Case Study: Soil Mapping in Chincoteague Bay Maryland

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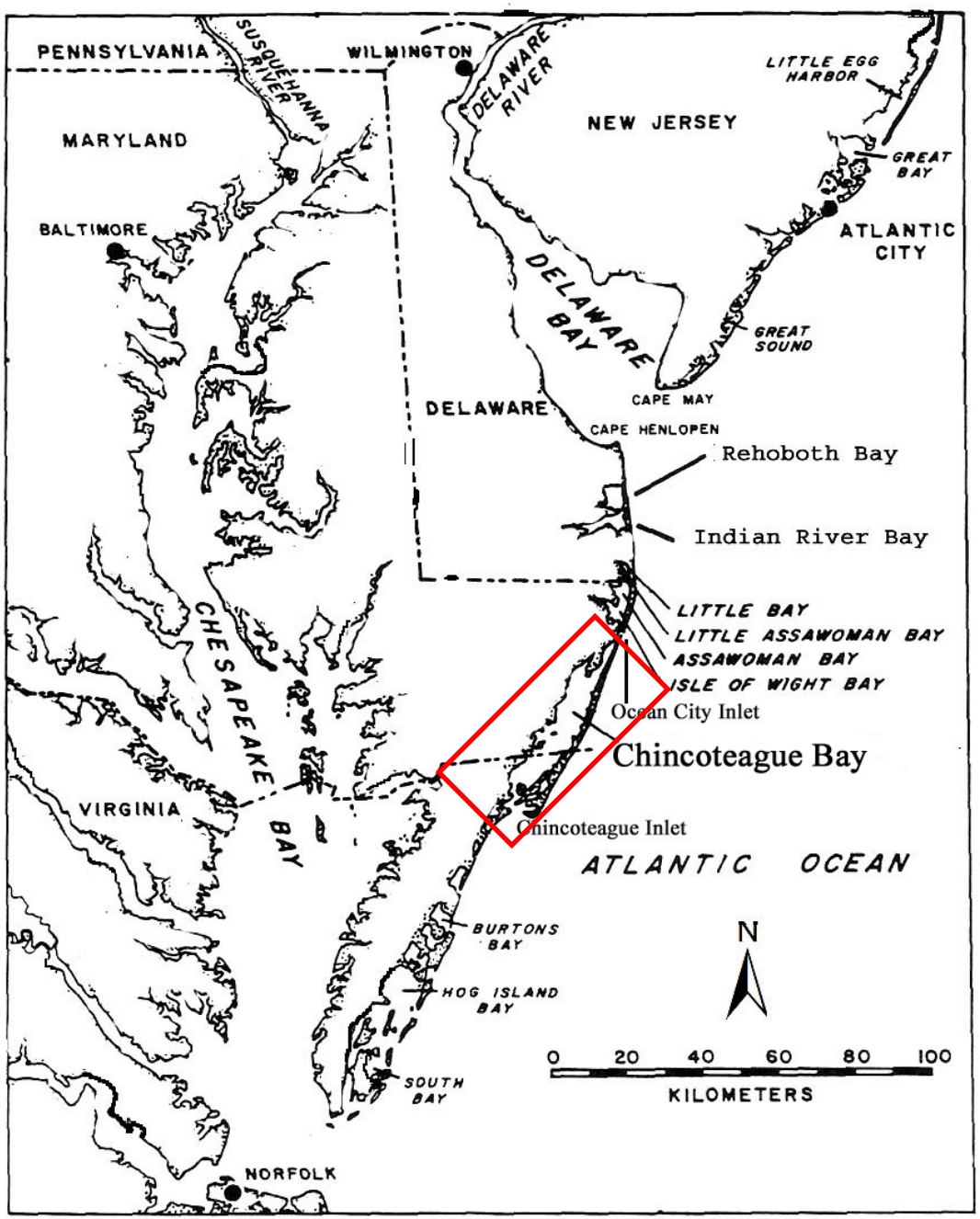
Based upon the PhD work of Danielle Balduff

Currently: USDA-NRCS
Wetland Team Leader
Massillon, OH

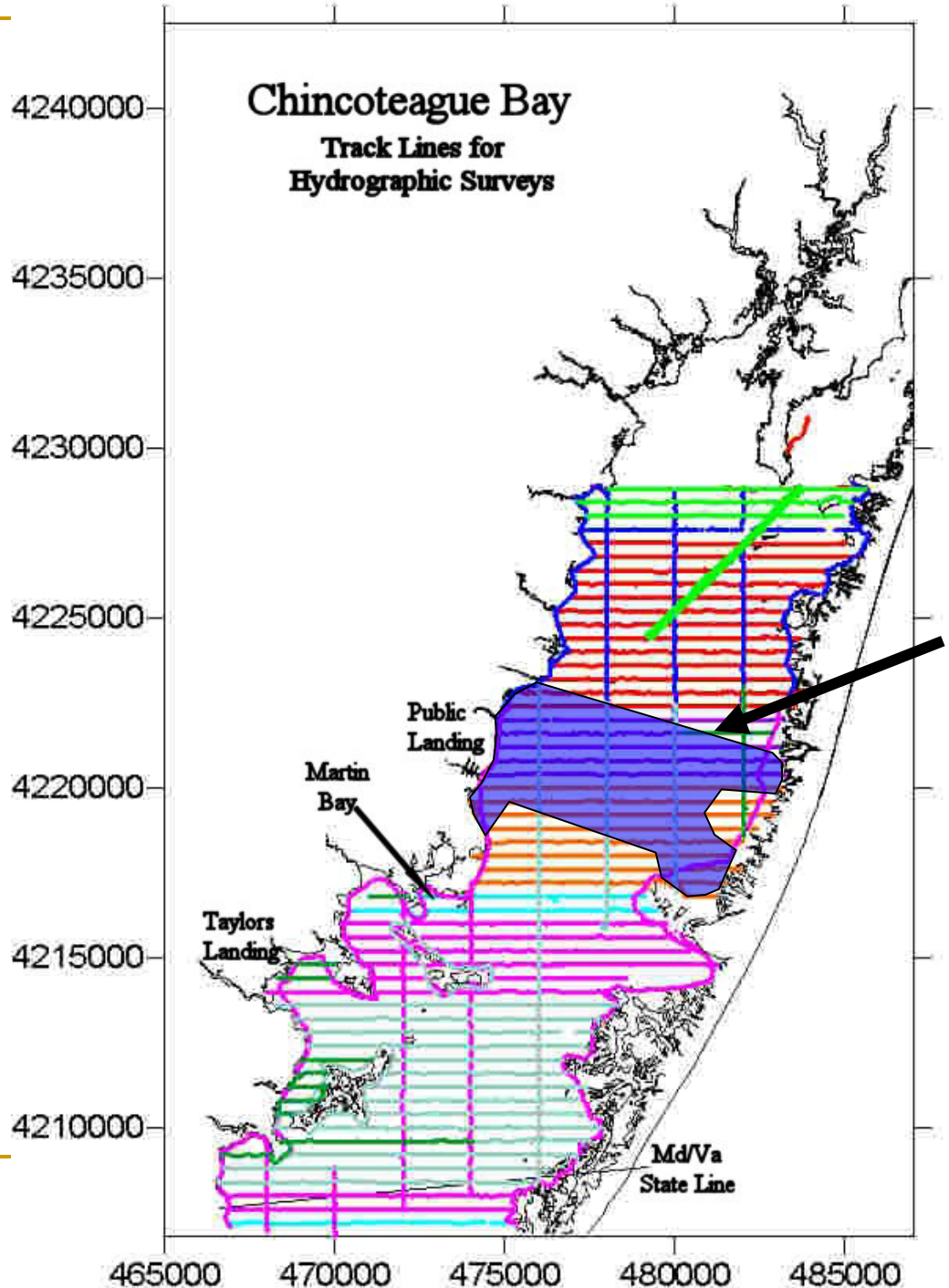
Study Area

- Chincoteague Bay, Maryland
  - Size - 19,000 ha
  - Microtidal lagoon
    - Average Daily Range of 10 to 20 cm
  - Polyhaline Salinity
    - Range of 26 to 34 ppt
  - Water Depth
    - less than 2.5 m
  - Largely undeveloped

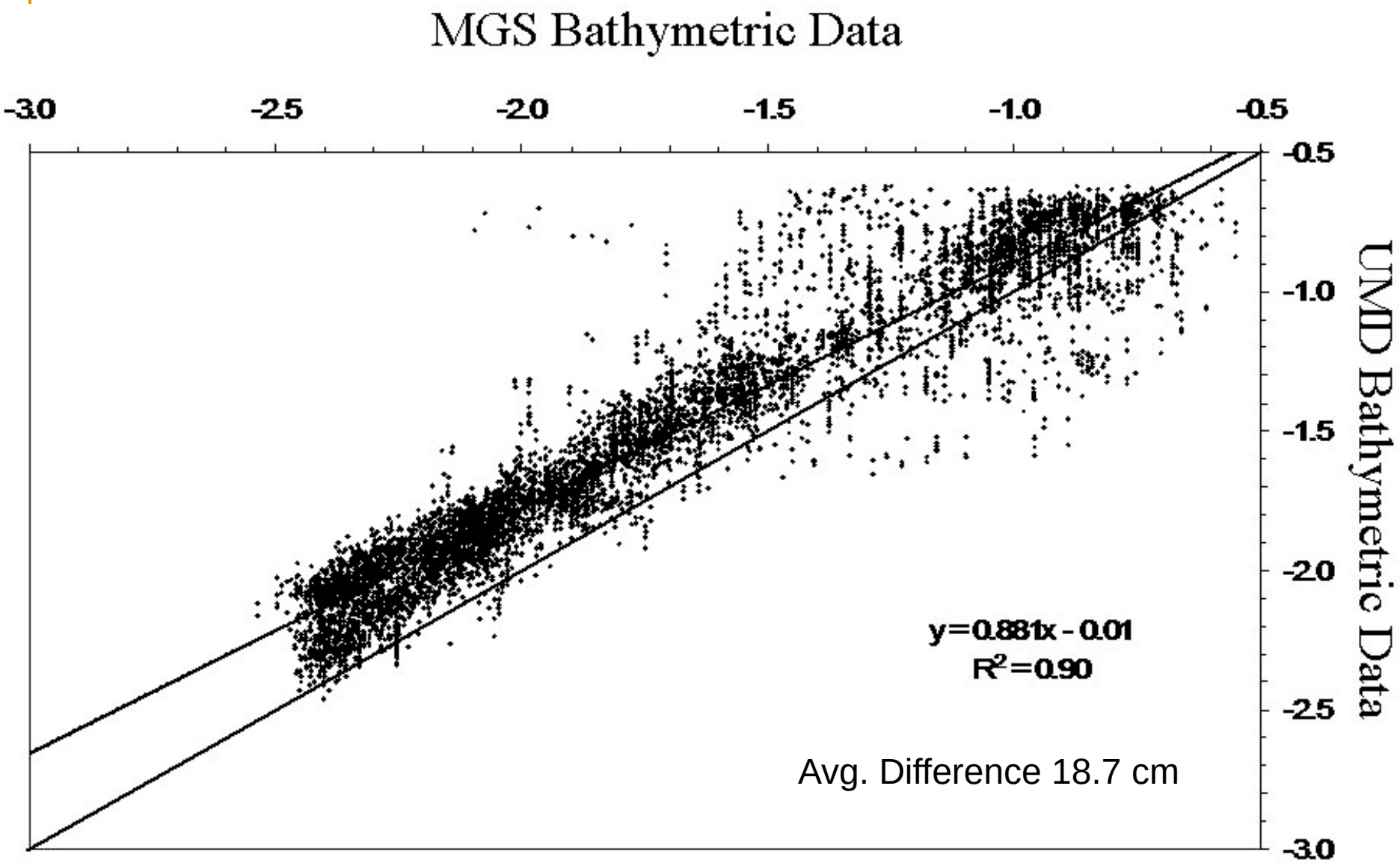


Bathymetric Data

- A bathymetric data set collected by Maryland Geological Survey during summer 2003
- We, then, obtained bathymetric data set for a small portion (4600 ha) of Chincoteague Bay near Public Landing during 2003
- The MGS data set was evaluated for use in our study based on the smaller independent data set we had collected

