Site Specific Soil Mapping: Area 3 of the de Coppet Estate

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1. INTRODUCTION

The considerable variability of soils across southern Rhode Island soils reflects a diverse array of glacial and postglacial Holocene landscape processes. Characterizing this variability represents an important component of land assessment, but the coarse spatial resolution of the Rhode Island Soil Survey maps (1:15,840 scale; Rector, 1981) makes them poor tools for the task. Site specific soil mapping (Stolt, 2015), by contrast, provides a powerful means of precisely assessing soil character and variability. We here provide an example of this approach, with a high-resolution (1:2400 scale) soil map of a kame terrace on the de Coppet Estate in Richmond, Rhode Island.

Bequeathed to the state of Rhode Island in 1937, the de Coppet Estate has been managed by the Department of Environmental Management since 2014 (State of Rhode Island Office of the Governor, 2014). The 1,825 acre property is currently a wildlife preserve, and features trails designated for wildlife viewing and hiking. The study area lies on the southern end of the Estate, along a transect just north of Bailey Pond and No Bottom Pond.

The area represents part of the southernmost confluence in Rhode Island of the Late Proterozoic Sterling igneous suite of the Hope Valley subterrane and the Late Proterozoic Esmond and Devonian Scituate igneous suites of the Esmond-Dedham subterrane (Hermes et al., 1994; Appendix 1). A probable fault between these subterranes sits in the southwest corner of the study area. Two Esmond-Scituate contacts occur within the area. The first, part of the major contact between these units running across southern Rhode Island, occurs in the woods just east of Hillsdale Road. The second contact lies on the western edge of the study area, where an inclusion of Scituate granite forms a prominent ridge on the landscape. This ridge likely represented the interface between ice and the upland during development of the kame terrace.

Rhode Island Soil Survey mapping (Rector, 1981; Appendix 2) indicates that silt and sandy loams dominate the study area. These soils generally increase in coarse fragment content and become progressively better drained from east to west across the study area, though some poorly drained areas exist between Bailey pond and the uplands at the western margin. Notably, the coarse resolution of this previous mapping necessitated that variability within these units be qualitatively estimated rather than explicitly mapped, and that the nature of transitions between them—for example, between a unit at a summit and one at a toeslope—be overlooked. We therefore focus our mapping effort on characterizing soil transitions and variability across the study area.

2. METHODS

Mapping followed the procedures outlined by Stolt (2015). We first delimited landscape using a topographic map of the study area, in order to determine the most probable bounds of major soil

