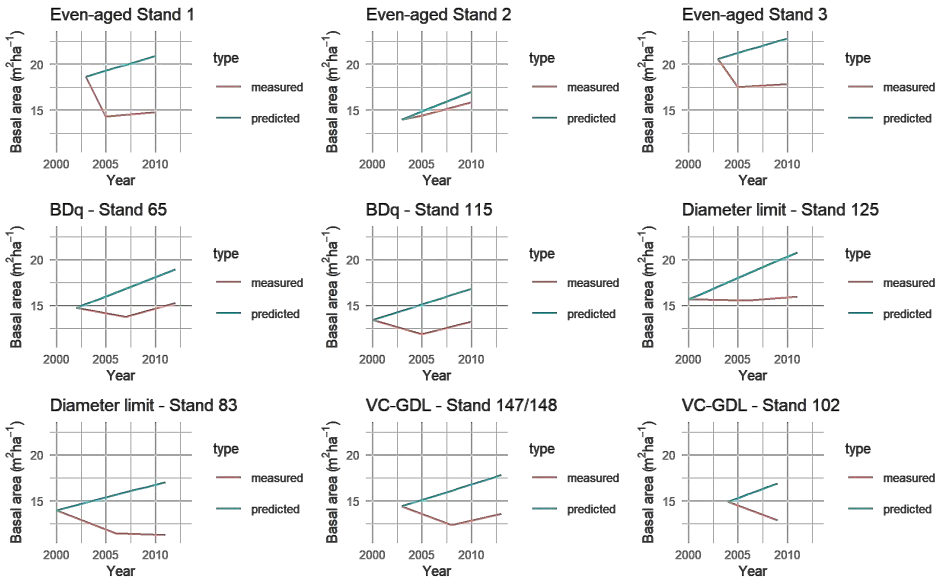

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BDq

Entries
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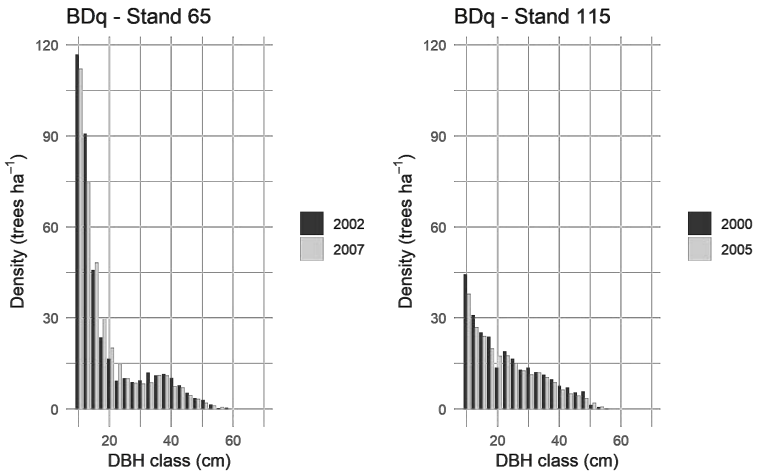
1992



Entries
1996

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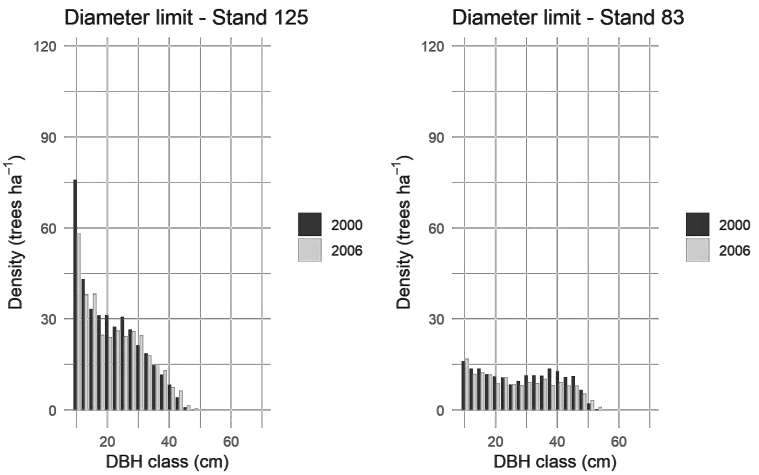
Diameter-limit

Entries
1992



Entries
1996

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Volume guiding diameter-limit