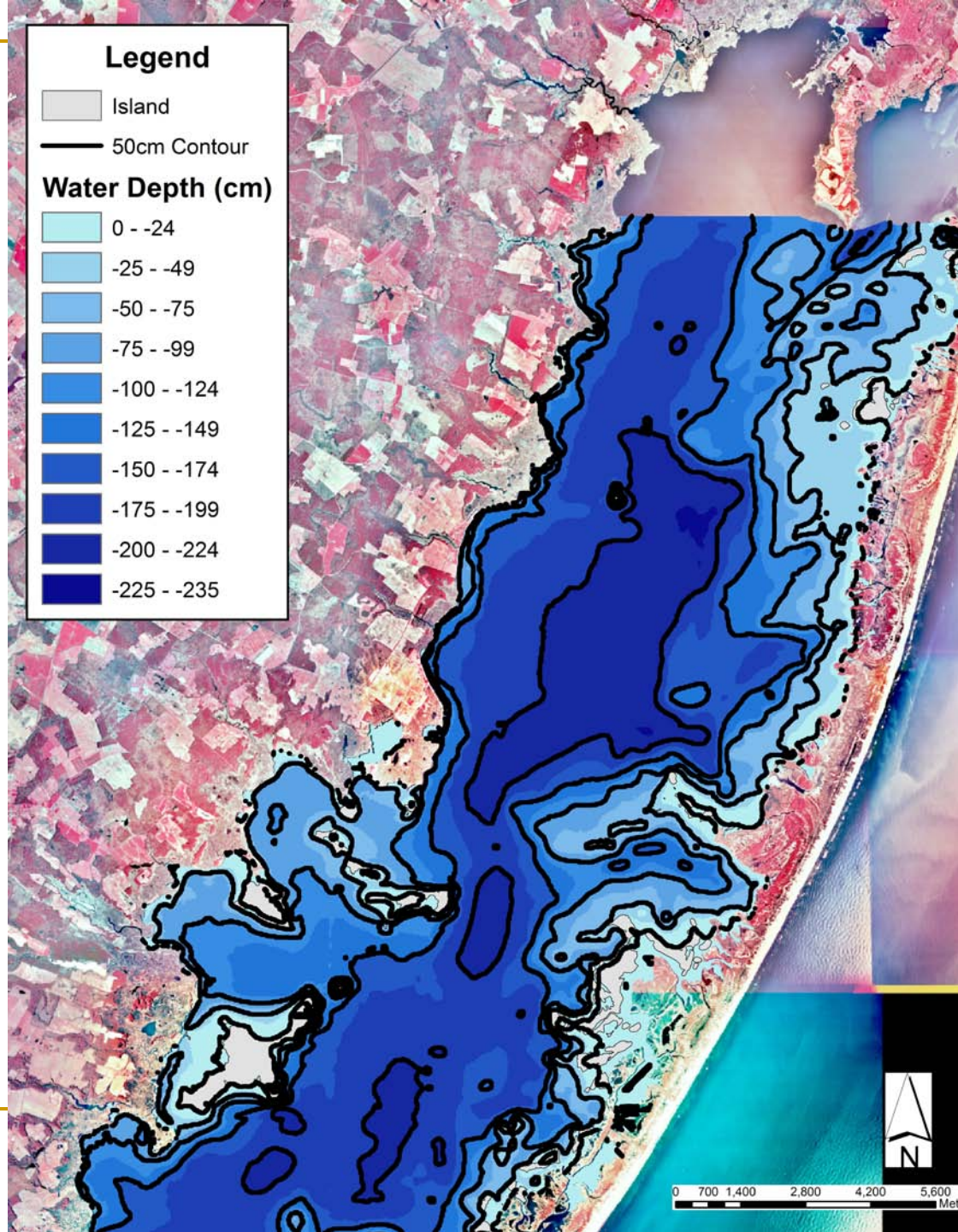


Area of comparison



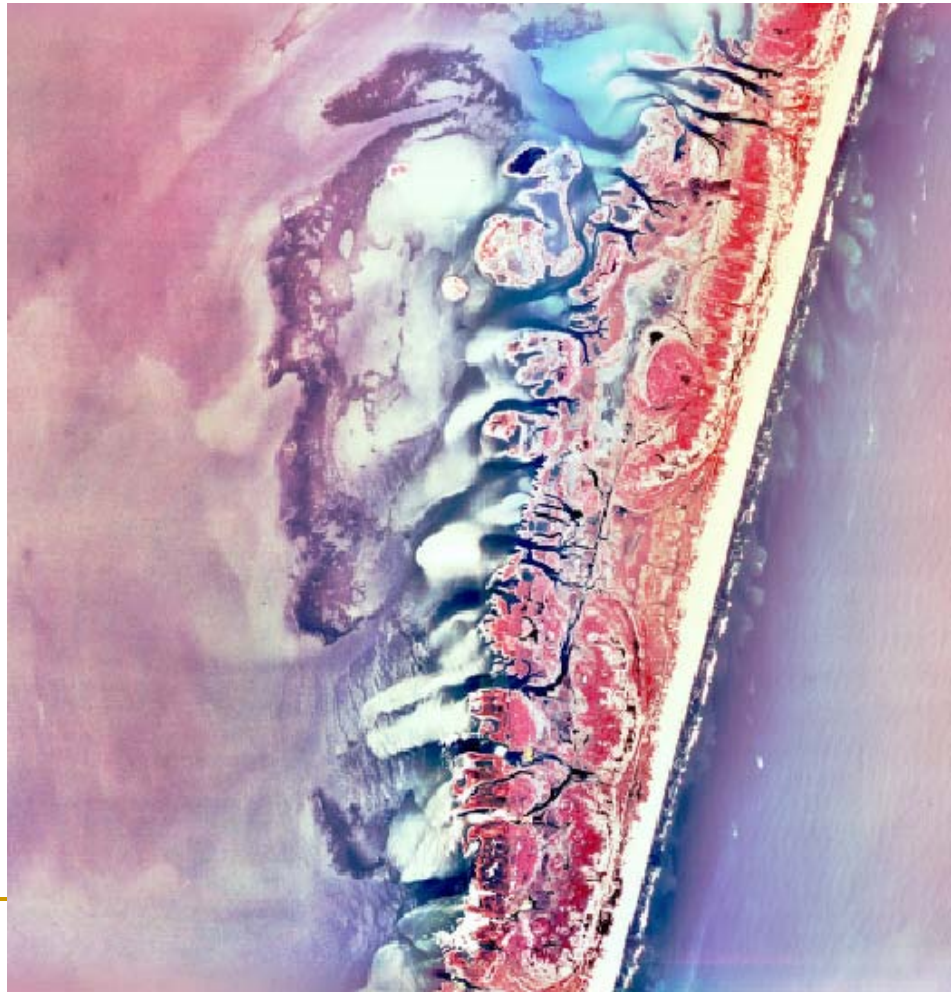
Points of comparison within 20m of each other

DEM of Chincoteague Bay



Identification of Subaqueous Landforms

- False Color Infrared Photographs
  - Aids in the identification of washover fans and scour channels



Identification of Subaqueous Landforms

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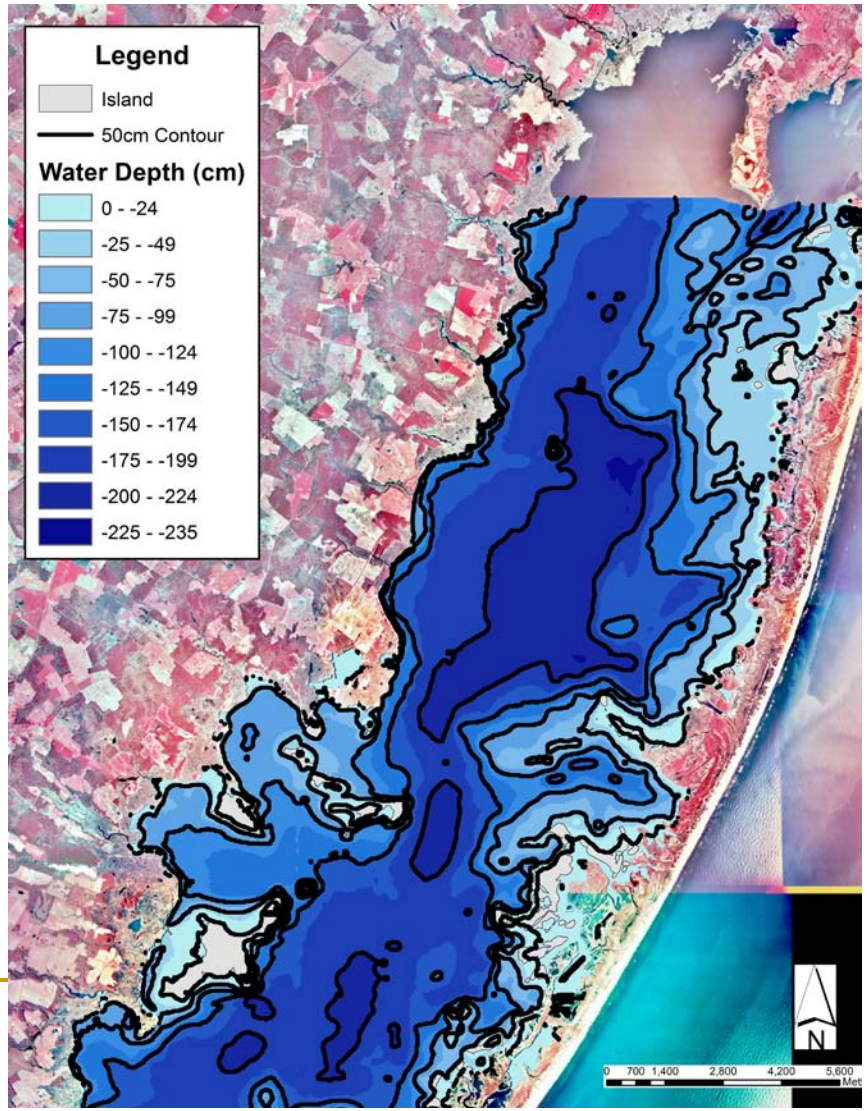

Identification of Subaqueous Landforms

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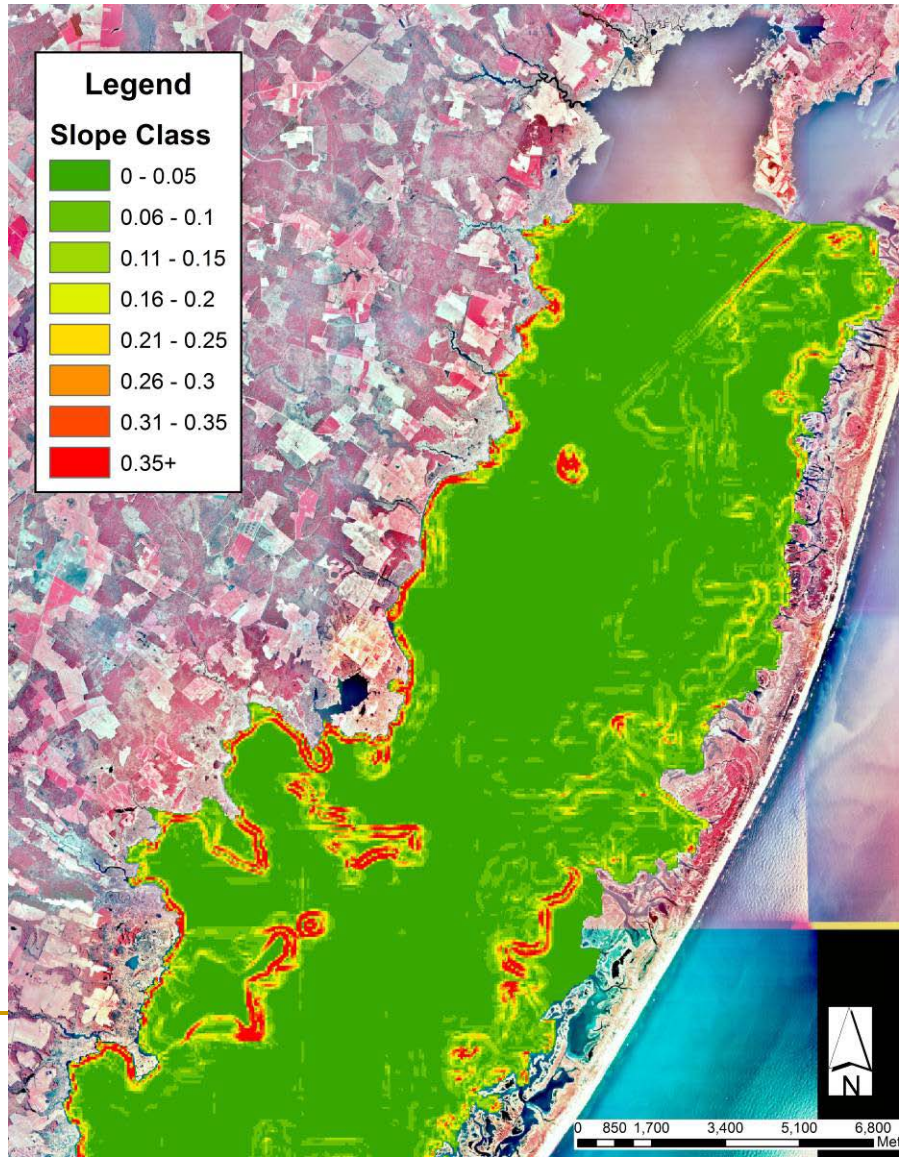
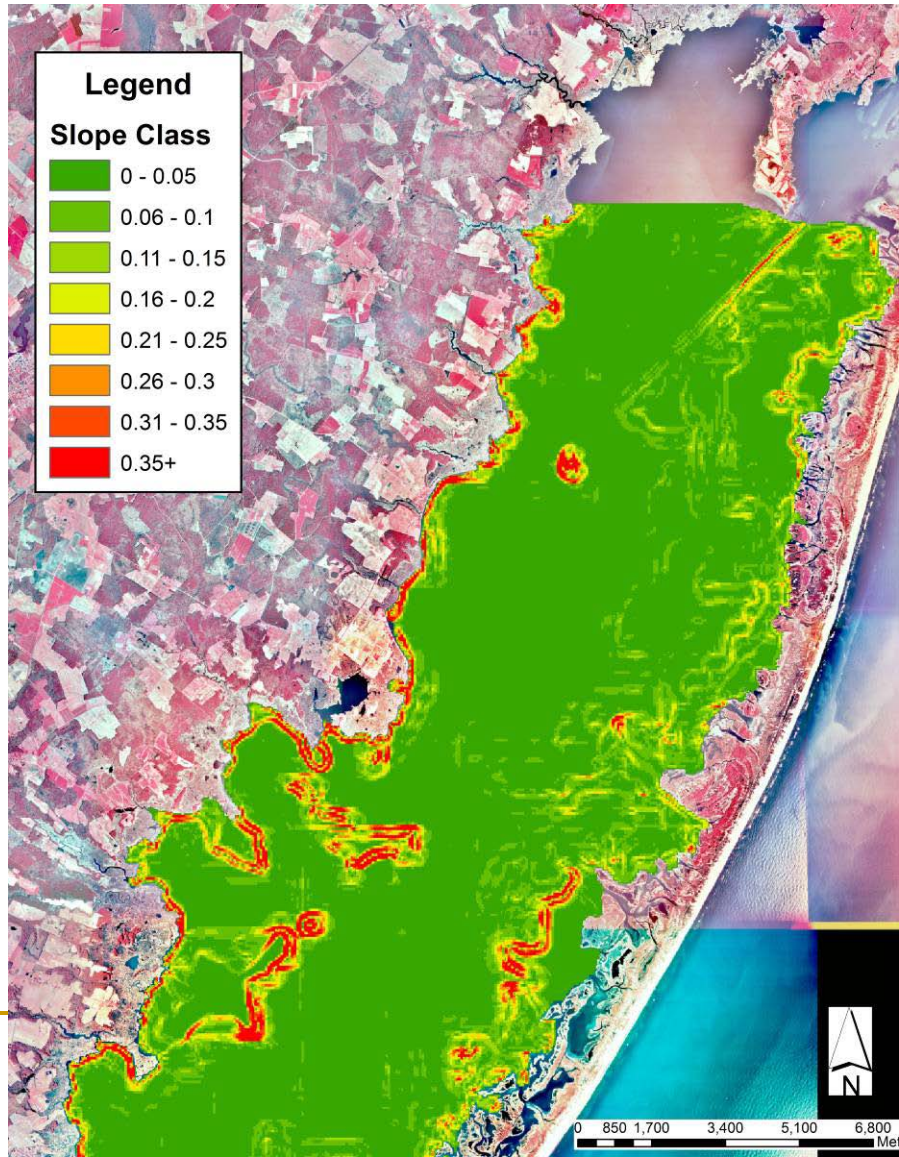
- Slope



