Cost-Effectiveness of Natural Resource-Based Adaptation Strategies in the Florida Keys

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Presentation Outline

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BACKGROUND & RESEARCH OBJECTIVES

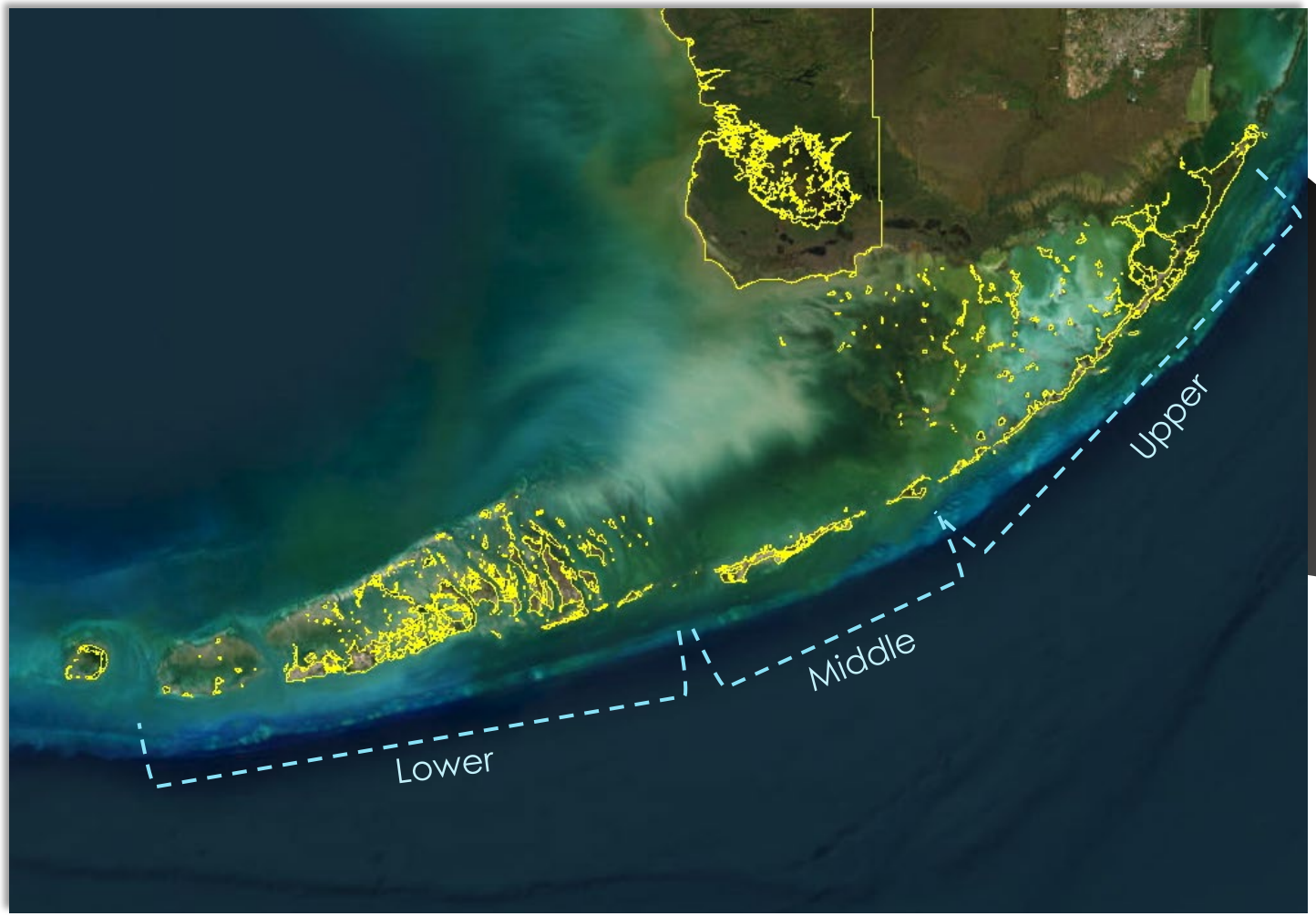
Research Motivation & Objectives

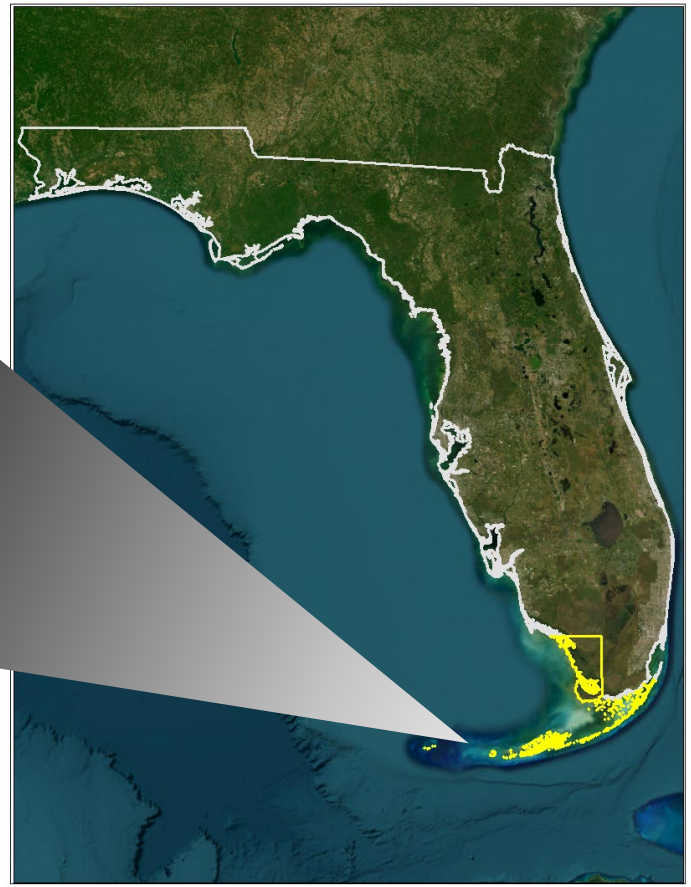
The Florida Keys (Monroe County) is home to **unique ecosystems** that are experiencing **impacts from climate change and sea level rise**.

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.

Study Area: Monroe County/Florida Keys





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: Habitat Change

SLAMM Output - County wide acres of land area; "present" is cross walk from FWC CLC Nov - 2019 to SLAMM NWI categories.

