Climate Resilience through Green Infrastructure:

Discussion about Ecosystem Services, Habitat Connectivity, and Future Change

June 16, 2021

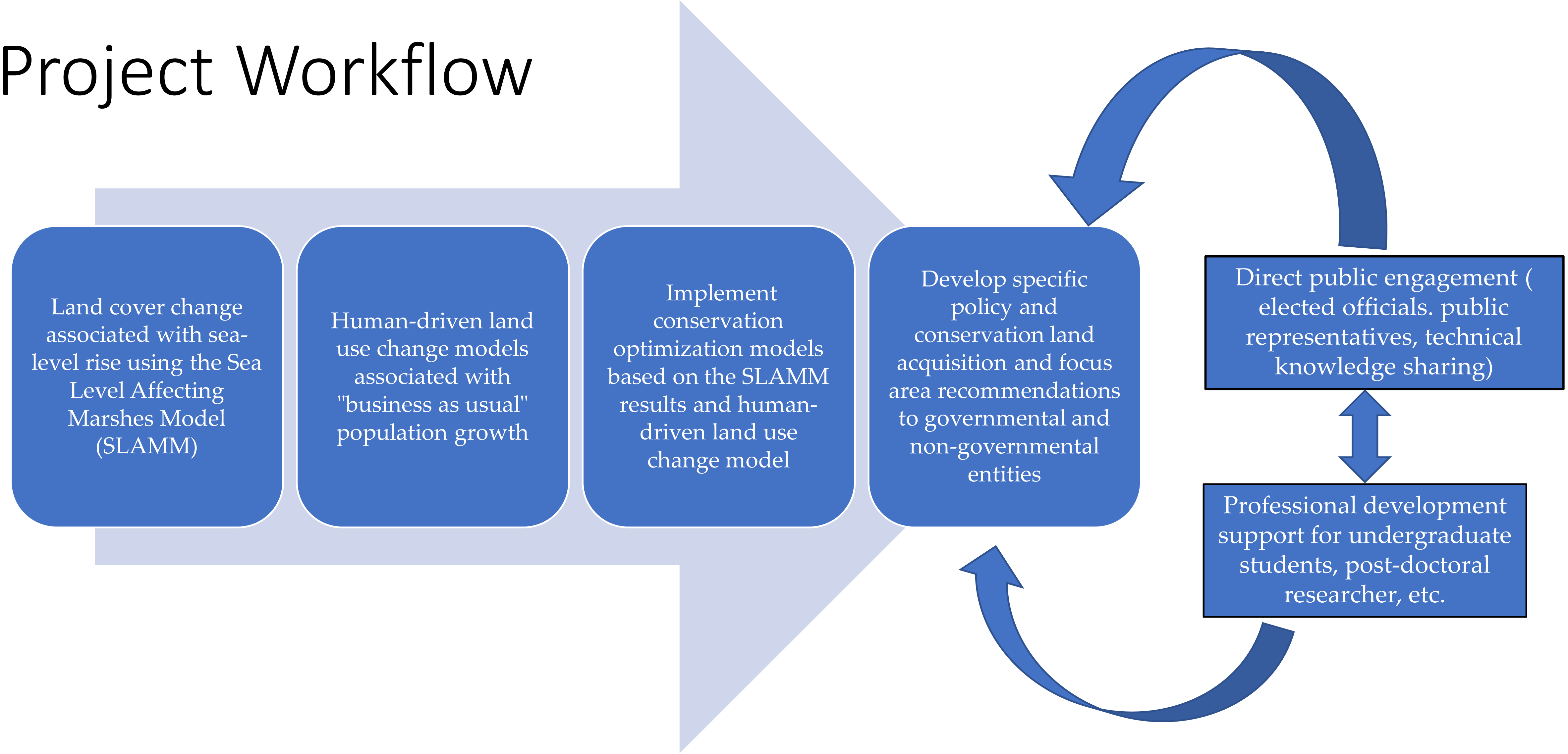
Project Team

- Katrina Locke – Volusia County
- Dr. Jason Evans – Stetson University
- Dr. Chris De Bodisco – Stetson University
- Dr. Janardan Mainali – Stetson University
- Thomas Ruppert, Esq. – Florida Sea Grant
- Charles Abbatantuono – ECFRPC
- Tara McCue, AICP - ECFRPC

Project Overview and Goals

- Project funded by Florida Sea Grant, but building on work just completed through the FDEP Coastal Resilient Program
- Model future conditions and other vulnerabilities to open space
- Identify barriers to habitat corridors and migration
- Examine Open Space through a Resilience Lens
- Engage stakeholders and experts to advance solutions and vet data and impacts
- Develop specific policy and conservation land acquisition recommendations and processes to establish focus areas
- Identify focus areas for adaptation solutions

Project Workflow



Goals of Today's Workshop

Overview	Go over some key terminology associated with green infrastructure, ecosystem services, and modeling approaches
Present (& Discuss!)	Present results from the Sea Level Affecting Marshes Model (SLAMM) and set-up of the Marxan optimization model for Volusia County
Prioritizations	Discussion ways in which a climate resilience lens might (or might not?) inform prioritization of land acquisitions within Volusia County
Looking Forward	Planning for (hopefully) having an in-person workshop to get into nitty-gritty spatial planning sometime in early Fall


Go to www.menti.com and use the code 50 98 77 4
What does "Green Infrastructure" mean to you?
Mentimeter
Press S to show image

Green Infrastructure includes natural or living features (including engineered struc tures built to mimic natural features in look and functionality) that perform critical natural processes.

Infrastructure and Environment

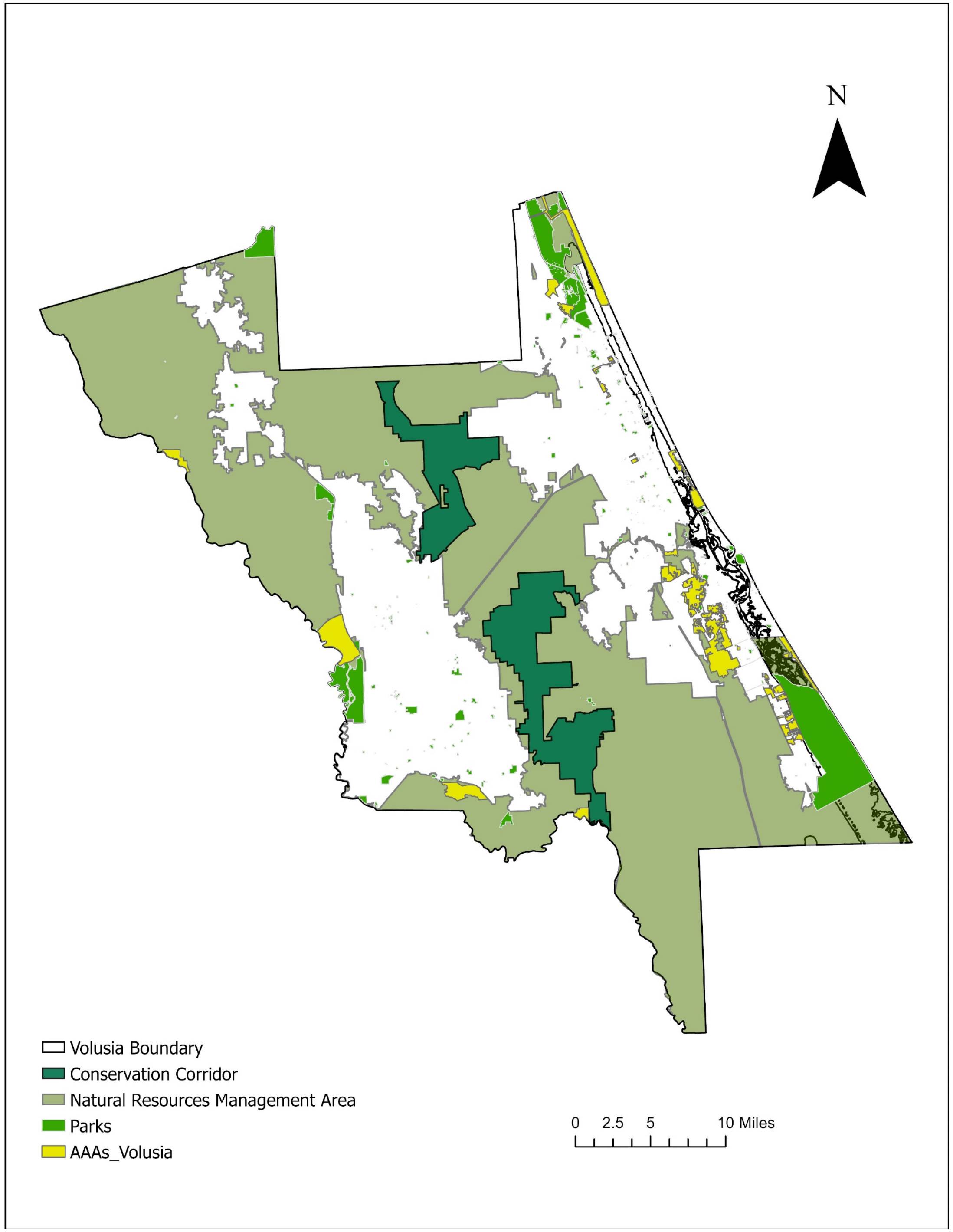
Encourage development of cross-disciplinary plans, policies and strategies to protect the health, safety and economic welfare of residents, businesses and visitors through recognition that natural disasters, changes to climate, and human manipulation require careful consideration of when and how to develop infrastructure, natural resources and a built environment that can withstand and adapt to these changes.

Objectives

- Prioritize the use of Green Infrastructure as a first line of defense.
- Promote interconnectivity of natural lands for habitat migration.
- Enhance stormwater systems to be more resilient.
- Improve water quality in surface water bodies.
- Incorporate resiliency into local and regional plans, policies, processes and objectives.
- Preserve and adapt the built environment to keep people safe from and mitigate current and future natural hazards.
- Improve community mobility while improving vulnerable transportation infrastructure.

Informing current and future conservation purchases

- Current and future landcover, including climate risk
- Existing protected areas and green infrastructure priority areas
    - Existing parks
    - Conservation Corridor
    - Natural Resource Management Area
    - Adaptation Action Areas



Local Conservation Context

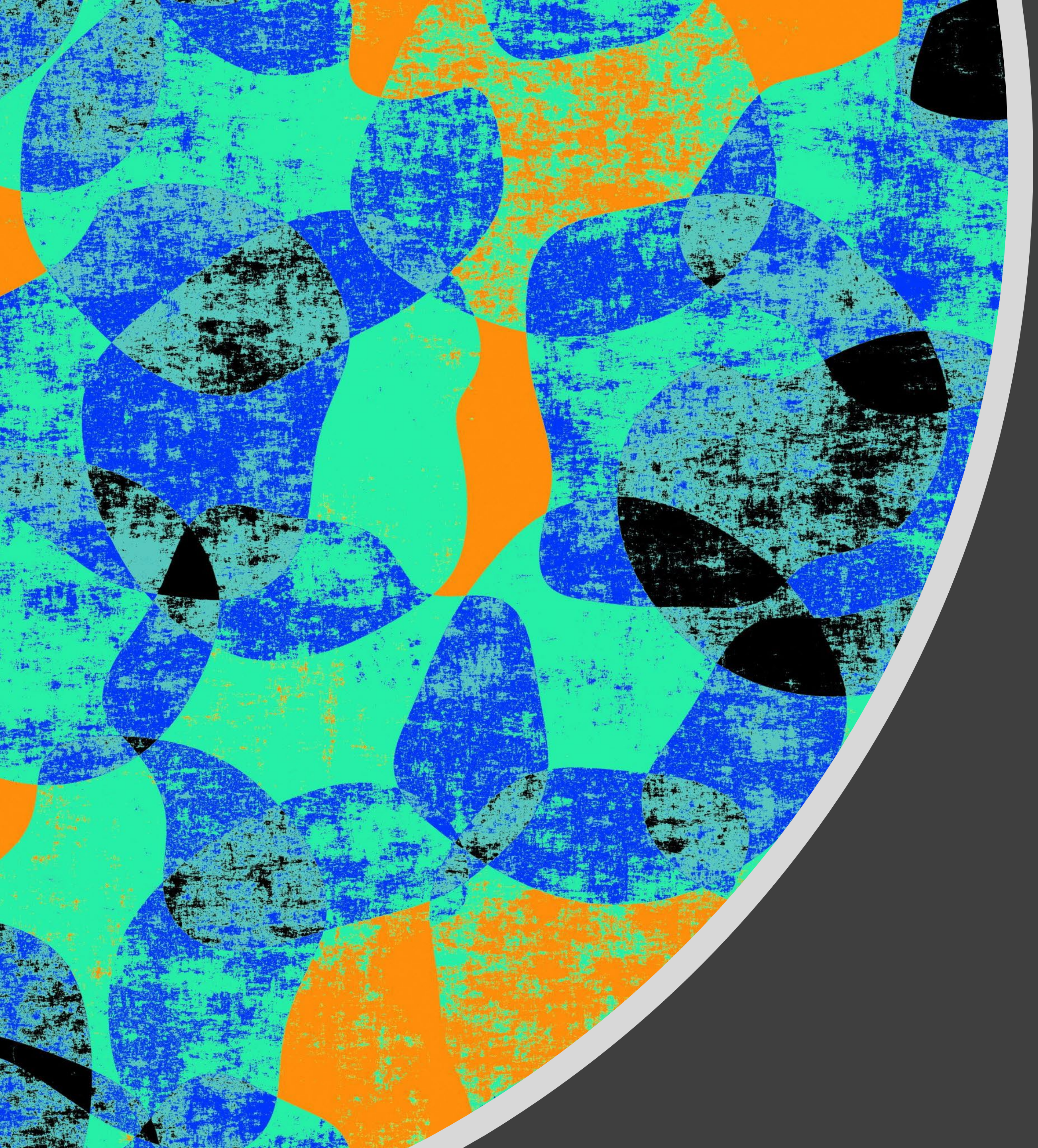
Volusia Forever and Volusia ECHO were both re-approved by voters in 2020

Our applied research project was funded **before** these programs were re-approved, but we do hope that results from the project can help inform implementation of these programs

