D09 FIU Site Characterization
Supporting Data

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1 DESCRIPTION

1.1 Purpose

Data collected, analyzed and described here are used to inform the site design activities for NEON project Teams: EHS (permitting), FCC, ENG and FSU. This report was made based on actual site visit to the 3 NEON sites in Domain 09. This document presents all the supporting data for FIU site characterization at D09.

1.2 Scope

FIU site characterization data and analysis results presented in this document are for the three D09 tower locations: Woodworth (Advanced), Dakota Coteau Field School Relocatable site (DCFS; Relocatable 1), and Northern Great Plains Research Laboratory Relocatable site (NGPRL, Relocatable 2). Issues and concerns for each site that need to be in focus are also addressed in this document according to our best knowledge.

Disclaimer: all latitude and longitude points are subject to the tolerances of our measurement system, i.e., GPS.

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Applicable Documents

AD[01]	NEON.DOC.011008 _ FIU Tower Design Science Requirements
AD[02]	NEON.DOC.011000 _ FIU Technical and Operation Requirements
AD[03]	
AD[04]	NEON.DOC.011029 _ FIU Precipitation Collector Site Design Requirements

2.2 Reference Documents

RD[01]	NEON.DOC.000008	NEON Acronym List
RD[02]	NEON.DOC.000243	NEON Glossary of Terms
RD[03]		
RD[04]		

2.3 Acronyms

2.4 Verb Convention

"Shall" is used whenever a specification expresses a provision that is binding. The verbs "should" and "may" express non-mandatory provisions. "Will" is used to express a declaration of purpose on the part of the design activity.

3 WOODWORTH (ADVANCED TOWER SITE)

3.1 Site description

NEON Woodworth candidate advanced tower site (47.127611°, -99.240108°) was located within Woodworth Field Station property (Figure 1). After FIU site characterization, we microsited the tower location for ~100 m toward west at 47.12802°, -99.24133° to maximize the tower fetch area within the property boundary and same management unit.

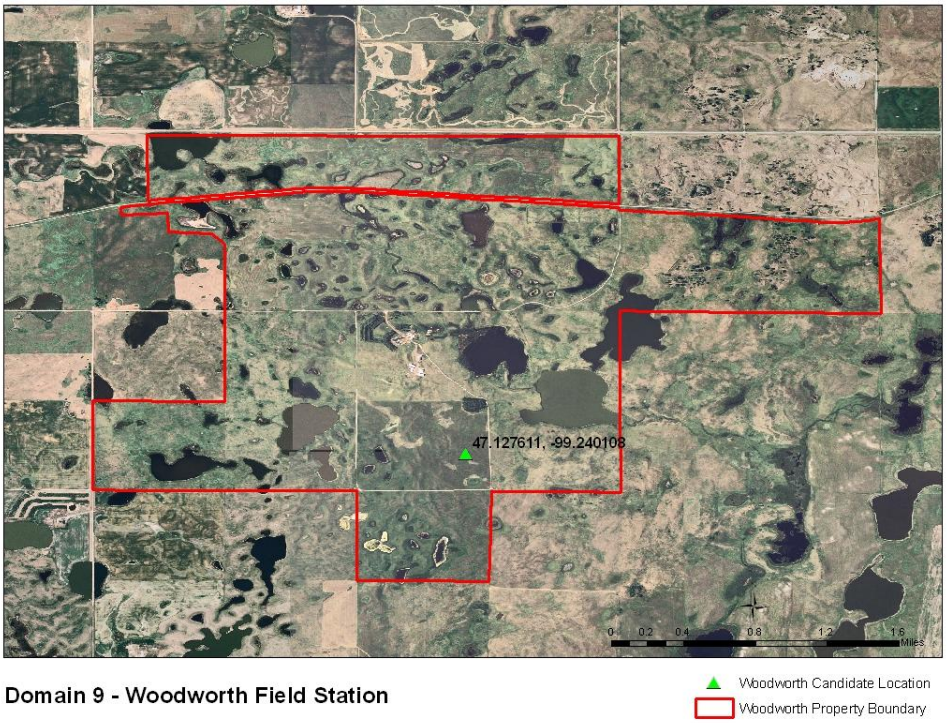


Figure 1. NEON candidate site tower location and boundary map

The Woodworth Field Station is located about 65 km (40 miles) NW of Jamestown, just east of Woodworth, ND, in the heart of the Missouri Coteau, on a 2,651-acre Waterfowl Production Area dedicated to research by the U.S. Fish and Wildlife Service. The Station has a dormitory-laboratory, a storage building, and a gas building. The land is owned by the U.S. Fish and Wildlife Service; while these buildings are owned by the U.S. Geological Survey. The Station is maintained throughout the year but only used from spring to fall. The Station has a 10-acre enclosure with an observation tower which has been used for research of carnivore behavior (Info source: http://www.npwrc.usgs.gov/about/facility.htm).

Info below is from USGS web http://www.npwrc.usgs.gov/resource/birds/wpwood/study.htm:

Management: Since 1969, the station has been used for studying the response of wildlife to applied treatments of grazing, burning, idling, and annual cropping.
Soil: The major soil association of the area is Buse-Barnes (Omodt et al. 1968; Patterson et al. 1968). This association occurs on hilly to rolling and undulating topography with pothole depressions common

between hills, knobs, and ridges. This association has no major stream drainage. Surface runoff flows into many pothole depressions that are usually inundated for several weeks or longer in spring and summer. Svea, Renshaw, Fordville, Sioux, Parnell, Colvin, and Tetonka soils also occur in this association. Svea soils occur on the concave side slopes and foot slopes of the knolls and hills. Renshaw, Fordville, and Sioux soils occur on small areas of outwash. Renshaw soils are moderately deep and Sioux soils are shallow over a gravel substratum. Parnell, Colvin, and Tetonka are the main soils found in wetland basins on the area.

Climate: The continental climate of this area is characteristic of much of the northern Great Plains, having a low precipitation-high evaporation ratio and cold winters-warm summers. The average number of clear days between sunrise and sunset is 112 per year. Average depth of frost penetration is 1.5 m and the extreme is 2 m. Average relative humidity is 68%. Several studies have shown that for the past few hundred years, the northern grasslands have occupied their present areas with rather arid weather conditions.

Precipitation: Precipitation records indicate that total annual precipitation varied from a low of 23 cm in 1967 to a high of 58 cm in 1965. Mean annual precipitation for the years 1964-81 was 41 cm and the long-term (>50 years) mean annual for the vicinity was 44 cm. Precipitation is nearly always in the form of snow during winter. The first substantial rains of spring usually occur in early April, but sometimes in late March. Precipitation is greatest during summer, usually peaking in June. Precipitation amounts decrease rapidly throughout the fall, and the first significant snowfall usually occurs in late November. Average mean annual snowfall is 86 cm for the study area. Mean date of first 2.5 cm or more of snow depth is 5 December and the mean date of last 2.5 cm of snow cover in spring is 25 March.

Temperature: Mean annual temperature for the vicinity is 4°C. January is the coldest month and July is the warmest. The extreme high temperature for the vicinity was 48°C and the extreme low -58°C. Mean length of freeze-free days is 120 and usually occurs between 20 May and 15 September. Local topography of the area affects temperature in two ways. First, this area, on the eastern edge of the Missouri Coteau, is higher than surrounding physiographic regions. Temperatures on this area are usually from 1 to 3°C colder for this reason. Second, colder air accumulates in pothole depressions, often causing temperatures there to be several degrees colder than nearby uplands.

Wind: The prevailing wind flow is from the northwest with an average daily speed of 16 km/h. Winds are usually sustained strong breezes rather than occasional gales. Wind speeds are usually highest during the afternoon and lowest at night. At wetland sites, winds of 40-48 km/h often last for 6 h and have been known to last for as long as 15 h. Winds of more than 48 km/h have been observed to last longer than 6 h. Wind is an important factor affecting evapotranspiration rates on wetlands as well as on uplands.

Climate info below is for Jamestown from http://weather-warehouse.com/WeatherHistory/PastWeatherData_JamestownStateHospital_Jamestown_ND_January.html , we assume this info is also similar to the weather at our NEON site.

Year	Lowest temp	Highest temp	Warmest min temp	Coldest max temp	Average min temp	Average max temp	Mean temp	Total ppt	Total snowfall	Max 24hr ppt	Max 24hr snowfall
	(F)	(F)	(F)	(F)	(F)	(F)	(F)	(In)	(In)	(In)	(In)
2010	-30	42	29	-11	0.6	15.5	8.1	0.73	13	0.4	7
2009	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
2008	-23	41	17	-9	-2.7	17.5	7.4	0.08	0.5	0.03	0.5
2007	-23	50	33	-8	0.6	21.7	11.2	0.05	1.5	0.04	1

2006	2	42	32	21	19.7	31.1	25.4	0.13	1	0.04	1
2005	-23	41	24	-8	-4.7	14.8	5.1	0.75	7.8	0.37	3
2004	-28	38	16	-21	-5.5	12.4	3.5	0.58	11	0.23	5
2003	-23	42	34	2	-0.1	20.2	10.1	0.35	8.2	0.13	3
2002	-12	48	33	5	8	25.5	16.8	0.21	2	0.11	1
2001	-25	44	25	4	6.7	26.5	16.6	0.12	3	0.12	3
2000	-14	40	24	5	3.9	22.3	13.1	0.06	4	0.03	1.5
1999	-23	42	26	-7	-0.7	14.7	7	1.11	19.9	0.42	5
1998	-17	43	25	-6	4.9	18.4	11.6	0.49	4.9	0.2	1.5
1997	-28	41	28	-15	-6.2	11	2.4	0.94	10.8	0.52	4
1996	-27	43	32	-15	-7.3	10	1.4	0.64	14.1	0.2	6
1995	-15	40	29	3	3.5	17.4	10.5	0.28	5.5	0.13	2
1994	-32	31	10	-18	-10.3	4.3	-3	1.18	19.5	0.3	7
1993	-22	41	34	-5	-0.8	18.2	8.7	0.81	11	0.3	5
1992	-16	45	33	6	10	30.5	20.2	0.32	8.5	0.16	4
1991	-20	43	21	-4	-0.5	19.4	9.5	0.2	2	0.15	2
1990	-8	52	33	4	15.4	32.8	24.1	0.15	1.2	0.1	1.2
1989	-23	44	27	-11	3.3	25.9	14.6	1.53	22	0.5	6
1988	-26	42	28	-5	-3.2	18.4	7.6	0.93	14	0.25	3
1987	-22	47	31	0	10.6	26.4	18.5	0.1	4	0.08	2
1986	-23	43	32	0	9.4	23.4	16.4	0.2	3	0.08	1
1985	-34	33	18	-10	-5.5	15.3	4.9	0.22	3	0.12	2

3.2 Ecosystem

Vegetation and land cover information at surrounding region are presented below:

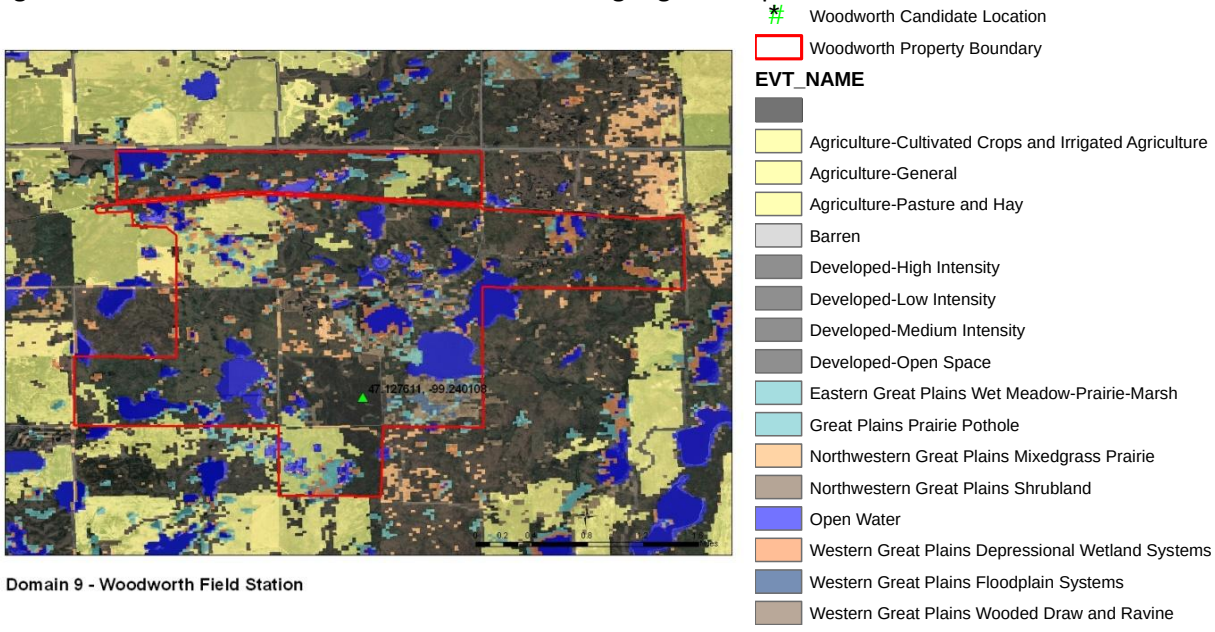


Figure 2. Vegetative cover map of Woodworth and surrounding areas (information is from USGS, http://landfire.cr.usgs.gov/viewer/viewer.htm).

Table 1. Percent Land cover type at Woodworth site
(information is from USGS, http://landfire.cr.usgs.gov/viewer/viewer.htm)

Vegetation Type	Area (km^2)	Percent
No Data	5.77	54.31
Agriculture-Cultivated Crops and Irrigated Agriculture	0.45	4.26
Agriculture-General	0.15	1.41
Agriculture-Pasture and Hay	0.38	3.59
Developed-Low Intensity	0.01	0.11
Developed-Open Space	0.20	1.85
Eastern Great Plains Wet Meadow-Prairie-Marsh	0.34	3.24
Great Plains Prairie Pothole	0.18	1.70
Northwestern Great Plains Mixedgrass Prairie	0.15	1.43
Open Water	1.43	13.47
Western Great Plains Depressional Wetland Systems	0.72	6.76
Western Great Plains Floodplain Systems	0.10	0.97
Western Great Plains Wooded Draw and Ravine	0.73	6.90
Total Area sq km	10.63	100.00

According to the previous study, the area was about 85% grasslands and 15% croplands and Upland Sandpipers nested mainly on the grasslands. The unplowed grassland is mixed-grass prairie with native dominants of *Agropyron trachycaulum, Koeleria cristata, Stipa comata* and *S. viridda.* This grassland is heavily infested with two shrubs, *Symphoricarpus occidentalis* and *Elaeagnus argentea* and invaded by exotic cool-season grasses such as *Poa pratensis, Bromus inermis* and *Agropyron repens*. The plowed grassland has been seeded with various grasses such as *Agropyron intermedium, A. elongatum, A. cristatum*, plus alfalfa (*Medicago sativa*) and sweet clover (*MeGlotus sp.*). Vegetation commonly used as nesting cover by Upland Sandpipers in this area was reported by Higgins et al. (info source: http://elibrary.unm.edu/sora/Wilson/v087n01/p0096-p0102.pdf)

The ecosystem around and in the NEON tower airshed at this site is an old field being restored to native prairie. It has been re-seeded with native plant species once, and this may be done again in the near future. Roundup herbicide was applied at the onset of the restoration activities. Evidence of plowing, piles rocks in the field, and the application of roundup herbicide all indicate this field was previously cultivated. Bare ground counts for 60%-70% ground coverage at this field. But the bare ground could dramatically reduce after NEON construction at this site due to re-seeding. Many forbs and grass seedlings are present, which are probably native species germinating following re-seeding. This ecosystem is not a wildland Pothole Prairie, but instead a regenerating prairie. Neil Shook said that unplowed native prairie does exist at Woodworth, Wei Lin explained that those sites were not chosen because they were too close to trees. Soil contains a lot of rocks (~2 cm in diameter). Some larger cobbles are also present. Prescribed burns and grazing management types may apply in the future. Re-seeding and roundup treatment may be used again as part of the site management.

The restored native prairie is the representative ecosystem that NEON design is focused on at this site (Figure 3). Further investigation is needed to determine the species. Canopy height was ~0.4 m by the time of FIU site characterization, but expects up to ~ 0.8-1m in summer. LAI is estimated to be ~ 1.

Figure 3. The restored prairie is the representative ecosystem at Woodworth Advanced site

Table 2. Ecosystem and site attributes for Woodworth Advanced tower site.

Ecosystem attributes	Measure and units
Mean canopy height[b]	1.0 m
Surface roughness[a]	0.2 m
Zero place displacement height[a]	0.6 m
Structural elements	Open grassland, uniform
Time zone	central time zone
Magnetic declination	5° 38' E changing by 0° 8' W/year

Note, [a] From field observation. [b] estimated from best knowledge.

3.3 Soils

3.3.1 Soil description

Soil data and soil maps (Figures 4) below for Woodworth Advanced tower site were collected from 2.2 km^2 NRCS soil maps(http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm), which centered at the tower location, to determine the dominant soil types in the larger tower foot print. This was done to assure that the soil array is in the dominant (or in the co-dominant) soil type present in the tower footprint.

