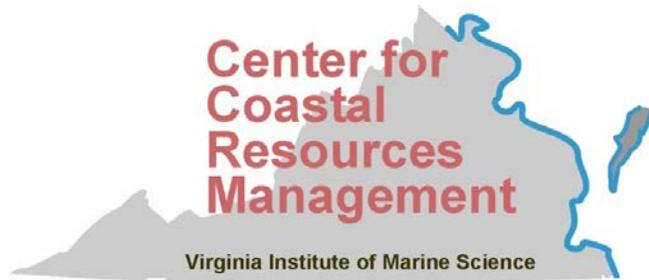


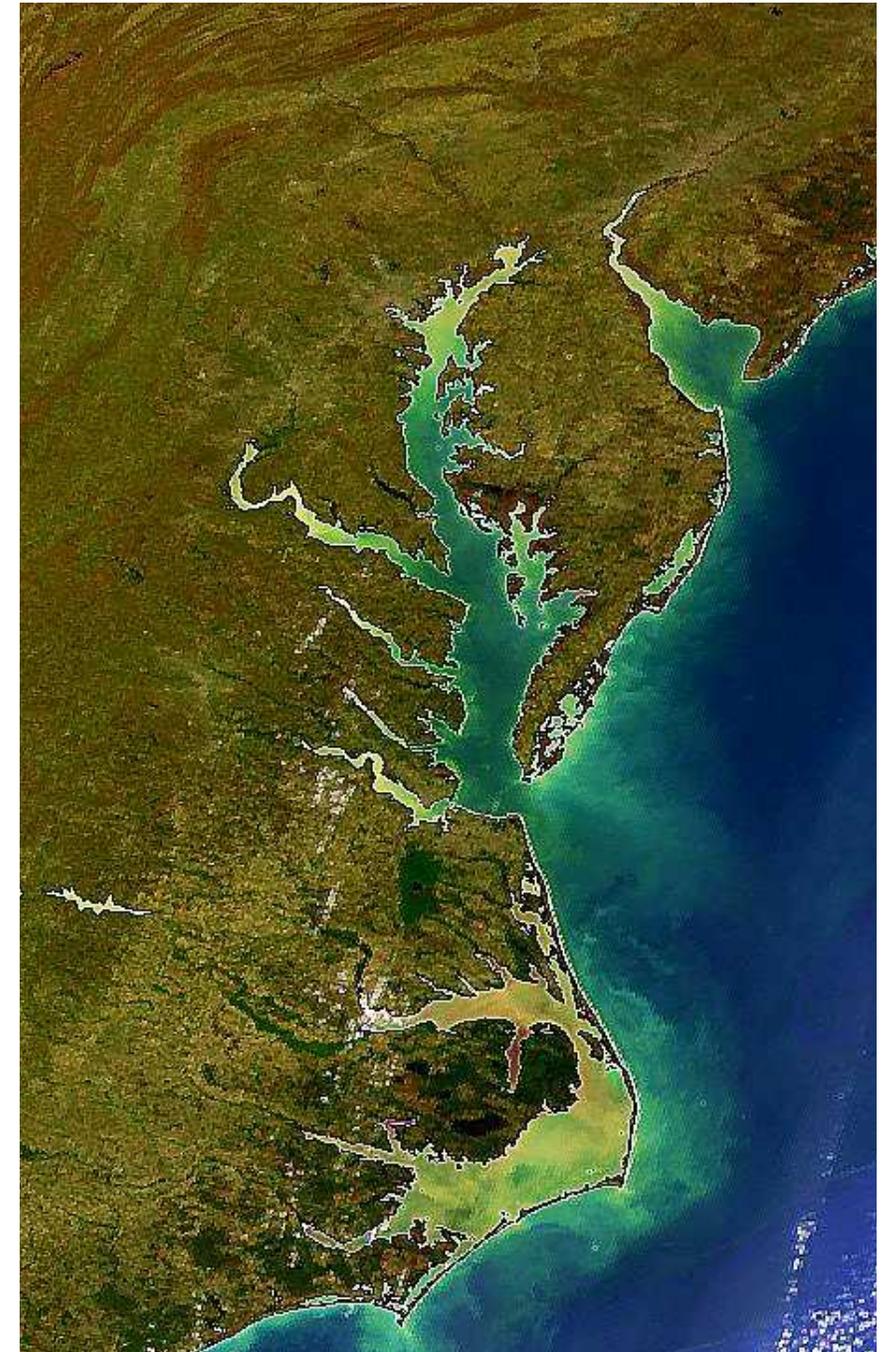
Coastal System Science past, present, future

Carl Hershner



Past

- System composition and function
 - Estuary – Coast – Watershed
 - Multiple models
 - Linked, nested ensembles
- Restoration
 - Stressor identification
 - Tipping points
 - Legacy issues
 - Mitigation design
 - Uncertainty



Watershed

64,000 sq. miles

covers 6 states

Susquehanna River = 50%
of freshwater inflow

18 million people

14:1

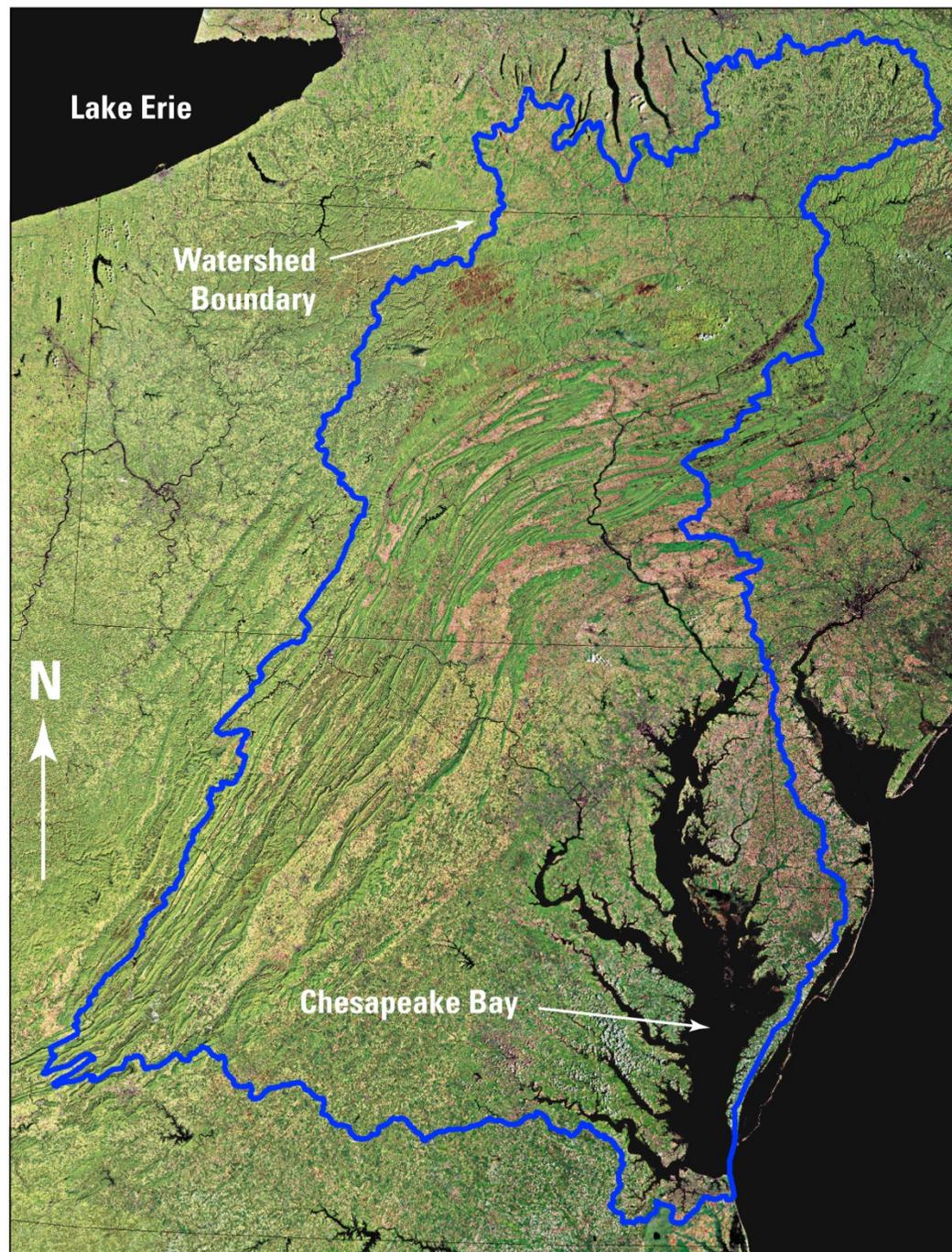
Bay

200 miles long

3.4 to 35 miles wide

15 trillion gallons

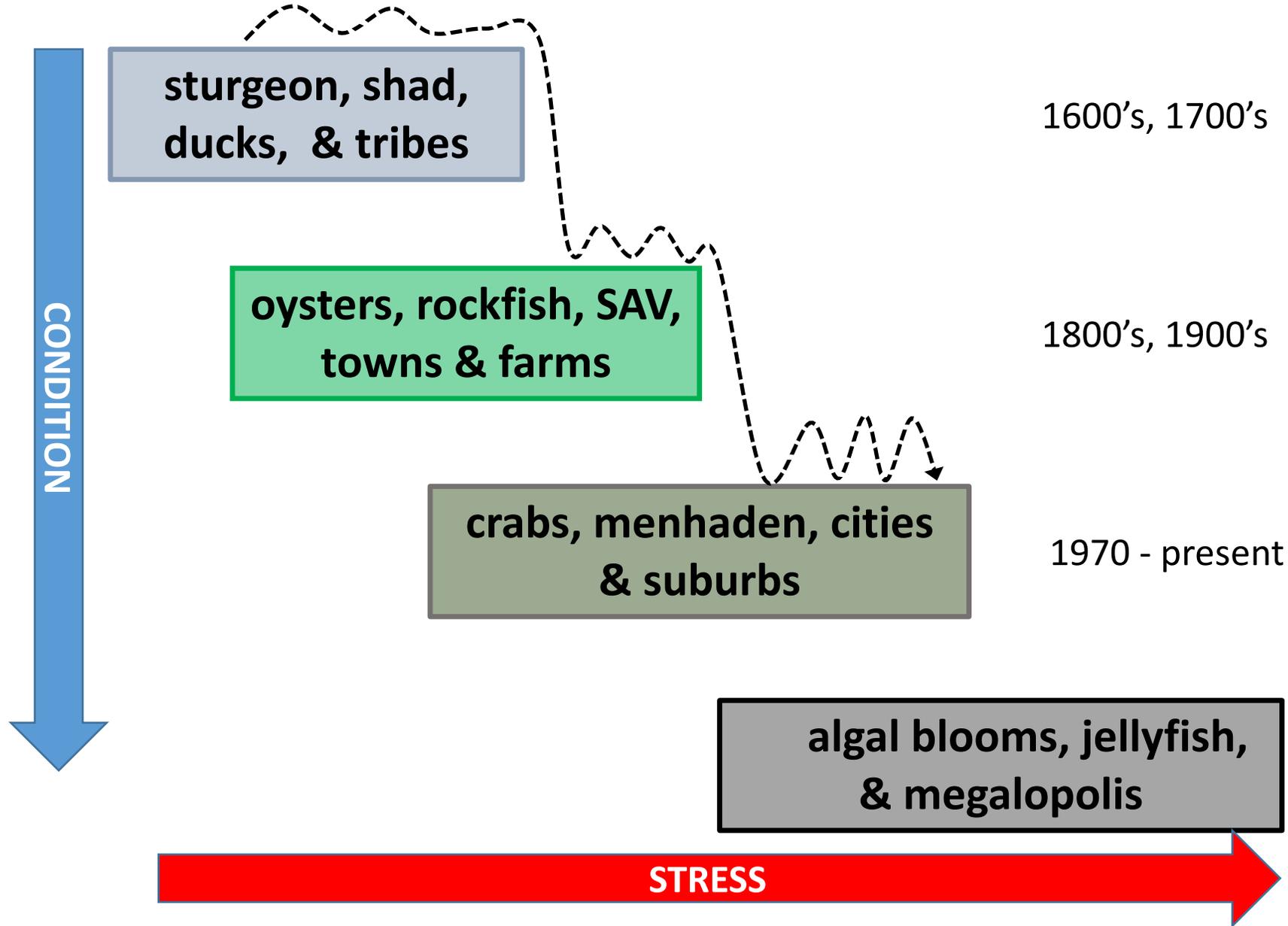
21 ft avg. depth



Systems ecology
Climax communities
Outwelling
Estuarine circulation
Eutrophication
Top down & bottom up
Microbial loops
Foundation species
Keystone species
Ecological flows