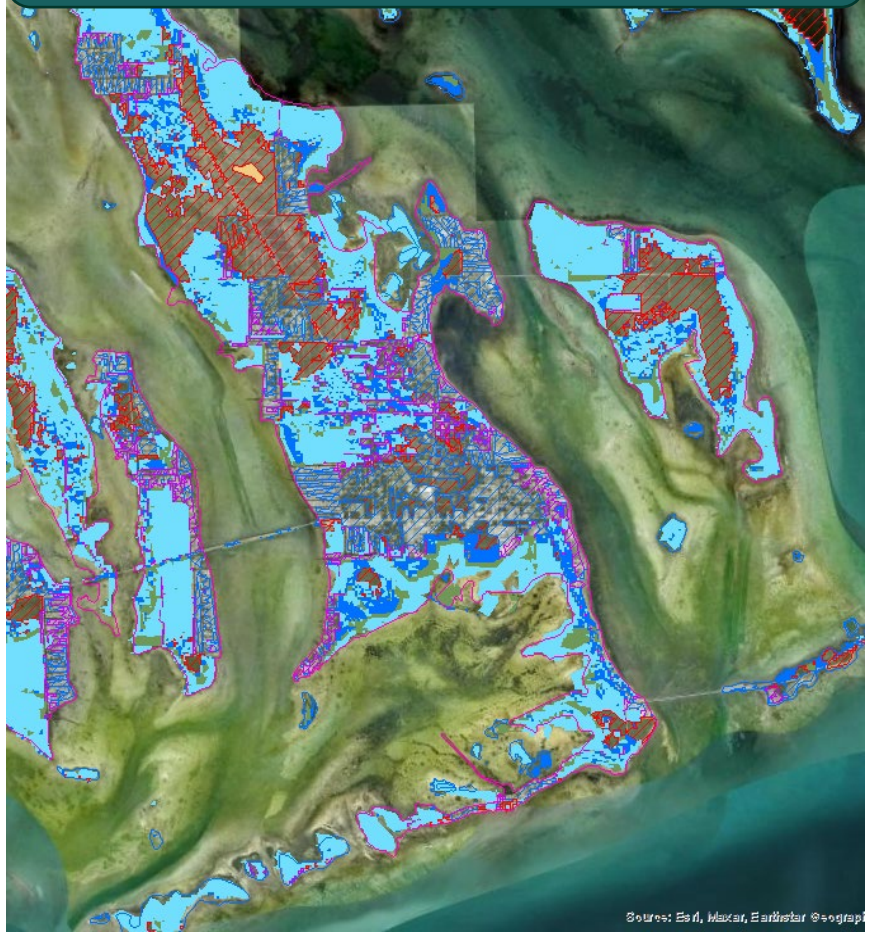
Habitat Type	Present	2040	Change	2070	Change from Present	Change from 2040	2100	Change from Present	Change from 2070
Developed Dry Land	18117.0	15650.2	-14%	9457.7	-48%	-40%	4660.3	-74%	-70%
Undeveloped Dry Land	13885.0	8441.5	-39%	4607.6	-67%	-45%	2243.0	-84%	-73%
Swamp	35076.6	160.0	-100%	61.8	-100%	-61%	36.5	-100%	-77%
Cypress Swamp	31795.3	15.1	-100%	0.1	-100%	-99%	0.0	-100%	-100%
Inland-Fresh Marsh	147827.4	788.3	-99%	68.3	-100%	-91%	25.0	-100%	-97%
Trans. Salt Marsh	0.0	452.1		67.8		-85%	1190.9		163%
Mangrove	342369.1	240306.2	-30%	24375.0	-93%	-90%	15148.5	-96%	-94%
Tidal Flat	3591.7	570.9	-84%	194.3	-95%	-66%	1025.7	-71%	80%
Ocean Beach	122.3	111.4	-9%	57.0	-53%	-49%	25.2	-79%	-77%
Rocky Intertidal	7978.6	3555.5	-55%	790.0	-90%	-78%	203.7	-97%	-94%
Inland Open Water	573.6	195.7	-66%	86.7	-85%	-56%	56.4	-90%	-71%
Estuarine Open Water	17664.2	314304.0	1679%	538375.5	2948%	71%	548125.6	3003%	74%
Open Ocean	1596.4	1809.3	13%	2013.5	26%	11%	2097.3	31%	16%
Irreg.-Flooded Marsh	0.0	0.4		0.0		-100%	0.4		-8%
Tidal Swamp	15.1	4.5	-70%	2.4	-84%	-47%	1.0	-93%	-77%
Flooded Developed Dry Land	0.0	2466.8		8659.2		251%	13456.7		446%
Flooded Forest	0.0	31780.2		31795.2		0%	31795.3		0%
Aggregated Non Tidal	32002.0	26558.5	-17%	22724.5	-29%	-14%	20359.9	-36%	-23%
Freshwater Non-Tidal	214699.3	963.5	-100%	130.2	-100%	-86%	61.5	-100%	-94%
Open Water	19834.1	316309.0	1495%	540475.7	2625%	71%	550279.4	2674%	74%
