ADAPTING TO CLIMATE CHANGE IN COASTAL NATIONAL PARKS: ESTIMATING THE EXPOSURE OF ALL PARK ASSETS TO 1M OF SEA-LEVEL RISE

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High exposure results listed by asset type.

Historic: > 50 years old

Introduction & Purpose

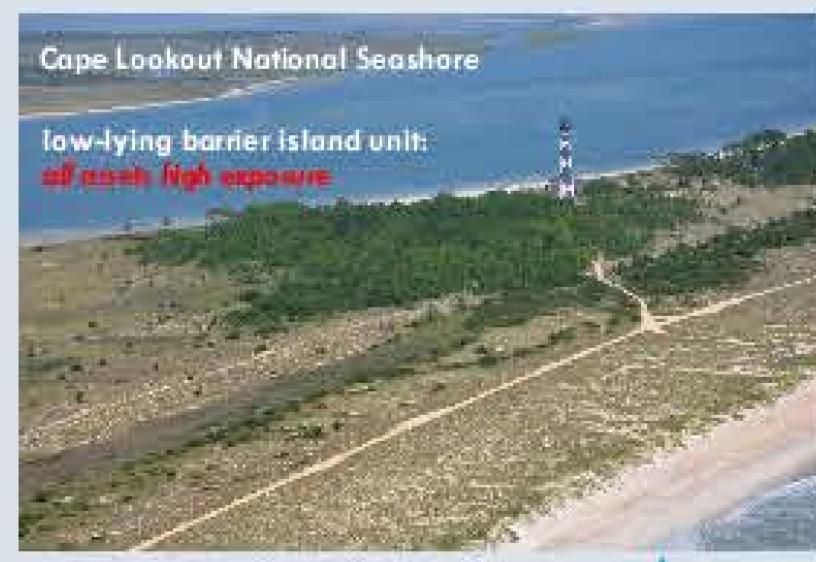
Over the next century, warming global temperatures will present many challenges for the National Park Service (NPS) & public land managers. Rising sea level will be one of the most obvious & challenging impacts of this warming. Even a minor increase in sea level will have significant effects on coastal hazards, natural resources & assets within national parks.

To begin addressing these climate related issues, the Program for the Study of Developed Shorelines (PSDS) at Western Carolina University (WCU) has partnered with NPS to assess the vulnerability of infrastructure within coastal national parks. This collaborative project has focused on identifying NPS assets that may be threatened by a future 1 m rise in sea level, which can be expected to occur in the next 100 to 150 years. These data will be used to provide a "big picture" view of what is at risk in coastal parks in terms of the types of assets (civil war forts to hiking trails) & the overall replacement value of the assets at risk.



Methods & Analysis

This project utilized an existing NPS database Facilities Management Software System; FMSS) containing a comprehensive list of assets within each unit. There are >10,000 assets within these 40 coastal units. A variety of methods were used to assess the exposure of each asset to SLR including the acquisition of existing digital datasets, collaboration with park staff & field visits. Below is the summary of these methods.



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Broad Categorization of Extremely Low Elevation Units

 Several low lying (often barrier island) units were considered all high exposure • Primarily southeast & gulf coasts units already at risk to storms & coastal hazards

2) "First-Cut" of Assets in High Elevation Units

- Utilized FMSS Location Hierarchy to eliminate entire groups of assets within "areas" of high elevation
- Primarily units on west coast
- 80 % of assets at OLYM are in high elevation zones

