Mapping ecosystem services for National Park Service management

Ken Bagstad, Eva DiDonato, Phillip Cook, Pat Kenney,
Lena Le, Kirsten Leong, and Michael Rikard

University of Idaho
College of Natural Resources

Washington State University

USGS
science for a changing world

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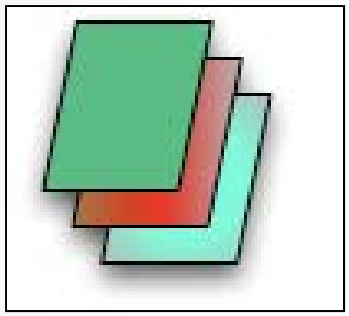
General premises & Project goals

- NPS has collected visitation, spending, and economic impact data for years
- This isn't the only benefit National Parks provide to their surrounding communities and more distant beneficiaries
- Activities outside of a park can have important impacts on park resources
- Understanding how and where people value the landscape plus where ecosystem services are generated may help identify potential management synergies and conflicts - useful information for park planning

Biophysical ecosystem services modeling

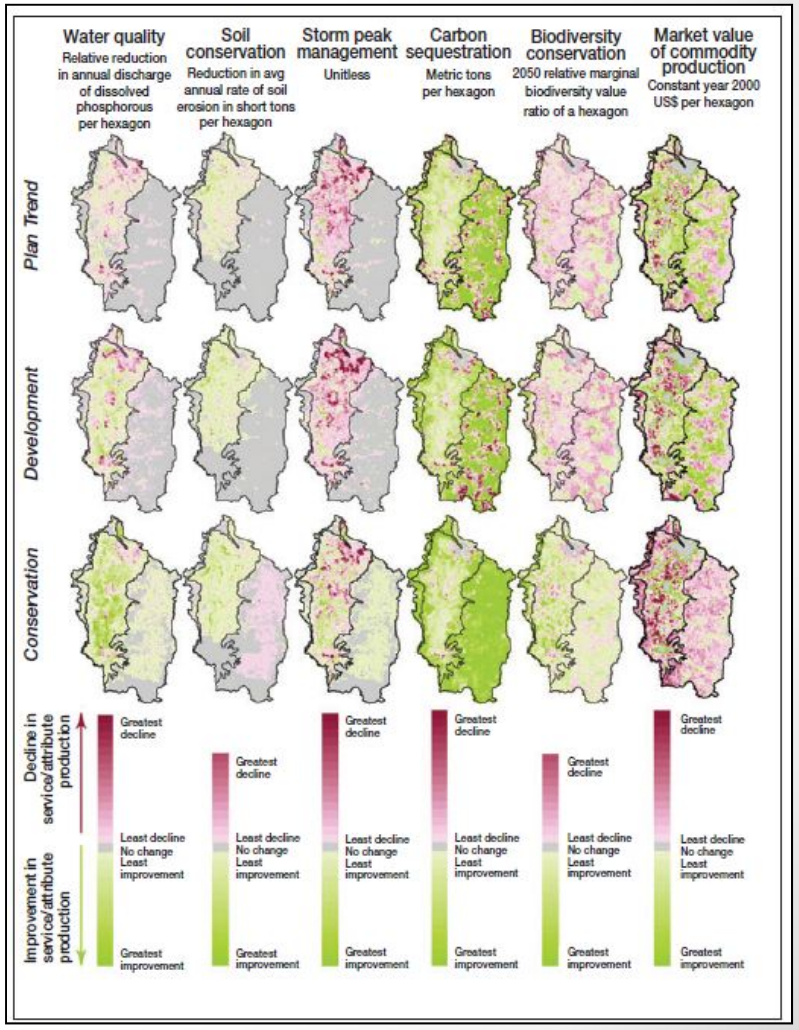


GIS database

"Ecological production function"

E.g., Artificial Intelligence for Ecosystem Services (ARIES), Integrated Valuation of Ecosystem Service Tradeoffs (InVEST), others

Maps quantifying ES tradeoffs, hotspots, co-benefits



Nelson et al. 2009

Cultural ecosystem service mapping

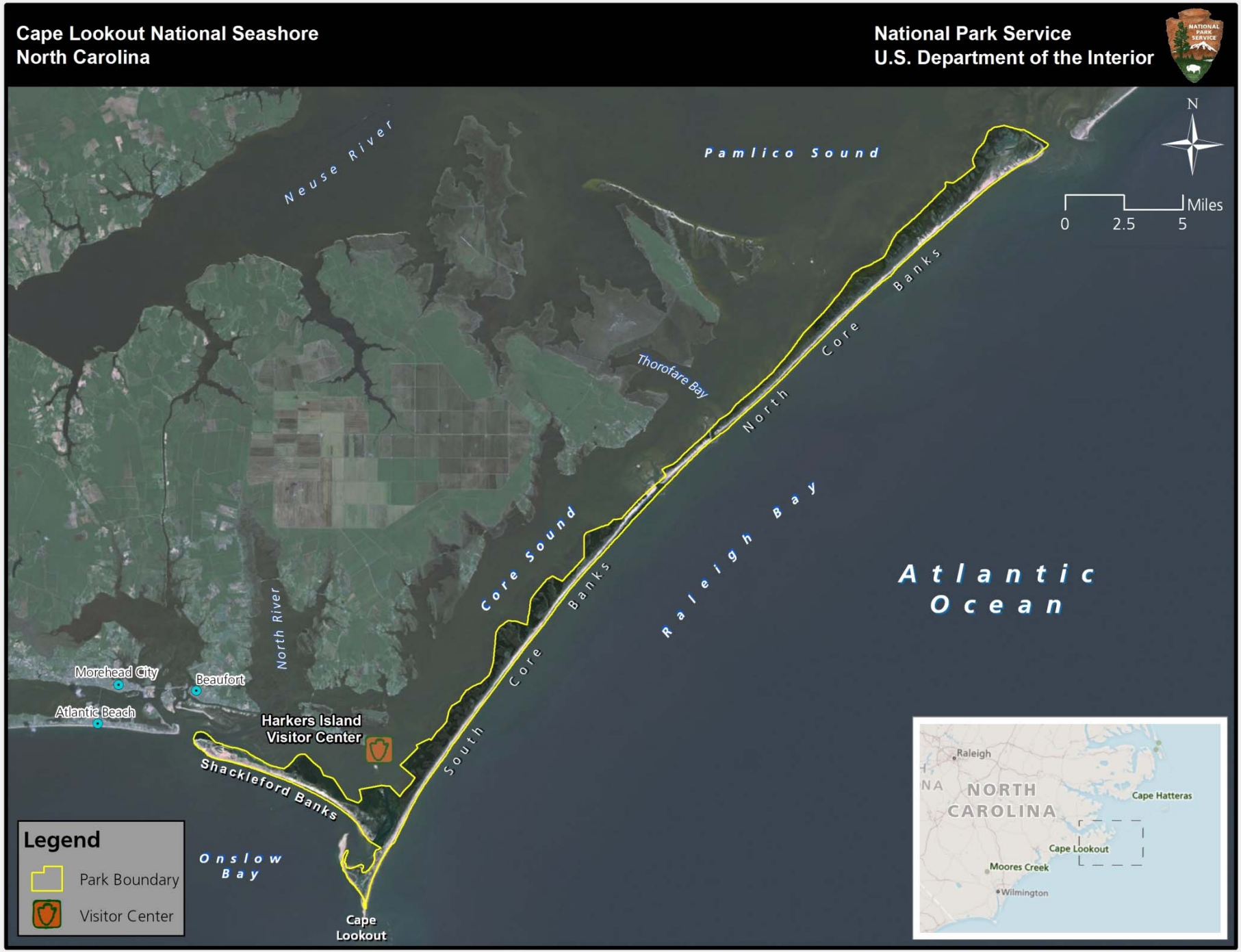
Social Values for Ecosystem Services (SolVES) tool (Sherrouse et al. 2011, 2014)