Ecosystem based
management
EcoPath/EcoSim
Atlantis

Chesapeake Bay regime shifts





rainfall



nutrients



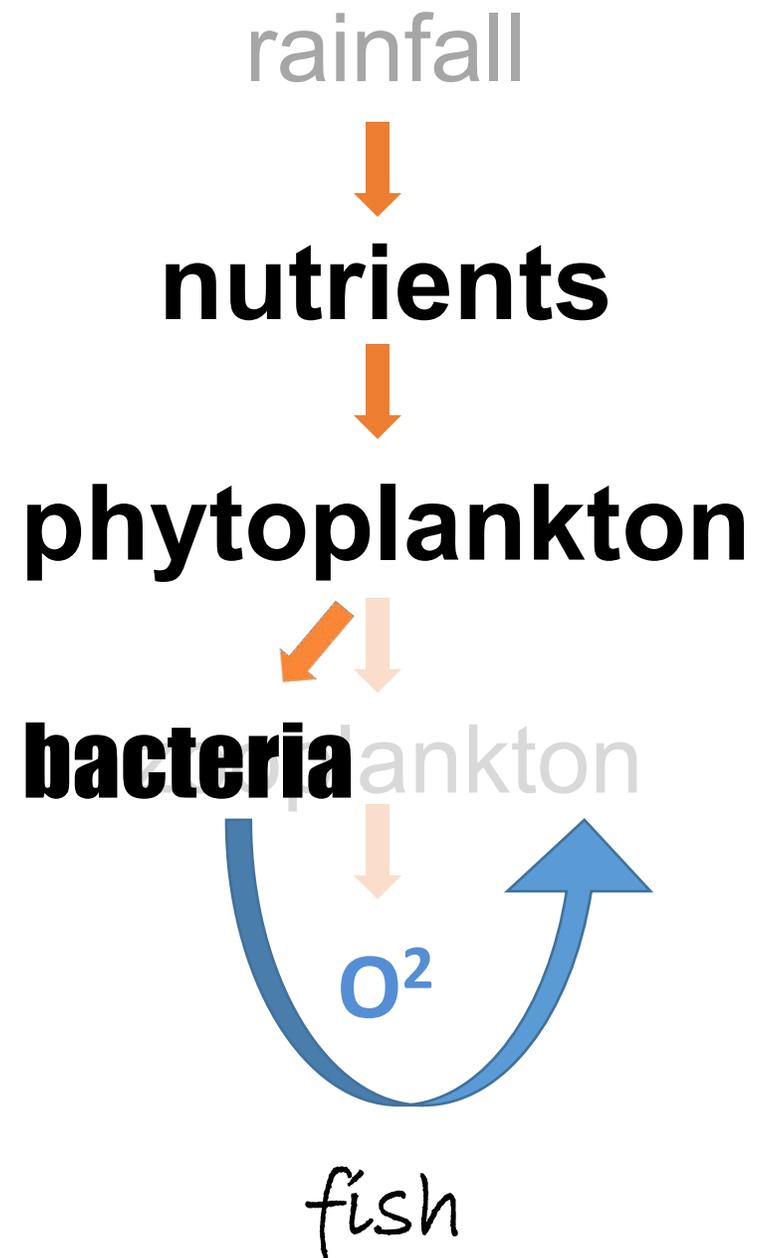
phytoplankton



zooplankton



juvenile fish



What is a TMDL?

- **T**otal **M**aximum **D**aily **L**oad
 - Amount of pollutants that a water body can receive and still support designated uses
 - Drinking
 - Swimming
 - Fishing
 - Identify sources
 - Identifies load reductions
- Implementation is key

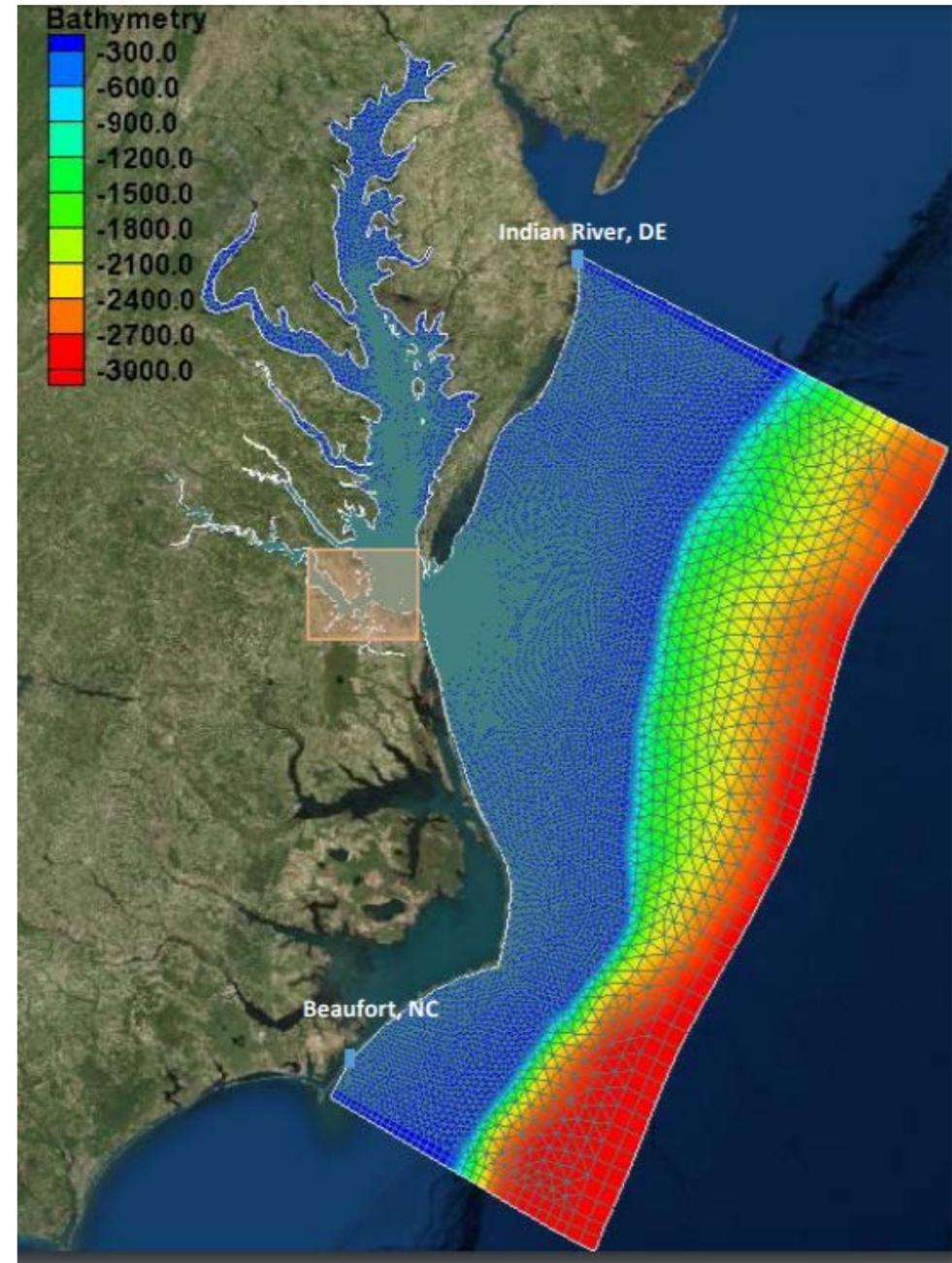


How do we decide who does what?

CBP Model

- Watershed model
 - nutrient and sediment loads coming off the land
- Stream/river model
 - biologically mediated changes in loads as they flow downstream
- Bay hydrodynamic model
 - water parcel movement in the Bay and its tributaries
- Bay water quality model
 - biologically mediated changes as things slosh around in the Bay

SCHISM



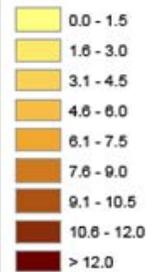
Bay Restoration

All Sources of Total Nitrogen

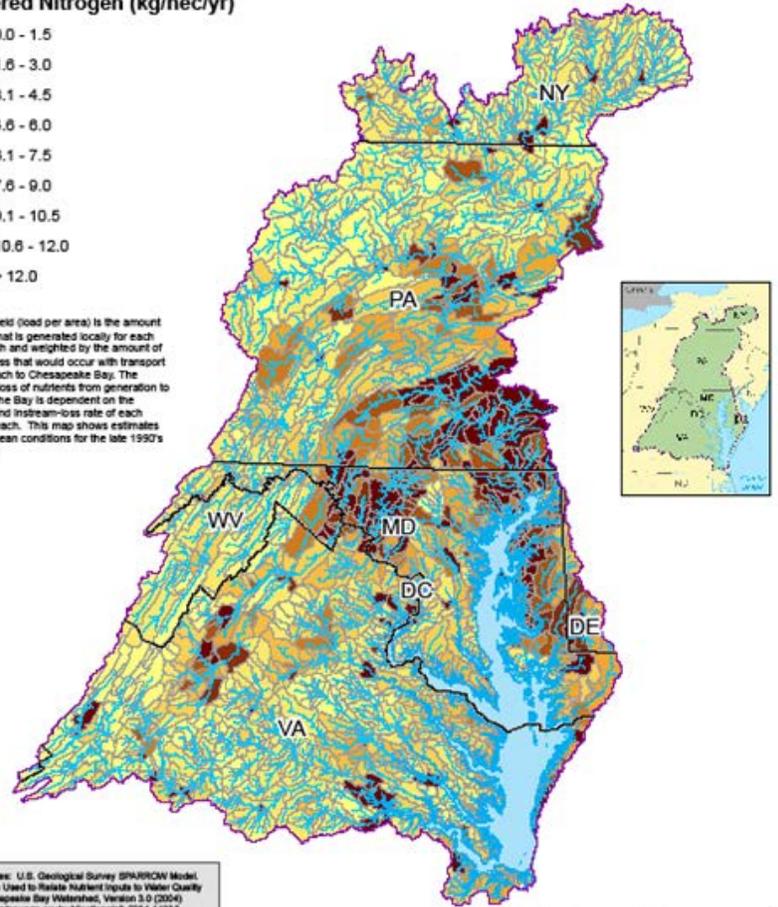
Delivered Yield to the Chesapeake Bay



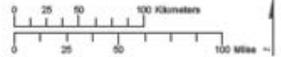
Delivered Nitrogen (kg/hectare/yr)



Delivered yield (load per area) is the amount of nutrient that is generated locally for each stream reach and weighted by the amount of in-stream loss that would occur with transport from the reach to Chesapeake Bay. The cumulative loss of nutrients from generation to delivery to the Bay is dependent on the travel time and in-stream loss rate of each individual reach. This map shows estimates based on mean conditions for the late 1990's time period.



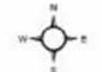
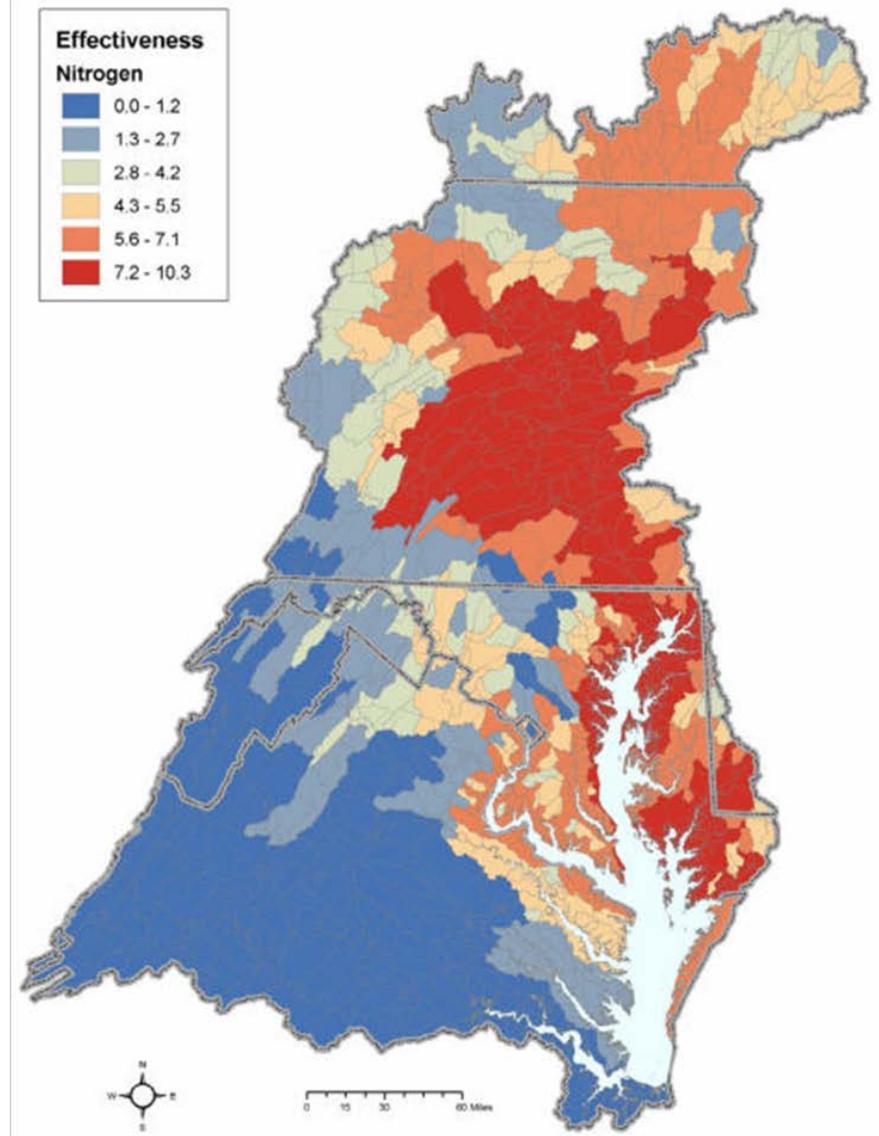
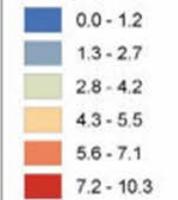
Data Source: U.S. Geological Survey SPARROW Model, Digital Data Used to Relate Nutrient Inputs to Water Quality in the Chesapeake Bay Watershed, Version 3.0 (2004) (<http://md.water.usgs.gov/publications/03-2004-1433/>)
 For more information, visit www.chesapeakebay.net
 Designer: www.chesapeakebay.net/terms/faq.htm

