Marsh Vulnerability Index:
Assessing the Health of Delaware's Marshes

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Purpose

- Develop health index for *Spartina alterniflora* salt marshes
- To take place in two sites under DNERR and Inland Bays
  - Combine marsh elevation data (RTK) with biomass sampling to determine elevation growth range and productivity correlation for *S. alterniflora*
  - Correlate to tidal datum in each watershed
- Classify healthy, degrading, and severely degrading short-form *Spartina alterniflora* marsh regions based upon correlation
  - Degraded and severely degraded are known to have lower elevations
- Monitor Delaware's marshes response to Relative Sea Level Rise and to promote conversation, restoration and monitoring
- Upon completion, MVI could be used in other Mid-Atlantic states for regional comparison and planning

Background Information

- "The Relationship of Smooth Cordgrass (*Spartina alterniflora*) to Tidal Datums: A Review" states that *S. alterniflora* tend to grow in relation to Mean High and Mean Low Water (McKee and Patrick, 1988)
  - Elevations within watersheds are dependant upon tidal datums

- These dominant salt marsh macrophytes are said to be foundation species (Pennings and Bertness, 2001) because of their modification of the physical environment, their influence on species interaction and resource availability, and the subsequent effect they have on community structure (Bruno and Bertness, 2001).

- The success of the salt marsh vegetation to constantly modify the elevation of its habitat toward an equilibrium with sea level, depends on a number of factors including the rate of relative sea level rise (RSLR, land subsidence plus the eustatic change in sea level), sediment supply, and tidal range (Stevenson et al., 1986, Reed 1995).

Background Information

- For every marsh there is an optimum rate of RSLR, an optimum depth at which the marsh community is productive, and an equilibrium depth that can be greater or less than the optimum (Morris et al. 2002)

- The marsh surface and tidal surface elevation relationship is one of the ultimate controls in dictating wetland flooding frequency, length of inundation, available and potential suspended sediment concentrations, and type and density of vegetation cover (Morris et al., 2002).

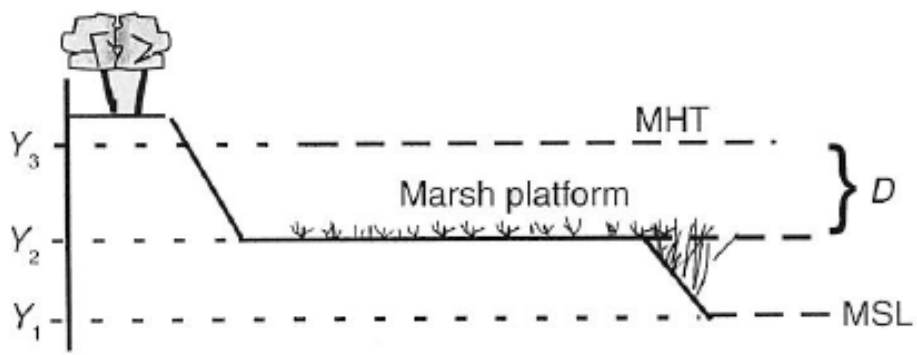


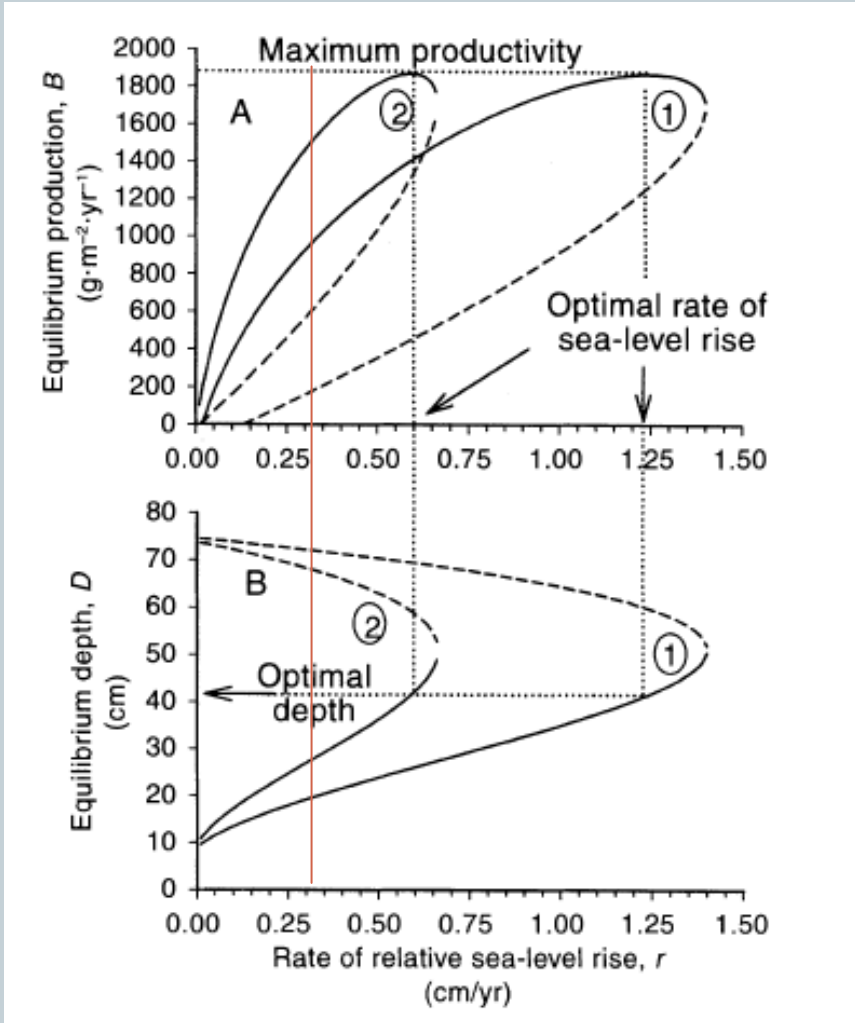
FIG. 3. Idealized geometric relationships among mean sea level (MSL) at elevation Y_1, mean high tide (MHT) at Y_3, and the equilibrium position Y_2 of the marsh platform at depth (D) relative to MHT.

Morris et al. 2002

Background Information

- RSLR in Delaware:
  - Reedy Point – 3.46 mm/yr (NOAA)
  - Lewes – 3.20 mm/yr (NOAA)

