

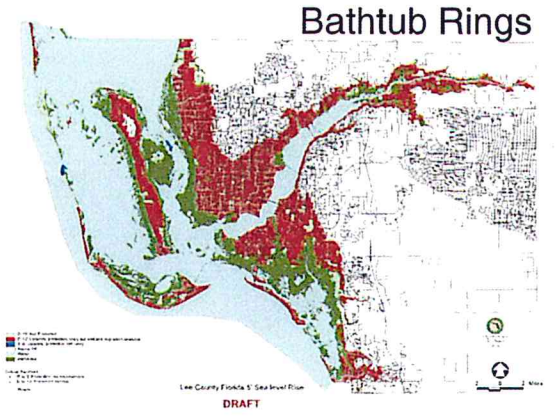
Strategic Growth and Sea-Level Rise

A Proposed Role for LAPS

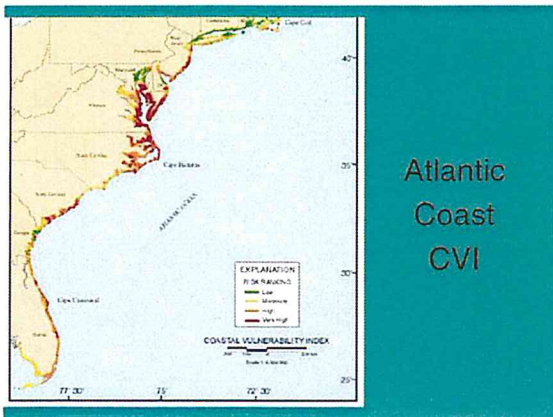
- ### Coastal Refuges
- 159 of 538 refuges
 - Refuge System's most valuable properties
 - Ongoing land acquisition

- ### Sea-Level Rise
- Global sea levels rose approximately 0.15 m during 20th century.
 - Satellite data from 1993- 2006 indicate a rate of 3.3 mm/year.
 - IPCC (2007) projects 0.18-0.59 m sea-level rise by 2100.
 - IPCC estimates are considered conservative.

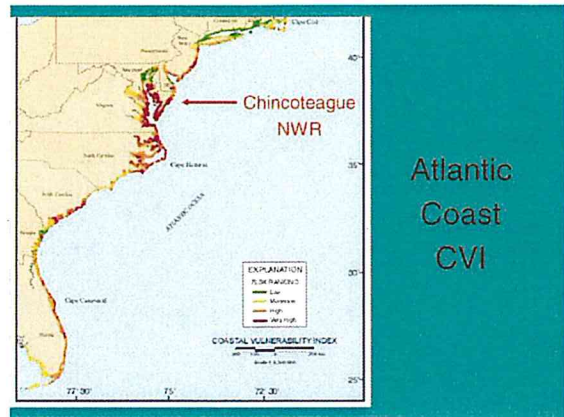
- ### Assessing the Impacts of Sea-Level Rise
- "Bathtub ring" models predict coastlines.
 - Physical models incorporate geomorphology.
 - Bruun Rule: sea-level rise x causes 100x recession
 - Coastal Vulnerability Index
 - Ecological models incorporate biology.
 - ZIMM
 - SLAMM



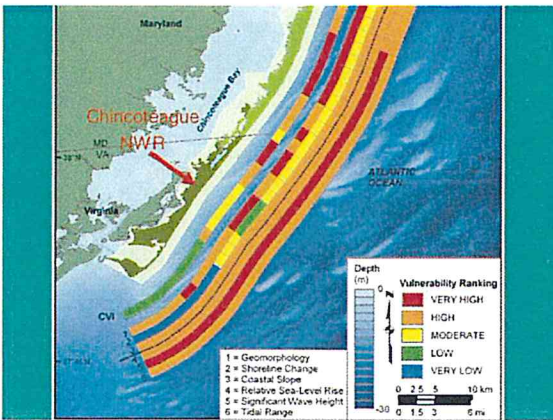
- ### Coastal Vulnerability Index
- Indicates "the relative risk that physical changes will occur as sea level rises" (USGS).
 - Variables modeled:
 - Tidal range
 - Wave height
 - Coastal slope
 - Shoreline change
 - Geomorphology
 - Historical rate of relative sea-level rise