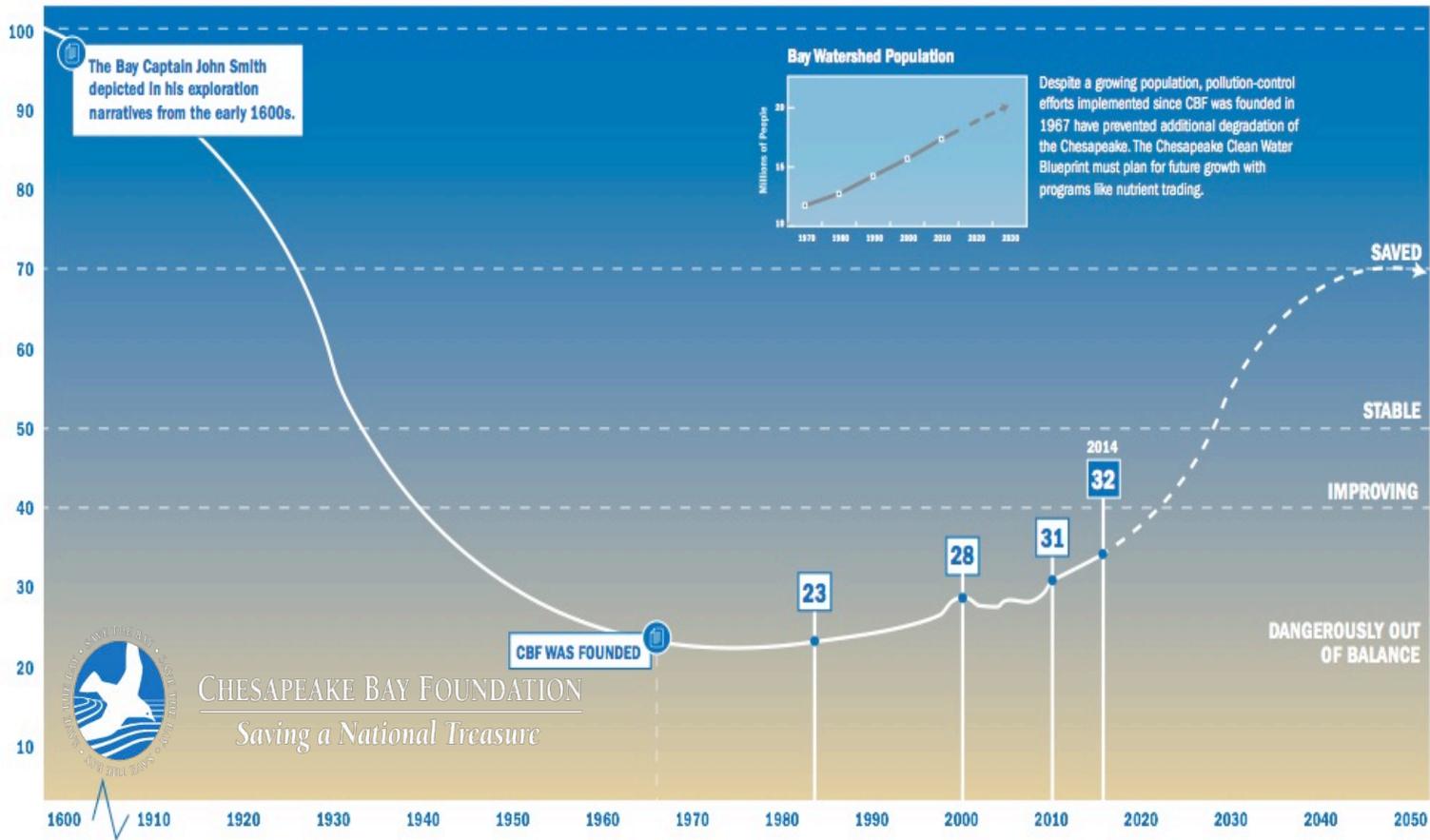


Created by JW, 2/12/08

UTM Zone 18N, NAD 83

Effectiveness Nitrogen

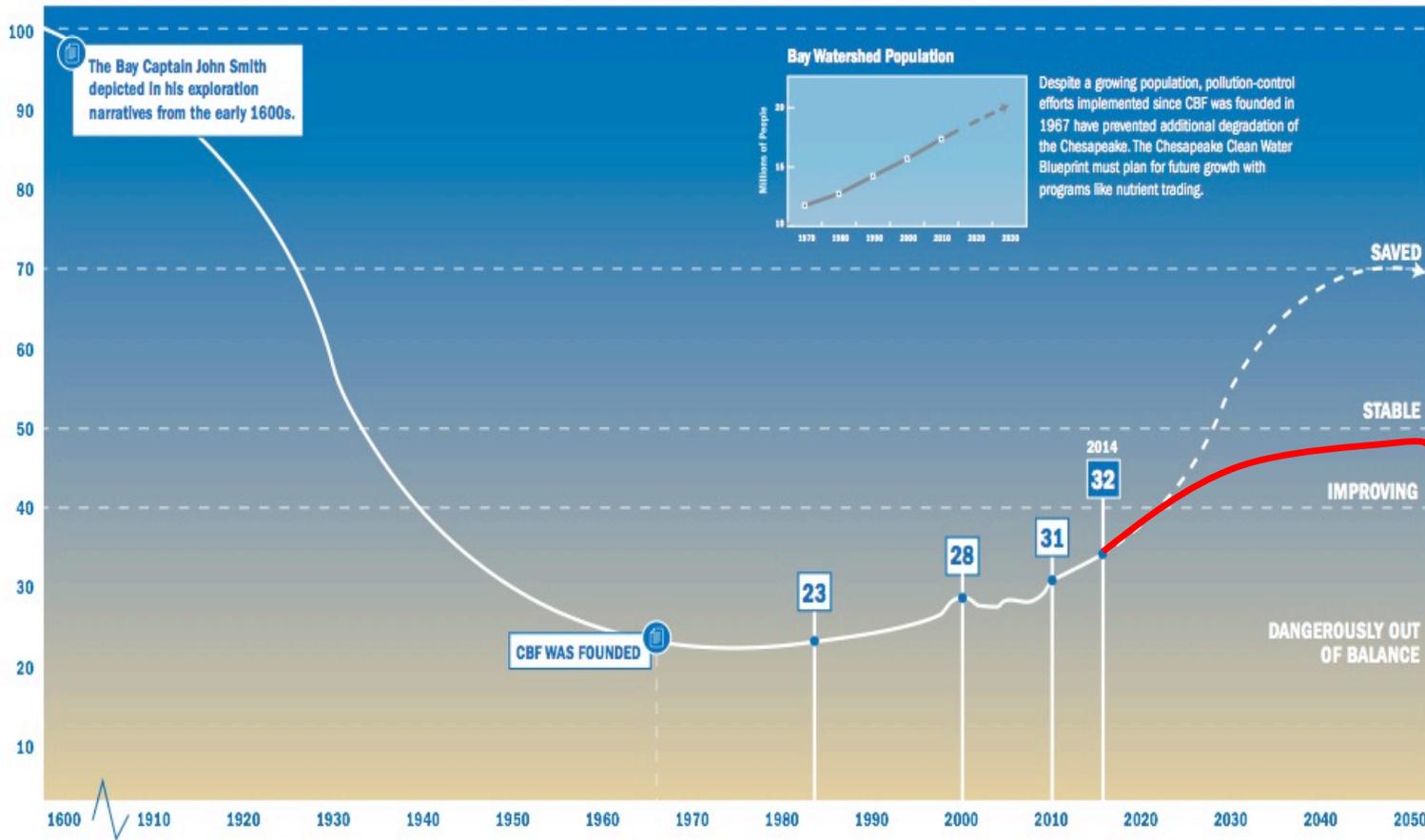




dissolved oxygen
phosphorus
nitrogen
water clarity
toxics

oysters
rockfish
blue crabs
shad

underwater grasses
wetlands
resource lands
forest buffers

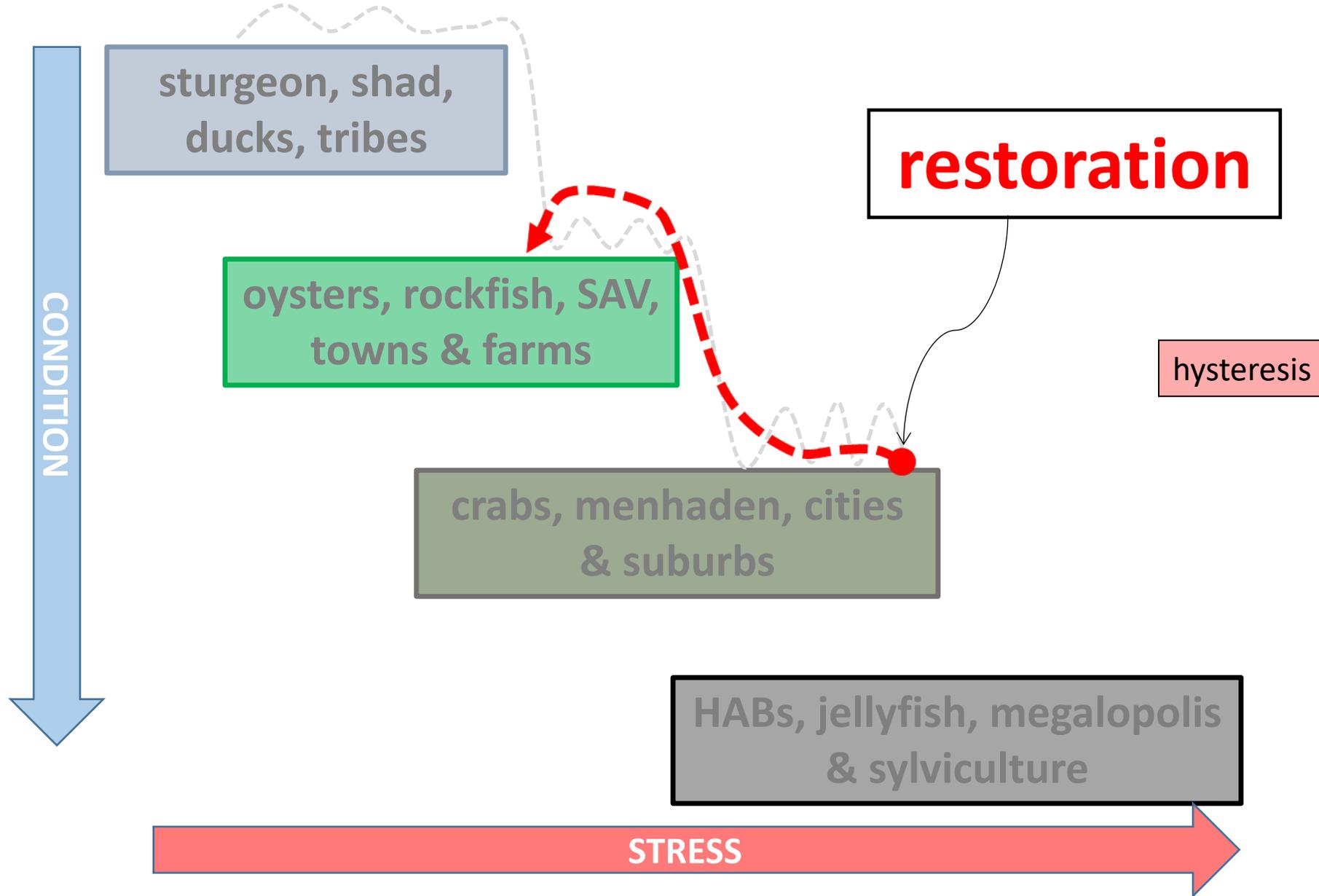


dissolved oxygen
 phosphorus
 nitrogen
 water clarity
 toxics

oysters
 rockfish
 blue crabs
 shad

underwater grasses
 wetlands
 resource lands
 forest buffers

Chesapeake Bay regime shifts



PRESENT

- Risk & Vulnerability
 - Value of information
 - Informing decisions
 -
- Adaptation & Mitigation
 - Tipping points
- Motivation



