

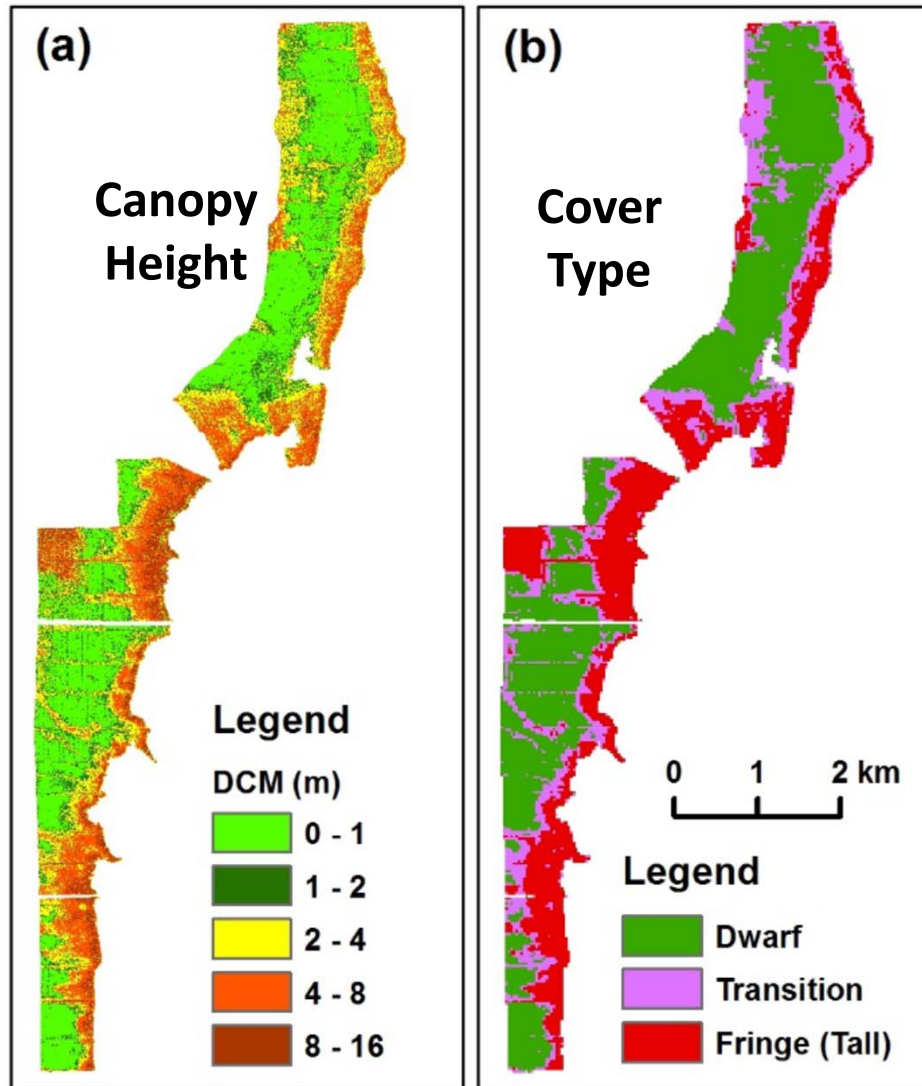
**Disturbance, site, and vegetation feedbacks create landscape structure in South Florida coastal wetlands**

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## A complex, human-modified coastal landscape in southern Biscayne Bay, FL



Forests in (1) intertidal positions adjacent to coast, (2) along current or former tidal creeks, or (3) along man-made ditches or levees are much more productive than (4) periodically flooded “forests” in interior basins on carbonate mud sediments (formerly coastal marshes)

We divided the landscape into Fringe, Transition, and Dwarf forest based on a LiDAR-derived digital canopy model