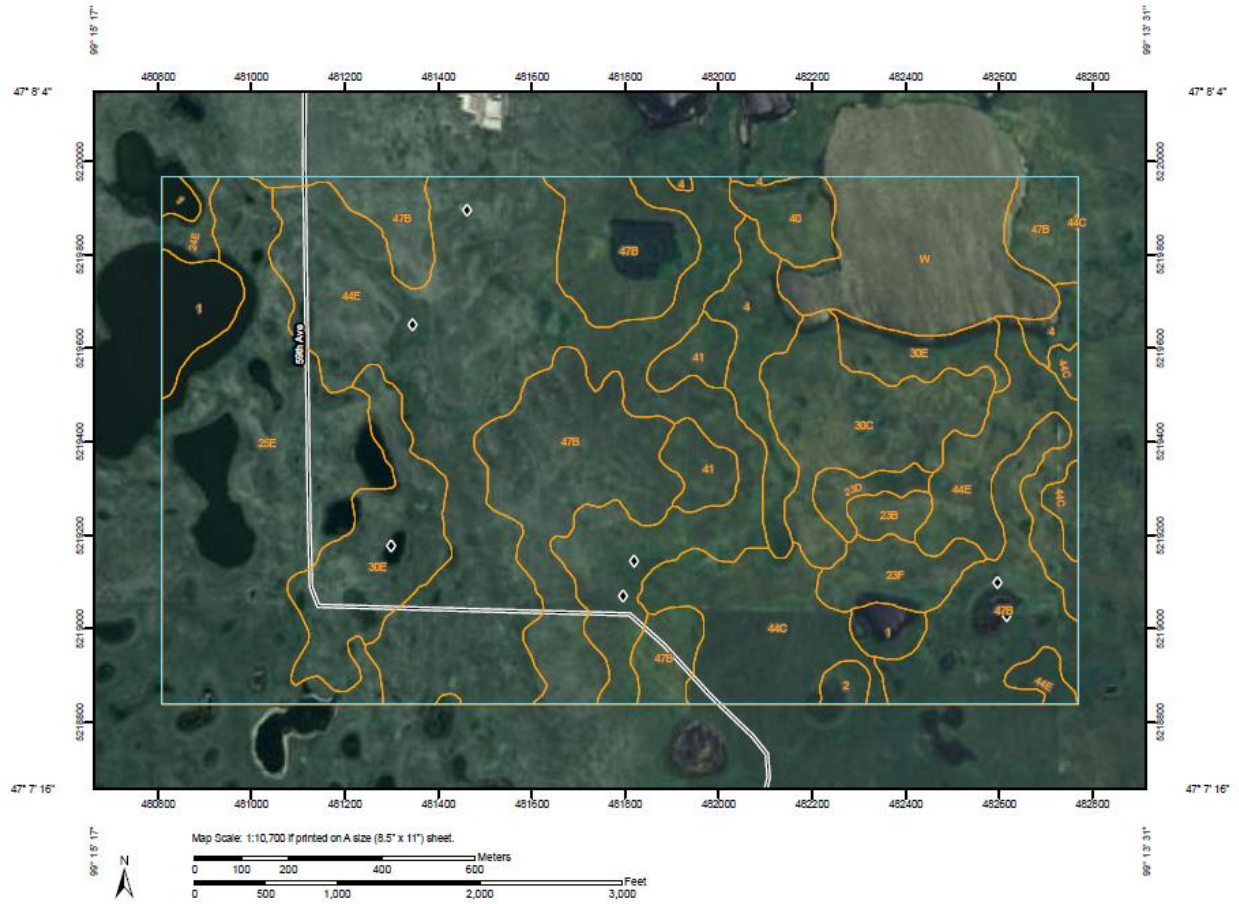


Figure 4. 2.2 km^2 soil map for Woodworth NEON advanced tower site.

Map Unit Description The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions in this report, along with the maps, can be used to determine the composition and properties of a unit. A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils. Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called non-contrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soil types or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit

descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas. An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a soil series. All the soils of a series have major horizons that are similar in composition, thickness, and arrangement. Soils of a given series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into soil phases. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series. Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups. A complex consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example. An association is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example. An undifferentiated group is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example. Some surveys include miscellaneous areas. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example. Additional information about the map units described in this report is available in other soil reports, which give properties of the soils and the limitations, capabilities, and potentials for many uses. Also, the narratives that accompany the soil reports define some of the properties included in the map unit descriptions.

Table 3. Soil Series and percentage of soil series within 2.2 km^2.
Area Object Interest (AOI) is the mapping unit from NRCS.

Stutsman County, North Dakota (ND093)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
1	Southam silty clay loam, 0 to 1 percent slopes	13.4	2.4%
2	Parnell silty clay loam, 0 to 1 percent slopes	2.1	0.4%
4	Hamerly-Parnell complex, 0 to 3 percent slopes	18.1	3.3%
23B	Barnes-Svea loams, 3 to 6 percent slopes	3.8	0.7%
23D	Barnes-Buse loams, 9 to 15 percent slopes	4.4	0.8%
23F	Buse-Svea loams, 15 to 35 percent slopes	10.0	1.8%
24E	Barnes-Svea-Buse loams, 9 to 25 percent slopes	3.4	0.6%
25E	Barnes-Buse-Parnell complex, 0 to 35 percent slopes	82.0	15.0%
30C	Svea-Sioux loams, 3 to 9 percent slopes	28.8	5.3%
30E	Sioux-Barnes loams, 9 to 25 percent slopes	34.9	6.4%
40	Divide-Marysland loams, 0 to 2 percent slopes	7.8	1.4%
41	Fordville-Renshaw loams, 0 to 2 percent slopes	10.1	1.8%
44C	Sioux-Arvilla sandy loams, 2 to 9 percent slopes	30.7	5.6%
44E	Sioux-Arvilla sandy loams, 9 to 25 percent slopes	157.9	28.8%
47B	Renshaw-Sioux loams, 0 to 6 percent slopes	105.2	19.2%
W	Water	35.0	6.4%
Totals for Area of Interest		**547.5**	**100.0%**

Stutsman County, North Dakota 23D—Barnes-Buse loams, 9 to 15 percent slopes Map Unit Setting Elevation: 1,000 to 2,050 feet Mean annual precipitation: 16 to 20 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 140 days **Map Unit Composition** Buse and similar soils: 38 percent Barnes and similar soils: 35 percent Minor components: 27 percent **Description of Buse Setting** Landform: Hills, ridges Landform position (two-dimensional): Shoulder, summit Down-slope shape: Convex Across-slope shape: Convex Parent material: Fine-loamy till **Properties and qualities** Slope: 9 to 15 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 1 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Available water capacity: High (about 10.5 inches) **Interpretive groups** Land capability (nonirrigated): 6e Ecological site: Thin Loamy (R055BY068ND) Other vegetative classification: Limy Upland (G055BY400ND) **Typical profile** 0 to 8 inches: Loam 8 to 40 inches: Loam 40 to 60 inches: Loam **Description of Barnes Setting** Landform: Ridges, hills Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear **Properties and qualities** Slope: 9 to 15 percent Depth to restrictive feature: More than 80

inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 1 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Available water capacity: High (about 10.5 inches) **Interpretive groups** Land capability (nonirrigated): 4e Ecological site: Loamy (R055BY064ND) Other vegetative classification: Loam (G055BY100ND) **Typical profile** 0 to 7 inches: Loam 7 to 19 inches: Loam 19 to 37 inches: Loam 37 to 60 inches: Loam **Minor Components Svea** Percent of map unit: 20 percent Landform: Knolls Landform position (two-dimensional): Footslope Down-slope shape: Concave Across-slope shape: Linear Ecological site: Loamy (R055BY064ND) Other vegetative classification: Loam (G055BY100ND) **Swenoda, well drained** Percent of map unit: 3 percent Landform: Knolls Landform position (two-dimensional): Footslope Down-slope shape: Concave Across-slope shape: Linear Ecological site: Sandy (R055BY062ND) Other vegetative classification: Loam (G055BY100ND) **Balaton** Percent of map unit: 1 percent Landform: Rises Landform position (two-dimensional): Summit, shoulder Down-slope shape: Convex Across-slope shape: Convex Ecological site: Thin Loamy (R055BY068ND) Other vegetative classification: Limy Upland (G055BY400ND) **Southam, undrained** Percent of map unit: 1 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Other vegetative classification: Not suited (G055BY000ND) **Sioux** Percent of map unit: 1 percent Landform: Ridges on hills Landform position (two-dimensional): Shoulder, summit Down-slope shape: Convex Across-slope shape: Convex Ecological site: Very Shallow (R055BY069ND) Other vegetative classification: Not suited (G055BY000ND) **Parnell, undrained** Percent of map unit: 1 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Ecological site: Wet Land (R055BY070ND) Other vegetative classification: Not suited (G055BY000ND)

Stutsman County, North Dakota 25E—Barnes-Buse-Parnell complex, 0 to 35 percent slopes: Map Unit Setting Elevation: 1,000 to 2,050 feet Mean annual precipitation: 16 to 20 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 140 days **Map Unit Composition** Barnes and similar soils: 33 percent Parnell, undrained, and similar soils: 24 percent Buse and similar soils: 18 percent Minor components: 25 percent **Description of Barnes Setting** Landform: Ridges Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear Parent material: Fine-loamy till **Properties and qualities** Slope: 15 to 25 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 1 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Available water capacity: High (about 10.5 inches) **Interpretive groups** Land capability (nonirrigated): 6e Ecological site: Loamy (R055BY064ND) Other vegetative classification: Steep Loam (G055BY109ND) **Typical profile** 0 to 7 inches: Loam 7 to 19 inches: Loam 19 to 37 inches: Loam 37 to 60 inches: Loam **Description of Parnell, Undrained Setting** Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Parent material: Alluvium **Properties and qualities** Slope: 0 to 1 percent Depth to restrictive feature: More than 80 inches Drainage class: Very poorly drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low (0.01 to 0.14 in/hr) Depth to water table: About 0 to 12 inches Frequency of flooding: None Frequency of ponding: Frequent Calcium carbonate, maximum content: 3 percent Gypsum, maximum content: 2 percent Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm) Available water capacity: High (about 10.6 inches) **Interpretive groups** Land capability (nonirrigated): 5w Ecological site: Wet Land (R055BY070ND) Other vegetative

classification: Not suited (G055BY000ND) **Typical profile** 0 to 15 inches: Silty clay loam 15 to 22 inches: Silt loam 22 to 32 inches: Silty clay loam 32 to 55 inches: Silty clay 55 to 60 inches: Silty clay **Description of Buse Setting** Landform: Ridges Landform position (two-dimensional): Summit, shoulder Down-slope shape: Convex Across-slope shape: Convex Parent material: Fine-loamy till **Properties and qualities** Slope: 15 to 35 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 1 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Available water capacity: High (about 10.5 inches) **Interpretive groups** Land capability (nonirrigated): 7e Ecological site: Thin Loamy (R055BY068ND) Other vegetative classification: Not suited (G055BY000ND) **Typical profile** 0 to 8 inches: Loam 8 to 40 inches: Loam 40 to 60 inches: Loam **Minor Components Svea, well drained** Percent of map unit: 9 percent Landform: Knolls Landform position (two-dimensional): Footslope Down-slope shape: Concave Across-slope shape: Linear Ecological site: Loamy (R055BY064ND) Other vegetative classification: Loam (G055BY100ND) **Vallers** Percent of map unit: 6 percent Landform: Depressions, flats Down-slope shape: Concave, linear Across-slope shape: Concave, linear Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Hamerly** Percent of map unit: 6 percent Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Limy Subirrigated (R055BY058ND) Other vegetative classification: Subirrigated (G055BY700ND) **Tonka, undrained** Percent of map unit: 2 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Southam, undrained** Percent of map unit: 1 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Other vegetative classification: Not suited (G055BY000ND) **Sioux** Percent of map unit: 1 percent Landform: Ridges Landform position (two-dimensional): Shoulder, summit Down-slope shape: Convex Across-slope shape: Convex Ecological site: Very Shallow (R055BY069ND) Other vegetative classification: Not suited (G055BY000ND)

Stutsman County, North Dakota 23B—Barnes-Svea loams, 3 to 6 percent slopes: Map Unit Setting Elevation: 1,000 to 2,050 feet Mean annual precipitation: 16 to 20 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 140 days **Map Unit Composition** Barnes and similar soils: 60 percent Svea and similar soils: 21 percent Minor components: 19 percent **Description of Barnes Setting** Landform: Rises Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear Parent material: Fine-loamy till **Properties and qualities** Slope: 3 to 6 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: About 48 to 72 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 1 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Available water capacity: High (about 10.5 inches) **Interpretive groups** Land capability (nonirrigated): 2e Ecological site: Loamy (R055BY064ND) Other vegetative classification: Loam (G055BY100ND) **Typical profile** 0 to 7 inches: Loam 7 to 19 inches: Loam 19 to 37 inches: Loam 37 to 60 inches: Loam **Description of Svea Setting** Landform: Rises Landform position (two-dimensional): Footslope Down-slope shape: Concave Across-slope shape: Linear **Properties and qualities** Slope: 3 to 6 percent Depth to restrictive feature: More than 80 inches Drainage class: Moderately well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: About 36 to 60 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 1 percent

Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Sodium adsorption ratio, maximum: 5.0 Available water capacity: High (about 10.9 inches) **Interpretive groups** Land capability (nonirrigated): 2e Ecological site: Loamy Overflow (R055BY059ND) Other vegetative classification: Loam (G055BY100ND) **Typical profile** 0 to 10 inches: Loam 10 to 19 inches: Loam 19 to 37 inches: Loam 37 to 60 inches: Loam **Minor Components Buse** Percent of map unit: 14 percent Landform: Rises Landform position (two-dimensional): Shoulder, summit Down-slope shape: Convex Across-slope shape: Convex Ecological site: Thin Loamy (R055BY068ND) Other vegetative classification: Limy Upland (G055BY400ND) **Sioux** Percent of map unit: 1 percent Landform: Rises Landform position (two-dimensional): Summit, shoulder Down-slope shape: Convex Across-slope shape: Convex Ecological site: Very Shallow (R055BY069ND) Other vegetative classification: Very Shallow To Gravel (G055BY003ND) **Vallers** Percent of map unit: 1 percent Landform: Depressions, flats Down-slope shape: Concave, linear Across-slope shape: Concave, linear Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Hamerly** Percent of map unit: 1 percent Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Limy Subirrigated (R055BY058ND) Other vegetative classification: Subirrigated (G055BY700ND) **Parnell** Percent of map unit: 1 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Ecological site: Wet Land (R055BY070ND) Other vegetative classification: Not suited (G055BY000ND) **Tonka** Percent of map unit: 1 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND)

Stutsman County, North Dakota 24E—Barnes-Svea-Buse loams, 9 to 25 percent slopes: Map Unit Setting Elevation: 1,000 to 2,050 feet Mean annual precipitation: 16 to 20 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 140 days **Map Unit Composition** Barnes and similar soils: 40 percent Buse and similar soils: 23 percent Svea, well drained, and similar soils: 20 percent Minor components: 17 percent **Description of Barnes Setting** Landform: Ridges, hills Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear **Properties and qualities** Slope: 9 to 15 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 1 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Available water capacity: High (about 10.5 inches) **Interpretive groups** Land capability (nonirrigated): 4e Ecological site: Loamy (R055BY064ND) Other vegetative classification: Loam (G055BY100ND) **Typical profile** 0 to 7 inches: Loam 7 to 19 inches: Loam 19 to 37 inches: Loam 37 to 60 inches: Loam **Description of Buse Setting** Landform: Ridges Landform position (two-dimensional): Shoulder, summit Down-slope shape: Convex Across-slope shape: Convex Parent material: Fine-loamy till **Properties and qualities** Slope: 15 to 25 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 1 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Available water capacity: High (about 10.5 inches) **Interpretive groups** Land capability (nonirrigated): 7e Ecological site: Thin Loamy (R055BY068ND) Other vegetative classification: Limy Upland (G055BY400ND) **Typical profile** 0 to 8 inches: Loam 8 to 40 inches: Loam 40 to 60 inches: Loam **Description of Svea, Well Drained Setting** Landform: Ridges on hills Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear **Properties and qualities** Slope: 9 to 15 percent Depth to restrictive feature:

More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 1 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Sodium adsorption ratio, maximum: 5.0 Available water capacity: High (about 10.9 inches) **Interpretive groups** Land capability (nonirrigated): 4e Ecological site: Loamy (R055BY064ND) Other vegetative classification: Loam (G055BY100ND) **Typical profile** 0 to 10 inches: Loam 10 to 19 inches: Loam 19 to 37 inches: Loam 37 to 60 inches: Loam **Minor Components Svea** Percent of map unit: 8 percent Landform: Rises Landform position (two-dimensional): Footslope Down-slope shape: Concave Across-slope shape: Linear Ecological site: Loamy Overflow (R055BY059ND) Other vegetative classification: Loam (G055BY100ND) **Tonka, undrained** Percent of map unit: 2 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Southam, undrained** Percent of map unit: 2 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Other vegetative classification: Not suited (G055BY000ND) **Parnell, undrained** Percent of map unit: 2 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Ecological site: Wet Land (R055BY070ND) Other vegetative classification: Not suited (G055BY000ND) **Hamerly** Percent of map unit: 2 percent Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Limy Subirrigated (R055BY058ND) Other vegetative classification: Subirrigated (G055BY700ND) **Sioux** Percent of map unit: 1 percent Landform: Ridges Landform position (two-dimensional): Shoulder, summit Down-slope shape: Convex Across-slope shape: Convex Ecological site: Very Shallow (R055BY069ND) Other vegetative classification: Not suited (G055BY000ND)

Stutsman County, North Dakota 23F—Buse-Svea loams, 15 to 35 percent slopes: Map Unit Setting Elevation: 1,000 to 2,050 feet Mean annual precipitation: 16 to 20 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 140 days **Map Unit Composition** Buse and similar soils: 45 percent Svea and similar soils: 23 percent Minor components: 32 percent **Description of Buse Setting** Landform: Ridges Landform position (two-dimensional): Shoulder, summit Down-slope shape: Convex Across-slope shape: Convex Parent material: Fine-loamy till **Properties and qualities** Slope: 15 to 35 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 1 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Available water capacity: High (about 10.5 inches) **Interpretive groups** Land capability (nonirrigated): 7e Ecological site: Thin Loamy (R055BY068ND) Other vegetative classification: Not suited (G055BY000ND) **Typical profile** 0 to 8 inches: Loam 8 to 40 inches: Loam 40 to 60 inches: Loam **Description of Svea Setting** Landform: Ridges on hills Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear **Properties and qualities** Slope: 9 to 15 percent Depth to restrictive feature: More than 80 inches Drainage class: Moderately well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: About 36 to 60 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 1 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Sodium adsorption ratio, maximum: 5.0 Available water capacity: High (about 10.9 inches) **Interpretive groups** Land capability (nonirrigated): 4e Ecological site: Loamy (R055BY064ND) Other vegetative classification: Loam (G055BY100ND) **Typical profile** 0 to 10 inches: Loam 10 to 19 inches:

Loam 19 to 37 inches: Loam 37 to 60 inches: Loam **Minor Components Barnes** Percent of map unit: 28 percent Landform: Ridges Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear Ecological site: Loamy (R055BY064ND) Other vegetative classification: Steep Loam (G055BY109ND) **Sioux** Percent of map unit: 2 percent Landform: Ridges Landform position (two-dimensional): Shoulder, summit Down-slope shape: Convex Across-slope shape: Convex Ecological site: Very Shallow (R055BY069ND) Other vegetative classification: Not suited (G055BY000ND) **Lamoure, occasionally flooded** Percent of map unit: 1 percent Landform: Flats on flood plains Down-slope shape: Linear Across-slope shape: Linear Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Renshaw** Percent of map unit: 1 percent Landform: Ridges on hills Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear Ecological site: Shallow Gravel (R055BY063ND) Other vegetative classification: Not suited (G055BY000ND)

