Halinity in Coastal Soils

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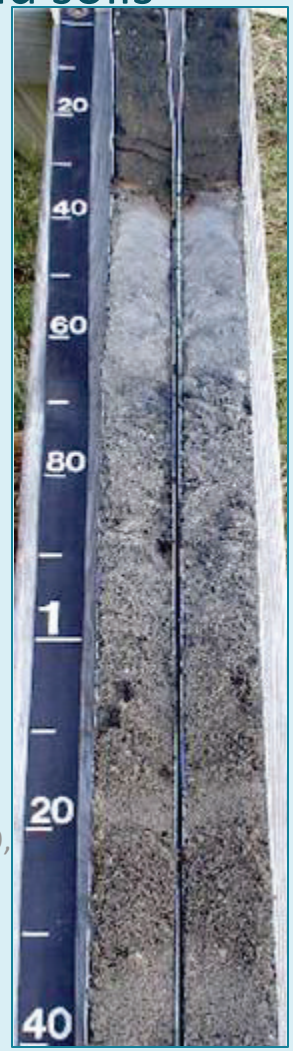
Problem

- NRCS needs to clearly identify soils influenced by ocean derived salts
- Previously, saline soils (result of irrigation) raised concern for land productivity. NRCS salinity classes developed to classify these arid soils based on productivity/ lack thereof:

Salinity Class	Electrical Conductivity (mmhos cm^{-1})
Nonsaline	0 to <2
Very slightly saline	2 to <4
Slightly saline	4 to <8
Moderately saline	8 to <16
Strongly saline	≥16

(Soil Survey Staff 1993, 2012)

- Soil mapping by the NRCS in RI and CT has shown that coastal soils require different salinity interpretations
- Interpretations: shellfish productivity, eelgrass restoration/ aquatic habitat, heavy metal content potential, mooring sites, use of dredged material explored by NRCS staff and URI (Salisbury2009, Surabian 2007, Bradley 2006, Erich et al 2010)
- Research resulted in salinity/conductivity data



Problem

- What is “low salt”?
- What other breaks do we need?

98	Westbrook mucky peat
99	Westbrook mucky peat, low salt

Current Salinity and Halinity Classes

- Halinity classes established by other agencies for other uses
  - ex) 1979 USFWS created "Classification of Wetlands and Deepwater Habitats of the US" for ecological classification

Coastal Modifiers[a]	Inland Modifiers[b]	Salinity (parts per thousand)	Approximate Specific conductance (µMhos at 25°C)
Hyperhaline	Hypersaline	>40	>60,000
Euhaline	Eusaline	30.0-40	45,000-60,000
Mixohaline (Brackish)	Mixosaline[c]	0.5-30	800-45,000
Polyhaline	Polysaline	18.0-30	30,000-45,000
Mesohaline	Mesosaline	5.0-18	8,000-30,000
Oligohaline	Oligosaline	0.5-5	800-8,000
Fresh	Fresh	<0.5	<800

[a] Coastal Modifiers are used in the Marine and Estruarine Systems.
[b] Inland Modifiers are used in the Riverine, Lacustrine, and Palustrine Systems.
[c] The term Brackish should not be used for inland wetlands or deepwater habitats.

- The salinity of inland water made of:
  - Cations- Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}
  - Anions- CO_3^{2-}, SO_4^{2-}, Cl^{-}
- Note: '**halinity**' is used in ocean affected wetlands because dominant anions in sea are **halides**- (mostly NaCl)

(Cowardin, et. al 1979)

Significance

Wassents

Key to Great Groups

LAA. Wassents that have, in all horizons within 100 cm of the mineral soil surface, an electrical conductivity of less than 0.2 dS/m in a 5:1, by volume, mixture (not extract) of water and soil.