Atlantic Coast CVI



Atlantic Coast CVI

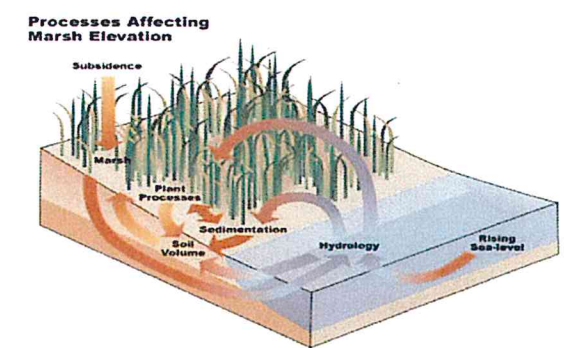


A Problem with CVI for Refuge System Purposes

- Indicates "the relative risk that **physical changes** will occur as sea level rises."
- What physical changes?
 - "That's the thing we don't know." (Trieler)
 - Erosion?
 - Inundation?
 - Wetland loss?
- CVI is a "general guide" to vulnerability.

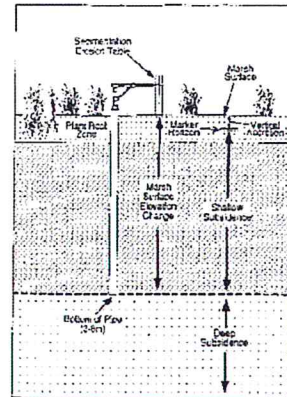
Sea Level Affecting Marshes Model

- Independent variables
 - Historic relative sea-level rise
 - Projected global eustatic sea-level rise
 - Surface elevations
 - Accretion
 - Erosion (habitat-specific)
 - Tidal range
 - Spatial arrangement of habitats
 - Severe storm frequency
- Intermediate variables ("Enlightenment")
 - Fetch
 - Erosion (spatially explicit)
 - Projected local eustatic sea-level rise
 - Projected relative sea-level rise
 - Subsurface resource extraction
 - isostatic rebound
 - tectonic movement
- Dependent variables
 - Wetland type
 - Estuarine salinity

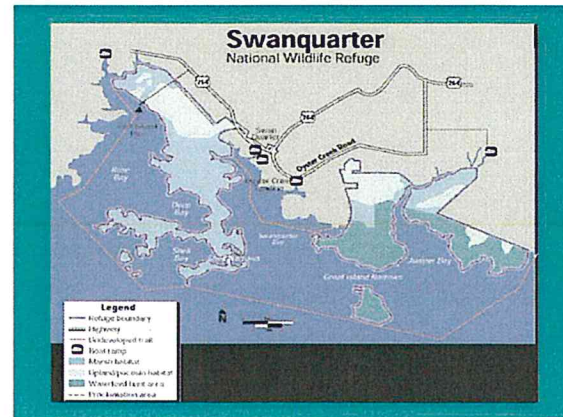
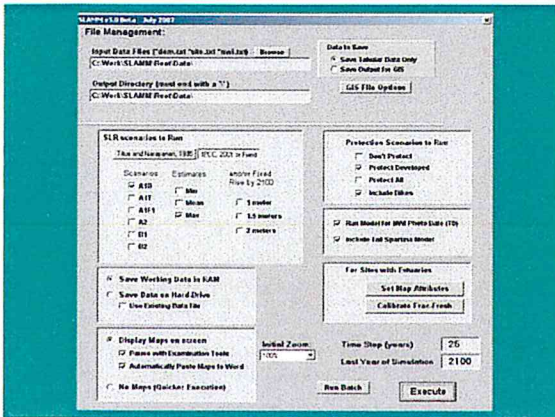


SLAMM Data Sources

- Historic relative sea-level rise - NOAA
- Projected eustatic sea-level rise – IPCC
- Digital elevation map - USGS
- Tide ranges - NOAA
- National Wetland Inventory map - USGS
- Refuge boundaries - FWS