Stutsman County, North Dakota 40—Divide-Marysland loams, 0 to 2 percent slopes: Map Unit Setting Elevation: 1,000 to 2,050 feet Mean annual precipitation: 16 to 20 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 140 days **Map Unit Composition** Divide and similar soils: 59 percent Marysland and similar soils: 28 percent Minor components: 13 percent **Description of Divide Setting** Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Parent material: Glaciofluvial deposits **Properties and qualities** Slope: 0 to 2 percent Depth to restrictive feature: 20 to 40 inches to strongly contrasting textural stratification Drainage class: Somewhat poorly drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: About 18 to 42 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 45 percent Gypsum, maximum content: 2 percent Maximum salinity: Nonsaline to slightly saline (2.0 to 8.0 mmhos/cm) Sodium adsorption ratio, maximum: 2.0 Available water capacity: Low (about 4.7 inches) **Interpretive groups** Land capability (nonirrigated): 2s Ecological site: Limy Subirrigated (R055BY058ND) Other vegetative classification: Subirrigated (G055BY700ND) **Typical profile** 0 to 8 inches: Loam 8 to 12 inches: Loam 12 to 22 inches: Loam 22 to 26 inches: Gravelly loamy coarse sand 26 to 60 inches: Gravelly coarse sand **Description of Marysland Setting** Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Parent material: Glaciofluvial deposits **Properties and qualities** Slope: 0 to 1 percent Depth to restrictive feature: 20 to 40 inches to strongly contrasting textural stratification Drainage class: Poorly drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: About 0 to 18 inches Frequency of flooding: None Frequency of ponding: Rare Calcium carbonate, maximum content: 45 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Available water capacity: Low (about 5.5 inches) **Interpretive groups** Land capability (nonirrigated): 2w Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Typical profile** 0 to 9 inches: Loam 9 to 27 inches: Loam 27 to 60 inches: Gravelly sand **Minor Components Colvin** Percent of map unit: 4 percent Landform: Flats, depressions Down-slope shape: Linear, concave Across-slope shape: Linear, concave Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Fordville** Percent of map unit: 3 percent Landform: Rises Down-slope shape: Linear Across-slope shape: Linear Ecological site: Loamy (R055BY064ND) Other vegetative classification: Droughty Loam (G055BY120ND) **Hamerly** Percent of map unit: 3 percent Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Limy Subirrigated (R055BY058ND) Other vegetative classification: Subirrigated (G055BY700ND) **Arvilla** Percent of map unit: 2 percent Landform: Rises Down-slope shape: Convex Across-slope shape: Linear Ecological site: Shallow Gravel (R055BY063ND) Other vegetative classification: Very Droughty

Loam (G055BY130ND) **La prairie, rarely flooded** Percent of map unit: 1 percent Landform: Rises on flood plains Down-slope shape: Convex Across-slope shape: Linear Ecological site: Loamy (R055BY064ND) Other vegetative classification: Loam (G055BY100ND)

Stutsman County, North Dakota 41—Fordville-Renshaw loams, 0 to 2 percent slopes: Map Unit Setting Elevation: 1,000 to 2,050 feet Mean annual precipitation: 16 to 20 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 140 days **Map Unit Composition** Fordville and similar soils: 47 percent Renshaw and similar soils: 23 percent Minor components: 30 percent **Description of Fordville Setting** Landform: Rises Down-slope shape: Linear Across-slope shape: Linear Parent material: Glaciofluvial deposits **Properties and qualities** Slope: 0 to 2 percent Depth to restrictive feature: 20 to 40 inches to strongly contrasting textural stratification Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: About 48 to 72 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 10 percent Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm) Available water capacity: Low (about 4.8 inches) **Interpretive groups** Land capability (nonirrigated): 2s Ecological site: Loamy (R055BY064ND) Other vegetative classification: Droughty Loam (G055BY120ND) **Typical profile** 0 to 6 inches: Loam 6 to 24 inches: Loam 24 to 27 inches: Gravelly coarse sand 27 to 60 inches: Gravelly coarse sand **Description of Renshaw Setting** Landform: Rises Down-slope shape: Convex Across-slope shape: Linear Parent material: Glaciofluvial deposits **Properties and qualities** Slope: 0 to 2 percent Depth to restrictive feature: 15 to 20 inches to strongly contrasting textural stratification Drainage class: Somewhat excessively drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 5 percent Available water capacity: Low (about 3.3 inches) **Interpretive groups** Land capability (nonirrigated): 3e Ecological site: Shallow Gravel (R055BY063ND) Other vegetative classification: Very Droughty Loam (G055BY130ND) **Typical profile** 0 to 7 inches: Loam 7 to 15 inches: Loam 15 to 20 inches: Gravelly loamy sand 20 to 60 inches: Gravelly sand **Minor Components Spottswood, moderately well drained** Percent of map unit: 8 percent Landform: Rises, flats Down-slope shape: Convex, linear Across-slope shape: Linear Ecological site: Loamy Overflow (R055BY059ND) Other vegetative classification: Overflow (G055BY500ND) **Sioux** Percent of map unit: 6 percent Landform: Rises Landform position (two-dimensional): Summit Down-slope shape: Convex Across-slope shape: Convex Ecological site: Very Shallow (R055BY069ND) Other vegetative classification: Very Shallow To Gravel (G055BY003ND) **Arvilla** Percent of map unit: 5 percent Landform: Rises Down-slope shape: Convex Across-slope shape: Linear Ecological site: Shallow Gravel (R055BY063ND) Other vegetative classification: Very Droughty Loam (G055BY130ND) **Svea, well drained** Percent of map unit: 5 percent Landform: Rises Down-slope shape: Concave Across-slope shape: Linear Ecological site: Loamy Overflow (R055BY059ND) Other vegetative classification: Overflow (G055BY500ND) **Divide** Percent of map unit: 4 percent Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Limy Subirrigated (R055BY058ND) Other vegetative classification: Subirrigated (G055BY700ND) **Buse** Percent of map unit: 2 percent Landform: Rises Landform position (two-dimensional): Summit, shoulder Down-slope shape: Convex Across-slope shape: Convex Ecological site: Thin Loamy (R055BY068ND) Other vegetative classification: Limy Upland (G055BY400ND)

Stutsman County, North Dakota 4—Hamerly-Parnell complex, 0 to 3 percent slopes: Map Unit Setting Elevation: 1,000 to 2,050 feet Mean annual precipitation: 16 to 20 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 140 days **Map Unit Composition** Hamerly and similar soils:

39 percent Parnell and similar soils: 35 percent Minor components: 26 percent **Description of Hamerly Setting** Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Parent material: Fine-loamy till **Properties and qualities** Slope: 0 to 3 percent Depth to restrictive feature: More than 80 inches Drainage class: Somewhat poorly drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: About 18 to 42 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 45 percent Gypsum, maximum content: 2 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Sodium adsorption ratio, maximum: 5.0 Available water capacity: High (about 10.5 inches) **Interpretive groups** Land capability (nonirrigated): 2e Ecological site: Limy Subirrigated (R055BY058ND) Other vegetative classification: Subirrigated (G055BY700ND) **Typical profile** 0 to 8 inches: Loam 8 to 35 inches: Loam 35 to 60 inches: Loam **Description of Parnell Setting** Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Parent material: Alluvium **Properties and qualities** Slope: 0 to 1 percent Depth to restrictive feature: More than 80 inches Drainage class: Very poorly drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low (0.01 to 0.14 in/hr) Depth to water table: About 0 to 12 inches Frequency of flooding: None Frequency of ponding: Frequent Calcium carbonate, maximum content: 3 percent Gypsum, maximum content: 2 percent Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm) Available water capacity: High (about 10.6 inches) **Interpretive groups** Land capability (nonirrigated): 3w Ecological site: Wet Land (R055BY070ND) Other vegetative classification: Not suited (G055BY000ND) **Typical profile** 0 to 15 inches: Silty clay loam 15 to 22 inches: Silt loam 22 to 32 inches: Silty clay loam 32 to 55 inches: Silty clay 55 to 60 inches: Silty clay **Minor Components Vallers** Percent of map unit: 13 percent Landform: Depressions, flats Down-slope shape: Concave, linear Across-slope shape: Concave, linear Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Tonka** Percent of map unit: 7 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Cresbard** Percent of map unit: 2 percent Landform: Rises Down-slope shape: Linear Across-slope shape: Linear Ecological site: Clayey (R055BY056ND) Other vegetative classification: Clayey Subsoil (G055BY210ND) **Southam** Percent of map unit: 2 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Other vegetative classification: Not suited (G055BY000ND) **Svea** Percent of map unit: 2 percent Landform: Rises Down-slope shape: Concave Across-slope shape: Linear Ecological site: Loamy (R055BY064ND) Other vegetative classification: Loam (G055BY100ND)

Stutsman County, North Dakota 2—Parnell silty clay loam, 0 to 1 percent slopes Map Unit Setting Elevation: 1,000 to 2,050 feet Mean annual precipitation: 16 to 20 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 140 days **Map Unit Composition** Parnell and similar soils: 75 percent Minor components: 25 percent **Description of Parnell Setting** Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Parent material: Alluvium **Properties and qualities** Slope: 0 to 1 percent Depth to restrictive feature: More than 80 inches Drainage class: Very poorly drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low (0.01 to 0.14 in/hr) Depth to water table: About 0 to 12 inches Frequency of flooding: None Frequency of ponding: Frequent Calcium carbonate, maximum content: 3 percent Gypsum, maximum content: 2 percent Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm) Available water capacity: High (about 10.6 inches) **Interpretive groups** Land capability (nonirrigated): 3w Ecological site: Wet Land (R055BY070ND) Other vegetative classification: Not suited (G055BY000ND) **Typical profile** 0 to 15 inches: Silty clay loam 15 to 22 inches: Silt loam 22 to 32 inches: Silty clay loam 32 to 55 inches: Silty clay 55 to 60 inches: Silty clay **Minor Components Tonka** Percent of map unit: 10 percent Landform: Depressions Down-slope shape:

Concave Across-slope shape: Concave Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Colvin** Percent of map unit: 8 percent Landform: Flats, depressions Down-slope shape: Linear, concave Across-slope shape: Linear, concave Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Vallers** Percent of map unit: 3 percent Landform: Depressions, flats Down-slope shape: Concave, linear Across-slope shape: Concave, linear Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Southam** Percent of map unit: 2 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Other vegetative classification: Not suited (G055BY000ND) **Hamerly** Percent of map unit: 2 percent Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Limy Subirrigated (R055BY058ND) Other vegetative classification: Subirrigated (G055BY700ND)

Stutsman County, North Dakota 47B—Renshaw-Sioux loams, 0 to 6 percent slopes: Map Unit Setting Elevation: 1,000 to 2,050 feet Mean annual precipitation: 16 to 20 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 140 days **Map Unit Composition** Renshaw and similar soils: 48 percent Sioux and similar soils: 34 percent Minor components: 18 percent **Description of Renshaw Setting** Landform: Rises Down-slope shape: Convex Across-slope shape: Linear Parent material: Glaciofluvial deposits **Properties and qualities** Slope: 0 to 2 percent Depth to restrictive feature: 15 to 20 inches to strongly contrasting textural stratification Drainage class: Somewhat excessively drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 5 percent Available water capacity: Low (about 3.3 inches) **Interpretive groups** Land capability (nonirrigated): 3e Ecological site: Shallow Gravel (R055BY063ND) Other vegetative classification: Very Droughty Loam (G055BY130ND) **Typical profile** 0 to 7 inches: Loam 7 to 15 inches: Loam 15 to 20 inches: Gravelly loamy sand 20 to 60 inches: Gravelly sand **Description of Sioux Setting** Landform: Rises Landform position (two-dimensional): Summit, shoulder Down-slope shape: Convex Across-slope shape: Convex Parent material: Glaciofluvial deposits **Properties and qualities** Slope: 2 to 6 percent Depth to restrictive feature: More than 80 inches Drainage class: Excessively drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Available water capacity: Low (about 3.6 inches) **Interpretive groups** Land capability (nonirrigated): 6s Ecological site: Very Shallow (R055BY069ND) Other vegetative classification: Very Shallow To Gravel (G055BY003ND) **Typical profile** 0 to 7 inches: Loam 7 to 24 inches: Very gravelly loamy coarse sand 24 to 60 inches: Very gravelly coarse sand **Minor Components Fordville** Percent of map unit: 7 percent Landform: Rises Landform position (two-dimensional): Footslope Down-slope shape: Concave Across-slope shape: Linear Ecological site: Loamy (R055BY064ND) Other vegetative classification: Droughty Loam (G055BY120ND) **Arvilla** Percent of map unit: 5 percent Landform: Rises Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear Ecological site: Shallow Gravel (R055BY063ND) Other vegetative classification: Very Droughty Loam (G055BY130ND) **Barnes** Percent of map unit: 3 percent Landform: Rises Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear Ecological site: Loamy (R055BY064ND) Other vegetative classification: Loam (G055BY100ND) **Spottswood, moderately well drained** Percent of map unit: 2 percent Landform: Rises, flats Down-slope shape: Convex, linear Across-slope shape: Linear Ecological site: Loamy Overflow (R055BY059ND) Other vegetative classification: Overflow (G055BY500ND) **Divide** Percent of map unit: 1 percent Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Limy Subirrigated (R055BY058ND) Other vegetative classification: Subirrigated (G055BY700ND)

Stutsman County, North Dakota 44C—Sioux-Arvilla sandy loams, 2 to 9 percent slopes Map Unit Setting Elevation: 1,000 to 2,050 feet Mean annual precipitation: 16 to 20 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 140 days **Map Unit Composition** Sioux and similar soils: 61 percent Arvilla and similar soils: 21 percent Minor components: 18 percent **Description of Sioux Setting** Landform: Knolls Landform position (two-dimensional): Summit, shoulder Down-slope shape: Convex Across-slope shape: Convex Parent material: Glaciofluvial deposits **Properties and qualities** Slope: 6 to 9 percent Depth to restrictive feature: More than 80 inches Drainage class: Excessively drained Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Available water capacity: Low (about 3.1 inches) **Interpretive groups** Land capability (nonirrigated): 6s Ecological site: Very Shallow (R055BY069ND) Other vegetative classification: Not suited (G055BY000ND) **Typical profile** 0 to 7 inches: Sandy loam 7 to 24 inches: Very gravelly loamy coarse sand 24 to 60 inches: Very gravelly coarse sand **Description of Arvilla Setting** Landform: Rises Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear Parent material: Glaciofluvial deposits **Properties and qualities** Slope: 2 to 6 percent Depth to restrictive feature: More than 80 inches Drainage class: Somewhat excessively drained Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 10 percent Available water capacity: Low (about 3.2 inches) **Interpretive groups** Land capability (nonirrigated): 3e Ecological site: Shallow Gravel (R055BY063ND) Other vegetative classification: Very Droughty Loam (G055BY130ND) **Typical profile** 0 to 5 inches: Sandy loam 5 to 10 inches: Sandy loam 10 to 16 inches: Sandy loam 16 to 31 inches: Gravelly coarse sand 31 to 60 inches: Gravelly coarse sand **Minor Components Renshaw** Percent of map unit: 6 percent Landform: Rises Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear Ecological site: Shallow Gravel (R055BY063ND) Other vegetative classification: Very Droughty Loam (G055BY130ND) **Fordville** Percent of map unit: 5 percent Landform: Rises Landform position (two-dimensional): Footslope Down-slope shape: Concave Across-slope shape: Linear Ecological site: Loamy (R055BY064ND) Other vegetative classification: Droughty Loam (G055BY120ND) **Clontarf, well drained** Percent of map unit: 2 percent Landform: Rises Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear Ecological site: Sandy (R055BY062ND) Other vegetative classification: Droughty Loam (G055BY120ND) **Svea, well drained** Percent of map unit: 2 percent Landform: Rises Down-slope shape: Concave Across-slope shape: Linear Ecological site: Loamy Overflow (R055BY059ND) Other vegetative classification: Overflow (G055BY500ND) **Divide** Percent of map unit: 2 percent Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Limy Subirrigated (R055BY058ND) Other vegetative classification: Subirrigated (G055BY700ND) **Embden** Percent of map unit: 1 percent Landform: Rises Down-slope shape: Concave Across-slope shape: Linear Ecological site: Loamy Overflow (R055BY059ND) Other vegetative classification: Overflow (G055BY500ND)

Stutsman County, North Dakota 44E—Sioux-Arvilla sandy loams, 9 to 25 percent slopes Map Unit Setting Elevation: 1,000 to 2,050 feet Mean annual precipitation: 16 to 20 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 140 days **Map Unit Composition** Sioux and similar soils: 63 percent Arvilla and similar soils: 24 percent Minor components: 13 percent **Description of Sioux Setting** Landform: Ridges Landform position (two-dimensional): Shoulder, summit Down-slope shape: Convex Across-slope shape: Convex Parent material: Glaciofluvial deposits **Properties and**

qualities Slope: 15 to 25 percent Depth to restrictive feature: More than 80 inches Drainage class: Excessively drained Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Available water capacity: Low (about 3.1 inches) **Interpretive groups** Land capability (nonirrigated): 6s Ecological site: Very Shallow (R055BY069ND) Other vegetative classification: Not suited (G055BY000ND) **Typical profile** 0 to 7 inches: Sandy loam 7 to 24 inches: Very gravelly loamy coarse sand 24 to 60 inches: Very gravelly coarse sand **Description of Arvilla Setting** Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear **Properties and qualities** Slope: 9 to 15 percent Depth to restrictive feature: More than 80 inches Drainage class: Somewhat excessively drained Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 10 percent Available water capacity: Low (about 3.2 inches) **Interpretive groups** Land capability (nonirrigated): 6e Ecological site: Shallow Gravel (R055BY063ND) Other vegetative classification: Not suited (G055BY000ND) **Typical profile** 0 to 5 inches: Sandy loam 5 to 10 inches: Sandy loam 10 to 16 inches: Sandy loam 16 to 31 inches: Gravelly coarse sand 31 to 60 inches: Gravelly coarse sand **Minor Components Fordville** Percent of map unit: 4 percent Landform: Rises Landform position (two-dimensional): Footslope Down-slope shape: Concave Across-slope shape: Linear Ecological site: Loamy (R055BY064ND) Other vegetative classification: Droughty Loam (G055BY120ND) **Clontarf, well drained** Percent of map unit: 3 percent Landform: Knolls Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear Ecological site: Sandy (R055BY062ND) Other vegetative classification: Droughty Loam (G055BY120ND) **Renshaw** Percent of map unit: 3 percent Landform: Ridges on hills Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear Ecological site: Shallow Gravel (R055BY063ND) Other vegetative classification: Not suited (G055BY000ND) **Buse** Percent of map unit: 1 percent Landform: Ridges Landform position (two-dimensional): Shoulder, summit Down-slope shape: Convex Across-slope shape: Convex Ecological site: Thin Loamy (R055BY068ND) Other vegetative classification: Not suited (G055BY000ND) **Embden, well drained** Percent of map unit: 1 percent Landform: Knolls Landform position (two-dimensional): Footslope Down-slope shape: Concave Across-slope shape: Linear Ecological site: Sandy (R055BY062ND) Other vegetative classification: Loam (G055BY100ND) **Divide** Percent of map unit: 1 percent Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Limy Subirrigated (R055BY058ND) Other vegetative classification: Subirrigated (G055BY700ND)