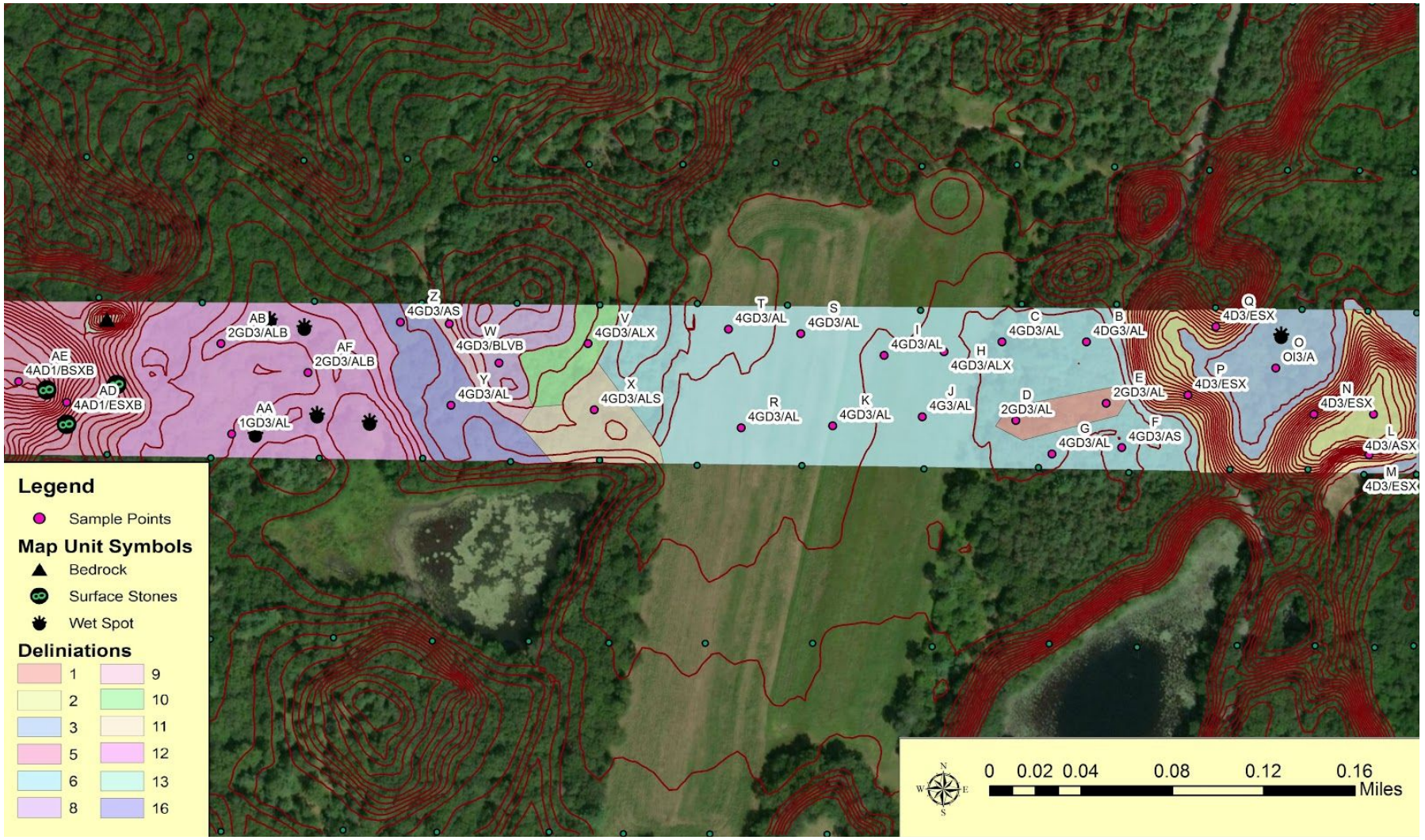
bodies. We then obtained an initial perspective of soils of these units by setting sampling points at regular intervals along parallel transects within them.

We collected soil samples from up to a maximum depth of 150 cm using a shovel and bucket auger, and placed them in a plastic tray to observe horizon properties. We assessed all samples for texture, parent material, redoximorphic features, depth to seasonal high-water table, and depth to bedrock or densic layer. We also noted the slope and stoniness class of each sampling locality, and recorded GPS coordinates using the Compass feature of an Apple iPhone. After establishing relative abundances of soils across the study area, we prepared profile descriptions of the five most common.

We assessed variability across the study area by collecting additional samples within the five largest mapping units after initial sampling. We placed these sampling localities in those areas most sparsely covered by our initial transects.

3. SITE SPECIFIC SOIL MAP

All mapping was done using Arc 10.4.1 GIS software. Polygon shapefiles were used to delineate out differing soil series, and points shapefiles were added relatively near the location they were mapped. Points were labeled with their name and their map units. **Note:** labels U and AC did not load in on the map. Label U is the unnamed point south of point W, and label ACC is hidden by point AD's label, just west of it. Map unit features were also added as a point shapefile,detailing bedrock, surface stones, and wet spots as described in the SOP for the project. Scale bar, north arrow and legend were all added in layout view, with scale bar being in miles. A 1:24,000 basemap was also included as an extent indicator for our field of study.


Z
4GD3/AS
AB
2GD3/ALB
W
4GD3/BLVB
V
4GD3/ALX
T
4GD3/AL
S
4GD3/AL
I
4GD3/AL
C
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B
4DG3/AL
Q
4D3/ESX
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Miles