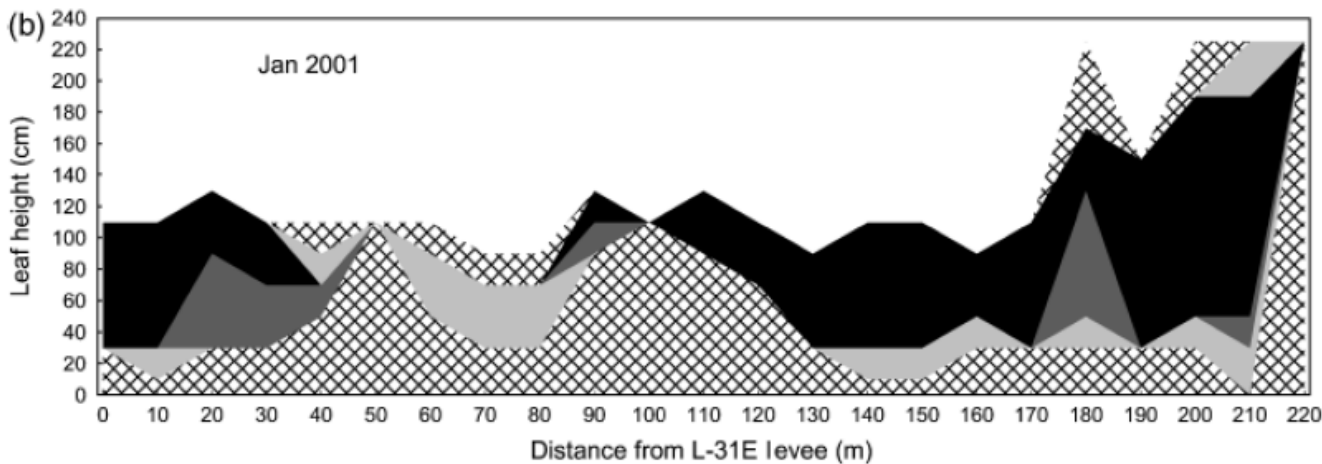
## Chilling damage in a changing climate in coastal landscapes of the subtropical zone: a case study from south Florida