Stutsman County, North Dakota 30E—Sioux-Barnes loams, 9 to 25 percent slopes Map Unit Setting Elevation: 1,000 to 2,050 feet Mean annual precipitation: 16 to 20 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 140 days **Map Unit Composition** Sioux and similar soils: 36 percent Barnes and similar soils: 29 percent Minor components: 35 percent **Description of Sioux Setting** Landform: Ridges Landform position (two-dimensional): Shoulder, summit Down-slope shape: Convex Across-slope shape: Convex Parent material: Glaciofluvial deposits **Properties and qualities** Slope: 15 to 25 percent Depth to restrictive feature: More than 80 inches Drainage class: Excessively drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Available water capacity: Low (about 3.6 inches) **Interpretive groups** Land capability (nonirrigated): 7s Ecological site: Very Shallow (R055BY069ND) Other vegetative classification: Not suited (G055BY000ND) **Typical profile** 0 to 7 inches:

Loam 7 to 24 inches: Very gravelly loamy coarse sand 24 to 60 inches: Very gravelly coarse sand **Description of Barnes Setting** Landform: Ridges, hills Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear **Properties and qualities** Slope: 9 to 15 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 1 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Available water capacity: High (about 10.5 inches) **Interpretive groups** Land capability (nonirrigated): 4e Ecological site: Loamy (R055BY064ND) Other vegetative classification: Loam (G055BY100ND) **Typical profile** 0 to 7 inches: Loam 7 to 19 inches: Loam 19 to 37 inches: Loam 37 to 60 inches: Loam **Minor Components Buse** Percent of map unit: 14 percent Landform: Ridges Landform position (two-dimensional): Summit, shoulder Down-slope shape: Convex Across-slope shape: Convex Ecological site: Thin Loamy (R055BY068ND) Other vegetative classification: Limy Upland (G055BY400ND) **Arvilla** Percent of map unit: 11 percent Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear Ecological site: Shallow Gravel (R055BY063ND) Other vegetative classification: Not suited (G055BY000ND) **Clontarf, well drained** Percent of map unit: 4 percent Landform: Rises Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear Ecological site: Sandy (R055BY062ND) Other vegetative classification: Droughty Loam (G055BY120ND) **Fordville** Percent of map unit: 4 percent Landform: Rises Landform position (two-dimensional): Footslope Down-slope shape: Concave Across-slope shape: Linear Ecological site: Loamy (R055BY064ND) Other vegetative classification: Droughty Loam (G055BY120ND) **Southam, undrained** Percent of map unit: 1 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Other vegetative classification: Not suited (G055BY000ND) **Embden** Percent of map unit: 1 percent Landform: Rises Landform position (two-dimensional): Footslope Down-slope shape: Concave Across-slope shape: Linear Ecological site: Loamy Overflow (R055BY059ND) Other vegetative classification: Overflow (G055BY500ND)

Stutsman County, North Dakota 1—Southam silty clay loam, 0 to 1 percent slopes Map Unit Setting Elevation: 1,000 to 2,050 feet Mean annual precipitation: 16 to 20 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 140 days **Map Unit Composition** Southam and similar soils: 80 percent Minor components: 20 percent **Description of Southam Setting** Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Parent material: Alluvium **Properties and qualities** Slope: 0 to 1 percent Depth to restrictive feature: More than 80 inches Drainage class: Very poorly drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low (0.01 to 0.14 in/hr) Depth to water table: About 0 to 12 inches Frequency of flooding: None Frequency of ponding: Frequent Calcium carbonate, maximum content: 15 percent Gypsum, maximum content: 2 percent Maximum salinity: Nonsaline to slightly saline (2.0 to 8.0 mmhos/cm) Sodium adsorption ratio, maximum: 2.0 Available water capacity: High (about 10.4 inches) Interpretive groups Land capability (nonirrigated): 3w Other vegetative classification: Not suited (G055BY000ND) **Typical profile** 0 to 16 inches: Silty clay loam 16 to 40 inches: Silty clay 40 to 60 inches: Silty clay **Minor Components Vallers** Percent of map unit: 6 percent Landform: Depressions, flats Down-slope shape: Concave, linear Across-slope shape: Concave, linear Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Parnell** Percent of map unit: 6 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Ecological site: Wet Land (R055BY070ND) Other vegetative classification: Not suited (G055BY000ND) **Minnewaukan** Percent of map unit: 3 percent

Landform: Beaches Down-slope shape: Linear Across-slope shape: Linear Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Hamerly** Percent of map unit: 3 percent Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Limy Subirrigated (R055BY058ND) Other vegetative classification: Subirrigated (G055BY700ND) **Lallie** Percent of map unit: 2 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND)

Stutsman County, North Dakota 30C—Svea-Sioux loams, 3 to 9 percent slopes: Map Unit Setting Elevation: 1,000 to 2,050 feet Mean annual precipitation: 16 to 20 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 140 days **Map Unit Composition** Svea and similar soils: 32 percent Sioux and similar soils: 26 percent Minor components: 42 percent **Description of Svea Setting** Landform: Rises Landform position (two-dimensional): Footslope Down-slope shape: Concave Across-slope shape: Linear **Properties and qualities** Slope: 3 to 6 percent Depth to restrictive feature: More than 80 inches Drainage class: Moderately well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: About 36 to 60 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 1 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Sodium adsorption ratio, maximum: 5.0 Available water capacity: High (about 10.9 inches) **Interpretive groups** Land capability (nonirrigated): 2e Ecological site: Loamy Overflow (R055BY059ND) Other vegetative classification: Loam (G055BY100ND) **Typical profile** 0 to 10 inches: Loam 10 to 19 inches: Loam 19 to 37 inches: Loam 37 to 60 inches: Loam **Description of Sioux Setting** Landform: Knolls Landform position (two-dimensional): Summit, shoulder Down-slope shape: Convex Across-slope shape: Convex Parent material: Glaciofluvial deposits **Properties and qualities** Slope: 6 to 9 percent Depth to restrictive feature: More than 80 inches Drainage class: Excessively drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Available water capacity: Low (about 3.6 inches) **Interpretive groups** Land capability (nonirrigated): 6s Ecological site: Very Shallow (R055BY069ND) Other vegetative classification: Not suited (G055BY000ND) **Typical profile** 0 to 7 inches: Loam 7 to 24 inches: Very gravelly loamy coarse sand 24 to 60 inches: Very gravelly coarse sand **Minor Components Fordville** Percent of map unit: 14 percent Landform: Rises Landform position (two-dimensional): Footslope Down-slope shape: Concave Across-slope shape: Linear Ecological site: Loamy (R055BY064ND) Other vegetative classification: Droughty Loam (G055BY120ND) **Buse** Percent of map unit: 8 percent Landform: Knolls Landform position (two-dimensional): Shoulder, summit Down-slope shape: Convex Across-slope shape: Convex Ecological site: Thin Loamy (R055BY068ND) Other vegetative classification: Limy Upland (G055BY400ND) **Barnes** Percent of map unit: 7 percent Landform: Rises Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear Ecological site: Loamy (R055BY064ND) Other vegetative classification: Loam (G055BY100ND) **Renshaw** Percent of map unit: 7 percent Landform: Rises Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear Ecological site: Shallow Gravel (R055BY063ND) Other vegetative classification: Very Droughty Loam (G055BY130ND) **Hamerly** Percent of map unit: 4 percent Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Limy Subirrigated (R055BY058ND) Other vegetative classification: Subirrigated (G055BY700ND) **Tonka** Percent of map unit: 2 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND)

Stutsman County, North Dakota W—Water: Map Unit Composition Water: 100 percent **Description of Water** Setting Landform: Depressions **Properties and qualities** Depth to water table: About 0 to 12 inches Frequency of ponding: Frequent

3.3.2 Soil semi-variogram description

The goal of this aspect of the site characterization is to determine the minimum distance between the soil plots in the soil array such that data farther apart can be considered spatially independent. The collected field data will be used to produce semivariograms, which is a geostatistical technique to characterize spatial autocorrelation between mapped samples of a quantitative variable (*e.g.*, soil property data in our case). In an empirical semivariogram, the average of the squared differences of a response variable is computed for all pairs of points within specified distance intervals (lag classes). The output is presented graphically as a plot of the average semi-variance versus distance class (Figure 5). For the theoretical variogram models considered here, the semivariance will converge on the total variance at distances for which values are no longer spatially auto-correlated (this is referred to as the range, Figure 5).

For the theoretical variograms considered here, three parameters estimated from the data are used to fit a semivariogram model to the empirical semivariogram. This model is then assumed to quantitatively represent the correlation as a function of distance (Figure 5), the range, the sill (the sill is the asymptotic value of semi-variance at the range), and the nugget (which describes sampling error or variation at distances below those separating the closest pairs of samples). The range, sill and nugget are estimated from theoretical models that are fitted to the empirical variograms using non-linear least squares methods.

The variogram analysis will be used, to determine the spatial scales at which we can consider soil measurements spatially independent. This characterization will directly inform the minimum distance between *i*) soil plots within each soil array, *ii*) the soil profile measurements, *iii*) EP plots, and *iv*) the microbial sampling locations. These data will directly inform NEON construction and site design activities.

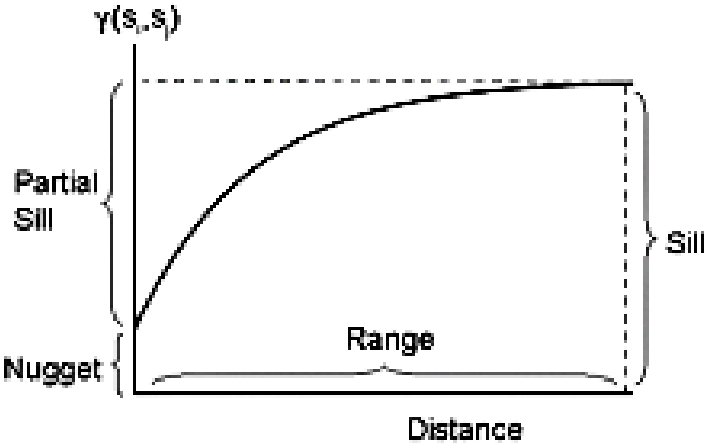


Figure 5. Example semivariogram, depicting range, sill, and nugget.

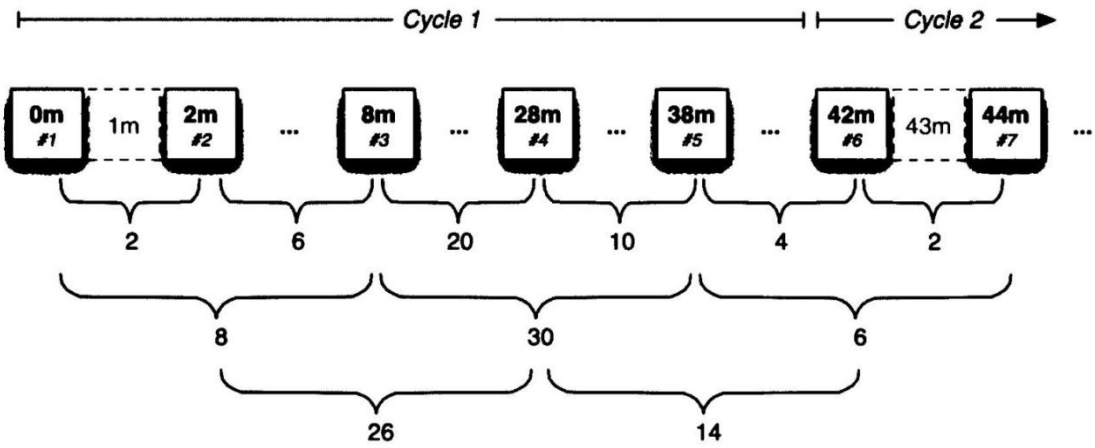


Figure 6. Spatially cyclic sampling design for the measurements of soil temperature and soil water content.

Field measurements of soil temperature (0-12 cm) and moisture (0-15 cm) were taken on 27 May 2010 at the Woodworth site. The sampling points followed the spatially cyclic sampling design by Bond-Lamberty et al. (2006) (Figure 6). Soil temperature and moisture measurements were collected along three transects (210 m, 84 m, and 84 m) located in the expected airshed at Woodworth. Details of how the airshed was determined are provided below. Soil temperature was measured with platinum resistance temperature sensors (RTD 810, Omega Engineering Inc., Stamford CT) and soil moisture was measured with time domain diaelectric sensors (CS616, Campbell Scientific Inc., Logan UT).

As well as measuring soil temperature and moisture at each sample point in Figure 6, measurements were also taken 30 cm in front and behind the sampling point along the axis of the transect. For example, at the 2 m sampling point, soil temperature and moisture was measured at 1.7 m, 2 m, and 2.3 m; this data is referred to as mobile data, since the measurements were taken at many different locations. In addition, soil temperature and moisture were continuously recorded at a single fixed location (stationary data) throughout the sampling time to correct for changes in temperature and moisture throughout the day.

Data collected were used for geospatial analyses of variograms in the R statistical computing language with the geoR package to test for spatial autocorrelation (Trangmar *et al.* 1986; Webster & Oliver 1989; Goovaerts 1997; Riberiro & Diggle 2001) and estimate the distance necessary for independence among soil plots in the soil array. To correct for changes in temperature and moisture over the sampling period, the stationary data was subtracted from the mobile data. In many instances a time of day trend was still apparent in the data even after subtracting the stationary data from the mobile data. This time of day trend was corrected for by fitting a linear regression. The data were further de-trended using elevation, slope, and aspect from a digital elevation map and the residuals were used for the semivariogram analysis. Soil temperature and moisture data, R code, graphs, and R output can be found at: P:\FIU\FIU_Site_Characterization\DXX\YYYYYY_Characterization\Soil Measurements\Soil Data Analysis (where XX = domain number and YYYYYY = site name).

3.3.3 Results and interpretation

3.3.3.1 Soil Temperature

Soil temperature data residuals, after accounting for changes in temperature in the stationary data, any remaining time of day trend, elevation, slope and aspect, were used for the semivariogram analysis (Figure 7). Exploratory data analysis plots show that there was no distinct patterning of the residuals (Figure 8, left graph) and directional semivariograms do not show anisotropy (Figure 8, center graph). An isotropic empirical semivariogram was produced and a spherical model was fitted using Cressie weights (Figure 8, right graph). The model indicates a distance of effective independence of 14 m for soil temperature.

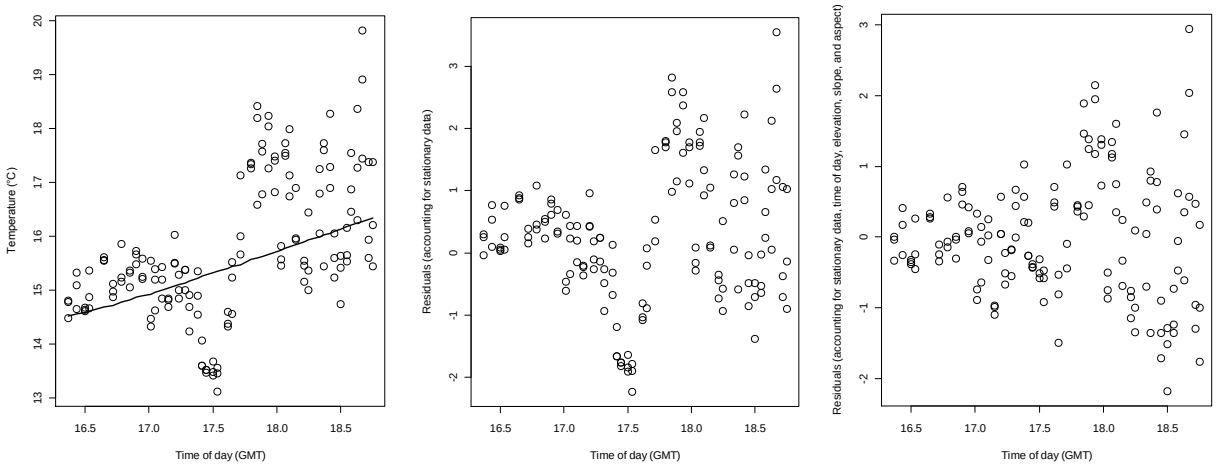


Figure 7. Left graph: mobile (circles) and stationary (line) soil temperature data. Center graph: temperature data after correcting for changes in temperature in the stationary data (circles) and a linear regression based on time of day (line). Right graph: residual temperature data after correcting for changes temperature in the stationary data and the time of day regression. Data in the right graph were used for the semivariogram analysis.