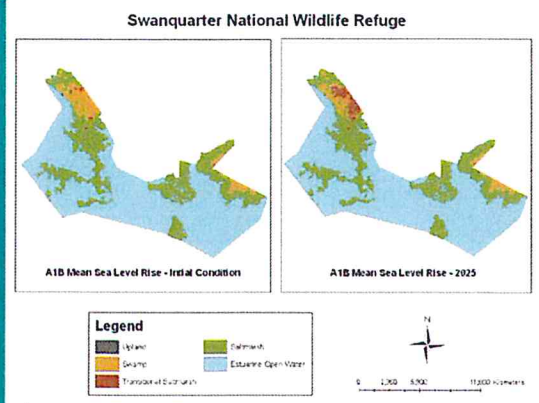


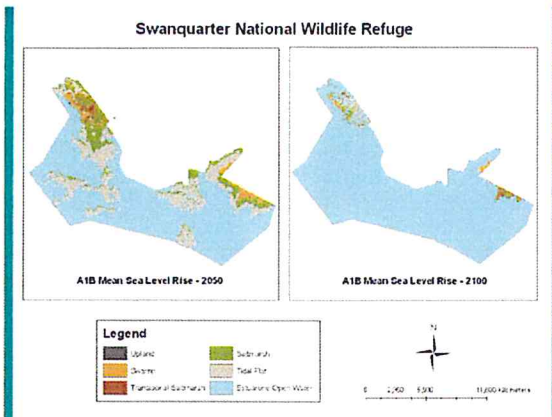
SET
Station



Swanquarter SLAMM Results

	Area of habitat change in hectares				Percentage of habitat change (+) habitat gain, (-) habitat loss			
	Initial Condition	2025	2050	2100	Initial Condition	2025	2050	2100
Dry Land	15	3	2	0	0%	-15%	-33%	-99%
Hardwood Swamp	54	60	43	18	5%	+10%	-52%	-83%
Transitional Salt Marsh	68	115	231	67	0%	+407%	+242%	+42%
Saltmarsh	481	478	129	24	28%	0%	-64%	-95%
Tidal Flat	0	0	135	250	0%	N/A	N/A	N/A
Estuarine Open Water	1143	1140	1140	1140	67%	0%	0%	+44%





Strategic Growth and LAPS

- ## Strategic Growth
- No policy per se but SHC document and Draft Strategic Growth Policy (602 FW 5)
 - "Threshold standards"
 - Conserves a priority conservation target
 - Provides habitat connections
 - Promotes biological integrity
 - Invests in healthy lands
 - LAPS

- ## Climate Change Threshold Standards?
- Example, "The purposes of the project must be sustainable in the context of climate change, based upon the best available science and sound professional judgment."
 - Threatened and endangered species
 - Prairie potholes, western fringe
 - Southwestern grasslands
 - Coastal wetlands
 - Problem: most ecological transitions a matter of degree, not absolute.

- ## LAPS
- Projects often not proposed unless known to achieve high LAPS score
 - Projects proposed unlikely to be acquired without high LAPS score
 - Draft Strategic Growth Policy (602 FW 5): "Ensure that all proposed expansions of existing refuges and the establishment of new refuges... achieve a sufficiently high LAPS score."

LAPS Components

- Migratory birds
- Threatened and endangered species
- Fisheries and aquatic resources
- Ecosystem conservation

LAPS Components and Coastal Refuges

- Migratory birds
- Threatened and endangered species
- Fisheries and aquatic resources
- Ecosystem conservation (?)

LAPS Traits

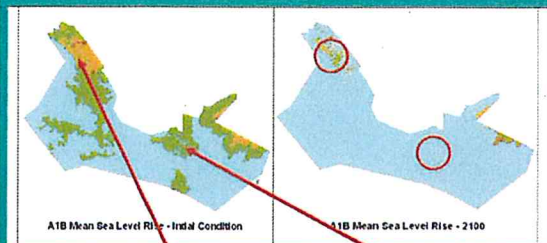
- Benefit analysis (not cost/benefit)
- Degree of threat vs. ecological integrity
 - Threatened and endangered species
 - Imperiled ecosystems
 - Intact ecosystems
- Philosophy of ceteris paribus

Benefits and Sea-Level Rise



- Benefits not sustainable
- Not bad if costs are minimal
- Not good if costs are high

Ceteris Paribus...



Paying for this is better than paying for that.