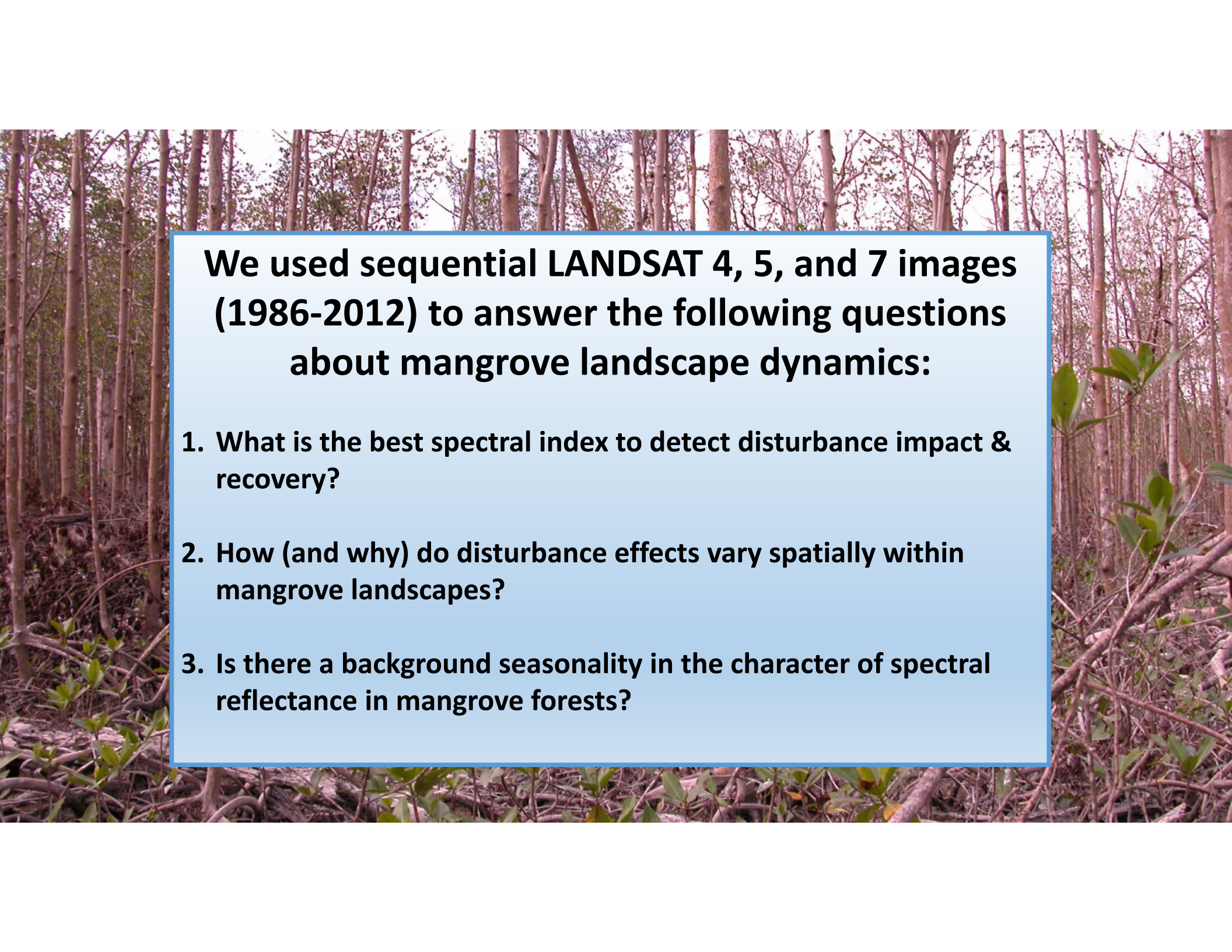
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**Repeated chilling damage, 3 times in 7 years, 1996-2003, at temperatures of 0-3°C**

**Result in change in vegetation composition from *R. mangle* to *L. racemosa* and *C. erectus***





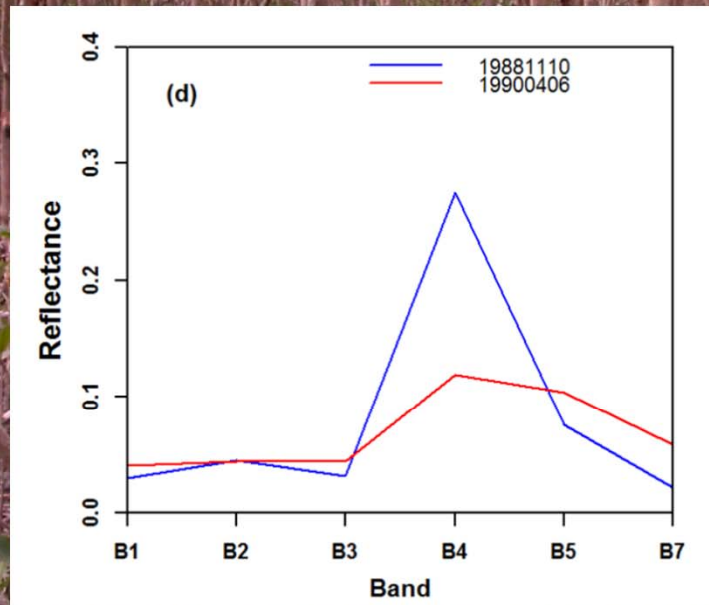
**We used sequential LANDSAT 4, 5, and 7 images (1986-2012) to answer the following questions about mangrove landscape dynamics:**

- 1. What is the best spectral index to detect disturbance impact & recovery?**
- 2. How (and why) do disturbance effects vary spatially within mangrove landscapes?**
- 3. Is there a background seasonality in the character of spectral reflectance in mangrove forests?**