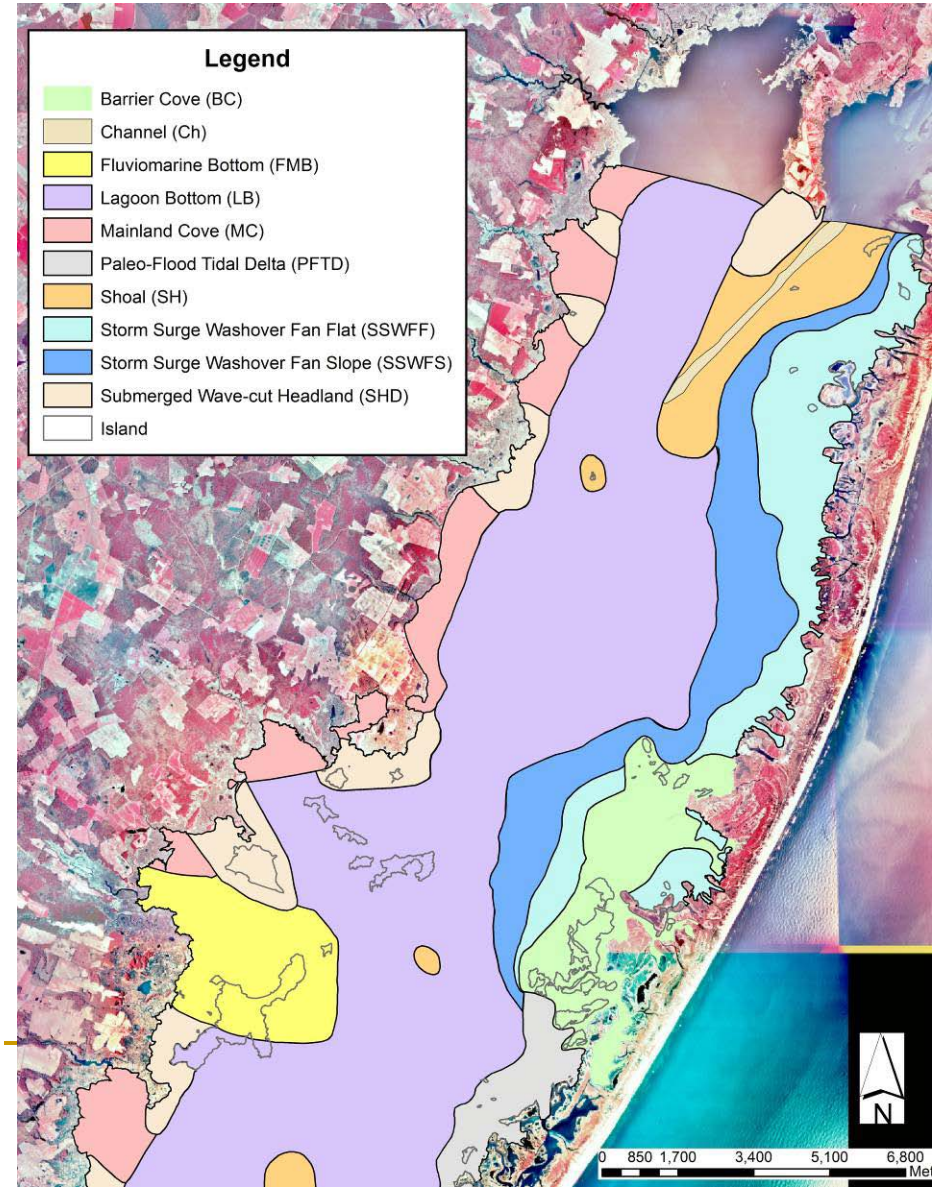
Identification of Subaqueous Landforms

- False Color Infrared Photographs
  - Aids in the identification of washover fans and scour channels
- Bathymetric Data
  - Data set collected by Maryland Geological Survey
- Slope
- Landscape Shape
- Geographical Relationships
  - Proximity to barrier island, mainland, mouth of a tidal creek
- Depositional Environment
  - Low-energy or high-energy



Subaqueous Landforms

- Ten landforms were identified
  - Storm-surge washover fan flat
  - Barrier Cove
  - Paleo-flood tidal delta
  - Storm-surge washover fan slope
  - Lagoon bottom
  - Mainland cove
  - Submerged wave-cut headland
  - Fluviomarine bottom
  - Shoal
  - Dredged Channel



Prior Soil Landscape Analysis

Sinepuxent Bay, MD Soils and Landforms (from Demas)

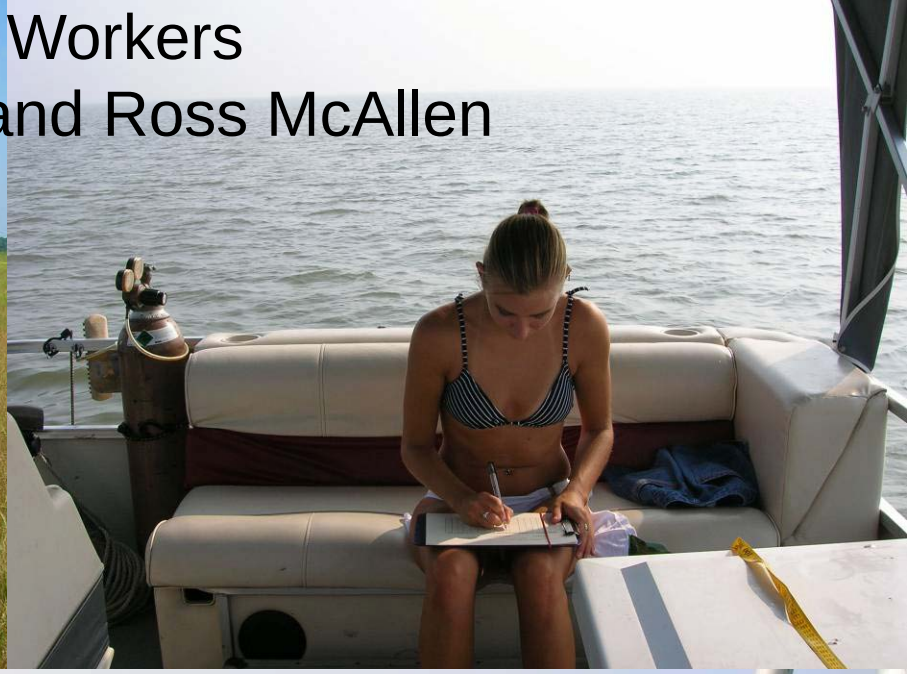
- **Mid-Bay Shoal:** Sinepuxent soil series (Coarse-loamy, Typic Sulfaquents)
- **Overwash Fans:** Fenwick soil series (Typic Psammaquents)
- **Barrier Island Flats:** Tizzard soil series (Coarse-loamy, Sulfic Fluvaquents)
- **Shallow Mainland Coves:** Newport soil series (Typic Psammaquents)
- **Deep Mainland Coves:** Southpoint soil series (Fine-silty, Typic Sulfaquents)
- **Transition Zones:** Wallops soil series (Typic Psammaquents)
- **Central Basin:** No series available (Fine-silty, Typic Sulfaquents)

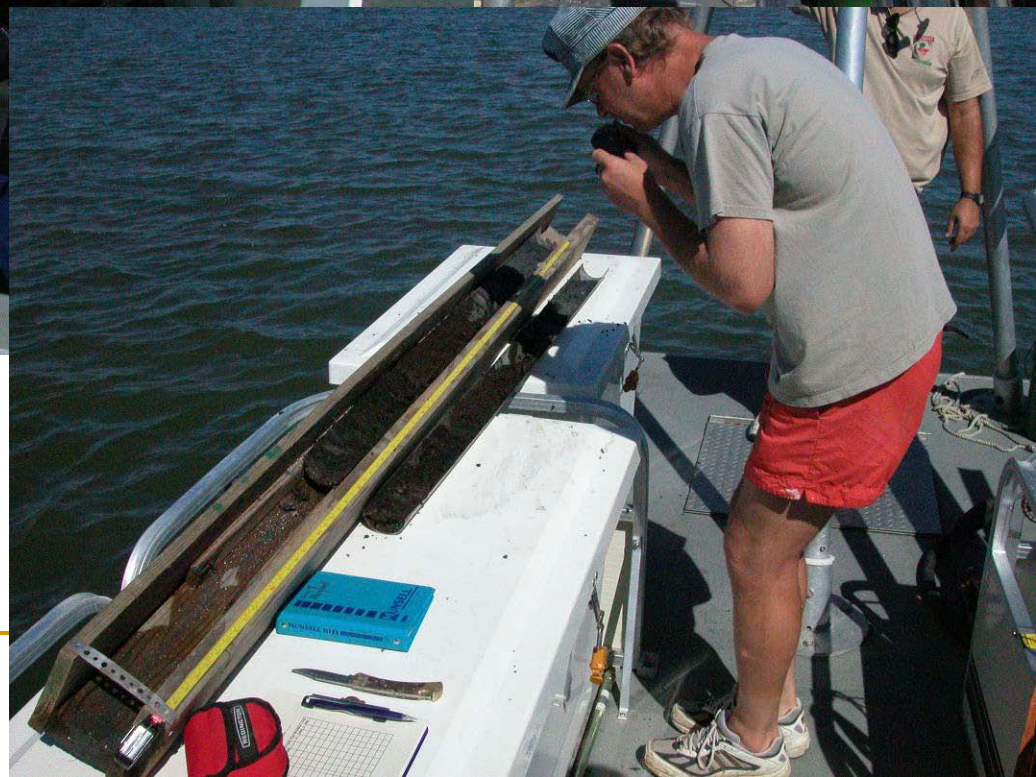
Prior Soil Landscape Analysis

Ninigret Pond, RI Soils and Landforms (from Bradley and Stolt)

- **Lagoon Bottom:** Typic Hydraquents
- **Storm-surge Washover Fan Flats:** Typic Sulfaquents
- **Flood-tidal Delta Flat:** Typic Psammaquents
- **Storm-surge Washover Fan Slope:** Typic Fluvaquents
- **Flood-tidal Delta Slope:** Typic Fluvaquents
- **Shoal:** Typic Endoaquents
- **Mainland Submerged Beach:** Typic Endoaquents
- **Barrier Coves:** Typic Sulfaquents
- **Mainland Shallow Coves:** Typic Endoaquents
- **Mid-lagoon Channel:** Typic Endoaquents
- **Mainland Coves:** Thapto-histic Hydraquents

Student Workers
Amanda Haase and Ross McAllen

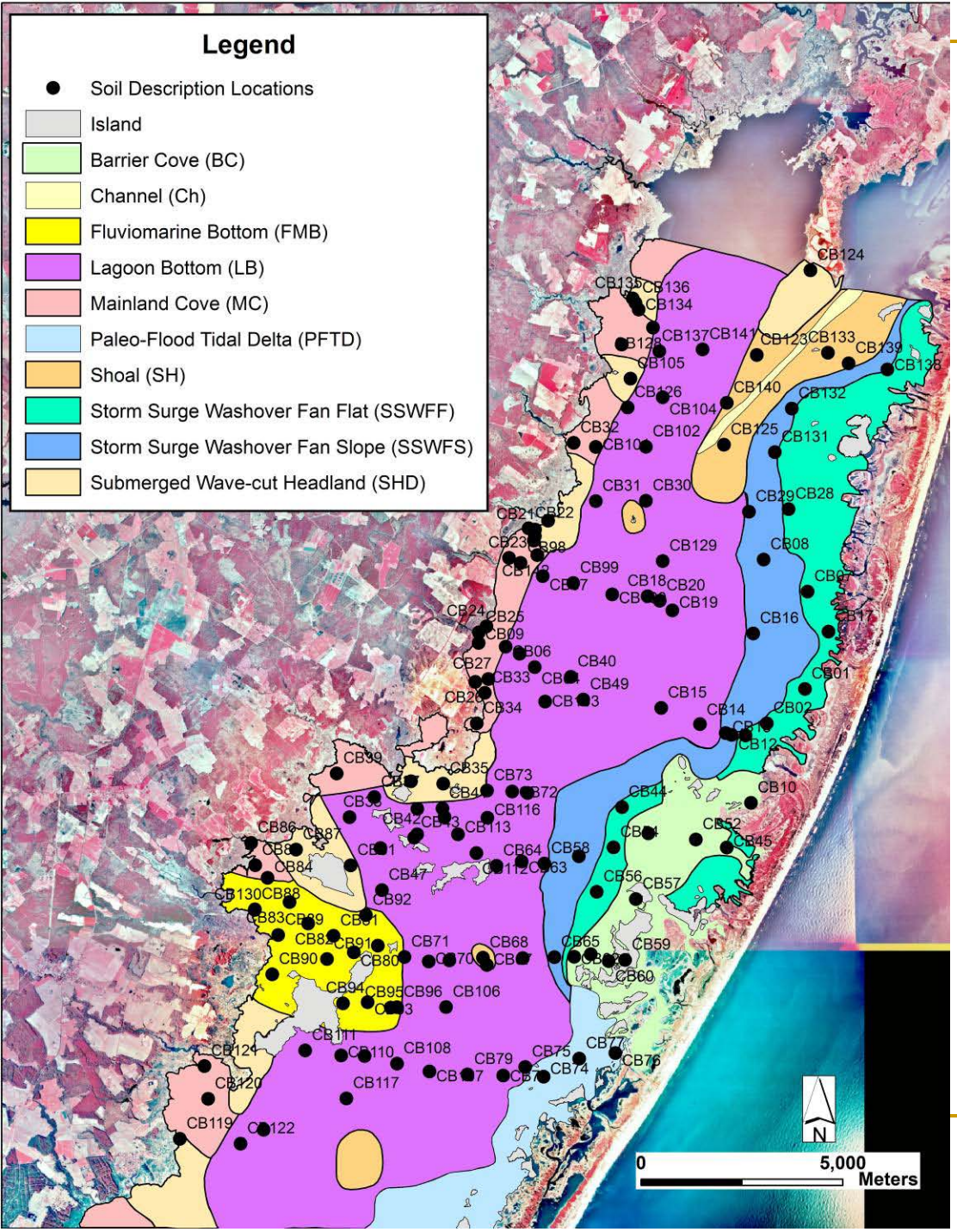




Guest Scientists

Mark Stolt

Phil King



146 Full Pedon Descriptions

17 Partial Pedon Descriptions or Notes

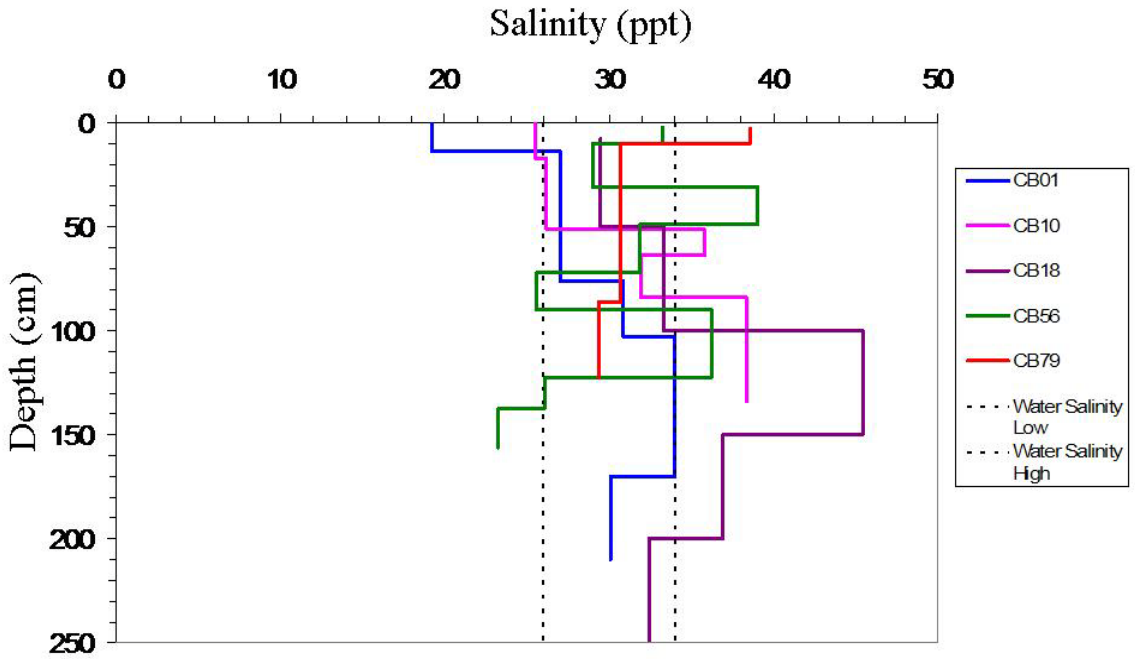
Data Collected

- Profile descriptions
- Characterization Data – on selected pedons
  - Particle-size data
  - Acid Volatile Sulfides and Chromium Reducible Sulfides
  - Moist Incubation pH data
  - Mineralogy (grain counting and x-ray diffraction)
  - Salinity (electrical conductivity)
  - Total C, Organic C, and Carbonate C
- Classified according to Soil Taxonomy
- ^{14}C dates obtained from 5 buried organic horizons