- Aesthetic
- Biodiversity
- Cultural
- Economic
- Future
- Historic
- Intrinsic
- Learning
- Life Sustaining
- Recreation
- Spiritual
- Therapeutic

Potential management implications

		Biophysical ecosystem services	
		High biophysical ES	Low biophysical ES
Cultural ecosystem services	High cultural ES	High support for ES-based management (if social values & ES delivery are compatible) OR potential conflict between ES-based management & traditional uses (if social values & ES delivery are not complimentary)	High support for traditional uses
	Low cultural ES	Public outreach needed to build support for ES-based management (e.g., for watershed protection programs)	Areas suitable for development or resource extraction, assuming other important natural or cultural resources are absent (e.g., high biodiversity, threatened & endangered species, Native American cultural significance)

Bagstad et al., accepted with revisions


Cape Lookout National Seashore
North Carolina
National Park Service
U.S. Department of the Interior
Neuse River
Pamlico Sound
N
Miles
0
2.5
5
Thorofare Bay
North Core Banks
South Core Banks
Core Sound
Raleigh Bay
Atlantic Ocean
North River
Morehead City
Beaufort
Atlantic Beach
Harkers Island
Visitor Center
Shackleford Banks
Onslow Bay
Cape Lookout
Legend
Park Boundary
Visitor Center
Raleigh
NORTH CAROLINA
Cape Hatteras
Cape Lookout
Moores Creek
Wilmington

Cape Lookout National Seashore
North Carolina

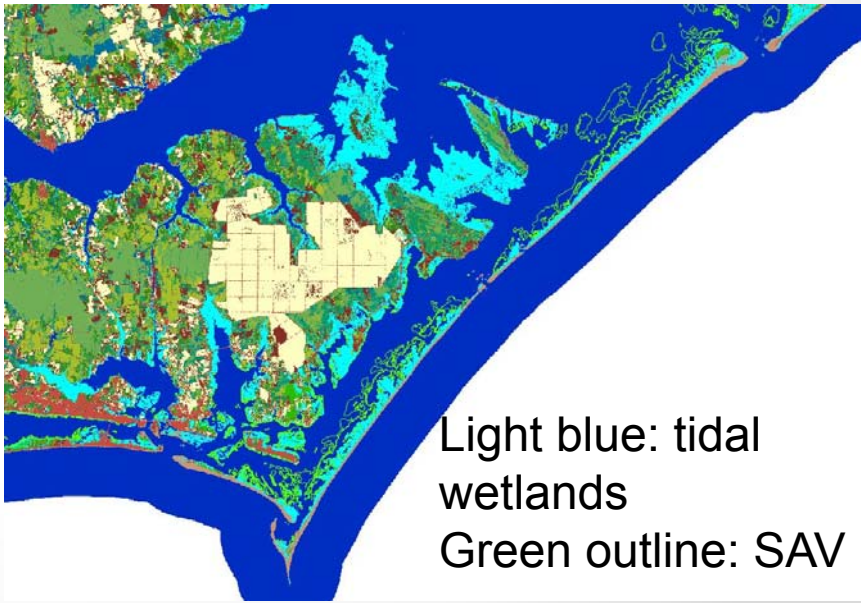
National Park Service
U.S. Department of the Interior

Biophysical ecosystem services modeling

- November 2013 stakeholder & scientists' meeting, Beaufort, NC
- Ranked top ecosystem services of concern
  - **Coastal storm protection**
  - **Fisheries**
  - **Sediment & nutrient impacts on water quality**
  - Scientific study
  - Carbon sequestration & storage
  - Scenic beauty
  - Cultural & archaeological history
  - Educational opportunities
  - Migratory species habitat
  - Property value benefits

Fisheries

- 7 species (shrimp, hard blue crab, hard clam, oyster, southern flounder, spot, striped mullet) are commercially valued in Carteret Co. and have habitat dependence on seagrass and/or tidal wetlands (NCDENR)
- Regression analysis: Predict the influence of added seagrass/tidal wetlands on catch, hence tie a value to the habitat.
- Catch per unit effort (lbs/trip) = $\alpha + \beta_1$(acres seagrass) + β_2(acres tidal wetland) + β_3(latitude) + ε