VOLUSIA ECHO

Preserving our quality of life

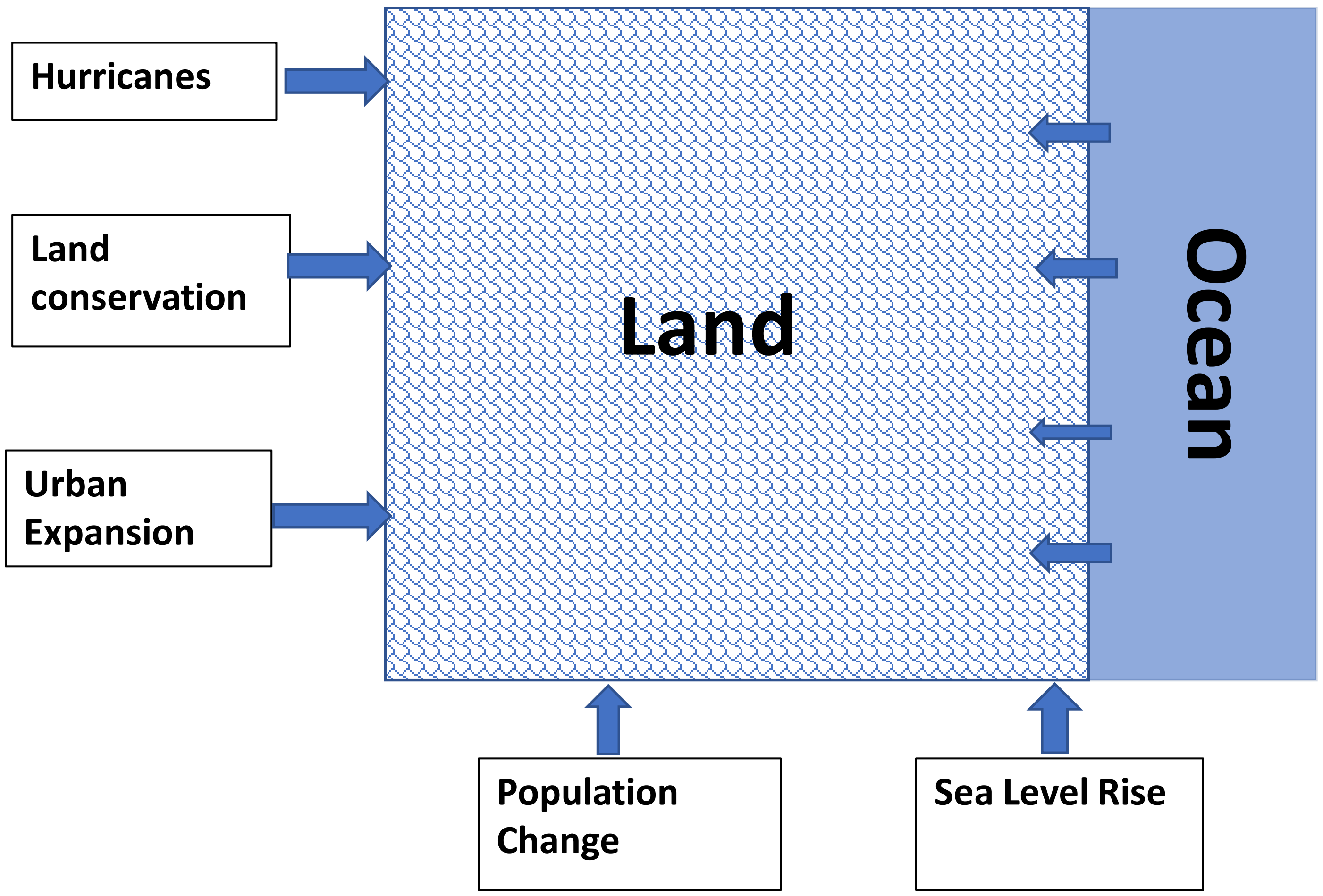
Volusia Forever



Landuse and Habitat Change Modelling

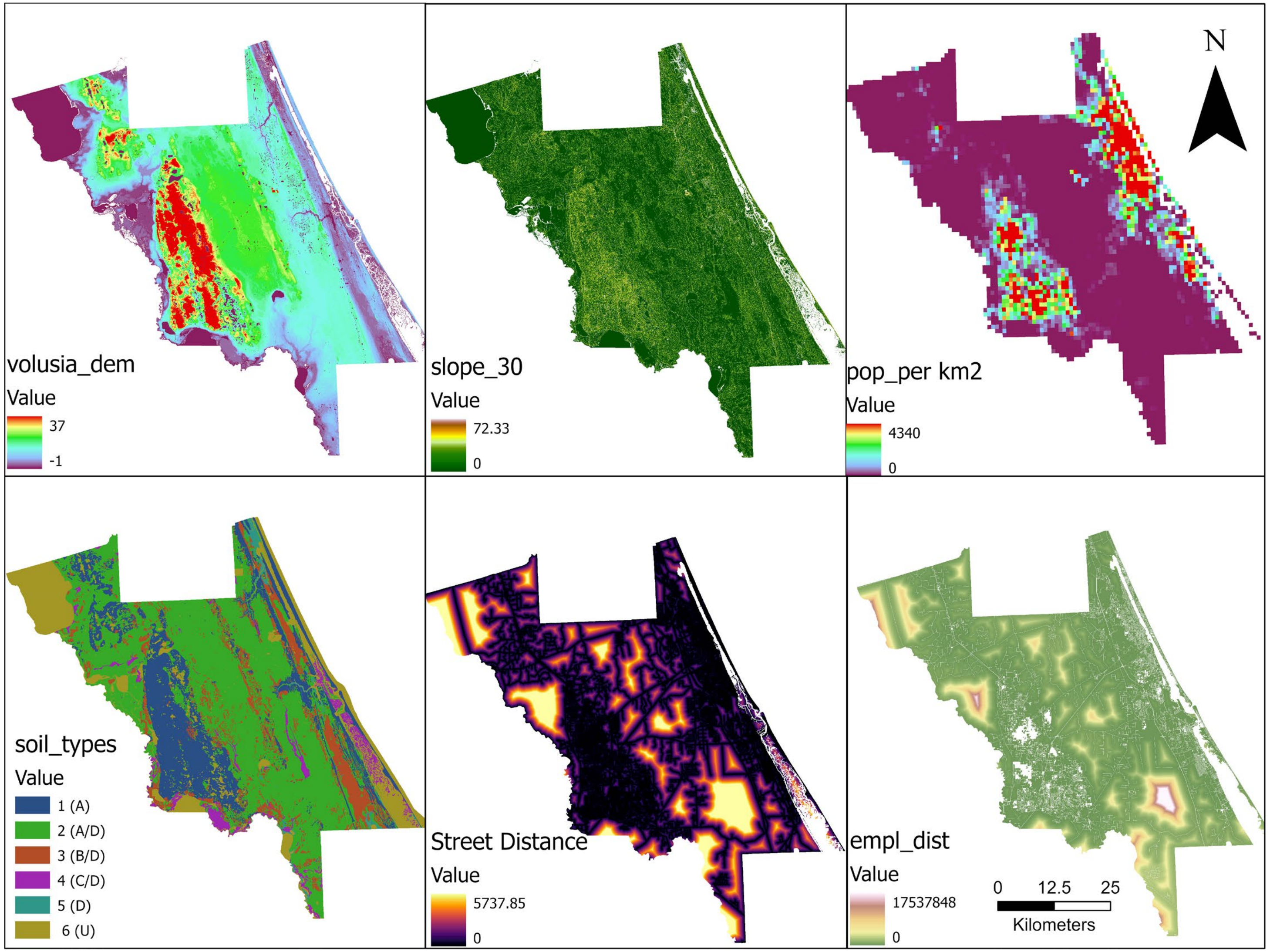
Dr. Jason Evans
Dr. Janardan Mainali

Spatial Conceptualization

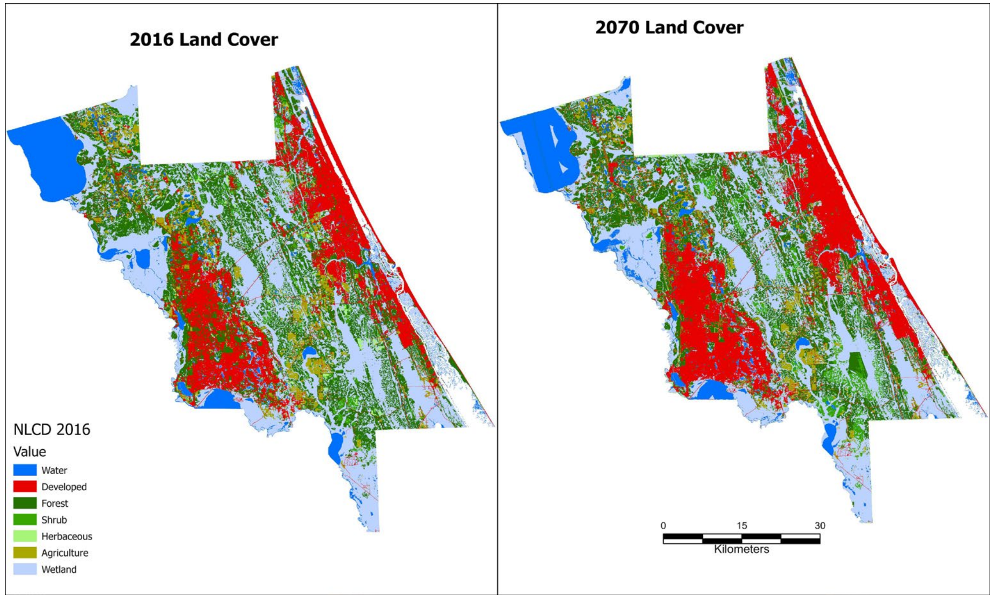


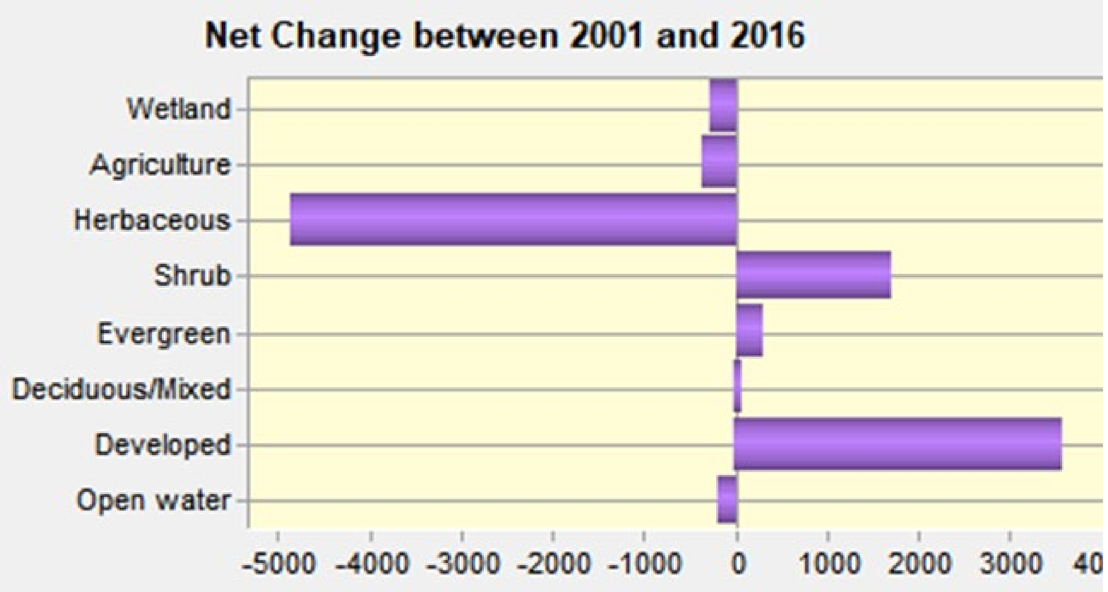
Landcover modeling

- Predictor variables
- NLCD 2001 and 2016 Data
- Reclassification into various
- Terrset Land Change Modeler
- Markov Chain Model and transition potentials based on predictor variables
- Landcover change prediction in different years



Model Output

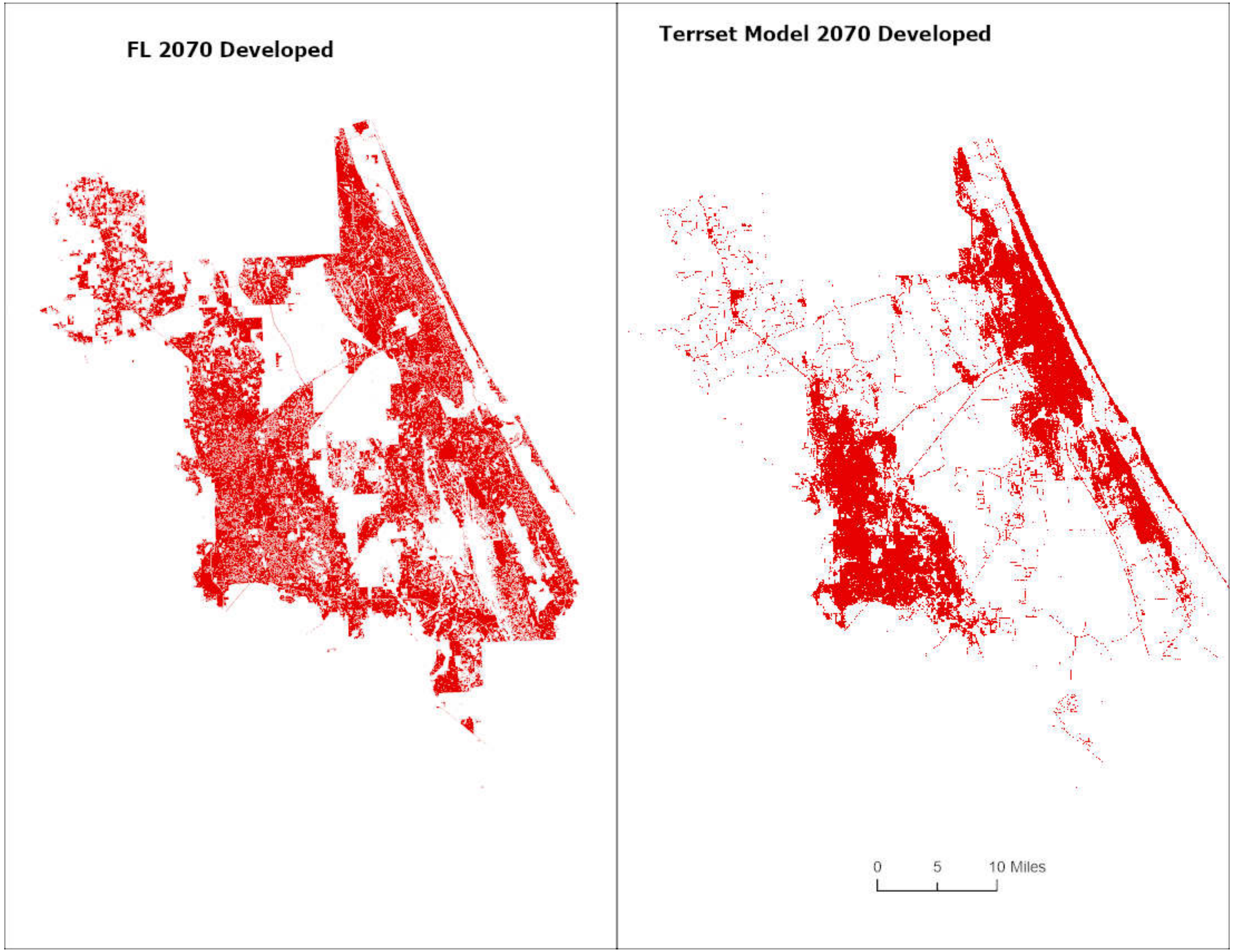




Accuracy of transition

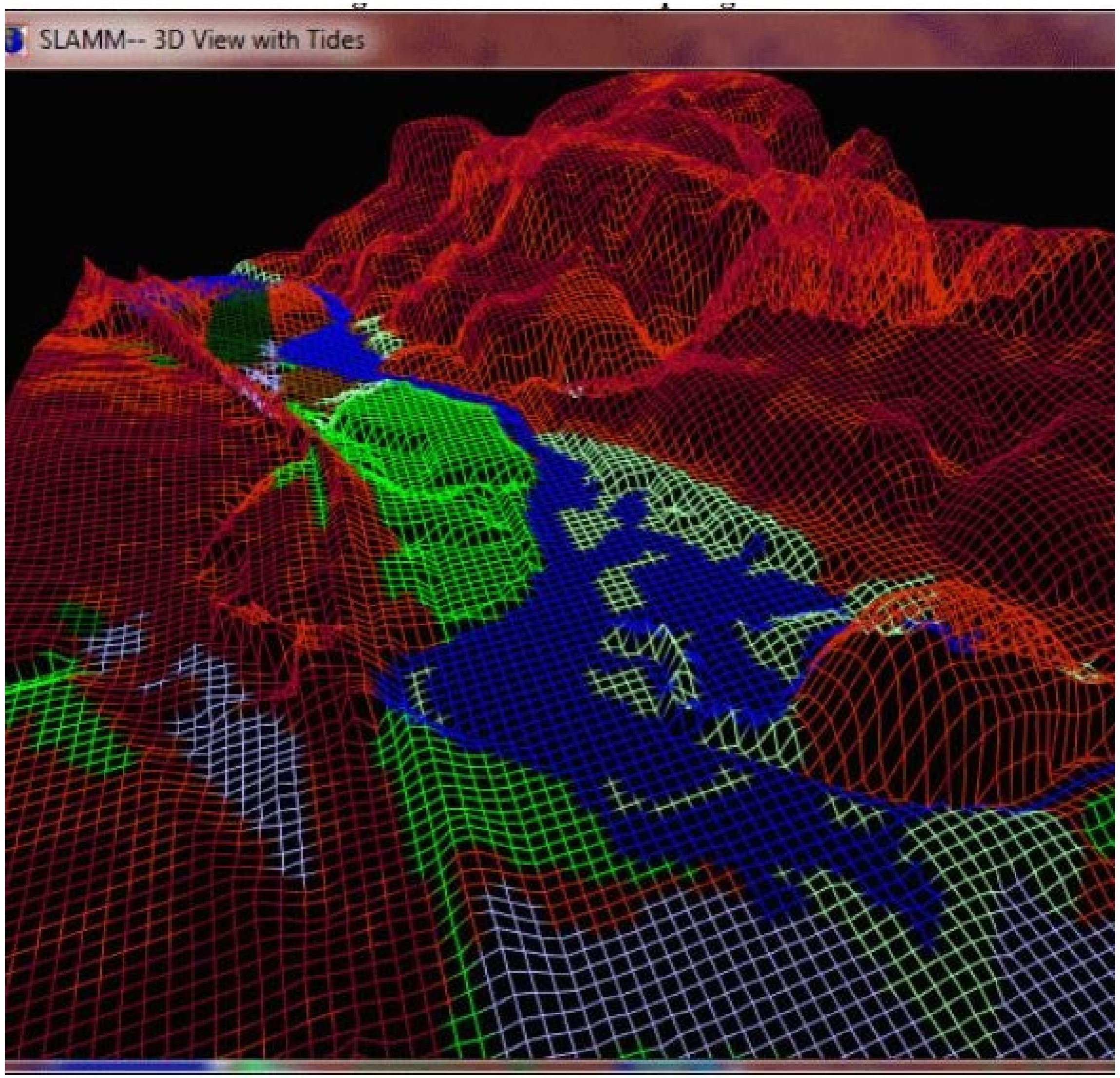
To Landcover	Accuracy	Skill Measure
Agriculture	13.22	0.07
Deciduous forest	15.63	0.091
Developed land cover	16.41	0.1
Evergreen	12.43	0.06
Herbaceous	11.76	0.05
Shrub	13.16	0.07
Water	14.26	0.08
Wetland	21.4	0.15