- Optimal depth is depth below MHT that results in maximum productivity

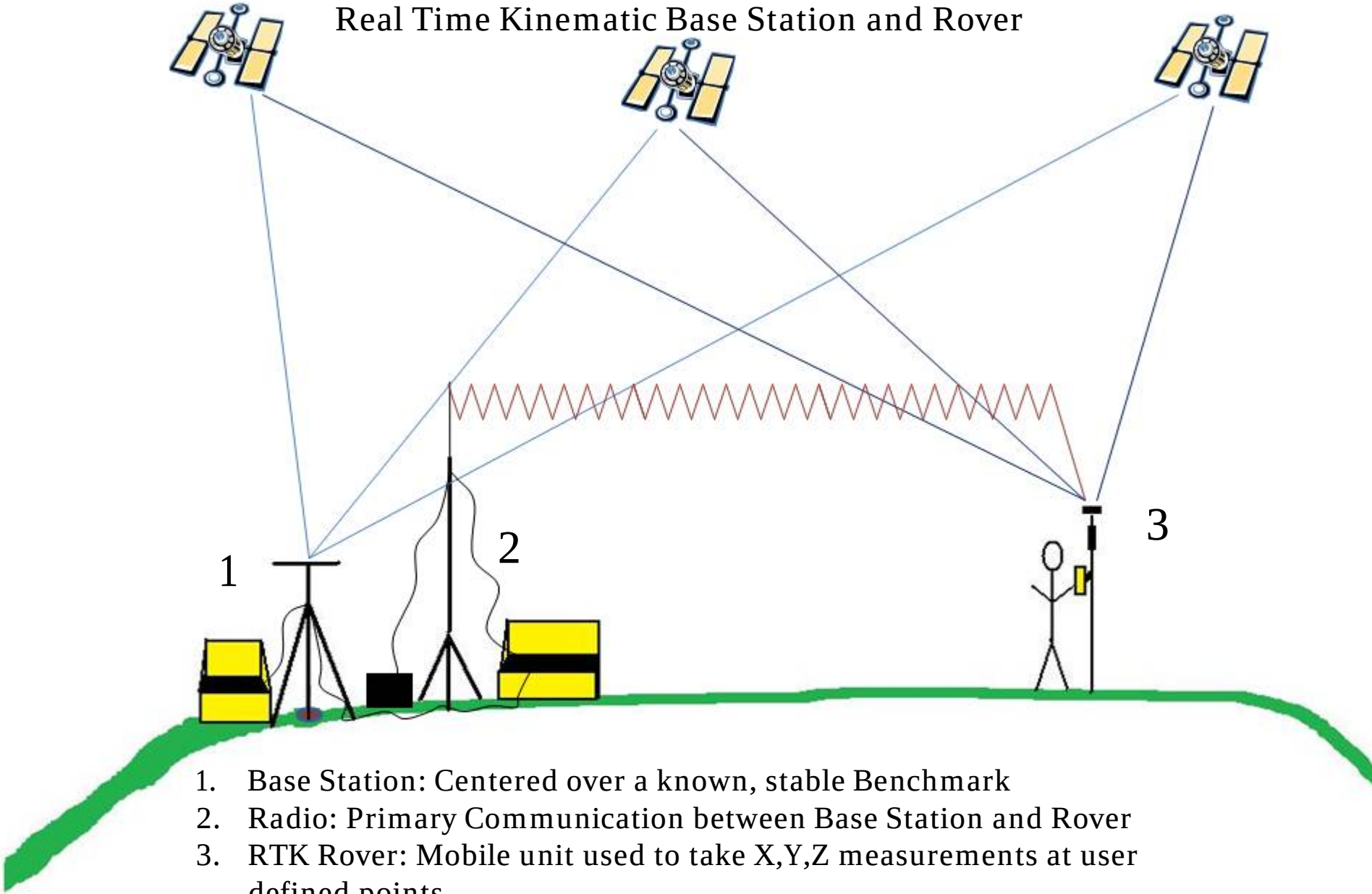


Morris et al. 2002

Methods

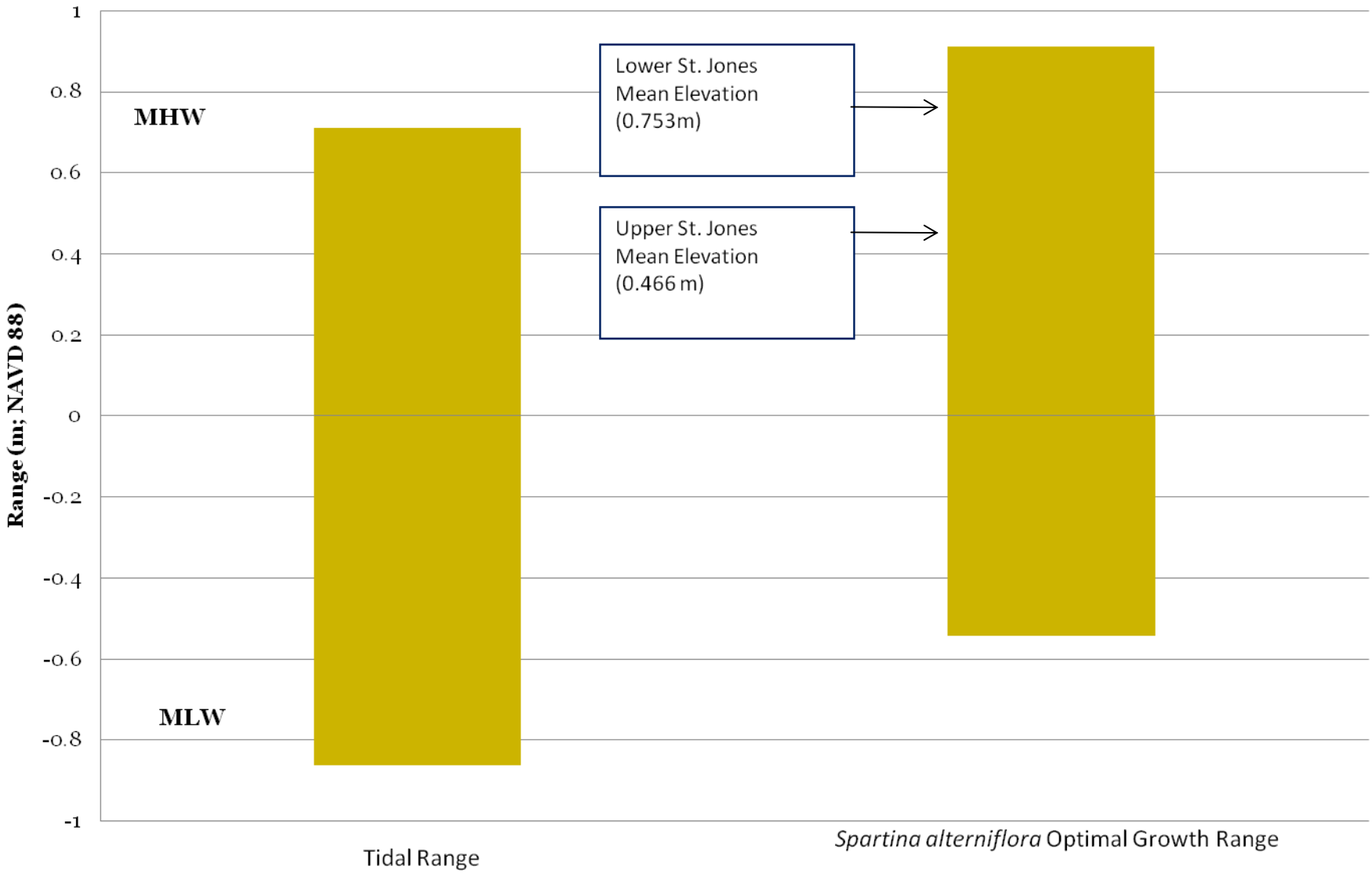
- Biomass Sampling
  - Three cores per site/ ~8 sites per watershed
  - Collect both above and below ground biomass samples
  - Sort and separate dead and alive plant matter
  - Perform simple statistics on DCP data and compare with MidTRAM data
  - Determine a “health correlation factor” for each watershed
  - Sampling methods utilized from MidTRAM
- Real-Time Kinematic (RTK) Survey
  - Provide elevation data for biomass sampling sites and additional *S. alterniflora* monotypic stands
  - Collect elevation data to help in correction of LiDAR vegetation error

Real Time Kinematic Base Station and Rover

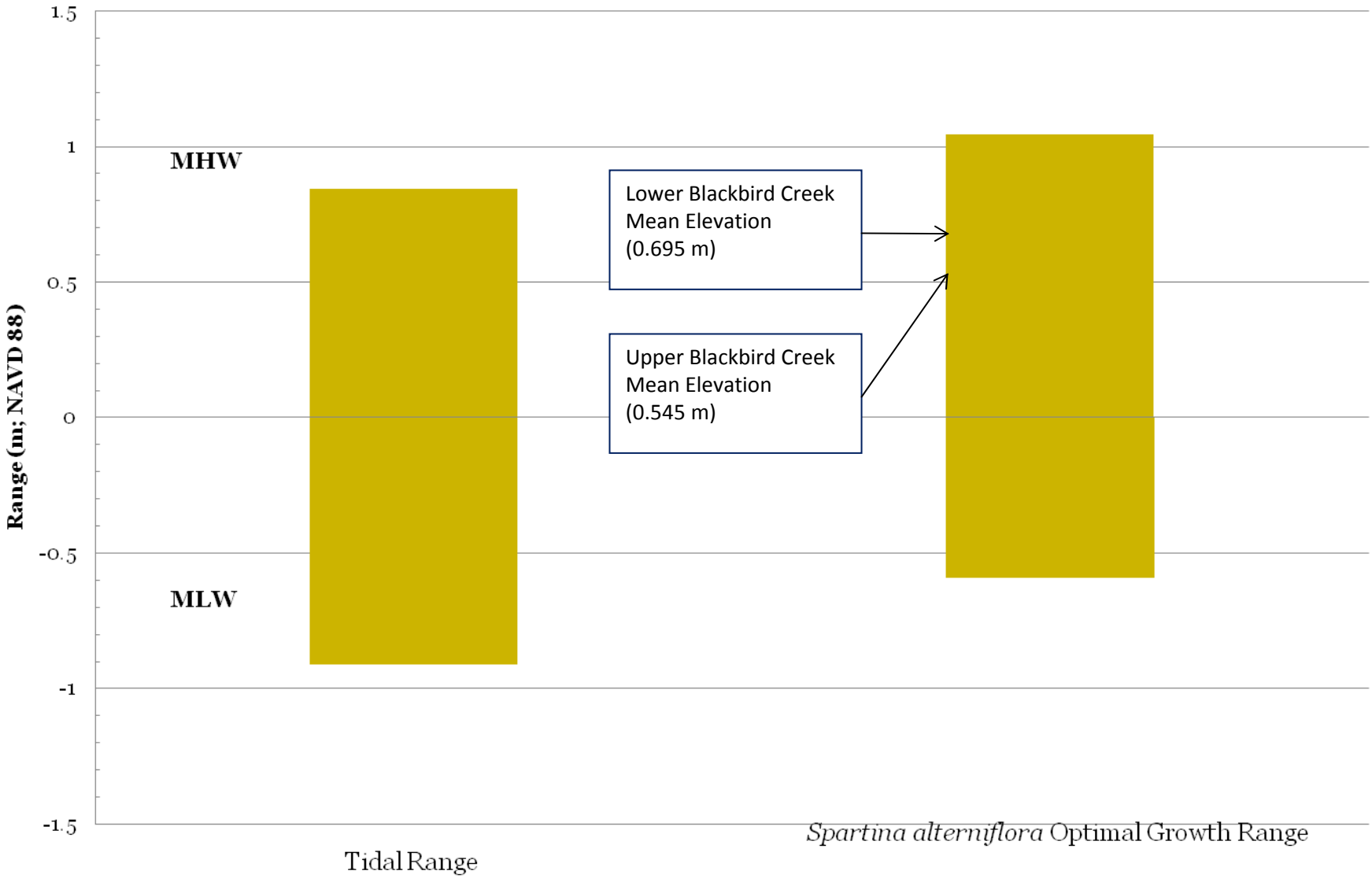


1. Base Station: Centered over a known, stable Benchmark
2. Radio: Primary Communication between Base Station and Rover
3. RTK Rover: Mobile unit used to take X,Y,Z measurements at user defined points