Light blue: tidal wetlands
Green outline: SAV

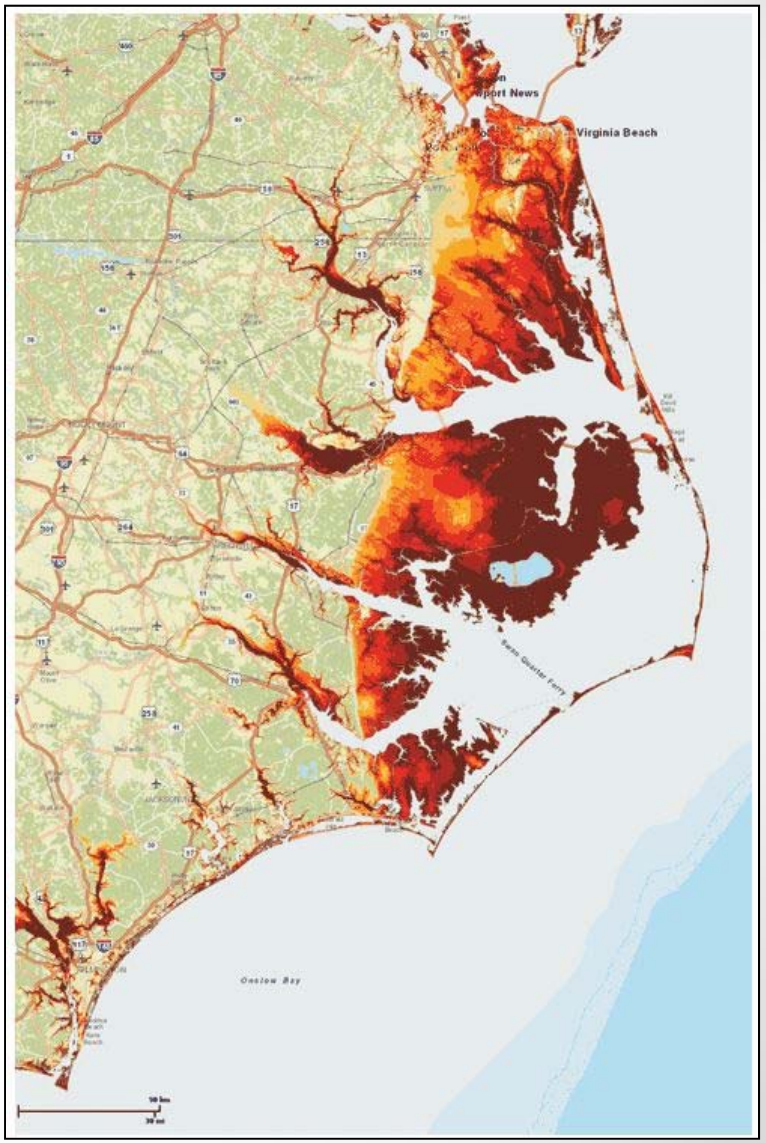
Fisheries

- Example: All else being equal, each extra acre of coastal wetland adds 4.9 lbs of southern flounder catch to a county; each extra acre of seagrass adds 5.2 lbs
- CALO includes 10,801 ac of coastal wetland plus 21,945 ac seagrass within or adjacent to the park
- This is responsible for 167,038 extra lbs of southern flounder catch in Carteret Co., valued at $2.77/lb, or #, or $462,696/year

Species	# of counties – incl. VA, SC, GA, E FL
Shrimp	29
Hard blue crab	65
Hard clam	22
Oyster	37
Southern flounder	20
Spot	34
Striped mullet	40

Coastal protection

- SLOSH model – being used for coastal NPS units system-wide
  - Model storm surge with and without Cape Lookout present under varying storm intensities and sea level rise scenarios
  - Valuation of property damage differentials with and without Cape Lookout using FEMA depth-damage curves



Areas potentially inundated by sea-level rise and increases in storm surge severity (Caffrey and Beavers 2013)

Coastal protection

Example: Category 1 hurricane, present day (mean tide), Carteret Co.

	With CALO	Without CALO	Difference
Structures affected	6,739	9,078	**2,339**
% of structures affected	11.3%	15.2%	**3.9%**
# people affected	7,721	10,401	**2,680**
Property value affected	$337.4 million	$478.0 million	**$140.6 million**
% property value affected	2.9%	4.1%	**1.2%**

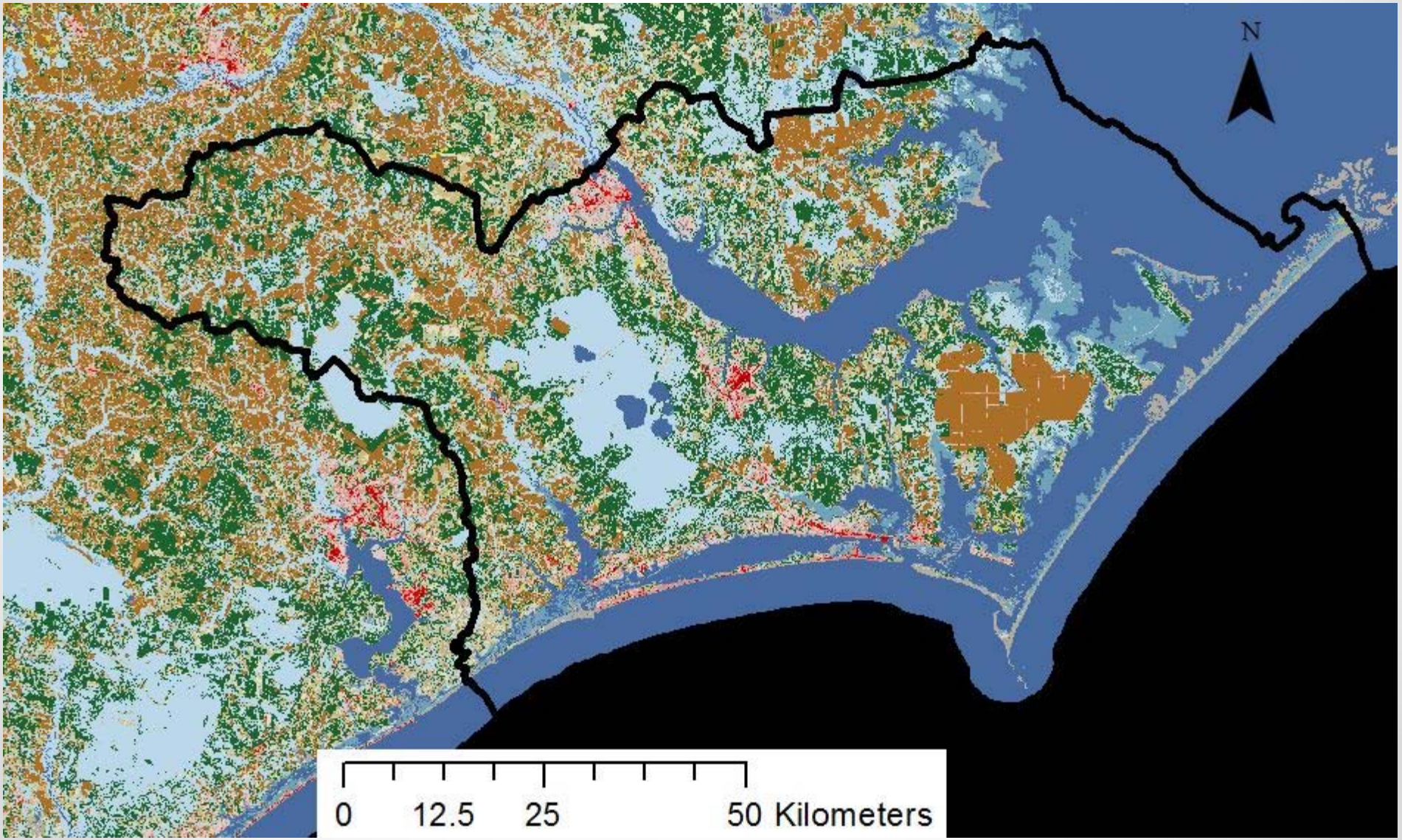
SLOSH model runs plus parcel value data (Carteret Co. Assessors' Office)