## Four spectral indices were tested

$$NDVI = \frac{\rho_4 - \rho_3}{\rho_4 + \rho_3}$$

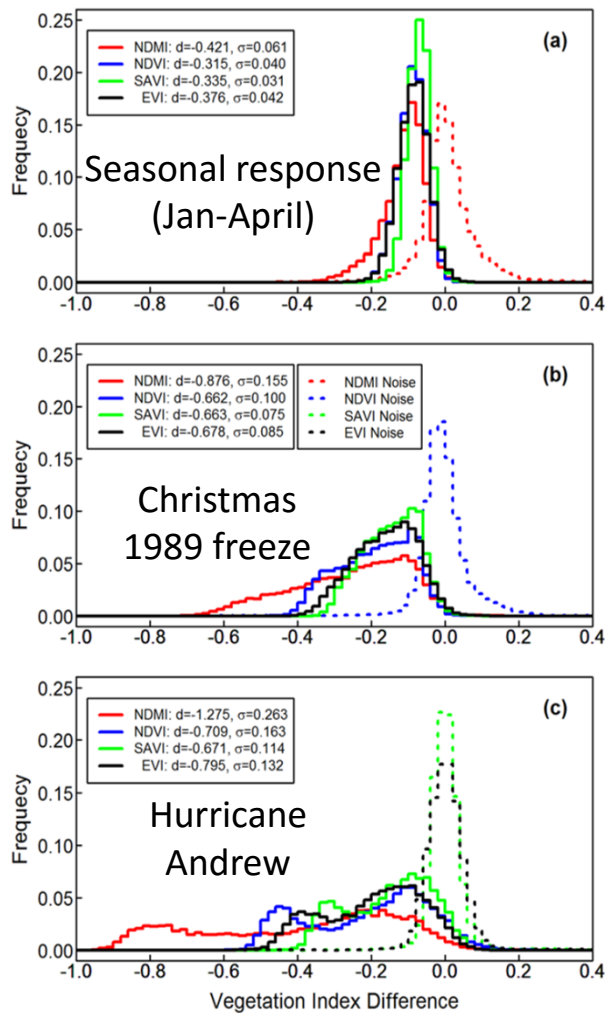
$$NDMI = \frac{\rho_4 - \rho_5}{\rho_4 + \rho_5}$$



