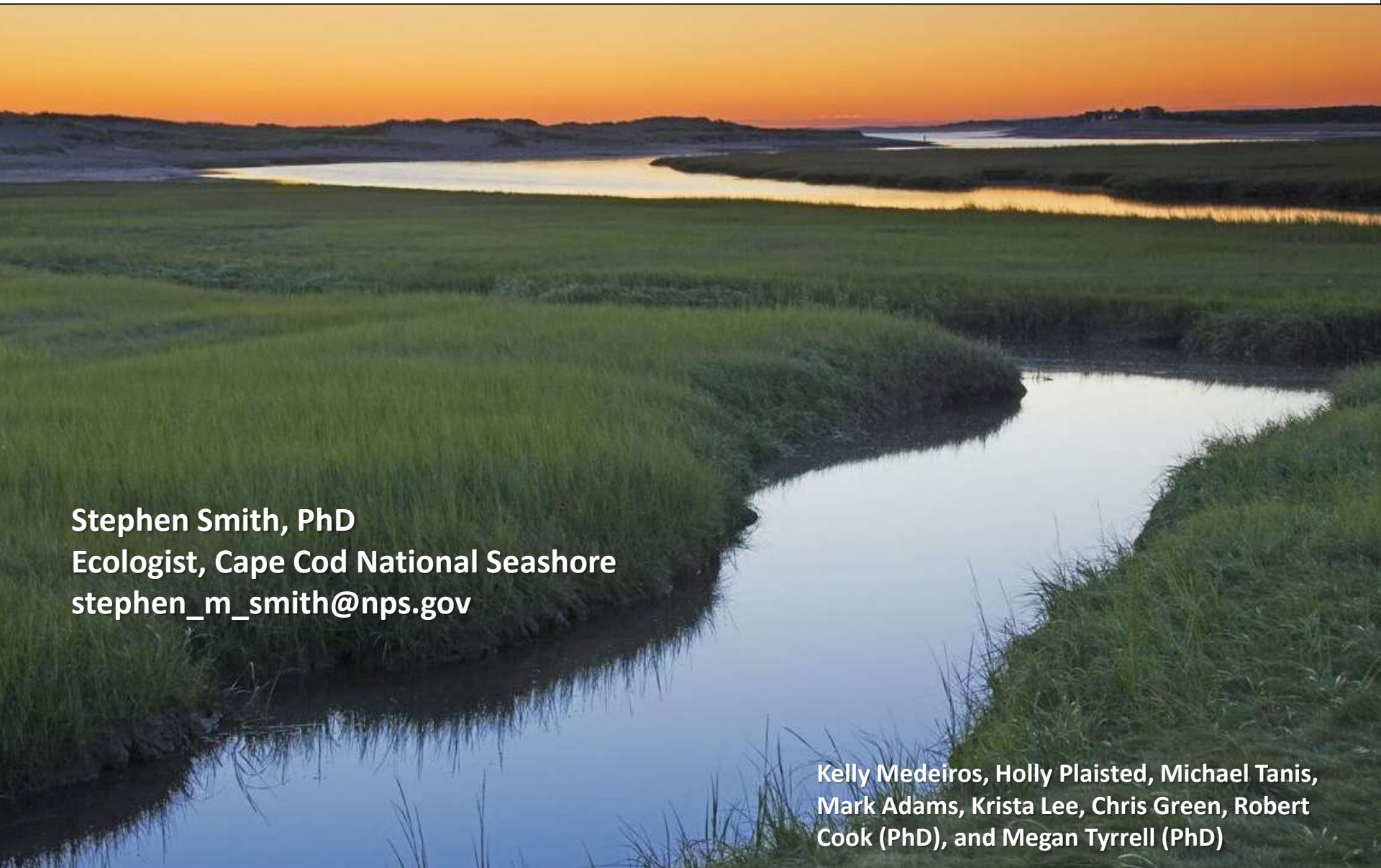
Salt marsh responses to sea level rise: past changes and predictions of future marsh losses and gains



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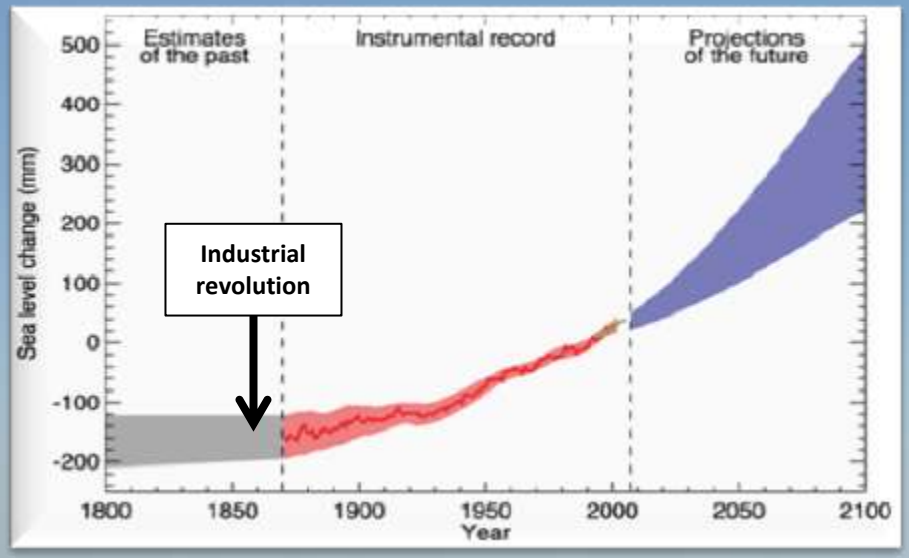