Ceteris Paribus...

- ...these seem more strategically grown...
 - Swanquarter, \$4/acre
 - Cape Romain, \$37/acre
 - St. Marks, \$108/acre
- ...than these...
 - Silvio O. Conte, \$7,768/acre
 - Passage Key, \$64,000/acre
 - Archie Carr, \$274,000/acre

Recent Growth (1997-2006)

Refuge	LAPS score	Acres	Price/acre
Aransas	N/A	440	0
St. Marks	683	2619	108
Ding Darling	658	58	1,433
Silvio O. Conte	608	31	7,766
E. B. Forsythe	606	2887	6,787
Bon Secour	524	502	2,000
Back Bay	521	743	7,777
Cape Romain	507	1008	37
Alligator River	498	722	1,650
Archie Carr	429	18	274,000

Recent Growth (1997-2006)

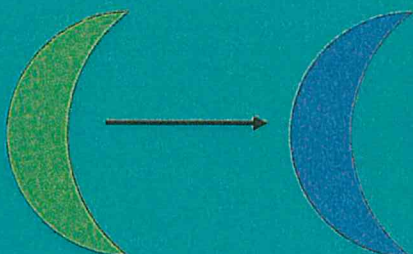
Refuge	Price/acre	LAPS score	Acres
Aransas	0	N/A	440
Cape Romain	37	507	1008
St. Marks	108	683	2619
Ding Darling	1,433	658	58
Alligator River	1,650	498	722
Bon Secour	2,000	524	502
E. B. Forsythe	6,787	606	2887
Silvio O. Conte	7,766	608	31
Back Bay	7,777	521	743
Archie Carr	274,000	429	18

Incorporating Sea-Level Rise into LAPS

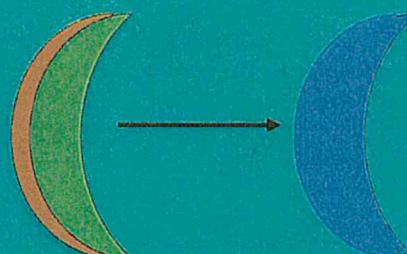
General Considerations

- Sea-level rise scenario – A1B maximum
- Time frame – 2100 AD
 - “for the benefit of present and future generations of Americans.”
 - “need to be thinking about 3 generations.”
- Award for projected mitigation; penalize for projected loss

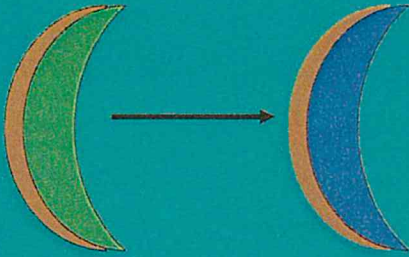
We don't want this:



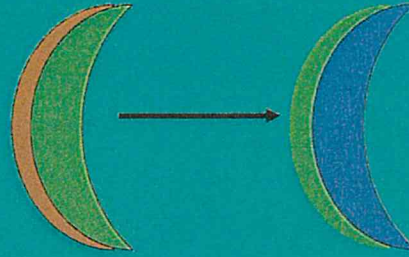
Or this:



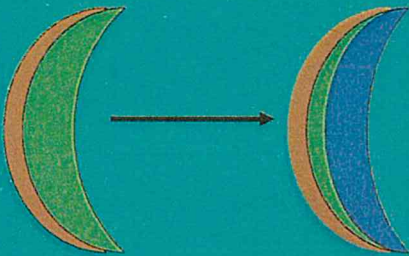
Or not much of this:



This wouldn't be so bad:



Even better:



Putting it into LAPS

- No score for total loss of land
- Complete score for no loss of land
- Partial score for partial loss of land
- Extra considerations for wetland habitats
 - Migratory bird refuges
 - Other refuges

Suggested Approach #1

- Use SLAMM
- Calculate proportion not projected to convert from terrestrial habitats to open saltwater.
- Multiply LAPS score by proportion to obtain LAPS score with basic sea-level rise adjustment.
- Wetland adjustments:
 - If all wetlands are lost, the adjusted LAPS score is the final LAPS score
 - If any wetlands are maintained, calculate further wetland adjustments...