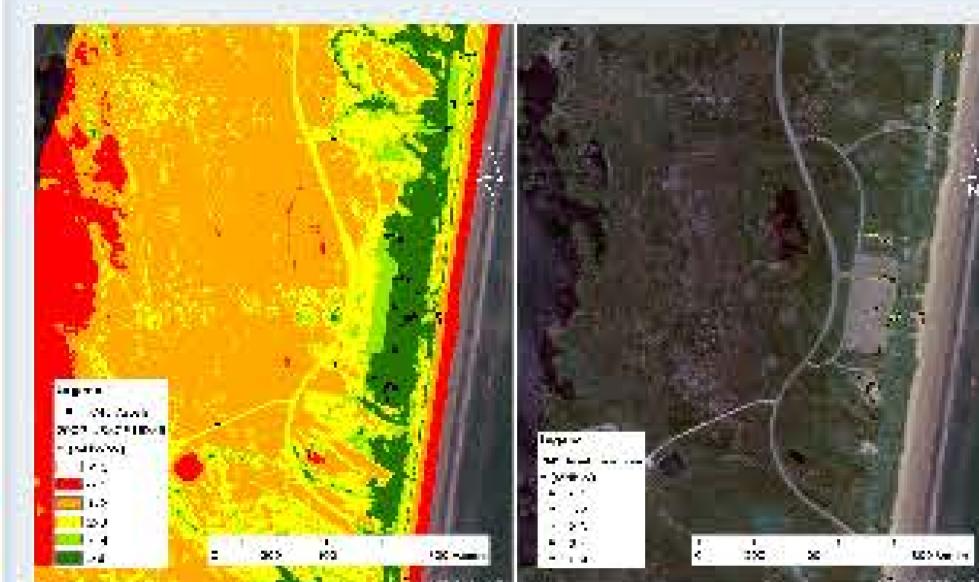
located & analyzed for exposure

3) Park Visits & Field Work

 GPS coordinates taken (if possible) & initial estimate of exposure based on discussion with NPS staff & field observations

4) GIS Analysis of Assets

* Elevation of assets within each applicable unit determined using GIS (geospatial & elevation data)



PAIS exposure analysis example. A) LIDAR DEM of a portion of PAIS & asset locations. B) Color coded assets for the same area based on elevations obtained from LiDAR DEM.

Categorization of Assets: High or Limited Exposure to SLR

- Assets placed into one of two
- categories, based on data, analysis & expertise
 - 1) High exposure
 - 2) Limited exposure

Sumi	mary	of	data	sources	for SLR	exposure a	nalys
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Data Type	Common Source(s)
LIDAR DEM	NOAA USGS USACE, bity and courty
Contour Data	NPSIRMA
GPS data	WCLI- Park visits
Asset geospelial data (e.g., roads, trails)	NPSIRMA
Geospatial buildings data	NPS-Facilities Management GIS Data Manager
Specific asset exposure	NPS staff discussions

FMSS location hierarchy areas for OLYM. Only 3 "areas" from the report are near the coast. All other areas & corresponding assets were automatically considered as having limited exposure to SLR due to elevation & distance from the shoreline.

6) Park Review

- Distributed to regions & units
- A number of units provided asset specific

reviews & recommendations

Results & Discussion

● High Exposure Assets O Limited Exposure Assets

Exposure Breakdown & Groups Low Exposure Group:

•CUIS & PAIS: barrier island parks with higher elevations & widths than similar barrier island units

16 of 40 units in this group
 Most are high elevation PWR & NER units

Intermediate Exposure Group:

- 26-75 % of assets high exposure
- 8 of 40 units in this group
- FIIS & GATE at higher end; both were affected by Hurricane Sandy
- Analysis was completed prior to storm; results likely differ if completed post storm (see Case Study)

High Exposure Group:

- > 75 % of assets high exposure
- 16 of 40 units in this group
- 11 had 100 % high exposure (from
- broad categorization, method 1) Most already at extremely high risk to

Service-Wide Exposure & Risk

CUIS map with LIDAR DEM & asset locations.

Notice the relatively high elevations (green

shades) & the overall width of the island.

- Total analyzed: almost 10,000 assets; worth over \$56 billion (CRV) 39 % of NPS assets were designated high exposure
- Combined value of > \$41 billion (CRV)
- SER has the highest % of assets at risk (87 %)
 - SER assets make up > 85% (\$35 billion) of total value at risk
- PWR & IMR = lowest % of high exposure assets Function of elevation differences between Atlantic & Pacific coasts
- NER = highest percentage of high exposure assets considered historic

Vationa	al & regio	onal SLR expo	sure da	ta results			
minus N	Total A:	ssets Analyzed			High Exposure Res	ults	
Region	# Assets	CRV	# Assets	% Assets	CRV	% of CRV	% Historia
NER	3059	\$10,550,294,321	1030	34%	\$5,149,630,164	49%	21%
SER	2735	\$37,067,371,857	2370	87%	\$35,331,312,364	95%	13%
PWR	3658	\$8,523,420,750	315	9%	\$1,216,515,566	14%	12%
IMR	104	\$86,532,148	14	13%	\$40,920,359	47%	0%
All Units	9556	\$56,227,619,076	3729	39%	\$41,738,378,453	74%	15%

Exposure results for all 40 coastal NPS units.