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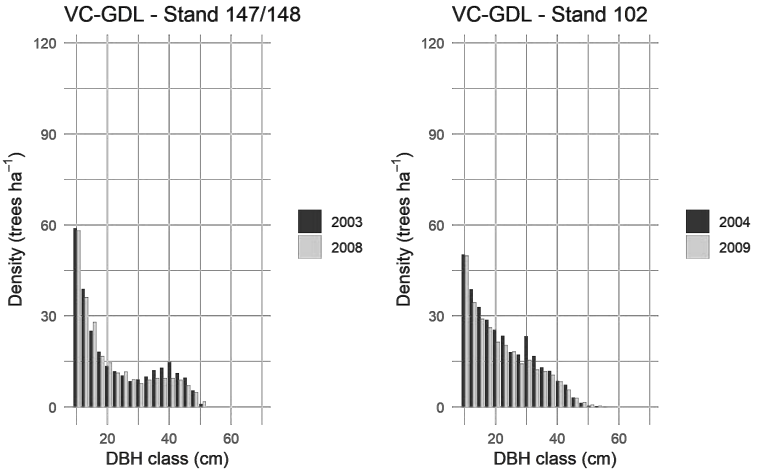
1988
1998



Entries
1996

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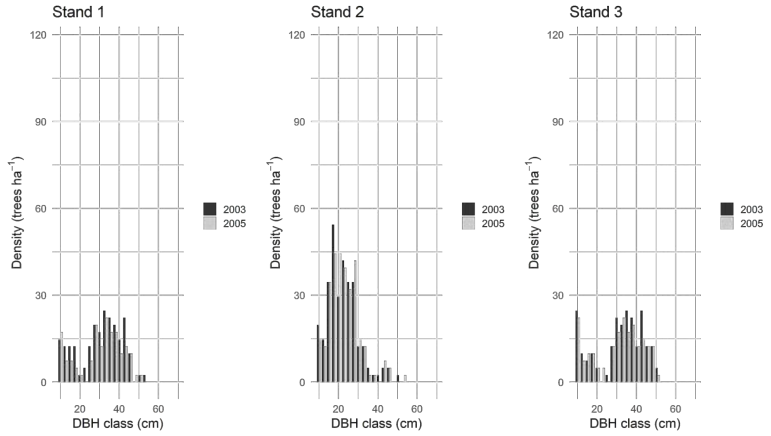
Even-aged Stands



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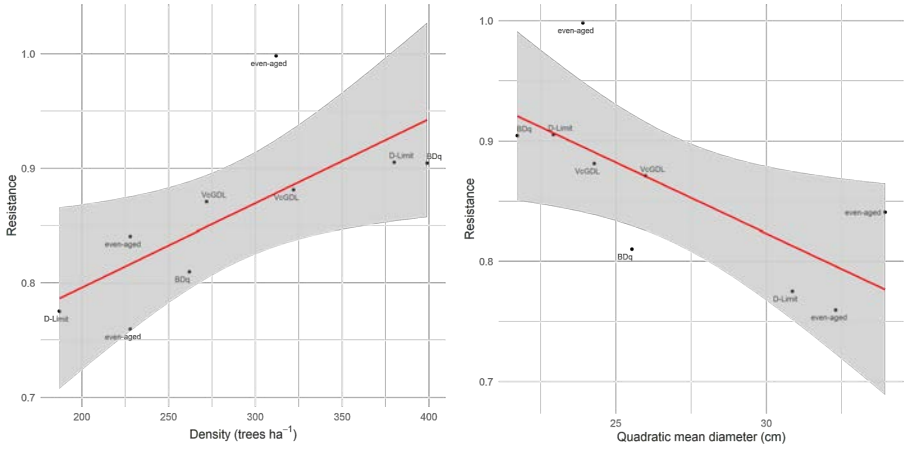
Stands that contained larger trees were less resistant than stands with smaller trees



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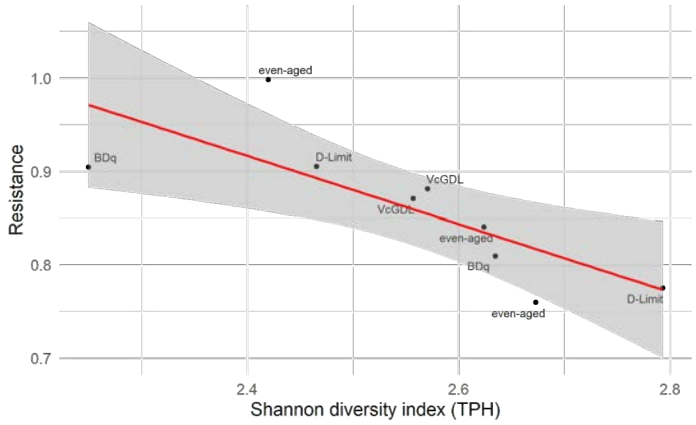
Structurally diverse stands were more resistant to damage