4. MAP UNIT DESCRIPTIONS AND VARIABILITY ASSESSMENT

Delineation Location (Point ID):	**Map Unit Symbol:**	**Map Unit Description:**
Field/Forest (B, C, F, H, I, J, K, R, S, T)	**4GD3/AL**	These soils occur on an upland landscape comprised of a mixture of open field and forest. The landscape is flat with a slope range of 0-3%. These parent materials for these soils consists of loess deposited over ice contact stratified deposits. The depth to densic contact in this unit consistently exceeded the sampling depths which ranged from 52cm-1m. The seasonal high water table of these soils exceeds the 1m sampling depth. In samples taken from the open field redoximorphic features were present at 43 cm, 70 cm, and 80 cm. This has been attributed to a high silt content as opposed to the presence of a seasonal high water table. A small inclusion within the forested area demonstrated evidence of a SHWT at roughly 60cm where redoximorphic features were present. Silt loam texture was observed in the surface horizons of all samples. Subsurface horizons possessed more varied textures yet were dominated by silt loams or loams. One observation exhibited a loamy skeletal subsurface while another was a sandy loam. This landscape is free of surface stones and boulders. Small inclusions based on differences in subsurface texture include: 4GD3/ALX, 4GD3/AS, 4G3/AL
Forest (D,E)	**2GD3/AL**	Soils are located on an upland landscape located in a forested area comprised of both deciduous and coniferous trees. The slopes of this unit are 0-3%. The parent materials making up these soils are loess deposited over ice contact stratified deposits. Densic contact does not occur within the first 1m of soil. The seasonal high water table was recorded a 52 cm and 73 cm and has been averaged to 63 cm. Surface horizons were silt loams. The subsurface horizons were predominantly silt loams with some sandy loams present. No surface stones or boulders were present in this area.
Scarp (M, N, L, P, Q)	**4D3/ESX**	These soils occur on the scarp of a kame terrace, with the northwestern face undisturbed and the south face previously cut and mined. The slope of this unit is roughly 45% with some areas of >45% on the southern face. The summit of this area features slope ranges from 0-3% and has been classified as an inclusion. The parent material of these soils is ice contact stratified deposits. The densic contact and seasonal high water table are both greater than 1m. The texture of the undisturbed face consisted of a sandy loam surface with an extremely

		gravelly loamy sand subsurface. The disturbed face of the scarp had both an extremely gravelly loamy sand surface and subsurface texture. There are no surface stones or boulders present in this unit. Areas of inclusion are: 4D3/ASX.
Wetland East (O)	**OI3/A**	These soils are found on a lowland at the toeslope of a kame terrace scarp. The slope in this area ranges from 0-3%. Organic materials are the parent material of this unit. Densic contact exceeds 1m. The seasonal high water table is within 10 cm and there was strong evidence of saturation near the surface. The materials composing the first 1m of horizons are sapric.
Wetland West (AA, AB, AF)	**2GD3/ALB**	Soils are located on a lowland landscape adjacent to a pond. Slopes range from 0-3%. The parent materials for these soils consists of loess deposited over ice contact stratified deposits. The depth to densic contact in these soils is greater than 1m. The seasonal high water table is located between 58 cm and 60 cm and averaged at 59cm. In one instance the seasonal high water table was evident at 50 cm in a sample hole closer to a visible wet spot. Surface horizons had silt loam textures while the subsurface texture was dominated by a sandy loam classification. The southern portion of this unit features surface boulders at a separation of 10-20m between them. Units of inclusion are: 1GD3/AL.
Saddle-Wet Boundary (Y, Z)	**4GD3/AS**	These soils occur on a footslope in a forested landscape bordering vernal pools extending from Bailey Pond. The landscape has a slope range of 0-3%. The parent materials for these soils consists of loess deposited over ice contact stratified deposits. The depth to densic contact exceeds 1m. The seasonal high water table of these soils is expected to slightly exceed the 1m sampling depth but standing water was visible in one sampling hole at a depth of just over 1m. Surface horizons are dominated by gravelly sandy loam textures, whereas the subsurface horizons are composed of gravelly loamy sand. One sample exhibited a gravelly loamy sand subsurface texture and has been noted as an inclusion. No surface stones or boulders were present in the area. A small area of inclusion present is: 4GD3/AL.
Saddle (U)	**4GD3/ASXB**	Soils occur on an upland landscape located on a saddle-like feature. Slopes range from 0-3% in this area. The parent material for these soils is loess over ice contact stratified deposits. There is no densic contact within 1m. The seasonal high water table exceeds a 1m depth. Surface horizons were silt loam. Subsurface horizons were loamy sand with a coarse

