A New Paradigm for Tampa Bay Coastal Habitat Restoration in the Face of Sea Level Rise

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Restore America’s Estuaries
December 12, 2016
Tampa Bay Critical Coastal Habitats

- Seagrass Meadows
- Mangrove Forests
- Salt Marshes
- Salt Barrens
Blue Carbon Benefits

*Data is per unit area, where tCO2eq/ha is tons of carbon dioxide equivalents per hectare

Source: Murray et al., 2011.
“Habitat Restoration Paradigms

1. Restore *areal extent to pre-development* conditions
   - Economically infeasible

2. Restore *areal extent to benchmark period* conditions
   - Circa 1950 period has been adopted by the TBEP as the benchmark period
   - Feasible for seagrass since benchmark areal extent of bay bottom still exists
   - Not feasible for emergent tidal wetlands due to dredge/fill impacts

3. Restore *relative proportions to benchmark period* conditions = “restoring the balance”
   - Assumes that estuarine-dependent species require critical habitats in pre-development “ratios” to complete their life cycles
Restoring the Balance (RTB) Paradigm

Ratio of benchmark proportion and current areal extent of the least impacted habitat type should be equivalent to the ratio of the benchmark proportion and restoration areal extent of the other habitat types

If: \[ x = \text{restoration target for habitat of interest} \]
\[ a = \text{current acreage of least impacted habitat} \]
\[ b = \text{benchmark proportion of habitat of interest} \]
\[ c = \text{benchmark proportion of least impact habitat} \]

Then,
\[ \frac{c}{a} = \frac{b}{x}, \text{ and} \]
\[ x = \frac{ab}{c} \]
~1950 vs ~2007 Habitat Ratios

ca. 1950: 63,306 total acres
25% Seagrass, 31% Mangrove, 10% Salt Marsh, 2% Salt Barren

2006/2007: 48,280 total acres
59% Seagrass, 9% Mangrove, 1% Salt Marsh, 1% Salt Barren
## RTB Habitat Restoration Targets

<table>
<thead>
<tr>
<th>Habitat Type</th>
<th>Protection Target</th>
<th>Restoration Target</th>
<th>2010 Deficit</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seagrass</td>
<td>29,647 ac.</td>
<td>38,552 ac.</td>
<td>-8,905</td>
<td>Restoration target to be attained primarily through water quality improvements</td>
</tr>
<tr>
<td>Mangrove</td>
<td>15,139 ac.</td>
<td>15,139 ac.</td>
<td>0</td>
<td>Preservation target only</td>
</tr>
<tr>
<td>Salt Marsh</td>
<td>4,395 ac.</td>
<td>6,313 ac.</td>
<td>-1,918</td>
<td>Restoration target to be attained through public private partnerships and mitigation</td>
</tr>
<tr>
<td>Salt Barren</td>
<td>447 ac.</td>
<td>1,287 ac.</td>
<td>-840</td>
<td>Restoration target to be attained through public private partnerships and mitigation</td>
</tr>
</tbody>
</table>

Source: *Tampa Bay Habitat Master Plan Update (TBEP, 2010).*
But...RTB Targets Did Not Consider SLR

Sources: Climate Central N.D.; Walsh et al. 2014; Parris et al. 2012.
Tampa Bay Area Elevations

Source: USGS, 2010
Elevation Determines Habitat Zonation

- Elevation differences of as little as 0.1 foot often determine habitat zonation.
- Elevation-driven habitat zonation is remarkably consistent around the bay.
Coastal Habitat Migration with SLR

There is clear evidence that Tampa Bay coastal habitats are actively migrating in response to SLR now:

- Landward expansion of mangroves into salt marshes
- Landward expansion of salt marshes into salt barrens
- Landward expansion tidal habitats into freshwater wetlands
Even a Little is A Lot!

