2025 PNREC Conference From Sea to Shining Sea: Presenting Best Lessons and Tools for Prioritizing Adaptation Strategies from the Florida

- PRESENTERS: Presenter: Amy Bainbridge
- **The Balmoral Group**

Keys

- Project Manager: Laila Racevskis, Ph.D.
- The Balmoral Group





Presentation Outline

Team Members: Valerie Seidel, Cortney Cortez, Alicia Barker, Grant Miller, Laila Racevskis





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Research Motivation & Objectives

The Florida Keys (Monroe County) is home to **unique ecosystems** that are experiencing **impacts from climate change and sea level rise**.

In its **2021 Vulnerability Assessment (VA)**, Monroe County identified the need to develop an **adaptation strategy focused specifically on its natural resources** to guide future planning efforts.

The Balmoral Group (TBG) was contracted to conduct a **cost-benefit analysis (CBA) of the natural resource adaptation strategies** identified in the Monroe County 2021 VA. TBG was sub to WSP.



Monroe County/Florida Keys



- Only coral barrier reef in the continental United States
- Largest documented contiguous seagrass community in the Northern Hemisphere.
- More than 6,000 animal species, along with an array of submerged historical and cultural resources
- One of our most cherished locations for diving, fishing, boating, and wildlife viewing.
- Highly sensitive to water quality issues



Not completely unlike Coastal Washington

- Loss of freshwater resources
- Sunny day flooding
- Key deer, Sea Turtles and Mangroves
- Coral Reef
 Degradation
- Hurricane frequency
- Tourism dependency

- Saltwater Intrusion
- Coastal erosion
- Sea level rise
- Ocean Acidification
- Habitat
 Ergamentat
- Fragmentation
- Storm surge impacts
- Loss of critical ecosystems

Salmon habitat threatened Heavy winter rainfall and summer droughts Desalination energy costs Displacement of coastal communities



Research Inputs



Natural resource adaptation strategies defined in Monroe County's 2021 VA



USFWS February 2024 RAD Workshop: Scientists identified key priority actions at a 3-day workshop specific to local species and threats that guided the development of CBA strategies



National Oceanic and Atmospheric Administration (NOAA) Sea Level Affecting Marshes Model (SLAMM) projections show dramatic shoreline changes by 2040 and 2070 that will impact Keys habitats



SLAMM Example: Big Pine Key

Current



2040







Adaptation Strategy Case Studies Used in CBA

Case studies were developed for each strategy based on local data & expert input:

Strategy	Case Study Used in CBA	Examples of Impacted Wildlife Species
Promote and Incentivize Rainwater Harvesting	Rainwater Harvesting: cistern installation or retrofit incentives to capture rainwater and provide freshwater to wildlife	Key deer Marsh rabbit
Expand Implementation of Passive Green Infrastructure	Mangrove Restoration	Smalltooth sawfish, manatee, hawksbill sea turtle, and Key Deer rely on this habitat at different life cycle stages; Schaus' swallowtail butterfly Silver rice rat
Incorporating VA into Land Acquisition & Management Strategy	Acquisition of land identified as critical environmental sites	Key deer Marsh rabbit Eastern indigo snake Stock Island tree snail
Implement Living Shorelines Projects in Vulnerable Locations	Living Shorelines	Key deer; Silver rice rat; Key Largo woodrat; Key Largo cotton mouse; Marsh rabbit
Work with Partner Agencies to Restore Wetlands	Wetland Restoration	Stock Island tree snail; Key deer; Silver rice rat Schaus' swallowtail butterfly Key Largo woodrat Key Largo cotton mouse Marsh rabbit





Decision Rules

- Ecological factors including:
 - 1. NOAA Sea Level Rise (SLR) & SLAMM data show the location will still be viable in 2040;
 - 2. potential hydrologic or other connectivity is compatible with the intended strategy; and
 - 3. input from scientists currently studying natural resource adaptation strategies for the Keys.

Site Identification

- Used decision rules to identify pool of potential candidate sites for each adaptation strategy.
- CBA was conducted across all candidate sites that were identified for each adaptation strategy.



