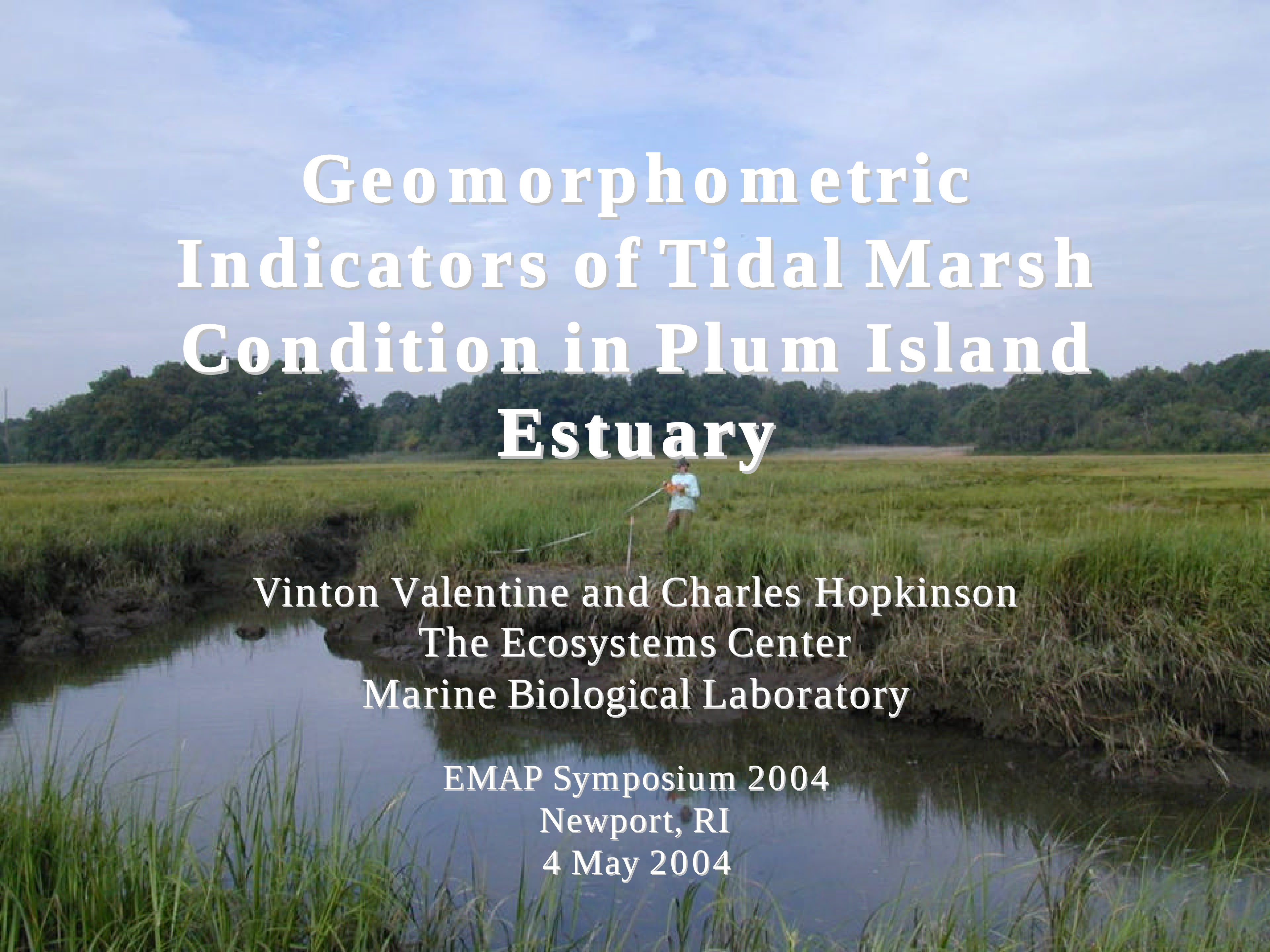

Geomorphometric Indicators of Tidal Marsh Condition in Plum Island Estuary

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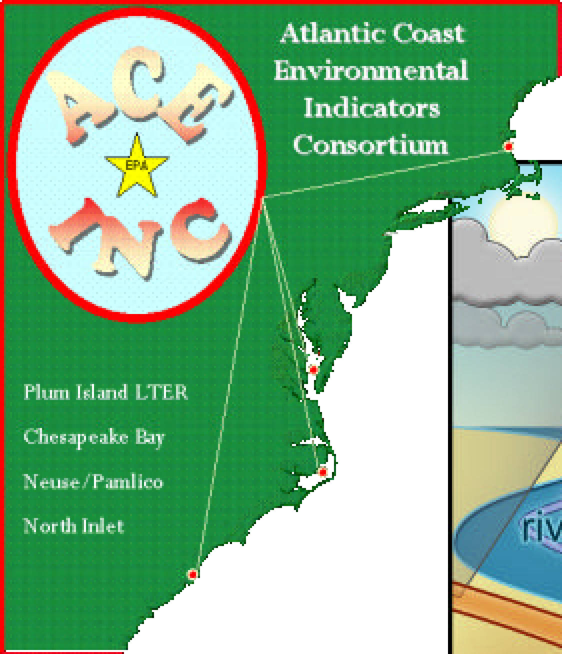
Intertidal Marshes as Critical Landscape Components

- Major source of organic matter fueling commercial and recreation fisheries
- Valuable habitat providing refuge for larval and juvenile organisms from predators
- Sink for high nutrient loads from human-dominated watersheds
- Buffer for urban and developed upland environments from catastrophic storms
- Aesthetically pleasing environment that affects real estate value and social systems

The Issues

- Natural forces and human activities in the coastal zone are contributing to the degradation and loss of critical tidal marsh habitat in estuaries
  - sea level rise
  - disruption of sediment supply
  - nutrient enrichment
  - altered hydrology and canaling
- The processes contributing to marsh degradation and loss are complex and include:
  - sedimentation
  - marsh plant production
  - peat accumulation and decomposition
  - erosion
  - ponding
  - marsh plant community shifts