Low Tidal	11692.6	4237.8	-64%	1041.3	-91%	-75%	1254.6	-89%	-70%

Source: Monroe County 2021 Vulnerability Assessment

SLAMM Example: Big Pine Key

Current

2040



Source: TBG work product; NOAA SLAMM data.

Keys Natural Resource Adaptation Strategies

Monroe County's 2021 VA identified the following natural resource adaptation strategies:

Promote and Incentivize Rainwater Harvesting	Expand Implementation of Passive Green Infrastructure	Incorporate VA into Overall Land Acquisition and Management Strategy	Implement Living Shoreline Projects in Vulnerable Locations	Work with Partner Agencies to Restore Wetlands
Strategy Examples:				
Increase onsite retention of rainwater for beneficial reuse	Trails, swales, wet retention areas, to provide aesthetic amenities as well as flood protection	Address changing habitat types with "migration" landwards	Harmonizing natural resource restoration and resiliency adaptation strategies	Provide more resilient habitats for listed species, slow floodwater, and improve water quality

Source: Monroe County 2021 Vulnerability Assessment

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

COST-BENEFIT ANALYSIS (CBA) RESULTS

Land Acquisition

Rainwater Harvesting

Wetland Restoration

Green Infrastructure

Living Shorelines

Land Acquisition

Benefits > Costs in all 44 candidate sites

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

Source: TBG work product.