Water quality

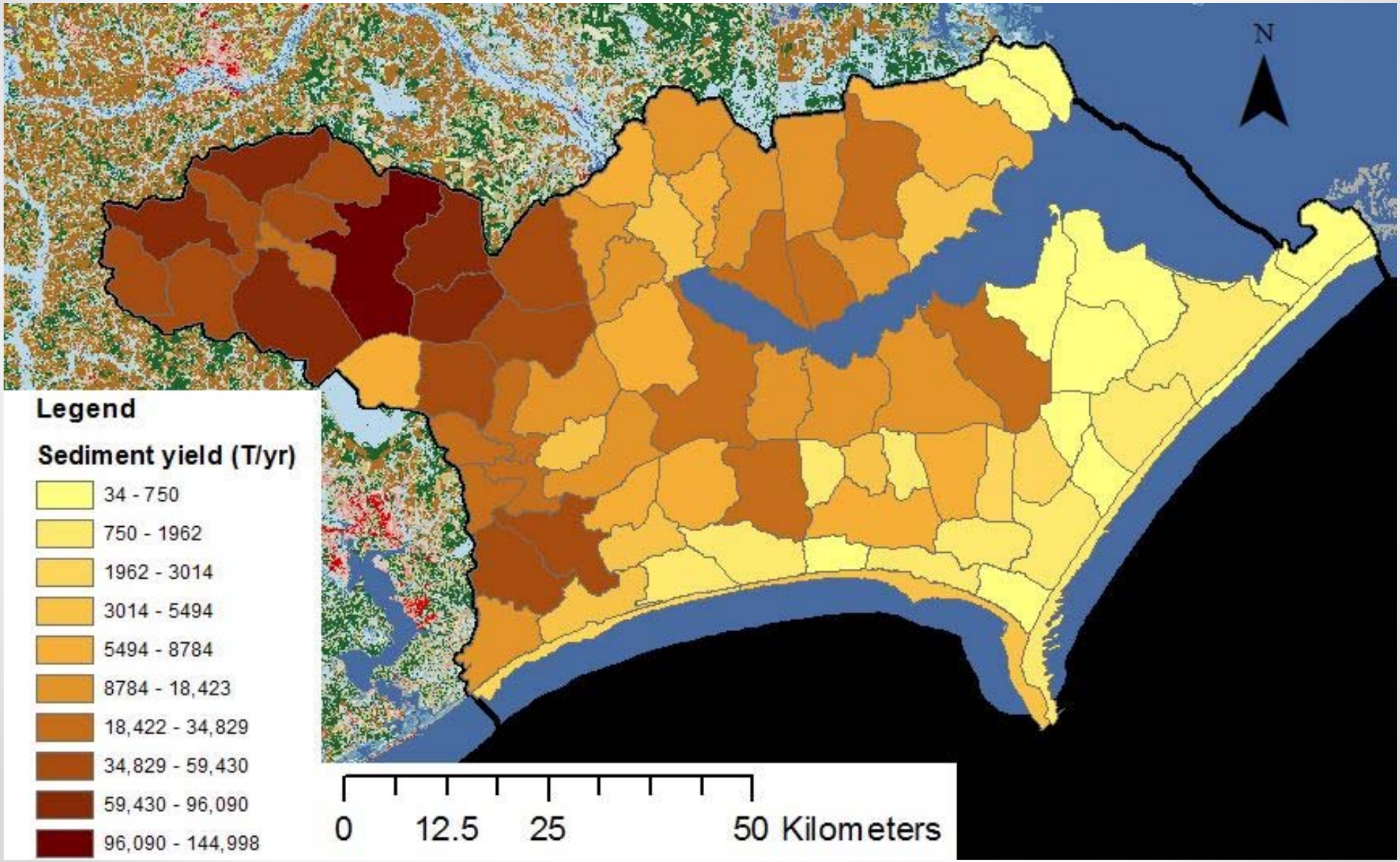
- Sediment: Revised Universal Soil Loss Equation – good for predicting sheet & rill erosion in flat, agricultural landscapes
- Nutrient modeling – N & P using regionally specific nutrient loading coefficients for different land cover types

- Compare: 1) contribution of HUC-12 subwatersheds to nutrient & sediment loading in waterways, 2) difference between developed & undeveloped barrier islands (Bogue Banks vs. Cape Lookout NS)

Water quality



Water quality



Cultural ecosystem services surveys

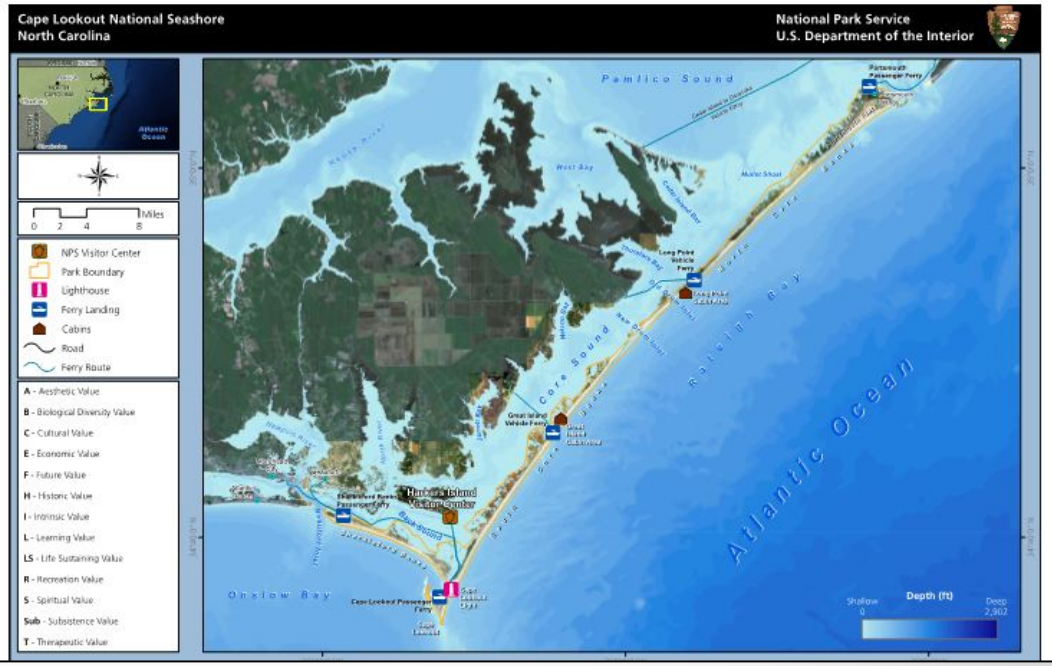
- Visitor surveys:
  - Oct-Nov 2013 (surf fishing)
  - June-July 2014 (summer beachgoing)
- Resident surveys: Mar-Apr 2014

7. Imagine that you could allocate 100 points towards what you value at Cape Lookout National Seashore and the surrounding waters. For example, you might assign 100 points to one value and zero to all the others, or you might assign 50 to one, 25 to another and 25 to another.