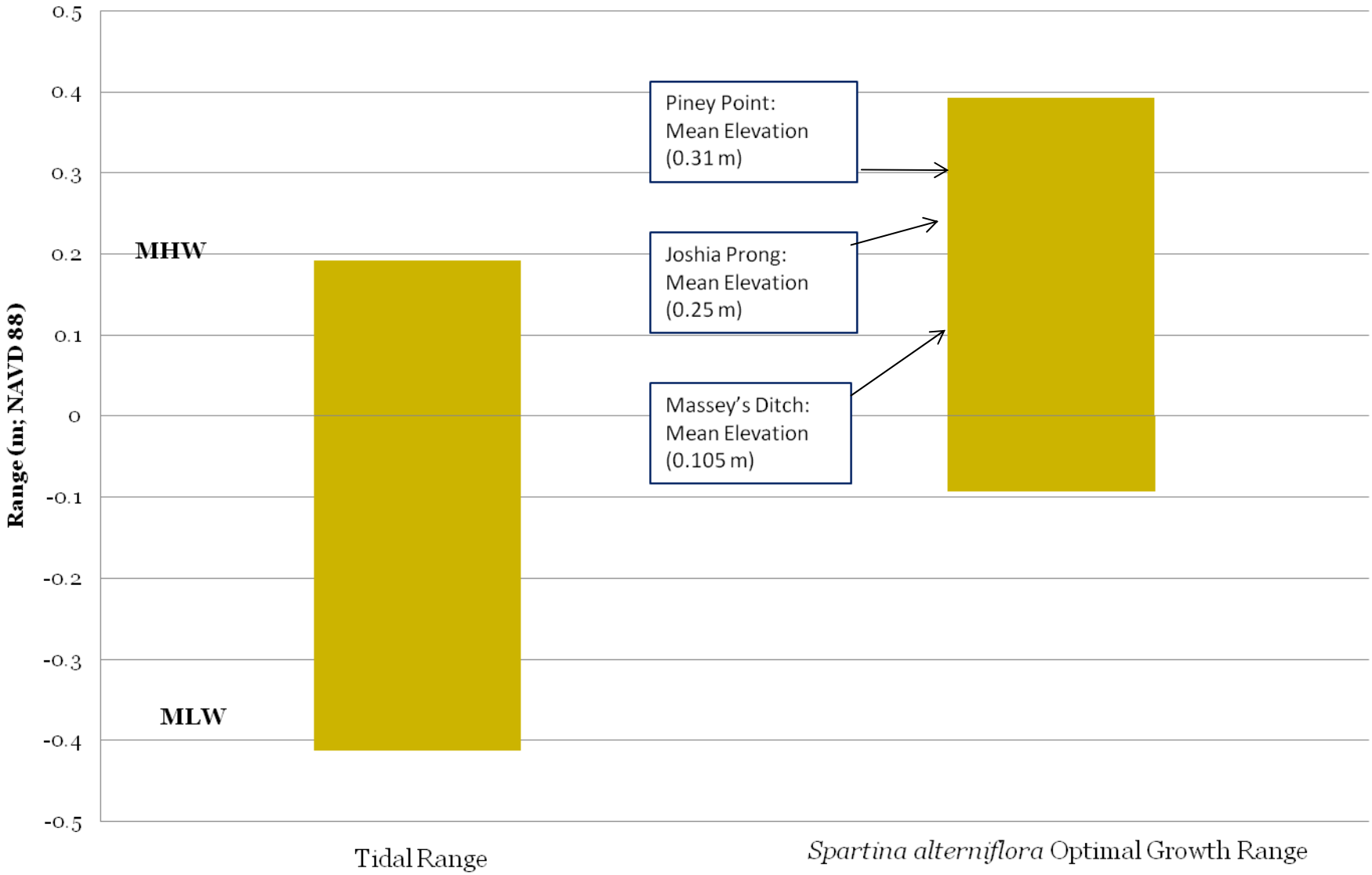
St. Jones River



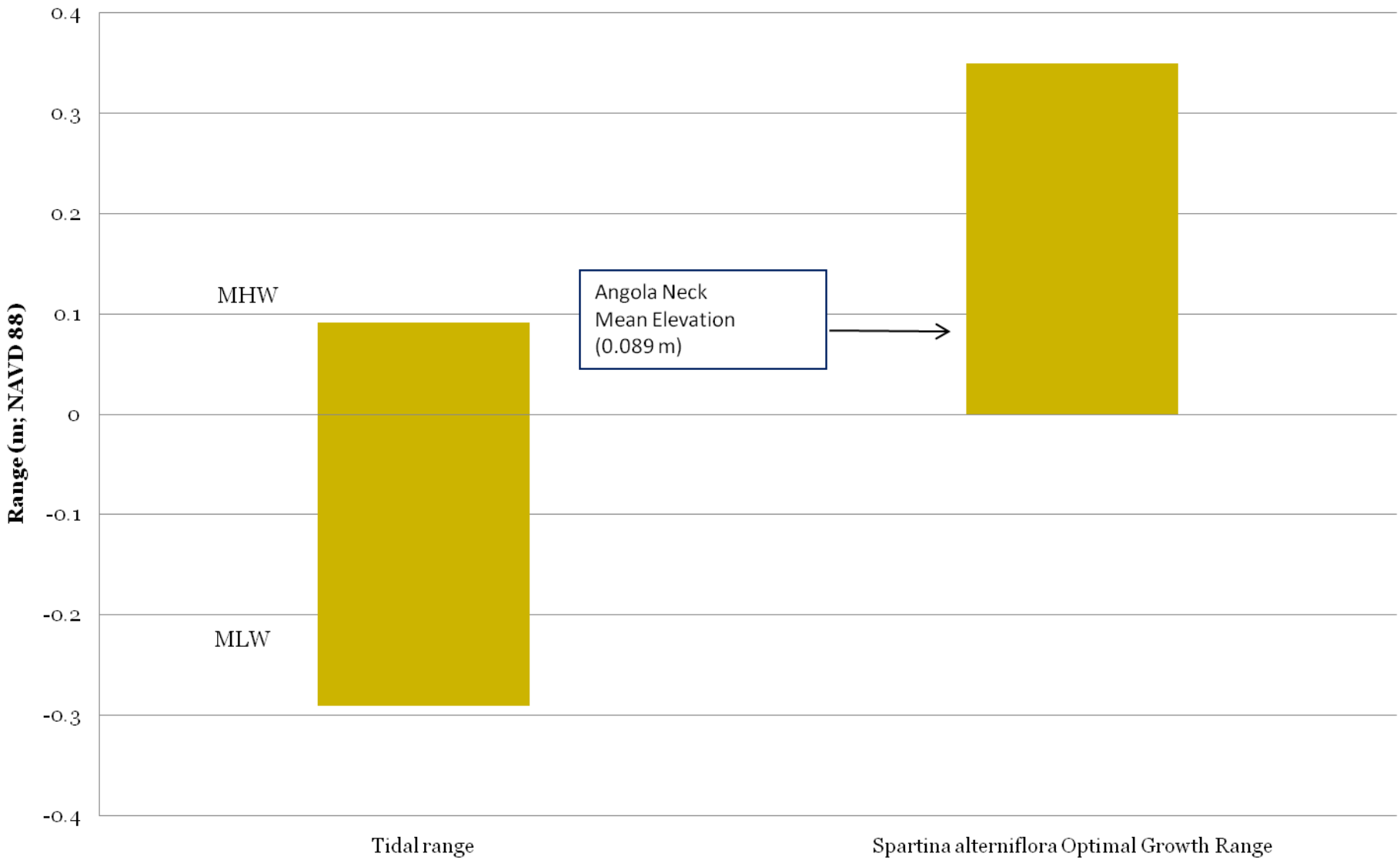
Blackbird Creek

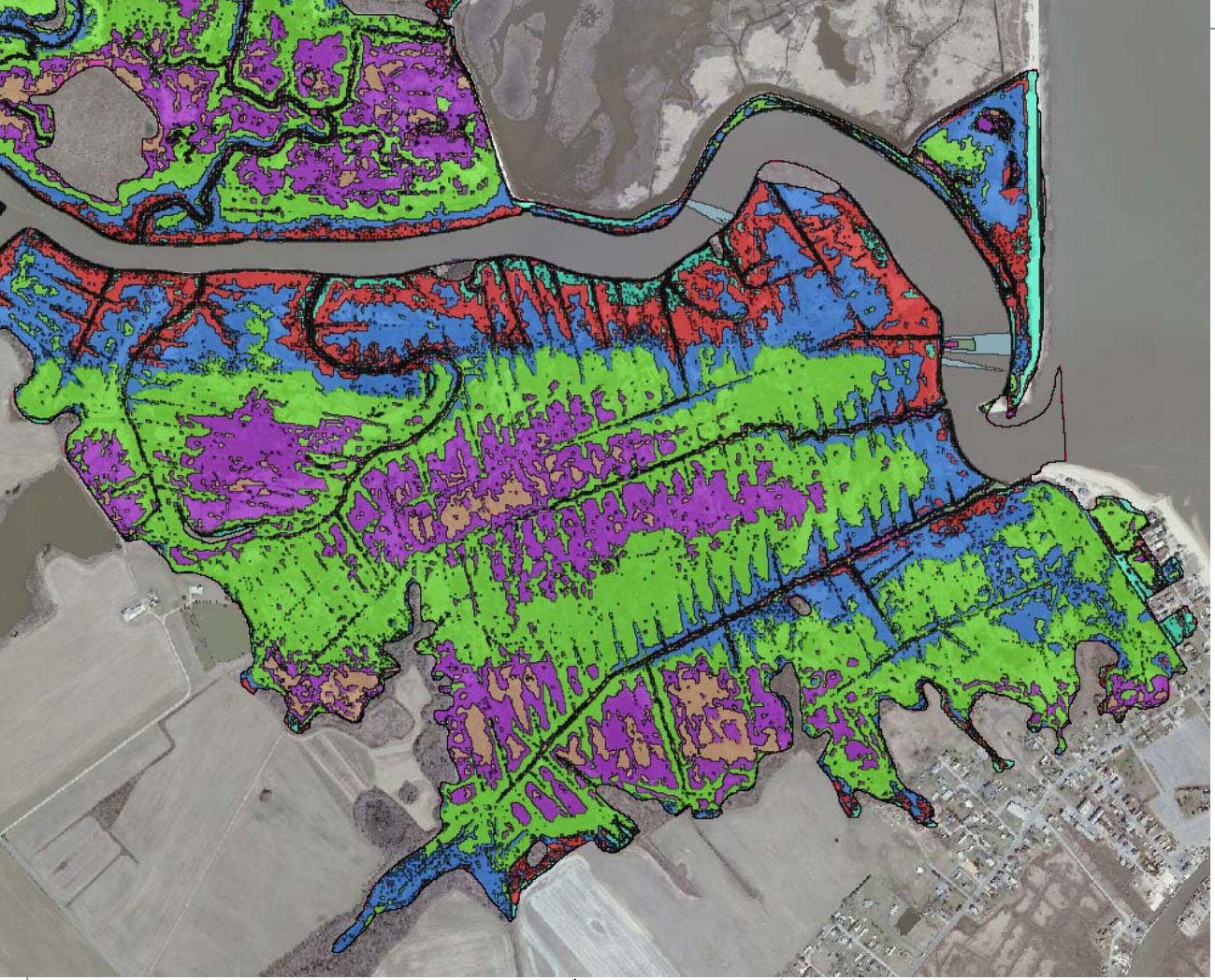


Indian River Bay

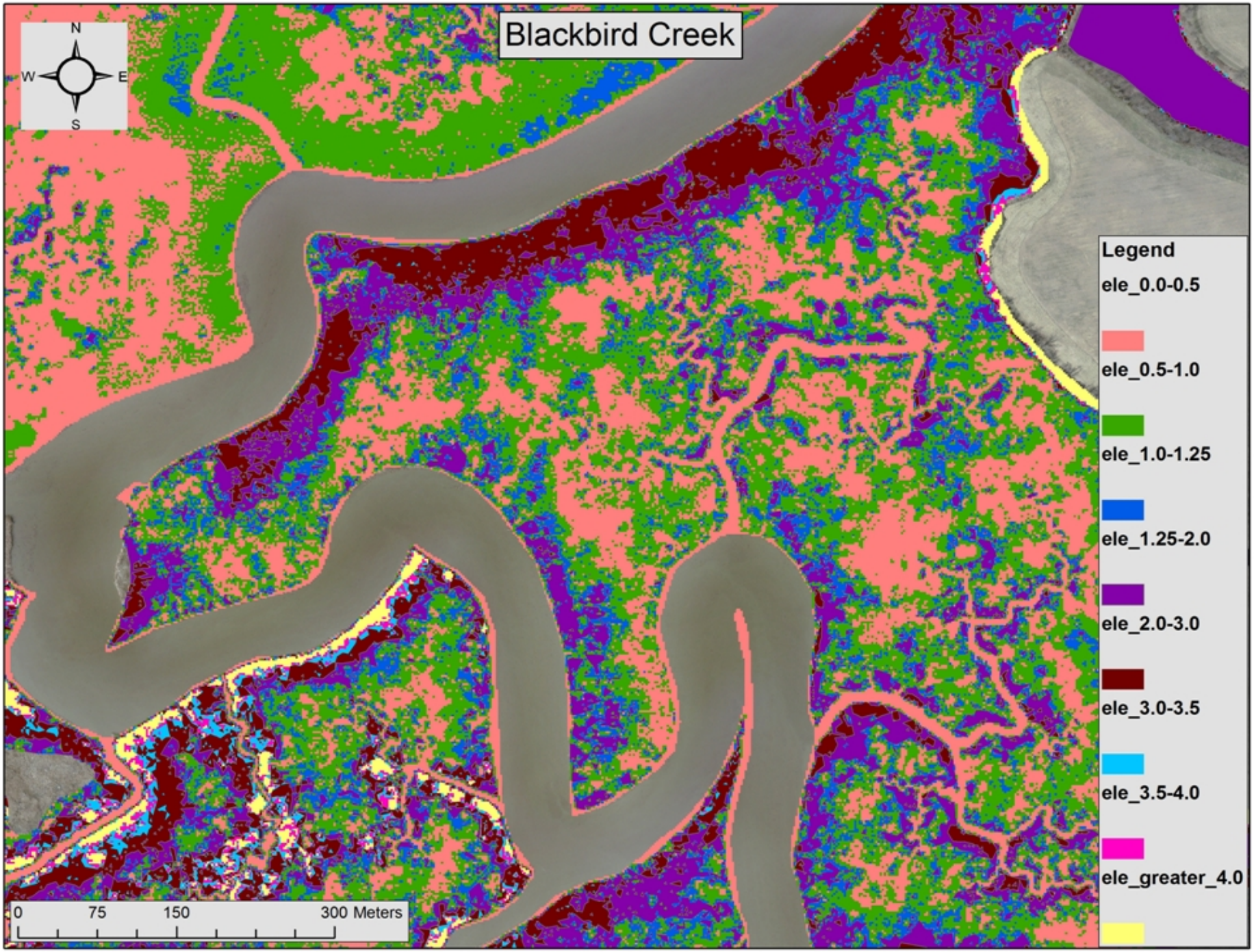


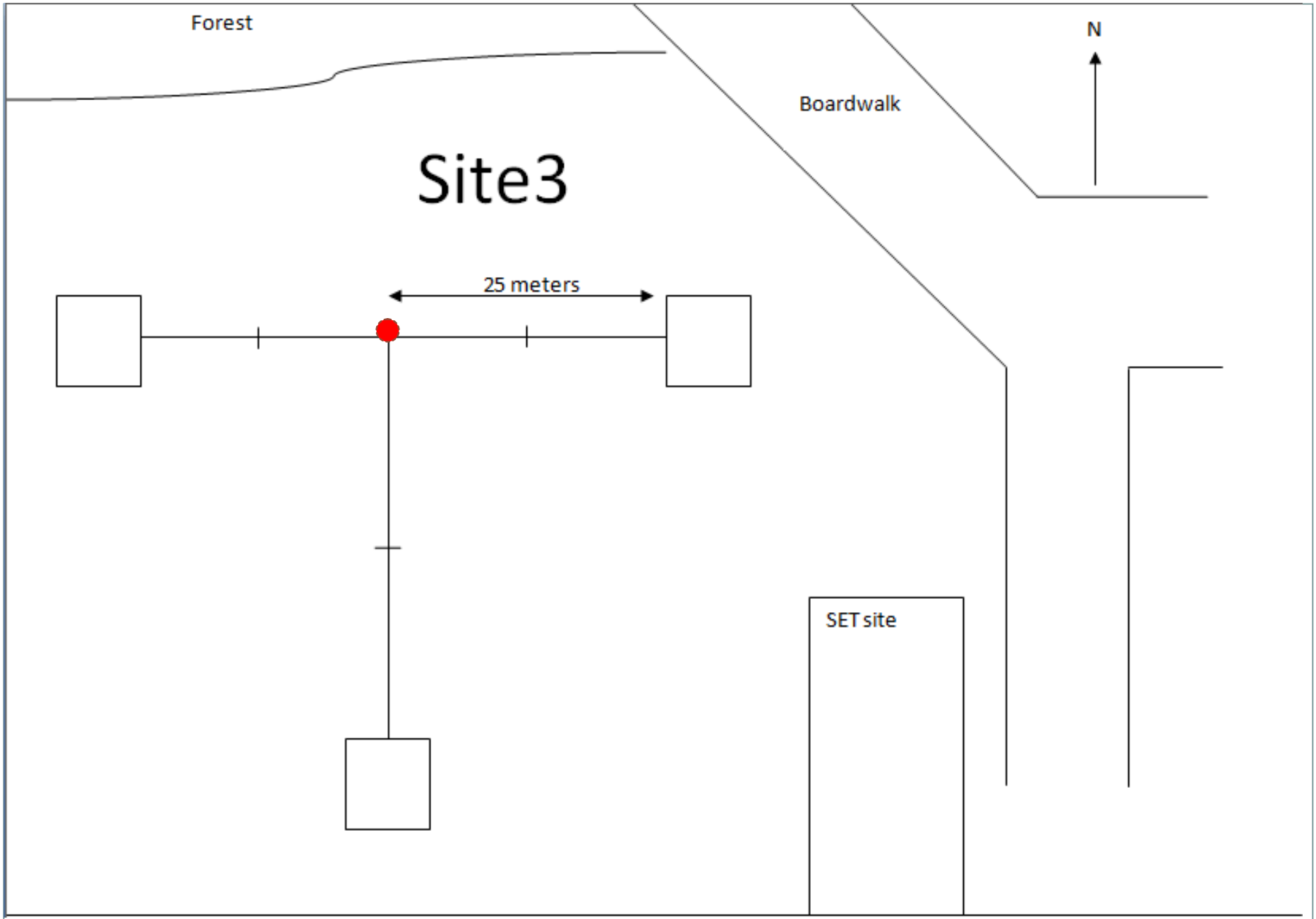
Rehoboth Bay

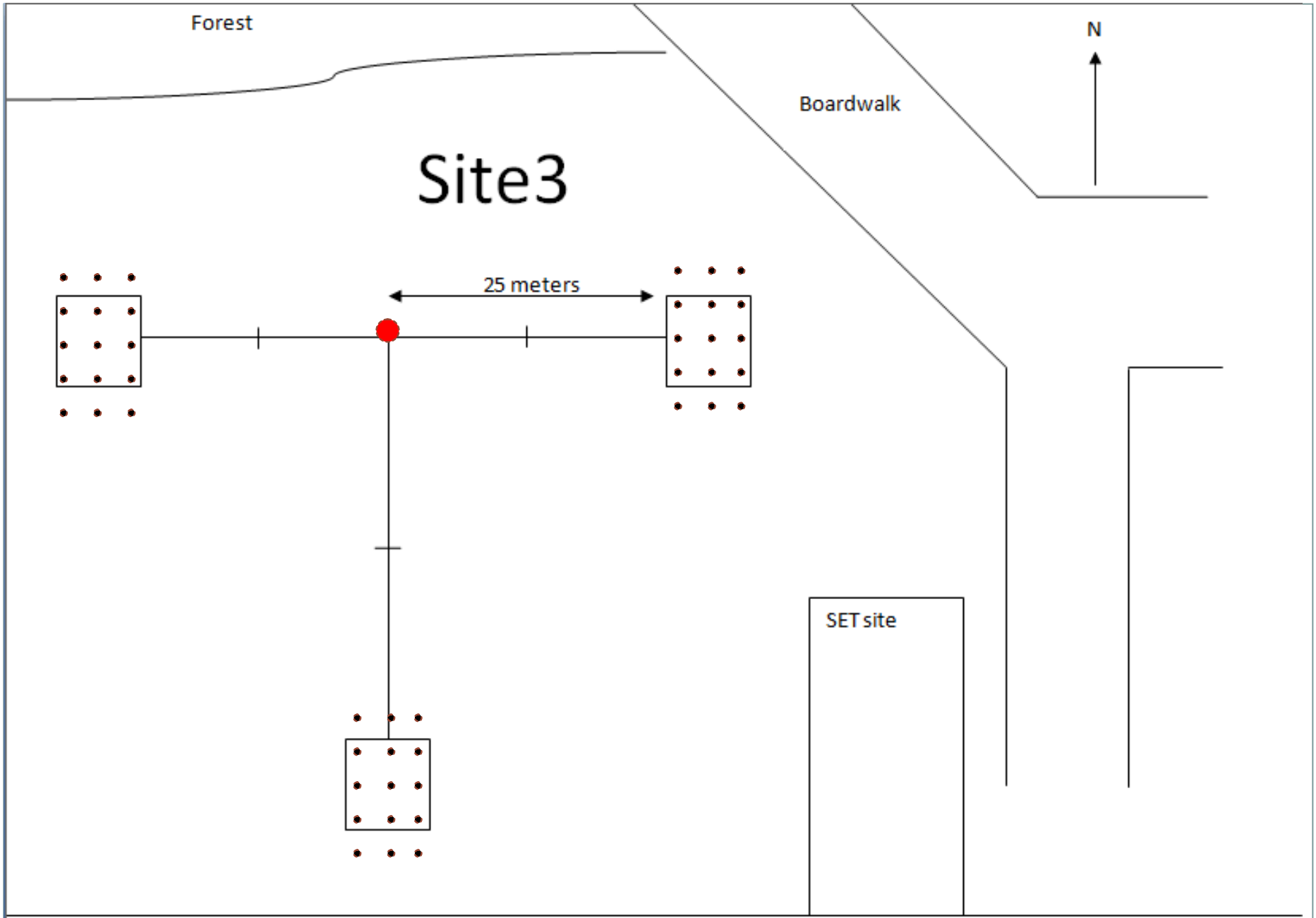