		fragment volume exceeding 35% giving the soils a skeletal modifier. Surface boulders were visible at less than 10m separation.
Saddle-West Slope (W)	**4GD3/BLVB**	These soils are located on an upland area leading from a saddle down to vernal pools. Loess deposited over ice contact stratified deposits are the parent materials for these soils. The slopes range from 0-3%. Densic contact is estimated to be greater than 1m with a total sampling depth of 54 cm. The seasonal high water table was greater than 54 cm and is estimated to exceed 1m based on landscape position. The texture of both surface and subsurface horizons was dominated by silt loam. Surface stones and boulders were visible at less than 10m separation in the surrounding area.
Saddle-Field Boundary North (V)	**4GD3/ALX**	These soils are located on an upland area with coniferous trees situated adjacent to an open field. The slopes range from 0-3%. The parent material for these soils is loess deposited over ice contact stratified deposits. Densic contact occurs at greater than 1m from the soil surface. The seasonal high water table also exceeds a 1m depth. The surface horizons of this unit are comprised of silt loam while the subsurface horizons are a very gravelly sandy loam to the point of being classified skeletal. There are no surface stones present in this area.
Saddle-Field Boundary South (X)	**4GD3/ALS**	These soils are located on an upland area adjacent to an open field. The slopes range from 0-3%. The parent materials for these soils are loess deposited over ice contact stratified deposits. Densic contact occurs at greater than 1m from the soil surface. The seasonal high water table also exceeds a 1m depth. The surface horizons of this unit are comprised of silt loam while the subsurface horizons are a very gravelly sandy loam to the point of being classified as skeletal. There are no surface stones present in this area.
Western Edge (AC, AD, AE)	**4AD2/BSXB**	Soils occur on an upland ridge located in a forested area. The slopes in this unit are primarily within the 3-8% range, however there are small inclusions featuring slopes of greater than 45%. The parent materials present is dense till. The denisic contact occurs at between 46 cm and 55 cm and is averaged at slightly greater than 50 cm. The seasonal high water table is located at a depth of greater than 1m. These soils feature a loamy sand surface texture underlain by a very gravelly loamy sand subsurface texture. Surface boulders and bedrock outcroppings are present and separated by roughly 10-20m. Areas of inclusion include: 4AD1/ESXB

5. PROFILE DESCRIPTIONS OF COMMONLY OBSERVED SOILS

4AD2/BSXB	
A	0-15 cm; brownish black (10YR 3/2) very gravelly loamy sand; 35% coarse fragment by volume; weak fine granular structure with friable moist consistence; many fine roots; clear smooth boundary.
Bw	15-47 cm; dull yellowish brown (10YR 5/4) very gravelly loamy sand; 35% coarse fragment; weak medium granular structure with friable moist consistence; clear smooth boundary.
Cd	47 cm; bright brown (10YR 6/6) very gravelly loamy sand and dense till.

2GD3/ALB	
Oe	0-7 cm; very dark grayish red (2.5YR 2.5/2) hemic texture; abrupt smooth boundary.
A	7-18 cm; black (10YR 2/1) silt loam; weak medium granular structure; friable; clear smooth boundary.
Bw1	18-49 cm; light yellowish brown (10YR 6/3) silt loam; weak fine subangular blocky structure with friable moist consistence; abrupt smooth boundary.
Bw2	48-70 cm; light yellowish brown (10YR 6/4) sandy loam; weak fine subangular structure with friable moist consistence; common distinct masses (7.5YR 7/6) visible beginning at 65cm; clear smooth boundary.
Cg	70 cm; light gray (2.5Y 7/1) sandy loam; weak fine subangular structure with friable moist consistence; common prominent masses (7.5YR 7/6) visible.

4GD3/AL	
Ap	0-10 cm; brownish black (10YR 3/1) silt loam; weak fine granular structure; friable; abrupt smooth boundary.
Bw1	10-36 cm; brown (10YR 3/4) silt loam; weak fine subangular blocky structure; friable; clear smooth boundary.

Bw2	36-70 cm; dull yellow orange (10YR 7/4); weak fine subangular blocky structure; friable ; few faint masses (7.5YR 7/6); clear wavy boundary.
C	70 cm; yellowish brown (10YR 7/7); weak fine subangular blocky structure; friable; few faint masses (7.5YR 7/6).