ADAPTVA

Evidence-based planning for changing climate



FORECASTS



ADAPTATIONS



TOOLS



DATA

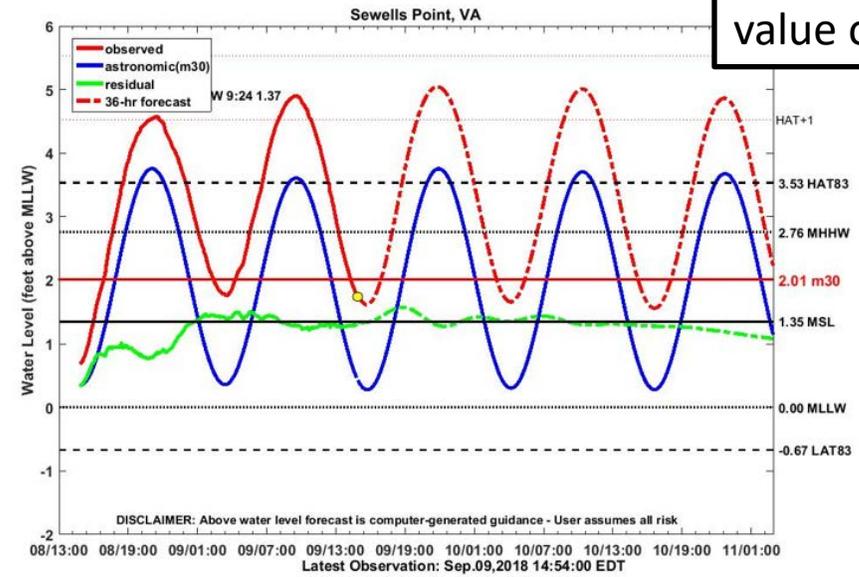


PLANNING & POLICY

Tidewatch Forecast

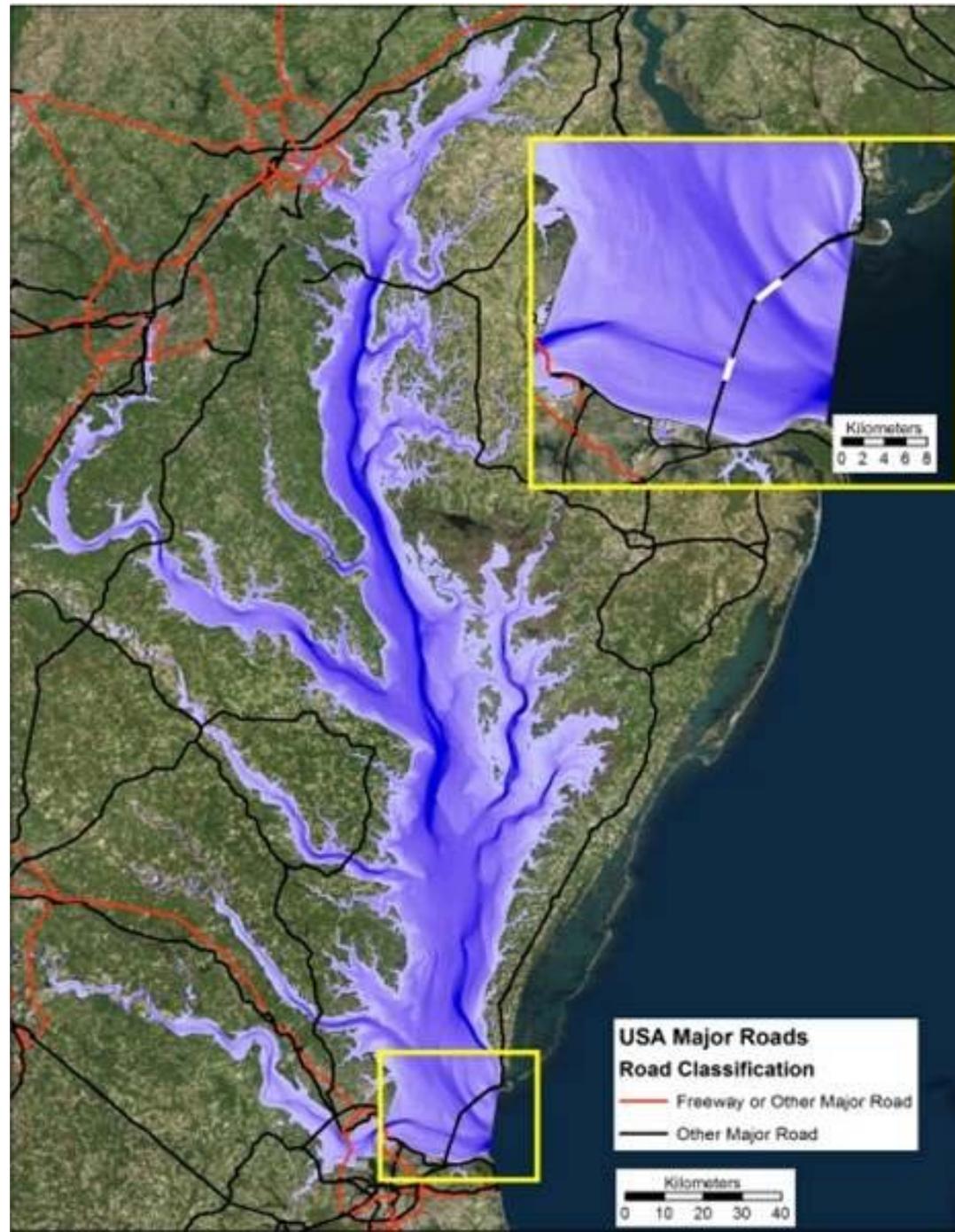


Coastal flooding for next 36 hours
9/9/2018 6AM



value of information

Chesapeake Bay storm surge barrier simulation



informing decisions

Lancaster County

adaptation & mitigation

1 county in analysis

Environmental variables:

Elevation

Depth to water table

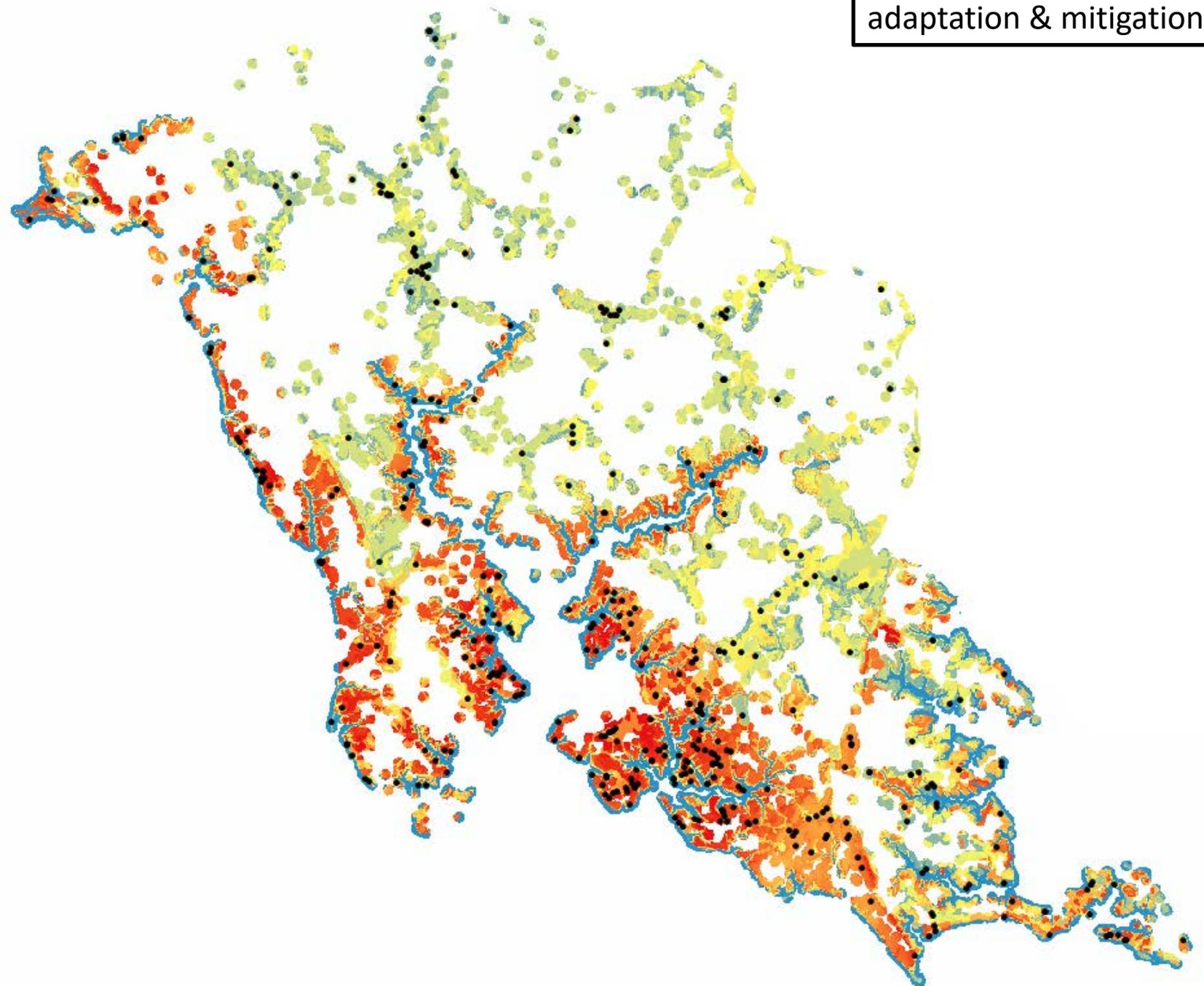
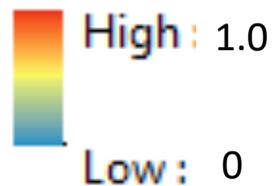
Hydric rating