All Analyzed Assets

Region	Unit	# Assets	CRV	# Assets	% Assets	CRV	% CRV	Exposure Range
	ACAD	584	\$741,643,375	69	12%	\$49,065,405	7%	Low
	ASIS	188	\$141,894,898	179	95%	\$135,180,045	95%	High
	BOHA	143	\$121,763,441	54	38%	\$55,498,822	46%	Intermediate
	BOST	77	\$608,380,029	65	84%	\$408,185,040	67%	High
	CACL	5	\$23,606,659	5	100%	\$23,606,659	100%	High
	CACO	414	\$248,946,088	70	17%	\$51,385,721	21%	Low
	FIIS	228	\$98,806,696	132	58%	\$56,036,479	57%	Intermediate
NER	FOMC	44	\$183,243,495	4	9%	\$77,494,234	42%	Low
	GATE	1089	36,594,927,986	302	28%	\$2,672,440,355	41%	Intermediate
	GEWA	56	\$37,708,870	2	4%	\$4,984,022.67	13%	Low
	GOIS	32	\$153,484,095	11	34%	\$71,223,382	46%	Intermediate
	NEBE	20	n/a	5	25%	n/a	n/a	Low
	SAHI	43	\$41,787,745	4	2%	\$1,122,038	3%	Low
	SAMA	32	\$41,641,700	27	84%	\$30,948,717	74%	High
	STLI	104	\$1,512,459,244	104	100%	\$1,512,459,244	100%	High
	BICY	254	\$1,030,477,750	210	83%	\$41.4,159,499	40%	High
	BISC	68	\$67,913,211	68	100%	\$67,913,211	100%	High
	CAHA	559	\$1,173,309,846	559	100%	\$1,173,309,846	100%	High
	CALO	289	\$878,717,414	289	100%	\$878,717,414	100%	High
	CANA	167	\$88,404,508	167	100%	\$88,404,508	100%	High
	CASA	54	\$26,571,807,938	54	100%	\$26,571,807,938	100%	High
SER	CUIS	204	\$112,431,019	33	16%	\$19,361,490	17.%	Low
PERIOD .	DESO	10	\$3,366,160	10	100%	\$3,366,160	100%	High
	EVER	493	\$657,087,096	493	100%	\$657,087,096	100%	High
	FOPU	52	\$286,318,757	52	100%	\$286,318,757	100%	High
	FOSU	38	\$1,230,735,376	38	100%	\$1,230,735,376	100%	High
	GUIS	436	\$4,938,540,247	355	81%	\$3,930,189,186	80%	High
	TIMU	111	\$28,262,535	42	38%	\$9,941,883	35%	Intermediate
	CABR	55	\$41,741,304	0	0%	50	0%	Low
	CHIS	1,66	\$160,239,240	23	1.4%	\$46,691,845	29%	Low
	FOPO	17	\$208,178,640	5	29%	\$191,161,089	92%	Intermediate
	GOGA	1049	34,934,700,016	114	11%	\$617,570,959	13%	Low
num	LEWI	50	\$33,397,041	35	70%	\$18,047,865	54%	Intermediate
PWR	OLYM	873	\$973,129,278	72	8%	\$37,500,350	4%	Low
	PORE	639	\$739,325,357	25	4%	\$34,929,157	5%	Low
	REDW	490	\$367,895,176	20	4%	\$7,871,075	2%	Low
	SAFR	49	\$901,209,688	21	43%	\$262,743,226	29%	Intermediate
	SAMO	270	\$163,605,010	0	0%	S 0	0%	Low
IMP	PAAL	26	\$9,366,512	0	0%	\$0	0%	Low
IMR	PAIS	78	\$77,165,636	14	18%	\$40,920,359	53%	Low