Frasiwassents, p. 142

- Soil halinity determined by flooding frequency; reflected in species diversity
- Tides deliver salts, sediment, O_2, and OM
- Additional energy creates marsh productivity of up to 1000 g/m^2 →ultimately *feeds shellfish and finfish* (Warren and Fell 1995)
- NRCS currently uses 0.2 dS/m to break between fresh (*frasi*) and other subaqueous soils (Soil Survey Staff 2010)

Study Area

Relatively flat coastal lowland consisting of marine and alluvial deposits, organic peat, glacial outwash and till materials

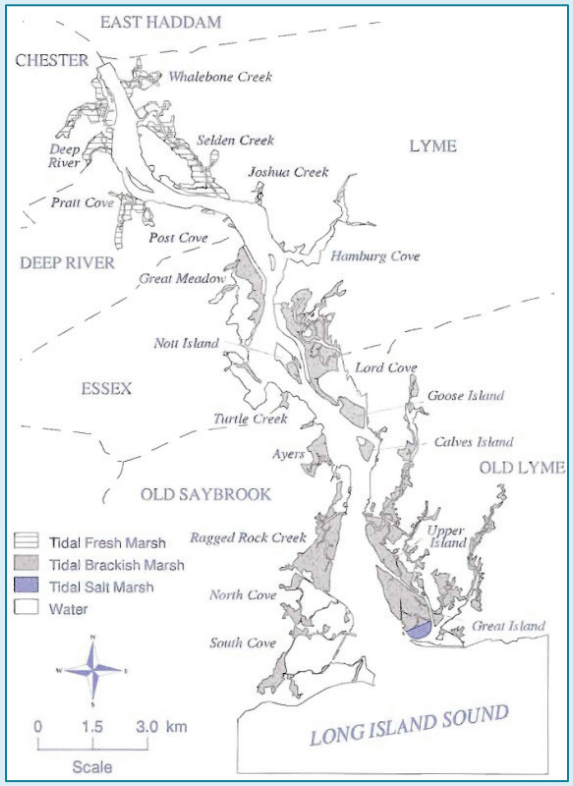


Image source: Warren and Fell 1995

Soils: Pacatuck, Westbrook, Ipswich, Sandyhook, and Matunuck and subaqueous soils

Soils formed as drowned coastline as sea level rise occurred after last continental glacier retreated (Hill and Shearin 1970)

Land uses: combo of preserves (Great Island) and rec areas (boat launches) with intermixed commercial and residential zones

Halinity Classes*

Classes determined by grouping like vegetative communities after preliminary sampling:

*names subject to change

Low Marsh	High Marsh	Back Marsh	Upland Edge	Fresh
Spartina alterniflora	*Spartina patens, Distichlis spicata, & Juncus gerardii*	*Bolboschoenus maritimus & Schoenoplectus robustus*	*Iva frutescens & Panicum virgatum*	*Typha x glauca & Phragmites australis*
smooth cordgrass	saltmeadow cordgrass, saltgrass, blackgrass	salt marsh bullrush	marsh elder, switchgrass	hybrid cattail, common reed