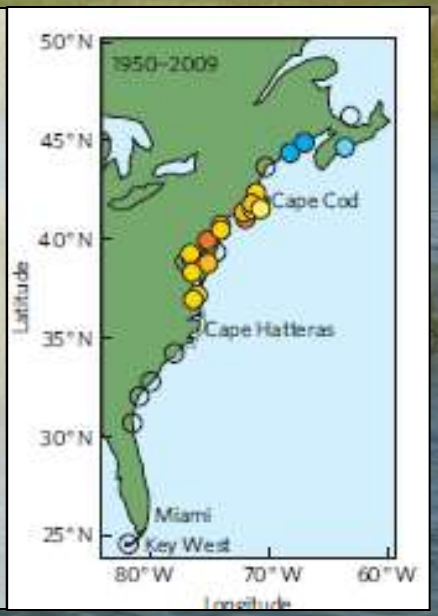
Rapid rise now occurring over last 100 years and accelerating in recent decades

Pre-industrial rate of SLR:
- **~1 mm/year**

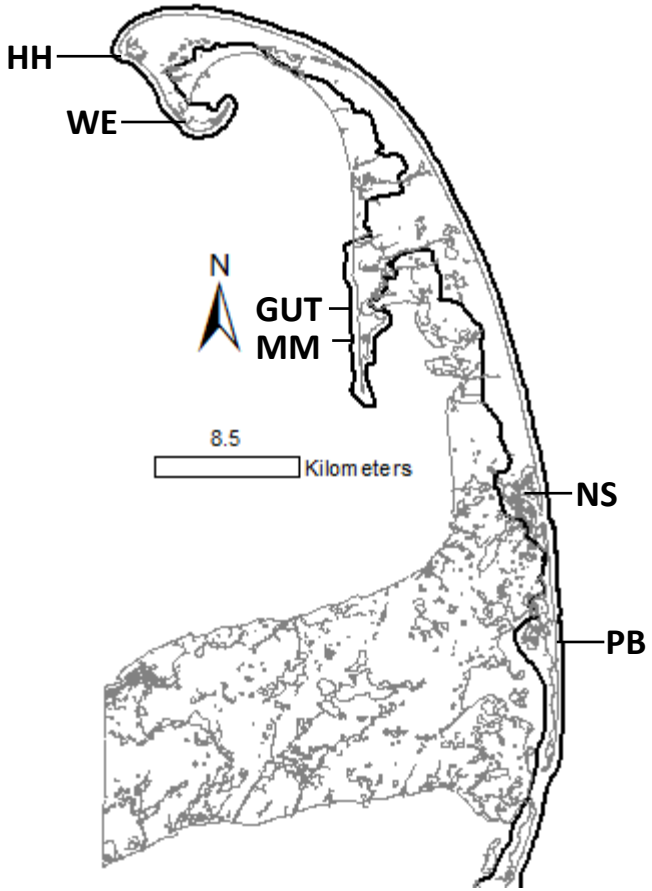
Current rates of SLR:
- **~3 mm/year**

Projected rates of SLR by 2100:
- **~6-11 mm/year**

CACO accretion: 0.8 to 4 mm/yr