Research Organization



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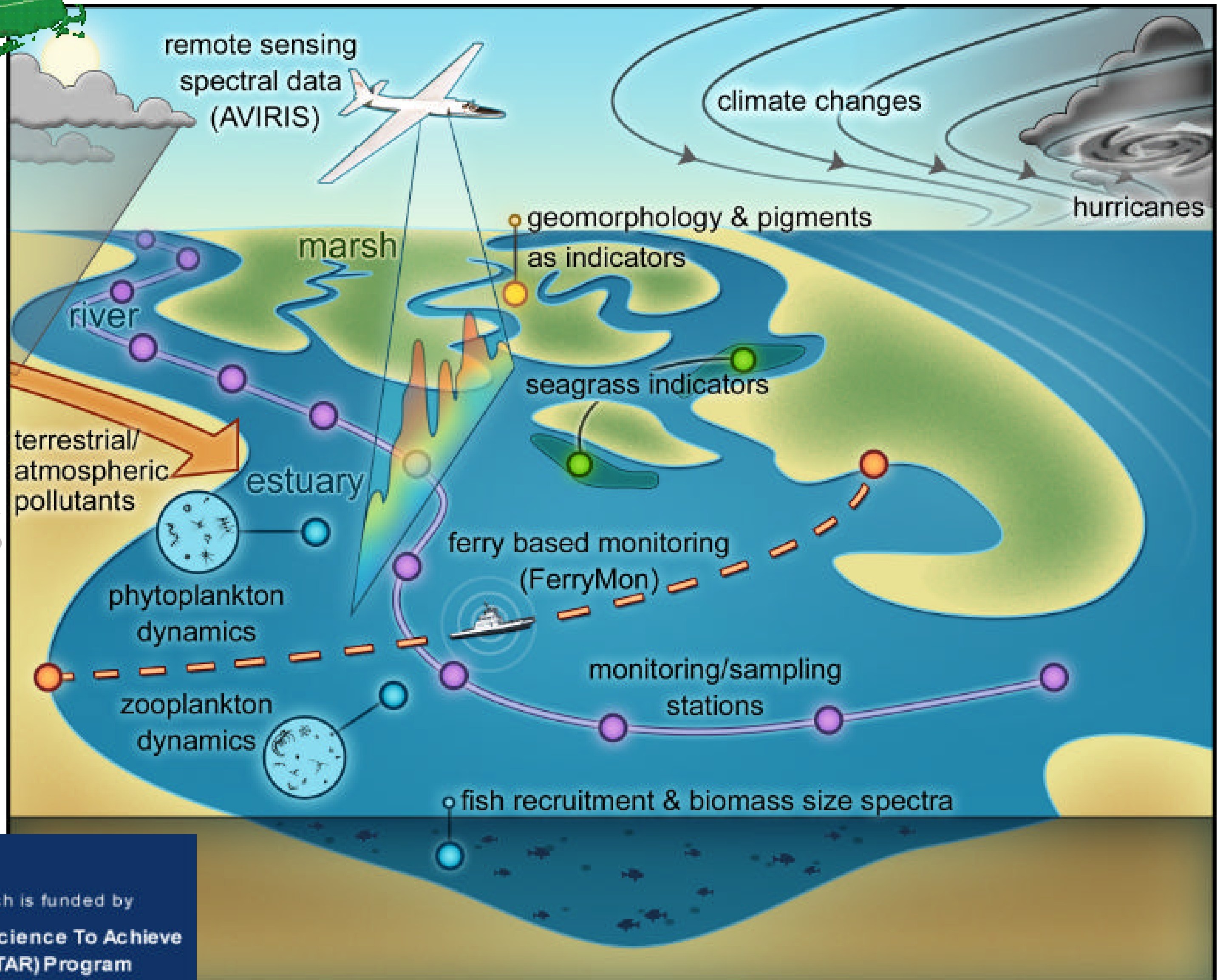