$$SAVI = \frac{\rho_4 - \rho_3}{\rho_4 + \rho_3 + L} (1 + L)$$

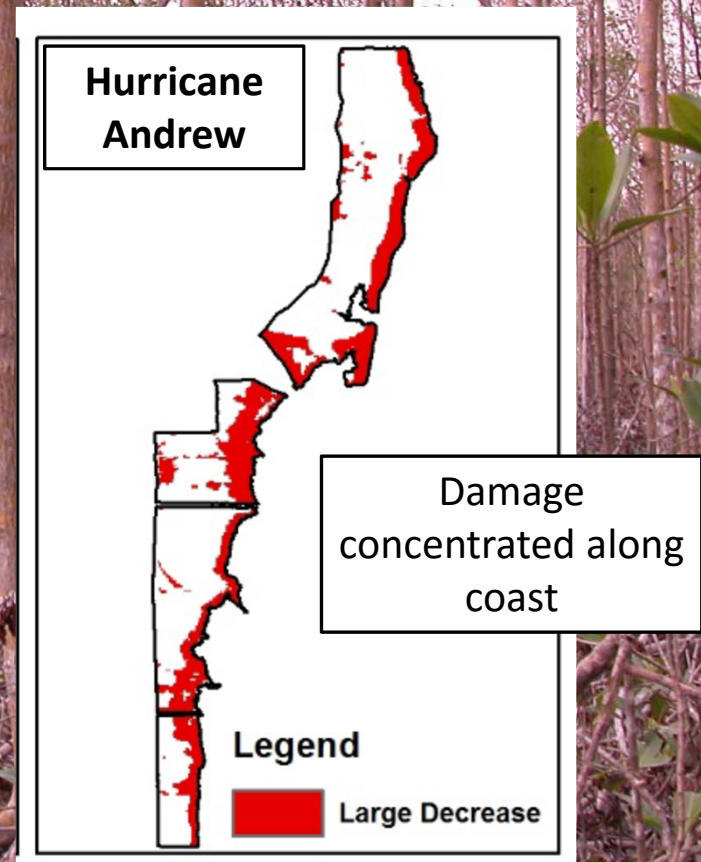
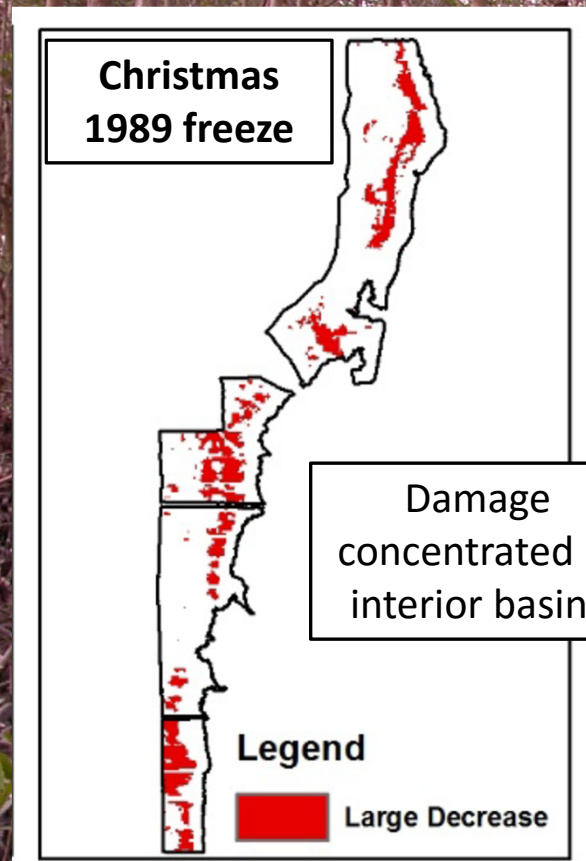
$$EVI = G \frac{\rho_4 - \rho_3}{\rho_4 + C_1 \rho_3 - C_2 \rho_1 + S}$$