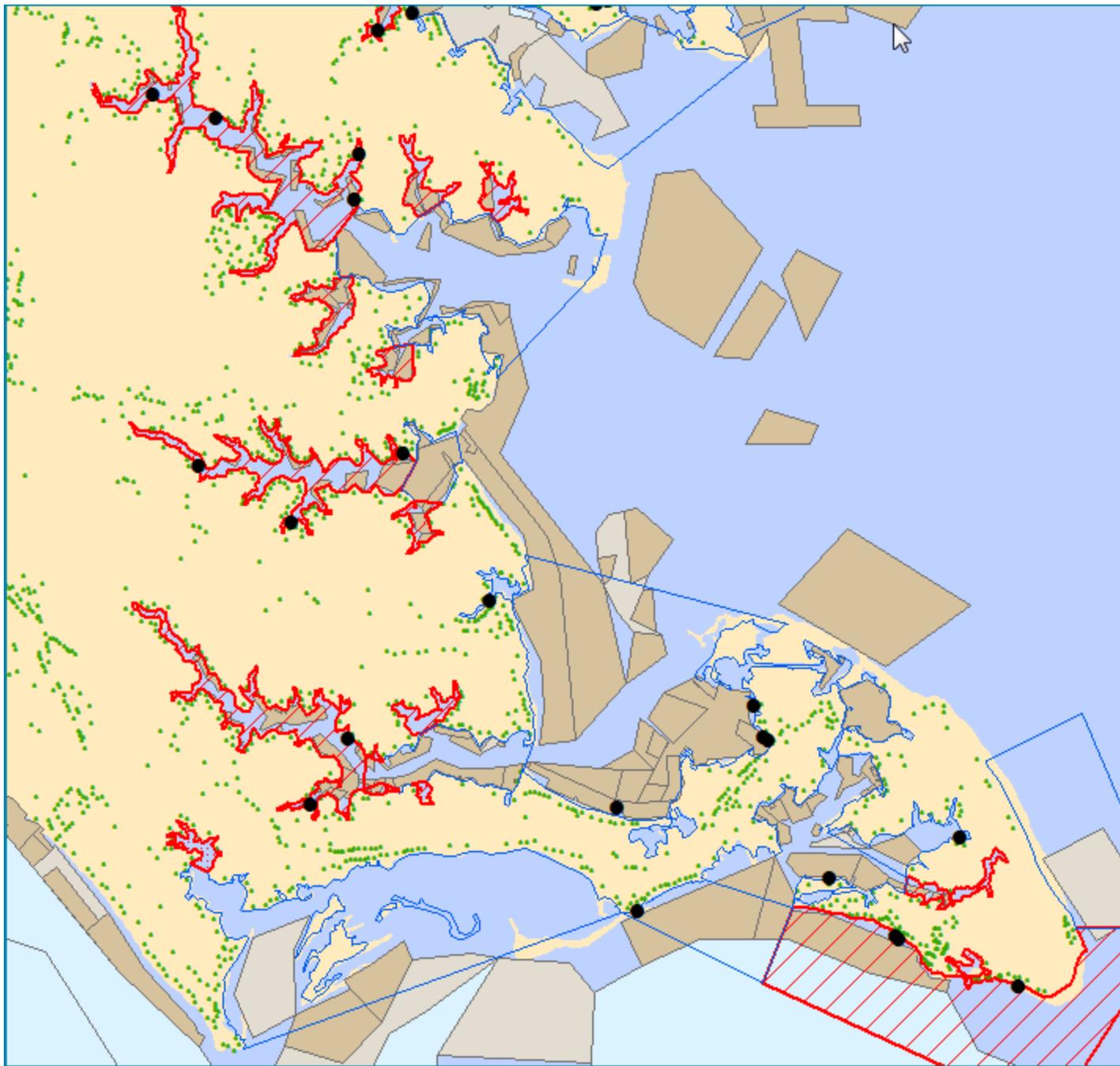
Percent sand

Septic absorption

- Septic failure

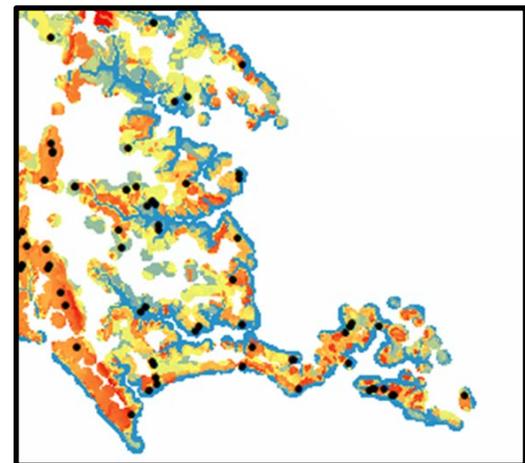
Probability of failure



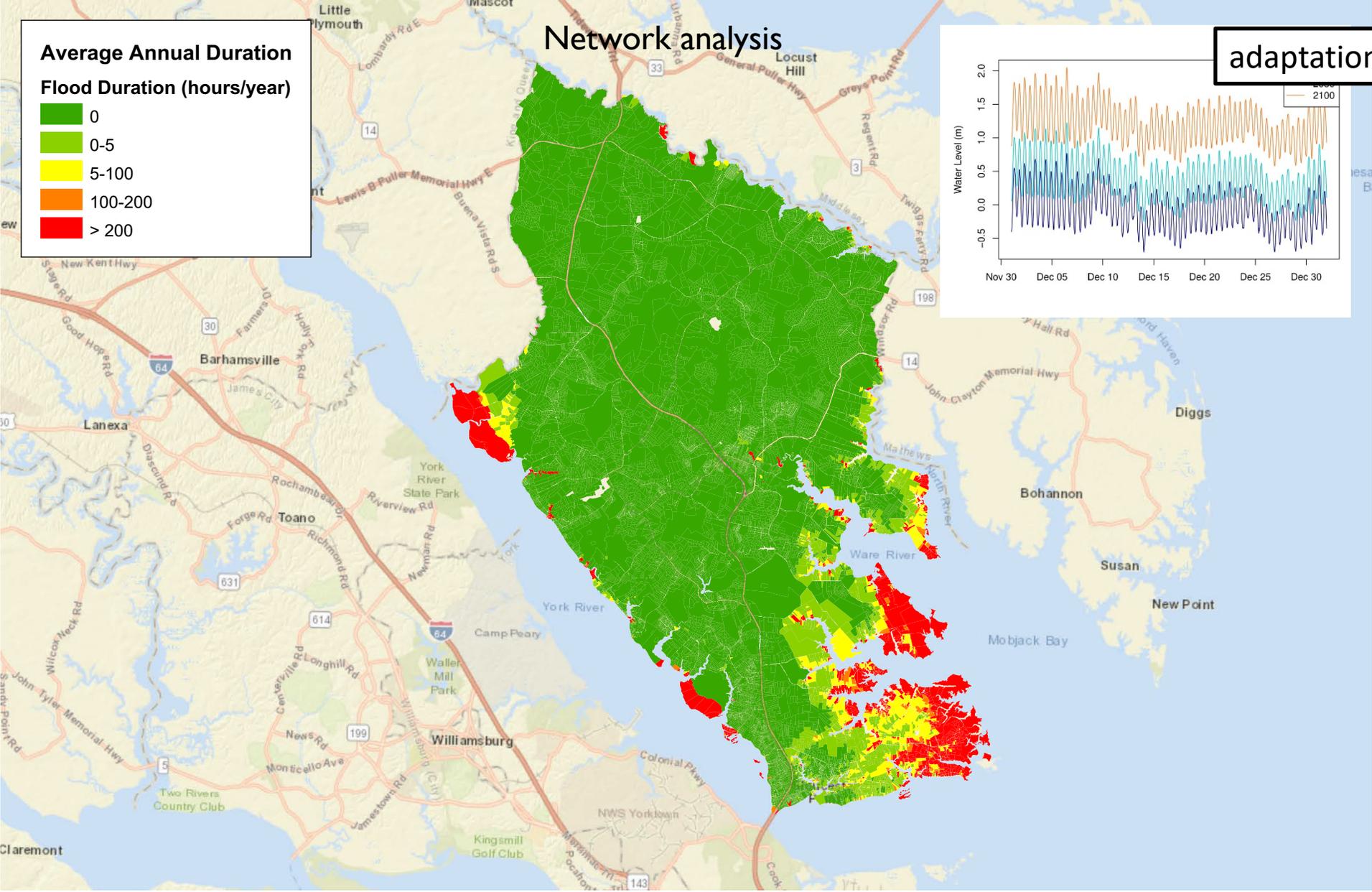
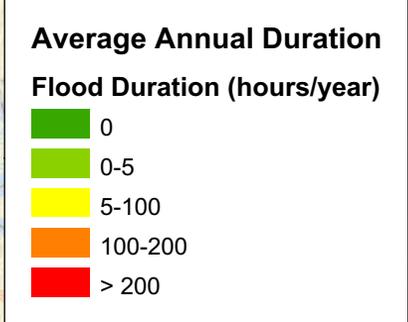


adaptation & mitigation

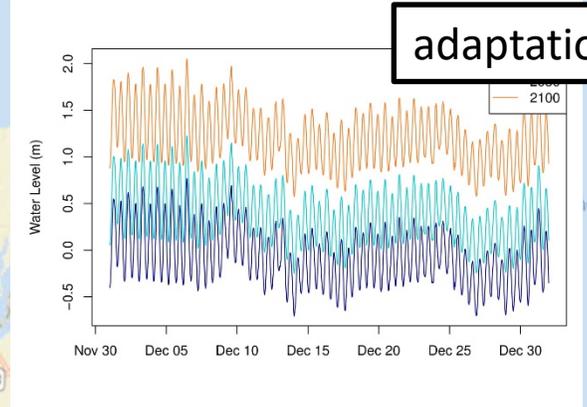
- Oyster garden permits (private) ●
- ClassifiedShellfishWaters20180228
COND_TYPE, CLOSED_PARAMETER
 - Emergency Restricted, Year Round - Relay Only
 - Prohibited
 - Restricted
 - Seasonally Restricted (Closed Apr-Oct)
 - Conditionally Approved (Closed 10days following >0.5" rain)
 - Conditionally Approved (Closed 10days following >1" rain)
 - Conditionally Approved (Closed Apr-Aug)
 - Conditionally Approved (Closed Apr-Oct)
 - Prohibited-Nonproductive, No Resource
 - Open, NA
- Virginia Address Points ●
- Oyster ground applications (private) ■
- Oyster ground leases (private) ■
- Baylor grounds (public) ■