Morphological / Characterization Data Issues

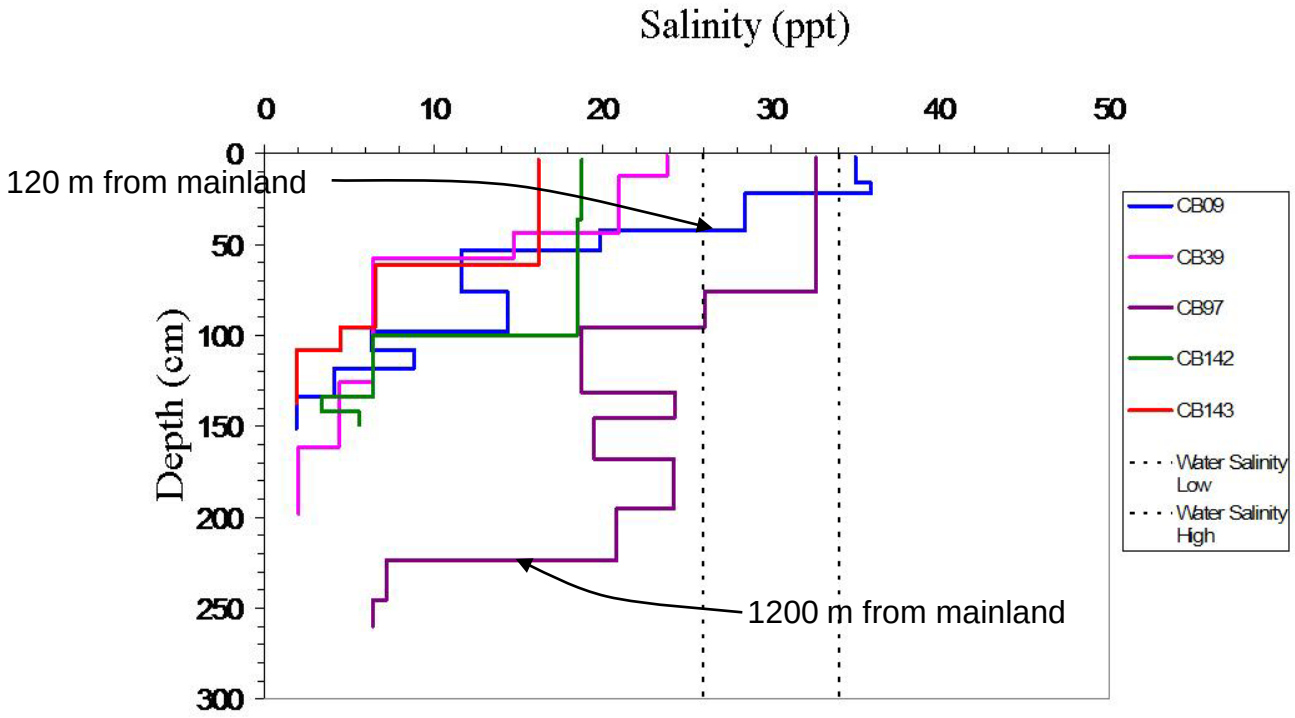
- Field estimates of soil texture
  - Sandy soils pretty good (more fine sands)
  - Finer textures – tendency to overestimate clay
- Field estimates of *n*-value
  - Field estimates useful
  - Lab calculations meaningless
- Moist incubation pH
  - Allow incubation for longer than 8 weeks

Porewater Salinity – Soils near the barrier island



- **Storm-surge washover fan flats** (CB01 and CB56),
- **Barrier coves** (CB10),
- **Lagoon bottom** (CB18 and CB79).
- No salinity trend with depth
- No decrease below 20 ppt
- Dashed lines show salinity range of Chincoteague Bay.

Porewater Salinity - Soils near the mainland



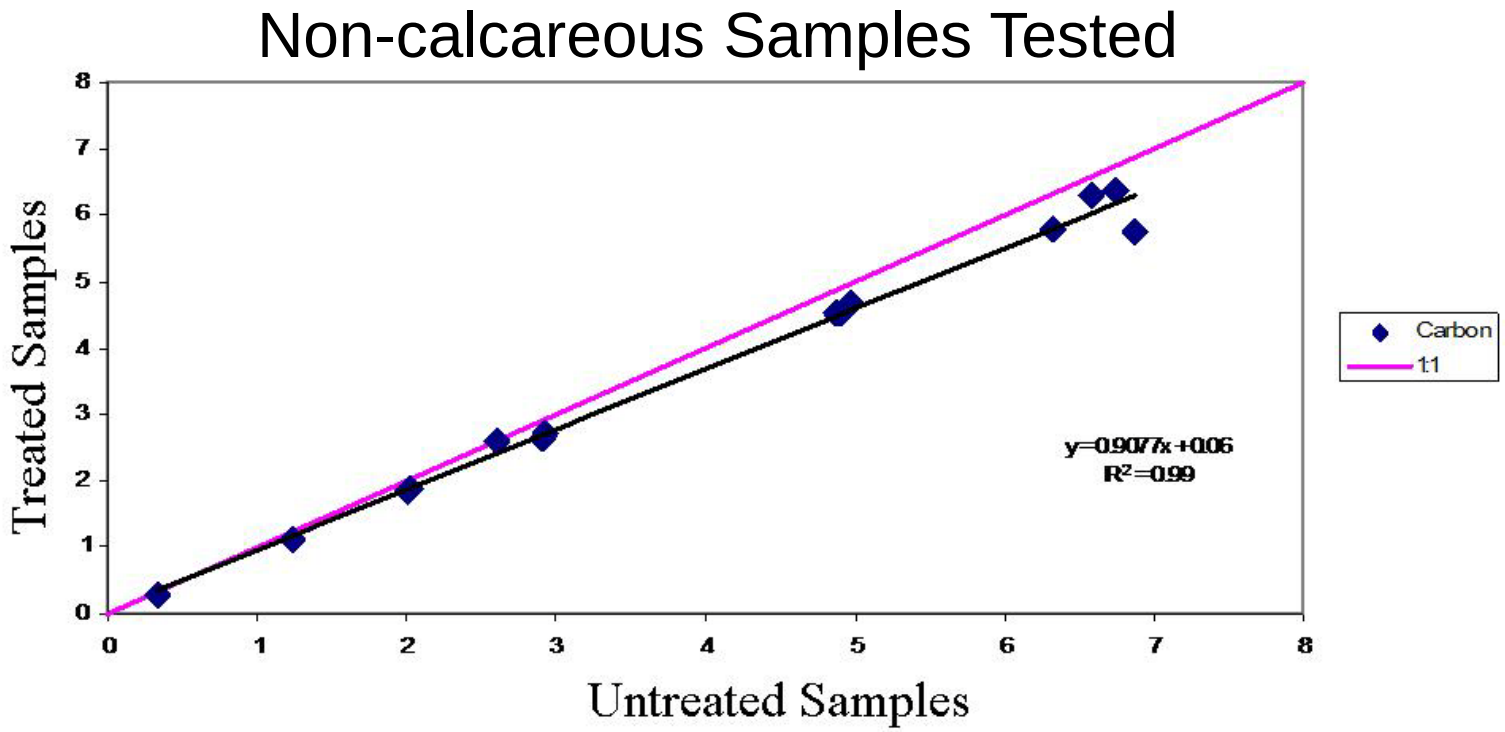
- Salinity near the surface approached that of the overlying bay water
- Decreases with depth - attributed to groundwater influx
- Dashed lines represent the salinity range found within Chincoteague Bay.

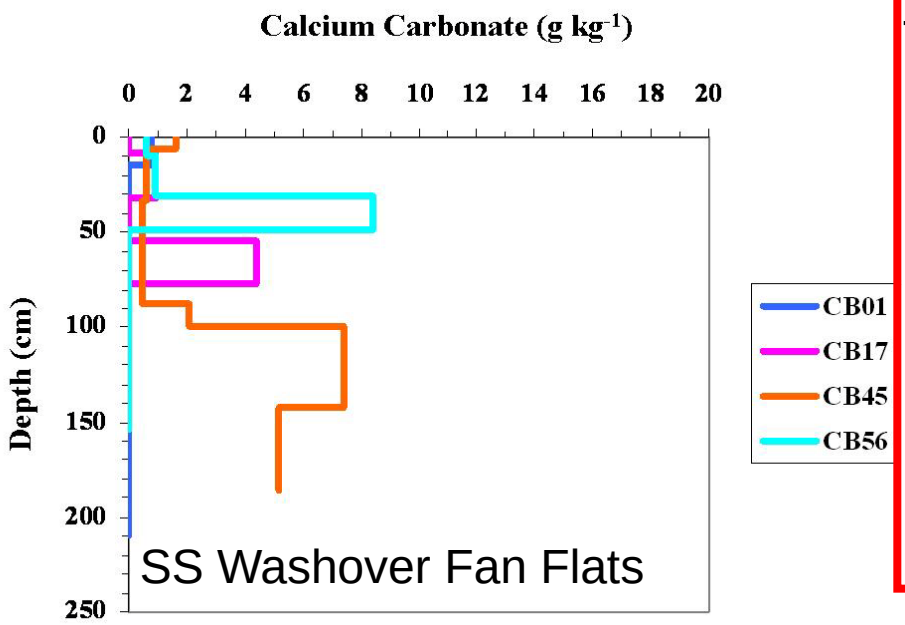
Calcium carbonate determinations

- Low carbonate and moderate OC levels
- Standard Method
  - Treat samples with with 5% sulfurous acid to dissolve carbonates
  - Then run untreated and treated samples through high temperature (950C) combustion furnace
    - Untreated samples = total Carbon (IC and OC)
    - Treated samples = OC
    - Difference = IC

Calcium carbonate determinations

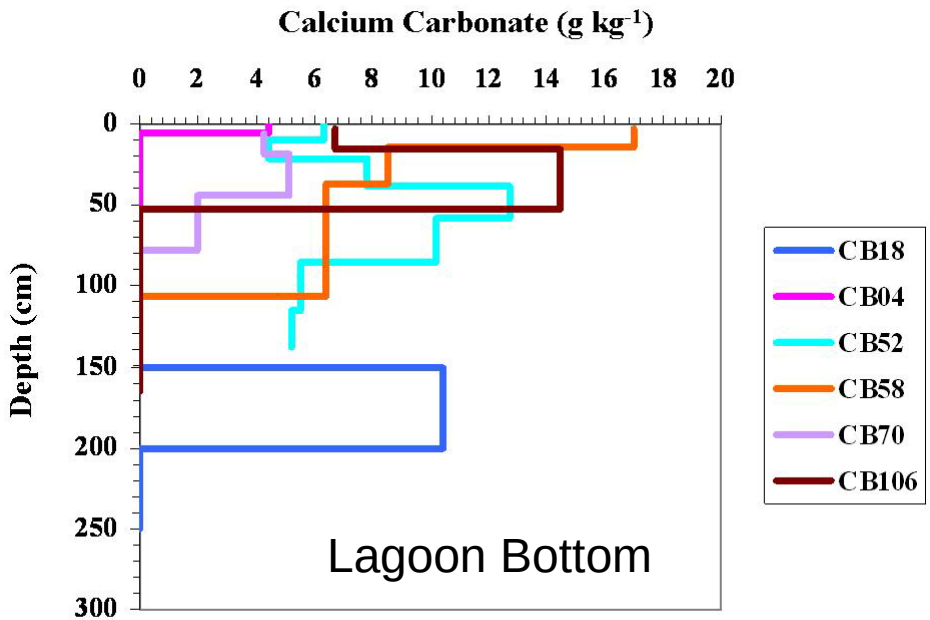
- **Problem with the method!**
- Some (approx 7%) of OC was oxidized by sulfurous acid
- Led to overestimation of carbonates
- Can be serious if carbonates are low and OC moderate