Strategy	Candidate Sites
Rainwater Harvesting	110
Land Acquisition	44
Wetland Restoration	76
Green Infrastructure/ Mangrove Restoration	843
Living Shorelines	1,718

Land Acquisition

Benefits > Costs in all 44 candidate sites

5.85	Average BCR
\$65 Million	Total Benefits
\$13.9 Million	Total Costs

Candidates:

• Proposed for state acquisition; not already managed for conservation by public or other entities; and still intact per NOAA 2040 SLR & SLAMM.

Costs & Benefits:

- Costs = per-acre state land acquisition costs
- Benefits = public willingness to pay (WTP) for T/E species habitat protection and forest ecosystems

Findings:

• Benefit-Cost Ratios vary across Upper/Lower Keys





Rainwater Harvesting

Candidates:

 Reverse of wetland selection with salinity data per USFWS GIS; non-federal ownership; intact per NOAA 2040 SLR & SLAMM; and random selection based on annual local cistern incentive program uptake.

Costs & Benefits:

- Costs = Local aqueduct authority cistern incentive program payments & mosquito control monitoring costs
- Benefits = Public WTP for T/E species habitat and avoided flooding costs provided by cisterns.

Findings:

- High BCRs and very low costs
- According to ecological experts, one of the most urgent strategies for protection of T/E wildlife species such as the Key deer, marsh rabbit, and others.



Source: TBG work product.

Benefits > Costs in all 110 candidate sites

4.81	Average BCR
\$3.7 Million	Total Benefits
\$874,000	Total Costs



Wetland Restoration

Candidates:

 Undeveloped/open space properties; connected to existing wetland or one parcel removed on a named island; intact per NOAA 2040 SLR & SLAMM; aggregated minimum 0.25 acres in size

Costs & Benefits:

- Costs = per-acre wetland restoration costs in the Keys with construction cost multiplier applied (e.g., costs of construction are highest in the Lower Keys)
- Benefits = public WTP for coastal ecosystem and forest ecosystem services.

Findings:

- Highest BCRs found in Upper Keys where construction costs are lower, and where direct connectivity with existing wetlands exists
- Lowest BCRs found in non-forested Lower Keys parcels where restoration sites are further from current existing wetlands



Source: TBG work product.

Benefits > Costs in 58 of 76 candidate sites	
1.54	Average BCR
\$1.2 Million	Total Benefits
\$780,000	Total Costs



Green Infrastructure

Candidates:

 Undeveloped properties or open space connected w/in 25m to existing mangroves; intact per NOAA 2040 SLR and SLAMM; minimum aggregated size 0.25 acres.

Costs & Benefits:

 Assigned characteristics based on current shoreline condition and assigned tiered costs & benefits per current condition & compatible treatment: 1) fully green, 2) hybrid and 3) gray based on discussion with local aquatic restoration experts.

Findings:

- Lower BCRs found where shoreline primarily man-made and/or with rip-rap and existing mangroves
- Higher BCRs found where shoreline has beach and vegetated shoreline with existing mangroves.



Source: TBG work product.

Benefits > Costs in 777 of 843 candidate sites

3.34	Average BCR
\$229 Million	Total Benefits
\$134 Million	Total Costs



Living Shorelines

Candidates:

 County-owned or underdeveloped properties; connected to existing salt marsh or one parcel removed; intact per NOAA 2040 SLR & SLAMM; minimum shoreline length 100 ft; minimum size 0.25 acres.

Costs & Benefits:

- Costs = Keys living shoreline construction costs, adjusted for Keys construction multiplier
- Benefits = Protection from storms for adjacent habitats and open spaces; public WTP for ecosystem services.

Findings:

- Parcels with larger areas have higher BCRs
- There is little geographic variation throughout the Keys in cost-effectiveness of this strategy



Source: TBG work product.