## Frequency dist'n of inter-periodic change in 4 spectral indices across all pixels

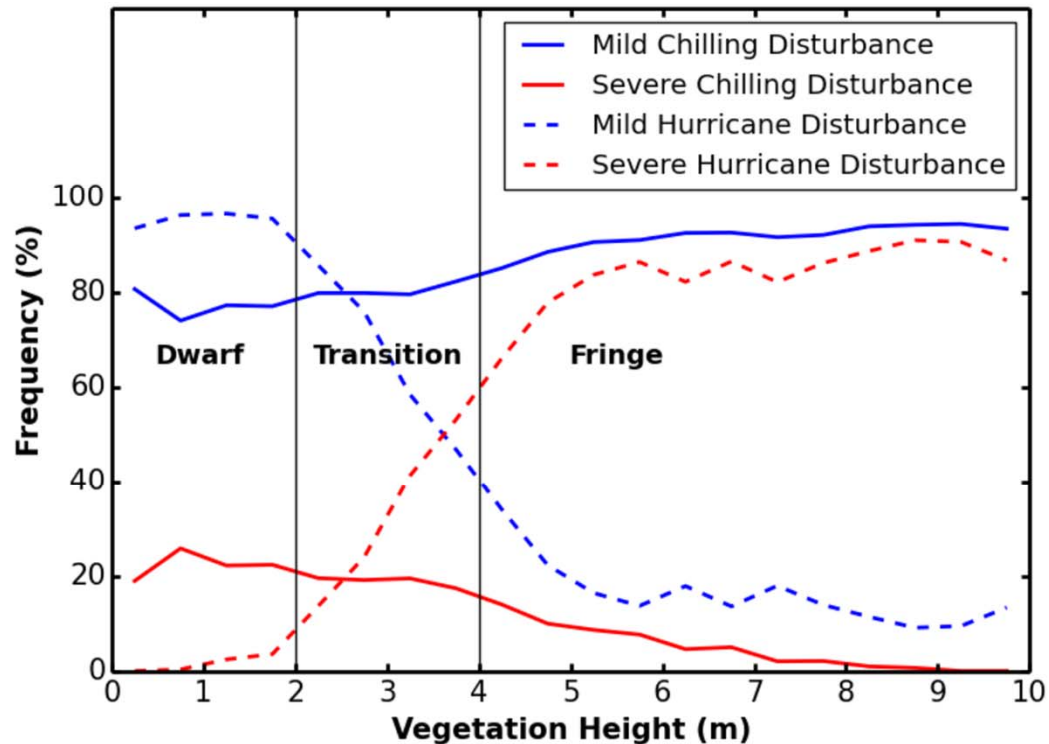


- 1. Top figure:** distributions of differences between January and April values to noise (hatched curve) for all 4 indices across the study area.
- 2. Middle figure:** Based on Cohen's  $d$  statistic, mean change from pre- to post-freeze event (Christmas 1989) in NDMI (red) differed more from background variation than did NDVI (blue), SAVI (green), or EVI (black).
- 3. Lower figure:** the same pattern among indices as above was observed for damage due to Hurricane Andrew (Aug 1992).
- 4. All figures:** NDMI difference also had the highest standard deviation, suggesting it was most sensitive to change.

**Based on NDMI change, spatial distribution of damage caused by freeze and hurricane differed sharply**

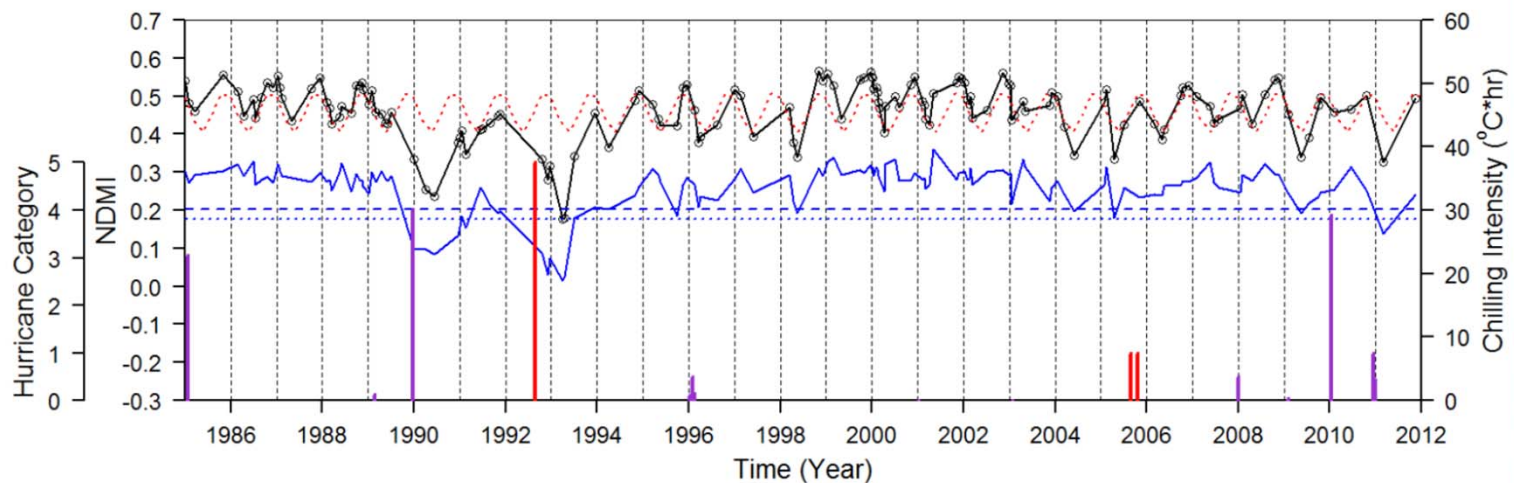


Though these disturbances affected the entire study area, the most severe impacts from freezes and hurricanes were strongly but inversely related to canopy height