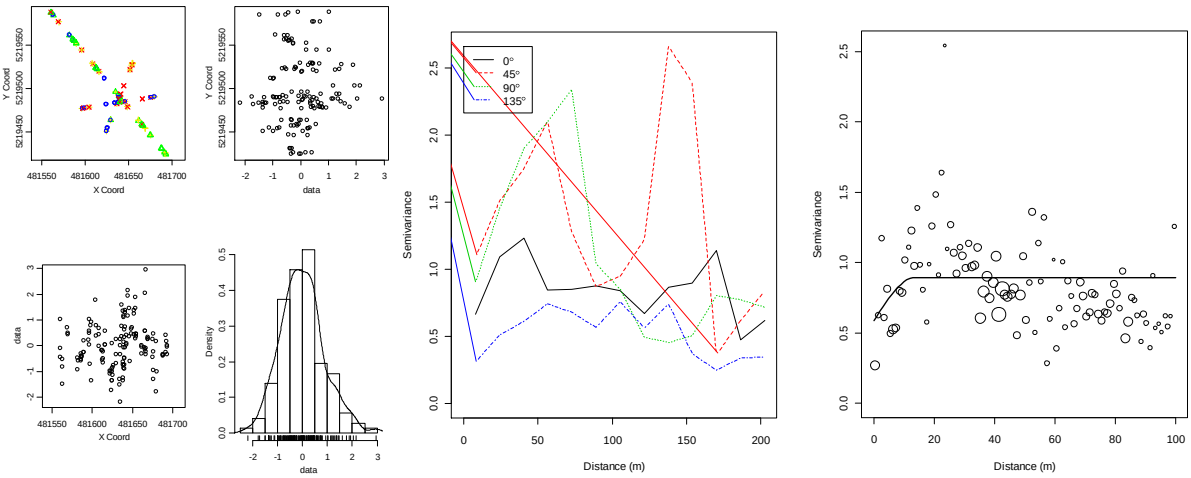


Figure 8. Left graphs: exploratory data analysis plots for residuals of temperature. Center graph: directional semivariograms for residuals of temperature. Right graph: empirical semivariogram (circles) and model (line) fit to residuals of temperature.

3.3.3.2 Soil water content

Soil water content data residuals, after accounting for changes in water content in the stationary data, any remaining time of day trend, elevation, slope and aspect, were used for the semivariogram analysis (Figure 9). Exploratory data analysis plots show that there was no distinct patterning of the residuals (Figure 10, left graph) and directional semivariograms do not show anisotropy (Figure 10, center graph). An isotropic empirical semivariogram was produced and a spherical model was fitted using Cressie weights (Figure 10, right graph). The model indicates a distance of effective independence of 8 m for soil water content.

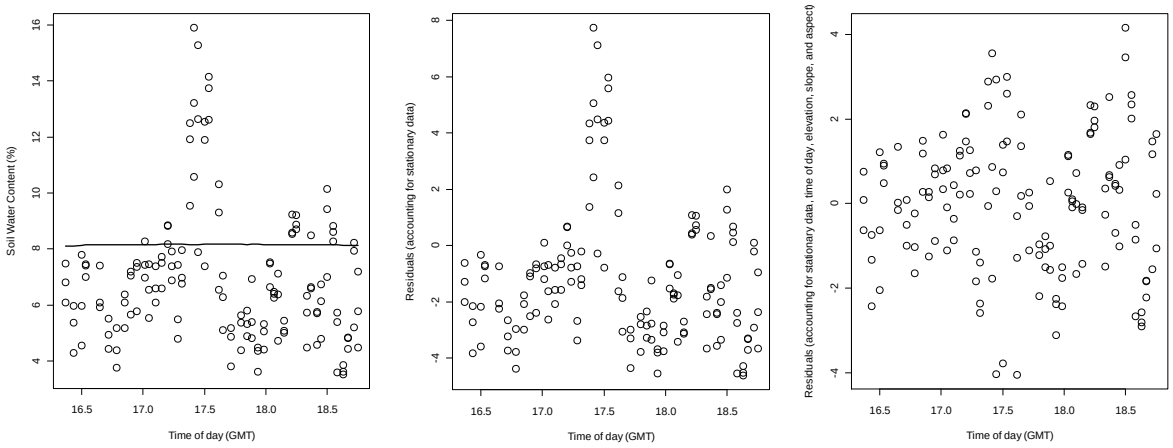


Figure 9. Left graph: mobile (circles) and stationary (line) soil water content data. Center graph: water content data after correcting for changes in water content in the stationary data (circles) and a linear regression based on time of day (line). Right graph: residual water content data after correcting for changes water content in the stationary data and the time of day regression. Data in the right graph were used for the semivariogram analysis.

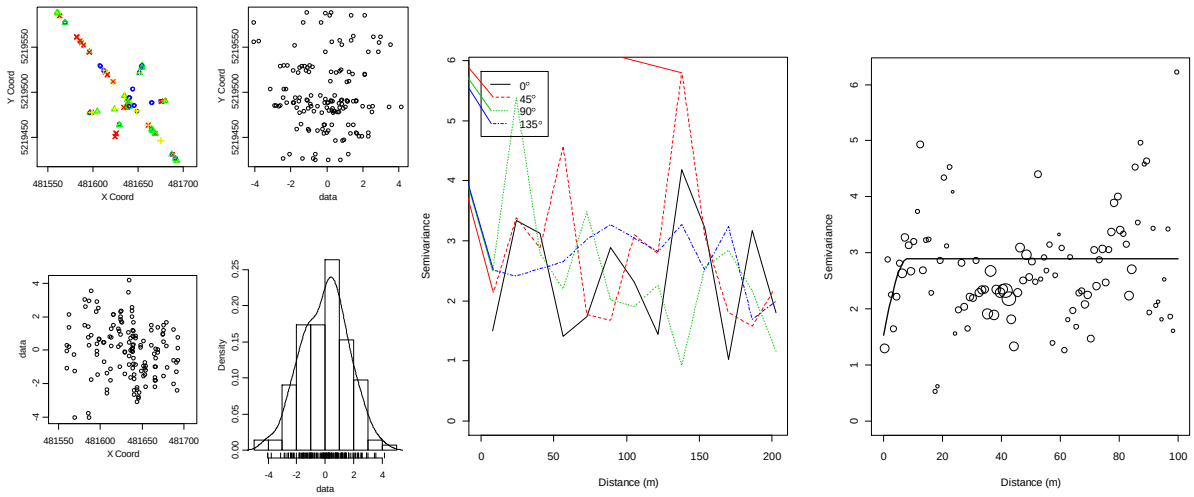


Figure 10. Left graphs: exploratory data analysis plots for residuals of soil water content. Center graph: directional semivariograms for residuals of water content. Right graph: empirical semivariogram (circles) and model (line) fit to residuals of water content.

3.3.3.3 Soil array layout and soil pit location

The minimum distance allowable between soil plots is 25 m to ensure a degree of spatial independence in non-measured soil parameters (i.e., other than temperature and water content) and the maximum distance allowable between soil plots is 40 m due to cost constraints. The estimated distance of effective independence was 14 m for soil temperature and 8 m for soil moisture. Based on these results and the site design guidelines the soil plots at Woodworth shall be placed 25 m apart. The soil array shall follow the linear soil array design (Soil Array Pattern B) with the soil plots being 5 m x 5 m. The direction of the soil array shall be 280° from the soil plot nearest the tower. The location of the first soil plot will be approximately 47.12812°, -99.24150°. The exact location of each soil plot will be chosen by an FIU team member during site construction to avoid placing a soil plot at an unrepresentative location (e.g., rock outcrop, drainage channel, large tree, etc). The FIU soil pit for characterizing soil horizon depths, collecting soil for site-specific sensor calibration, and collecting soil for the FIU soil archive will be located at 47.128110°, -99.239021° (primary location); or 47.127651°, -99.239030° (alternate location 1 if primary location is unsuitable); or 47.127259°, -99.239035° (alternate location 2 if primary location is unsuitable). Soil pit locations are 50-60 m from the access road so that they are in the same soil type as the soil array; since the site has been plowed recently, the disturbance caused by getting a small backhoe to these locations is not expected to significantly affect the site. A summary of the soil information is shown in Table 4 and site layout can be seen in Figure 11.

Dominant soil series at the site: Renshaw-Sioux loams, 0 to 6 percent slopes. The taxonomy of this soil is shown below:
Order: Mollisols
Suborder: Ustolls
Great group: Hapludolls
Subgroup: Calcic Hapludolls-Entic Hapludolls

Family: Fine-loamy over sandy or sandy-skeletal, mixed, superactive, frigid Calcic Hapludolls-Sandy-skeletal, mixed, frigid Entic Hapludolls
Series: Renshaw-Sioux loams, 0 to 6 percent slopes

Table 4. Summary of soil array and soil pit information at Woodworth. 0° represents true north and accounts for declination.

Soil plot dimensions	5 m x 5 m
Soil array pattern	B
Distance between soil plots: x	25 m
Distance from tower to closest soil plot: y	17 m
Latitude and longitude of 1st soil plot OR direction from tower	47.12812°, -99.24150°
Direction of soil array	280°
Latitude and longitude of FIU soil pit 1†	47.128110°, -99.239021° (primary location) †
Latitude and longitude of FIU soil pit 2†	47.127651°, -99.239030° (alternate 1) †
Latitude and longitude of FIU soil pit 3†	47.127259°, -99.239035° (alternate 2) †
Dominant soil type	Renshaw-Sioux loams, 0 to 6 percent slopes
Expected soil depth	0.38 m to >2 m
Depth to water table	>2 m

Expected depth of soil horizons	**Expected measurement depths***
0-0.18 m (Loam)	0.09 m
0.18-0.38 m (Loam)	[A]0.28 m
0.38-0.51 m (Gravelly loamy sand)	0.45 m
0.51-1.52 m (Gravelly sand)	[A]1.02 m
1.52-2.00 m	[A]2.00 m

*Actual soil measurement depths will be determined based on measured soil horizon depths at the NEON FIU soil pit and may differ substantially from those shown here.
†Soil pit locations are 50-60 m from the access road so that they are in the same soil type as the soil array.
[A]current depths of the soil CO2

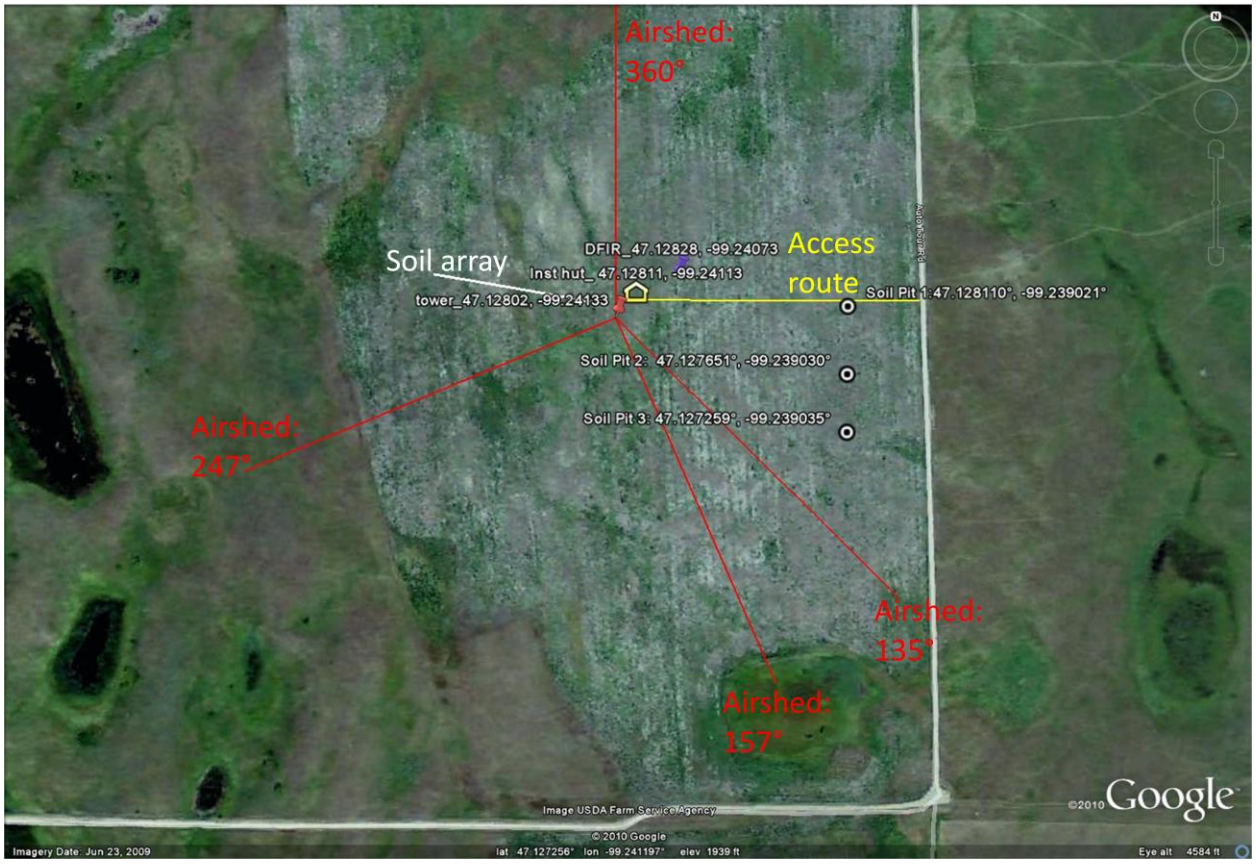


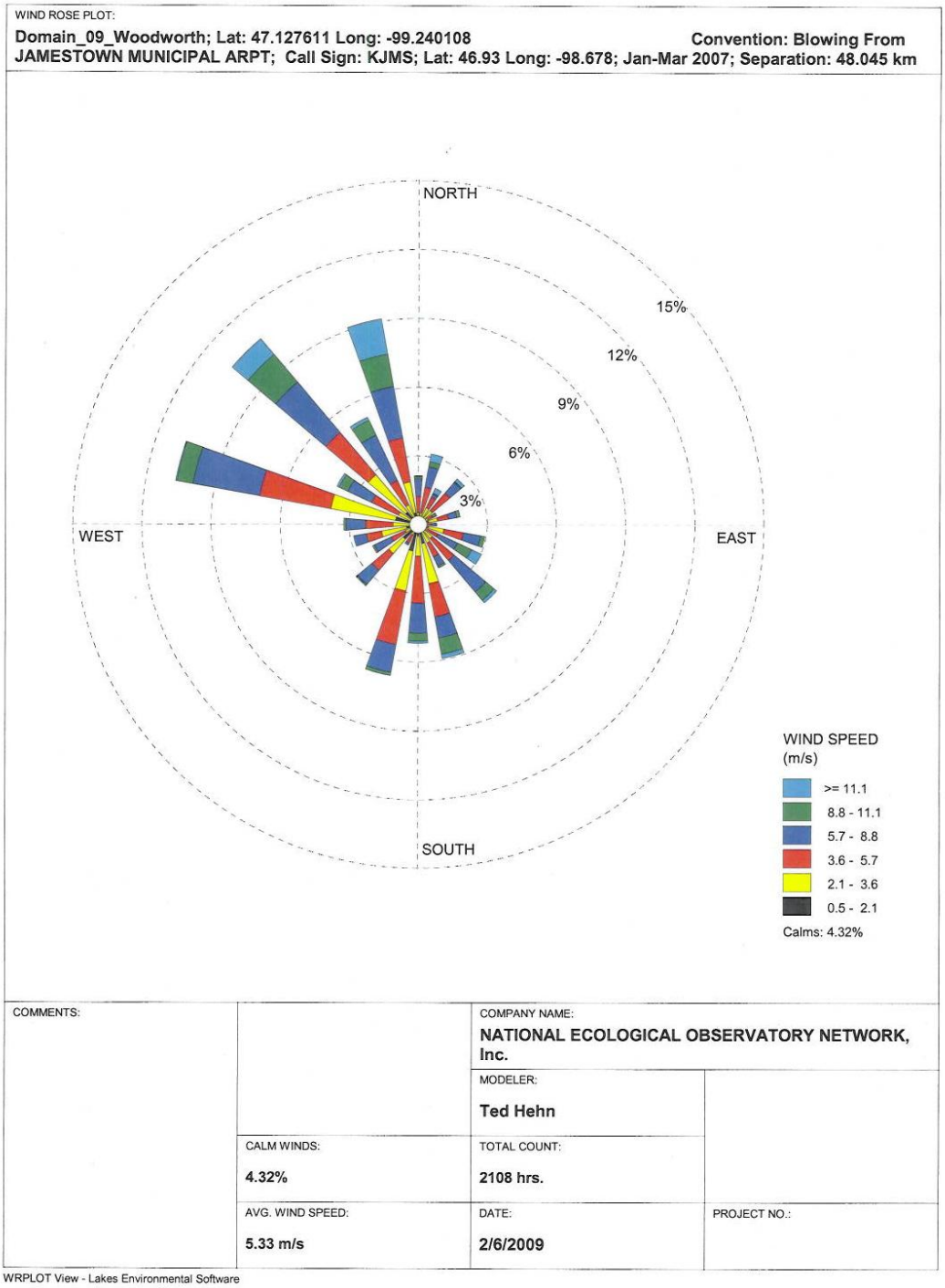
Figure 11. Site layout at Woodworth showing soil array and location of the FIU soil pit.