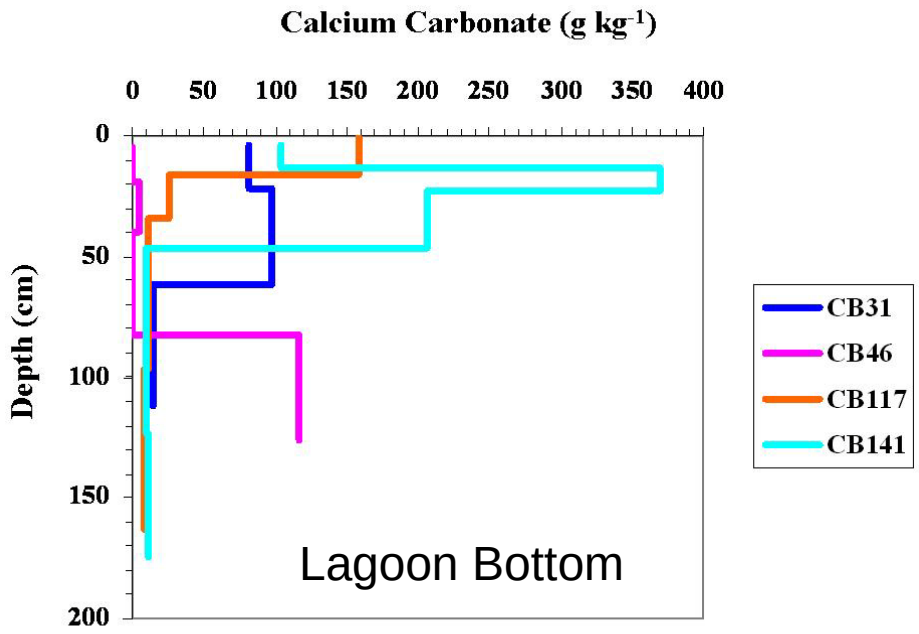




Theoretical Contribution of OC to $CaCO_3$

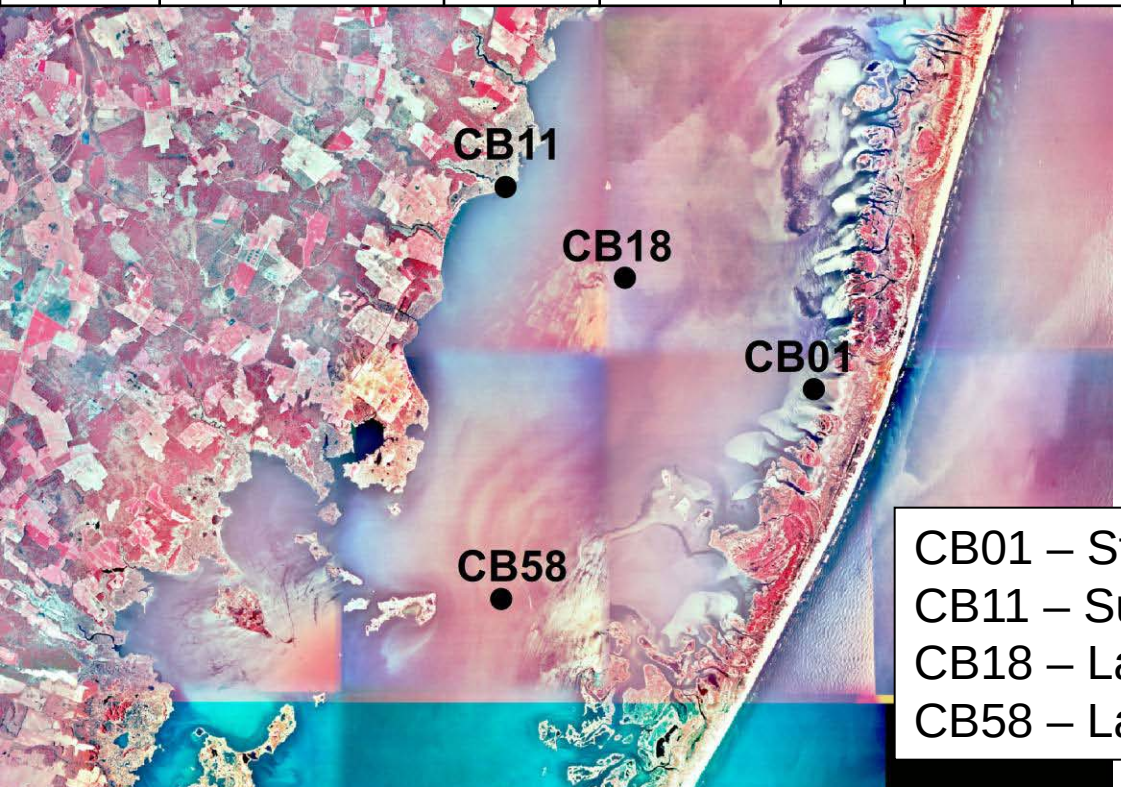
% OC	7% of OC	equiv of % CaCO3	g/kg CaCO3
0.2	0.014	0.1	**1.2**
0.5	0.035	0.3	**2.9**
1	0.070	0.6	**5.8**
1.5	0.105	0.9	**8.8**
2	0.140	1.2	**11.7**
2.5	0.175	1.5	**14.6**





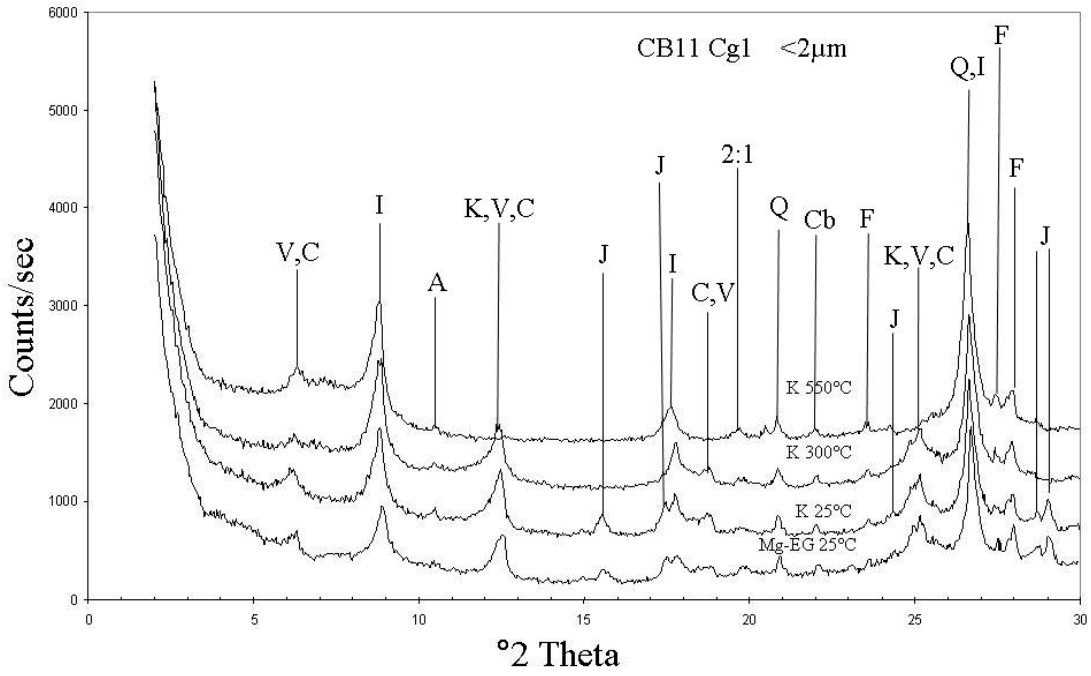
Mineralogy of Selected Pedons

Sample	Control Section	Quartz	Feldspar	Mica	Opaque	Garnet	Amphibole	Diatoms/Sponge Spicules	Other
		----------%---------- (0.020 – 2 mm fraction)							
CB01	25-100 cm	**91.8**	5.8	0.0	1.7	0.3	0.0	0.0	0.3
CB11	25-56 cm	**66.5**	27.7	0.9	1.6	0.0	2.4	0.8	0.0
CB18	25-100 cm	**54.5**	29.5	4.0	1.7	0.0	10.0	0.2	0.0
CB58	25-100 cm	**59.0**	29.6	3.5	0.6	0.0	7.0	0.3	0.0



CB01 – Storm-surge Washover Fan Flat
CB11 – Submerged Wave-cut Headland
CB18 – Lagoon Bottom
CB58 – Lagoon Bottom

Clay Mineralogy <2 um



Sample	Quartz	Illite	Chlorite	Vermiculite	Kaolinite	Feldspars	Amphiboles	Cristobalite	Jarosite
CB11 Cg1, 12-36 cm	XX†	XXX	XX	X	XX	X	x	x	x
CB11 Cg2, 36-56 cm	XX	XXX	XX	X	XX	X	x	x	x
CB18 Cg, 8-50 cm	XX	XXX	XX	X	XX	X	x	x	
CB18 Cg, 50-100 cm	XX	XXX	XX	X	XX	X	x	x	
CB58 Cg1, 14-37 cm	XX	XXX	XX	X	XX	X	x	x	
CB58 Cg2, 37-106 cm	XX	XXX	XX	X	XX	X	x	x	

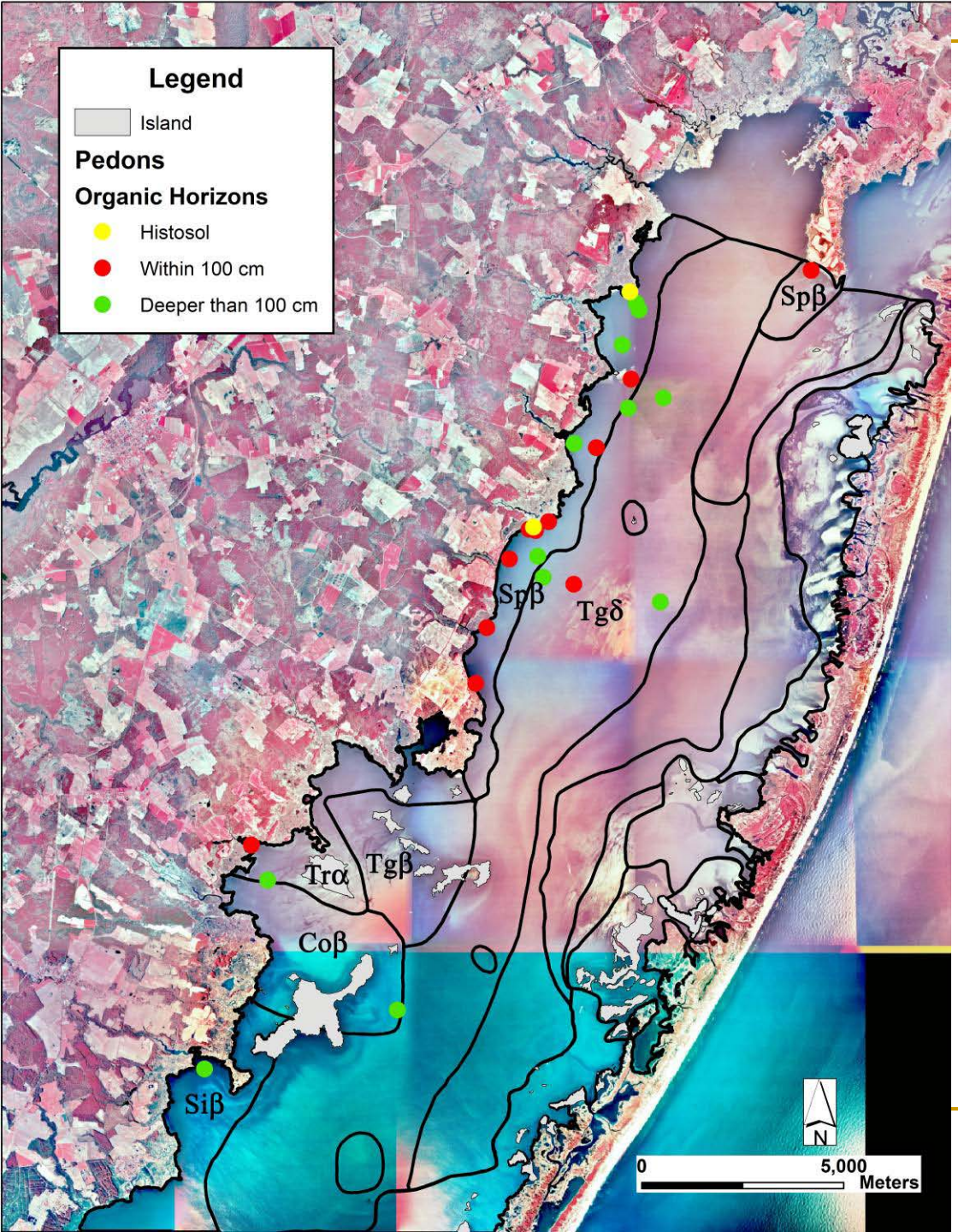
† x: 0-5%; X: 5-10%; XX: 10-30%; XXX: 30-70%; and XXXX: >70%.

Classification of CB Soils

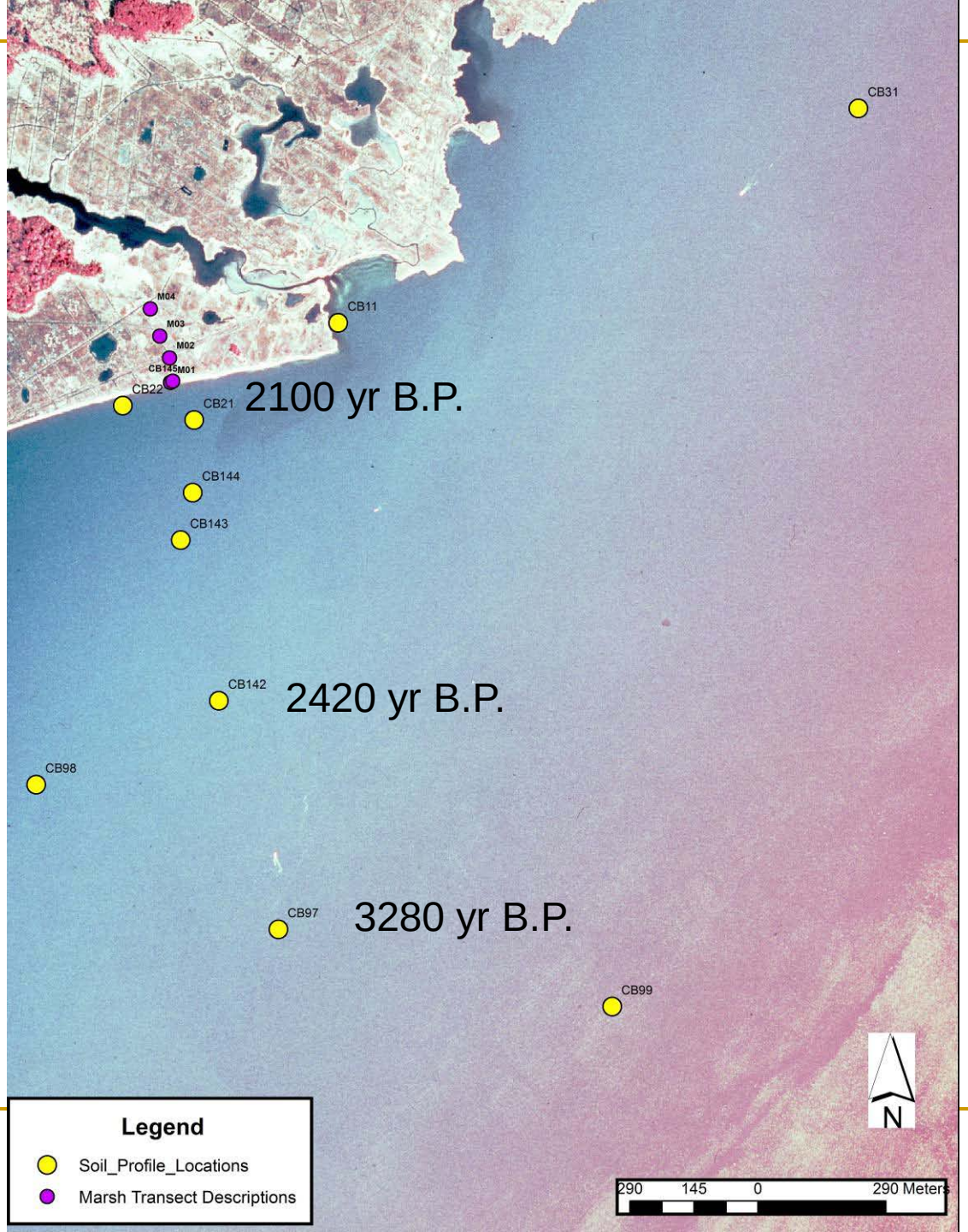
Order	Suborder	Great Group	Subgroup†	Family (PS) Class
Histosols (2)	Wassists (2)	Sulfiwassists (2)	**Sapric Sulfiwassists (2)**	
Entisols (144)	Wassents (144)	1. Psammowassents (20)	**1. Sulfic Psammowassents (20)**	
		2. Sulfiwassents (124)	**1. Haplic Sulfiwassents (26)**	1. Sandy, Haplic Sulfiwassents (10) 2. Sandy over loamy, Haplic Sulfiwassents (1) 3. Coarse-loamy, Haplic Sulfiwassents (13) 4. Fine-loamy, Haplic Sulfiwassents (2) 5. Fine, Haplic Sulfiwassents (1)
			2. Thapto-histic Sulfiwassents (6)	1. Coarse-silty, Thapto-histic Sulfiwassents (1) 2. Fine-loamy, Thapto-histic Sulfiwassents (2) 3. Fine-silty, Thapto-histic Sulfiwassents (2) 4. Fine, Thapto-histic Sulfiwassents (1)
			3. Aeric Sulfiwassents (2)	1. Coarse-loamy, Aeric Sulfiwassents (2)
			4. Fluventic Sulfiwassents (88) THESE ARE THE TYPICAL ONES!	1. Coarse-loamy, Fluventic Sulfiwassents (4) 2. Fine-loamy, Fluventic Sulfiwassents (9) 3. Fine-silty, Fluventic Sulfiwassents (74) 4. Fine, Fluvic Sulfiwassents (1)
		3. Hydrowassents (1)	**1. Sulfic Hydrowassents (1)**	1. Coarse-silty, Sulfic Hydrowassents (1)