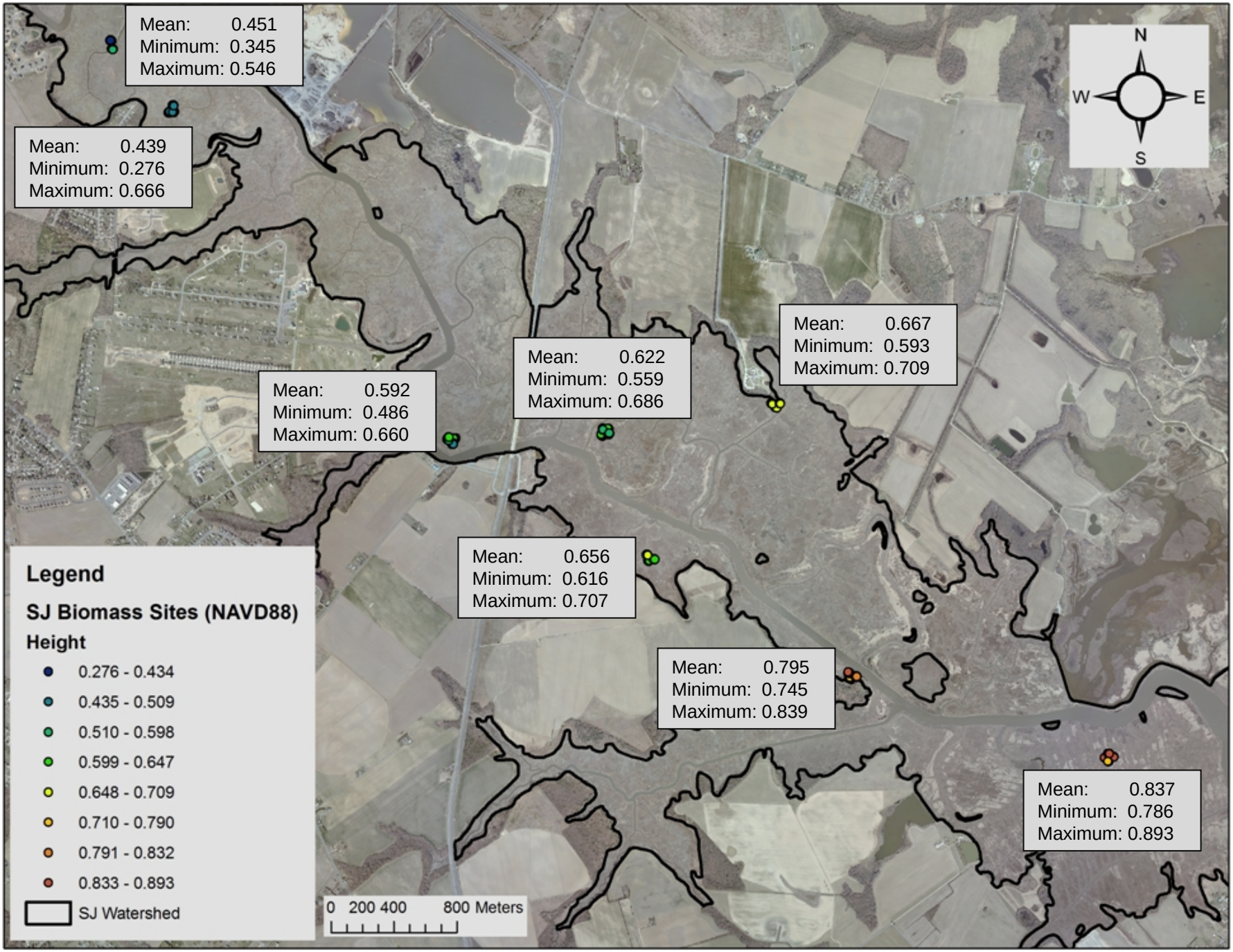


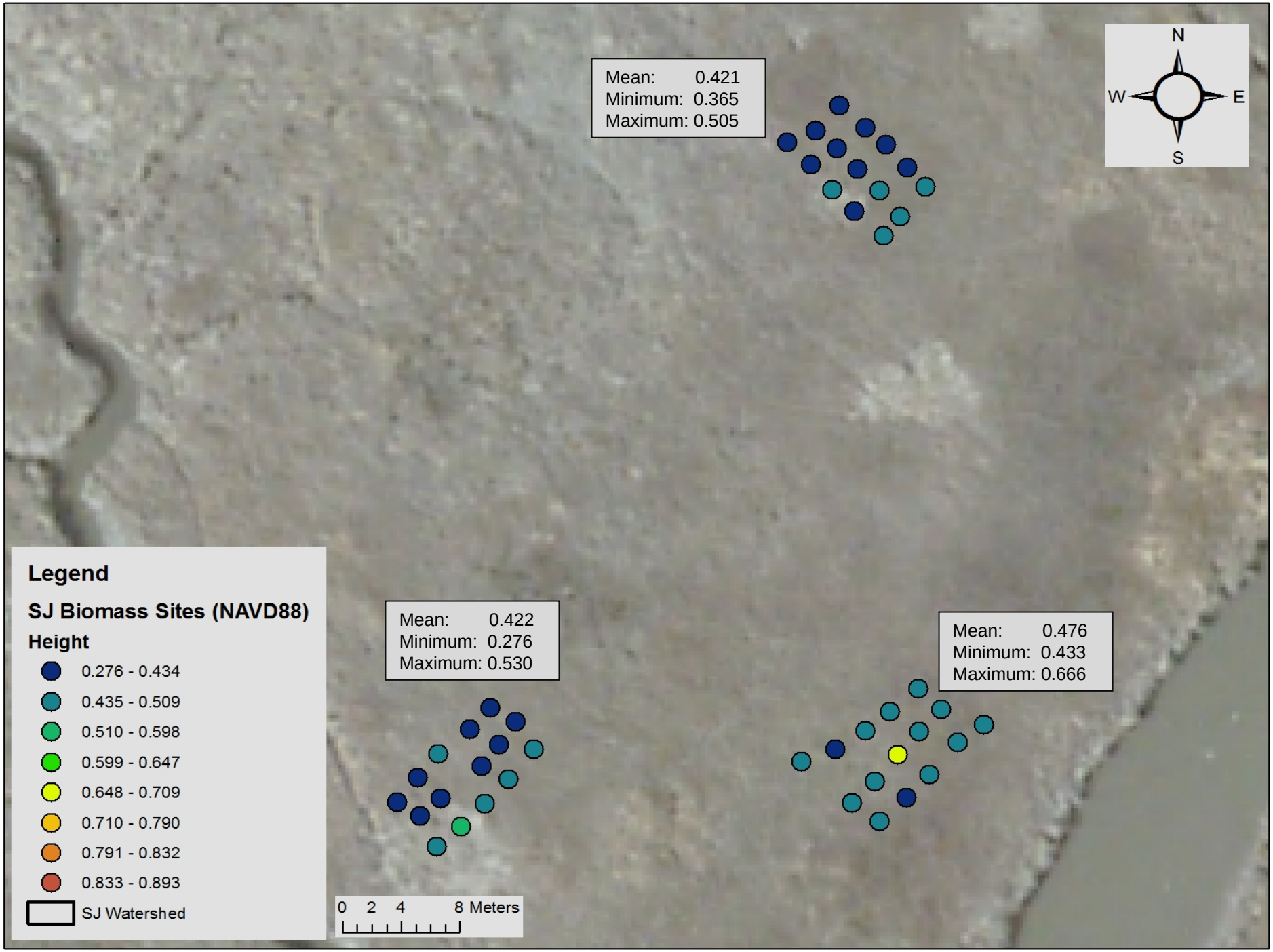
Elevation	MidTRAM	SETs/Elevation	Random (Hawth)	Totals	**4 additional sites fell on the border of 2 ranges.**
0.5-1.6				0	
1.6-2.1	1	2		3	One btwn (1.6-2.1) and (2.1-2.5)
2.1-2.5	3		2	5	One between (2.1-2.5) and (2.5-2.75)
2.5-2.75	1	2	1	4	