Asset Types At Risk

- Buildings & parking make up majority of high exposure assets
- Fortifications make up most (over 80 %) of the total value (CRV)

- Function of extremely high CRV of historic features in FMSS

- Fort at CASA: valued in FMSS > \$25 billion
- High value reduces ability to compare other asset types

Analysis Without Forts			high exposure as % of total CRV, v remov	v í th forti	
• Re-analyzed without forts to	Asse	t Description	CRV	% CRV	% Historic
compare other asset types		Building	82,816,396,622,25	37,17%	18%
ildings make up over 37% of the	Mainta	ined Landscape	\$1,668,010,986,25	22.01%	8%
TO THE RESERVE OF THE PARTY OF	Marnall	Vaterfront System	\$1,041,180,713.81	12.74%	12%
CRV of high exposure asset types		Ross	8809,950,504.27	10.69%	7%
	- X	Trax	8452,381,156.18	6.97%	5%

FMSS, NPS Resources & Adaptation

A. FEMA Flood Zones

Legend

All Zone Assets

VE Zone Aspers

b 0.5 1.0 biliometers

VE Zone

AE Zone

Multiple pieces of data & information must be considered for climate change adaptation strategies:

- 1) FMSS asset characteristics: historic nature, asset priority (API), asset condition (FCI), value (CRV)
- 2) Consequences of action: effect strategy may have on other NPS resources, i.e. natural resources
- 3) Park specific enabling legislation & general management plan

Case Study: Hurricane Sandy & GATE

Comparison map of results from Sandy Hook portion of GATE, including FEMA flood zone

82% of assets on Sandy Hook were in FEMA high risk zones

Only 30% of assets were listed high exposure to long-term SLR

NPS must put together national & regional plans for climate change adaptation

B. LiDAR Elevation

non

Overview

 Sandy illustrated that many assets are at a higher risk to short term coastal hazards (i.e., storm surge & erosion) than previously acknowledged. A quick re-assessment was completed with new post-storm FEMA data to provide comparison to the pre-storm SLR exposure results for GATE.

 Method: Using GIS, analyzed # of assets located within the following FEMA flood hazard zones: 1) Special Flood Hazard Risk Area (AE zone) or 2) Coastal High Hazard Area (VE zone).

GATE analysis results

Summarized results from the SLR exposure analysis within original study Assets Total CRV CRV \$6,594,852,975 n/a

High 302 28% \$2,672,440,355 41%

Pre-Sandy SLR exposure analysis = 28 % of the assets high exposure

The second secon			ysis within GATE. Co vere included in this	
	# Assets	% Assets	Total CRV	% CRV
Total Analyzed	986	n/a	\$6,054,494,902.78	n/a

57 % of assets in high risk FEMA zones

Post-Sandy FEMA flood zones analysis =

Case Study Summary

- Vital to understand & consider short term coastal hazards (erosion, storm surge, etc)
- Original SLR exposure analysis likely conservative estimate of assets at risk over next 100 yrs - storm impacts (especially units along east coast) may be more imminent threat

Conclusions & Next Steps

analysis (A) & the SLR exposure analysis (B) for assets within the area

Results from Sandy Hook (portion of GATE)

(HE = high exposure, LE = limited exposure).

in original exposure study



This study provides a broad overview of the high level of exposure to SLR faced by NPS assets- it is not meant to be used directly for decision making at the unit level. Much of the data needed for a more detailed asset specific analysis is not available for many units (at this time). FMSS does contain several pieces of data that can be used for decision making, including an asset's historical nature, priority to the unit, replacement value & overall condition.

We hope this project will bring attention to the need for broader guidance related to climate change adaptation, not only at the park level, but also by the NPS regional & national levels. Two ac projects are currently underway that will continue to build upon this analysis. 1) case studies related to climate change vulnerability & adaptation from NPS coastal parks, which will provide park managers with a suite of adaptation strategies that are currently being implemented to protect vulnerable coastal assets & 2) an extension of this project to analyze the exposure of another 30 coastal units to SLR.