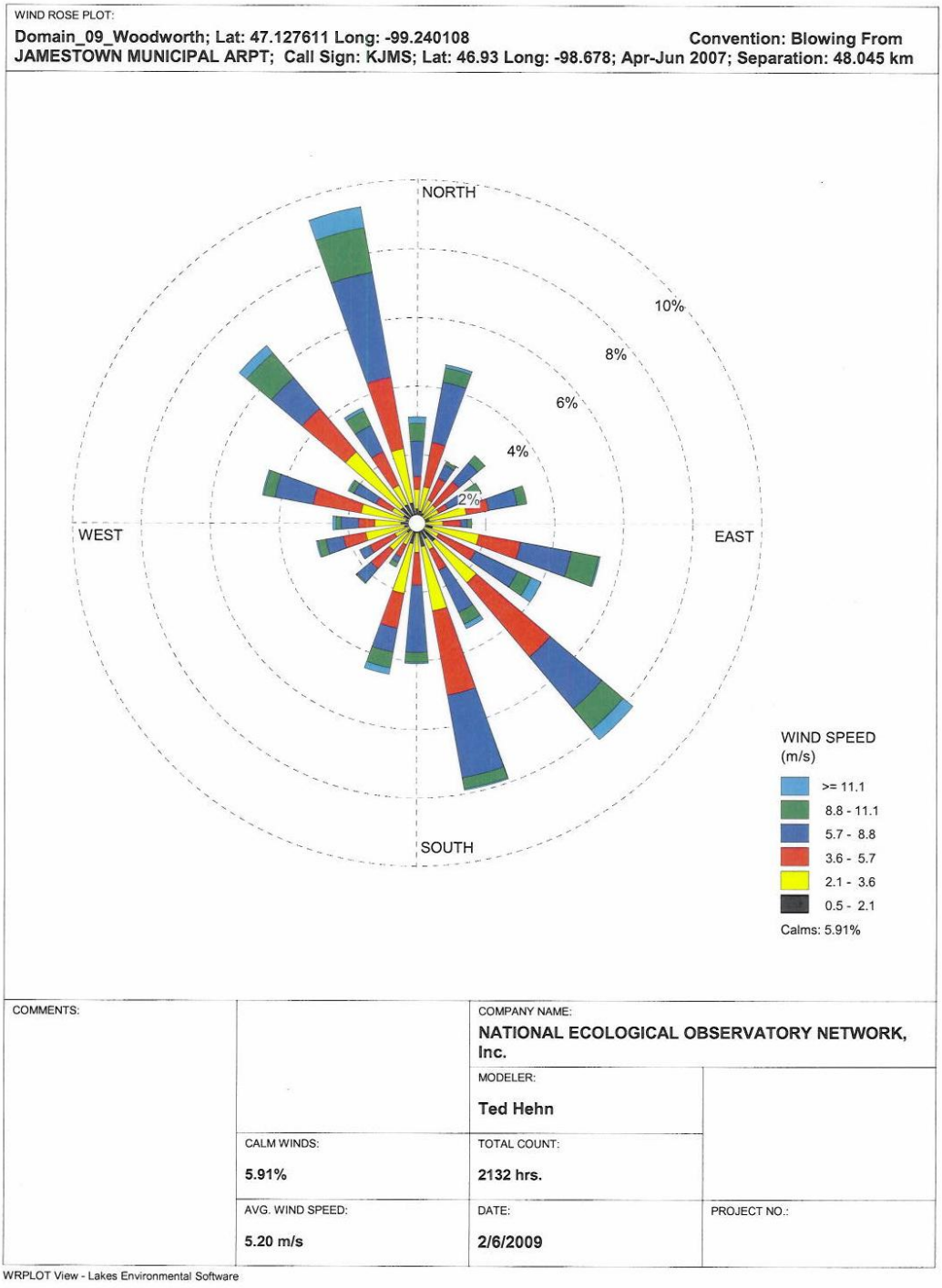
3.4 Airshed

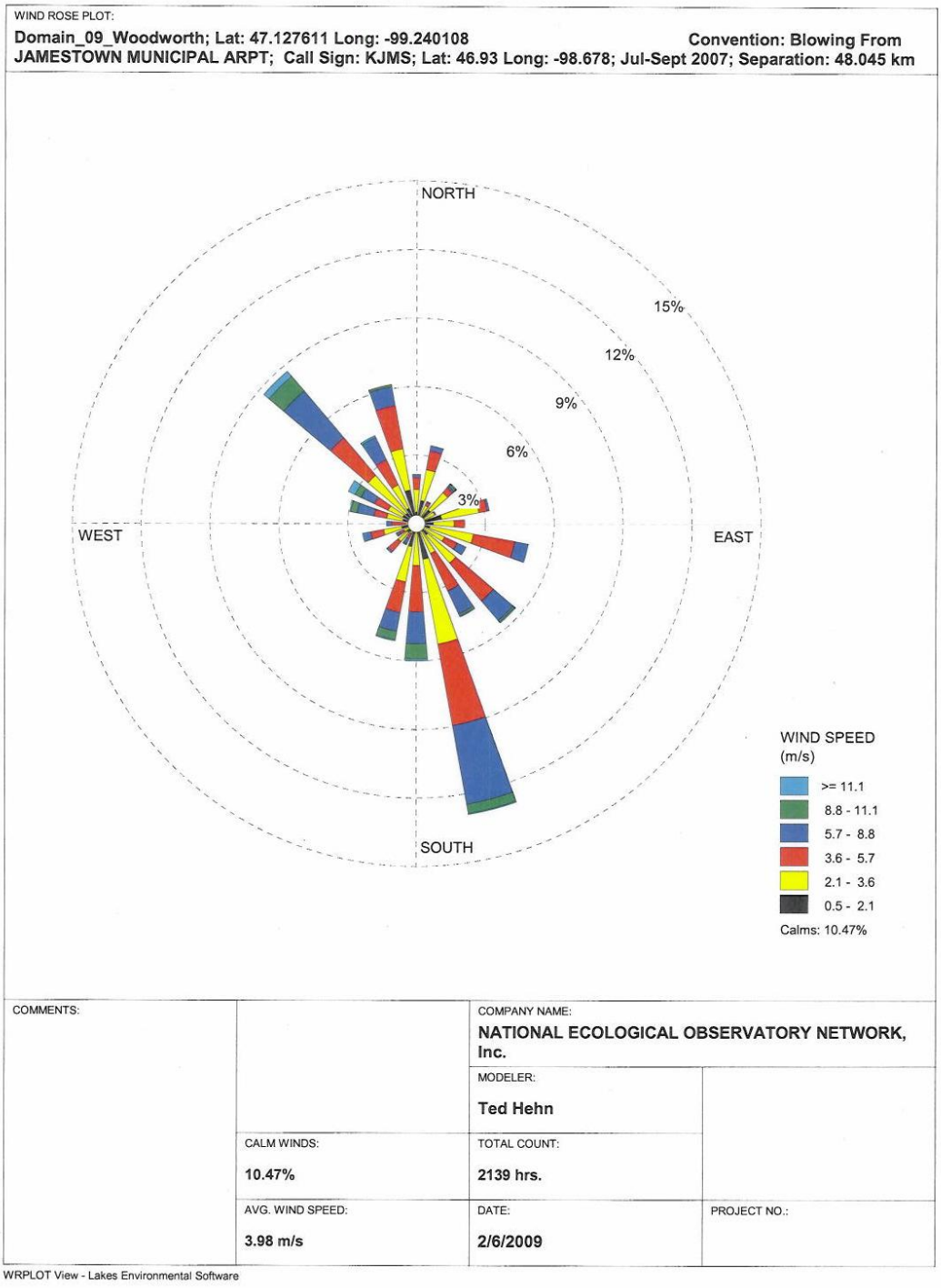
3.4.1 Seasonal windroses

Wind roses analytically determine and graphically represent the frequencies of wind direction and wind speed over a given timeseries, Figure 12. The weather data used to generate the following wind roses are 2007 data from Jamestown airport (46.93, -98.678), which is ~48 km from NEON tower site. Wind pattern from this set of wind roses are very similar to the wind patterns in the windroses made from the 1991-2005 wind data from Jamestown NDAWN Station (this set can be found in old FIU site visit report in 2008). Although the weather stations at Jamestown are ~ 48 km from NEON site, because the terrain is very flat, we assume that the wind patterns show in these two sets can representative the wind patterns at NEON site. The second set of windroses was made from long term wind data (15 years), therefore we consider this windrose set is more representative and will be used for further analysis. The orientation of the wind rose follows that of a compass (assume declination applied). When we describe the wind directions it should be noted that they are the cardinal direction that wind blows from. The directions of the rose with the longest spoke show wind directions with the largest frequency. These wind roses are subdivided into as 24 cardinal directions.

3.4.2 Results (graphs for wind roses)




WIND ROSE PLOT:
Domain_09_Woodworth; Lat: 47.127611 Long: -99.240108
Convention: Blowing From
JAMESTOWN MUNICIPAL ARPT; Call Sign: KJMS; Lat: 46.93 Long: -98.678; Apr-Jun 2007; Separation: 48.045 km
NORTH
EAST
SOUTH
WEST
10%
8%
6%
4%
2%
WIND SPEED
(m/s)
>= 11.1
8.8 - 11.1
5.7 - 8.8
3.6 - 5.7
2.1 - 3.6
0.5 - 2.1
Calms: 5.91%
COMMENTS:
COMPANY NAME:
NATIONAL ECOLOGICAL OBSERVATORY NETWORK, Inc.
MODELER:
Ted Hehn
CALM WINDS:
5.91%
TOTAL COUNT:
2132 hrs.
AVG. WIND SPEED:
5.20 m/s
DATE:
2/6/2009
PROJECT NO.:
WRPLOT View - Lakes Environmental Software


WIND ROSE PLOT:
Domain_09_Woodworth; Lat: 47.127611 Long: -99.240108
Convention: Blowing From
JAMESTOWN MUNICIPAL ARPT; Call Sign: KJMS; Lat: 46.93 Long: -98.678; Jul-Sept 2007; Separation: 48.045 km
NORTH
EAST
SOUTH
WEST
3%
6%
9%
12%
15%
WIND SPEED
(m/s)
>= 11.1
8.8 - 11.1
5.7 - 8.8
3.6 - 5.7
2.1 - 3.6
0.5 - 2.1
Calms: 10.47%
COMMENTS:
COMPANY NAME:
NATIONAL ECOLOGICAL OBSERVATORY NETWORK, Inc.
MODELER:
Ted Hehn
CALM WINDS:
10.47%
TOTAL COUNT:
2139 hrs.
AVG. WIND SPEED:
3.98 m/s
DATE:
2/6/2009
PROJECT NO.:
WRPLOT View - Lakes Environmental Software

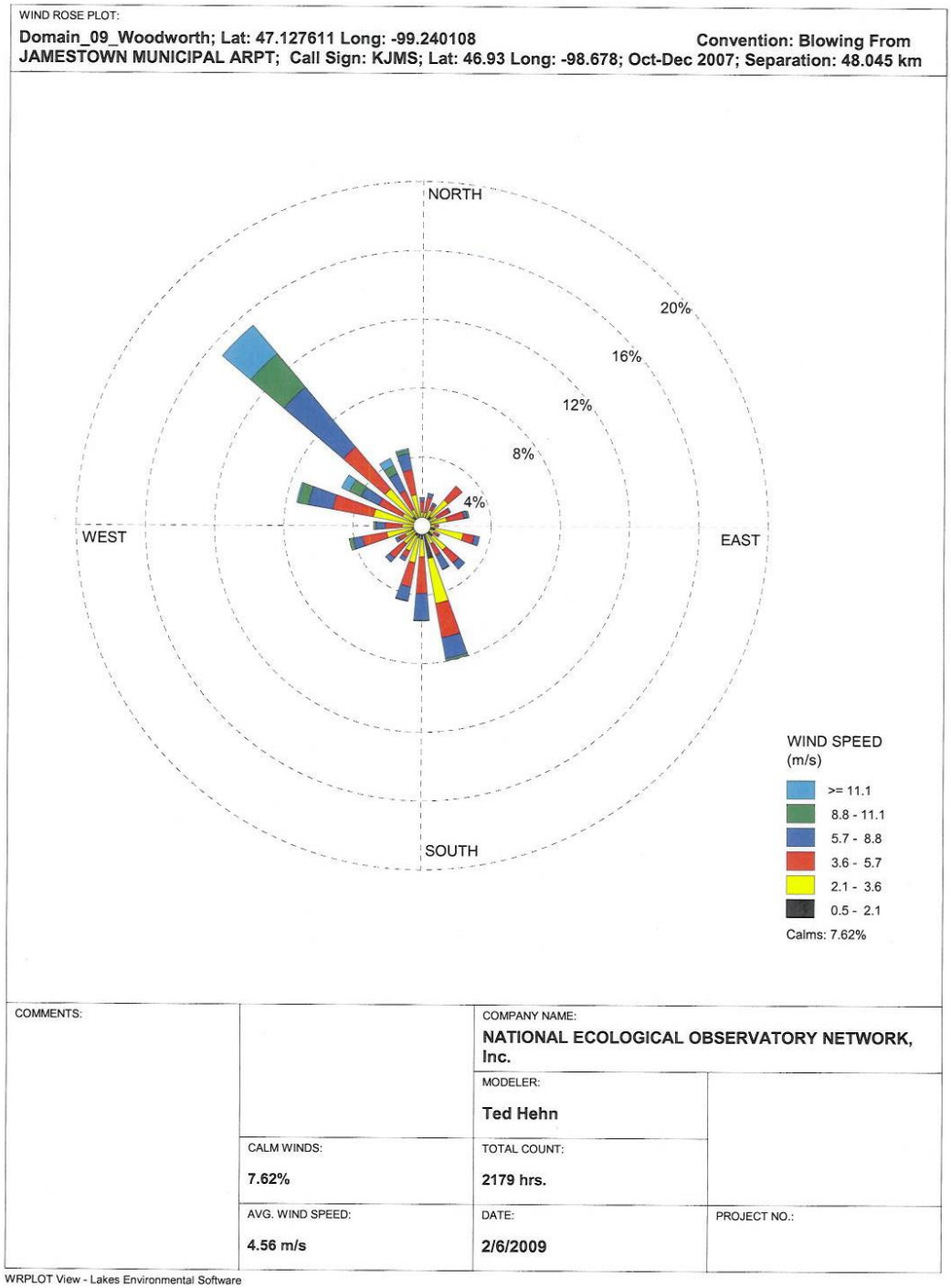
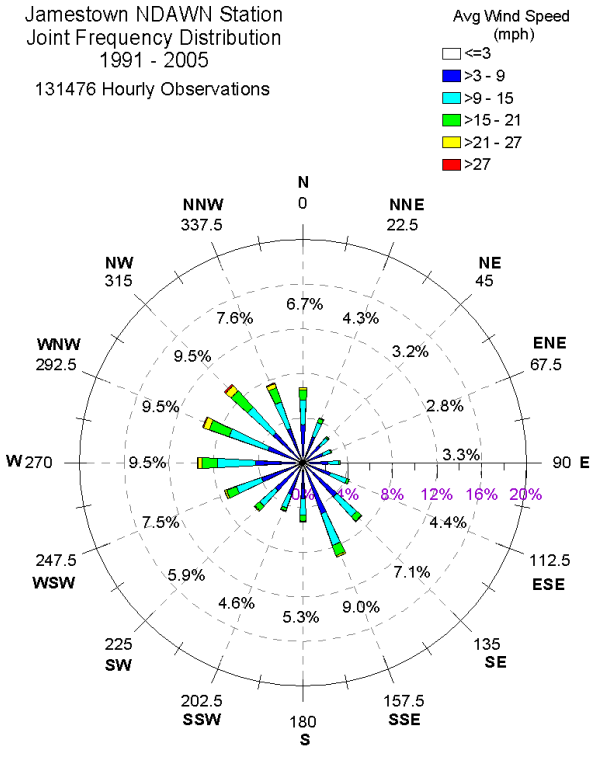
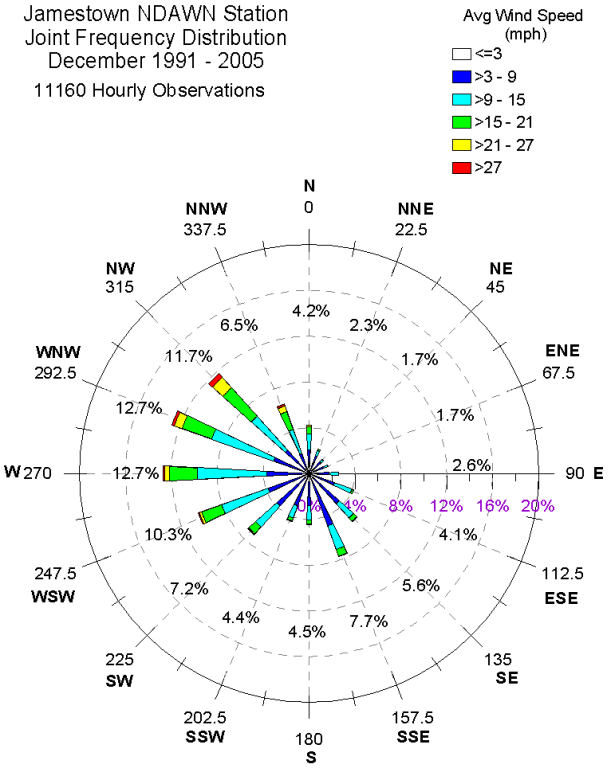
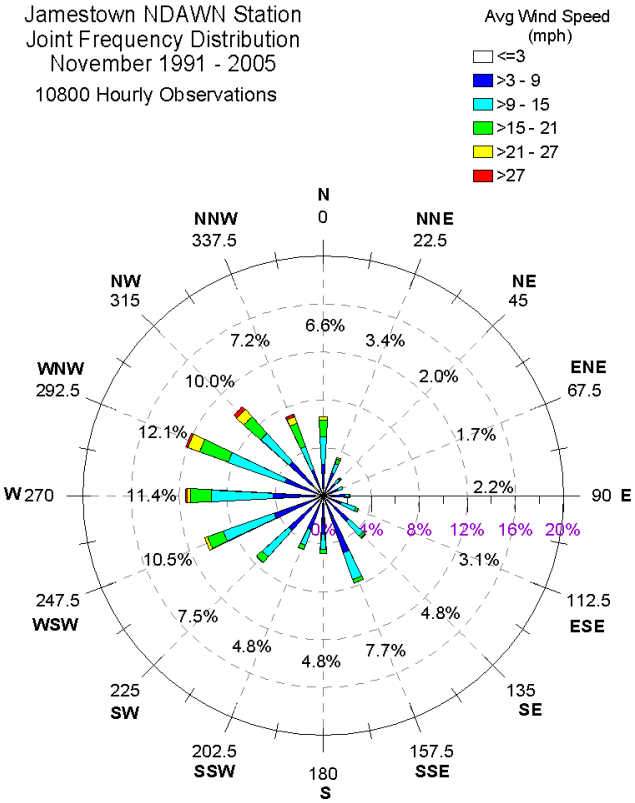
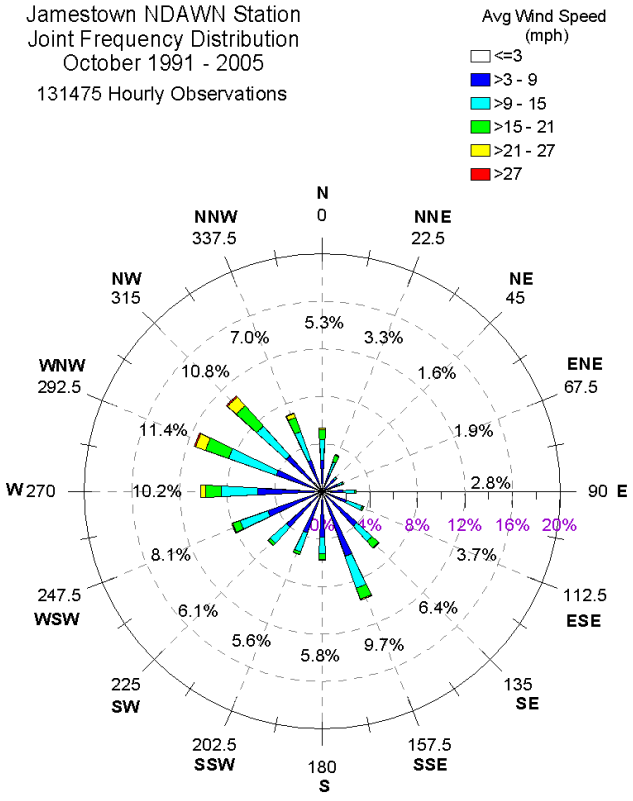


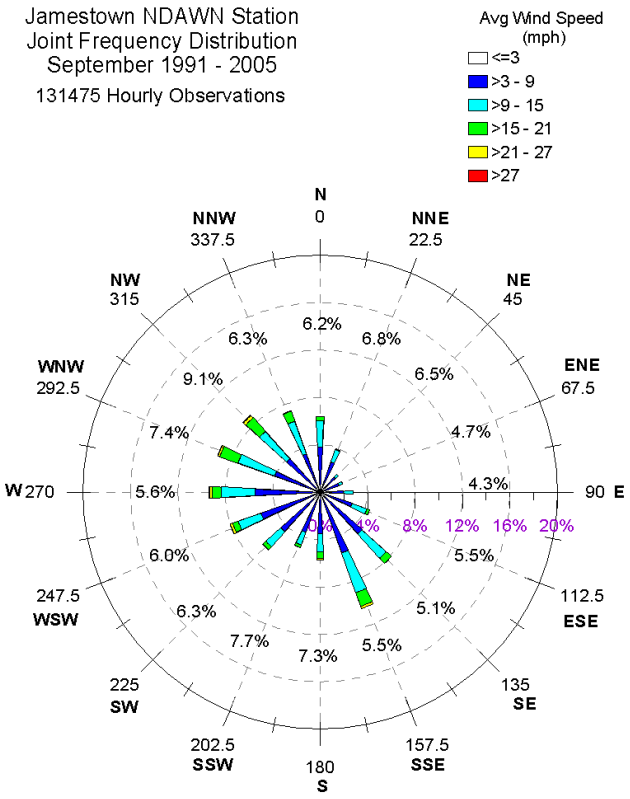
Figure 12. Windroses from Jamestown airport.
Data used here are hourly data from 2007 from Jamestown Airport, which is ~48 km from NEON tower site. It is assumed that the wind data was corrected for declination. Panels are (from top to bottom), Jan-Mar, Apr-Jun, Jul-Sept, and Oct-Dec.