2.75-3.0	2		1	3	One between (2.75-3.0) and(3.0-3.5)
3.0-3.5	4	1		5	
3.5-4.0	1	2		3	One between (3.5-4.0) and (4.0-4.5)
4.0-4.5				0	
4.5+				0	

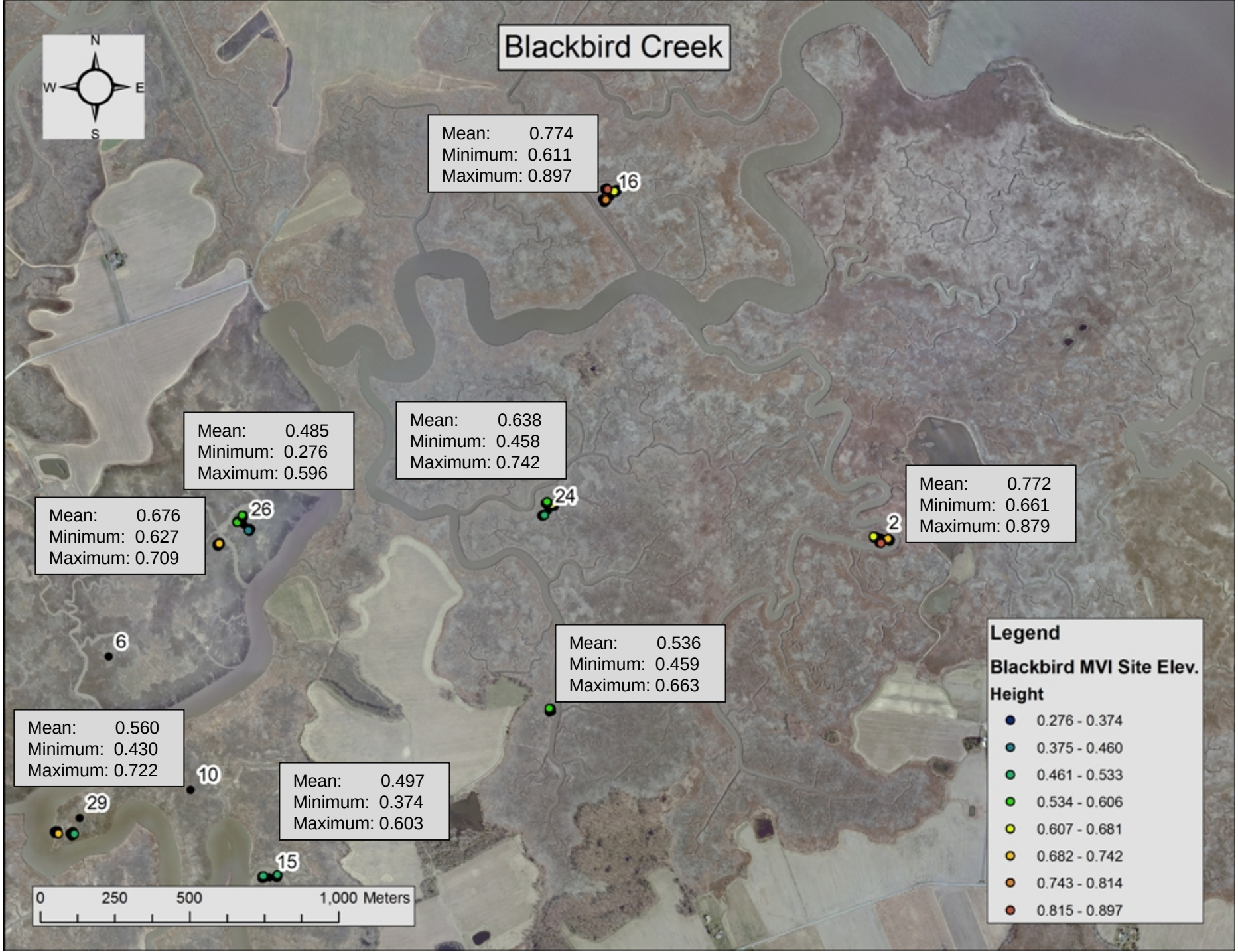

Blackbird Creek
N
W
E
S
Legend
ele_0.0-0.5
ele_0.5-1.0
ele_1.0-1.25
ele_1.25-2.0
ele_2.0-3.0
ele_3.0-3.5
ele_3.5-4.0
ele_greater_4.0
0
75
150
300 Meters