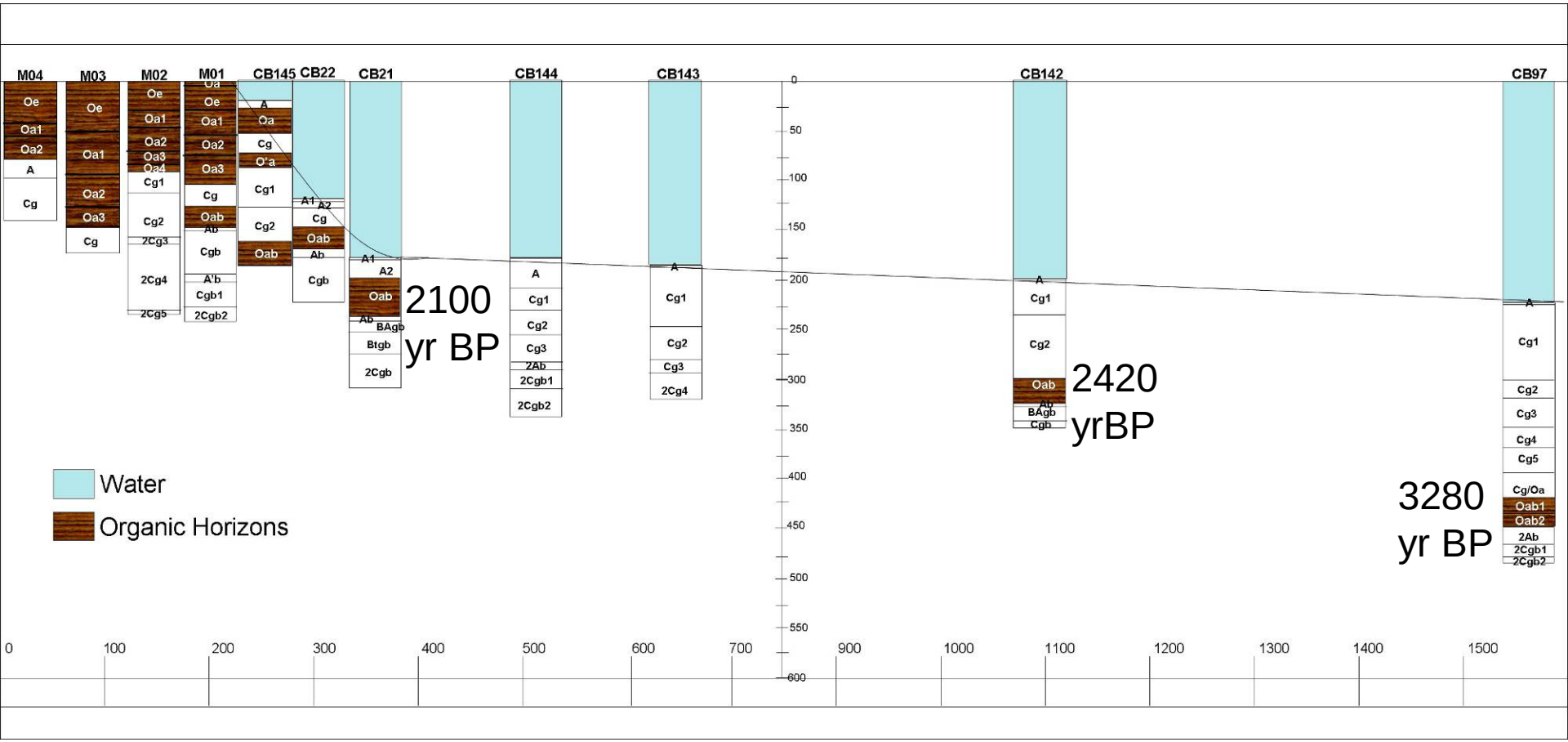
Eight new series proposed for use in CB

Soil Series Name	Soil Classification
Truitt	Fine-silty, mixed, active, nonacid, mesic Fluventic Sulfiwassents
Tingles	Fine-silty, mixed, active, nonacid, mesic Fluventic Sulfiwassents
Cottman	Coarse-loamy, mixed, active, nonacid, mesic Haplic Sulfiwassents
Figgs	Fine-loamy, mixed, active, nonacid, mesic Fluventic Sulfiwassents
Tumagan	Sapric Sulfiwassists
Middlemoor	Fine-silty, mixed, active, nonacid, mesic Fluventic Sulfiwassents
Coards	Fine-silty, mixed, active, nonacid, mesic Fluventic Sulfiwassents
Thorofare	Sandy, mixed, nonacid, mesic Haplic Sulfiwassents



Presence of buried organic horizons

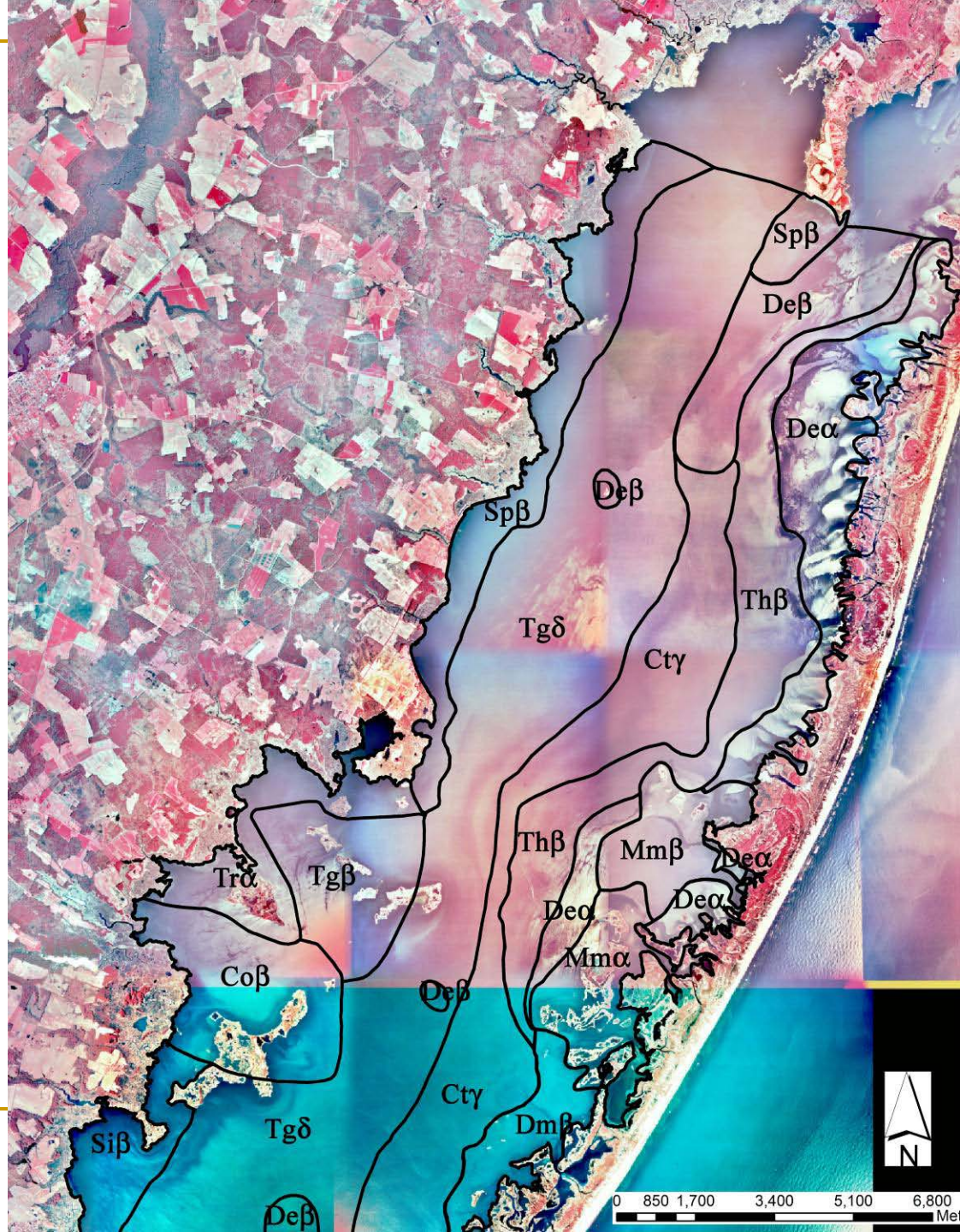

CB31
M04
M03
M02
CB145
M01
CB11
CB22
CB21
2100 yr B.P.
CB144
CB143
CB142
2420 yr B.P.
CB98
CB97
3280 yr B.P.
CB99
Legend
Soil_Profile_Locations
Marsh Transect Descriptions
N
290 145 0 290 Meters

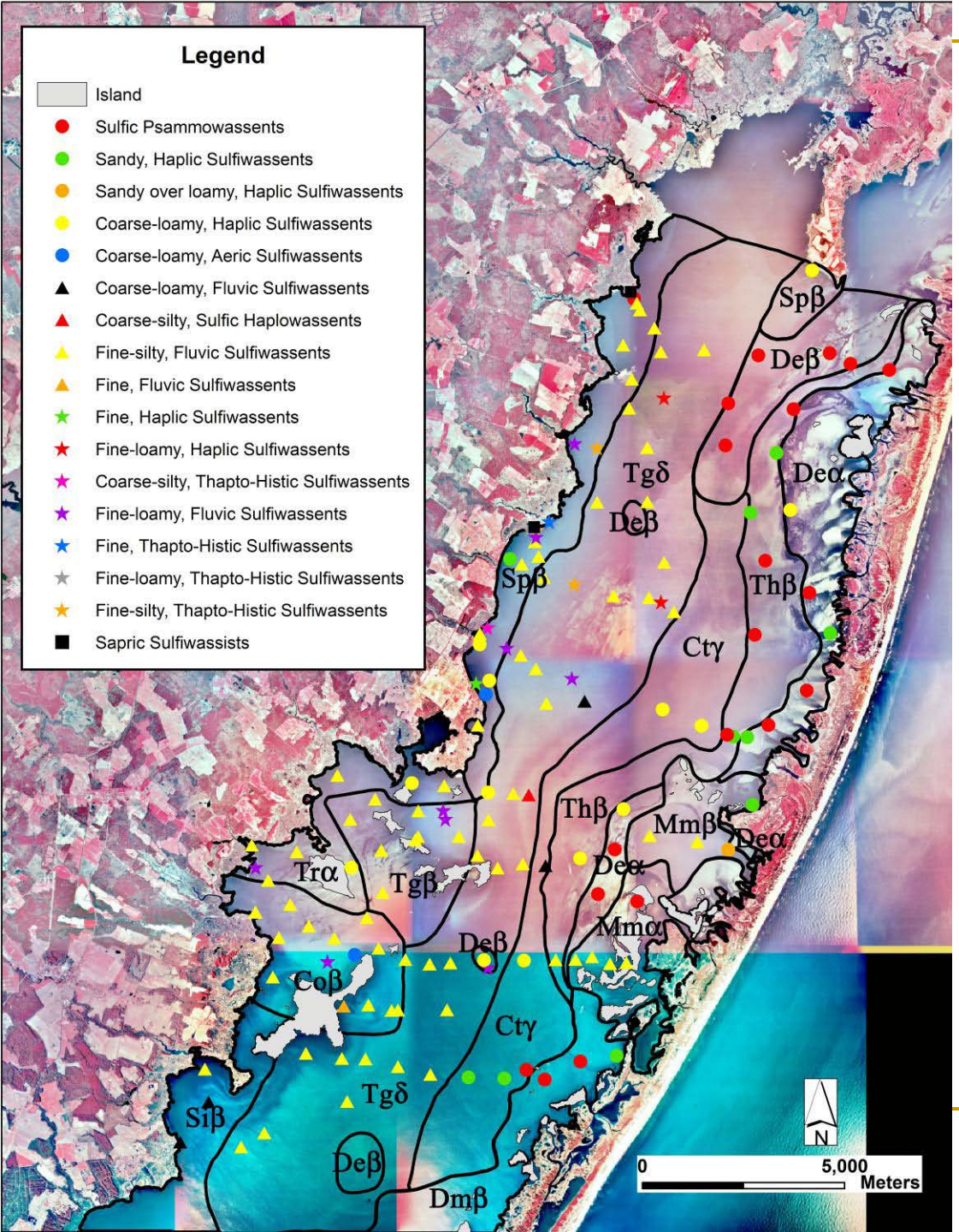


Long-Term Average Sea Level Rise: 1.25 mm yr^{-1}

Soil Map

- 13 Soil Map Units
- Map Unit Symbol
  - Series
  - Water Depth




Legend
Island
Sulfic Psammowassents
Sandy, Haplic Sulfiwassents
Sandy over loamy, Haplic Sulfiwassents
Coarse-loamy, Haplic Sulfiwassents
Coarse-loamy, Aeric Sulfiwassents
Coarse-loamy, Fluvic Sulfiwassents
Coarse-silty, Sulfic Haplowassents
Fine-silty, Fluvic Sulfiwassents
Fine, Fluvic Sulfiwassents
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Fine-loamy, Fluvic Sulfiwassents
Fine, Thapto-Histic Sulfiwassents
Fine-loamy, Thapto-Histic Sulfiwassents
Fine-silty, Thapto-Histic Sulfiwassents
Sapric Sulfiwassists
Spβ
Deβ
Deα
Tgδ
Deβ
Spβ
Thβ
Ctγ
Thβ
Mmβ
Deα
Deα
Trα
Tgβ
Mmα
Deβ
Coβ
Ctγ
Tgδ
Siβ
Deβ
Dmβ
N
0
5,000
Meters