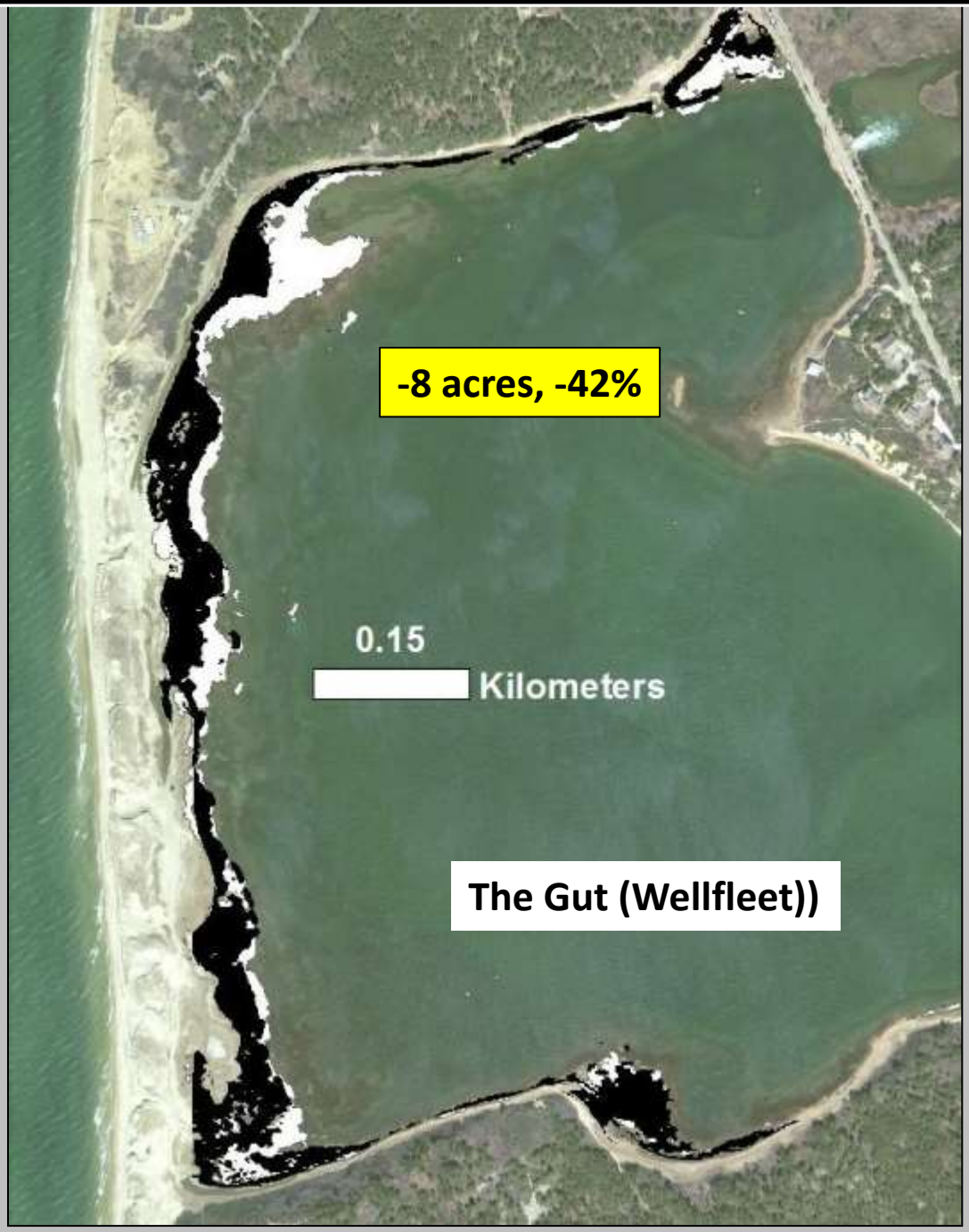


How has salt marsh vegetation changed in CCNS marshes over time?



high marsh 1984

high marsh 2013



high marsh 1984

high marsh 2013

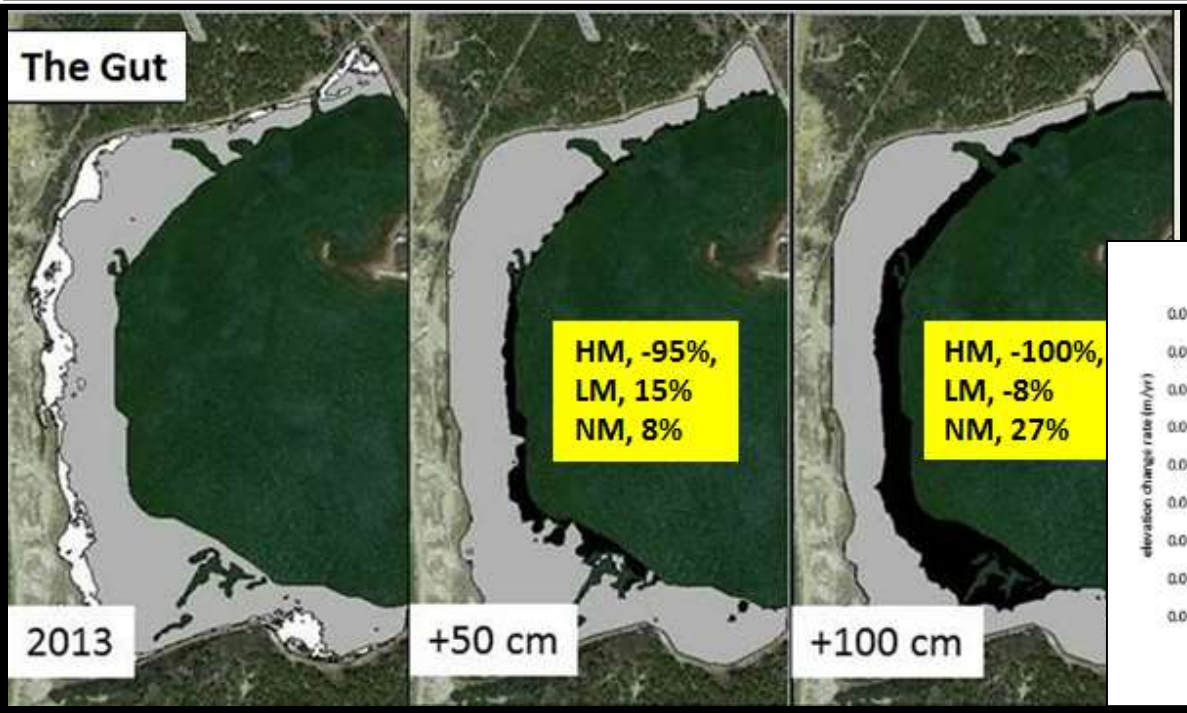
Elevation data collected according to 20 m grid pattern across entirety of marsh