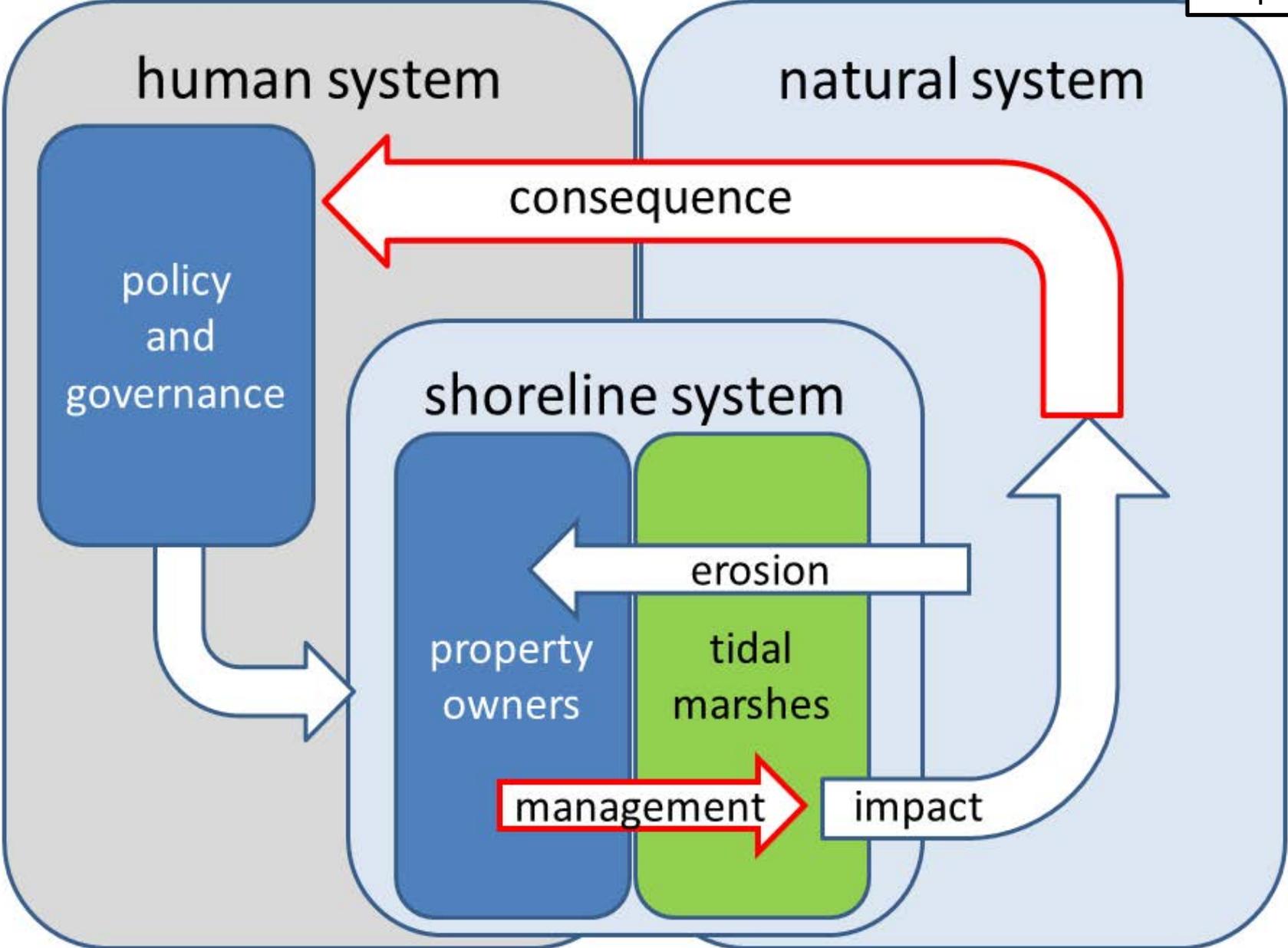
Network analysis

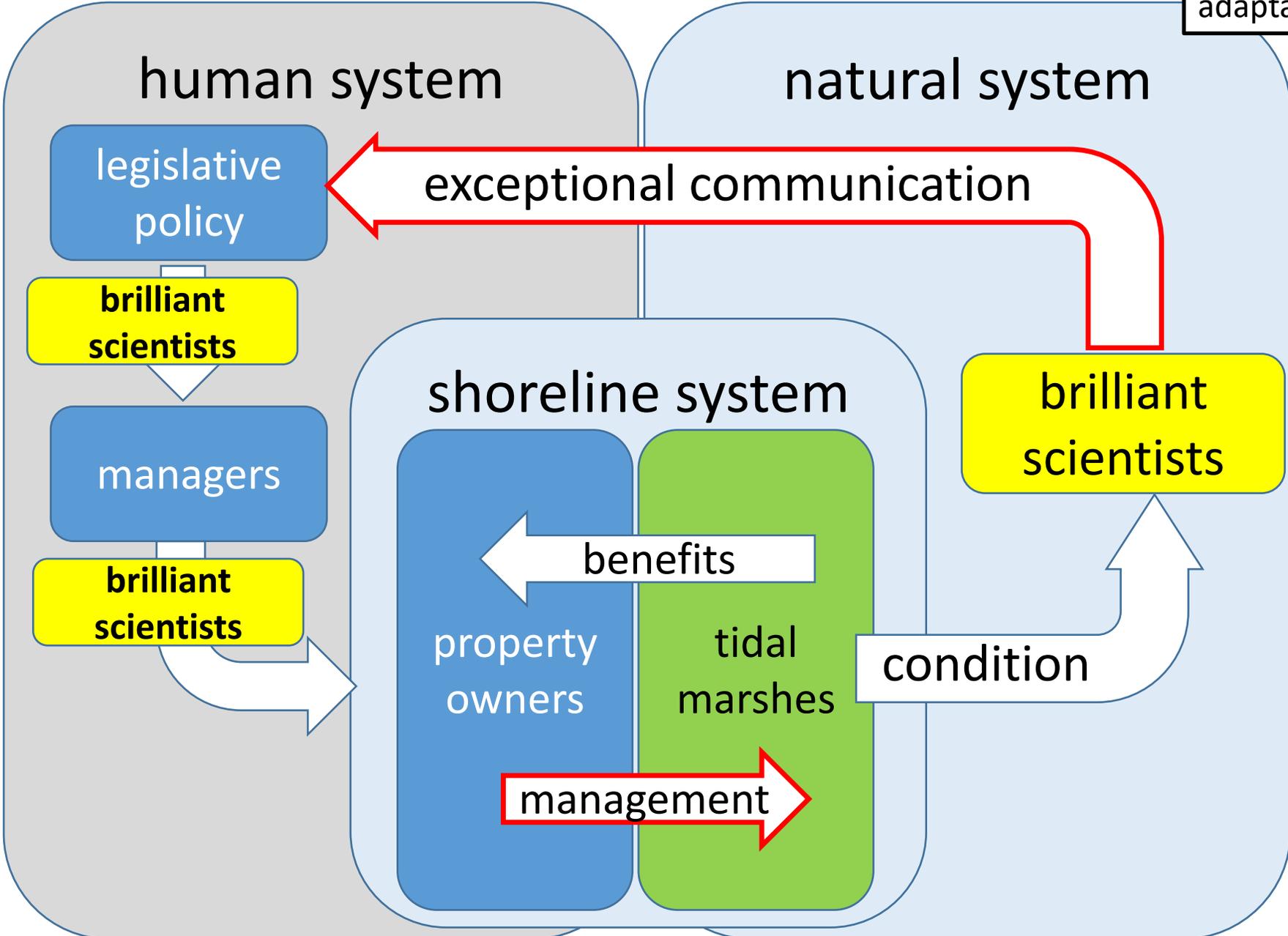


adaptation & mitigation



Average Annual Flooding: 2050





human system

natural system

legislative policy

brilliant scientists

managers

brilliant scientists

shoreline system

property owners

tidal marshes

brilliant scientists

exceptional communication

benefits

condition

management

macro

environmental

- exposure to risk
- ecosystem services

political

- regulation
- policy incentives

demographic

- community composition

economic

- income/well-being
- prices

social

- family obligations
- seeking education

micro

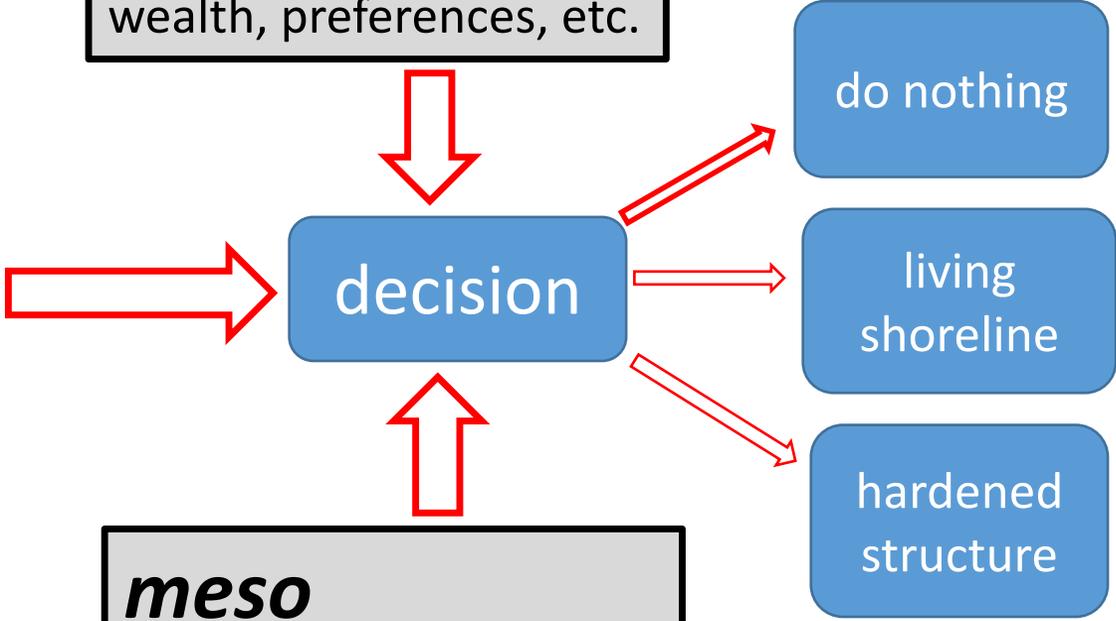
personal characteristics

age, sex, education, wealth, preferences, etc.

meso

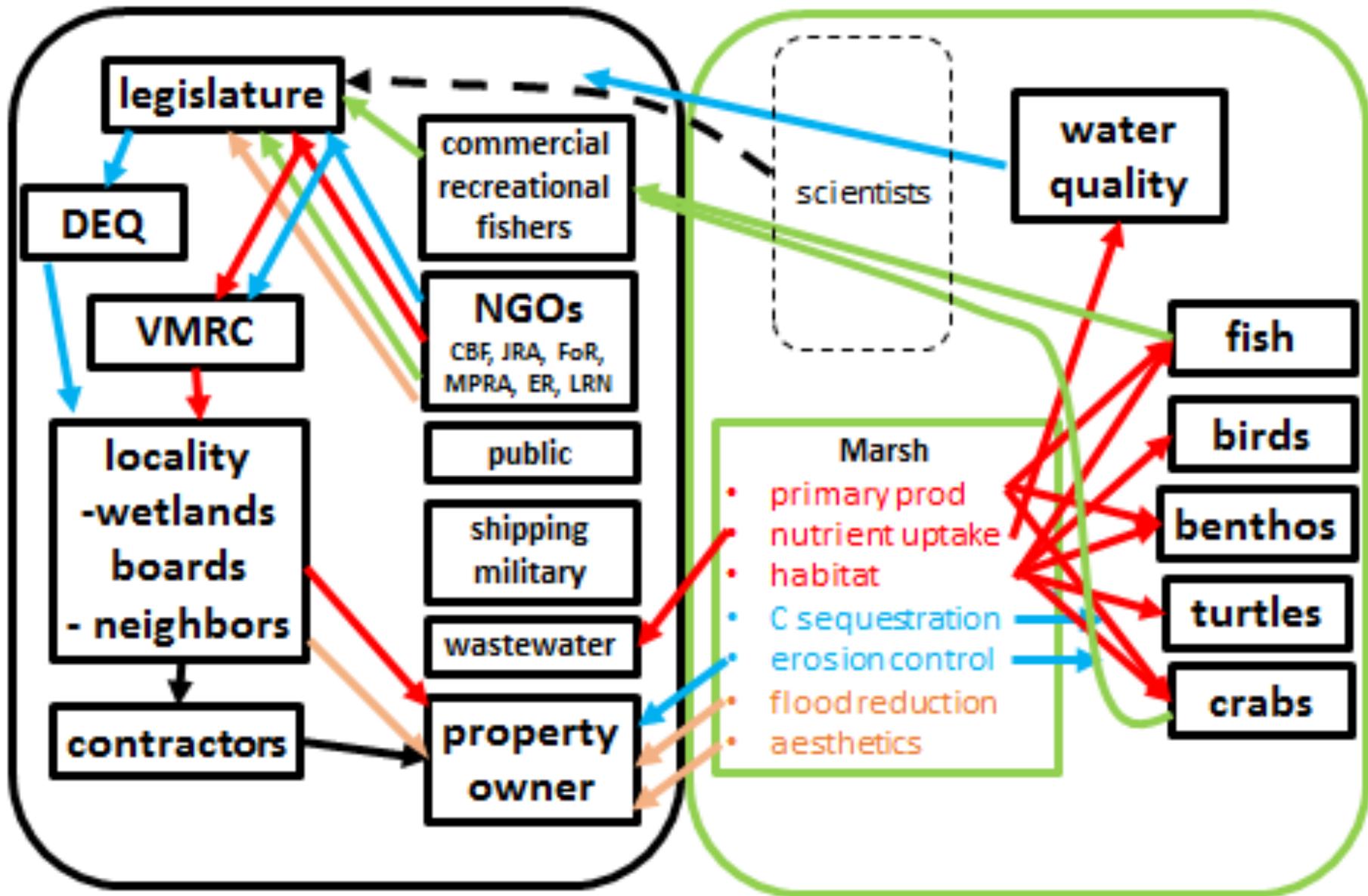
intervening obstacles and facilitators

legal framework, project cost, social network, outreach



adaptation & mitigation

HN complexity & mgmt. outcomes



- Ecosystem services**
- **Supporting**
 - primary production
 - nutrient cycling
 - habitat
 - **Regulating**
 - carbon sequestration
 - water quality
 - **Provisioning**
 - fish
 - **Cultural**
 - aesthetic
 - recreation

Step 3: Prioritize NNBFs for protection

Score and rank NNBFs based on:

1. Ability to mitigate flooding
 - Elevation = frequency of encountering flooding events
 - Capacity of NNBF type to mitigate flooding (e.g., ability to dampen waves)
2. Number of buildings the NNBF affects
3. Socio-economic co-benefits provided or potential

Tidal Marsh NNBF = High Benefit

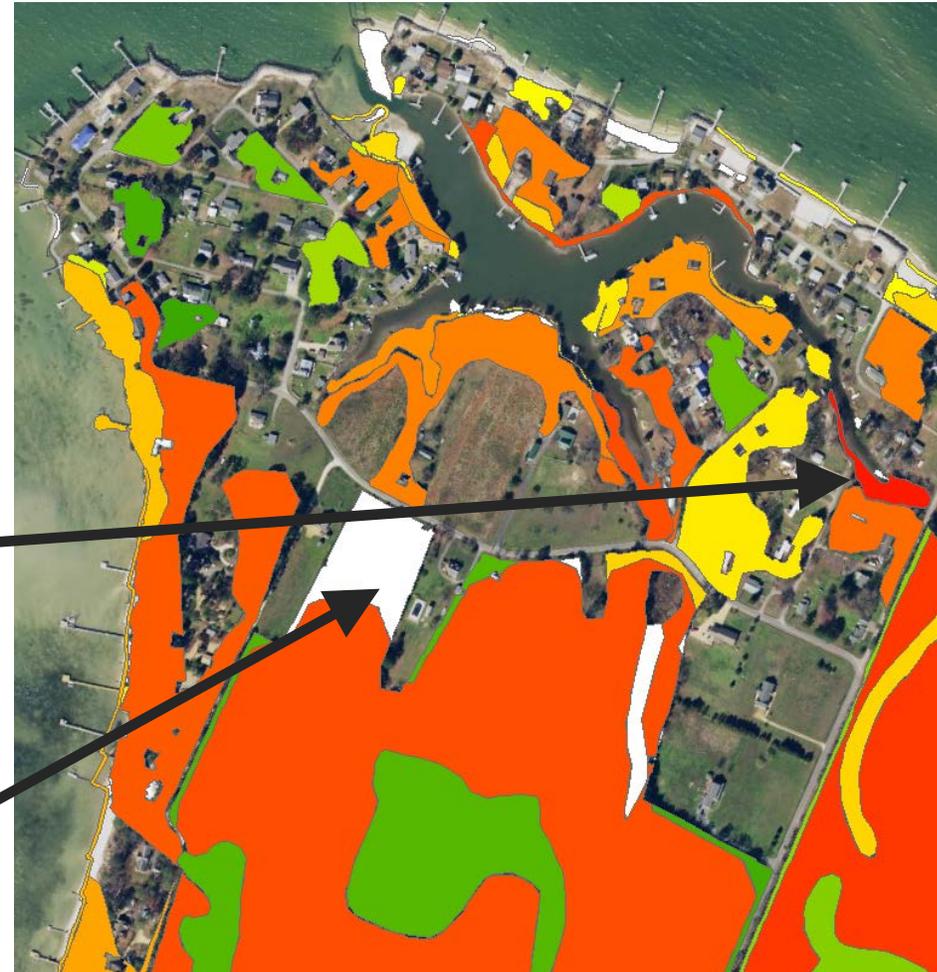
Low elevation = high frequency to intercept flood water
 Good capacity to mitigate flooding
 Benefits 32 buildings
 Offers water quality benefits and CRS credits

Wooded NNBF = Low Benefit

High elevation = low frequency of flood
 Good capacity to mitigate flooding
 Affects 0 buildings
 Out of RPA, no WQ or CRS credit avail.