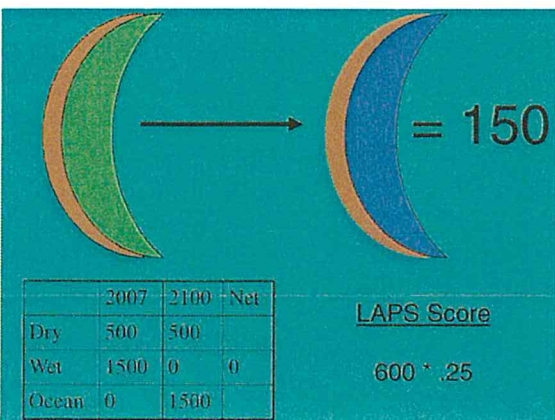
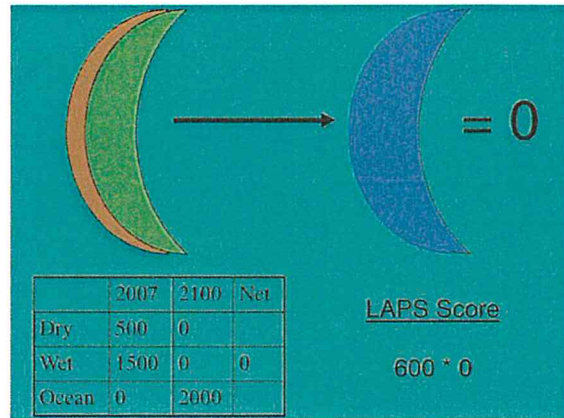
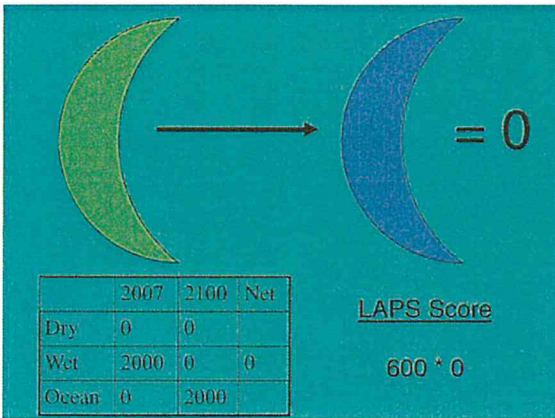
Wetland Adjustments

- Calculate projected net proportional loss or gain of wetlands
- If there is a net loss, multiply adjusted LAPS score by 1/net loss (that is, wetland proportion maintained) and add multiplicand to adjusted LAPS score to obtain final LAPS score.
- If there is a net gain:
 - Double-weight gain for migratory bird refuges
 - Add to dummy variable of 1.0
 - Multiply by adjusted LAPS score to obtain final LAPS score.

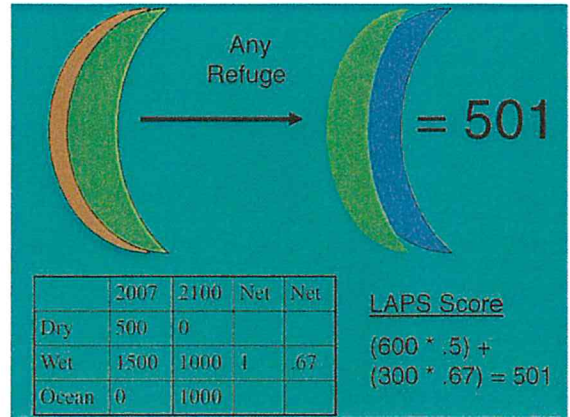
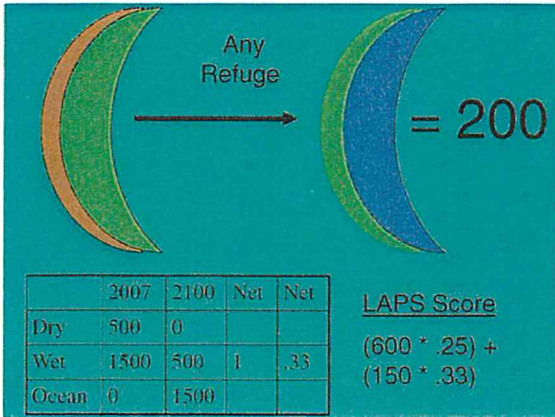
General Effects