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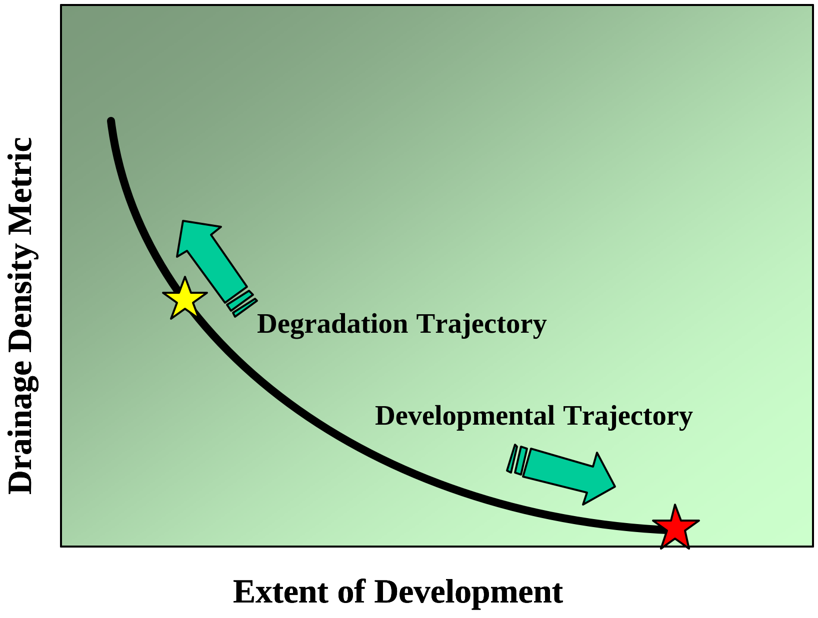
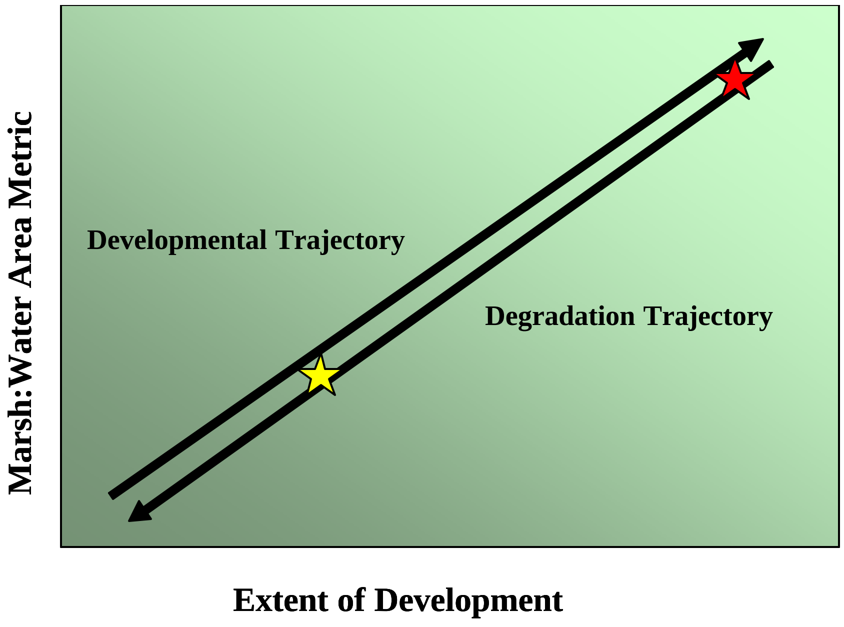
Research Goals