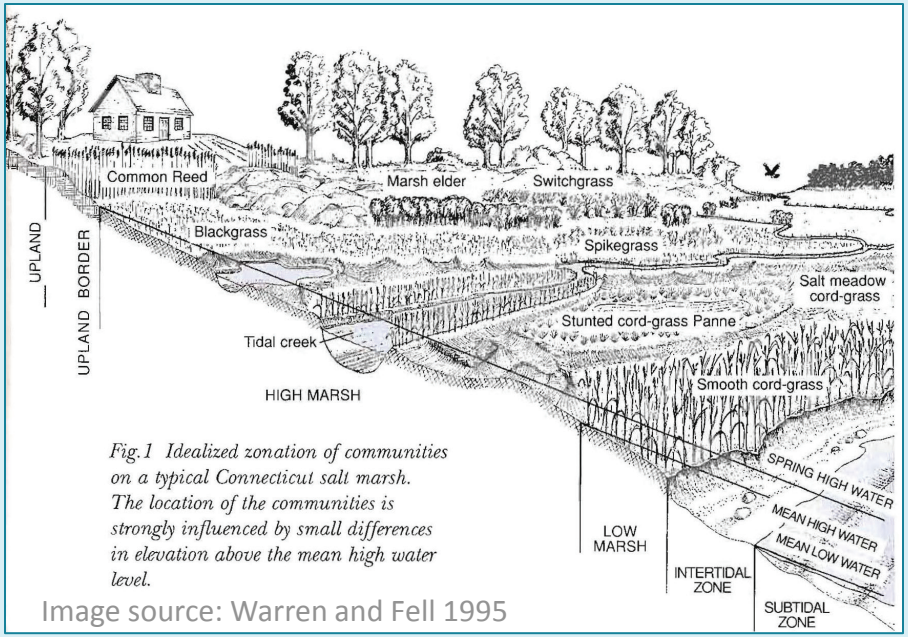


Fig.1 Idealized zonation of communities on a typical Connecticut salt marsh. The location of the communities is strongly influenced by small differences in elevation above the mean high water level.

Image source: Warren and Fell 1995

Methods

Field sampling

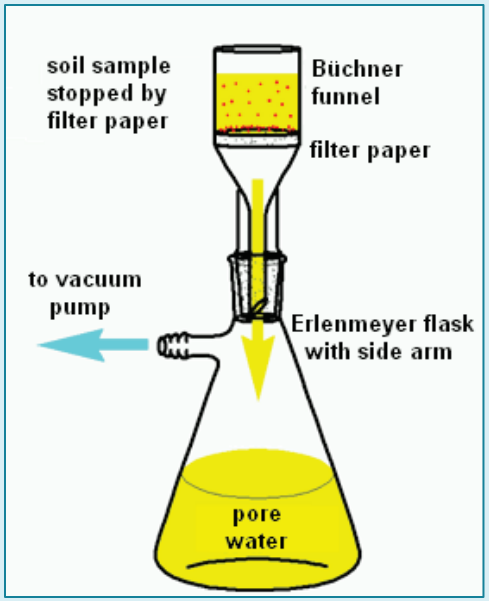
Sampling stratified vertically by soil horizon and across the landscape by preliminary halinity classes

- Hand-dug small pits, bucket augers, Macaulay peat sampler for softer or fluid soils
- Sampled within two hours of low tide of closest NOAA tide predictions (NOAA 2011)
- Locations described, recorded using GPS unit
- Horizons classified and described using standard NCSS procedures (Soil Survey Staff 1993)
  - 1 bulk density
  - 1 grab sample from each to about 1.3 m deep
- Entered into NASIS
- Samples frozen until lab analysis to reduce oxidation

Methods

Lab Work

- Organic samples
  - pH- 0.01 M $CaCl_2$
  - Degree of decomposition- sodium pyrophosphate colors and fiber content
- Mineral samples
  - PSDA
  - Percent organic content- LOI
  - 1:1 pH- equal volume soils and DI
- Bulk densities- dried @ 110°C & weighed
- Conductivity (EC)
  - $EC_{1:5vol}$- one part soil to five parts distilled water
  - $EC_{pore\ water}$- extracted water using vacuum pump
  - EC is the most accurate (±0.0002) way to measure salinity without full chemical analysis (Standard Methods 1999)



Methods described in *Soil Survey Lab Manual*

(Soil Survey Staff 1993)