Florida 2070 vs our model



Sea Level Affecting Marshes Model for Coastal and Riparian regions

- Wetland habitat change model – incorporates physical and biological process to predict future shift in habitat types
- Can incorporate various sea level rise scenarios
- Produces both spatially explicit and quantitative output
- Can aid in land conservation and management
- Used extensively by U.S. Fish and Wildlife Service and FWC for coastal ecosystem management and resilience planning

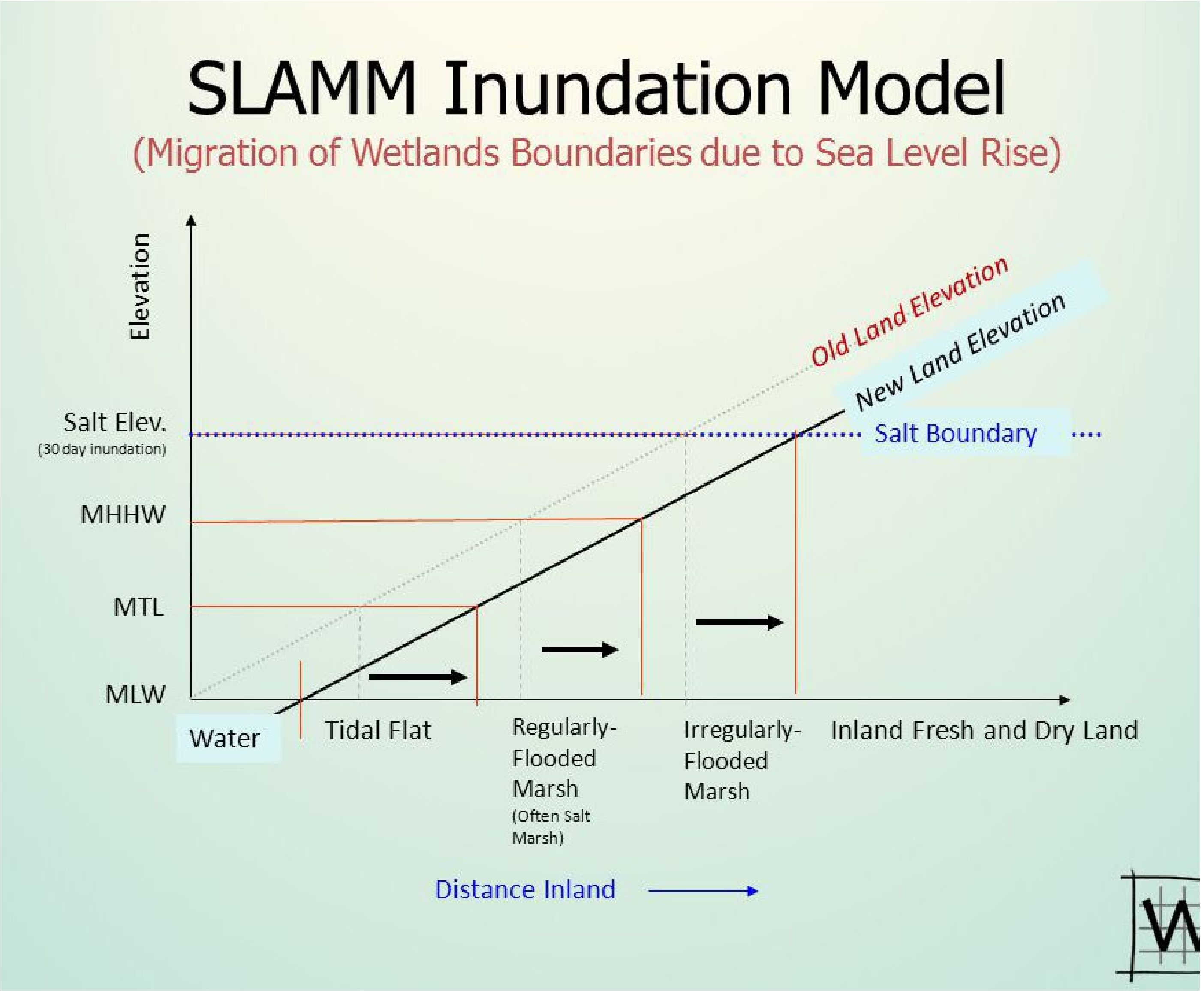


https://coast.noaa.gov/digitalcoast/tools/slamm.html

SLAMM

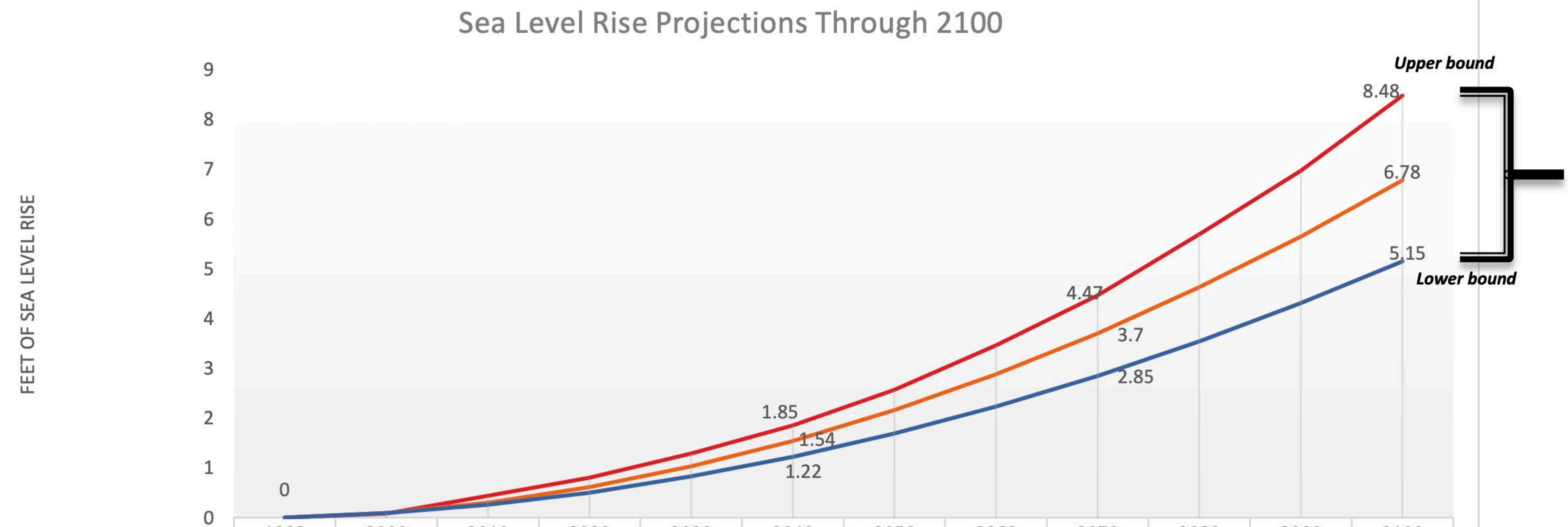
Table 2. Summary of SLAMM input parameters for Merritt Island NWR.

Parameter	S1	S2	S3	S4	S5
NWI Photo Date (YYYY)	2009	2009	2009	2009	1984
DEM Date (YYYY)	2007	2006	2007	2007	2007
Direction Offshore [n,s,e,w]	East	East	East	East	East
Historic Trend (mm/yr)	2.37	2.37	2.37	2.37	2.37
MTL-NAVD88 (m)	-0.29	-0.13	-0.17	-0.21	-0.21
GT Great Diurnal Tide Range (m)	1.2	0.28	0.28	0.28	0.28
Salt Elev. (m above MTL)	0.9	0.21	0.21	0.21	0.21
Marsh Erosion (horz. m /yr)	1.8	1.8	1.8	1.8	1.8
Swamp Erosion (horz. m /yr)	1	1	1	1	1
T.Flat Erosion (horz. m /yr)	0.5	0.5	0.5	0.5	0.5
Reg.-Flood Marsh Accr (mm/yr)	3.9	3.9	3.9	3.9	3.9
Irreg.-Flood Marsh Accr (mm/yr)	4.7	4.7	4.7	4.7	4.7
Tidal-Fresh Marsh Accr (mm/yr)	5.9	5.9	5.9	5.9	5.9
Inland-Fresh Marsh Accr (mm/yr)	5.9	5.9	5.9	5.9	5.9
Mangrove Accr (mm/yr)	7	7	7	7	7
Tidal Swamp Accr (mm/yr)	1.1	1.1	1.1	1.1	1.1
Swamp Accretion (mm/yr)	0.3	0.3	0.3	0.3	0.3
Beach Sed. Rate (mm/yr)	0.5	0.5	0.5	0.5	0.5
Freq. Overwash (years)	25	25	25	25	25
Use Elev Pre-processor [True,False]	FALSE	FALSE	FALSE	FALSE	FALSE



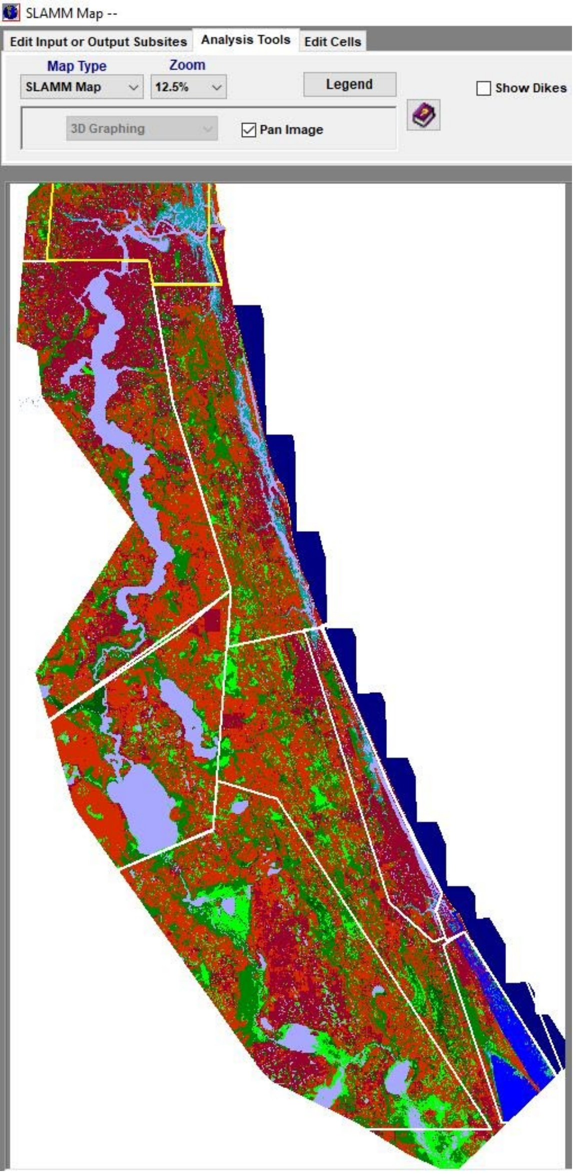
https://www.slideshare.net/riseagrant/sea-level-affecting-marshes-model-slamm

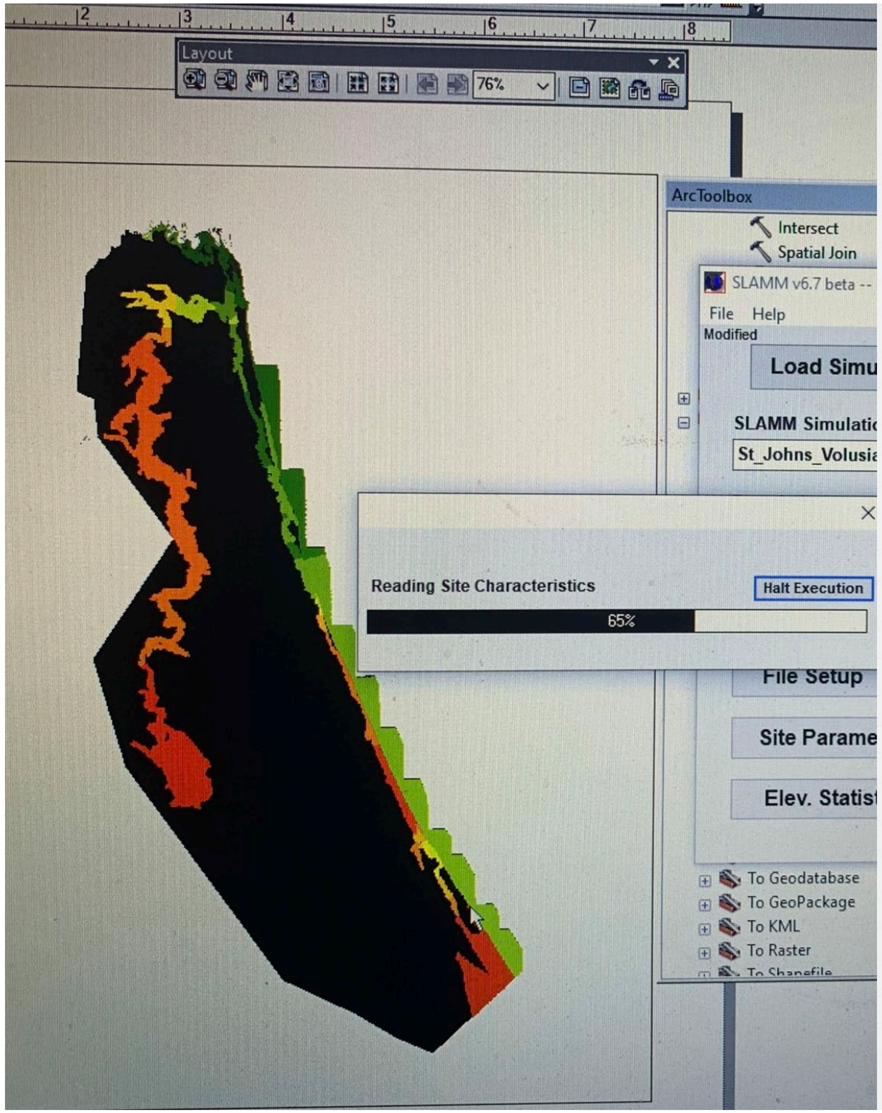
East Central Florida Regional Resilience Action Plan Sea Level Rise Projections



	1992	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
NOAA 2017 High	0	0.08	0.44	0.8	1.29	1.85	2.57	3.46	4.47	5.69	6.97	8.48
NOAA 2012 High	0	0.09	0.3	0.61	1.03	1.54	2.16	2.88	3.7	4.63	5.65	6.78
USACE 2013 High	0	0.09	0.26	0.5	0.83	1.22	1.69	2.23	2.85	3.54	4.31	5.15

The St. Johns River Makes Volusia County Complicated...