- Develop a suite of geomorphic indicators of intertidal marsh condition and value that can be applied coastwide
- Seek indicators that:
  - measure the magnitude of marsh development relative to maximum potential development
  - identify whether the marsh is in a developmental or degradative phase
  - ascertain the value of marsh from the perspective of 1) storm buffering, 2) habitat, and 3) sink/source strength of atmospheric CO_2
  - offer landscape, as well as site, information when assigning priorities and developing strategies for wetland conservation and restoration efforts

Hypothetical Indicator Trajectories





Storm Buffer Optimum -

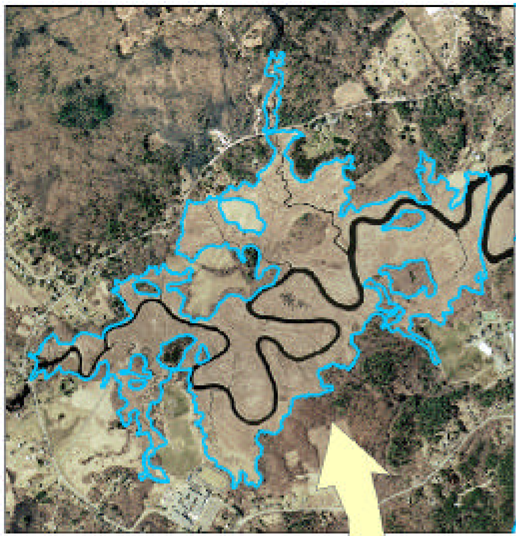
Habitat or CO_2 Sequestration Optimum -

Approach for This Study

- Selected regions in Plum Island Estuary marshes in northeastern Massachusetts, the site of an NSF Long-term Ecological Research (LTER) program, along gradients of salinity, sediment supply, vegetation community, and human impact
- Digitized tidal channels and mosquito ditches
  - Spring 2001 color orthophotography (MassGIS)
  - Wetlands cover data developed for the MA Department of Environmental Protection (DEP) Wetlands Conservancy Program (WCP) as starting point
- Generated distance from creek surface to use as a proxy for actual topographic surface
- Created basins from distance surface
- Generated centerline channel networks
- Calculated geomorphometric measures and related to selected regions

Study Locations

Plum Island Estuary



<u>Upper Parker River</u>

Healthy marshes
Flooded irregularly
Low salinity
Typha species and Spartina patens
High productivity
Few creeks
Very few ponds
Extensive ditch network