Methods

Data Analysis

- Sample size was calculated for each halinity class from the preliminary t-score, sample variance, and sample mean

$$n = t^2 * s^2/(avg * 0.15)^2$$

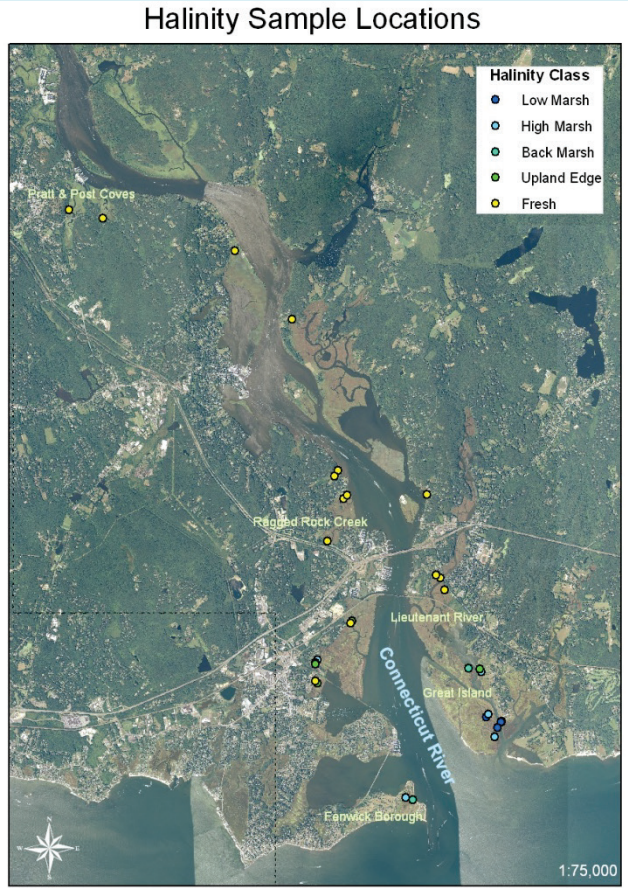
- EC values compared with halinity class using unequal ANOVA (JMP 2007)
- $EC_{1:5vol}$ and $EC_{porewater}$ values compared

Initial Results

- 21 initial sites sampled in fall/winter 2011, plus 14 this spring (180 total samples)
- Not normal distribution- skewed to lower numbers
- Hypothesis: 5 halinity classes are significantly different