8. Next please use the attached map and abbreviations above to identify the locations that best represent the values to which you assigned points.

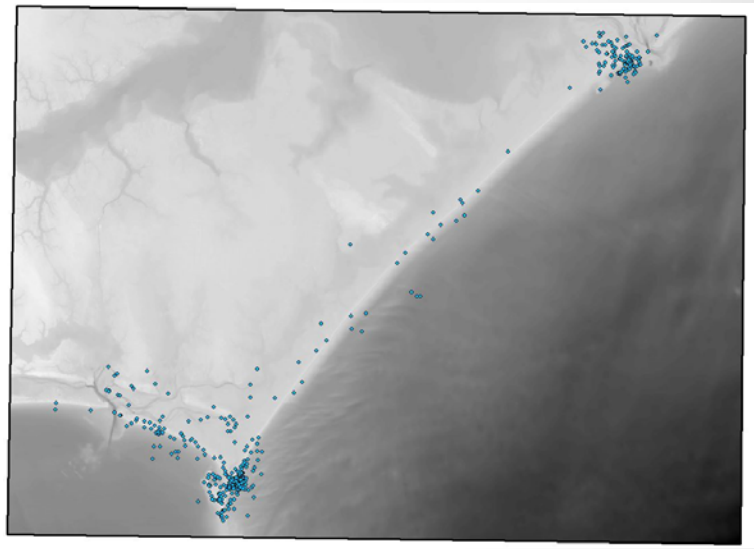
- Find a location on the map associated with each value you assigned (from question 7) and **draw a dot there.**
- Use the abbreviations listed and write it next to the dot assigned for the value (for example "A" for Aesthetic Value).
- Repeat the steps for additional locations and values. You may select up to **five locations** for each value type.

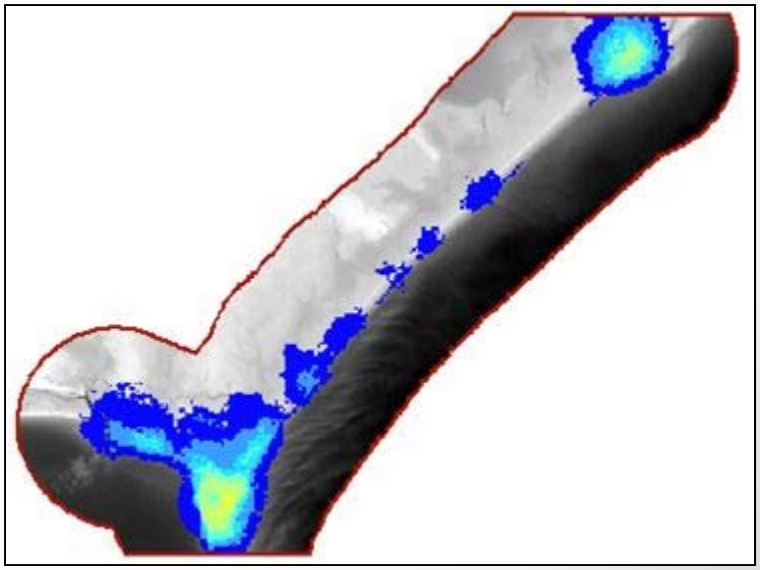
(This is an example of the map. The actual map size is 11x17)



Cultural ecosystem services mapping

- Value surfaces modeled based on points locations, social value type weightings, and environmental data layers, using MaxEnt





Marked points and value map for historic value – Carteret Co. residents

Value allocation - % of responses

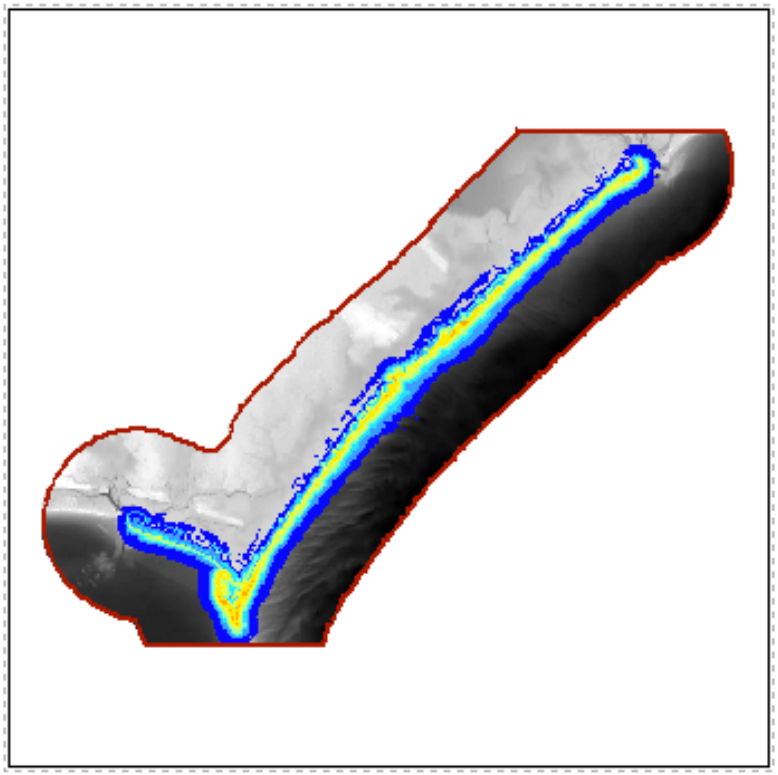
	Fall (n = 3,324 points)	Residents (n = 4,389 points)	Summer (n = 2,338 points)	TOTAL (n = 10,051 points)
Aesthetic	15.1%	13.4%	16.7%	14.7%
Biological diversity	9.6%	11.1%	11.3%	10.7%
Cultural	4.9%	6.2%	4.5%	5.4%
Economic	5.1%	7.5%	4.7%	6.0%
Future	10.5%	7.9%	9.6%	9.1%
Historic	5.9%	9.7%	11.1%	8.8%
Intrinsic	2.6%	4.1%	4.7%	3.8%
Learning	2.0%	5.5%	6.1%	4.5%
Life-sustaining	2.7%	7.2%	6.3%	5.5%
Recreational	24.6%	14.3%	12.3%	17.2%
Spiritual	3.2%	3.9%	2.9%	3.4%
Subsistence	2.0%	2.2%	0.5%	1.7%
Therapeutic	11.8%	6.9%	9.4%	9.1%