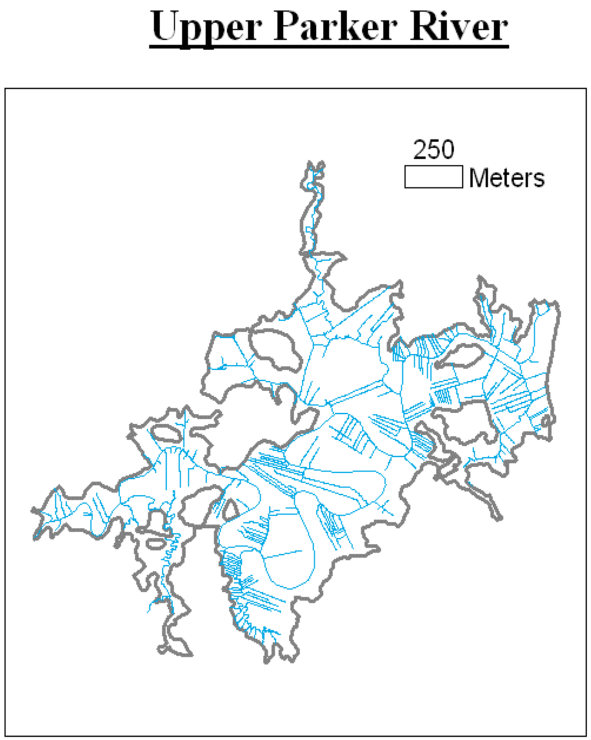
<u>Shad Creek</u>

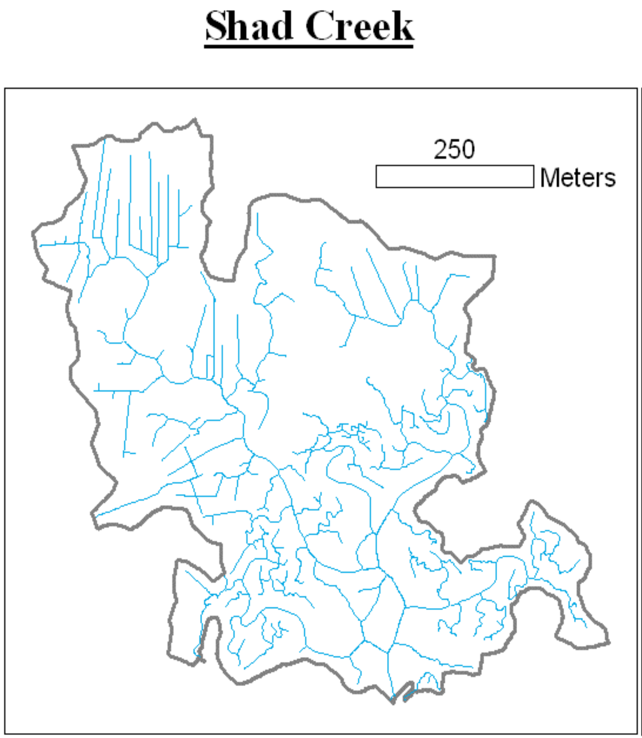
Degrading marshes
Flooded regulary
Moderate salinity
High sedimentation rates
Spartina alterniflora and S. patens
Extensive creek network
Extensive ponding
Some ditches