Candidates:

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

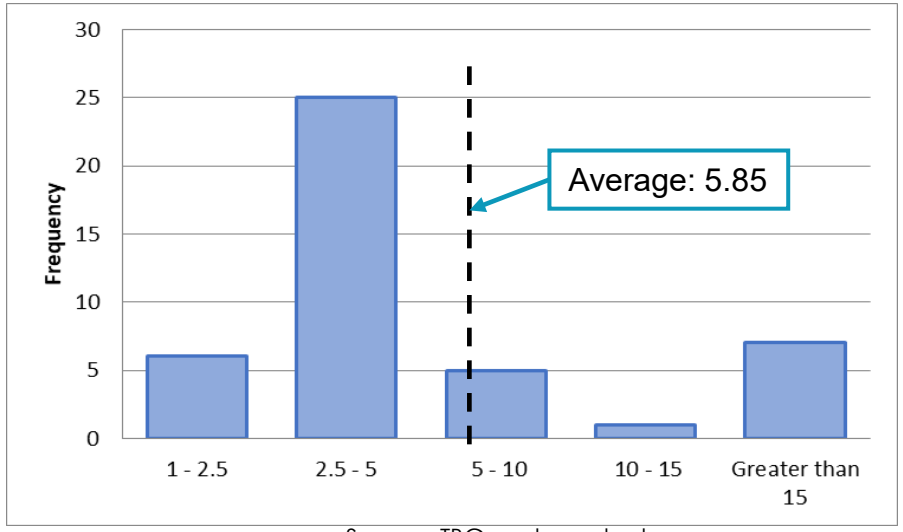
Costs & Benefits:

- 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

Project Benefit-Cost Ratios (BCR)



Source: TBG work product.

T/E = Threatened or Endangered

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

USFWS = U.S. Fish & Wildlife Service

Wetland Restoration

Candidates:

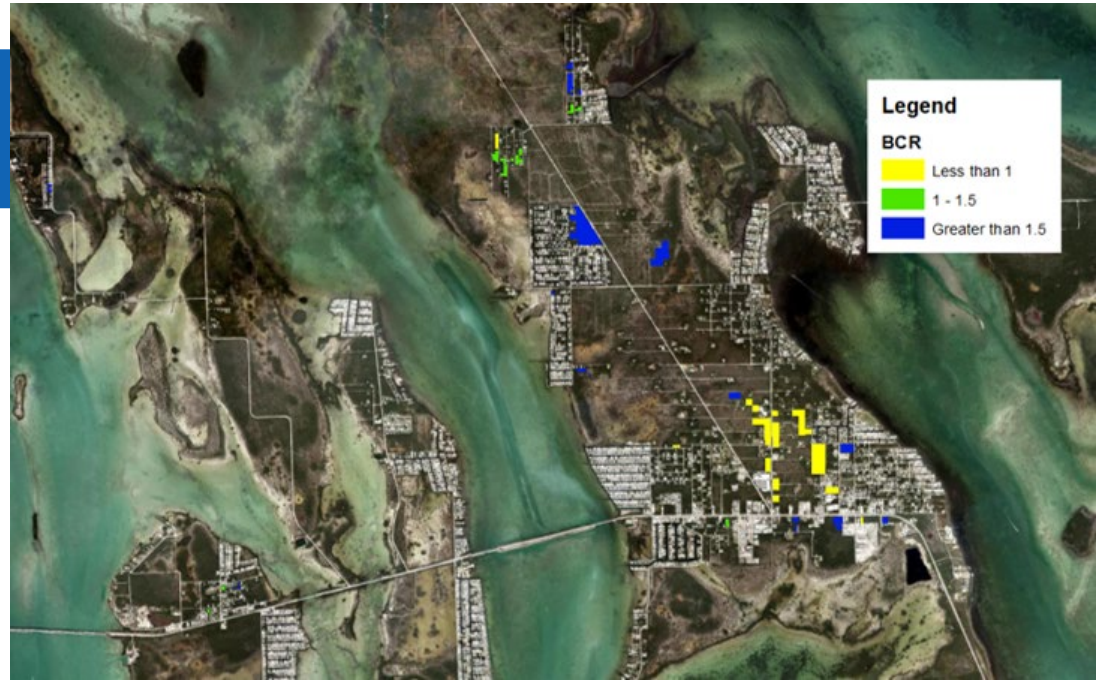
- Undeveloped/open space properties; connected to existing wetland or one parcel removed on a named island; intact per NOAA 2040 SLR & SLAMM; aggregated minimum 0.25 acres in size