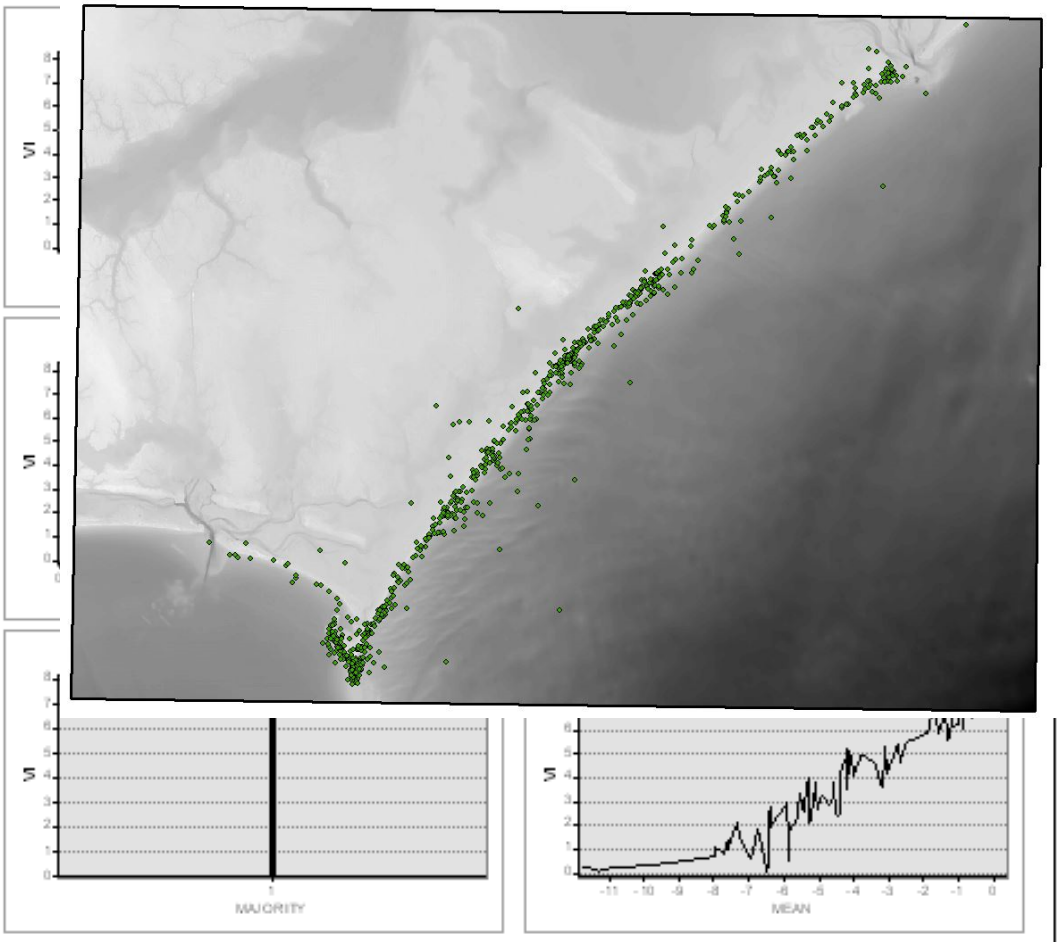
Pink and green cells indicate at least a 2% smaller or greater value than the next nearest neighbor