NNBF Flooding Mitigation Value

White = Zero score, Green = low score, Red = high score



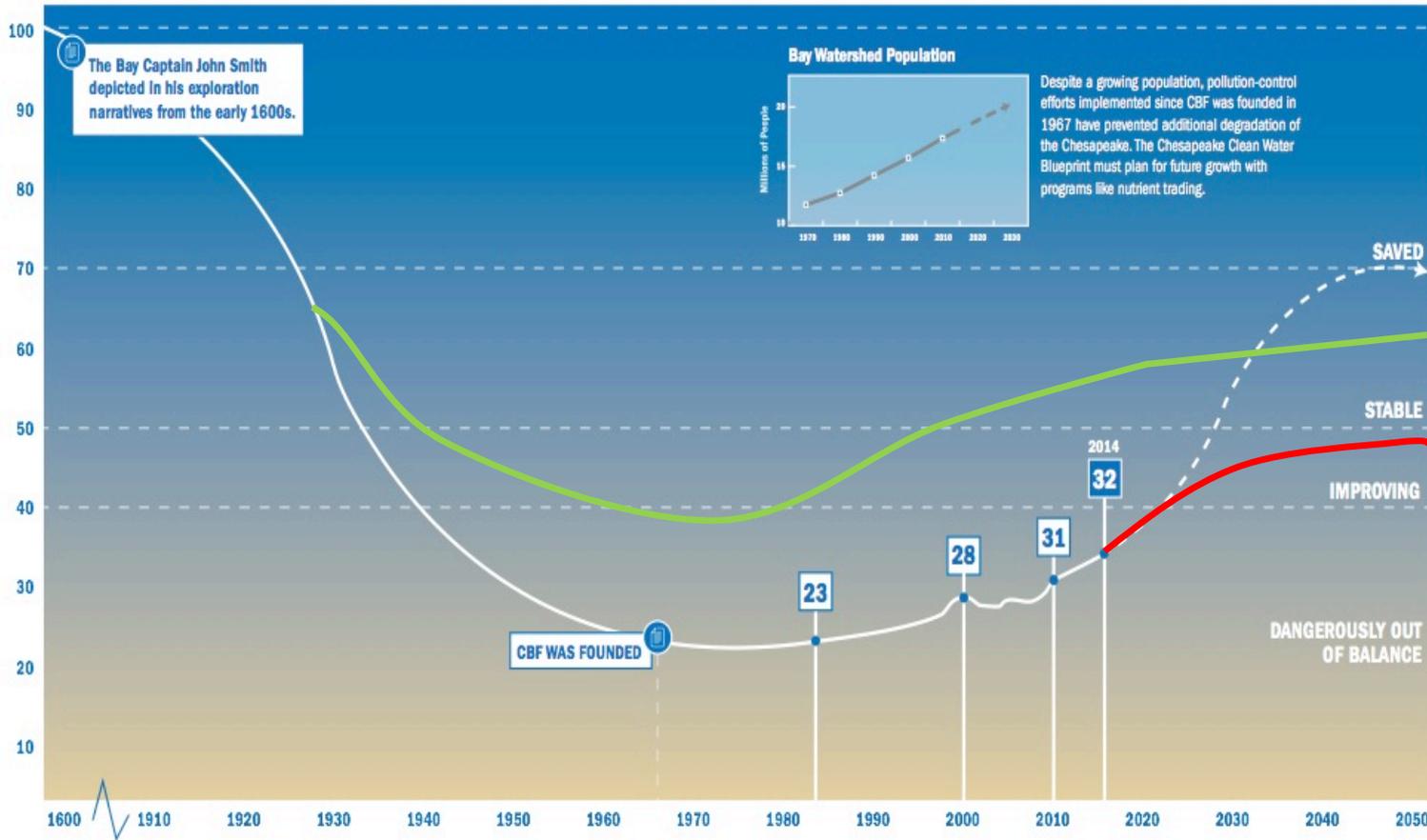
Gwynn's Island, Mathews

FUTURE

- Popular science challenges
 - Blue carbon
 - Biodiversity
 - Invasives
 - NNBF values
- Assessing goals
 - Use attainability in a changing system
- Assessing management value
 - Management scenario valuation
- Assessing “prestorage”



assessing goals



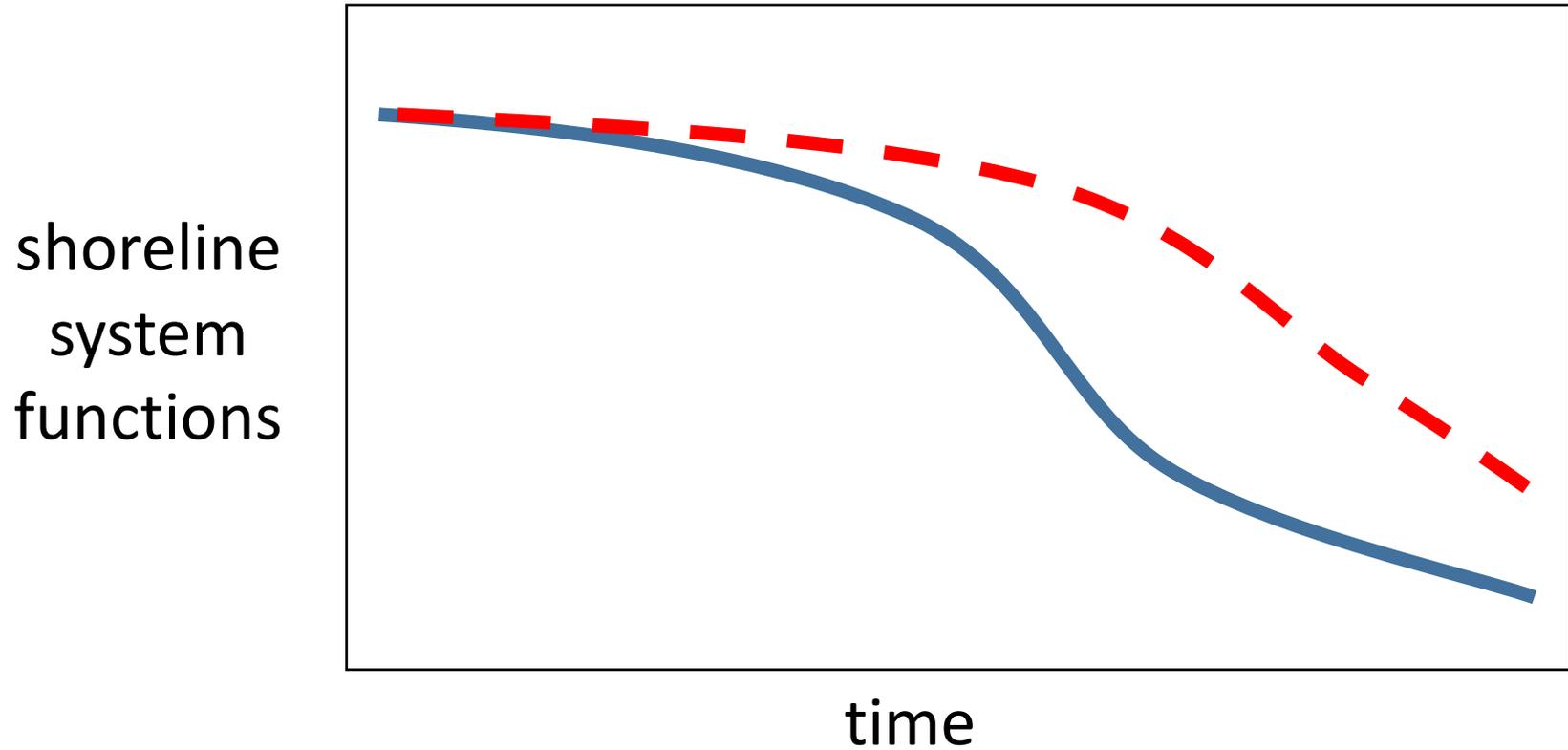
- *valuing services*
- *equity*
- *matching scales in management and analysis*

dissolved oxygen
 phosphorus
 nitrogen
 water clarity
 toxics

oysters
 rockfish
 blue crabs
 shad
humans

underwater grasses
 wetlands
 resource lands
 forest buffers

Hypothetical “sustainability” management outcome



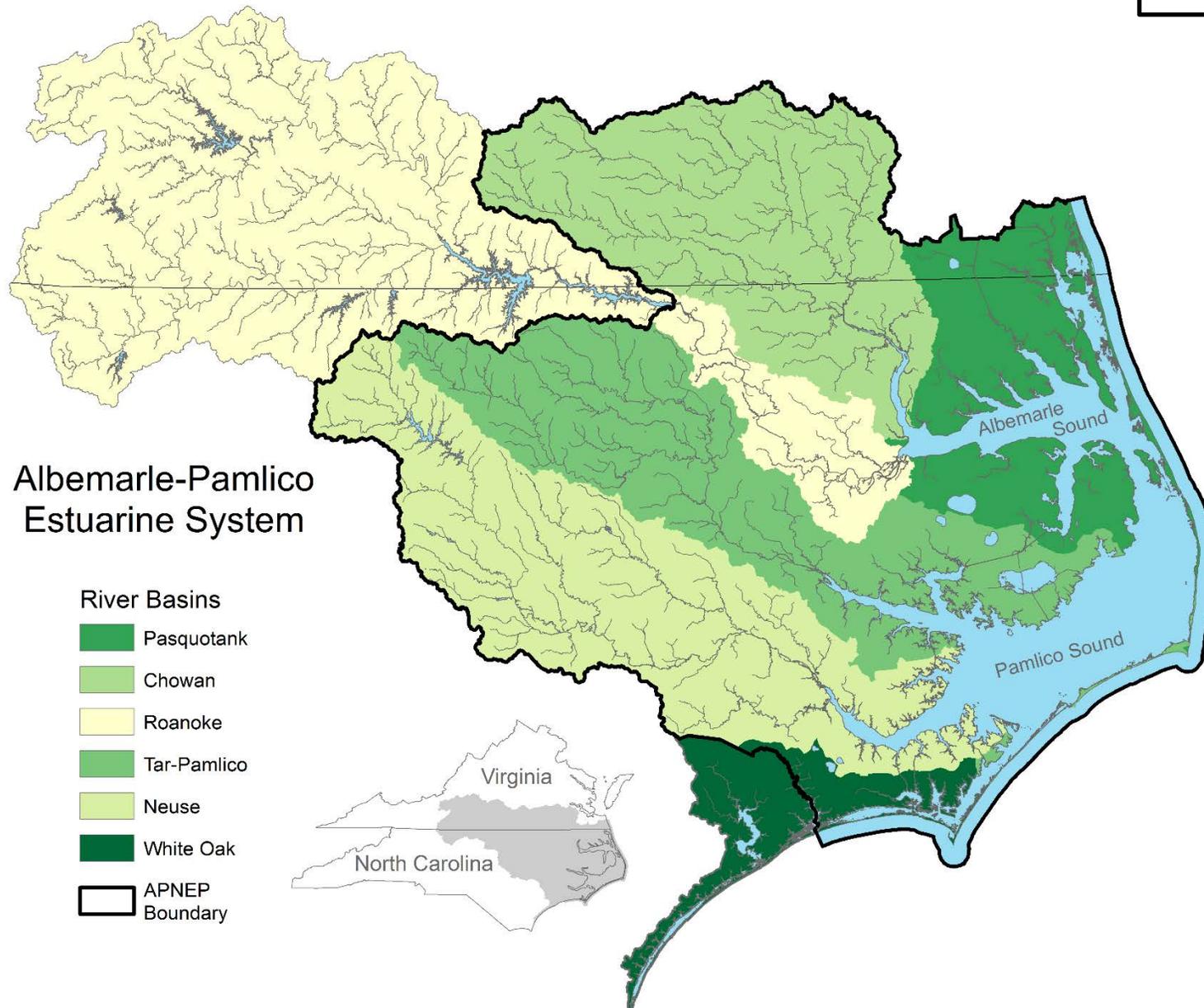
Scenario 1: current climate and human drivers