4GD3/ASXB	
A	0-7 cm; brown (10YR 3/4) silt loam; weak medium subangular blocky structure; friable; clear smooth boundary.
Ap	7-29 cm; dark grayish brown (10YR 3/2); silt loam; weak fine subangular blocky structure; friable; abrupt smooth boundary.
Bw	29-62 cm; light yellowish brown (10YR 6/4); gravelly sandy loam; 20% coarse fragment by volume; weak fine subangular blocky; friable; clear wavy boundary.
Cd	62 cm; bright brown (10YR 6/6); weak fine subangular blocky.

4D3/ESX	
A	0-8 cm; brown (7.5YR 4/4) sandy loam; weak fine granular structure; very friable; abrupt smooth boundary.
Bw	8-30 cm; brown (7.5YR 4/6) very gravelly loamy sand; 40% coarse fragment by volume; weak subangular blocky structure; friable; clear smooth boundary.
C	30 cm; brownish yellow (7.5YR 6/6) extremely gravelly sand; 75% coarse fragment by volume; structureless single grain.

6. REFERENCES

Hermes, O.D., Gromet, L.P., Murray, D.P., Hamidzada, N.A., Skehan, J.W., and Mosher, S. 1994. Bedrock geologic map of Rhode Island. Rhode Island Geological Survey, Kingston, RI.

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State of Rhode Island Office of the Governor. 2014. Governor Chafee, R.I. DEM Director Coit, Congressional Delegation and Local Officials Tour Hillsdale Forest and Wildlife Reservation. Press release. 12 September 2014.

Stolt, M.H. 2015. Standards and procedures for site specific soil mapping in Rhode Island. University of Rhode Island Cooperative Extension, Kingston, RI.

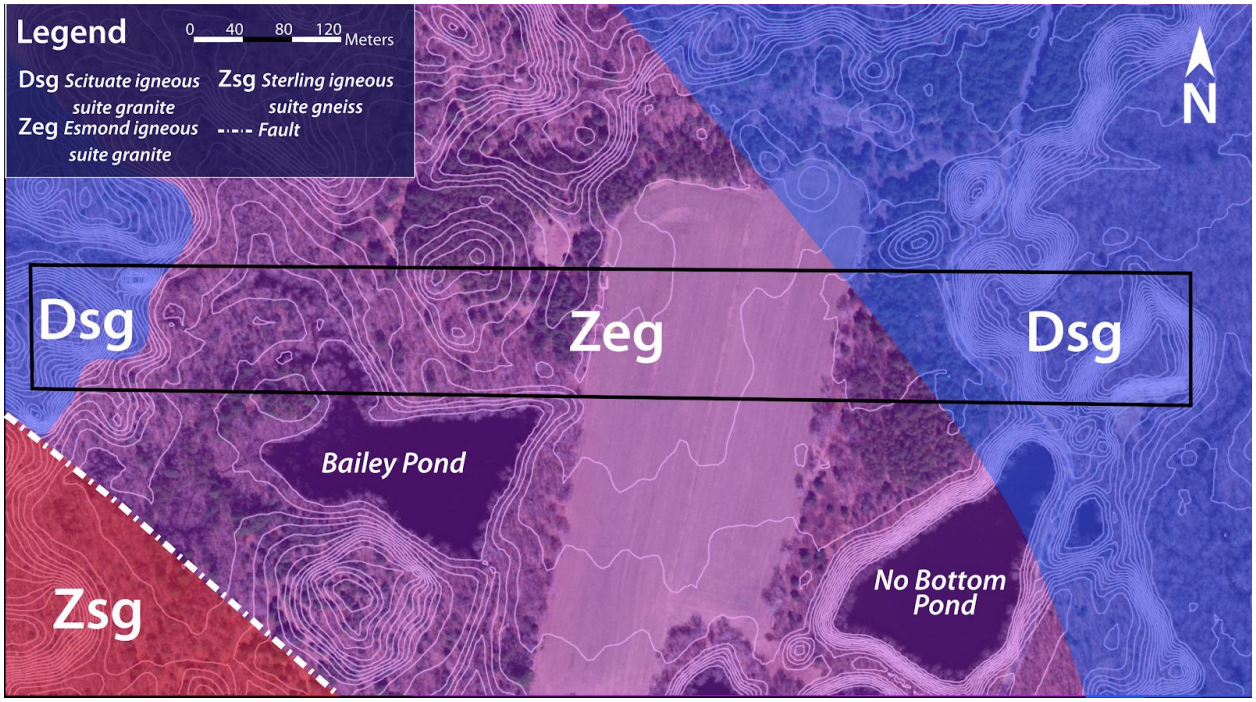
7. APPENDICES

APPENDIX 1. Bedrock map of study area.