Modeling marsh vegetation change with sea level rise

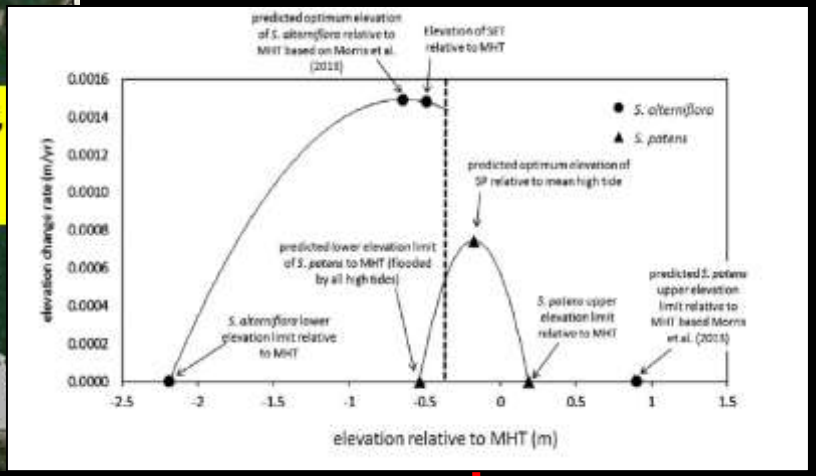
Tide data collected in each marsh

Data interpolated in ARCGIS to create digital elevation model

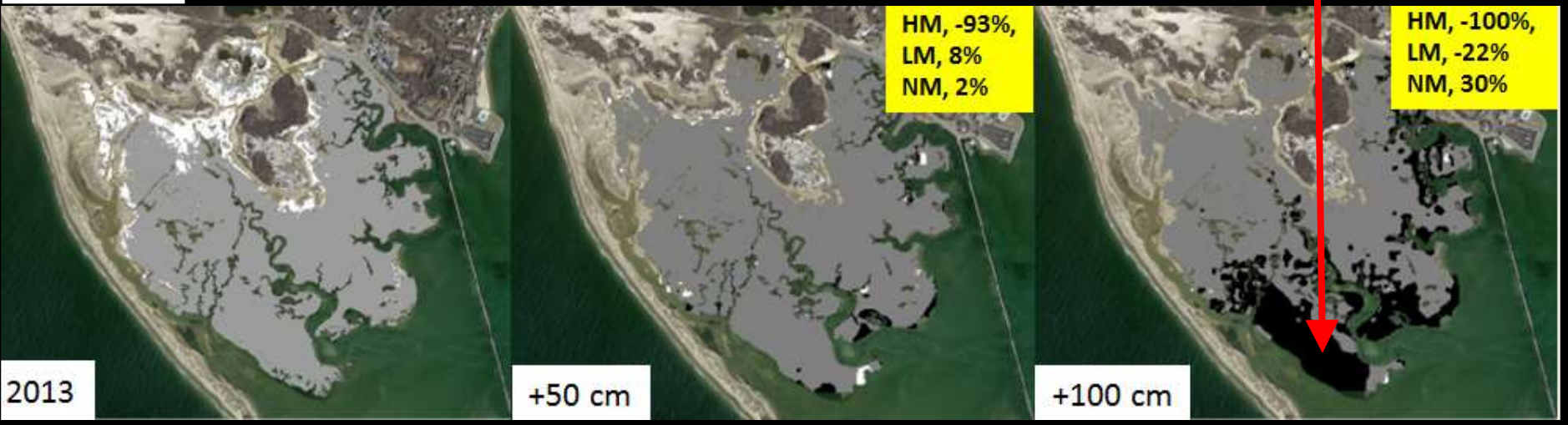
The Gut



Takes into account continued accretion and elevation change



West End



Opportunities for, and limitations on, salt marsh migration in response to SLR

- Average maximum tide heights from Smith et al. (2016)
- Add 1-m SLR, 2-m SLR
- Potential migration area calculated as area between maximum high tide elevation and current marsh