Scenario 2: aggressive management

assessing “prestorage”

Sam Pearsall

“aiming” systems

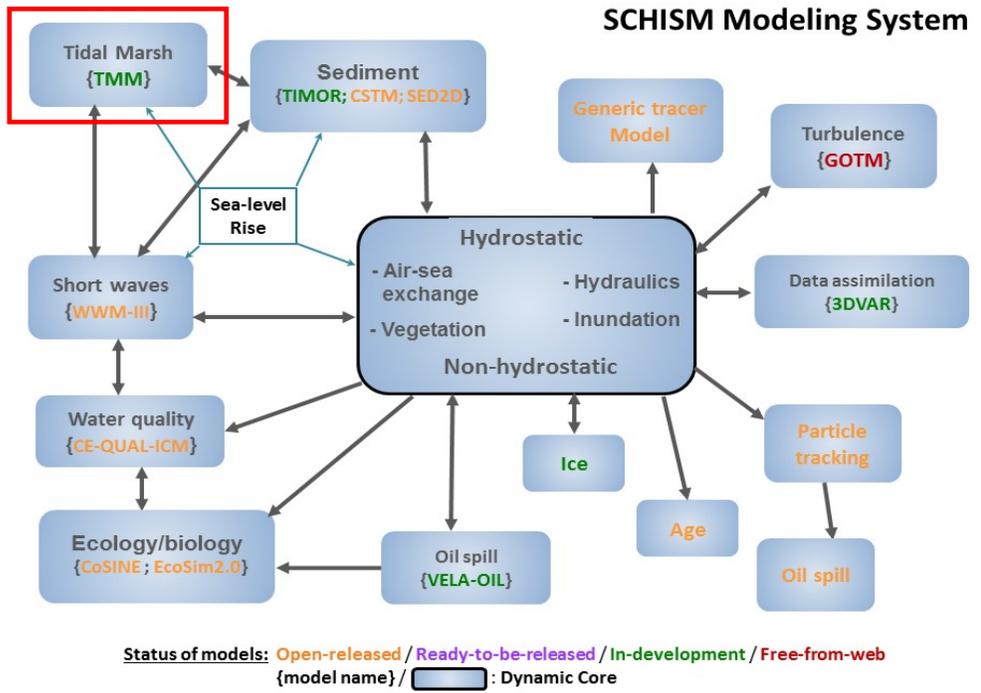


Carl Hershner

Center for Coastal Resources Management
Virginia Institute of Marine Science
College of William and Mary

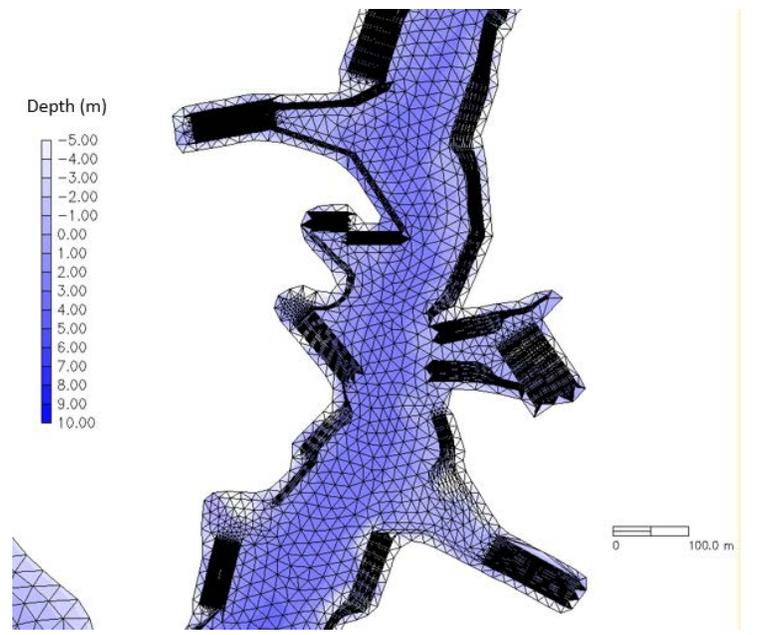
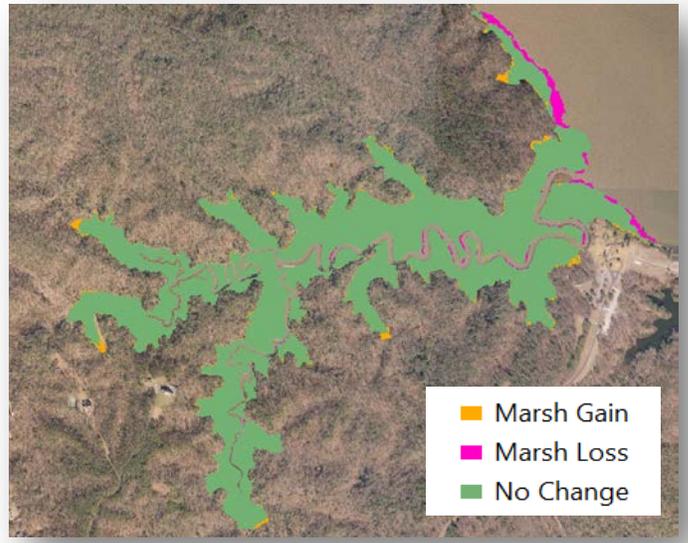
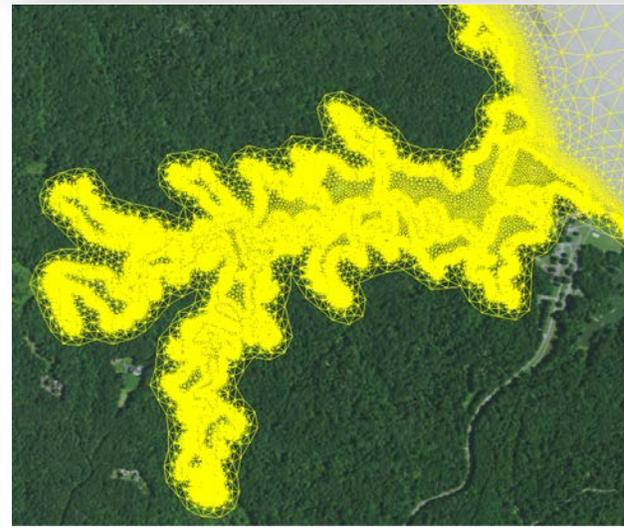
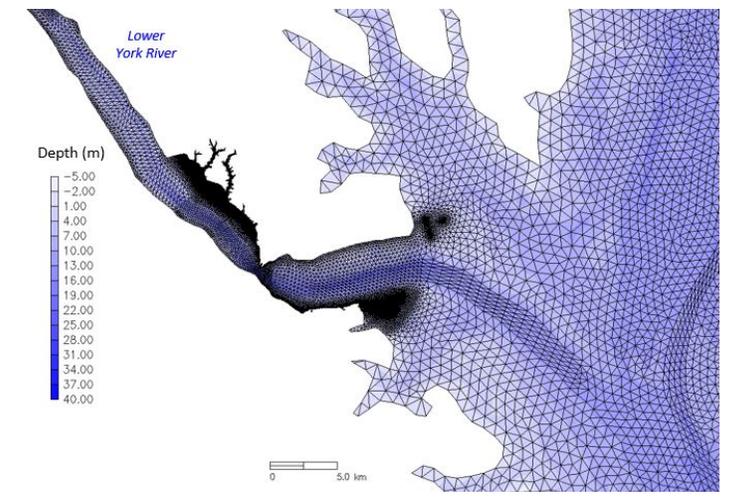
carl@vims.edu



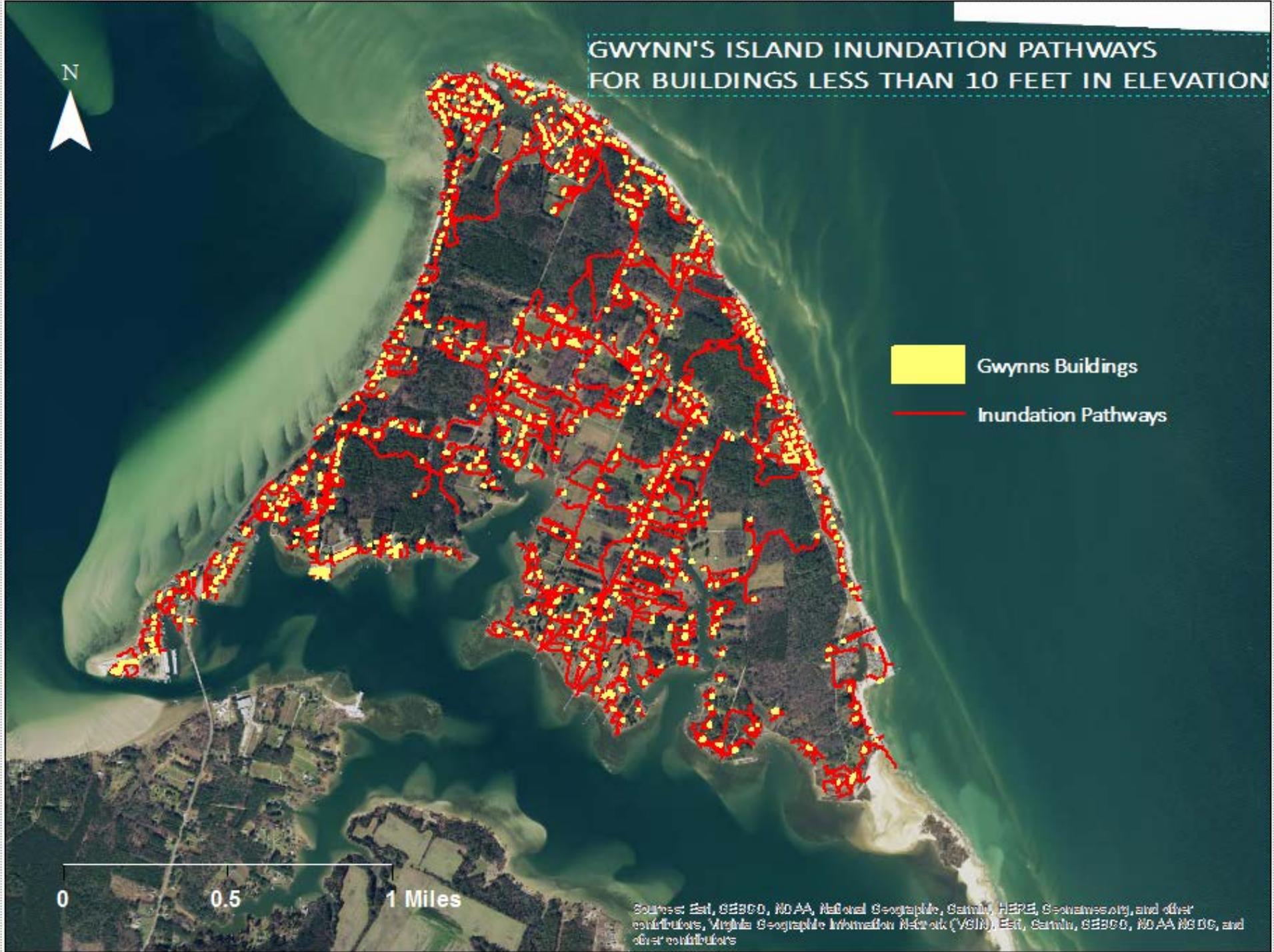


TIDAL MARSH MODEL (TMM)

Marsh areas are resolved at 1 meter cross-shore and 10-20 meters along-shore for fringe marshes



GWYNN'S ISLAND INUNDATION PATHWAYS FOR BUILDINGS LESS THAN 10 FEET IN ELEVATION



-  Gwynns Buildings
-  Inundation Pathways

0 0.5 1 Miles

Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors, Virginia Geographic Information Network (VGIN), Esri, Garmin, GEBCO, NOAA NED, and other contributors

How to we link NNBFs with the buildings they benefit? Inundation Pathways (IPs)



Inundation Pathways

For each building, we can count the number and types NNBFs that affect it

- *This building is benefitted by 1 NNBF (a tidal marsh)*

For each NNBF, we can count the number of buildings it affects

- *This tree area benefits 3 buildings*

NNBF Feature Types (in this map):

- Tidal Marsh
- Tree

CONCEPTUAL DIAGRAM OF CHESAPEAKE BAY ECOSYSTEM