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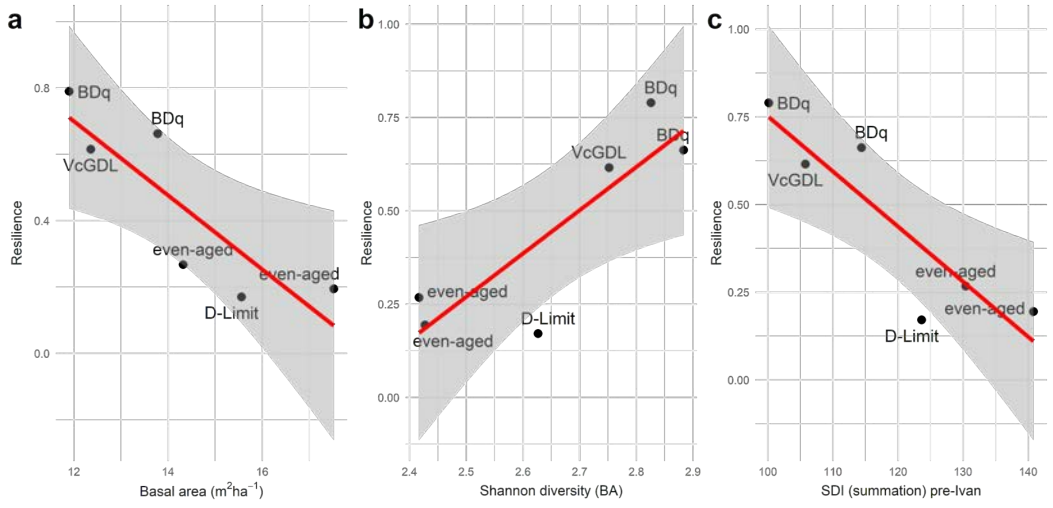
Stands with lower initial density and more structural diversity recovered more than denser more homogenous stands



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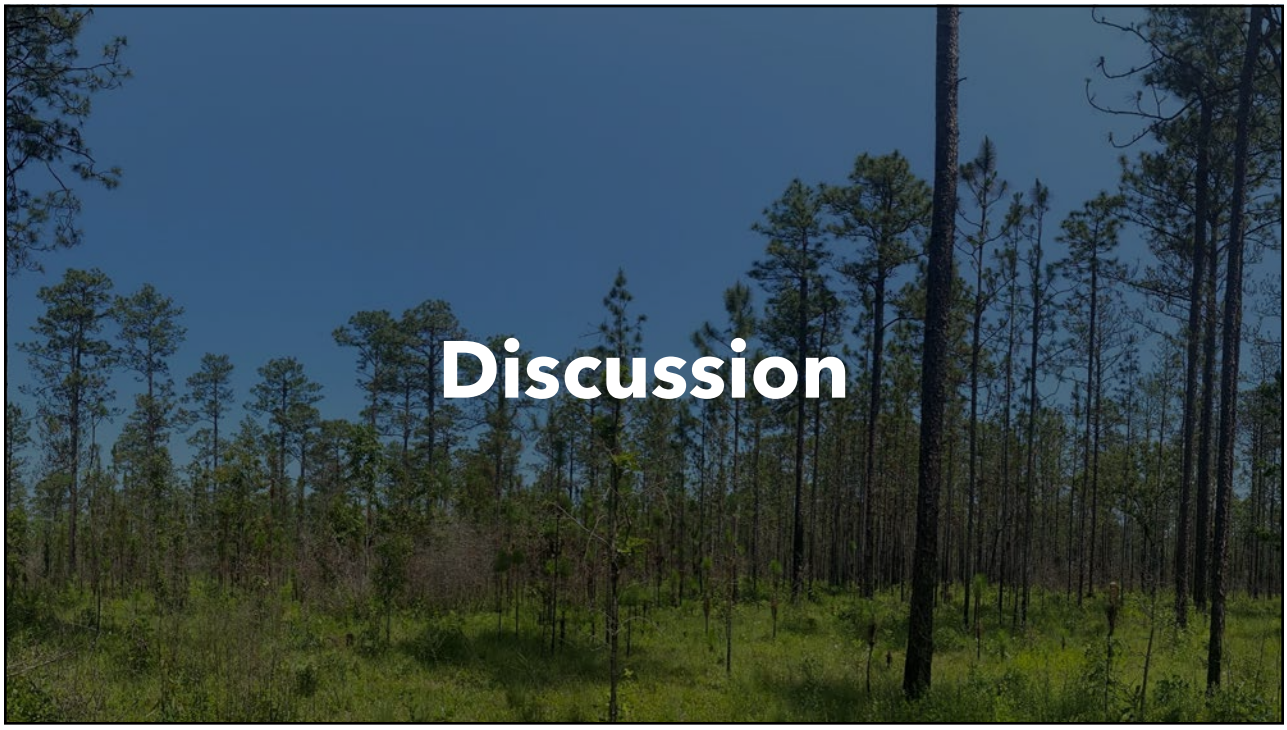
Discussion