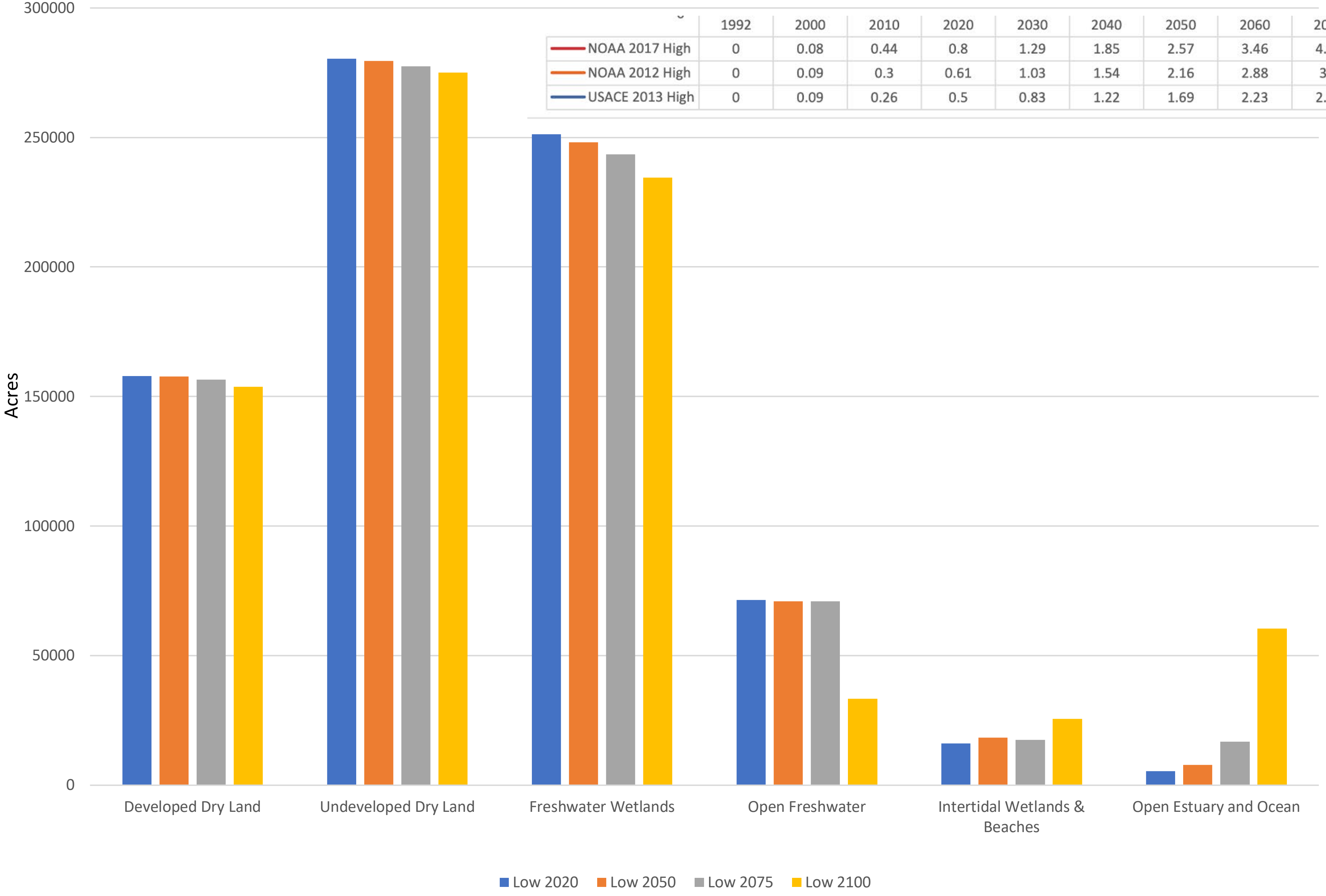




Parameter	Global	SubSite 1	SubSite 2	SubSite 3	SubSite 4	SubSite 5	SubSite 6	SubSite 7	SubSite 8
Description		Lower St. Jc	Lower St. Jc	Lake George	Above Lake	Duval_Flagle	Halifax	Volusia Ocea	Mosquito La
NWI Photo Date (YYYY)	2014	2014	2014	2014	2014	2014	2014	2014	2014
DEM Date (YYYY)	2007	2007	2007	2007	2007	2007	2007	2007	2007
Direction Offshore [n,s,e,w]	East	East	East	East	East	East	East	East	East
Historic Trend (mm/yr)	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37
Historic Eustatic Trend (mm/yr)	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37
MTL-NAVD88 (m)	0	0	0	0	0	0	0	0	0
GT Great Diurnal Tide Range (m)	0	1.25	0.5	0.1	0	1.65	0.5	1.15	0.2
Salt Elev. (m above MTL)	0	0.9	-1	-1	-1	1	0.25	0.8	0.2
Marsh Erosion (horz. m /yr)	0	1.8	1.8	0	0	1.8	1.8	1.8	1.8
Marsh Erosion Fetch (km)	0	0	0	0	0	0	0	0	0
Swamp Erosion (horz. m /yr)	0	1	1	1	1	1	1	1	1
T.Flat Erosion (horz. m /yr)	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Reg.-Flood Marsh Accr (mm/yr)	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
Irreg.-Flood Marsh Accr (mm/yr)	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Tidal-Fresh Marsh Accr (mm/yr)	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
Inland-Fresh Marsh Accr (mm/yr)	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
Mangrove Accr (mm/yr)	7	7	7	7	7	7	7	7	7
Tidal Swamp Accr (mm/yr)	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Swamp Accretion (mm/yr)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Beach Sed. Rate (mm/yr)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Irreg-Flood Collapse (m)	0	0	0	0	0	0	0	0	0
Reg-Flood Collapse (m)	0	0	0	0	0	0	0	0	0
Use Wave Erosion Model [True,False]	False	False	False	False	False	False	False	False	False
Use Elev Pre-processor [True,False]	False	False	False	False	False	False	False	False	False
H1 inundation (m above MTL)	0	0	0	0	0	0	0	0	0
H2 inundation (m above MTL; H2>H1)	0	0	0	0	0	0	0	0	0
H3 inundation (m above MTL: H3>H2)	0	0	0	0	0	0	0	0	0
H4 inundation (m above MTL; H4>H3)	0	0	0	0	0	0	0	0	0
H5 inundation (m above MTL; H5>H4)	0	0	0	0	0	0	0	0	0

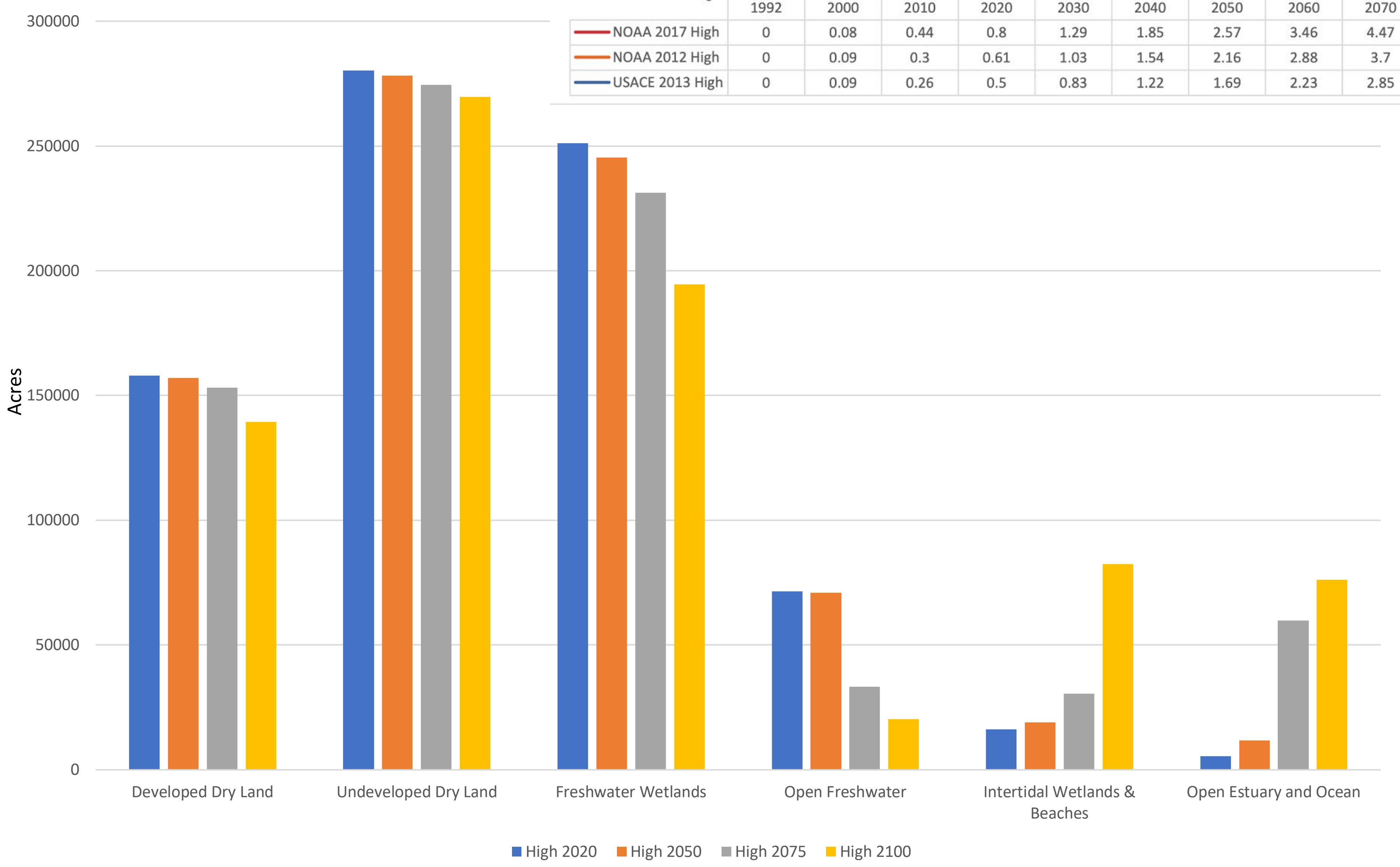
SLAMM Results for ECFRRAP Low Sea Level Rise

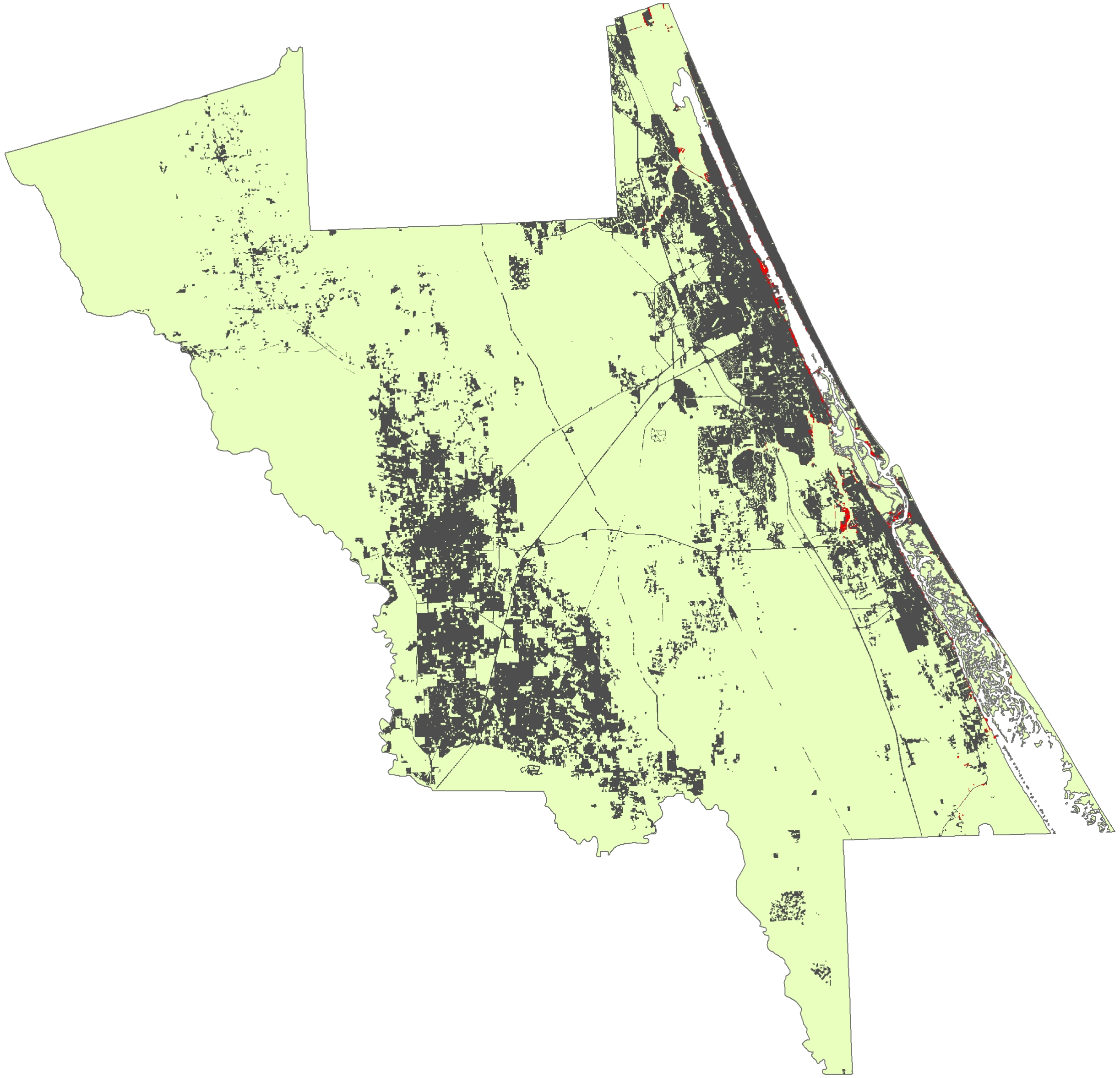
	1992	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
NOAA 2017 High	0	0.08	0.44	0.8	1.29	1.85	2.57	3.46	4.47	5.69	6.97	8.48
NOAA 2012 High	0	0.09	0.3	0.61	1.03	1.54	2.16	2.88	3.7	4.63	5.65	6.78
USACE 2013 High	0	0.09	0.26	0.5	0.83	1.22	1.69	2.23	2.85	3.54	4.31	5.15



SLAMM Results for ECRRAP High Sea Level Rise

	1992	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
NOAA 2017 High	0	0.08	0.44	0.8	1.29	1.85	2.57	3.46	4.47	5.69	6.97	8.48
NOAA 2012 High	0	0.09	0.3	0.61	1.03	1.54	2.16	2.88	3.7	4.63	5.65	6.78
USACE 2013 High	0	0.09	0.26	0.5	0.83	1.22	1.69	2.23	2.85	3.54	4.31	5.15