CALO_fishing_10km

All Surveys

Recreation

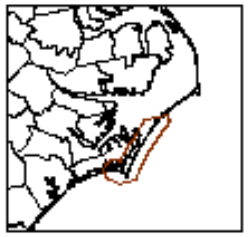




Study Area Final

Value Index

0 1 2 3 4 5 6 7 8 9 10



9 4.5 0 9 Miles

Recreation

Training AUC = 0.9405

Good model for study area

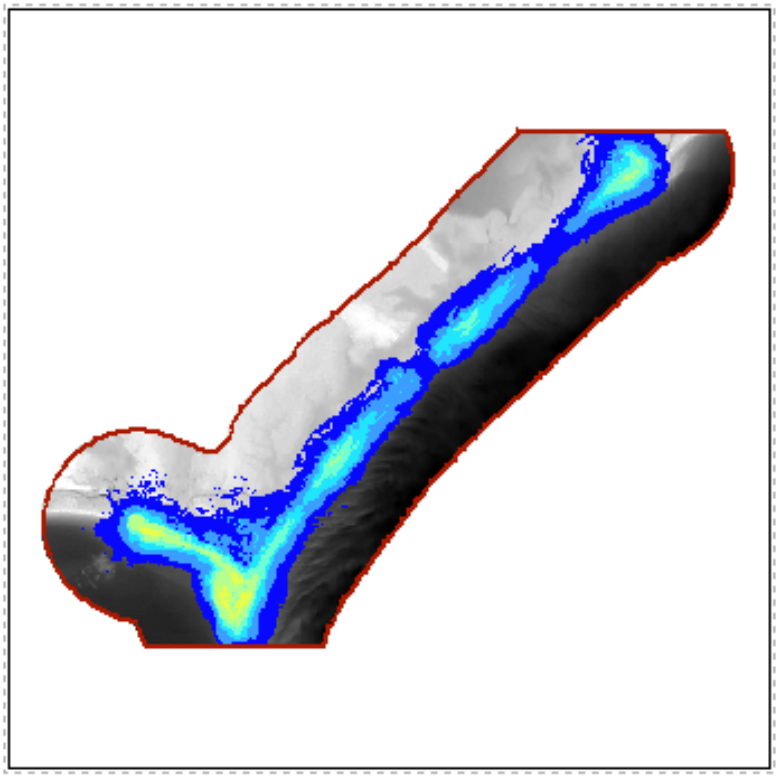
Test AUC = 0.9398

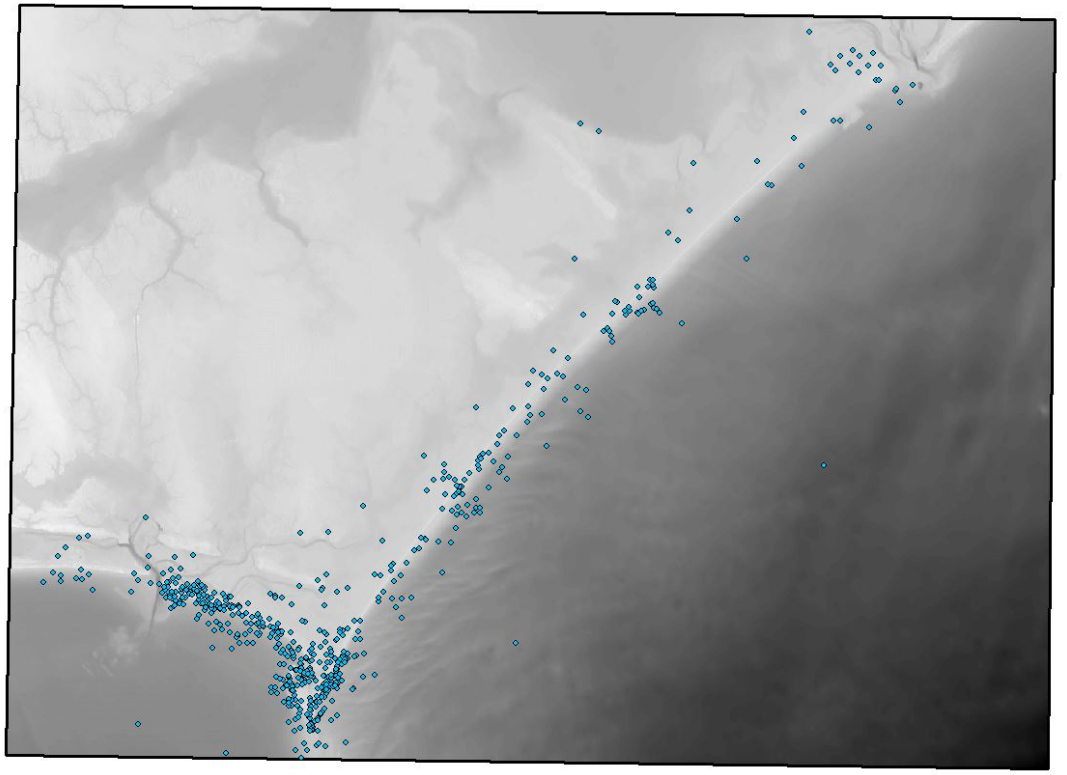
Good model for value transfer

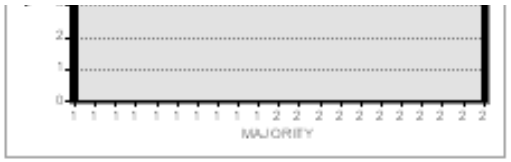
CALO_residents_10km

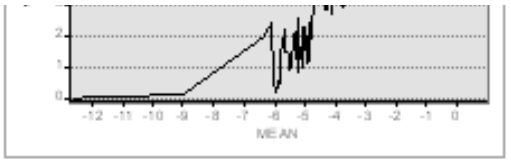
All Surveys

Recreation





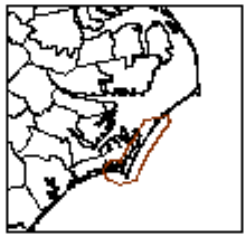




Study Area Final

Value Index

0 1 2 3 4 5 6 7 8 9 10



9 4.5 0 9 Miles

Recreation

Training AUC = 0.9168

Good model for study area

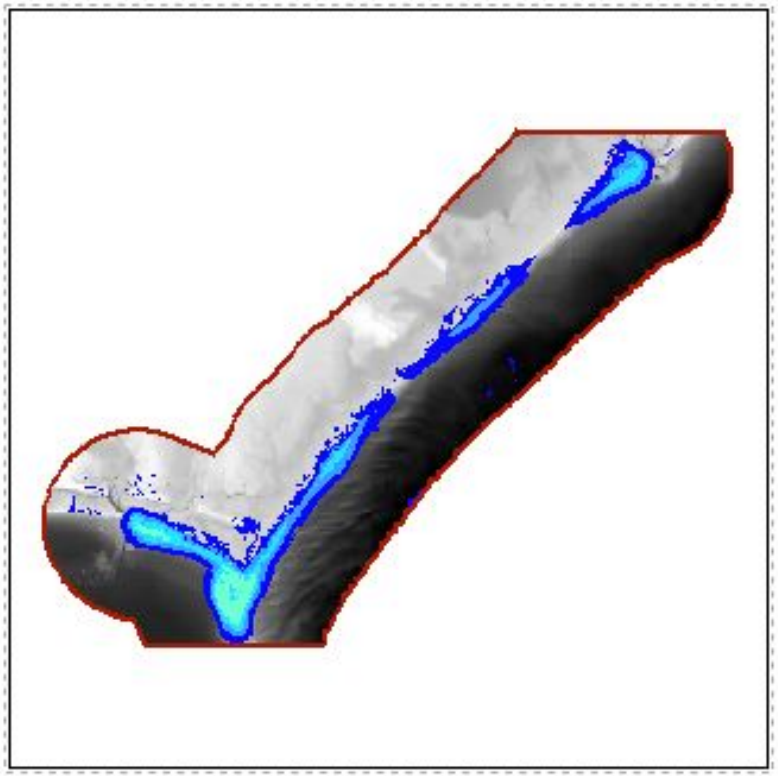
Test AUC = 0.9167

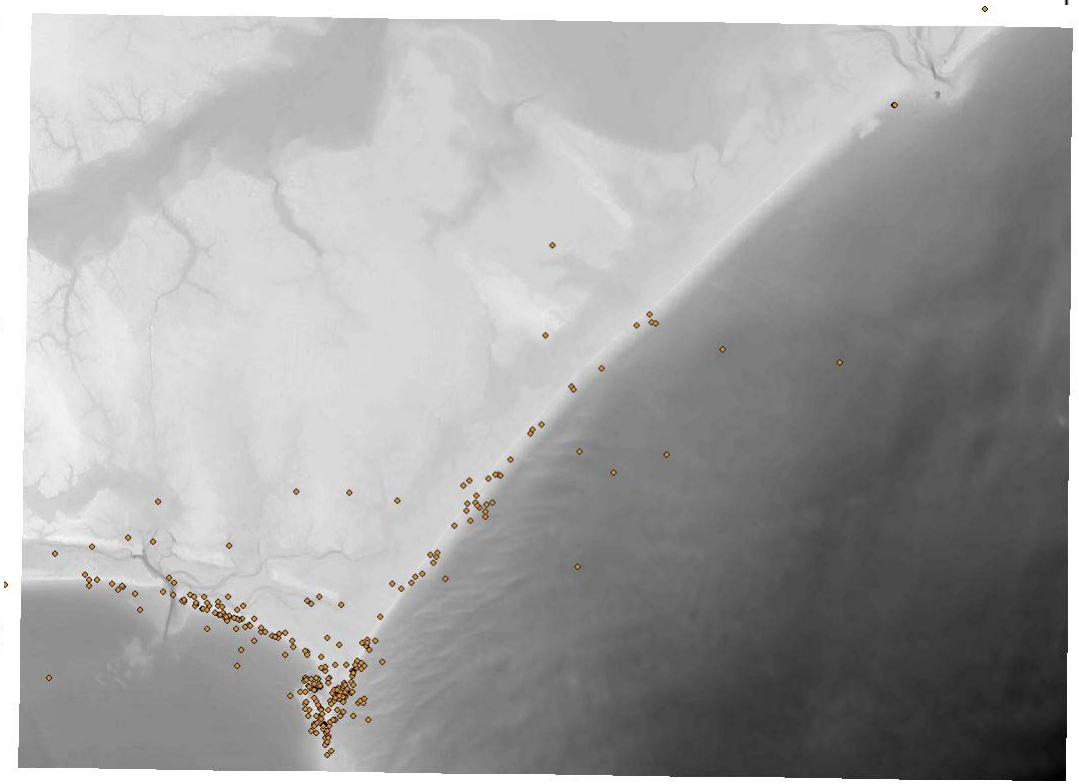
Good model for value transfer

summer_2014