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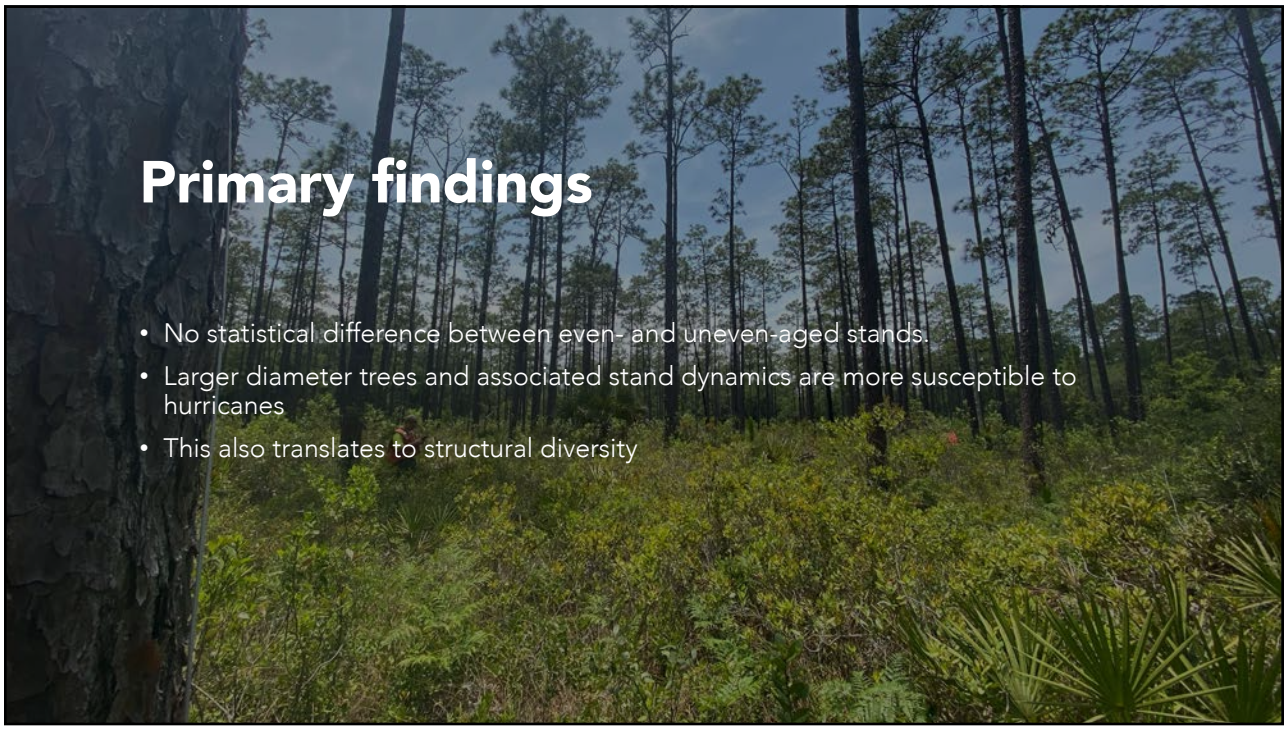
Primary findings
• No statistical difference between even- and uneven-aged stands.
• Larger diameter trees and associated stand dynamics are more susceptible to hurricanes
• This also translates to structural diversity