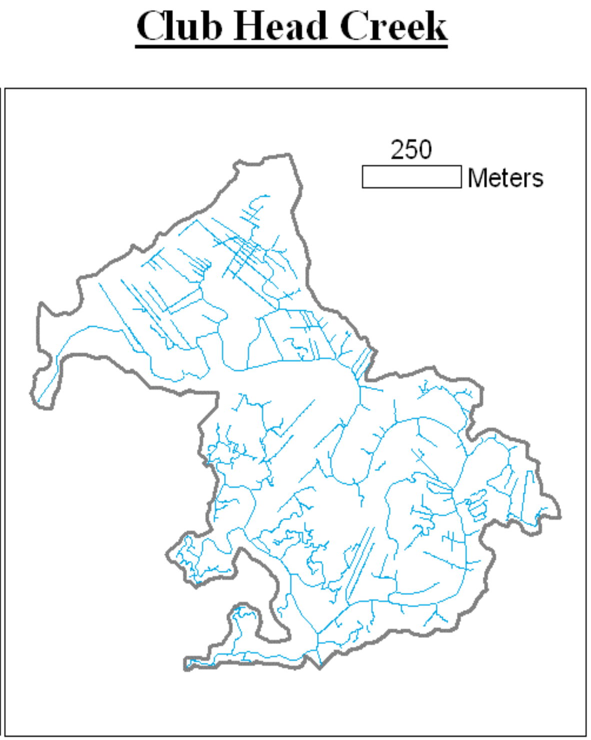
<u>Club Head Creek</u>

Degrading marshes
Flooded regulary
Moderate salinity
Lower sedimentation rates
Spartina patens with some S. alterniflora
High productivity
Broad creek network
Large expanses of ponds
Some ditches

Channel Networks







Geomorphometric Measures

- Drainage Density:

  D_d = Total Channel Length/Basin Area
- Constant of Channel Maintenance:

  $C = 1/D_d$
- Length of Overland Flow:

  $l_o = 1/(2D_d)$
- Sinuosity:

  P = Channel Segment Length/Segment Straight Line Distance
- Fractal Dimensions for individual streams, channel network, and branching structure:

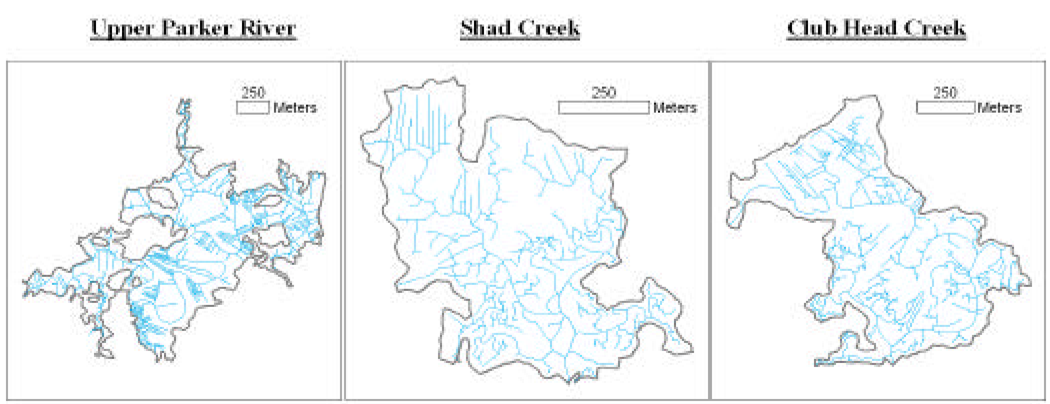
  D_s = negative slope of regression of log(box count) on log(grid resolution) for fine scales

  D_{cn} = negative slope of regression of log(box count) on log(grid resolution) for broad scales

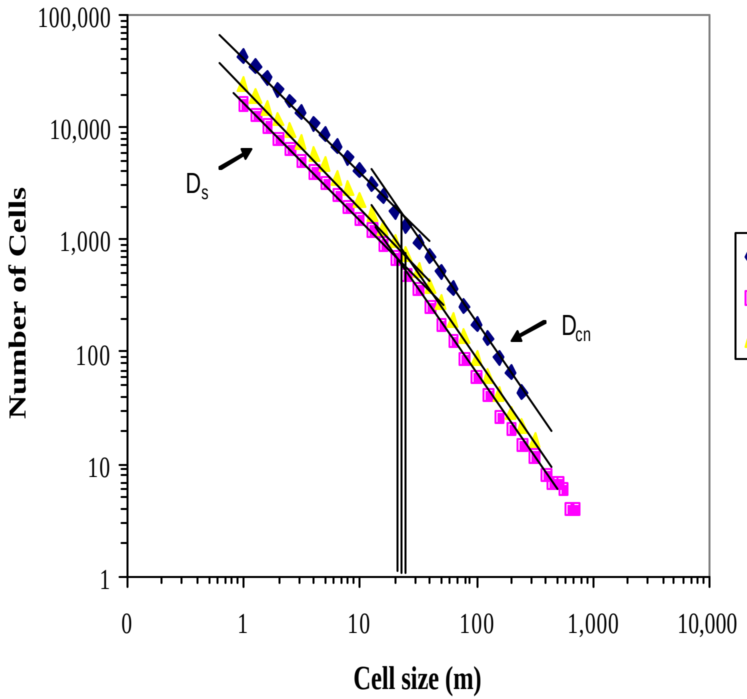
  $D_b = D_{cn}/D_s$ (related to log R_b/log R_l)(after Helmlinger et al. 1993)