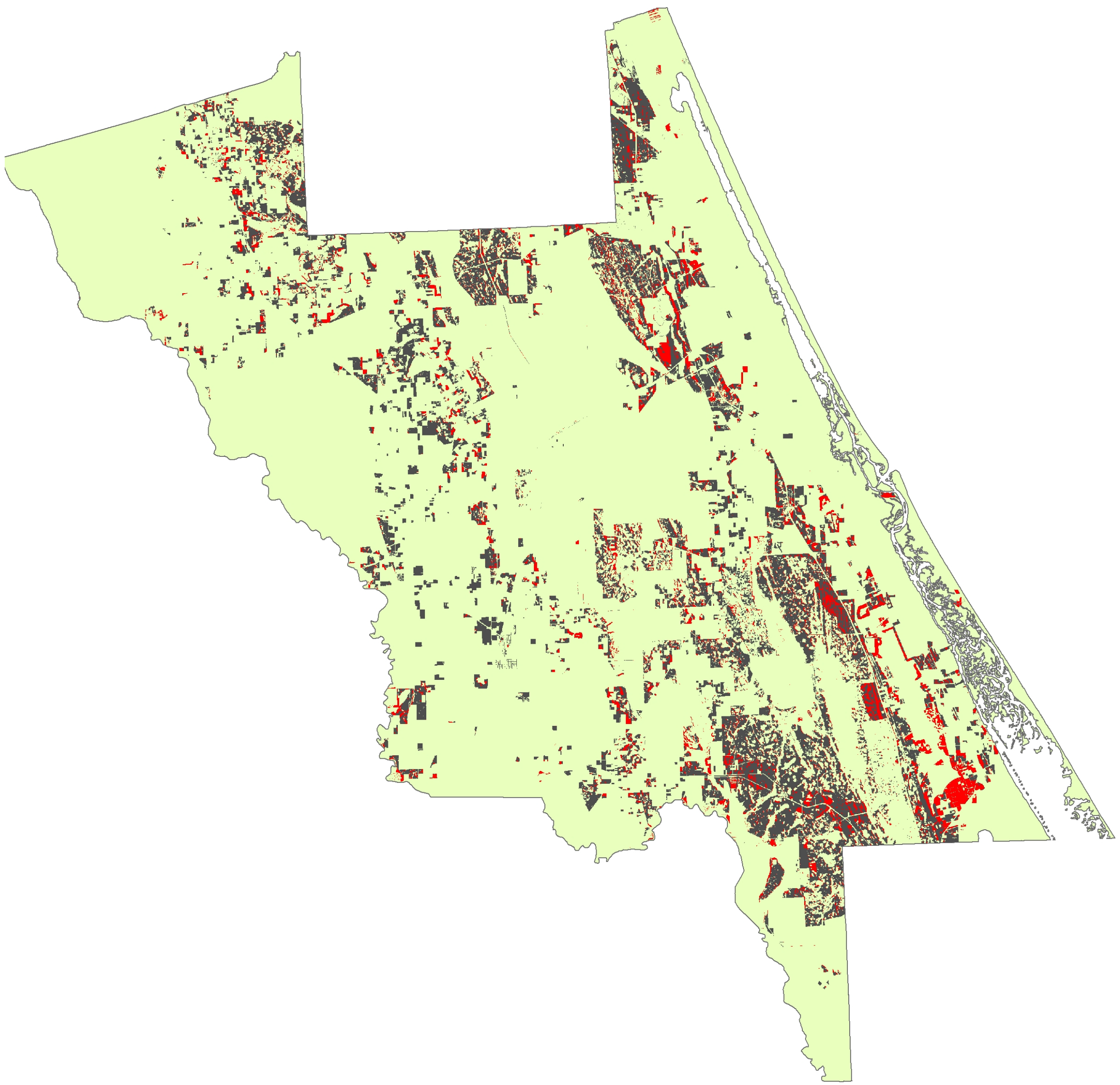


2070 Low Sea Level Rise (2.85’) with **current** developed lands

SLAMM shows:

1,517 acres (1%) of currently developed lands are shown as inundated by this scenario

156,942 of currently developed lands remain as developed (not inundated)

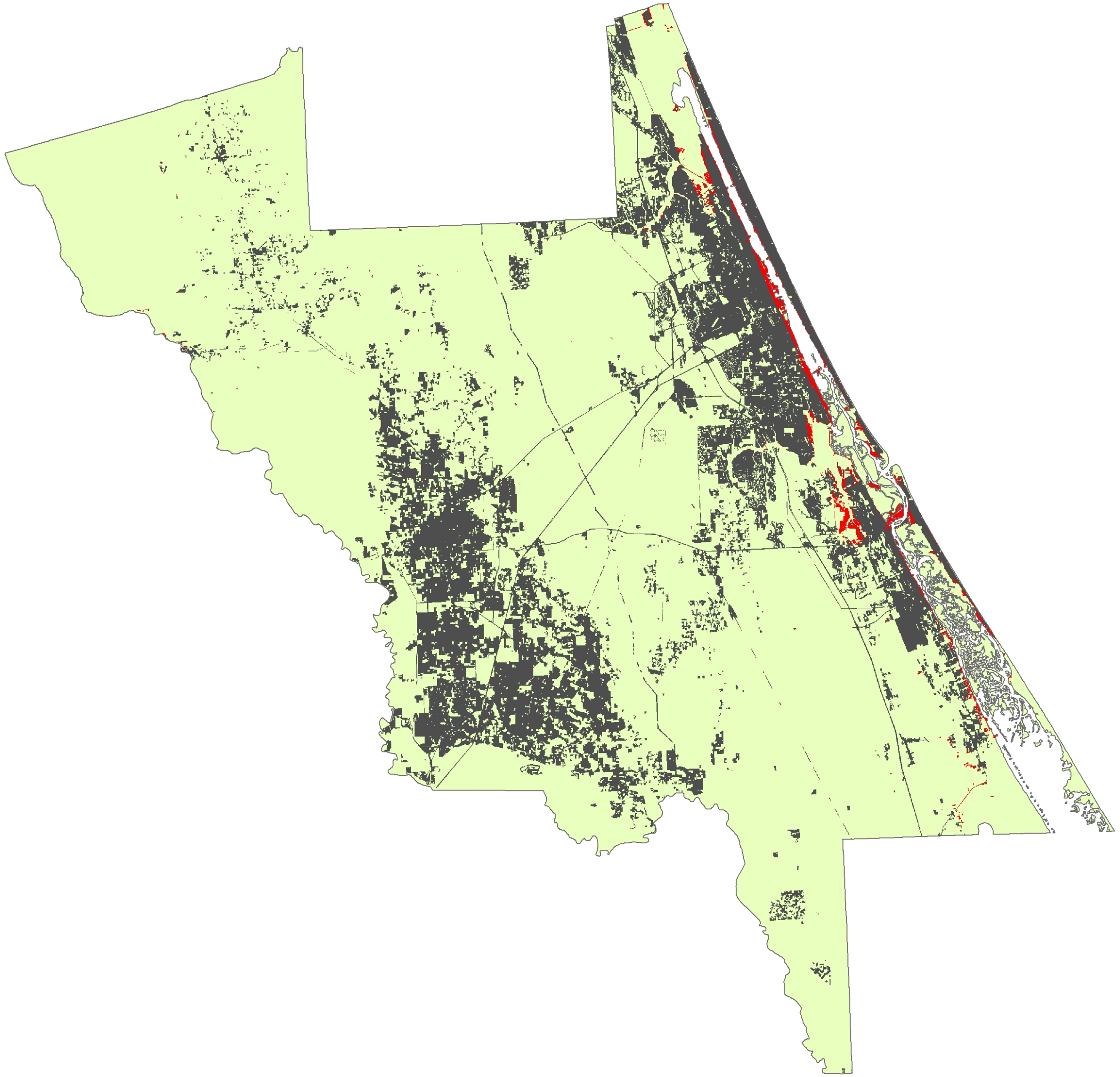


2070 Low Sea Level Rise (2.85’)
with **future** developed lands

SLAMM shows:

29,241 acres (23%) of lands shown as newly developed before 2070 are inundated by this scenario

96,311 of newly developed lands do not show potential conversion into wetland or open water

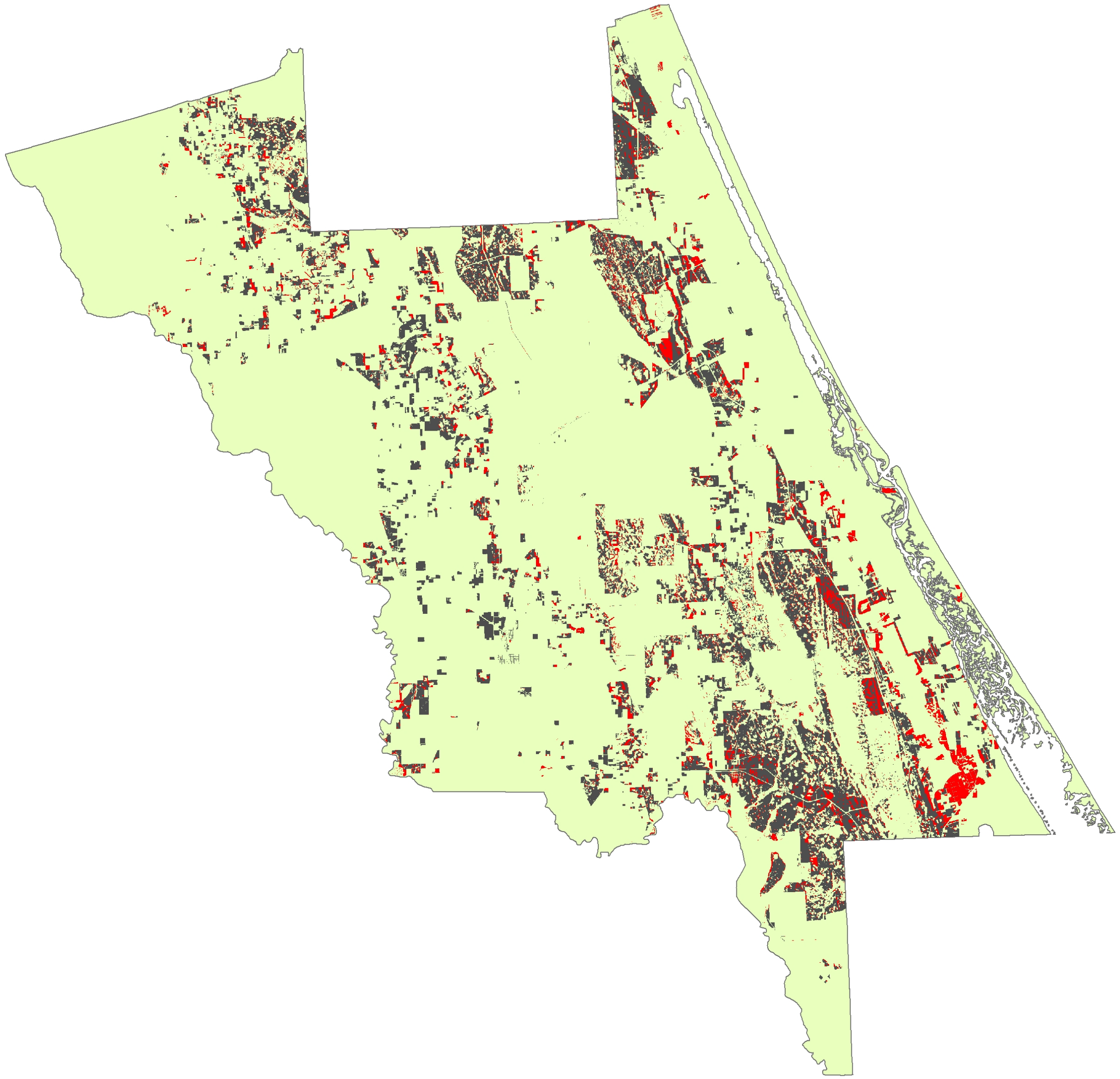


2070 High Sea Level Rise (4.47’) with **current** developed lands

SLAMM shows:

4,911 acres (3%) of currently developed lands are shown as inundated by this scenario

153,098 of currently developed lands remain as developed (not inundated)



2070 High Sea Level Rise (4.47’) with **future** developed lands

SLAMM shows:

29,738 acres (24%) of lands shown as newly developed before 2070 are inundated by this scenario

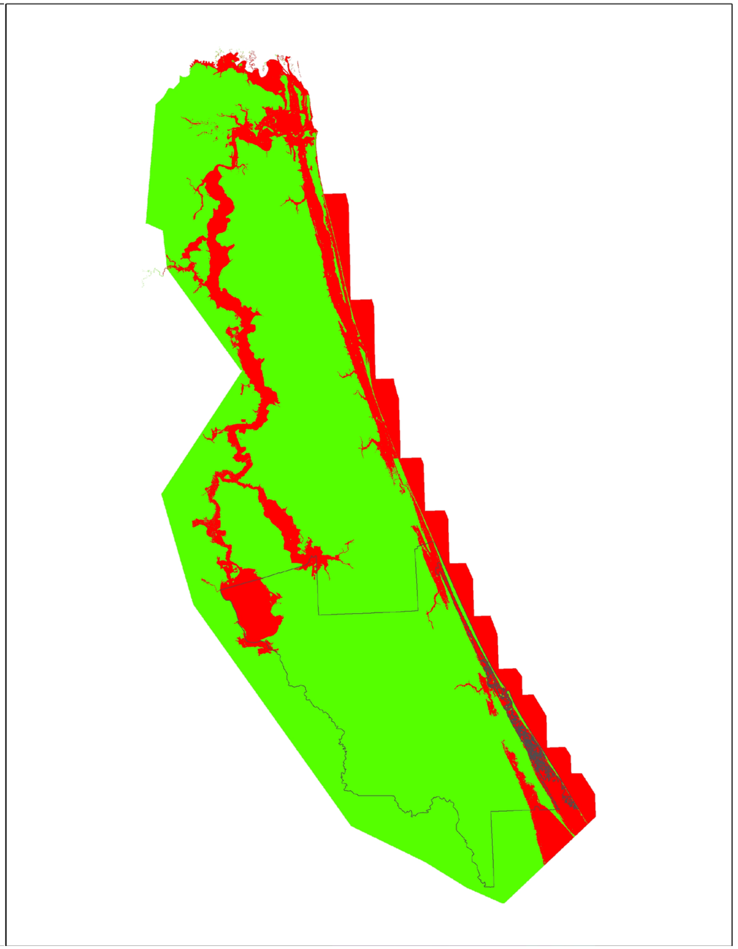
95,815 of newly developed lands do not show potential conversion into wetland or open water

Movement of Saltwater…

2020 Condition

2050 (Low)

2075 (Low)



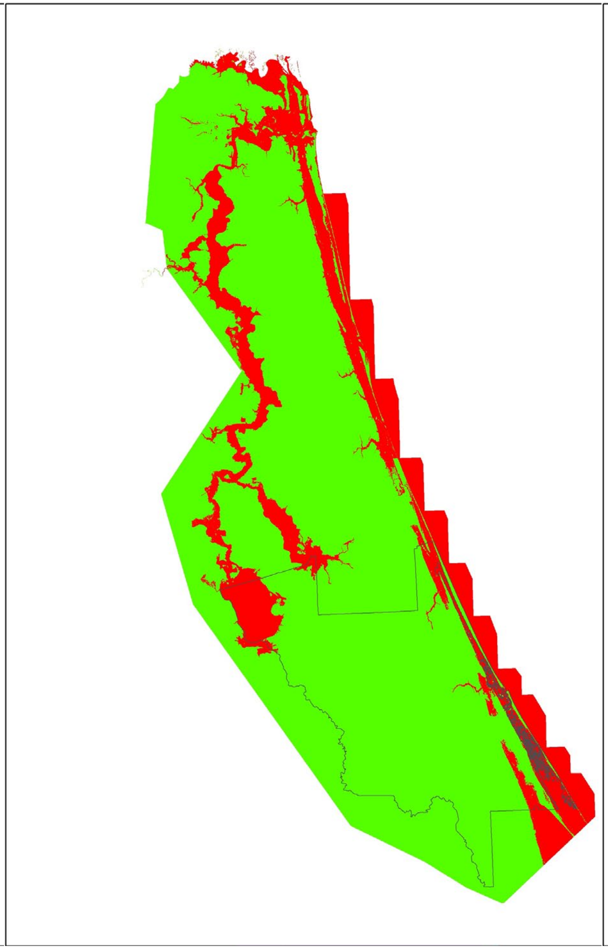
2100 (Low)

	1992	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
NOAA 2017 High	0	0.08	0.44	0.8	1.29	1.85	2.57	3.46	4.47	5.69	6.97	8.48
NOAA 2012 High	0	0.09	0.3	0.61	1.03	1.54	2.16	2.88	3.7	4.63	5.65	6.78
USACE 2013 High	0	0.09	0.26	0.5	0.83	1.22	1.69	2.23	2.85	3.54	4.31	5.15