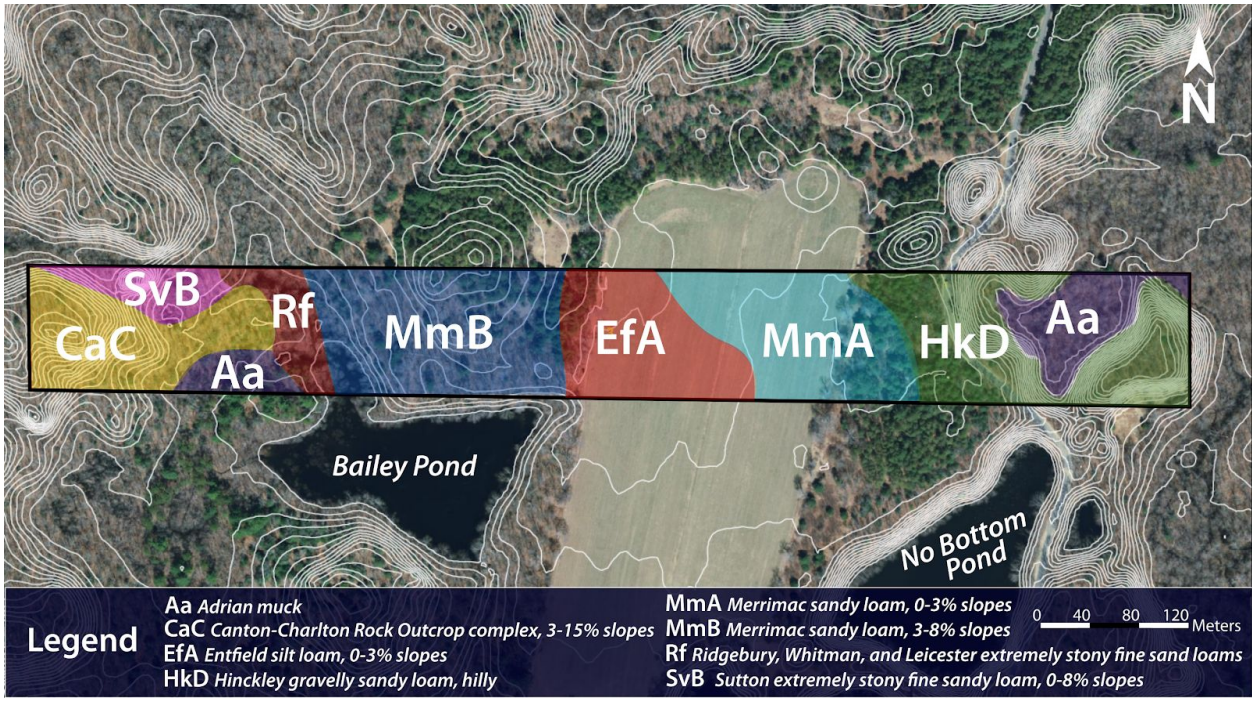
APPENDIX 2. Rhode Island Soil Survey map of study area.

APPENDIX 3. Field notes.

APPENDIX 1. Bedrock map of study area (bounds indicated by black box). Unit contacts inferred from surface outcrop where available, and otherwise redrawn from Hermes et al., 1994.



APPENDIX 2. Rhode Island Soil Survey map of study area, redrawn from Rector, 1981.



