Hurricanes and Mangroves: Structural Impacts of Hurricanes Irma and Maria on the Unique Mangrove Resources of St. John

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Photo: Caroline S. Rogers
Structure of this presentation

1. General overview of mangroves and hurricanes
2. Influences of Hurricanes Irma and Maria on the mangroves of St John
3. Can we influence recovery, and how?
4. Summary and questions
What are mangroves?

- Tidal saltwater forested wetlands
- 137,600 km²
- Losses of mangroves have historically been high
General overview of mangroves and hurricanes

Mangrove ecosystem goods and services

- Timber and forest products
- Fisheries
- Nutrient and sediment removal
- Coastal protection
- Carbon storage
Let’s add a positive note...

Valiela et al. (2001) = 2.07 %/year  
Duke et al. (2007) = 1-2 %/year  
FAO (2007) = 1-3 %/year

However, awareness campaigns, protective measures, and mangrove restoration projects have changed these trends over the last few decades....

1980s = 1.04 %/year*  
1990s = 0.72 %/year*  
2000s = 0.2 - 0.7 %/year**

General overview of mangroves and hurricanes

How many of you have heard that mangroves are “disturbance-adapted”?

Possible reasons:

(1) Mangroves often recover over time

Recovery dependent on:
- Intensity of hurricane
- Regeneration
- Soil surface elevation loss/gain
Possible reasons:

(2) Reproductive (and productivity) strategies appear to embrace storms

Some have suggested that peak production of propagules in Neotropical mangroves coincide by design with greater tropical storm activity (Aug – Oct)


https://www.tedleeuebanksphotography.com/Client-Galleries/Jamaica/i-8Dc96L7

https://naturalhistory2.si.edu/smsfp/irlspec/Lagunc_racemo.htm

http://www.mangrove.at/rhizophora-mangle_red-mangrove.html
If tropical storms of all intensities are included, Puerto Rico is affected by approximately 50 per century.
Very important to note, therefore, that mangroves are heavily affected by singular hurricane events. Most mangroves within repetitive storm-track areas have sustained hurricane damage previously and have already recovered to what they are now. This leads to two questions: (1) What limits recovery? (2) How can we help?

Of concern to us...

What happens if hurricane frequency increases?

What happens if mangroves are not healthy when a hurricane strikes?

aka. “Mangrove Heart Attack”

after, Dutta et al. 2015. *Nat. Hazards* 79, 775–790

Main focus of this U.S. Geological Survey science program is to assess the damage to the mangrove resource on St. John from the 2017 hurricane season, and assess the potential for recovery.

We measured characteristics of the mangrove forests and soils in two trips to St. John, 10-14 months after Hurricanes Irma/Maria, and re-constructed pre-hurricane forest structure to determine impact of the hurricanes.
Influences of Hurricanes Irma and Maria on the Mangroves of St. John

- Mangroves cover an area of ~45 ha
- Occupy ~11 km of shoreline (or 12%)
- Height range of 4 – 11 m tall
- At least three different types of mangrove forests on St. John (typology)
  - Isolated basin
  - Salt pond
  - Fringe
Influences of Hurricanes Irma and Maria on the Mangroves of St. John

**Isolated basin**

- Two sites, both at Annaberg
- Typically flooded by the highest of tides, or significant rainfall events with water retention
Salt pond

- Two sites (Francis Pond, Lameshur)

- Ponds permanently flooded with various connections to the ocean

- Both sites selected on St. John were very different; mortality a condition
Influences of Hurricanes Irma and Maria on the Mangroves of St. John

Fringe

- Three sites (Water Creek, Princess Bay, Mary Creek)
- Flooded by nearly every high tide, and most drained at ebb tide
- Mostly comprised of red mangrove, but all species often present

Princess Bay (Plot 401)

Red mangrove
Influences of Hurricanes Irma and Maria on the Mangroves of St. John

What did we do?

- Established 2, 5.65-m radius plots per site (0.02 ha)

- Measured diameter at breast height (dbh, 1.3 m above ground) of live standing, dead standing, and fallen trees.

- Re-constructed pre- and post-storm forest structure. Explain...

- Measured downed wood volume

- Measured regeneration in 1-m² sub-plots

- Soil samples to a maximum depth of 50 cm; 3-cm sections
Influences of Hurricanes Irma and Maria on the Mangroves of St. John

- 1600 to 2850 stems/ha before hurricanes
- Diameter distributions (no live trees)
- Missing small diameter class trees and of those present, there were lots of mortality in small diameter classes before hurricanes. Why?

- Diameter distribution typical
- Salt Pond = 6750 to 8100 stems/ha
- Fringe = 3150 to ~13000 stems/ha (Mary Creek)

- Many more dead standing trees. Trees shorter. But, also some survival.
Influences of Hurricanes Irma and Maria on the Mangroves of St. John

- A lot of what we found were seedlings present before the hurricanes.

- Regeneration was seemingly fairly low, but variable and not necessarily very different from other post-hurricane regeneration surveys at this point in time (10-14 months).

- 1.8 to 5.3 seedlings/m² (Everglades); 0.7 to 2.2 seedlings/m² (Nicaragua).

- Regeneration re-surveys on this trip (26 months)?
Influences of Hurricanes Irma and Maria on the Mangroves of St. John

- Hurricanes not likely to affect soil structure greatly unless recovery is delayed (peat collapse)

- Nitrogen content fairly low; sign of nutrient conservation in the uplands?

- Inorganic C content high in Isolated basin (>50%). Why?
Can we influence recovery, and how?

- Mangroves look horrible after hurricanes.

Ten Thousands Islands, Florida

St. John

Saipan, Northern Marianas Islands

What can we do?
Embracing the disturbance…

- Hurricane Wilma deposited 37 mm of sediment on to the mangrove soil surface in Everglades National Park.

- Reported a 42.8 mm increase in elevation, which decreased by 10.5 mm by June 2006 – due to settling.
Embracing the disturbance…

Hurricane Wilma deposited 37 mm of sediment on the mangrove soil surface in Everglades National Park. However, is the benefit long-term?

- Reported a 42.8 mm increase in elevation, which decreased by 10.5 mm by June 2006 – due to settling
Can we influence recovery, and how?

Ensuring that tidal hydrological flow is maintained…

Many established mangrove forests are stressed by subtle changes in hydrology brought on by development, and this needs to be recognized globally.


Marco Island, Florida, USA
Can we influence recovery, and how?

Actively planting seedlings to facilitate quicker regeneration…

- Maybe a solution, but acceptable sources of propagule material need to be found.

- Limited genetic variability may be a condition of mangrove development on Caribbean islands?

  - Genetic relatedness of *Rhizophora mangle* populations after recovery from Hurricane Hugo on St. John.

  - How important is this to maintain?

  - Ensuring post-planting survival. *E.g.*, Different environmental conditions, herbivory, browsing.

Bologna et al. 2019. *Diversity* 11, Article 65
While mangroves are considered stress-adapted ecosystems, there is a limit of that adaptability made more difficult by human-impacts to the landscape, limited regeneration potential in some environments, genetic bottlenecks, and lack of seed/propagule sources to promote expedient recovery.

That said, how the mangroves on St. John appeared before the hurricanes already represented recovery to that stage from past hurricanes. Legacies of past impact are part of being a disturbance-adapted ecosystem.

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