All Surveys

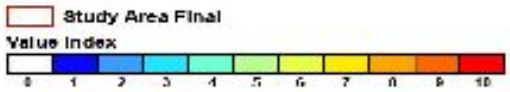
Recreation

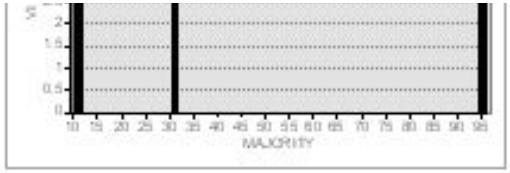


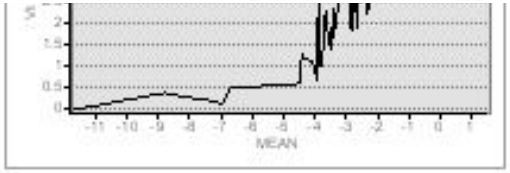


Study Area Final

Value Index







9 4.5 0 9 Miles

Recreation

Training AUC = 0.9383

Good model for study area

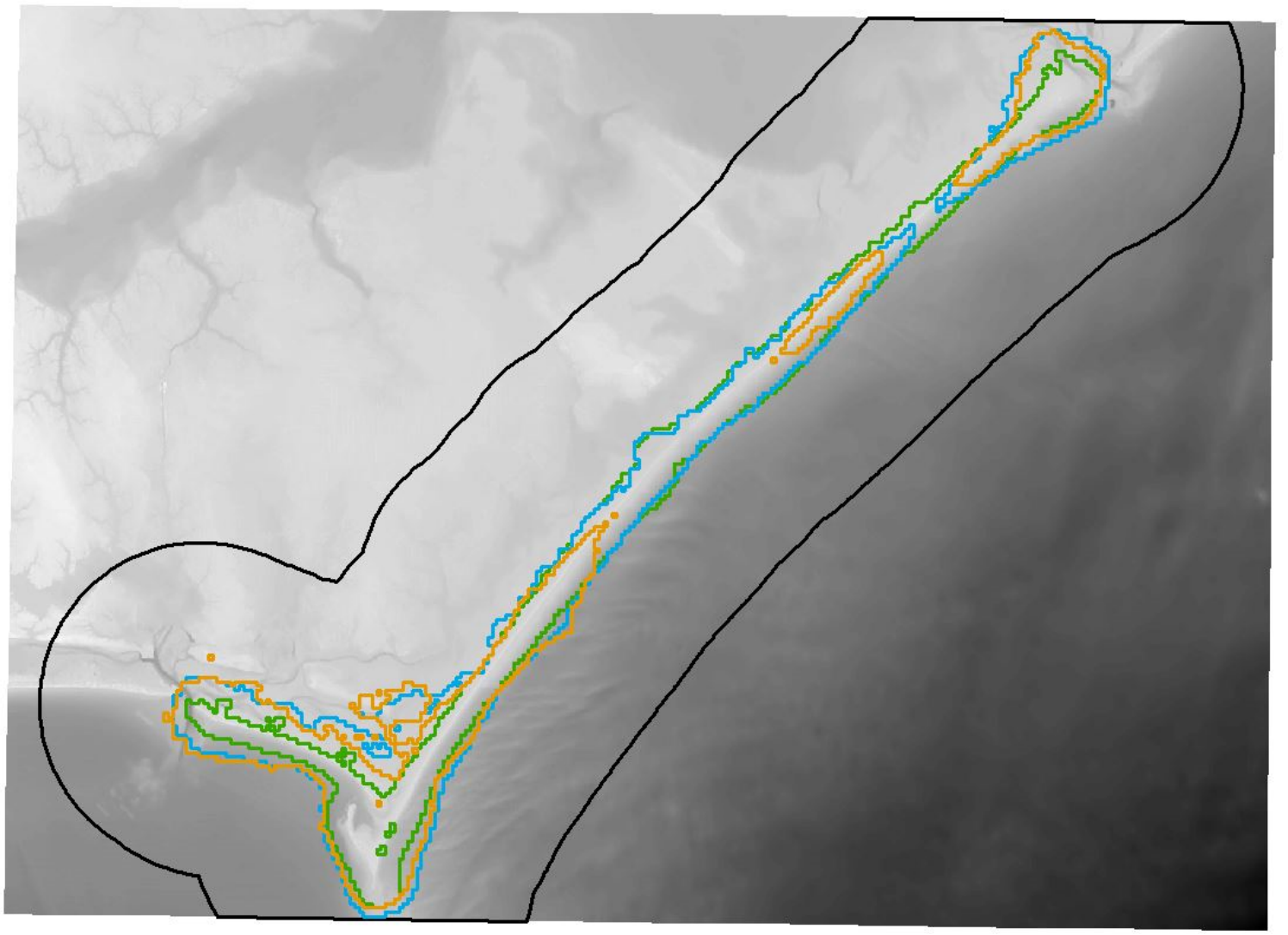
Test AUC = 0.9152

Good model for value transfer

Hotspots

Calculated using Getis-Ord GI* method, α = 0.05

Green = Fall visitors
Blue = Residents
Orange = Summer visitors



Next steps

- Finish hotspot mapping for biophysical ecosystem services; finalize joint biophysical-cultural ES hotspot mapping
- Analysis of ecosystem services at Cape Lookout under climate change scenarios
- Synthesize lessons learned in similar analysis for National Forests

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