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, & forested systems 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:

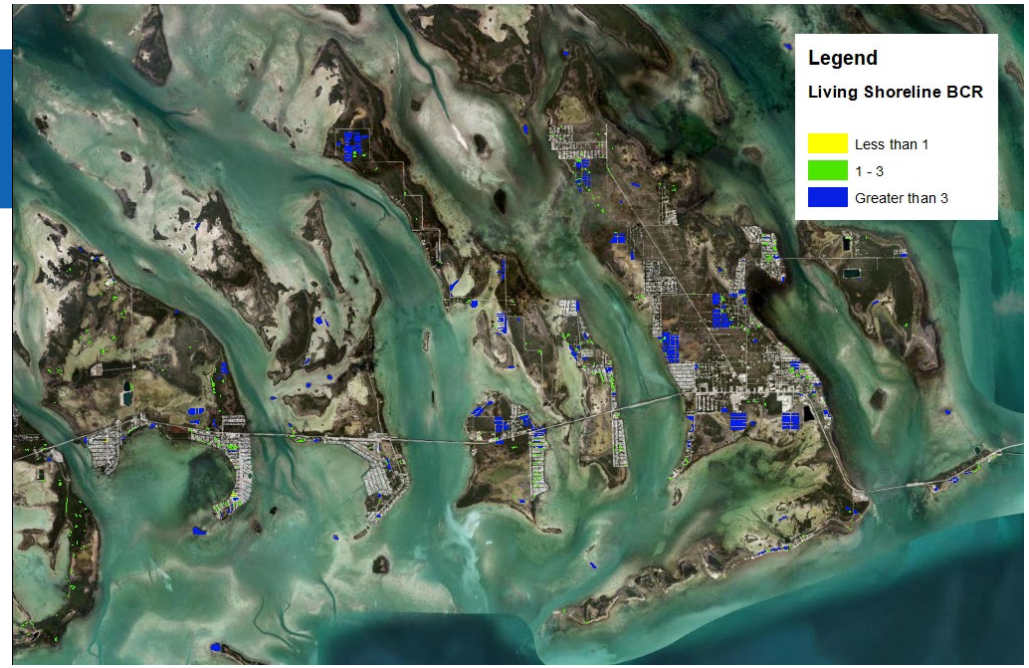
- County-owned or underdeveloped properties; connected to existing salt marsh or one parcel removed; intact per NOAA 2040 SLR & SLAMM; minimum shoreline length 100 ft; minimum size 0.25 acres.

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

3.07	Average BCR
$202 Million	Total Benefits
$62 Million	Total 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.

FINDINGS AND RECOMMENDATIONS

Summary of Findings

- CBA provides guidance in prioritizing strategies and specific sites for natural resource adaptation

Overall

- Upper Keys candidate sites are smaller in area, generating fewer ecosystem services relative to their Lower Keys counterparts

Land Acquisition

- High BCRs, low costs
- Considered one of the most urgent strategies for the protection of wildlife species by ecologists

Rainwater harvesting

- Freshwater wetlands are critical habitat for several species; vulnerable to SLR
- Site specifics drive BCR results

Wetland Restoration

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

Green infrastructure

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

Living Shorelines

Recommendations

Finding	Recommendation
Rainwater Harvesting	Consider prioritizing new rainwater harvesting incentive program
SLAMM Projections	Carefully consider predicted shoreline conditions in prioritizing current to near-term projects, due to projections of significantly altered shoreline shape and location
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
"Keys Factor" Construction Costs	Carefully consider CBA results relative to site selection for implementation-cost-heavy strategies
Shoreline Analysis	Carefully consider CBA results and specific shoreline conditions for site selection in living shoreline and mangrove restoration site selection decisions
Land Acquisition	Larger, forested areas tend to provide greater ecosystem services benefits

Source: TBG work product.

THANK YOU!
QUESTIONS?

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