All land lost	No land lost	Some land maintained but no wetlands	Some wetlands maintained	Net wetland gain
No LAPS score	Full LAPS score	LAPS penalty	LAPS penalty lower	LAPS score may increase
				Migratory bird refuge bonus

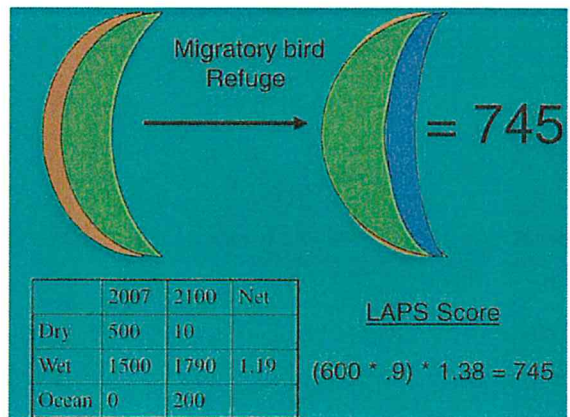
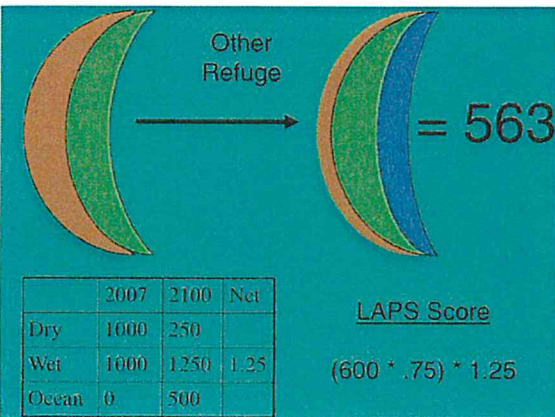
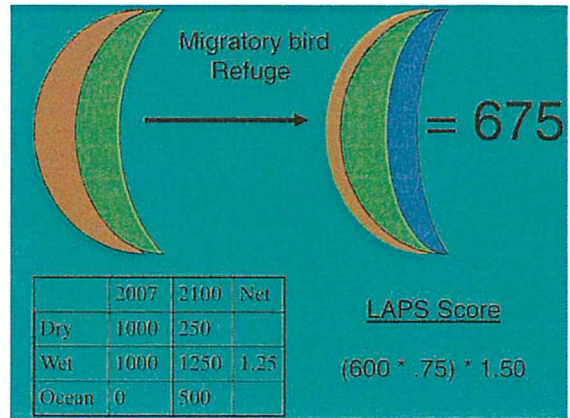
Basic Adjustments – All Wetlands Lost