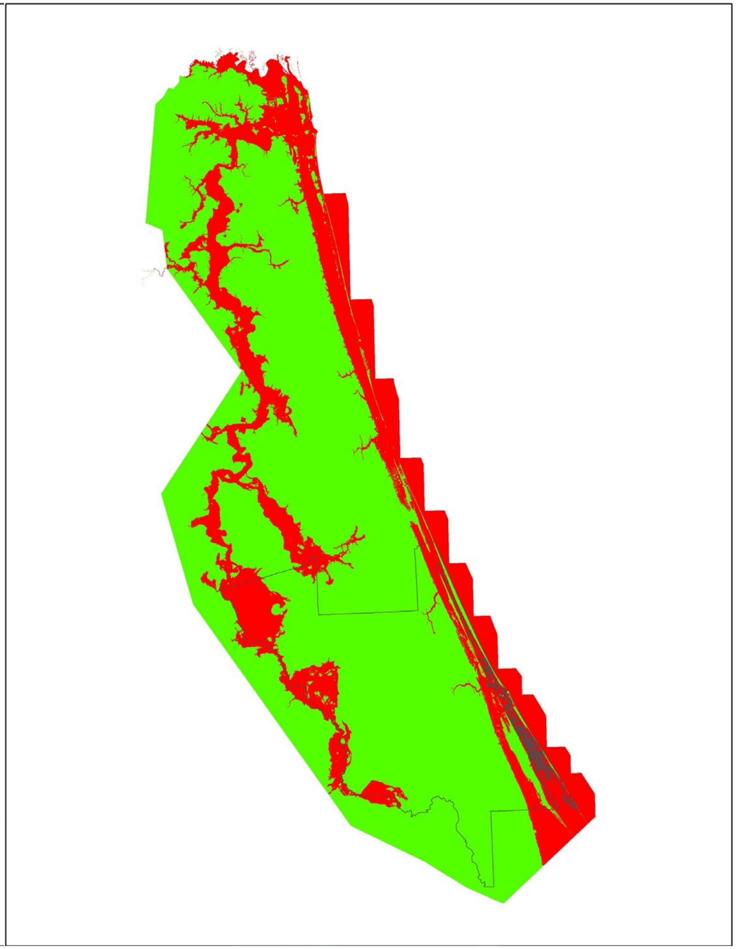
Movement of Saltwater…

2020 Condition

2050 (High)



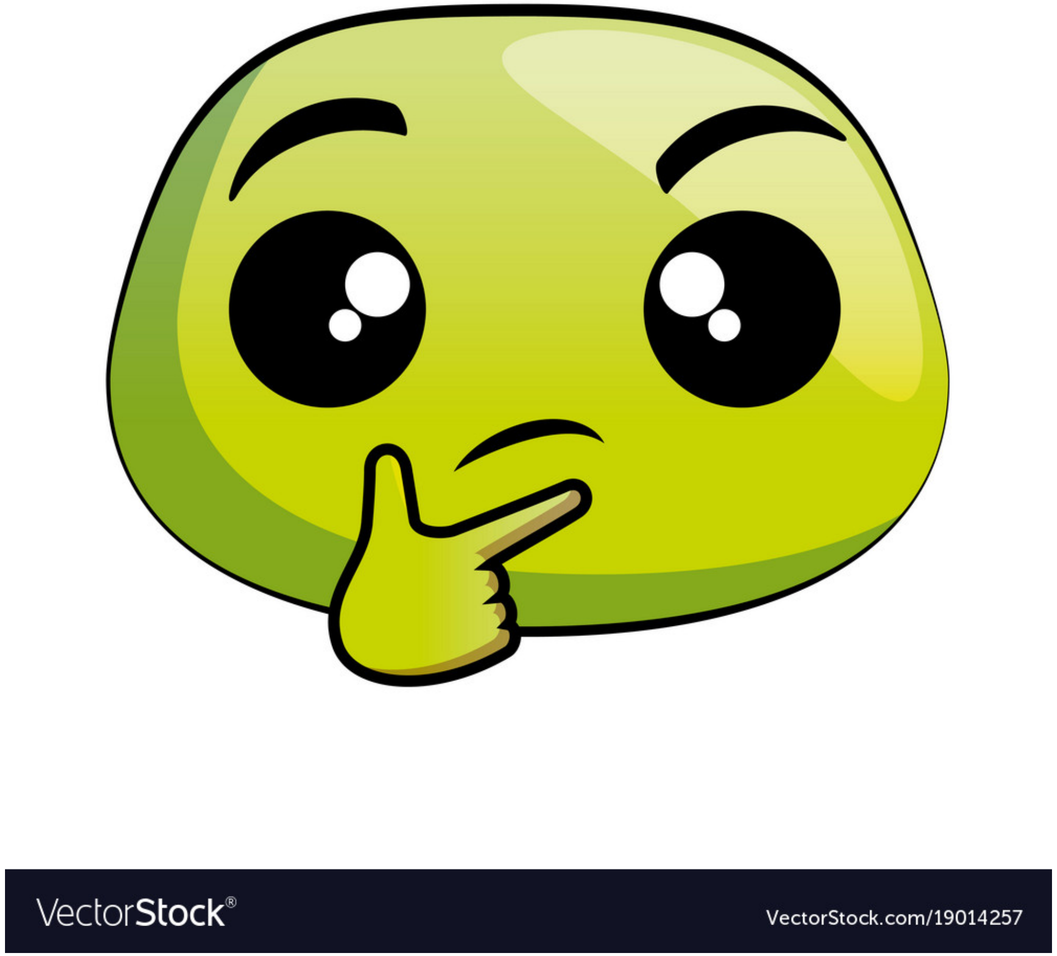
2075 (High)

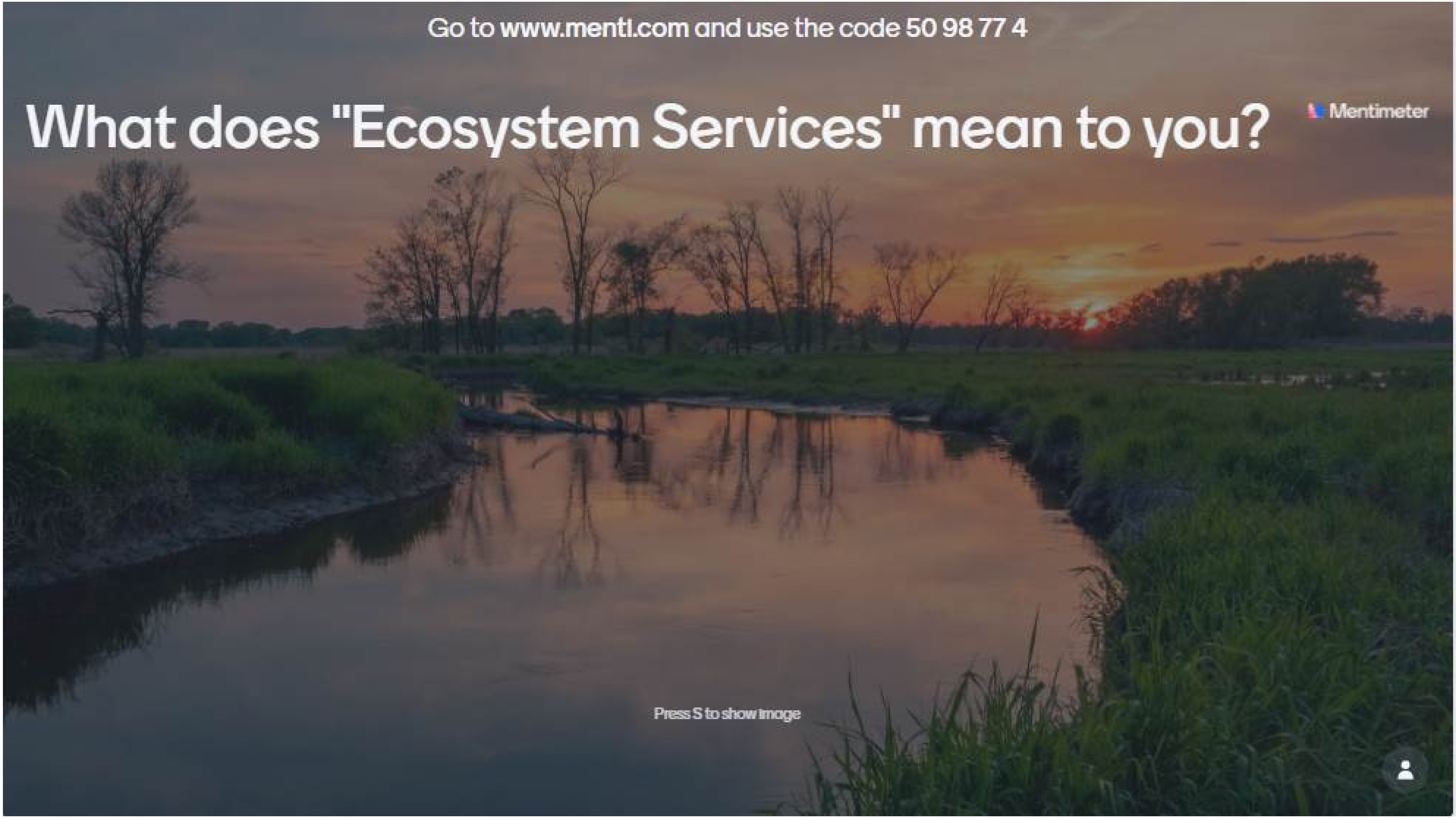


2100 (High)

	1992	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
NOAA 2017 High	0	0.08	0.44	0.8	1.29	1.85	2.57	3.46	4.47	5.69	6.97	8.48
NOAA 2012 High	0	0.09	0.3	0.61	1.03	1.54	2.16	2.88	3.7	4.63	5.65	6.78
USACE 2013 High	0	0.09	0.26	0.5	0.83	1.22	1.69	2.23	2.85	3.54	4.31	5.15

Thoughts, discussion, ideas?




Go to www.menti.com and use the code 50 98 77 4
What does "Ecosystem Services" mean to you?
Mentimeter
Press S to show image

Go to **www.menti.com** and use the code **50 98 77 4**

Which ecosystem services are most effected by development?

Press S to show image

Go to **www.menti.com** and use the code **50 98 77 4**

Which ecosystem services are most effected by climate change?

Press S to show image

Thomas Ruppert, Esq.
Dr. Chris de Bodisco

Volusia Land Use Planning

Collaborating for Resilience

Project Goal: Develop conservation actions that use scarce resources most effectively to minimize ecological and economic losses over time. Develop an implementable, locally acceptable, long term resilience plan to increase the economic and social value of natural resources in the face of changing environment.

Step One: Data Driven

1. Categorize land uses and habitat types
2. Identify Ecosystem Services associated with land uses and habitats
3. Calculate the economic and social value for each type of services
4. Map threats and range of conservation options
5. Prioritize actions based on highest net value post conservation

Collaborating for Resilience

Project Goal: Develop conservation actions that use scarce resources most effectively to minimize ecological and economic losses over time. Develop implementable, locally acceptable, long term resilience plan to increase economic and social value of natural resources in face of changing environment.

Step Two: Stakeholder Driven

1. Engage stakeholders with this information through engagement and seek direct input from them based on their values, attitudes, and perceptions about things like need, value, and political feasibility.
2. Utilize information from this stakeholder engagement to re-evaluate the costs and benefits of response options through modifying costs and benefits based on feedback. For example, by including an additional political feasibility cost factor.

Prioritization Process

1. Identify land uses and locate habitat types

2. Overlay environmental, demographic and economic characteristics

3. Develop map of economic and ecological features

4. Identify data-based areas of special interest

5. Incorporate local priorities

Habitat Type
Pine Flatwood
Mangrove Swamp
Saltwater Marsh
Upland Forest
Woodland Pasture

1. Identify Ecosystem Services provided by land use and habitats

PROVISIONING SERVICES	REGULATING SERVICES
Food	Influence on air quality
(Fresh) water supply	Climate regulation
Genetic resources	Moderation of extreme events
Medicinal resources	Regulation of water flows
Raw materials	Waste treatment / water purification
	Erosion prevention
HABITAT SERVICES	Nutrient cycling / soil fertility
Lifecycle maintenance (nurseries)	Pollination
Gene pool protection (conservation)	Biological control
CULTURAL SERVICES	
Opportunities for recreation / tourism	
Aesthetic information / Education	

Global ESV by Type and Land Use

	Marine	Coral reefs	Coastal systems	Coastal wetlands [a]	Inland wetlands	Fresh water (rivers/ lakes)	Tropical forest	Temperate forest	Woodlands	Grasslands
Provisioning services	102	55,724	2396	2998	1659	1914	1828	671	253	1305
1 Food	93	677	2384	1111	614	106	200	299	52	1192
2 Water				1217	408	1808	27	191		60
3 Raw materials	8	21,528	12	358	425		84	181	170	53
4 Genetic resources		33,048		10			13			
5 Medicinal resources				301	99		1504			1
6 Ornamental resources		472			114				32	
Regulating services	65	171,478	25,847	171,515	17,364	187	2529	491	51	159
7 Air quality regulation							12			
8 Climate regulation	65	1188	479	65	488		2044	152	7	40
9 Disturbance moderation		16,991		5351	2986		66			
10 Regulation of water flows					5606		342			
11 Waste treatment		85		162,125	3015	187	6	7		75
12Erosion prevention		153,214	25,368	3929	2607		15	5	13	44
13 Nutrient cycling				45	1713		3	93		
14 Pollination							30		31	
15 Biological control					948		11	235		
Habitat services	5	16,210	375	17,138	2455	0	39	862	1277	1214
16 Nursery service		0	194	10,648	1287		16		1273	
17 Genetic diversity	5	16,210	180	6490	1168		23	862	3	1214
Cultural services	319	108,837	300	2193	4203	2166	867	990	7	193
18 Esthetic information		11,390			1292					167
19 Recreation	319	96,302	256	2193	2211	2166	867	989	7	26
20 Inspiration		0			700					
21 Spiritual experience			21							
22 Cognitive development		1145	22					1		
Total economic value	**491**	**352,249**	**28,917**	**193,845**	**25,682**	**4267**	**5264**	**3013**	**1588**	**2,871**

ESV linked to coastal land uses

Ecosystem Goods and Services	Coastal Shelf	Beach	Estuary	Saltwater Wetland	Forest	Grass/ Rangelands	Cropland	Freshwater Wetland	Open Fresh Water	Riparian Buffer	Urban Greenspace
Gas/climate regulation		n/a			65	4		161			404
Disturbance regulation		32,794	344	373				4,397		106	
Water regulation						2		3,590			7
Water supply	626		59		196			1,856	492	2,310	
Soil formation	n/a	n/a			6	4			n/a		
Nutrient cycling	869	n/a	12814								
Waste treatment		n/a		6,508	53	53		1,008			
Pollination	n/a	n/a			195	16	10		n/a		
Biological control	24	n/a	47		2	14	14				
Habitat/refugia			378	242	1,110		999	136			
Aesthetic/recreation		17,851	351	31	147	1	18	1,690	428	1,647	2,562
Cultural/spiritual	42	29	18	216	1			1,070		5	

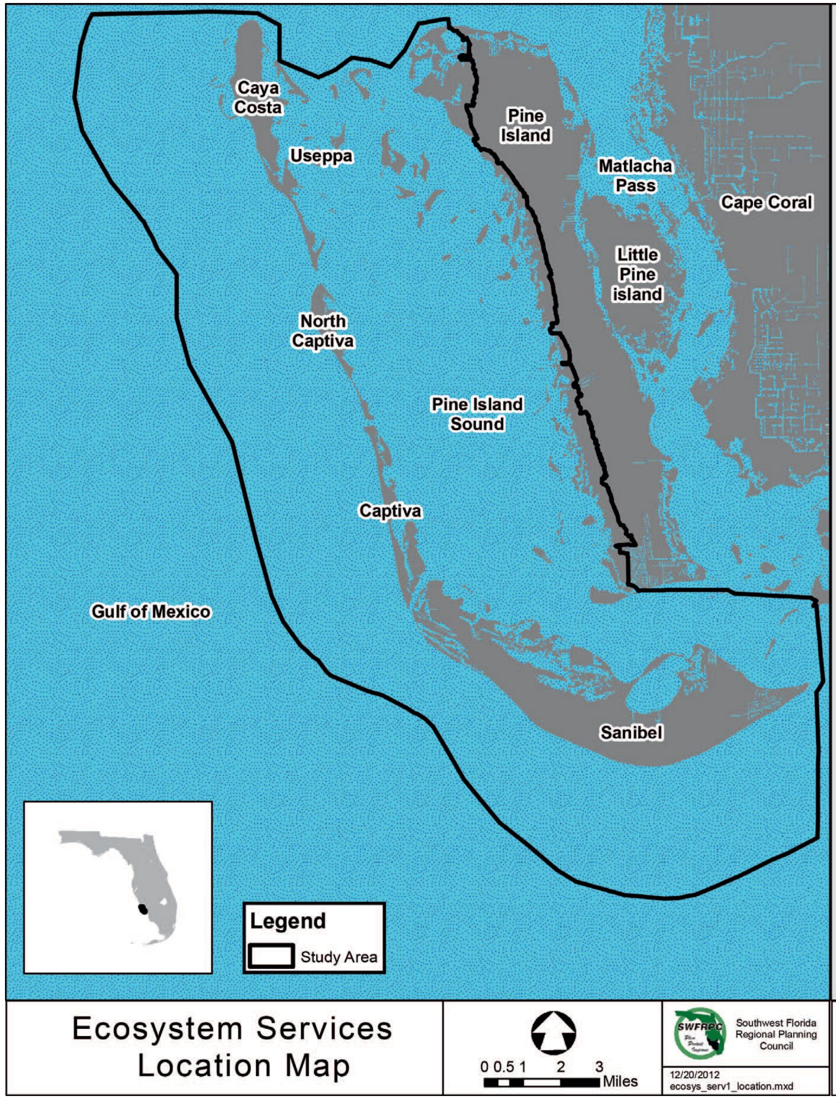
ESV linked to detailed land uses in Florida