Composition of Map Units Evaluated

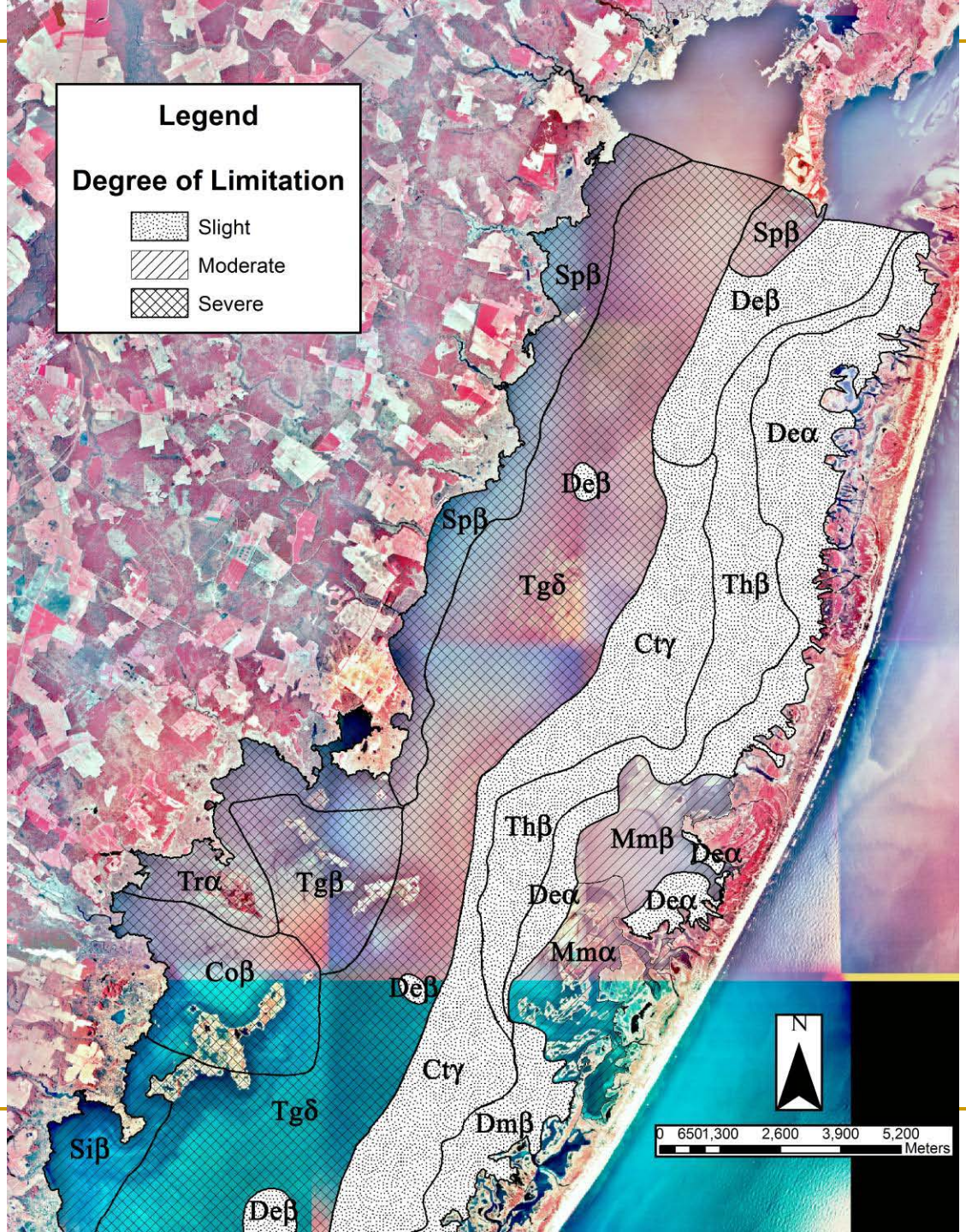
Map Unit	# Profiles (Total)	Series	# Observations (percentage)
Coβ	15	Coards† Tingles† Figgs Truitt Unnamed C	11 (72%) 1 (7%) 1 (7%) 1 (7%) 1 (7%)
Ctγ	7	Cottman† Thorofare† Demas† Sinepuxent	3 (43%) 2 (29%) 1 (14%) 1 (14%)
Deα	10	Demas† Thorofare† Cottman† Tizzard	5 (50%) 2 (20%) 2 (20%) 1 (10%)

Use of SAS Data for SAV Habitat Assessment

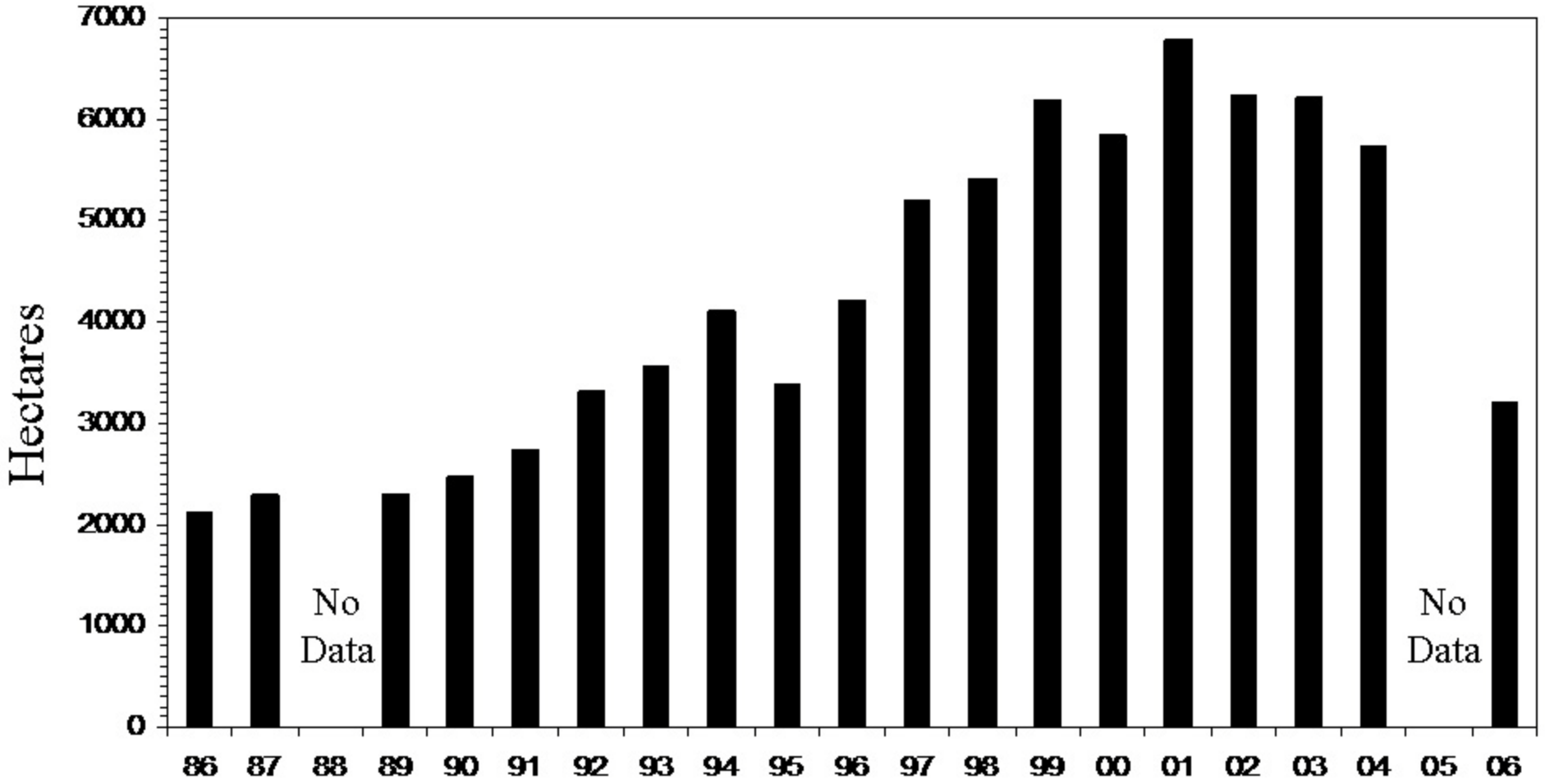
- Soil Properties used to determine suitability for SAV
- (from an examination of the published literature)
  - Sediment sulfide concentration
    - Favorable – < 5 g kg^{-1}
    - Strongly Detrimental – > 5 g kg^{-1}
  - Organic carbon content
    - Favorable – < 30 g kg^{-1}
    - Mildly Detrimental – 30 to 70 g kg^{-1}
    - Strongly Detrimental – > 70 g kg^{-1}
  - Texture
    - Favorable – S or LS (< 20% silt and clay)
    - Mildly Detrimental – SL, SCL, or L (20 to 50% silt and clay)
    - Strongly Detrimental – SiL, SiCL, CL, SiC, C (>50% silt and clay)

Favorable and Limiting Characteristics (example below – done for each Map Unit)

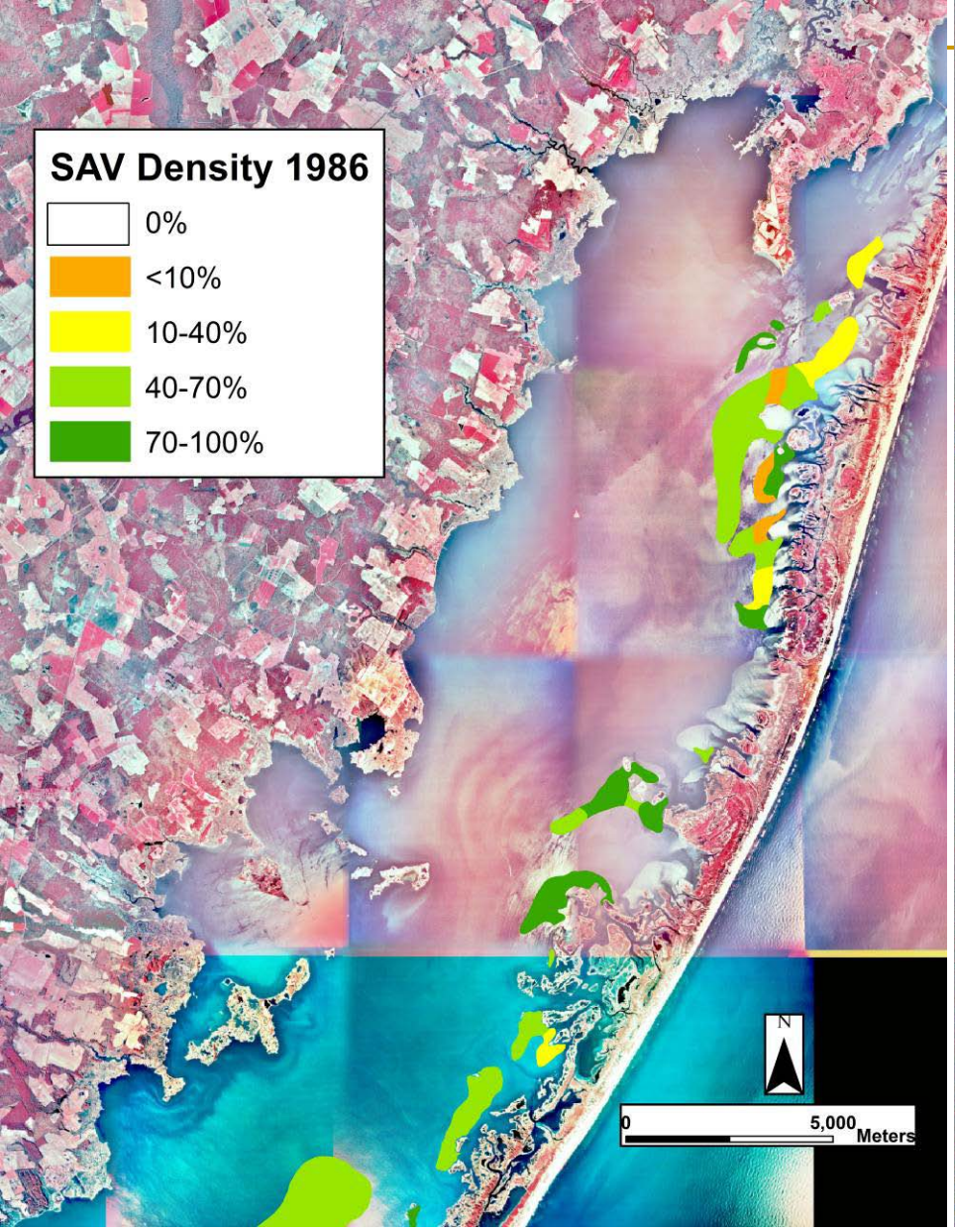
Soil Map Unit	Favorable Properties	Potentially Limiting Properties	Overall Rating
Coβ	Organic Carbon content 9.0-21.0 g/kg	High levels of sulfides, SiCL or CL textures	**Severe**
Deα	Organic Carbon content 0.4-2.7 g/kg, low levels of sulfides (0.07 to 0.32 g/kg), sandy textures		**Slight**

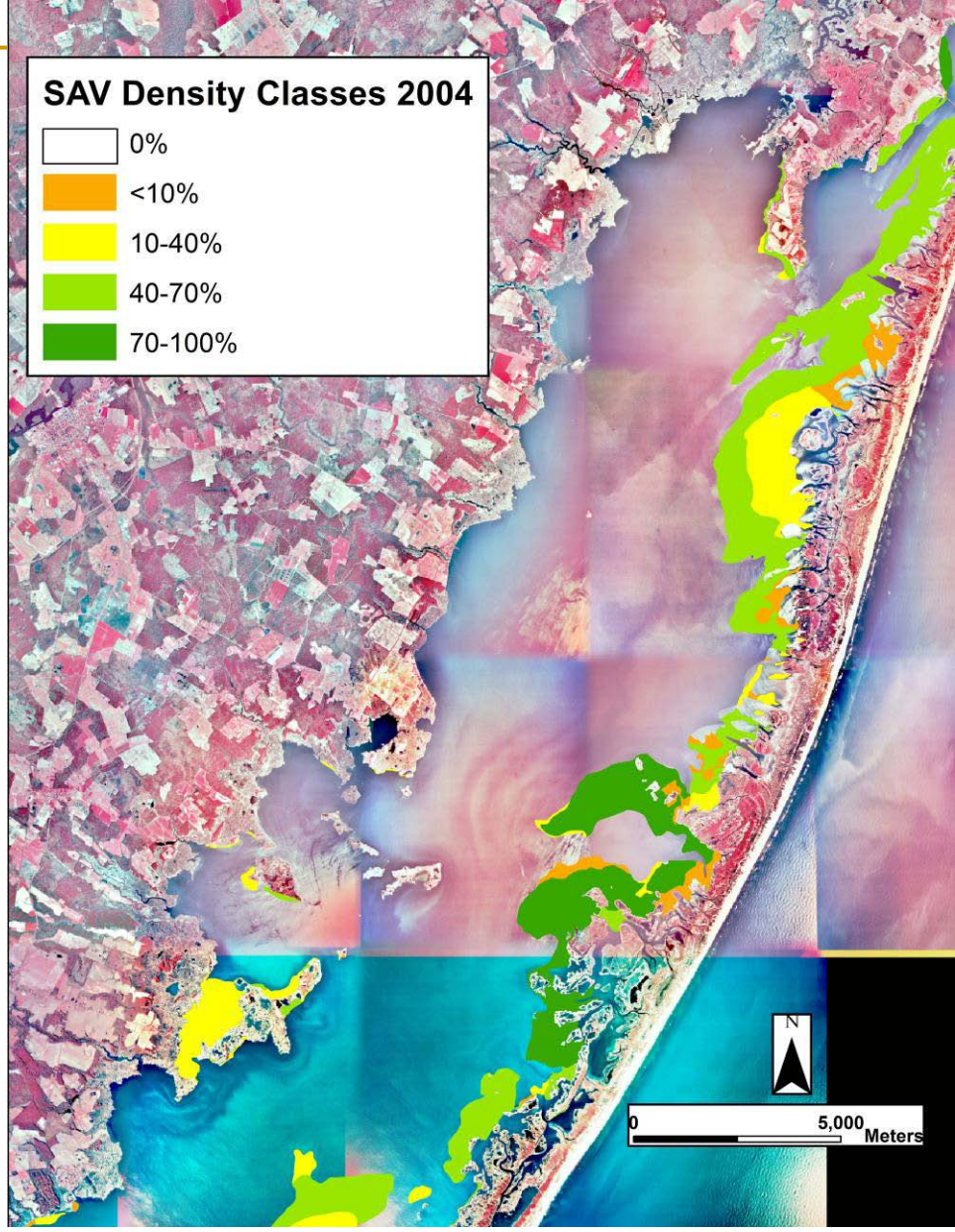

Legend
Degree of Limitation
Slight
Moderate
Severe
Spβ
Deβ
Deα
Tgδ
Thβ
Ctγ
Mmβ
Mmα
Trα
Tgβ
Coβ
Siβ
Dmβ
N
0 6501,300 2,600 3,900 5,200
Meters