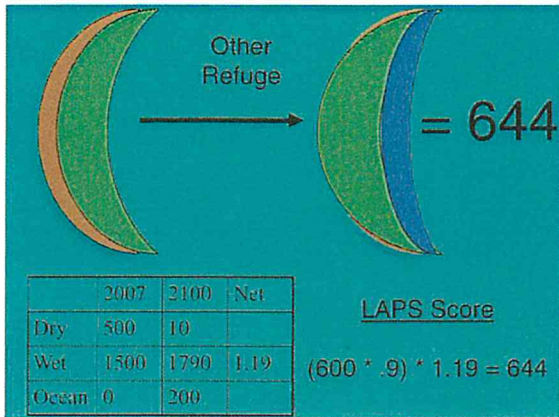


Basic and Wetland Adjustments – Net Loss of Wetlands



Basic and Wetland Adjustments – Net Gain of Wetlands

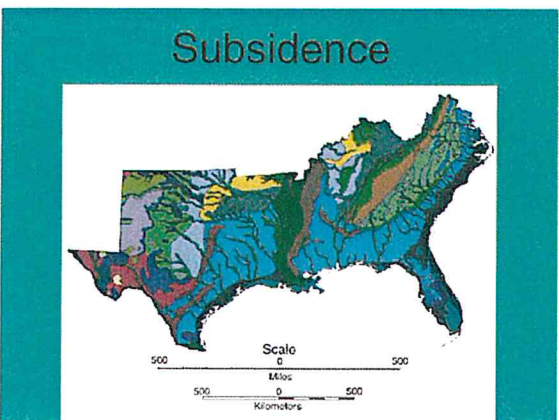
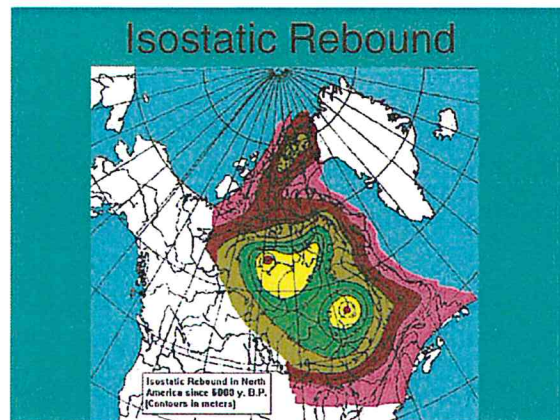




SLAMM Analyses

Refuge	Date	Refuge	Date	Refuge	Date
ACE Basin	2007	Featherstone	2007	Rappahannock R.	2008
Alligator River	2009	Fisherman Island	2008	Sipahwa Meadows	2009
Anacostia	2008	Horns Neck	2008	Swanquarter	2007
Back Bay	2008	James River	2008	Tuboo	2007
Bayou Sauvage	2008	Martin	2008	Veques	2007
Blackbird Island	2007	Mason Neck	2007	Waccamaw	2007
Blackwater	2008	Nansemond	2008	Wallop Island	2008
Cape Roman	2007	Nesquehly	2007	Walsaw	2007
Chincoteague	2008	Ocracoke Bay	2008	Wicopa	2008
Culebra	2007	Pelican Island	2007	Wolf Island	2007
Delta	2009	Pedney Island	2008		
Ding Baring	2008	Pine Island	2007		Contracted - 15
Duqueness	2008	Pum Tree Island	2008		Partners - 24
Eastern Shore VA	2008	Presque	2008		Students - 6
Egmont Key	2006	Protection Island	2008		

- ### Suggested Approach #2
- Useful when:
 - SLAMM unavailable
 - SLAMM available but project at PPP stage
 - Need knowledge only of habitat types
 - Lowest habitats will be lost
 - Swamps, mangroves, and freshwater marshes should convert to salt marshes
 - Adjust for coastal geomorphology



Example 1

- Moderate proportion of wetlands, North Carolina
- LAPS score = 600
- Adjusted LAPS score = $600 - (113 * 1.1) = 464$

A. Coastal Ecology Adjustment B. Geophysical Adjustment

Coastal habitats	%	E.A.E.	E.A.
Salt marsh, transitional marsh, tidal flat, oyster beach	35	500/2 = 250	75
Artificial fresh marsh, swamp, red, baldcypress, cypress/bayou	25	600/2 = 300	75
Total Adjustment			113

State	E.A.	G.A.E.	E.A.
ME, NH, MA	25	0.8	
RI, CT, NY	25	0.9	
NJ, DE		0.7	
MD, VA, NC		1.1	15%
SC, GA, FL, Atlantic		1.2	
IL, (Gulf), AL, MS, LA		1.9	
TX		1.3	
CA, OR, WA		1.0	

Example 2

- Moderate proportion of wetlands, Louisiana
- LAPS score = 600
- Adjusted LAPS score = $600 - (113 * 1.4) = 442$

A. Coastal Ecology Adjustment B. Geophysical Adjustment

Coastal habitats	%	E.A.P.	E.A.	State	E.A.	G.A.P.	E.A.
Submarine transitional marsh, tidal flats, ocean beach	25	600/2 = 300	75	ME, NH, MA	25	0.8	20
				RI, CT, NY	25	0.9	
				NI, DE		1.0	
				MD, VA, NC		1.1	
				SC, GA, FL (Atlantic)		1.2	
				IL, OH, AL, MS, LA		1.4	108
				TX		1.3	
				CA, OR, WA		1.0	
Adjacent fresh marsh, swamp, red mangrove, estuarine beach	25	600/2 = 300	48				
Total Adjustment			113				