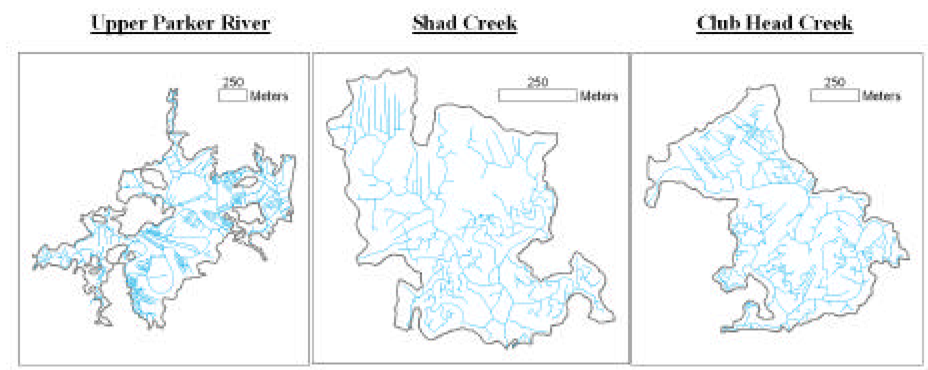
Classical Measures

Basin Name	Basin Area (ha)	Total Length (m)	D_d (m/ha)	C (sqm/m)	I_o (m)	P mean	P range
Upper Parker	143.25	34,181.6	*238.62*	**41.91**	**20.95**	*1.063*	*1.927*
Shad	44.09	13,104.8	**297.22**	*33.65*	*16.82*	**1.129**	3.325
Club Head	72.85	18,560.1	254.77	39.25	19.63	1.103	**3.536**



Fractal Dimensions





Basin Name	D_s	D_{cn}	D_b	Intersection (m)
Upper Parker	1.016	*1.577*	*1.552*	22.54
Shad	*1.012*	1.609	1.590	*20.46*
Club Head	**1.019**	**1.648**	**1.617**	**24.31**

Summary

- While more data and work are needed, geomorphometric indicators hold promise in describing tidal marshes and their condition
- Classical measures are applicable and provide foundation for assessing areas, establishing management priorities and targets, and monitoring status or restoration progress
  - D_d as indicator of landscape dissection and as surrogate for edge
  - C as integrator of water level and sedimentation changes
  - l_o as reflection of available nekton habitat
  - P as indicator of variable water velocity and varied edge habitat
- Fractal dimension analysis seems to provide additional and multiple characteristics
  - network pattern and distribution
  - sinuosity
  - channel support area
  - underlying processes, scaling, and observation limits

Acknowledgments

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Plans

- Calculate other measures:
  - number and mean length of terminal tributaries
  - mean area of terminal tributary basins
  - sinuosity of terminal tributaries for fractal comparison
  - edge length and edge density
  - number, density, and distribution of ponds and pannes
- Field checking and complete mapping
- Analyze entire Plum Island Estuary
- Run metrics on North Inlet, SC networks and compare
- Develop automated methods based on remote sensing to enable application of indicators to other systems in US coastal zone
- Interact with Massachusetts resource managers and USEPA/EMAP and AED personnel