Benefits > Costs in 1,703 of 1,718 candidate sites

3.07Average BCR\$202 MillionTotal Benefits\$62 MillionTotal Costs



Overall CBA Results

Strategy	Total Benefits	Total Costs	Net Benefits
Rainwater Harvesting	\$ 3.7 M	\$ 0.87 M	\$ 2.86 M
Land Acquisition	\$ 64.6 M	\$ 13.9 M	\$ 50.7 M
Wetlands	\$ 1.2 M	\$ 0.78 M	\$ 0.42 M
Green Infrastructure	\$ 228.7 M	\$ 134.2 M	\$ 94.4 M
Living Shoreline	\$ 202.0 M	\$ 61.9 M	\$140.2 M
Totals	\$ 500.2 M	\$ 211.6 M	\$ 288.6 M

Source: TBG work product.



Summary of Findings

 CBA provides guidance in prioritizing strategies and specific sites for natural resource adaptation • Upper Keys candidate sites are smaller in area, generating fewer ecosystem services relative to their Lower Keys counterparts

- High BCRs, low costs
 Considered one of the most urgent strategies for the protection of wildlife species by ecologists
- Freshwater wetlands are critical habitat for several species; vulnerable to SLR
- Site specifics drive BCR results

Overall

Land Acquisition

Rainwater harvesting Wetland Restoration

 Mangroves provide wide array of benefits for habitat protection & resilience
 Site specifics drive BCR results

- Provide valuable habitats and stabilize shoreline to enhance resilience
- Scale drives BCR results

Green infrastructure Living Shorelines

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Transferability to Washington Coast

 CBA provides guidance in prioritizing strategies and specific sites for natural resource adaptation • Strategic land acquisitions could protect vulnerable habitats, preserving biodiversity while serving as a buffer against storm surges and erosion. Many coastal communities rely on rainwater collection
Improve freshwater security on each island.
Currently a high reliance on

 Currently a high reliance on desalination Restoring stream corridors will slow the rate of water warming and reduce nutrients in marine habitats.
False Bay Watershed and other areas would benefit.
Excess nutrients and 'green tide' currently impact the area

Overall

Land Acquisition

Rainwater harvesting

Wetland Restoration

Native vegetation
Could help reduce coastal erosion and improve water quality in Washington's coastal communities. • Shoreline restoration will help salmon populations and wildlife diversity across the region.

• The Islands' shorelines and nearshore environmental provide vital spawning and rearing areas for herring, surf smelt, and other wildlife.

Green infrastructure

Living Shorelines

Recommendations



Finding	Florida Recommendation	Coastal Washington Application
Rainwater Harvesting	Consider prioritizing new rainwater harvesting incentive program	Continue implementing rainwater harvesting incentives; investment in storage infrastructure & filtration technology.
SLAMM Projections	Carefully consider predicted shoreline conditions in prioritizing current to near-term projects, due to projections of significantly altered shoreline shape and location	Use predictive shoreline modeling tools; Predictive modeling, particularly the Coastal Storm Modeling System (CoSMoS), to understand sea level rise by simulating future scenarios of coastal flooding and other related impacts, including changes in extreme water levels
Habitat Corridors	Consider strategies on a corridor rather than parcel basis; recognize that CBA results treat corridor results rather than site-specific results for most strategies	Emphasize large-scale habitat connectivity rather than isolated projects (ensuring that adaptation projects provide long-term ecological benefits).
"Keys Factor" Construction Costs	Carefully consider CBA results relative to site selection for implementation-cost-heavy strategies	Consider both economic feasibility and logistical constraints of remote and often roadless communities; ensure adaptation projects are prioritized for communities at highest risk
Shoreline Analysis	Carefully consider CBA results and specific shoreline conditions for site selection in living shoreline and mangrove restoration site selection decisions	Utilize detailed shoreline erosion mapping to guide the placement of projects involving kelp forests, salt marshes, and sediment trapping structures
Land Acquisition	Larger, forested areas tend to provide greater ecosystem services benefits	Focus on preserving intact streams, wetlands, and coastlines that offer critical ecosystem services.

Thank you for participating! Contact us with questions:

Amy Bainbridge

abainbridge@balmoralgroup.us | 206-600-4197