Example 3

- Moderate proportion of wetlands, Massachusetts
- LAPS score = 600
- Adjusted LAPS score = $600 - (113 * .8) = 510$

A. Coastal Ecology Adjustment B. Geophysical Adjustment

Coastal habitats	%	E.A.P.	E.A.	State	E.A.	G.A.P.	E.A.
Submarine transitional marsh, tidal flats, ocean beach	25	600/2 = 300	75	ME, NH, MA	25	0.8	20
				RI, CT, NY	25	0.9	
				NI, DE		1.0	
				MD, VA, NC		1.1	
				SC, GA, FL (Atlantic)		1.2	
				IL, OH, AL, MS, LA		1.4	
				TX		1.3	
				CA, OR, WA		1.0	
Adjacent fresh marsh, swamp, red mangrove, estuarine beach	25	600/2 = 300	48				
Total Adjustment			113				

Example 4

- Large proportion of wetlands, North Carolina
- LAPS score = 600
- Adjusted LAPS score = $600 - (263 * 1.1) = 311$

A. Coastal Ecology Adjustment B. Geophysical Adjustment

Coastal habitats	%	E.A.P.	E.A.	State	E.A.	G.A.P.	E.A.
Submarine transitional marsh, tidal flats, ocean beach	25	600/2 = 300	225	ME, NH, MA	25	0.8	20
				RI, CT, NY	25	0.9	
				NI, DE		1.0	
				MD, VA, NC		1.1	100
				SC, GA, FL (Atlantic)		1.2	
				IL, OH, AL, MS, LA		1.4	
				TX		1.3	
				CA, OR, WA		1.0	
Adjacent fresh marsh, swamp, red mangrove, estuarine beach	25	600/2 = 300	48				
Total Adjustment			263				

Example 5

- Large proportion of wetlands, Louisiana
- LAPS score = 600
- Adjusted LAPS score = $600 - (263 * 1.4) = 232$

A. Coastal Ecology Adjustment B. Geophysical Adjustment

Coastal habitats	%	E.A.P.	E.A.	State	E.A.	G.A.P.	E.A.
Submarine transitional marsh, tidal flats, ocean beach	25	600/2 = 300	225	ME, NH, MA	25	0.8	20
				RI, CT, NY	25	0.9	
				NI, DE		1.0	
				MD, VA, NC		1.1	
				SC, GA, FL (Atlantic)		1.2	
				IL, OH, AL, MS, LA		1.4	108
				TX		1.3	
				CA, OR, WA		1.0	
Adjacent fresh marsh, swamp, red mangrove, estuarine beach	25	600/2 = 300	48				
Total Adjustment			263				

Example 6

- Large proportion of wetlands, Massachusetts
- LAPS score = 600
- Adjusted LAPS score = $600 - (263 * 1.4) = 390$

A. Coastal Ecology Adjustment B. Geophysical Adjustment

Coastal habitats	%	E.A.P.	E.A.	State	E.A.	G.A.P.	E.A.
Submarine transitional marsh, tidal flats, ocean beach	25	600/2 = 300	225	ME, NH, MA	25	0.8	20
				RI, CT, NY	25	0.9	
				NI, DE		1.0	
				MD, VA, NC		1.1	
				SC, GA, FL (Atlantic)		1.2	
				IL, OH, AL, MS, LA		1.4	
				TX		1.3	
				CA, OR, WA		1.0	
Adjacent fresh marsh, swamp, red mangrove, estuarine beach	25	600/2 = 300	48				
Total Adjustment			263				

A question is begged: Should a project be penalized as much if, ceteris paribus, the cost is very low?

The End

2009 LAPS Scores

<u>Refuge</u>	<u>LAPS score</u>	<u>Acres</u>	<u>P/tee/acre</u>
Aransas	N/A	440	0
St. Marks	714	2619	108
Ding Darling	658	58	1,488
Silvio O. Conte	691	31	7,768
E. B. Forsythe	563	2887	6,787
Bon Secour	486	502	2,000
Back Bay	412	743	7,777
Cape Romain	507	1008	37
Alligator River	448	722	1,650
Archie Carr	429	18	274,000