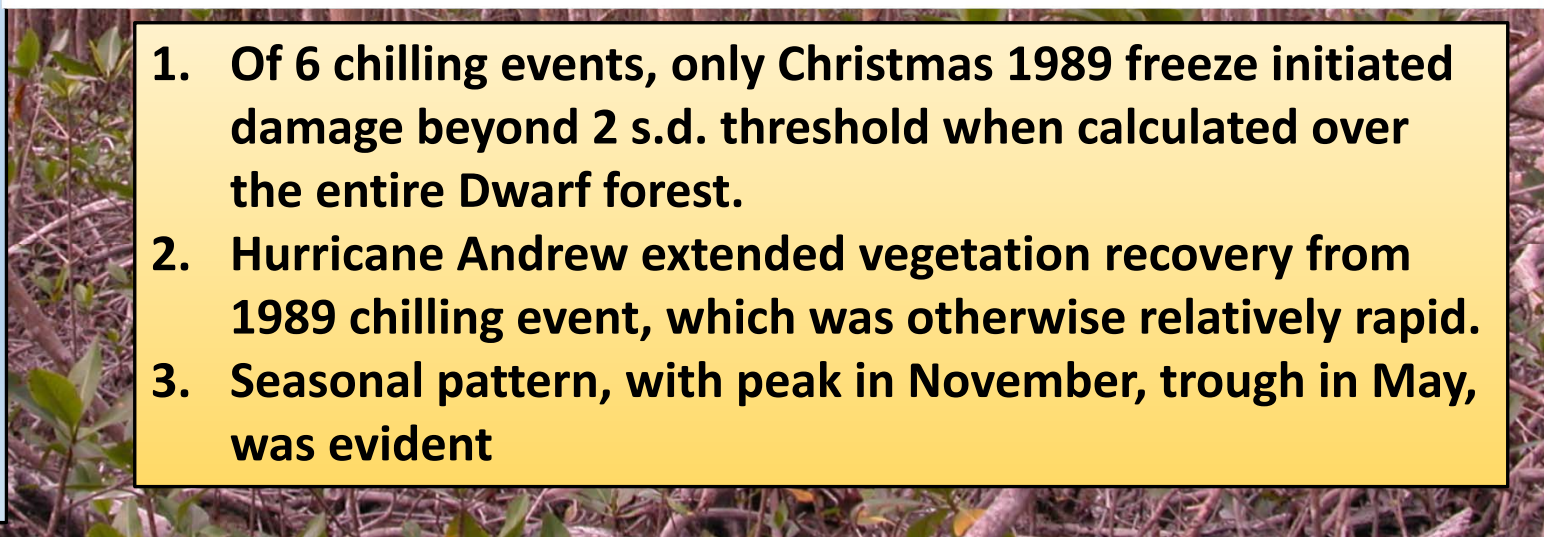


## 1986-2012 disturbance responses, Dwarf forest

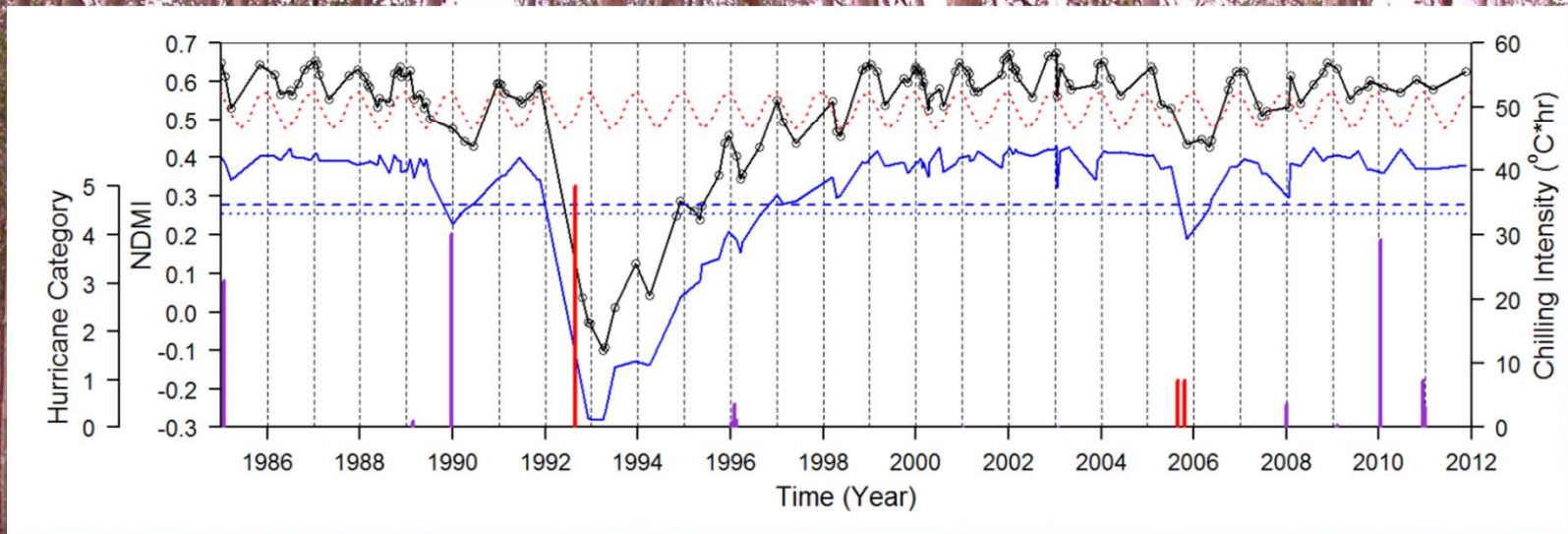


1. Black line is NDMI
2. Red-dot line is NDMI fitted seasonal curve
3. Solid blue line is standardized residual NDMI (off-set by 0.2)
4. Blue-broken lines are 2 and 3 s.d. beyond threshold (off-set by 0.2)
5. Purple bar is freeze event's chilling degree-hours (hrs  $<3^{\circ}\text{C}$  at closest weather station)
6. Red bar is hurricane's Saffir Simpson Index

1. Of 6 chilling events, only Christmas 1989 freeze initiated damage beyond 2 s.d. threshold when calculated over the entire Dwarf forest.
2. Hurricane Andrew extended vegetation recovery from 1989 chilling event, which was otherwise relatively rapid.
3. Seasonal pattern, with peak in November, trough in May, was evident



## 1986-2012 disturbance responses, Fringe forest



1. In the Fringe forest, the 1989 freeze, Hurricane Andrew, and two 2006 Category 1 hurricanes all deviated beyond the 3 s.d. threshold
2. NDMI recovery from Andrew took 7 years, but recovery from other events were very rapid.
3. Seasonal pattern was stronger and more consistent than in Dwarf forest, but offset by about one month later in the year.



## Conclusions

- 1. Of the four indices tested, NDMI appears to be superior for detecting the extent of chilling or hurricane damage, presumably due to processes expressed by Band 5.**
- 2. There are strong biophysical feedbacks between forest structure and vulnerability to disturbance, differing starkly between hurricanes and chilling events, and contributing to fine-grained patterns in the landscape. To understand these ecological patterns and their relationships to remotely sensed data, a finer-scaled analytical approach is needed, which we are currently pursuing.**
- 3. Seasonality in spectral reflectance in the mangrove forest is pronounced, and the origin and significance of this temporal pattern deserves more study.**