2011 LIDAR-LAS | 1m SLR | 2m SLR

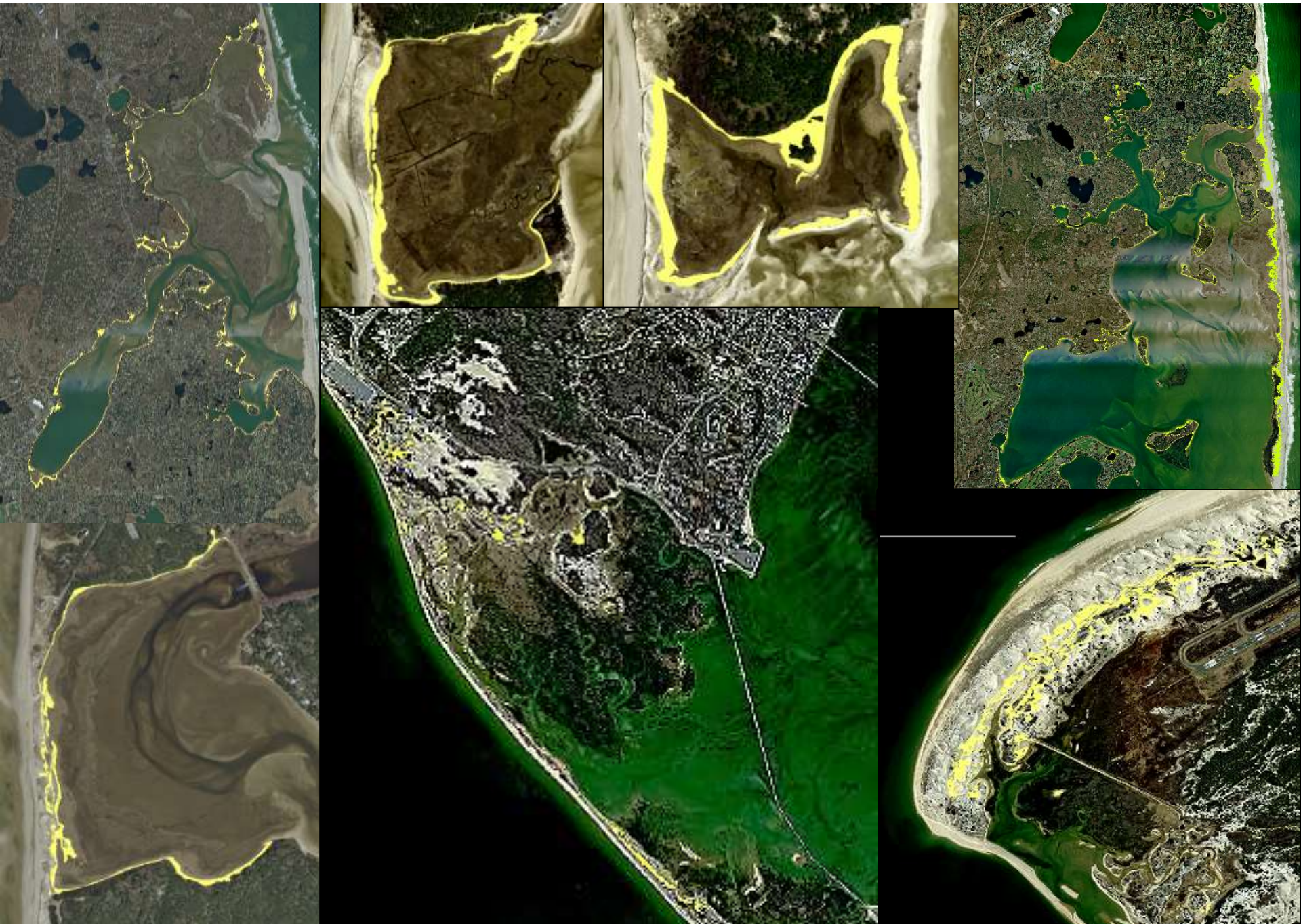
West End marsh - Provincetown

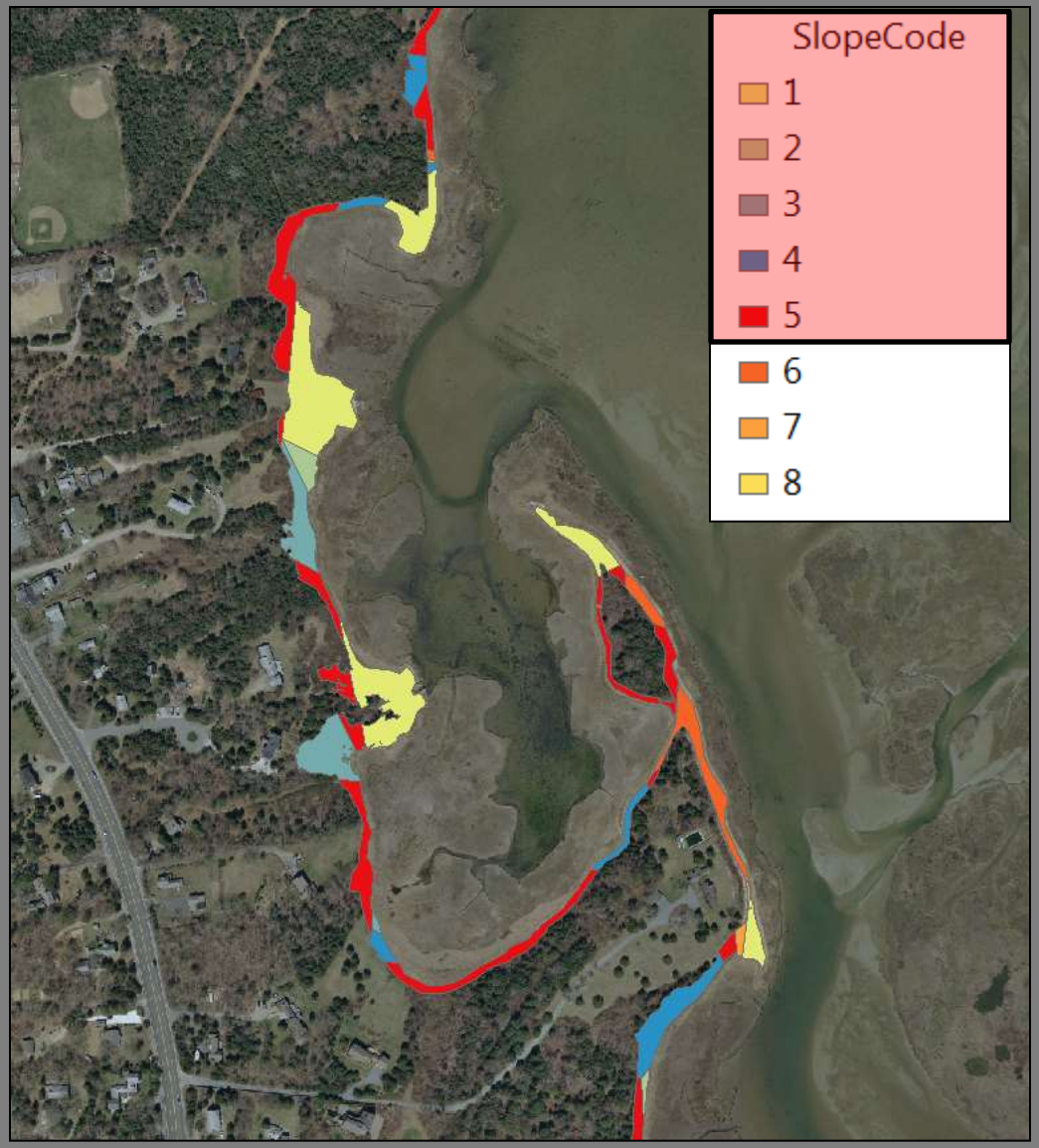
Marsh losses from:

Smith, S.M., M.C. Tyrrell, K. Medeiros, S. Fox, M. Adams, C. Mejia, A. Dijkstra, S. Janson, and M. Tanis. 2016. Hypsometry of Cape Cod Salt Marshes (Massachusetts, USA) and Predictions of Marsh Vegetation Changes in Response to Sea Level Rise. Journal of Coastal Research 33:537–547

JM, MM = losses assumed to be same as Gut
NS = calculated based on Smith et al. (2016) methods using new elevation data at 13%


West End marsh,
Provincetown
Potential areas for migration

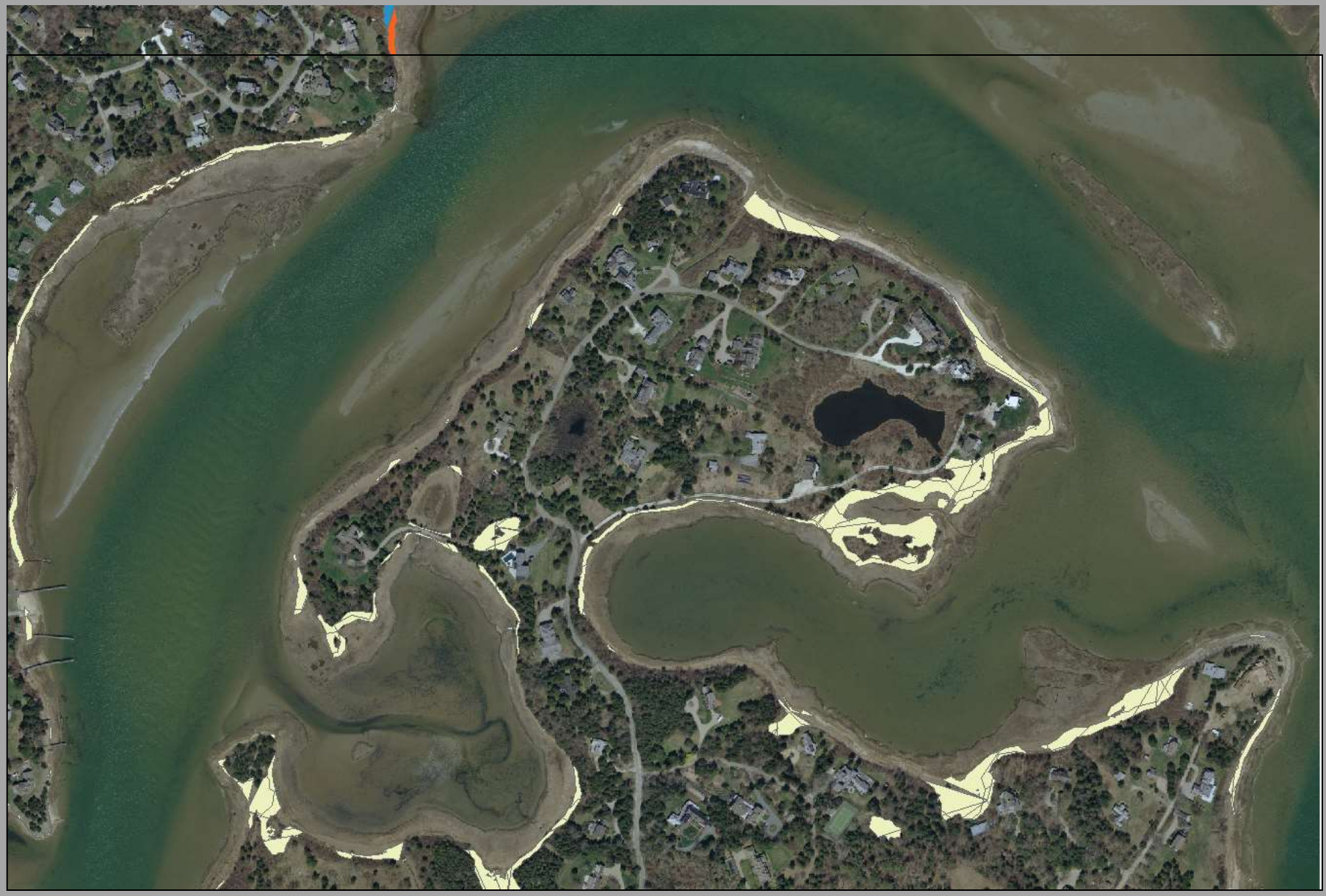




Slopes > 5% are extremely limiting (Brinson et al. 1995, Torio and Chmura 2013).