$$H_0: mean_1 \neq mean_2 \neq mean_3 \neq mean_4 \neq mean_5$$

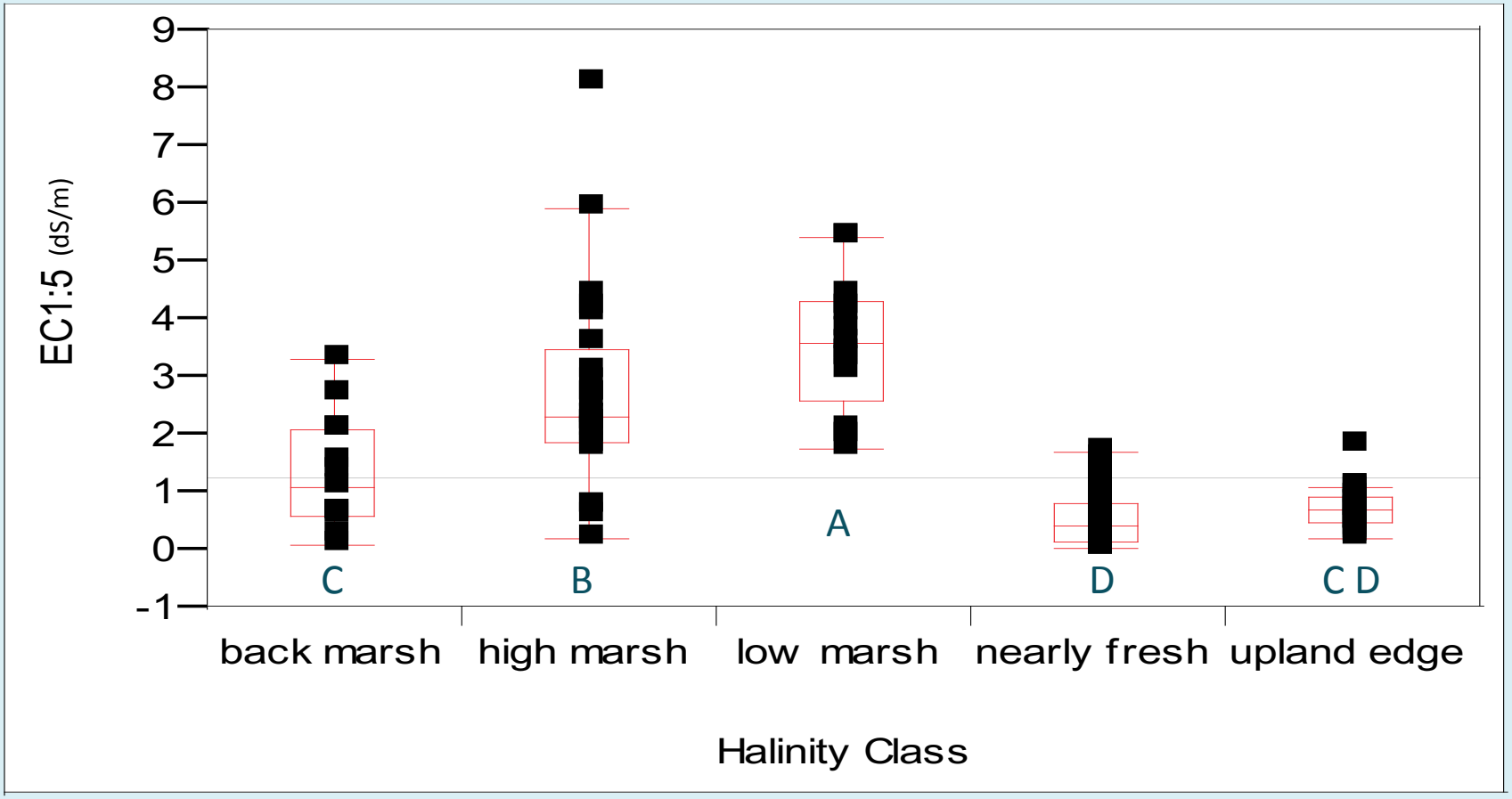
- Log scale no more "normal" fit, and less classes sig. different



$EC_{1:5}$

	Low Marsh	High Marsh	Back Marsh	Upland Edge	Nearly Fresh
	(*S. alterniflora*)	(*S. patens, Distichlis, & Juncus*)	(*Bolbo & Schoen*)	(*Iva & Panicum*)	(*Typha & Phrag*)
n	13	24	13	22	76
Mean	3.58	2.72	1.31	0.71	0.51
Standard Deviation	1.17	1.74	0.99	0.35	0.44
$n_{calculated}$	15	30	46	19	51

Initial Results



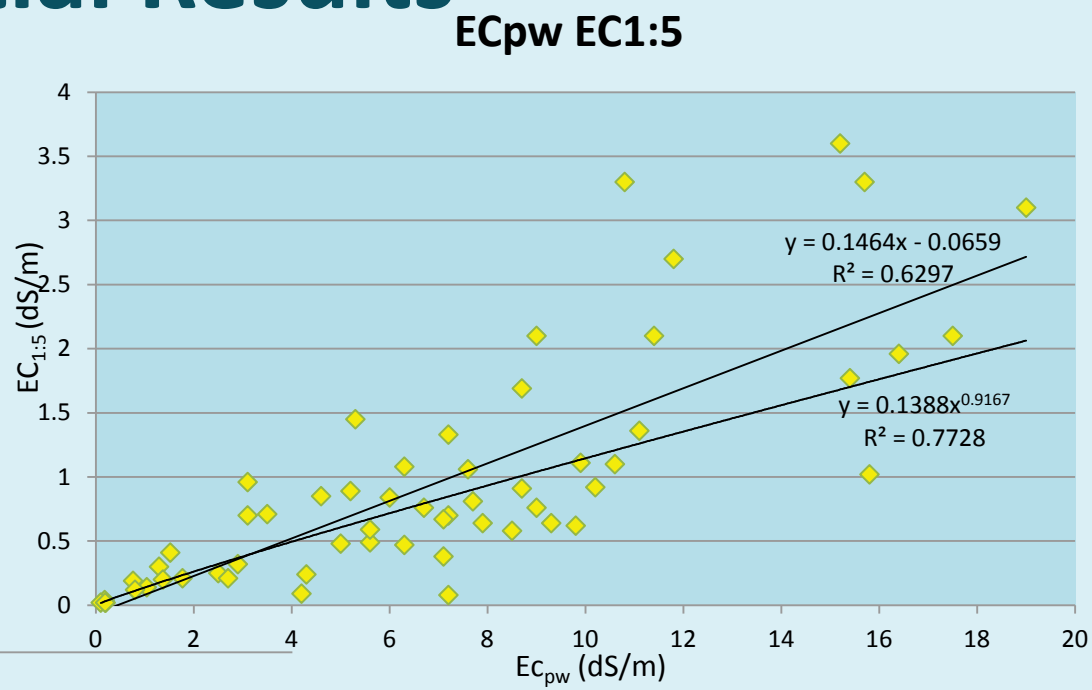
(JMP 2007)