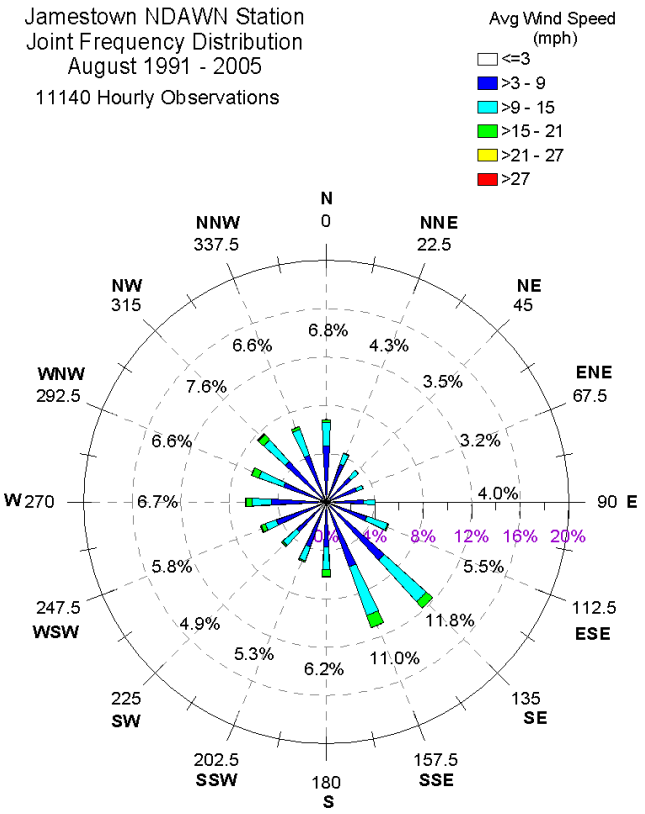

Jamestown NDAWN Station
Joint Frequency Distribution
1991 - 2005
131476 Hourly Observations
Avg Wind Speed (mph)
<=3
>3 - 9
>9 - 15
>15 - 21
>21 - 27
>27
N 0
NNE 22.5
NE 45
ENE 67.5
90 E
ESE 112.5
SE 135
SSE 157.5
180 S
SSW 202.5
SW 225
WSW 247.5
W 270
WNW 292.5
NW 315
NNW 337.5
6.7%
4.3%
3.2%
2.8%
3.3%
4.4%
7.1%
9.0%
5.3%
4.6%
5.9%
7.5%
9.5%
9.5%
9.5%
7.6%
0%
4%
8%
12%
16%
20%

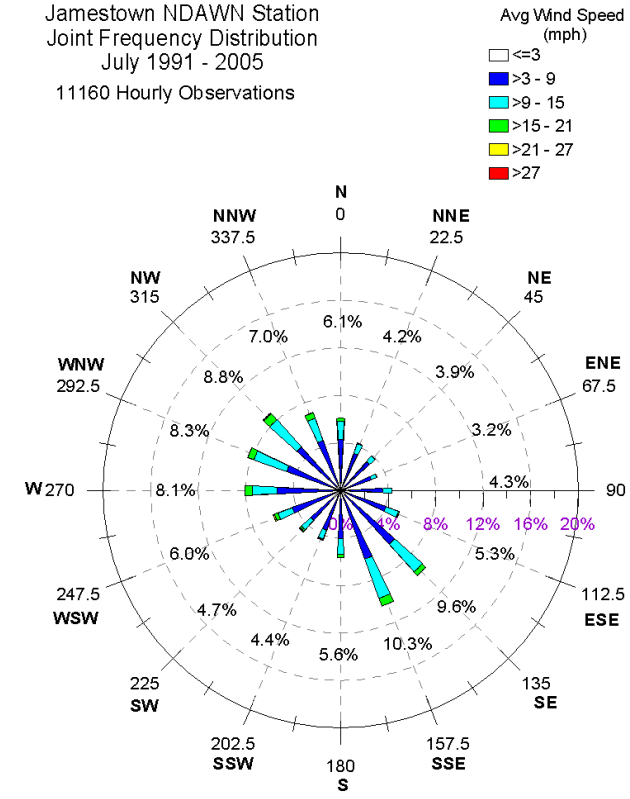

Jamestown NDAWN Station
Joint Frequency Distribution
December 1991 - 2005
11160 Hourly Observations
Avg Wind Speed (mph)
<=3
>3 - 9
>9 - 15
>15 - 21
>21 - 27
>27
N 0
NNE 22.5
NE 45
ENE 67.5
90 E
ESE 112.5
SE 135
SSE 157.5
180 S
SSW 202.5
SW 225
WSW 247.5
W 270
WNW 292.5
NW 315
NNW 337.5
4.2%
2.3%
1.7%
1.7%
2.6%
4.1%
5.6%
7.7%
4.5%
4.4%
7.2%
10.3%
12.7%
12.7%
11.7%
6.5%
0%
4%
8%
12%
16%
20%

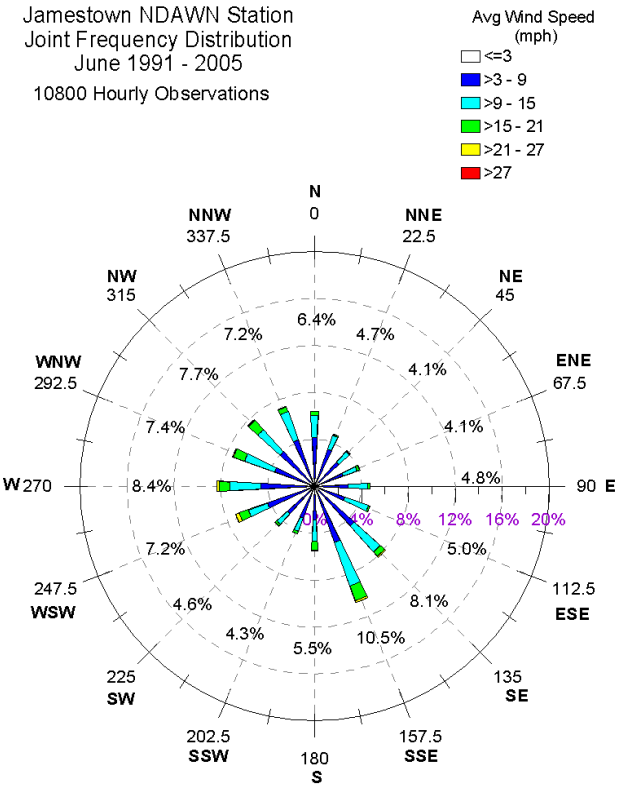

Jamestown NDAWN Station
Joint Frequency Distribution
November 1991 - 2005
10800 Hourly Observations
Avg Wind Speed (mph)
<=3
>3 - 9
>9 - 15
>15 - 21
>21 - 27
>27
N 0
NNE 22.5
NE 45
ENE 67.5
90 E
ESE 112.5
SE 135
SSE 157.5
180 S
SSW 202.5
SW 225
WSW 247.5
W 270
WNW 292.5
NW 315
NNW 337.5
6.6%
3.4%
2.0%
1.7%
2.2%
3.1%
4.8%
7.7%
4.8%
4.8%
7.5%
10.5%
11.4%
12.1%
10.0%
7.2%
0%
4%
8%
12%
16%
20%


Jamestown NDAWN Station
Joint Frequency Distribution
October 1991 - 2005
131475 Hourly Observations
Avg Wind Speed (mph)
<=3
>3 - 9
>9 - 15
>15 - 21
>21 - 27
>27
N 0
NNE 22.5
NE 45
ENE 67.5
90 E
ESE 112.5
SE 135
SSE 157.5
180 S
SSW 202.5
SW 225
WSW 247.5
W 270
WNW 292.5
NW 315
NNW 337.5
5.3%
3.3%
1.6%
1.9%
2.8%
3.7%
6.4%
9.7%
5.8%
5.6%
6.1%
8.1%
10.2%
11.4%
10.8%
7.0%
0%
4%
8%
12%
16%
20%


Jamestown NDAWN Station
Joint Frequency Distribution
September 1991 - 2005
131475 Hourly Observations
Avg Wind Speed (mph)
<=3
>3 - 9
>9 - 15
>15 - 21
>21 - 27
>27
N 0
NNE 22.5
NE 45
ENE 67.5
E 90
ESE 112.5
SE 135
SSE 157.5
S 180
SSW 202.5
SW 225
WSW 247.5
W 270
WNW 292.5
NW 315
NNW 337.5
6.2%
6.8%
4.7%
4.3%
5.5%
5.1%
5.5%
7.3%
7.7%
6.3%
6.0%
5.6%
7.4%
9.1%
6.3%
0%
4%
8%
12%
16%
20%


Jamestown NDAWN Station
Joint Frequency Distribution
August 1991 - 2005
11140 Hourly Observations
Avg Wind Speed (mph)
<=3
>3 - 9
>9 - 15
>15 - 21
>21 - 27
>27
N 0
NNE 22.5
NE 45
ENE 67.5
E 90
ESE 112.5
SE 135
SSE 157.5
S 180
SSW 202.5
SW 225
WSW 247.5
W 270
WNW 292.5
NW 315
NNW 337.5
6.8%
4.3%
3.5%
3.2%
4.0%
5.5%
11.8%
11.0%
6.2%
5.3%
4.9%
5.8%
6.7%
6.6%
7.6%
6.6%
0%
4%
8%
12%
16%
20%


Jamestown NDAWN Station
Joint Frequency Distribution
July 1991 - 2005
11160 Hourly Observations
Avg Wind Speed (mph)
<=3
>3 - 9
>9 - 15
>15 - 21
>21 - 27
>27
N 0
NNE 22.5
NE 45
ENE 67.5
E 90
ESE 112.5
SE 135
SSE 157.5
S 180
SSW 202.5
SW 225
WSW 247.5
W 270
WNW 292.5
NW 315
NNW 337.5
6.1%
4.2%
3.9%
3.2%
4.3%
5.3%
9.6%
10.3%
5.6%
4.4%
4.7%
6.0%
8.1%
8.3%
8.8%
7.0%
0%
4%
8%
12%
16%
20%


Jamestown NDAWN Station
Joint Frequency Distribution
June 1991 - 2005
10800 Hourly Observations
Avg Wind Speed (mph)
<=3
>3 - 9
>9 - 15
>15 - 21
>21 - 27
>27
N 0
NNE 22.5
NE 45
ENE 67.5
E 90
ESE 112.5
SE 135
SSE 157.5
S 180
SSW 202.5
SW 225
WSW 247.5
W 270
WNW 292.5
NW 315
NNW 337.5
6.4%
4.7%
4.1%
4.1%
4.8%
5.0%
8.1%
10.5%
5.5%
4.3%
4.6%
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7.2%
0%
4%
8%
12%
16%
20%

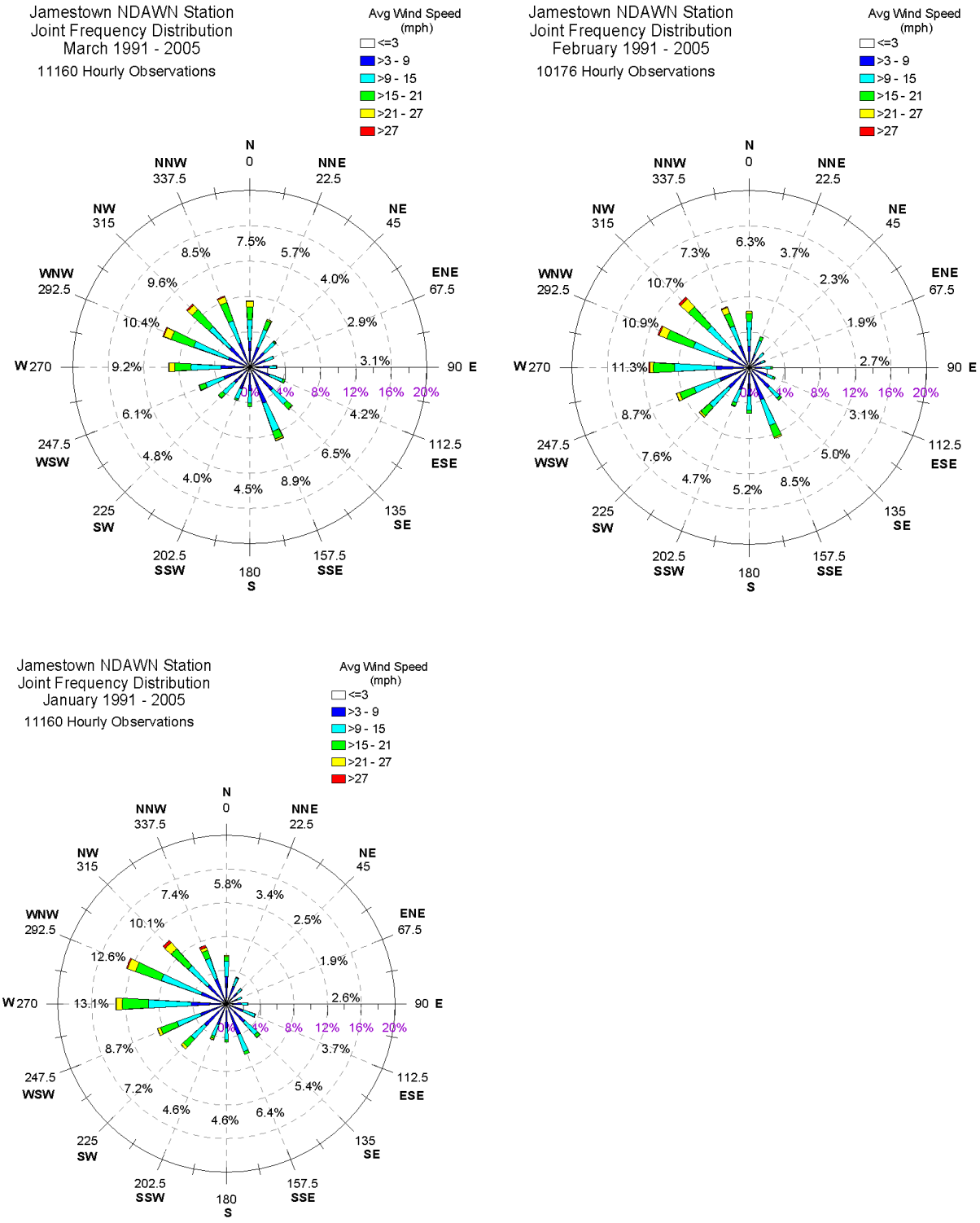


Figure 13. Windroses from Jamestown NDAWN Station.
Data used here are wind data from 1991-2005 from Jamestown NDAWN Station, which is ~48 km from NEON tower site. Wind roses were provided by local contacts. It is assumed that the wind data was corrected for declination. Panels (from top to bottom) represent annual and monthly wind patterns.

3.4.3 Resultant vectors

Not available.

3.4.4 Expected environmental controls on source area

Two types of models were commonly used to determine the shape and extent of the source area under different and contrasting atmospheric stability classes. An inverted plume dispersion model with modeled cross wind solutions were used for convective conditions (Horst and Weil 1994). For strongly stable conditions, and Lagrangian solution was used (Kormann and Meixner 2001). The source area models where bounded by the expected conditions depict the extreme conditions. Convective conditions typically have strong vertical mixing between the ecosystem and atmosphere (surface layer). Stable conditions typically have long source area and associated waveforms. Convective turbulence is often characterized by short mixing scales (scalar) and moderate daytime wind speeds, *e.g.,* 1-4 m s^{-2}. Higher wind speeds, like those experienced over the Rockies, are often the product of mechanical turbulence with long waveforms. Because thermal stratification is very efficient in suppressing vertical mixing, stable conditions also have typically very long waveforms.

As a general rule, shorter and less structurally complex ecosystems have good vertical mixing during all atmospheric stabilities. Taller and more structurally complex ecosystems have well mixed upper canopies during the daytime, and can be decoupled below the canopy under neutral and stable conditions. The type of turbulence (mechanical verse convective) and the physical attributes of the ecosystem control the degree of mixing, and the length and size of the source area.