SAV Areal Coverage in CB



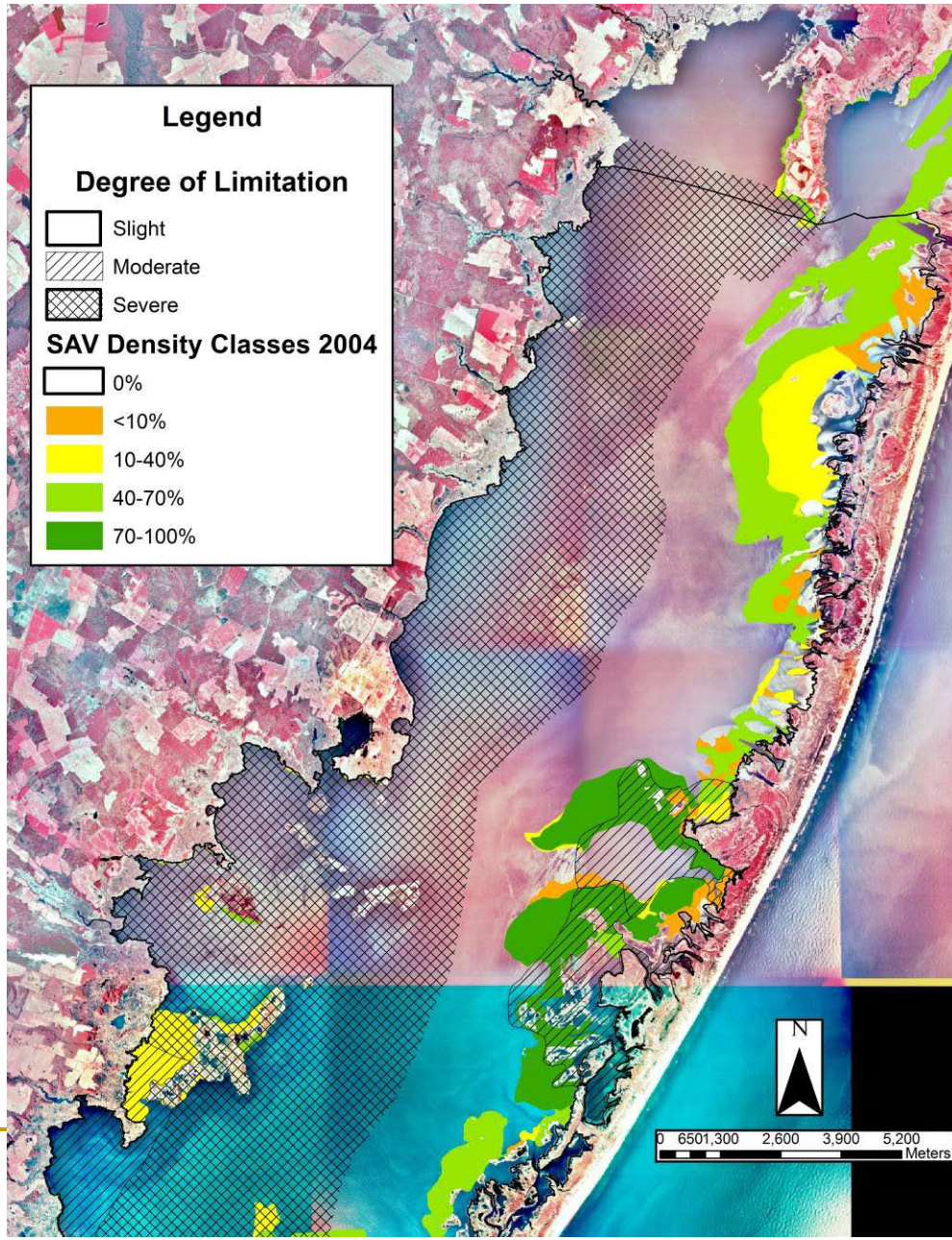
VIMS Data


SAV Density 1986
0%
<10%
10-40%
40-70%
70-100%
N
0
5,000
Meters

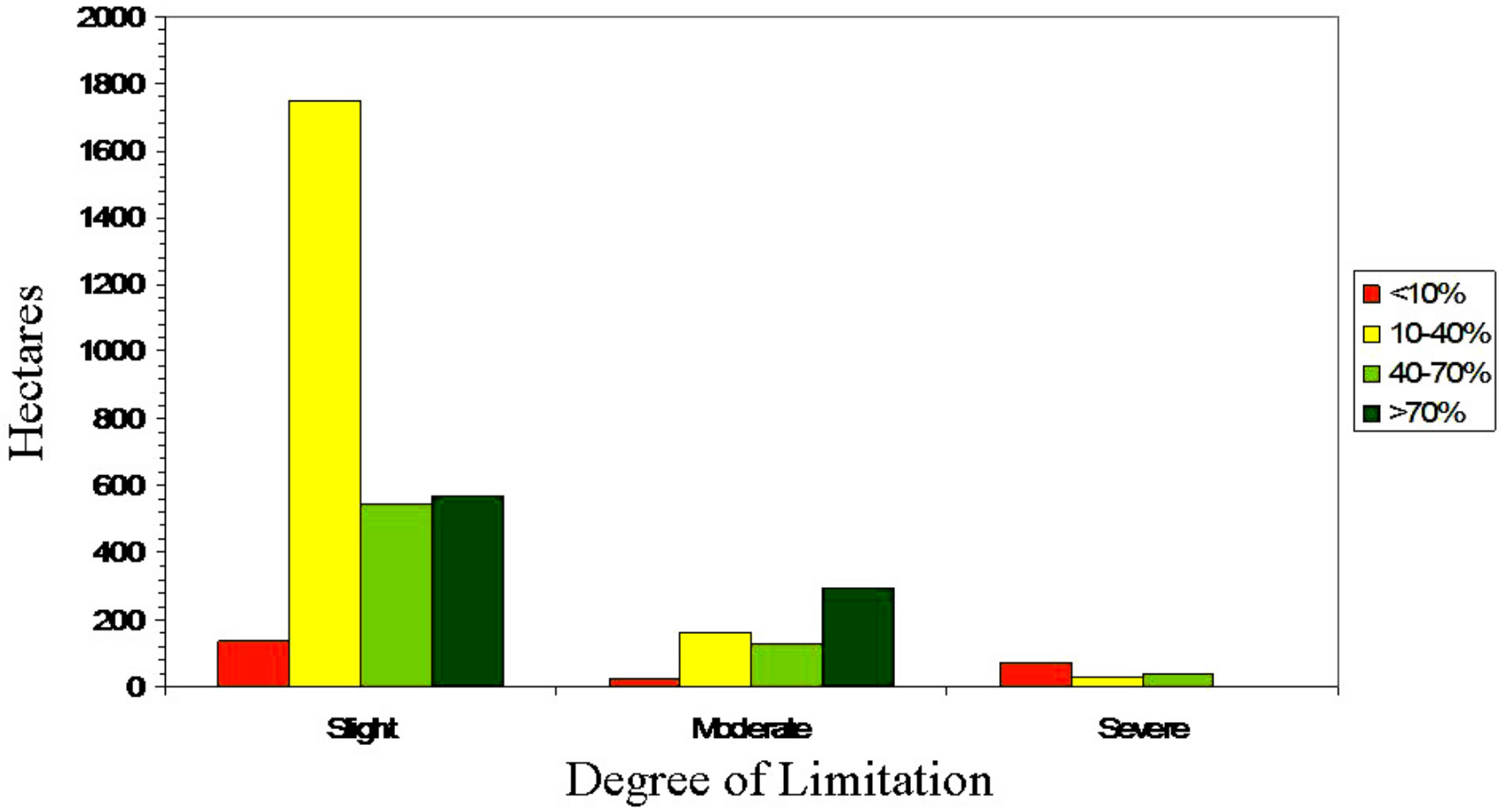

SAV Density Classes 2004
0%
<10%
10-40%
40-70%
70-100%
N
0
5,000
Meters

Suitability Map

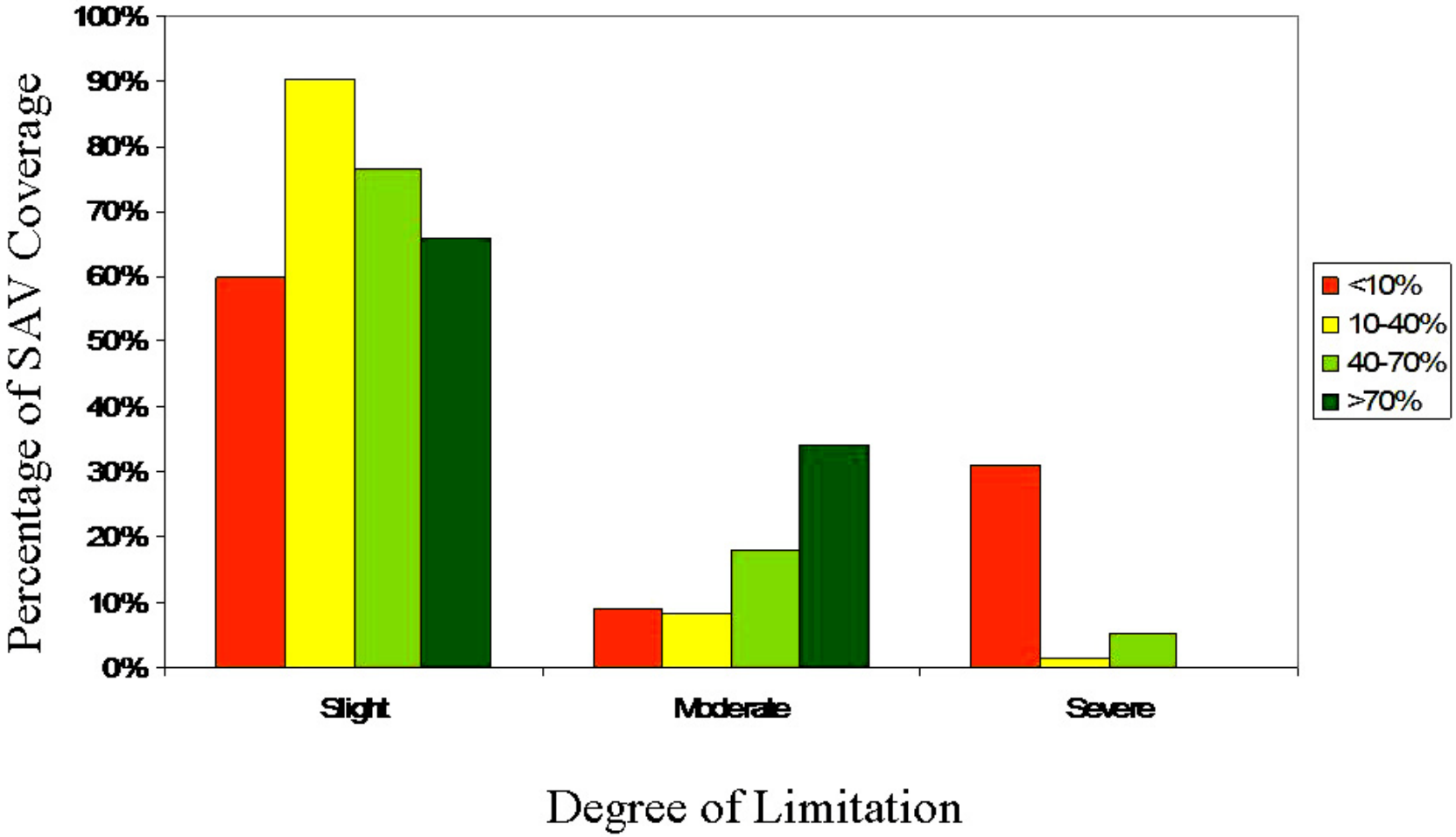
- Tested based on past and present SAV growth patterns in Chincoteague Bay based on data sets provided by VIMS
- Used 2004 VIMS data and compared it to our suitability map



Total Hectares of SAV within Suitability Classes



Percentage of SAV for each Suitability Class



Conclusions of SAV Suitability Assessment

- The greatest proportion of SAV occurs on soils with slight limitations
- Our assessment based on the soil characteristics seemed to accurately reflect the SAV distribution in Chincoteague Bay
- The soils that were well suited for SAV growth and success include
  - Demas soil series
  - Thorofare soil series
  - Cottman soil series
  - Tizzard soil series
- Other factors
  - Water depth, light pentration

Summary

- Using available (tested) bathymetry, a DEM was created.
- Subaqueous landforms were identified using all available information
- Morphological and characterization data were collected for soils within various landforms and landscape units
- Available subaqueous soil-landscape models for coastal lagoons were tested, applied and enhanced
- Eight new soil series were proposed
- A comprehensive soil resource inventory for Chincoteague Bay was developed
- The application of subaqueous soils data for the restoration of SAV was tested for CB

Conclusions

- The information collected during this study enriched the data set available on subaqueous soils at that time, and highlighted the importance of using subaqueous soil data in ecological studies
- This data set is now available for use in conjunction with other ecological studies for such purposes as identifying premium restoration sites for benthic flora and fauna and locating areas that are able to support engineering structures, etc.