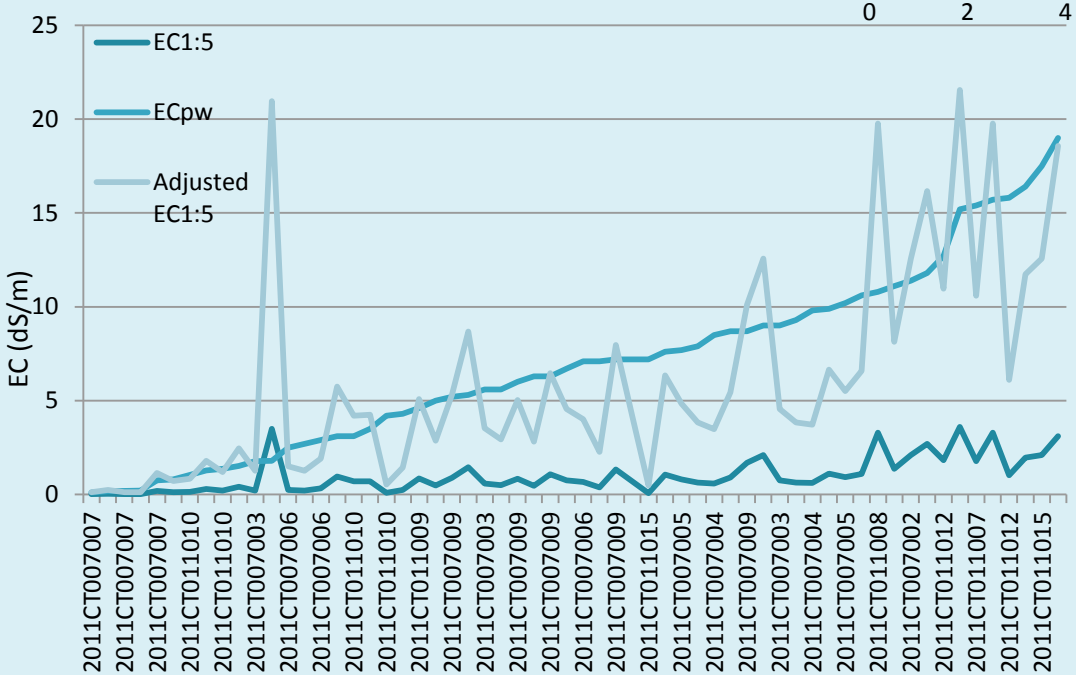
Halinity Class	Low Marsh	High Marsh	Back Marsh	Upland Edge	Nearly Fresh
Level	A	B	C	C D	D
Mean	3.578	2.723	1.307	0.708	0.510