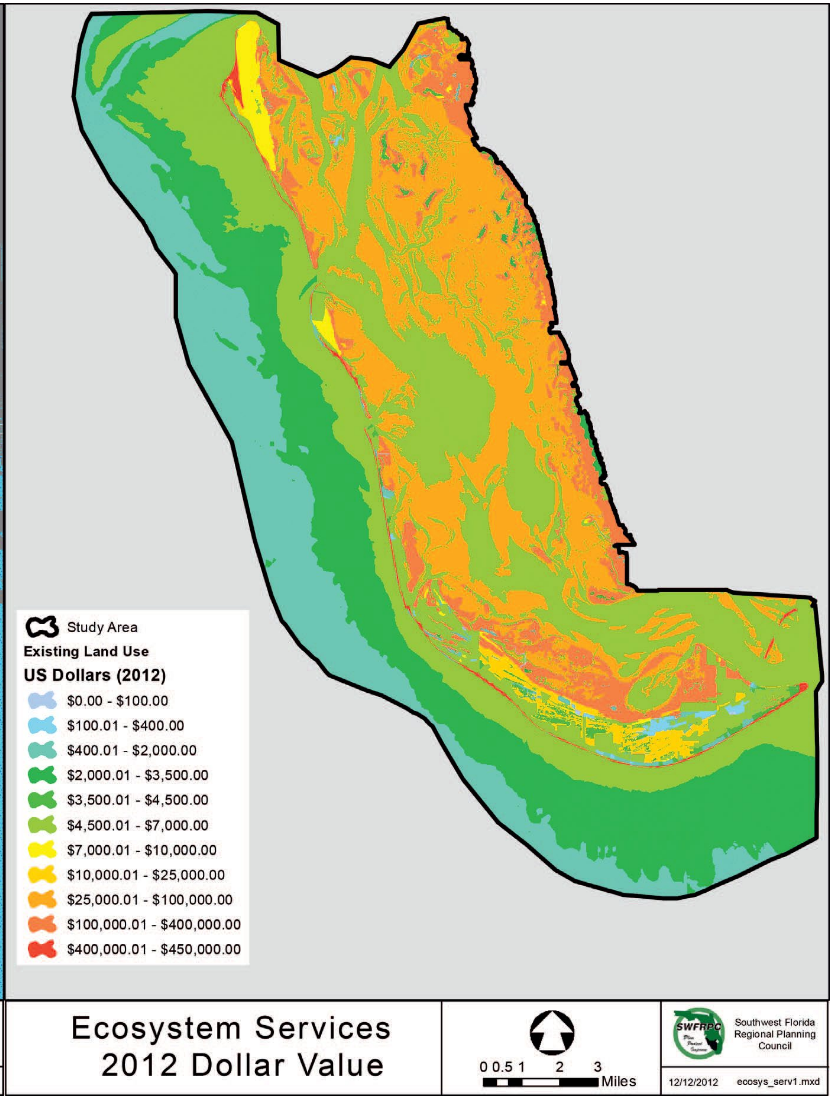
FNAI/FLUCCS	Total Acres	2012 value per acre	Total TEV value in 2012
Abandoned Field	939.46	54	50,393
Abandoned Pasture	203.09	54	10,894
Agriculture	750.09	1,158	868,424
Basin Marsh	20.93	16,517	345,697
Basin Marsh - Disturbed	86.35	8,258	713,113
Basin Swamp	256.09	14,518	3,717,935
Basin Swamp - Disturbed	210.83	7,259	1,530,423
Baygall	0.54	10,082	5,444
Blackwater Stream	19.02	6,300	119,826
Bottomland Forest	2.85	14,518	41,377
Cabbage Palm Flatwoods Disturbed	6.4	4,813	30,801
Canal/Ditch	154.32	102	15,744
Clearing	127.27	72	9,217
Coastal Berm	17.71	54	950
Coastal Grassland	125.01	54	6,706
Coastal Hydric Hammock	53.89	5,317	286,526
Coastal Hydric Hammock Disturbed	28.66	2,658	76,191
Coastal Strand	6.23	5,317	33,124

3. Develop a map that links values with risks.

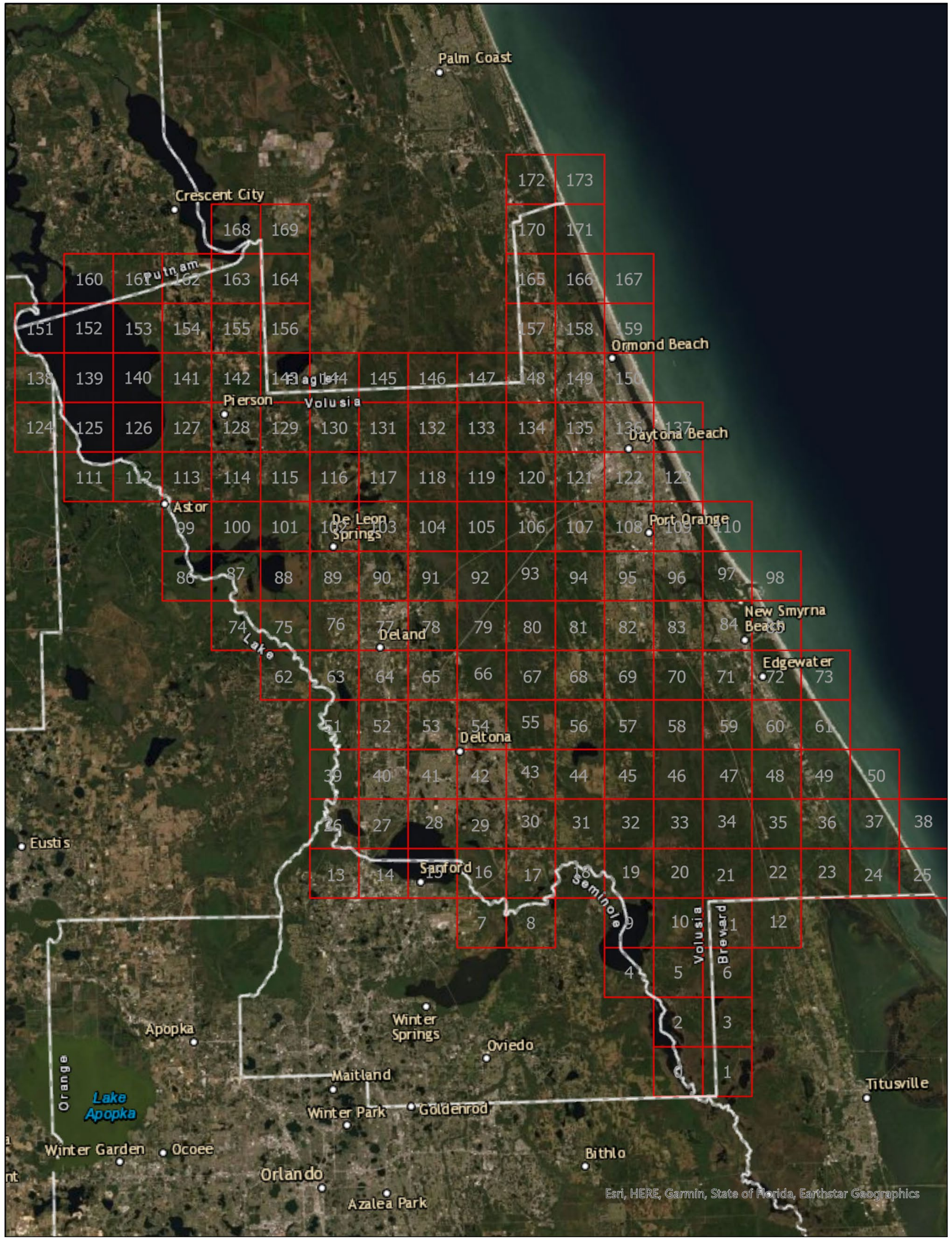
- Identify lands with the most valuable ecosystem services.
- Overlay that map with threats from developing land use changes, including sea level rise.
- Develop conservation cost estimates
- Prioritize conservation land targets that maximize net social benefits.

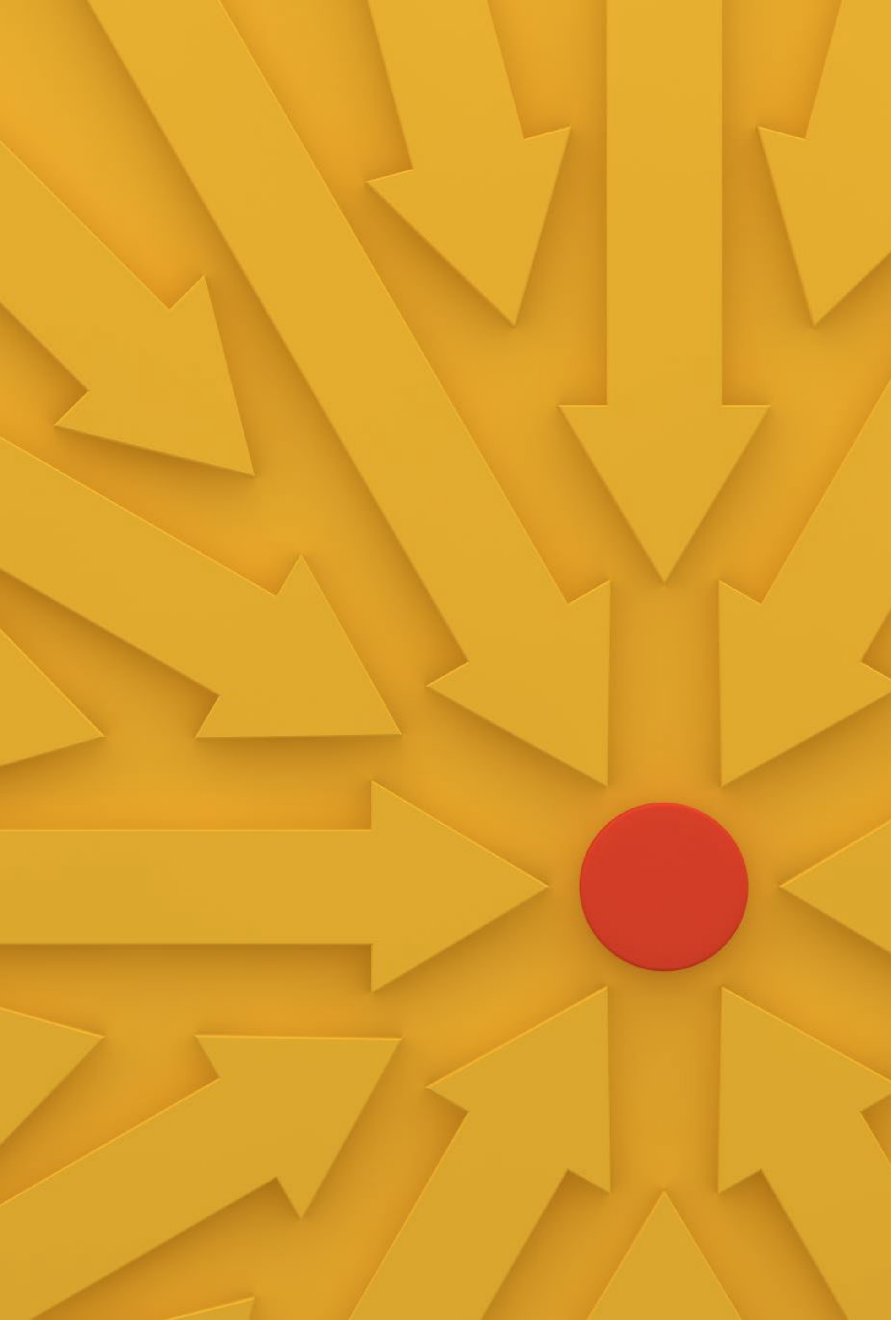
- Example from James Beever, Pine Island Sound SWFRPC, 2016





4. Identify data-based areas of special interest



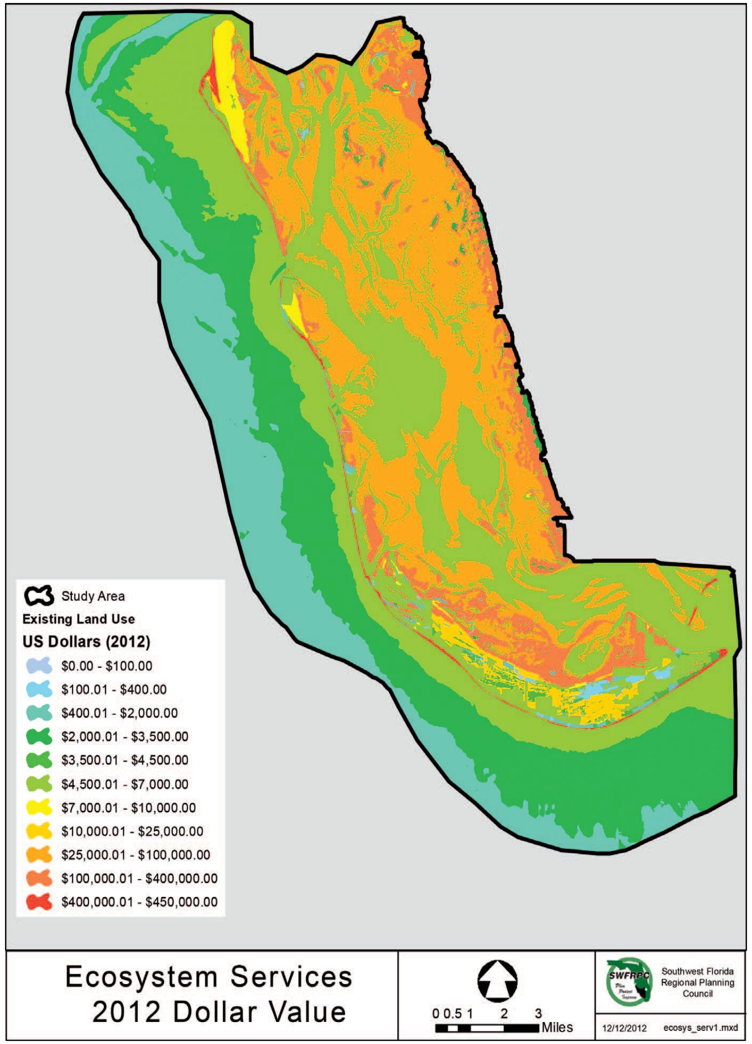


5. Identify local priorities and concerns to weight results

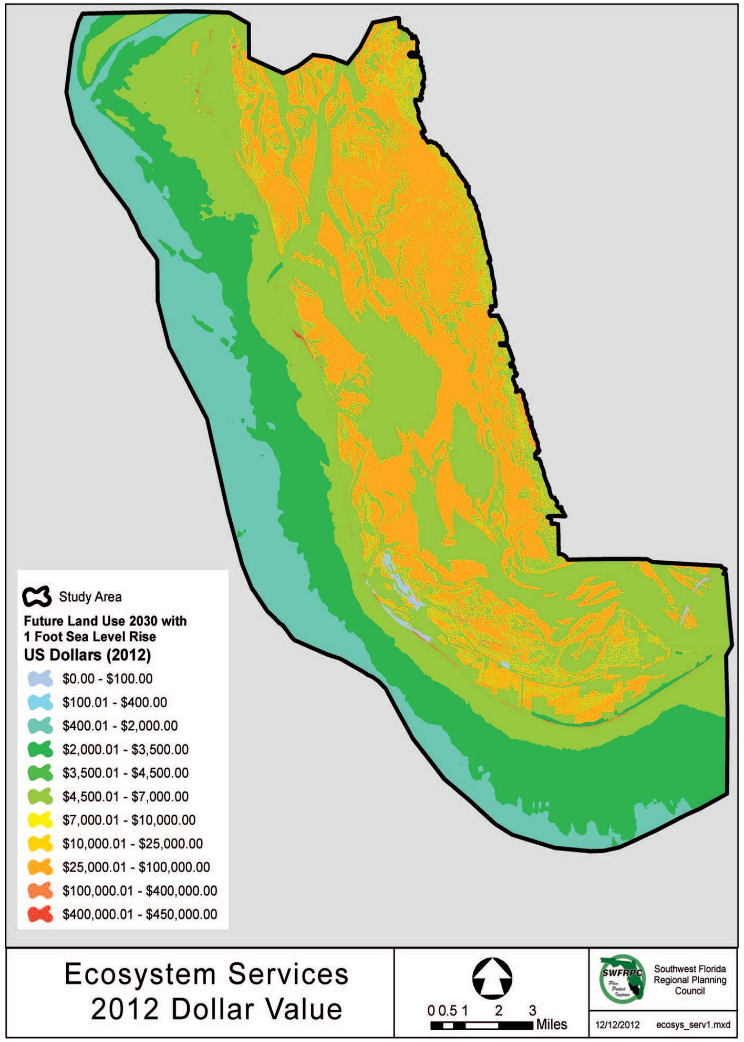
- Role of community: Clarify local values and priorities by identifying goals and perceived impediments.
    - What goal should drive land conservation?
        - Write one word that exemplifies the most important goal of conservation planning. You may list more than one goal, but use one word to describe each goal.
    - What do you see as key impediments to land conservation?
        - Write one word that exemplifies the most important goal of conservation planning. You may list more than one goal, but use one word to describe each goal.