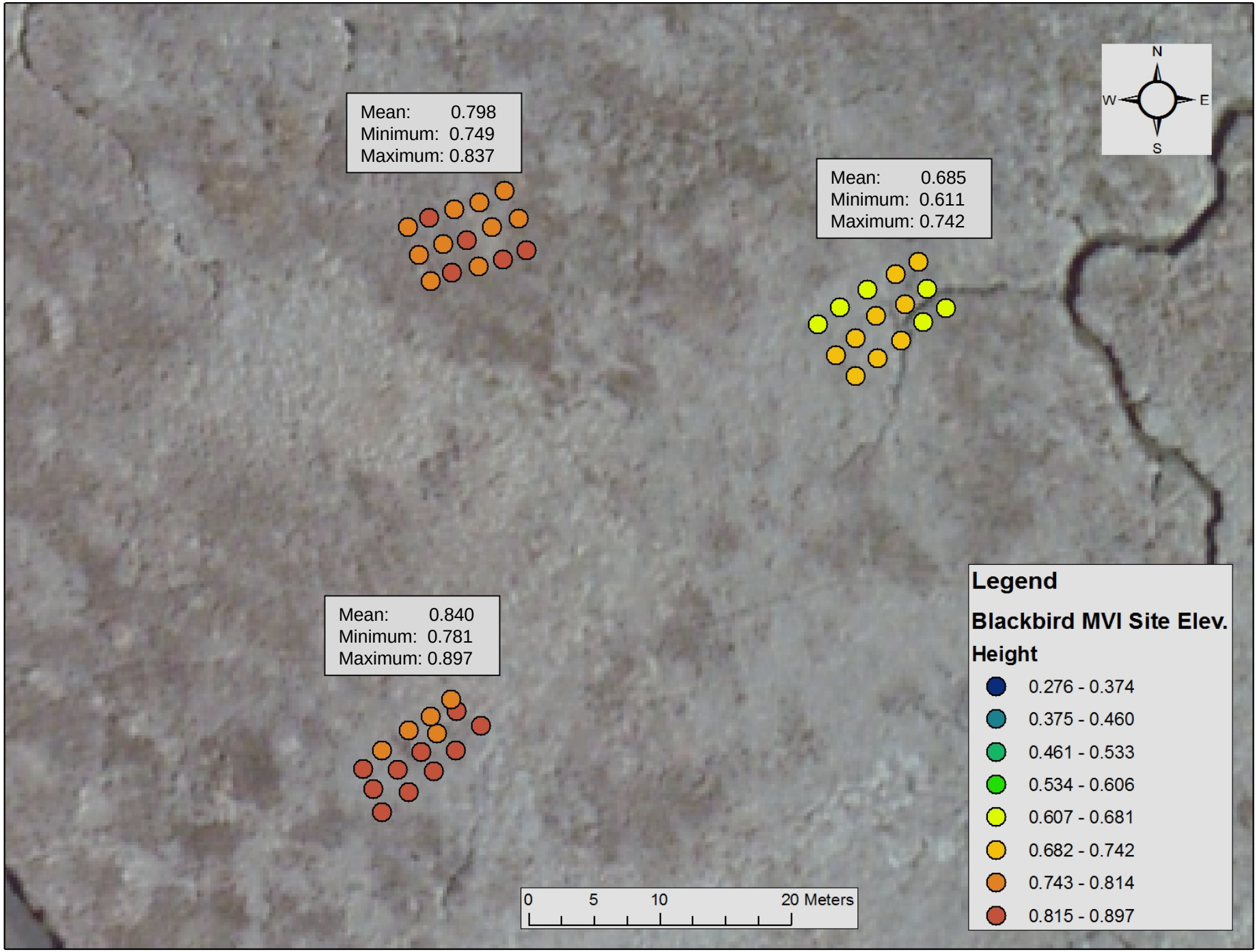

Forest
N
Boardwalk
Site3
25 meters
SET site

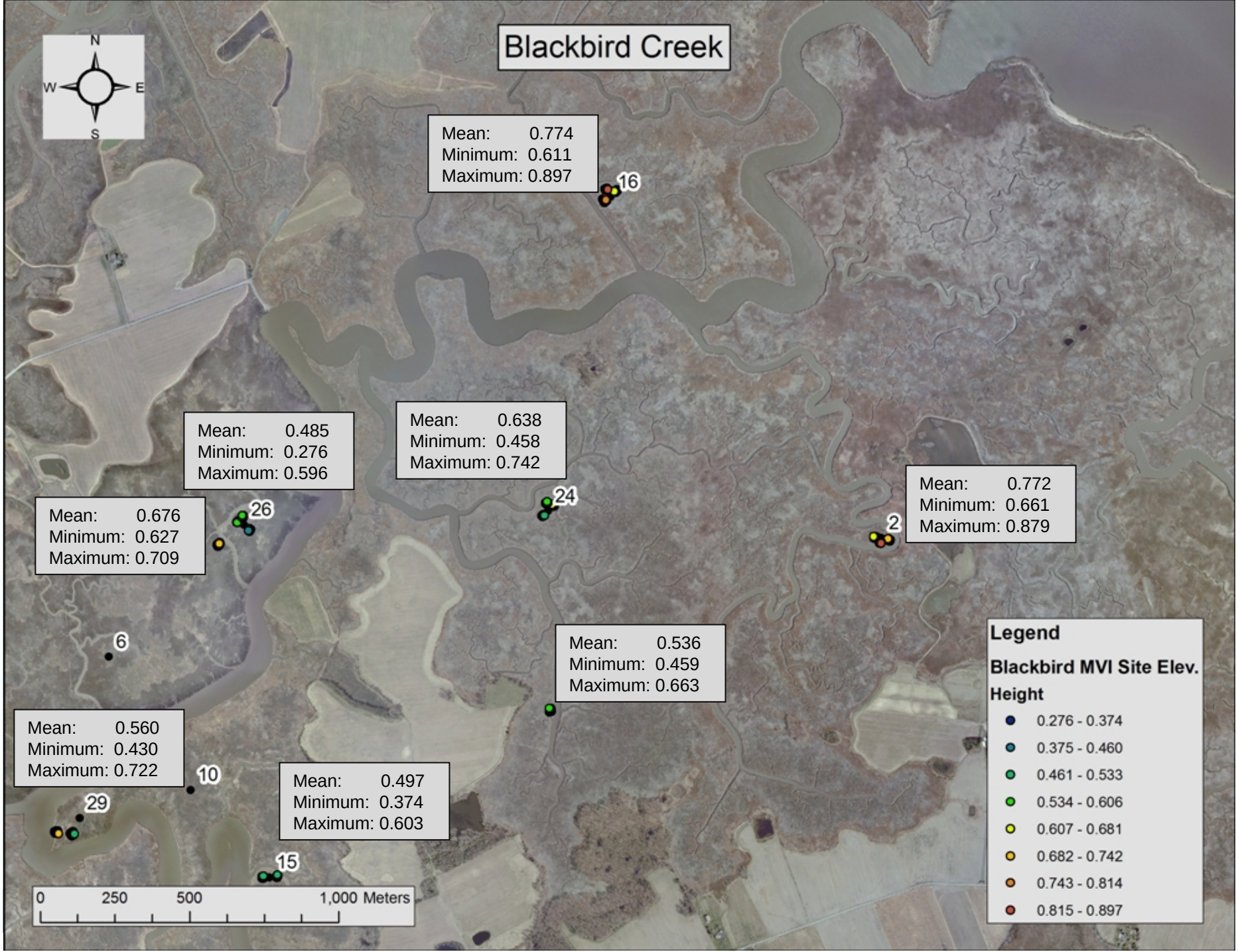

Forest
N
Boardwalk
Site3
25 meters
SET site

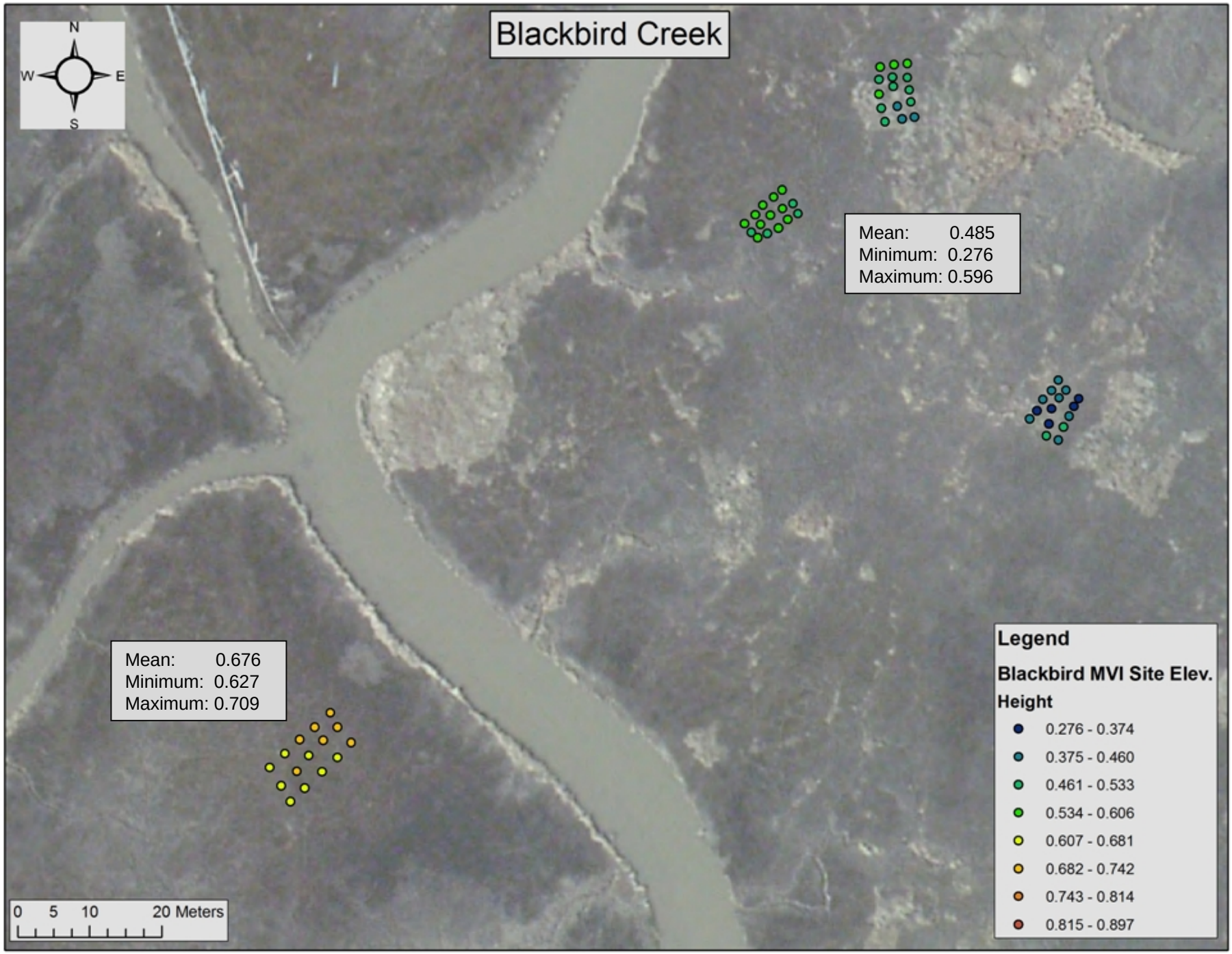

Mean: 0.451
Minimum: 0.345
Maximum: 0.546
Mean: 0.439
Minimum: 0.276
Maximum: 0.666
Mean: 0.592
Minimum: 0.486
Maximum: 0.660
Mean: 0.622
Minimum: 0.559
Maximum: 0.686
Mean: 0.667
Minimum: 0.593
Maximum: 0.709
Mean: 0.656
Minimum: 0.616
Maximum: 0.707
Mean: 0.795
Minimum: 0.745
Maximum: 0.839
Mean: 0.837
Minimum: 0.786
Maximum: 0.893
N
W
E
S
Legend
SJ Biomass Sites (NAVD88)
Height
0.276 - 0.434
0.435 - 0.509
0.510 - 0.598
0.599 - 0.647
0.648 - 0.709
0.710 - 0.790
0.791 - 0.832
0.833 - 0.893
SJ Watershed
0 200 400 800 Meters