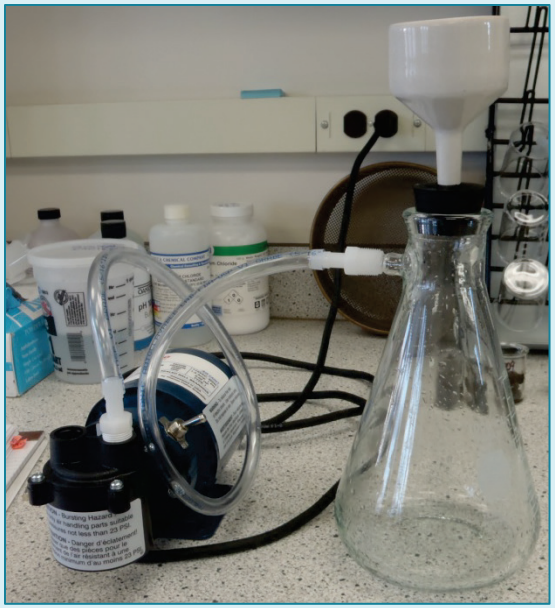
Initial Results

Methods comparison

- Power regression fits better than linear
- Line adjusted 1:5 values for dilution (EC ÷ 0.167)
- Outlier corresponds with graph crossing







Next Steps

- Additional sampling:

low marsh	high marsh	back marsh	upland edge	nearly fresh
3	6	35	0	0

To be within 15% of the mean. This is 44 more samples, or about 8 more sites.

- Reevaluate halinity classes- possibly combine fresh and upland edge; name more appropriately
- Evaluate current salinity ranges of coastal soils

Level					Mean $EC_{1:5}$
Westbrook mucky peat	A				3.3576190
Ipswitch mucky peat	A	B			2.9816667
Rippowam fine sandy loam		B	C		1.9225000
Hinkley gravelly sandy loam, 3-15 percent slopes			C	D	1.2760000
Pawcatuck mucky peat			C	D	0.8760000
Westbrook mucky peat, low salt				D	0.5858163
Water			C	D	0.3700000

Proposal

- Add $EC_{1:5}$ column into the component horizon table
- This action will allow for the collection of EC data throughout the country and allow for more useful halinity classes
- <u>Ultimately</u>:
  - Halinity classes will be used like salinity classes in arid soils, mainly as phases and for interpretations
  - *Frasi* break will be clarified

P	600099	164804	1		80		Westbrook C	low salt	series	☑	0.0	1.0	2.0	15	38

Horizon | Component Canopy Cover | Component Crop Yield | Component Diagnostic Features | Component Ecological Site | Component Erosion Accelerated

					SAR		EC			CEC-7			
		..		M...	RV	High	Low	RV	High	Low	RV	High	Low
P		Oe1		O	0.0	0.0	2.0	9.0	16.0	C 38.0	C 84.0	C 129.8	C
P		Oe2		O	0.0	0.0	2.0	9.0	16.0	C 38.0	C 78.1	C 129.8	C
P		Oe3		O	0.0	0.0	2.0	9.0	16.0	C 32.1	C 48.6	C 70.8	C
P		Cg1		C	0.0	0.0	16.0	28.5	32.0	C 6.8	C 25.3	C 34.2	C
P		Cg2		C	0.0	0.0	16.0	31.5	32.0	C 5.8	C 21.0	C 34.2	C

Proposal

Relationship to other data, validation, calculations

1) **A new column is to be added to the Component Horizon table: Horizon EC 1:5 (L, RV, H)**

Information for Table.Column: Horizon EC 1:5

Column Attributes

Attribute Name	Attribute Value
Column ID	
Column Physical Name	Ec1:5_r
Column Logical Name	electrical_cond_1:5_r
Column Group Label	EC
Column Label	RV
Logical Data Type	Float
Physical Data Type	Real
Not Null?	No
Decimal Precision	1
Minimum	0
Maximum	100
Units	millimhos per centimeter

Column Description:
The electrical conductivity of an extract from 1:5 volumetric dilution of water to soil.