- Prioritize actions based on highest post-conservation values with and without local priorities as weights

6. Develop two maps of conservation options



A. Develop one map that prioritizes conservation based on cost benefit analysis.
B. Develop a second map that weights priorities based on stakeholder goals and perceived impediments.
C. Compare these to learn how local values affect conservation priorities.

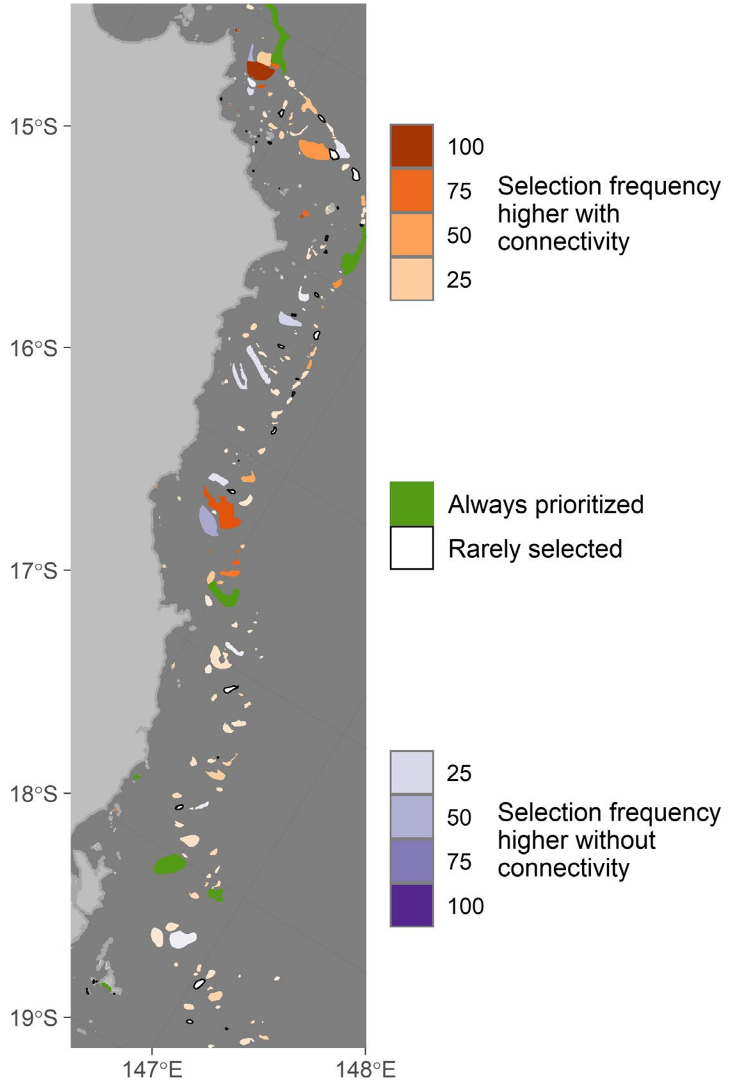


Landcover Change, Ecosystem Services, and Conservation Reserve Modelling

- Landcover trend analysis through 2070 (UF GeoPlan and 1000 Friends of Florida)
- Impact of Sea Level Rise using SLAMM (Sea Level Affecting Marshes Model)
- Overlay of existing and future development to sea-level rise inundation risk
- Optimization of potential regions for habitat conservation, flood mitigation, and other ecosystem services (Marxan)

Using Marxan to Make Informed Decisions

- Green infrastructure prioritization and optimization
- To make decisions about purchasing lands in a way that best achieves multiple objectives with recognition of limited financial resource
  - Habitat conservation
  - Species conservation
  - Maintaining habitat connectivity
  - Maximizing ecosystem services values
  - Minimizing cost

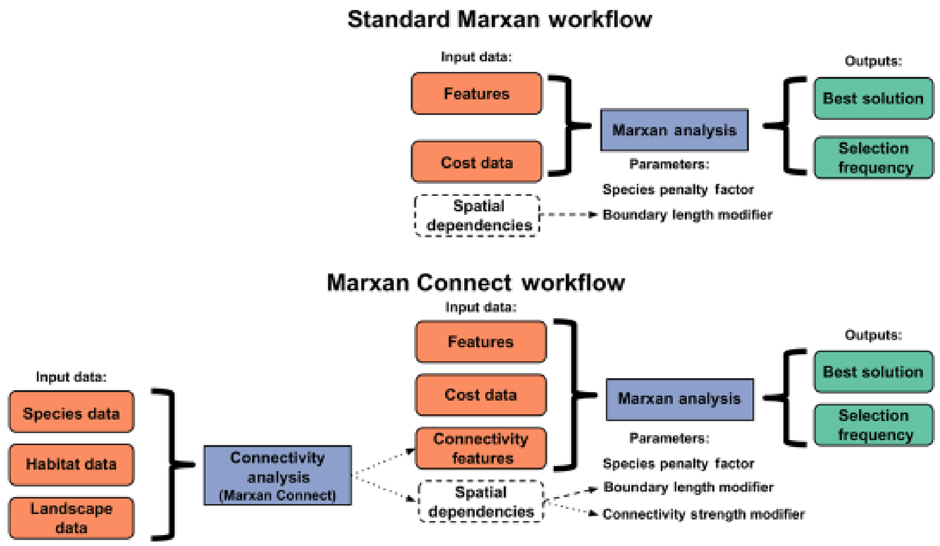


Daigle et al. 20202

Marxan as an Optimization tool

- Helps identify land parcels that maximize progress towards our biodiversity goals while minimizing acquisition or other user-controlled costs
- Uses user-defined data sets and returns a solution (geographic area to conserve) in the form of a table of land parcels from complex datasets
- Uses simulated annealing algorithm
- Marxan Score = Planning Unit Cost + Conservation Area Boundary Length + Ecosystem Service Value

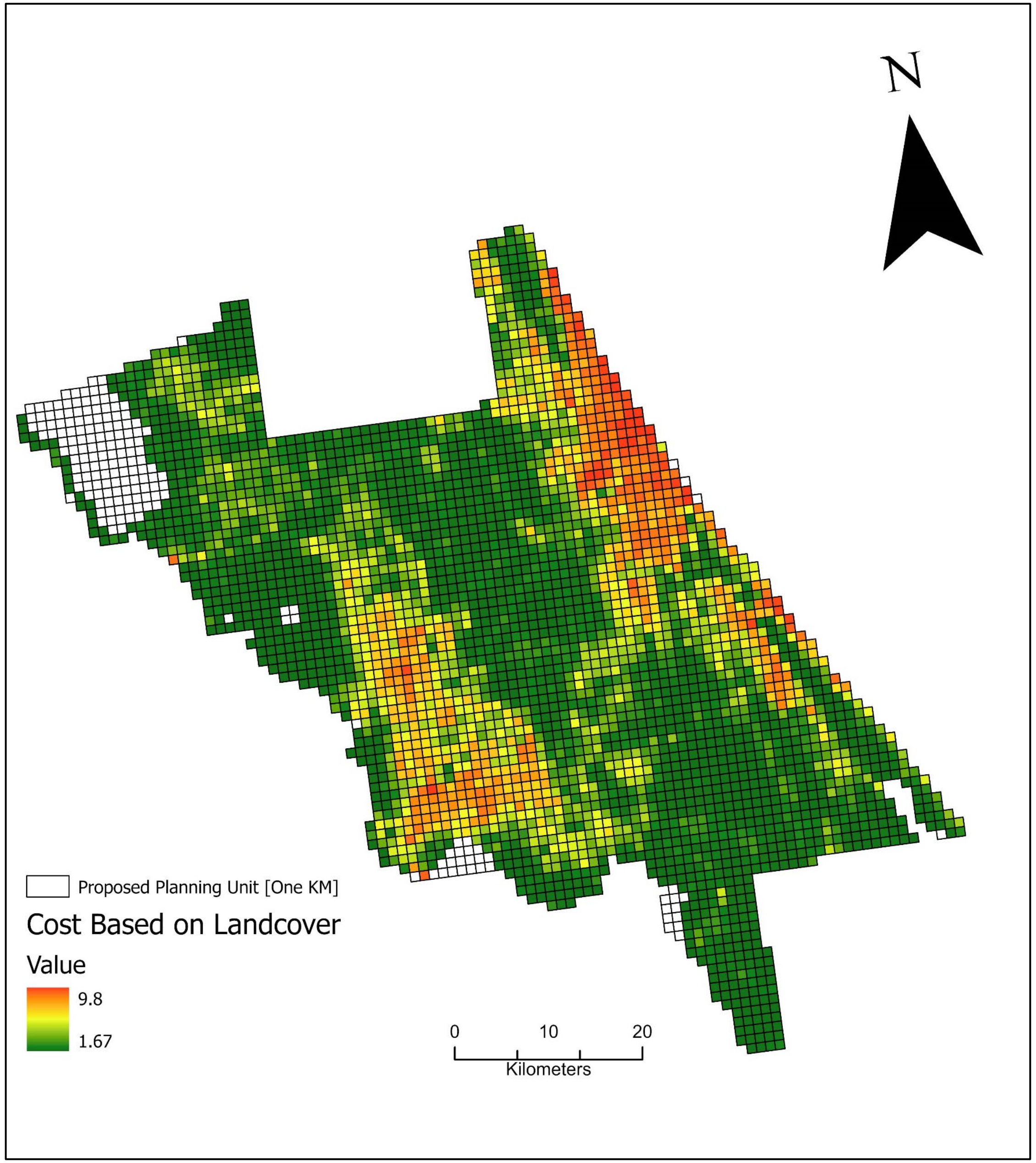
Marxan outline



https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/2041-210X.13349

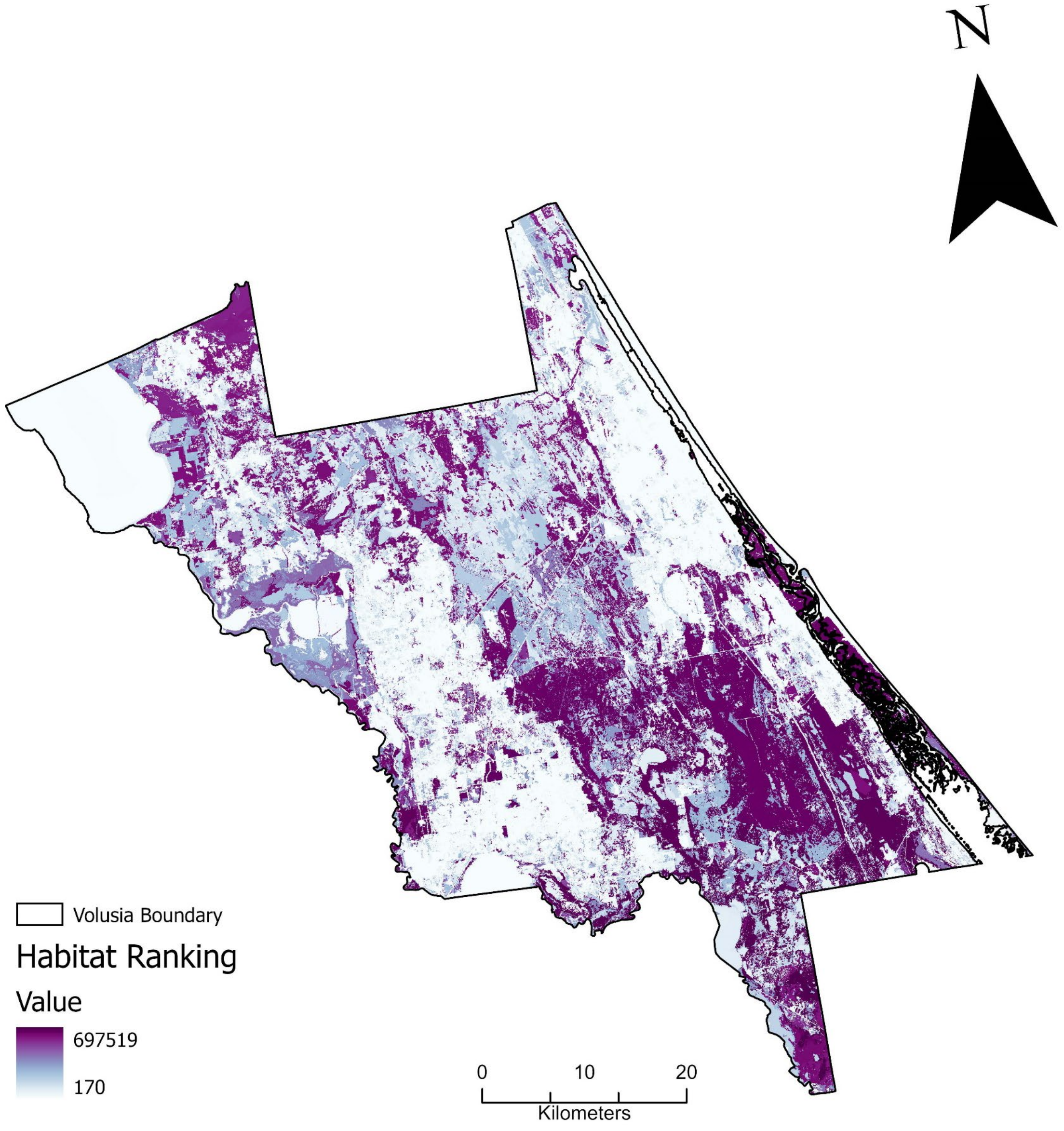
Our Marxan Run

- Planning unit: Spatial sub-units of the entire planning area- 1km^2
- Making use of various data:
    - Landcover
    - Species
    - Habitat
- Incorporate connectivity among various planning units
- Supplement efforts and target by county, cities, and state
- Contributing towards habitat conservation as well as flood protection and water quality



Potential Datasets

- Land cover data
  - SJRWMD land cover data vs. NLCD
- Integrated wildlife habitat ranking system composite data
- Point locations of plant and/or animal species (Florida Geoplan)



Go to **www.menti.com** and use the code **50 98 77 4**

Mentimeter

Are there any other variables or datasets that you think we should include in the Marxan model?

Next Steps

- Marxan model set up
- In-person workshop, hopefully in early fall at the Sandra Stetson Aquatic Center, for prioritization exercise
- Create policies and procedures to identify focus areas and relevant strategies
- Additional engagement


Questions and Open Discussion