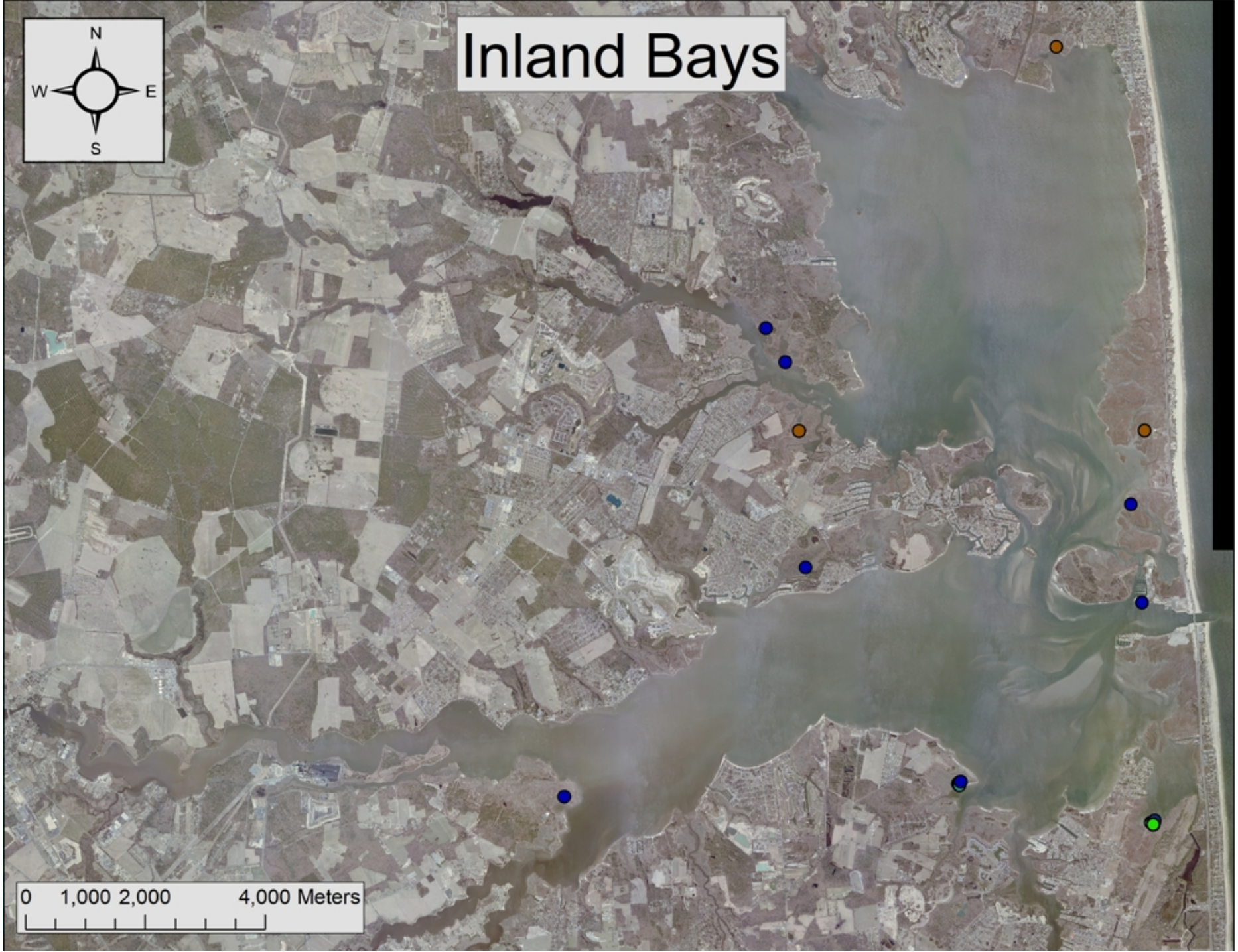

Mean: 0.421
Minimum: 0.365
Maximum: 0.505
N
W
E
S
Legend
SJ Biomass Sites (NAVD88)
Height
0.276 - 0.434
0.435 - 0.509
0.510 - 0.598
0.599 - 0.647
0.648 - 0.709
0.710 - 0.790
0.791 - 0.832
0.833 - 0.893
SJ Watershed
Mean: 0.422
Minimum: 0.276
Maximum: 0.530
Mean: 0.476
Minimum: 0.433
Maximum: 0.666
0 2 4 8 Meters

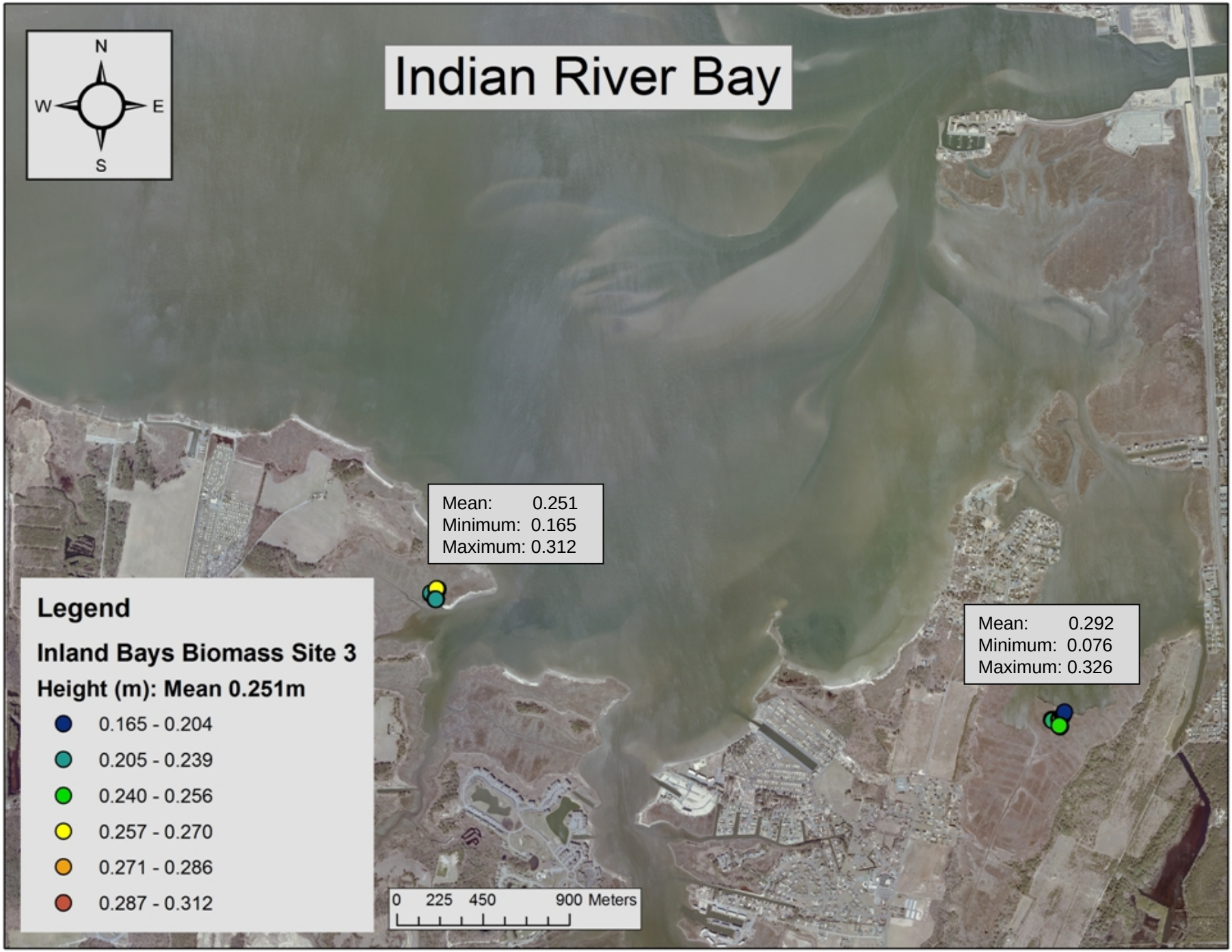

Blackbird Creek
N
W
E
S
Mean: 0.774
Minimum: 0.611
Maximum: 0.897
16
Mean: 0.485
Minimum: 0.276
Maximum: 0.596
Mean: 0.638
Minimum: 0.458
Maximum: 0.742
Mean: 0.676
Minimum: 0.627
Maximum: 0.709
26
24
Mean: 0.772
Minimum: 0.661
Maximum: 0.879
2
6
Mean: 0.536
Minimum: 0.459
Maximum: 0.663
Mean: 0.560
Minimum: 0.430
Maximum: 0.722
10
29
Mean: 0.497
Minimum: 0.374
Maximum: 0.603
15
0 250 500 1,000 Meters
Legend
Blackbird MVI Site Elev.
Height
0.276 - 0.374
0.375 - 0.460
0.461 - 0.533
0.534 - 0.606
0.607 - 0.681
0.682 - 0.742
0.743 - 0.814
0.815 - 0.897