APPENDIX 3. Field Notes

			Depth To (cm):					Texture					
Name	Lat	Long	Concentrations	Depletions	SHWT	Bedrock / Dense till	Parent Material	Surface	Subsurface	GPSC	Slope %	Stoniness Class	Map Unit Symbol
B	41.511	-71.64527	36	-	>67	>67	GD	Silt Loam	Sandy Loam	L	0-3	NONE	4DG3/AL
C	41.511	-71.64563	>60	-	>60	>60	GD	Silt Loam	Sandy Loam	L	0-3	NONE	4GD3/AL
D	41.511	-71.64583	73	-	73	>91	GD	Silt Loam	Silt Loam	L	0-3	NONE	2GD3/AL
E	41.511	-71.64513	52	-	52	>60	GD	Silt Loam	Sandy Loam	L	0-3	NONE	2GD3/AL
F	41.510	-71.64513	>79	-	>79	>79	GD	Silt Loam	Loamy Coarse Sand	S	0-3	NONE	4GD3/AS
G	41.510	-71.64563	>66	-	>66	>66	GD	Silt Loam	Sandy Loam	L	0-3	NONE	4GD3/AL
H	41.511	-71.64611	>61	-	>61	>61	GD	Silt Loam	Ex Grv Sandy Loam	LX	0-3	NONE	4GD3/ALX
I	41.511	-71.64694	>90	-	>90	>90	GD	Silt Loam	Loam	L	0-3	NONE	4GD3/AL
J	41.511	-71.64666	80	-	80	80	G	Silt Loam	Loam	L	0-3	NONE	4G3/AL
K	41.511	-71.6475	>60	-	>60	>60	GD	Silt Loam	Sandy Loam	L	0-3	NONE	4GD3/AL
L	41.511	-71.64333	>75	-	>75	>75	D	Silt Loam	V Grv Loamy Sand	SX	0-3	NONE	4D3/ASX
M	41.510	-71.64333	>150	-	>150	>150	D	Ex Grv Sandy Loam	Ex Grv Loamy Sand	SX	>45	NONE	4D3/ESX
N	41.510	-71.64361	>56	-	>56	>56	D	Sandy Loam	Ex Grv Loamy Sand	SX	>45	NONE	4D3/ESX
O	41.511	-71.64388	>150	-	0	>150	I	-	-	SAPRIC	0-3	NONE	OI3/A
P	41.511	-71.64444	>150	-	>150	>150	D	Sandy Loam	Ex Grv Loamy Sand	SX	>45	NONE	4D3/ESX
Q	41.511	-71.64416	>150	-	>150	>150	D	Sandy Loam	Ex Grv Loamy Sand	SX	>45	NONE	4D3/ESX
R	41.511	-71.64805	>72	-	>72	>72	GD	Silt Loam	Silt Loam	L	0-3	NONE	4GD3/AL
S	41.511	-71.64805	70	-	>100	>100	GD	Silt Loam	Silt Loam	L	0-3	NONE	4GD3/AL
T	41.511	-71.64777	43	-	>100	>100	GD	Silt Loam	Silt Loam	L	0-3	NONE	4GD3/AL
U	41.511	-71.64972	>80	-	>80	>80	GD	Silt Loam	Loamy Sand	SX	0-3	XB,S	4GD3/ASXB
V	41.511	-71.64916	>82	-	>82	>82	GD	Silt Loam	V grav Sandy Loam	LX	0-3	NONE	4GD3/ALX
W	41.511	-71.65027	>54	-	>54	>54	GD	Silt Loam	Silt Loam	L	0-3	VB	4GD3/BLVB
X	41.511	-71.64916	>105	-	>105	>105	GD	Silt Loam	Loam	L	0-3	S	4GD3/ALS
Y	41.511	-71.65027	52	-	>106	>106	GD	Silt Loam	Grv Sandy Loam	L	0-3	NONE	4GD3/AL
Z	41.511	-71.65055	>90	-	>100	>100	GD	Silt Loam	Grv Sandy Loam	S	0-3	NONE	4GD3/AS
AA	41.511	-71.65194	50	-	50	>90	GD	Silt Loam	Sandy Loam	L	0-3	NONE	1GD3/AL
AB	41.511	-71.65166	58	80	58	>120	GD	Silt Loam	Sandy Loam	L	0-3	B	2GD3/ALB
AC	511111	1.6536111	>55	-	>55	55	A	Loamy Sand	V Grv Loamy Sand	SX	3-8	B	4AD2/BSXB
AD	511111	1.6533333	>46	-	>46	46	A	Loamy Sand	V Grv Loamy Sand	SX	>45	B	4AD1/ESXB
AE	511111	1.6530555	>50	-	>50	50	A	Loamy Sand	V Grv Loamy Sand	SX	3-8	B	4AD2/BSXB
AF	511111	1.6527777	60	-	60	>89	GD	Silt Loam	Sandy Loam	L	0-3	B	2GD3/ALB