Global Mean Sea Level (inches) vs Year

- Observed Sea Level Rise
- Highest
- Intermediate-High
- Intermediate-Low

+20 inches by 2100!
Tampa Bay Coastal Habitat Ratios

Source: Sherwood & Greening, 2013
Coastal Habitat Migration with SLR

The “pinch out” effect

Problems with SLAMM in Tampa Bay

- Sea Level Affecting Marshes Model (SLAMM):
  - Does not simulate SLR effects on seagrass
  - Does not adequately simulate the evolution of fringing high marsh and salt barrens created by irregular tidal inundation
  - Does not adequately simulate the migration of brackish *Juncus* marshes in response to localized freshwater inputs
  - Over-predicts the evolution of mangroves in subtropical and tropical estuaries
Tampa Bay Habitat Evolution Model (HEM)

1 Adjusted for SLR Only
2 Adjusted for SLR and Accretion
3 Assumed to Rise with Sea Level, No Elevation Adjustment Required
## HEM 2100 Tampa Bay Predictions

<table>
<thead>
<tr>
<th>Run</th>
<th>Modeled Acreage in 2007</th>
<th>Acreage in 2100</th>
<th>Acreage difference 2100-2007</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(Run 1) Int. Low</td>
<td>(Run 3) Int. High</td>
</tr>
<tr>
<td>Developed Upland- Hard</td>
<td>461,640</td>
<td>461,640</td>
<td>461,640</td>
</tr>
<tr>
<td>Developed Upland- Soft</td>
<td>210,310</td>
<td>210,310</td>
<td>210,310</td>
</tr>
<tr>
<td>Undeveloped Upland</td>
<td>230,600</td>
<td>227,370</td>
<td>222,870</td>
</tr>
<tr>
<td>Freshwater Marsh</td>
<td>81,390</td>
<td>79,260</td>
<td>77,590</td>
</tr>
<tr>
<td>Salt Barrens</td>
<td>1,520</td>
<td>2,870</td>
<td>2,280</td>
</tr>
<tr>
<td>High Salt Marsh</td>
<td>2,290</td>
<td>2,500</td>
<td>1,090</td>
</tr>
<tr>
<td><em>Juncus</em> Marsh</td>
<td>4,250</td>
<td>4,530</td>
<td>2,430</td>
</tr>
<tr>
<td>Mangroves</td>
<td>13,990</td>
<td>16,040</td>
<td>4,870</td>
</tr>
<tr>
<td>Mudflat</td>
<td>0</td>
<td>0</td>
<td>840</td>
</tr>
<tr>
<td>Beach</td>
<td>70</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Seagrass</td>
<td>33,310</td>
<td>33,550</td>
<td>48,280</td>
</tr>
<tr>
<td>Open Water</td>
<td>338,710</td>
<td>339,960</td>
<td>345,880</td>
</tr>
</tbody>
</table>
HEM 2100 Predicted Mangrove Changes
HEM 2100 Predicted Seagrass Changes
Conclusions from HEM Analysis

- Tampa Bay critical coastal habitats are extremely sensitive to SLR

- Relatively small differences in SLR result in major predicted differences in habitat evolution outcomes

- In 2100 Tampa Bay could be either a:
  - Mangrove dominated system
  - Seagrass dominated system

- The balance of critical coastal habitats in Tampa Bay in 2100 will be very different than today
The Bigger Problem in Tampa Bay

MHHW elevation = 5.68 ft. NAVD
The New Paradigm

Integrate habitat restoration planning and design into long-term coastal resilience strategies
The New Paradigm – Element #1

• Identify and protect “essential” existing infrastructure and development in coastal flood prone areas
  – Protective measures include shoreline armoring, levees and pumps, and elevated structures, roadways and other critical infrastructure
The New Paradigm – Element #2

• Preserve and protect existing critical coastal habitats
  – New dredge and fill impacts to existing coastal wetlands are generally restricted by Clean Water Act regulations
  – Regulations can be weakened and laws can be repealed!
The New Paradigm – Element #3

- Restrict new infrastructure and development in coastal flood prone uplands
  - Restrictive measures include a range of regulatory and planning tools to curtail new development in coastal areas subject to nuisance tidal flooding and storm surge
  - Private insurance markets will eventually solve this problem!
The New Paradigm – Element #4

- Establish long-term coastal upland buffers
  - “Reserve” undeveloped parcels
    - Develop incentives/disincentives (e.g., rolling easements) for private owners of undeveloped parcels to maintain lower intensity land uses (e.g. agriculture)
  - Publicly acquire developed parcels depreciated by nuisance coastal flooding and storm surge
The New Paradigm – Element #5

• Prepare abandoned coastal uplands to accommodate future tidal inundation and habitat migration
  – Remove hard infrastructure
  – Site grading and channel creation
  – Design for salinity gradients and habitat “mosaics” under current and predicted future tidal conditions
So what can be done?

• Acknowledge that sea-level rise is real, and that the rate of rise is probably increasing

• Start planning for the future – now!