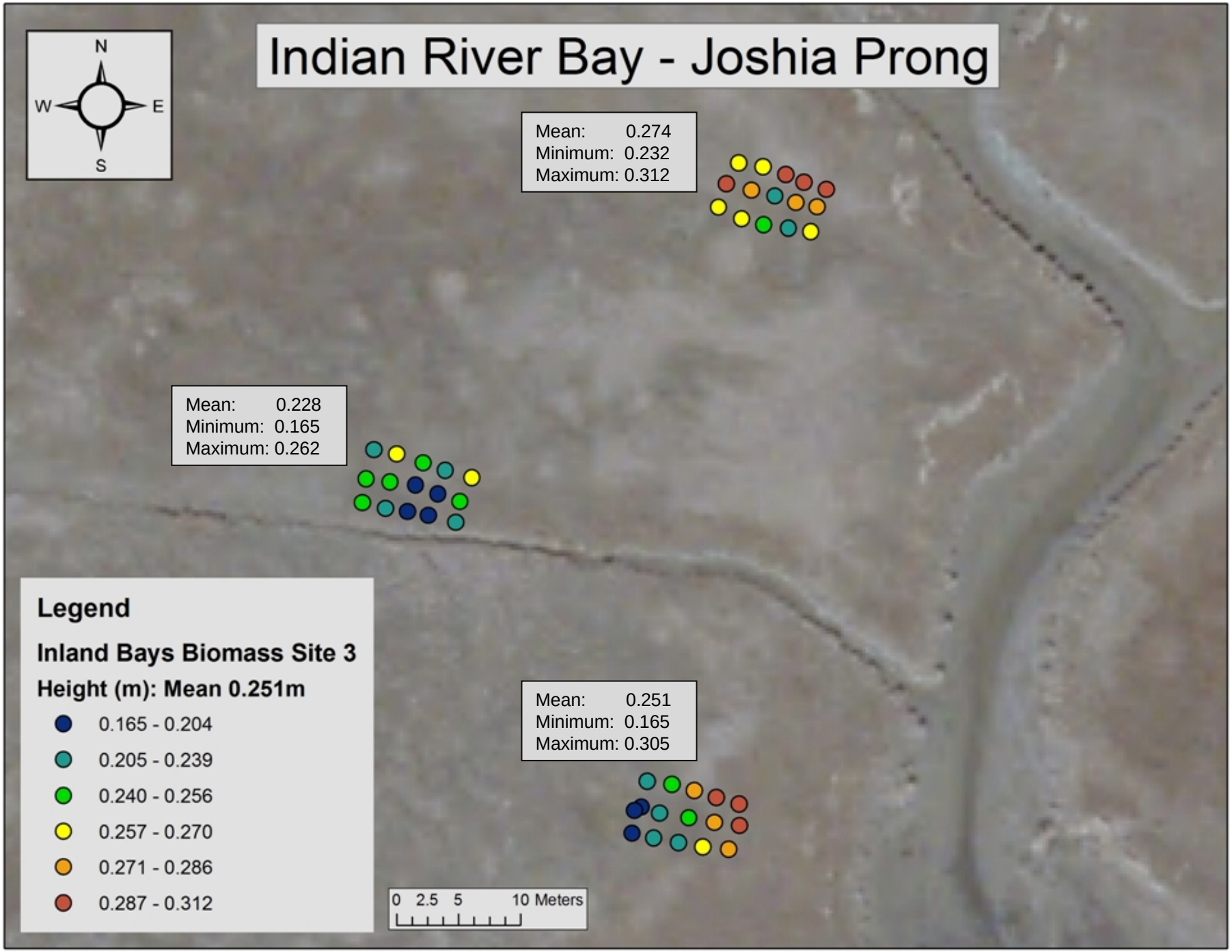

Mean: 0.798
Minimum: 0.749
Maximum: 0.837
Mean: 0.685
Minimum: 0.611
Maximum: 0.742
Mean: 0.840
Minimum: 0.781
Maximum: 0.897
N
W
E
S
Legend
Blackbird MVI Site Elev.
Height
0.276 - 0.374
0.375 - 0.460
0.461 - 0.533
0.534 - 0.606
0.607 - 0.681
0.682 - 0.742
0.743 - 0.814
0.815 - 0.897
0
5
10
20 Meters


Blackbird Creek
N
W
E
S
Mean: 0.774
Minimum: 0.611
Maximum: 0.897
16
Mean: 0.485
Minimum: 0.276
Maximum: 0.596
Mean: 0.638
Minimum: 0.458
Maximum: 0.742
Mean: 0.676
Minimum: 0.627
Maximum: 0.709
26
24
Mean: 0.772
Minimum: 0.661
Maximum: 0.879
2
6
Mean: 0.536
Minimum: 0.459
Maximum: 0.663
Mean: 0.560
Minimum: 0.430
Maximum: 0.722
10
29
Mean: 0.497
Minimum: 0.374
Maximum: 0.603
15
0 250 500 1,000 Meters
Legend
Blackbird MVI Site Elev.
Height
0.276 - 0.374
0.375 - 0.460
0.461 - 0.533
0.534 - 0.606
0.607 - 0.681
0.682 - 0.742
0.743 - 0.814
0.815 - 0.897


Blackbird Creek
N
W
E
S
Mean: 0.485
Minimum: 0.276
Maximum: 0.596
Mean: 0.676
Minimum: 0.627
Maximum: 0.709
Legend
Blackbird MVI Site Elev.
Height
0.276 - 0.374
0.375 - 0.460
0.461 - 0.533
0.534 - 0.606
0.607 - 0.681
0.682 - 0.742
0.743 - 0.814
0.815 - 0.897
0 5 10 20 Meters


Inland Bays
N
W
E
S
0 1,000 2,000 4,000 Meters


Indian River Bay
N
W
E
S
Mean: 0.251
Minimum: 0.165
Maximum: 0.312
Mean: 0.292
Minimum: 0.076
Maximum: 0.326
Legend
Inland Bays Biomass Site 3
Height (m): Mean 0.251m
0.165 - 0.204
0.205 - 0.239
0.240 - 0.256
0.257 - 0.270
0.271 - 0.286
0.287 - 0.312
0 225 450 900 Meters


Indian River Bay - Joshia Prong
N
W
E
S
Mean: 0.274
Minimum: 0.232
Maximum: 0.312
Mean: 0.228
Minimum: 0.165
Maximum: 0.262
Mean: 0.251
Minimum: 0.165
Maximum: 0.305
Legend
Inland Bays Biomass Site 3
Height (m): Mean 0.251m
0.165 - 0.204
0.205 - 0.239
0.240 - 0.256
0.257 - 0.270
0.271 - 0.286
0.287 - 0.312
0 2.5 5 10 Meters

BiomassWorkSheet-SJ [Compatibility Mode] - Microsoft Excel

Home Insert Page Layout Formulas Data Review View

Paste Cut Copy Format Painter Clipboard | Calibri 11 Font | Wrap Text Merge & Center Alignment | General Number | Conditional Formatting Format as Table Cell Styles Styles | Insert Delete Format Cells | AutoSum Fill Clear Sort & Filter Find & Select Editing

AB30

Below Ground Data

Site	Above ground	Below ground	Dead	Live	Plot #	Top	Bottom	Final Weight (0.00g)
SJ0002		x	x		1	x		140.66
SJ0002		x	x		2	x		37.98
SJ0002		x	x		3	x		108.49
SJ0002		x		x	1	x		13.34
SJ0002		x		x	2	x		18.19
SJ0002		x		x	3	x		15.73
SJ0003		x	x		1	x		105.27
SJ0003		x	x		2	x		109.95
SJ0003		x	x		3	x		63.31
SJ0003		x		x	1	x		14.03
SJ0003		x		x	2	x		15.50
SJ0003		x		x	3	x		28.31
SJ0004		x	x		1	x		92.59
SJ0004		x	x		2	x		118.50
SJ0004		x	x		3	x		117.27
SJ0004		x		x	1	x		22.93
SJ0004		x		x	2	x		21.48
SJ0004		x		x	3	x		21.83
SJ0006		x	x		1	x		58.66
SJ0006		x	x		2	x		83.59
SJ0006		x	x		3	x		78.31
SJ0006		x		x	1	x		22.65
SJ0006		x		x	2	x		6.35
SJ0006		x		x	3	x		17.80
SJ0010		**x**	**x**		**1**	**x**		**157.26**
SJ0010		**x**	**x**		**2**	**x**		**174.26**
SJ0010		**x**	**x**		**3**	**x**		**50.52**
SJ0010		**x**		**x**	**1**	**x**		**20.85**
SJ0010		**x**		**x**	**2**	**x**		**13.68**
SJ0010		**x**		**x**	**3**	**x**		**20.29**
SJ0011		x	x		1	x		44.03
SJ0011		x	x		2	x		99.82
SJ0011		x	x		3	x		132.98
SJ0011		x		x	1	x		6.46
SJ0011		x		x	2	x		8.48
SJ0011		x		x	3	x		18.00
SJ0002		x	x		1		x	123.95
SJ0002		x	x		2		x	36.33
SJ0002		x	x		3		x	59.01
SJ0002		x		x	1		x	0.39
SJ0002		x		x	2		x	3.44
SJ0002		x		x	3		x	0.26
SJ0003		x	x		1		x	83.47

Below Ground - ALL	
All	
Average	47.05
Standard Deviation	46.7772
Variance	2188.1
Median	22.79
Dead	
Average	82.85
Standard Deviation	35.9352
Variance	1291.34
Median	83.59
Live	
Average	9.08
Standard Deviation	8.92656
Variance	79.6835
Median	5.97
Top 15 Combined	
Average	57.76
Standard Deviation	49.5805
Variance	2458.23
Median	33.15
Top 15 Dead	
Average	95.07
Standard Deviation	37.0463
Variance	1372.43
Median	99.82
Top 15 Live	
Average	16.77
Standard Deviation	6.04965
Variance	36.5982
Median	17.80
Bottom 15 Combined	
Average	37.34
Standard Deviation	41.9313
Variance	1758.23
Median	10.75
Bottom 15 Dead	

SJ0002	
All	
Average	46.48
Standard Deviation	50.458
Variance	2546.01
Dead	
Average	84.40
Standard Deviation	45.6507
Variance	2083.98
Live	
Average	8.56
Standard Deviation	8.10984
Variance	65.7695
Top 15 Combined	
Average	55.73
Standard Deviation	54.9872
Variance	3023.59
Top 15 Dead	
Average	95.71
Standard Deviation	52.5194
Variance	2758.29
Top 15 Live	
Average	15.75
Standard Deviation	2.42508
Variance	5.88103
Bottom 15 Combined	
Average	37.23
Standard Deviation	48.7058
Variance	2372.25
Bottom 15 Dead	

SJ0003	
All	
Average	50.14
Standard Deviation	43.71
Variance	1910.57
Dead	
Average	89.95
Standard Deviation	16.6804
Variance	278.236
Live	
Average	10.32
Standard Deviation	11.0038
Variance	121.084
Top 15 Combined	
Average	56.06
Standard Deviation	43.7265
Variance	1912
Top 15 Dead	
Average	92.84
Standard Deviation	25.6834
Variance	659.639
Top 15 Live	
Average	19.28
Standard Deviation	7.85467
Variance	61.6959
Bottom 15 Combined	
Average	44.21
Standard Deviation	46.9781
Variance	2206.94
Bottom 15 Dead	

SJ 0004	
All	
Average	5
Standard Deviation	46.8
Variance	219
Dead	
Average	9
Standard Deviation	28.7
Variance	827
Live	
Average	1
Standard Deviation	11.5
Variance	134
Top 15 Combined	
Average	6
Standard Deviation	48.7
Variance	237
Top 15 Dead	
Average	10
Standard Deviation	14
Variance	213
Top 15 Live	
Average	2
Standard Deviation	0.75
Variance	0.5
Bottom 15 Combined	
Average	3
Standard Deviation	44.3
Variance	197
Bottom 15 Dead	

SJ Midtram Summary | Combined-raw | Combined Summary | Site Analysis-DCP | Site Analysis-MidTRAM

Overview

- Collect biomass samples throughout three watersheds
- Sort biomass and separate dead and alive plant matter
- Create a correlation between biomass results, tidal datum, and elevation data
- Use elevation data to correct error of vegetation in LiDAR

Acknowledgements

- **Christopher Bason [2]**
- **Amy Deller Jacobs [3]**
- **Andy Howard [3]**
- **Alison B. Rogerson[3]**
- **Gabrielle Lyons[1]**
- **Lara R. Allison[3]**

- 1. DNREC, Delaware Coastal Programs
- 2. Delaware Center for the Inland Bays
- 3. DNREC, Watershed Assessment Section