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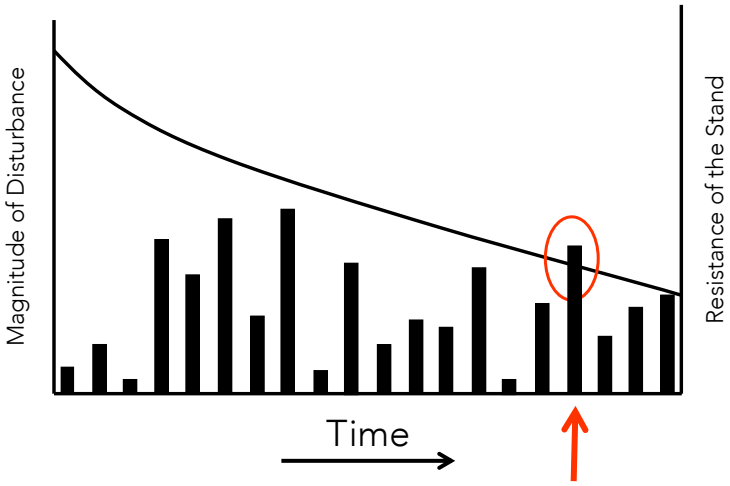
When is a stand destroyed?



Adapted from Oliver and Larson 1996

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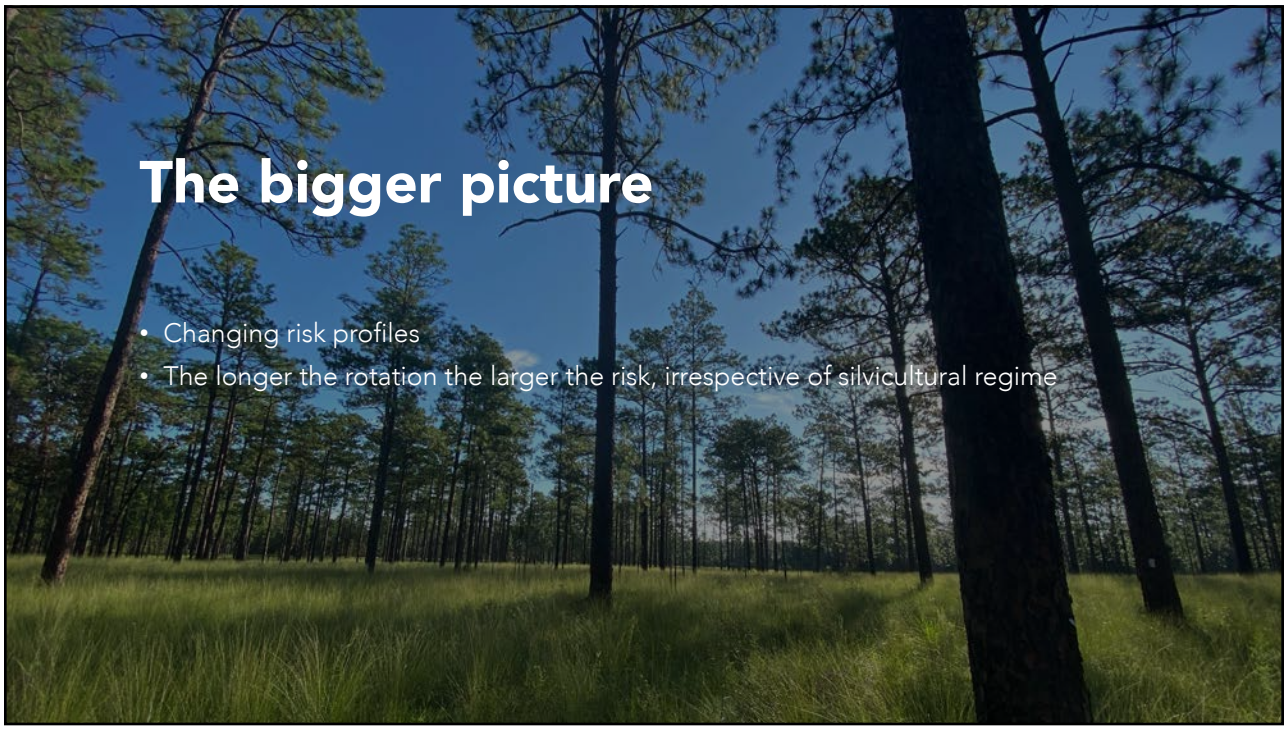

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Thank you

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