LU05_DESC

- Brushland/Successional
- Commercial
- Forest
- Forested Wetland
- Low Density Residential
- Marina
- Medium Density Residential
- Multi-Family Residential
- Non-Forested Wetland
- Open Land
- Participation Recreation
- Pasture
- Saltwater Sandy Beach
- Saltwater Wetland
- Very Low Density Residential
- Water
- Water-Based Recreation



Elimination of “hardscape” and steep slopes

Unimpeded migration

	marsh area 2013 (m^2)	potential migration area (m^2)	% migration relative to current marsh area (m^2)	SM loss w/ 100 cm SLR (m^2)	Unimpeded migration (m^2)	% original
GU	131004	24989	19%	35371	120622	92%
HH	408735	186186	46%	94009	500912	123%
JM	42552	14563	34%	11489	45626	107%
MM	224810	23575	10%	60699	187686	83%
NS	2953828	316379	11%	392859	2877348	97%
PB	3892168	1081353	28%	311373	4662147	120%
WE	618999	100721	16%	185700	534021	86%
Totals	8272095	1747766	21%	1091500	8928362	**108%**

Limited by land use and slopes

	Natural area (m^2)	Natural area with slopes <5° (m^2)	Area of structures (m^2)	Natural area with slopes <5° minus structures (m^2)	Corrected (m^2)	% original
GU	24989	21452	0	21452	117085	89%
HH	186186	176454	0	176454	491179	120%
JM	14563	13583	0	13583	44646	105%
MM	23575	20740	0	20740	184851	82%
NS	298427	247075	3323	243753	2804722	95%
PB	1130542	981573	8927	972646	4624201	119%
WE	158061	89955	0	89955	523254	85%
Totals	1836344	1550831	12249	1538582	8789939	**106%**

Limited by slopes > 1%

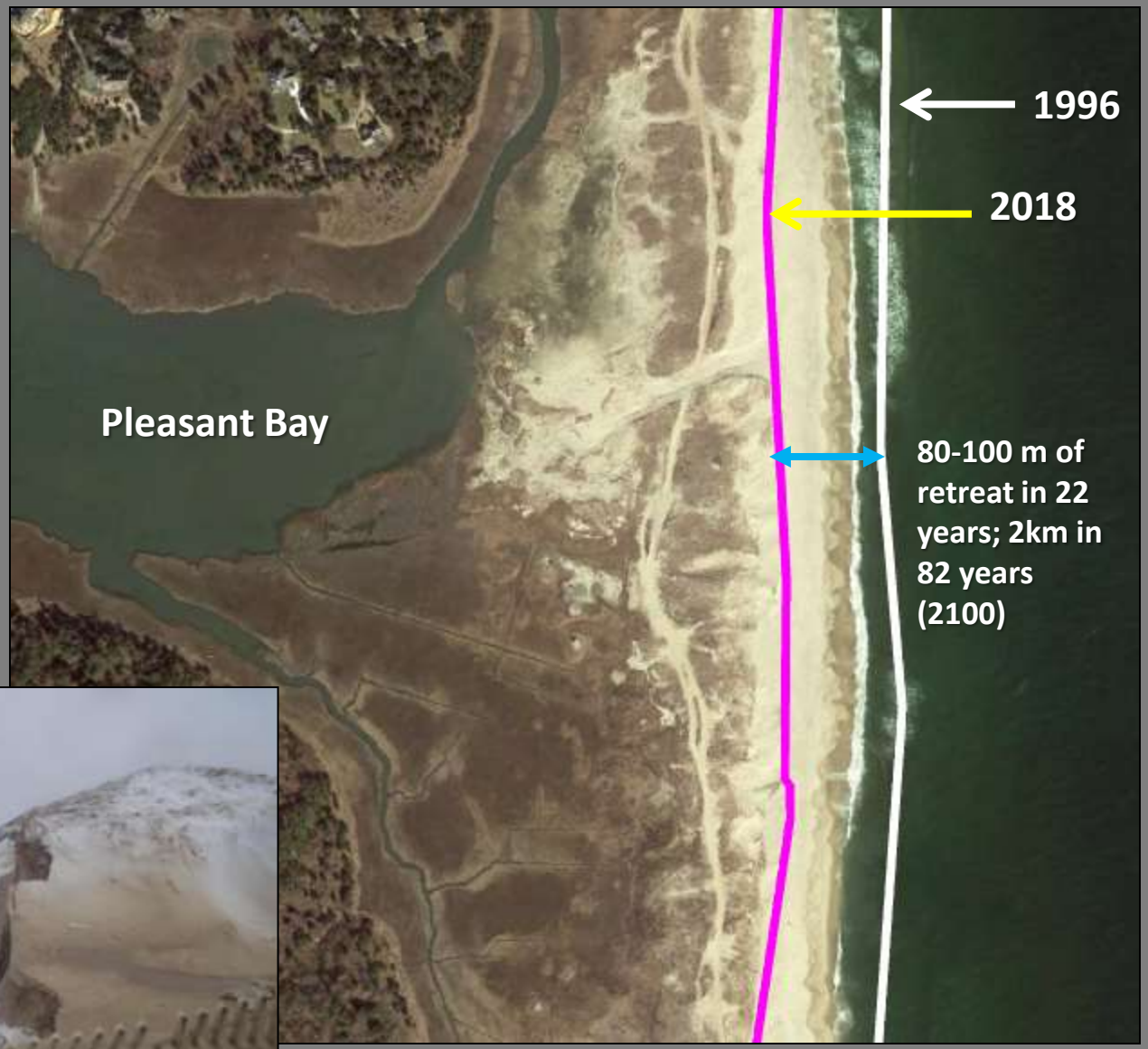
	Natural area (m^2)	Natural area with slopes < 1° (m^2)	Area of structures (m^2)	Natural area with slopes < 1° minus structures (m^2)	Corrected (m^2)	% original
GU	24989	3513	0	3513	99146	76%
HH	186186	30556	0	30556	345281	84%
JM	14563	2616	0	2616	33679	79%
MM	23575	7369	0	7369	171481	76%
NS	298427	42762	3323	39439	2600408	88%
PB	1130542	388178	8927	379251	4030807	104%
WE	158061	13646	0	13646	446945	72%
Totals	1836344	488640	12249	476390	7727747	**93%**