Attribute Name (addition):

1:5 Electrical Conductivity

Data Type: (check one)

_____ text <256 characters: length _____

_____ text >256 characters

_X___ number lowest value: 0.0 highest value : 100.0 unit of measure: millimhos per centimeter (equivalent to deciSiemens per meter)

integer___ float__X_ decimal places __1__ Maximum Length

___ choice list new choice (attached) choice definition (attached)

Definition of attribute:

The electrical conductivity of a 1:5 by volume mixture of soil to water.

A new column should be added to the Component Horizon table as EC 1:5.

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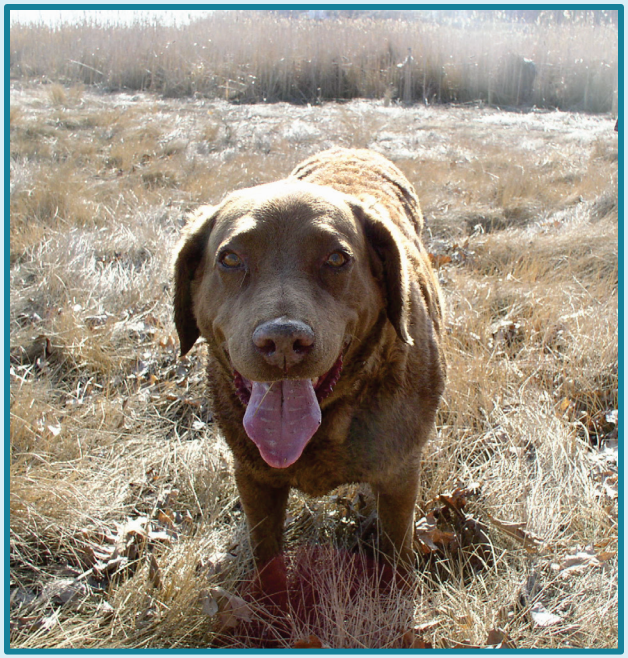
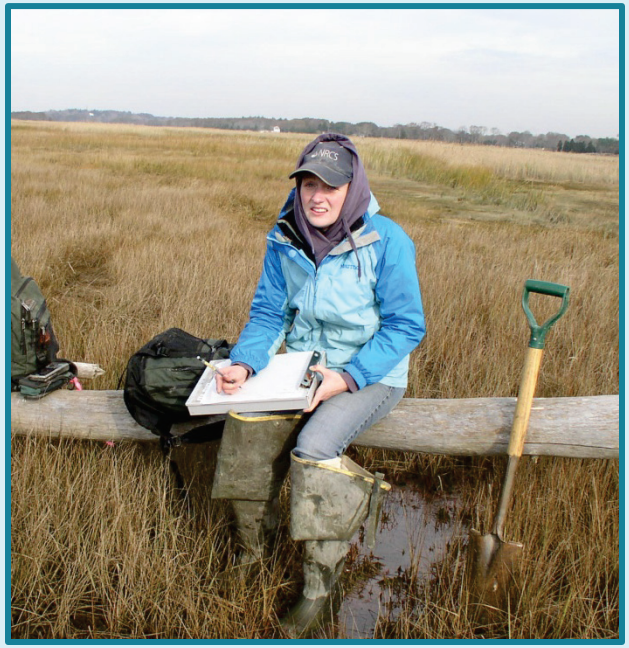
Acknowledgements

I would like to thank…

- CT NRCS for assistance and support, especially Debbie Surabian, Donald Parizek, Nels Barrett, and Jacob Isleib
- Graduate advisor Glenn Warner and graduate committee members Juliana Barrett, Jack Clausen, and Doug Wysocki
- Undergraduate lab helpers Faye Koenigsmark, Rebecca Trueman, and Alex Pivarnik and NRCS Earth Team volunteers Diane Lambert and Caroline Martin
- National Cooperative Soil Survey for funding



Questions?



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