Loss of barrier beach

5% slopes	BB portion of migration area	% total migration area	Corrected (m2)	% original
GU	14994	60%	102091	78%
HH			491179	120%
JM	4317	30%	40329	95%
MM	10704	45%	174147	77%
NS	31981	11%	2772741	94%
PB	593132	52%	4031069	104%
WE	18034	11%	505220	82%
Totals	673162	37%	8116777	**98%**

1% slopes	BB portion of migration area	% total mig area	Corrected (m2)	% original
GU	14994	60%	84152	64%
HH			345281	84%
JM	4317	30%	29362	69%
MM	10704	45%	160777	72%
NS	31981	11%	2568427	87%
PB	593132	52%	3437675	88%
WE	18034	11%	428911	69%
Totals	673162	37%	7054585	**85%**

BUT: erosion of barrier spits (~0.5-1m/year)




Jeremy Marsh, Wellfleet
1999
2018
2100

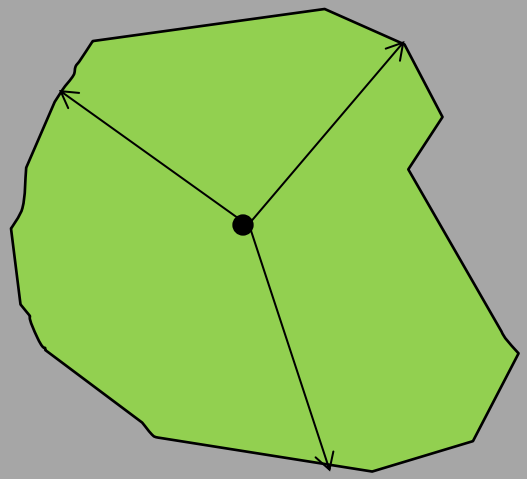
	BB portion of migration area (m^2)	% total migration area
GU	14994	60%
HH	-	
JM	4317	30%
MM	10704	45%
NS	31981	10%
PB	593132	55%
WE	18034	18%
	673162	**39%**

gone by 2100 (?)


2/2018
2018
98 m
Google Earth

- **salt marsh losses may be more (or less) in some marshes vs. others**

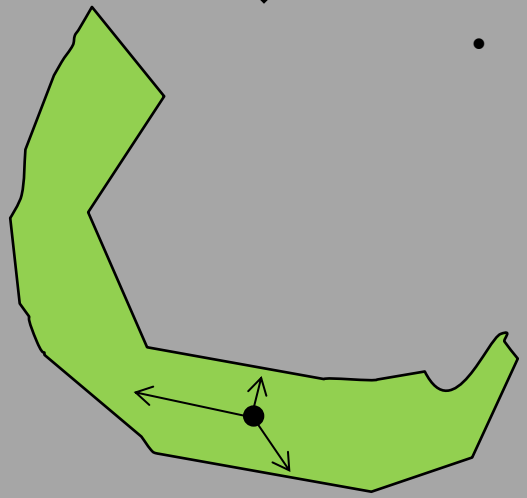
- **Gut and HH have very low accretion rates of ~1 mm/yr, so may succumb to SLR much sooner**



Does marsh geometry matter?

- reduced proximity to marsh edges
- increased exposure, erosion
- increased proximity to uplands, including developed
- reduced groundwater attenuation

Reed et al. (2018)
Stark et al. (2015, 2017)
Temmerman et al. (2005)



Scenario much worse for Cape Cod marshes will heavily developed adjacent t uplands

Thanks for listening!

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and…

NOAA

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National Park Service

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