Here, we used a web-based footprint model to determine the footprint area under various conditions (model info: http://www.geos.ed.ac.uk/abs/research/micromet/EdiTools/). Winds used to run the model and generate following model results are extracted from the wind roses. Vegetation information, temperature and energy information were either from the RFI document, previous site visit report, available data files or best estimated from experienced expert. Measurement height was determined from the Tower Height Info document provided by ENG group, then verify according to the real ecosystem structure after FIU site characterization at site. Runs 1-3 and 4-6 represents the expected conditions for summer and winter conditions, respectively, with maximum and mean windspeeds (daytime convective) and nighttime (stable atmospheres) conditions. The wind vector for each run was estimated from wind roses and is placed as a centerline in the site map included in the graphics. The width of the footprint was also estimated using the length between the isopleth of 80% cumulative flux and center line to calculate the angle from centerline. This information, along with distance of the cumulative flux isopleths and wind direction, will define the source area for the flux measurements on the top of the tower.

Table 5. Expected environmental controls to parameterize the source area model, and associated results from Woodworth advanced site.

Parameters	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	
Approximate season	summer			winter			Units
	Day (max WS)	Day (mean WS)	Night	Day (max WS)	Day (mean WS)	night	qualitative
Atmospheric stability	Convective	convective	Stable	Convective	convective	Stable	qualitative

Measurement height	11	11	11	11	11	11	m
Canopy Height	3.9	3.9	3.9	3.9	3.9	3.9	m
Canopy area density	3.162	3.16	3.162	1.259	1.259	1.259	m
Boundary layer depth	2079	2079	1065	811	811	621	m
Expected sensible heat flux	450	450	29	22	22	-47	W m^{-2}
Air Temperature	28	28	21	2	2	-20	°C
Max. windspeed	11	3.8	3.8	11	4.6	4.6	m s^{-1}
Resultant wind vector	165	165	165	314	314	314	degrees
Results							
(z-d)/L	-0.02	-0.34	-0.04	0	-0.01	0.04	m
d	3.1	3.1	3.1	2.7	2.7	2.7	m
Sigma v	2.9	2	0.99	2.6	1.2	1.8	m^2 s^{-2}
Z0	0.17	0.17	0.17	0.26	0.26	0.26	m
u*	1.2	0.48	0.41	1.3	0.54	0.5	m s^{-1}
Distance source area begins	0	0	0	0	0	0	m
Distance of 90% cumulative flux	750	350	700	750	700	900	m
Distance of 80% cumulative flux	400	200	400	400	400	500	m
Distance of 70% cumulative flux	300	150	250	300	300	350	m
Peak contribution	55	35	55	55	55	55	m

Note: 1. the model output in this table and the footprint graphs below are based on the original candidate tower site at 47.12761111, -99.24010833. The actual ecosystem structure and similar to estimate and the final tower location (47.12802, -99.24133) is only ~100 m apart. Footprint analysis in section 3.4.5 is not redone based on the new tower site. 2. The tower height used in this model 11 m, but deign height will be 6 m. Thus the length of the source area will be shorter than reported above.

3.4.5 Results (source area graphs)

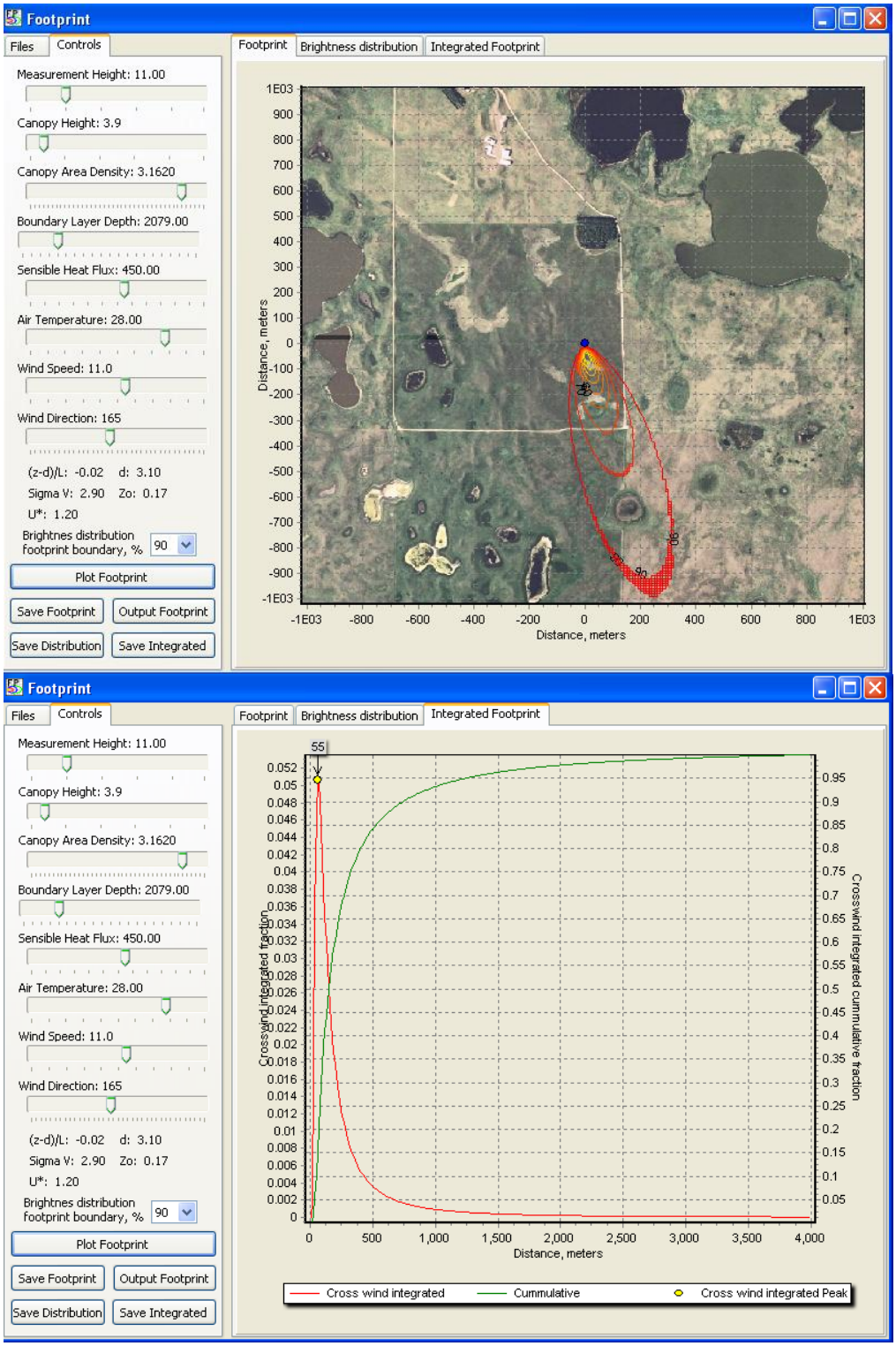


Figure 14. summer, daytime, max wind speed

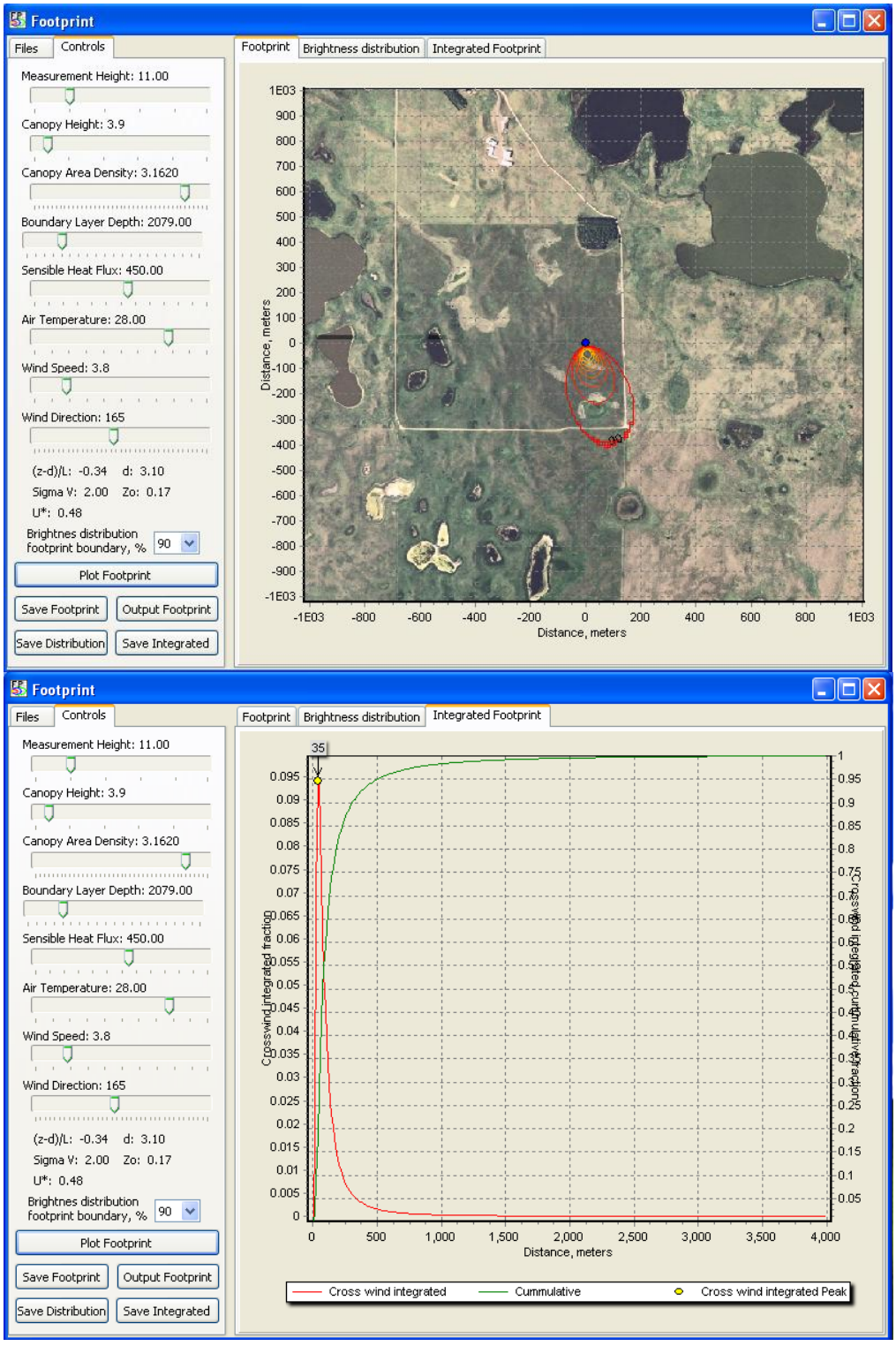


Figure 15. summer, nighttime, mean wind speed

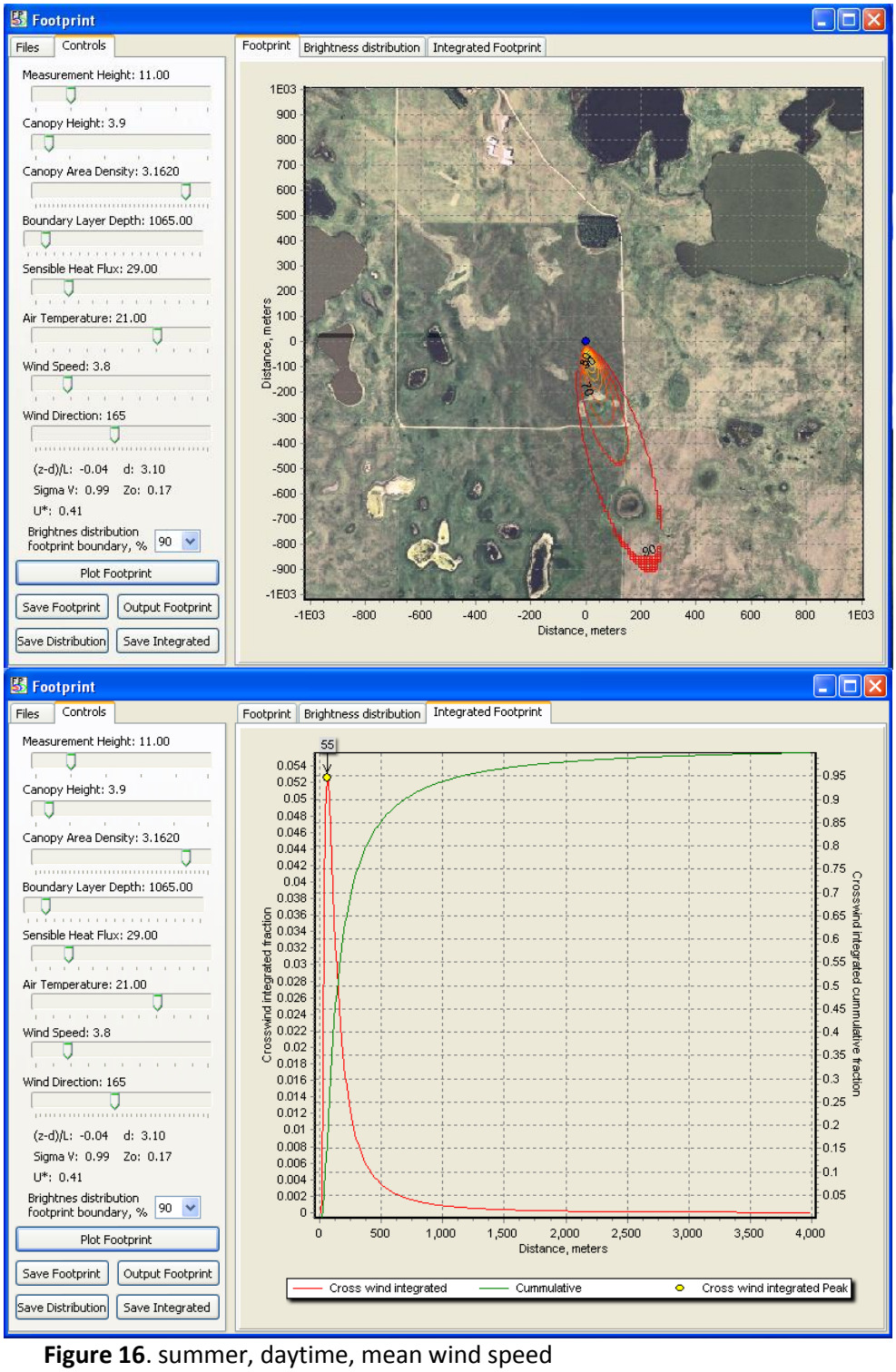


Figure 16. summer, daytime, mean wind speed

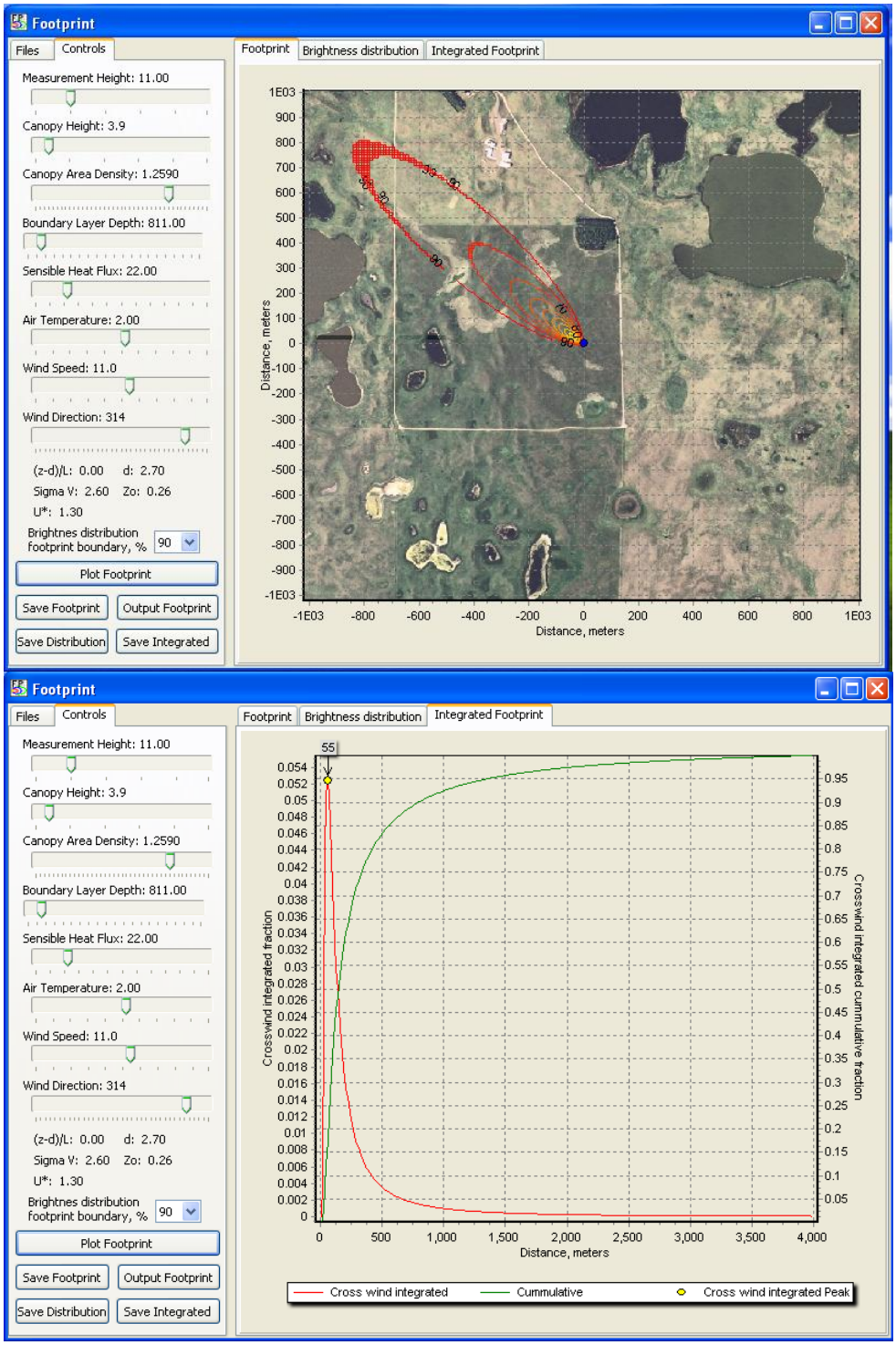


Figure 17. winter, daytime, max wind speed

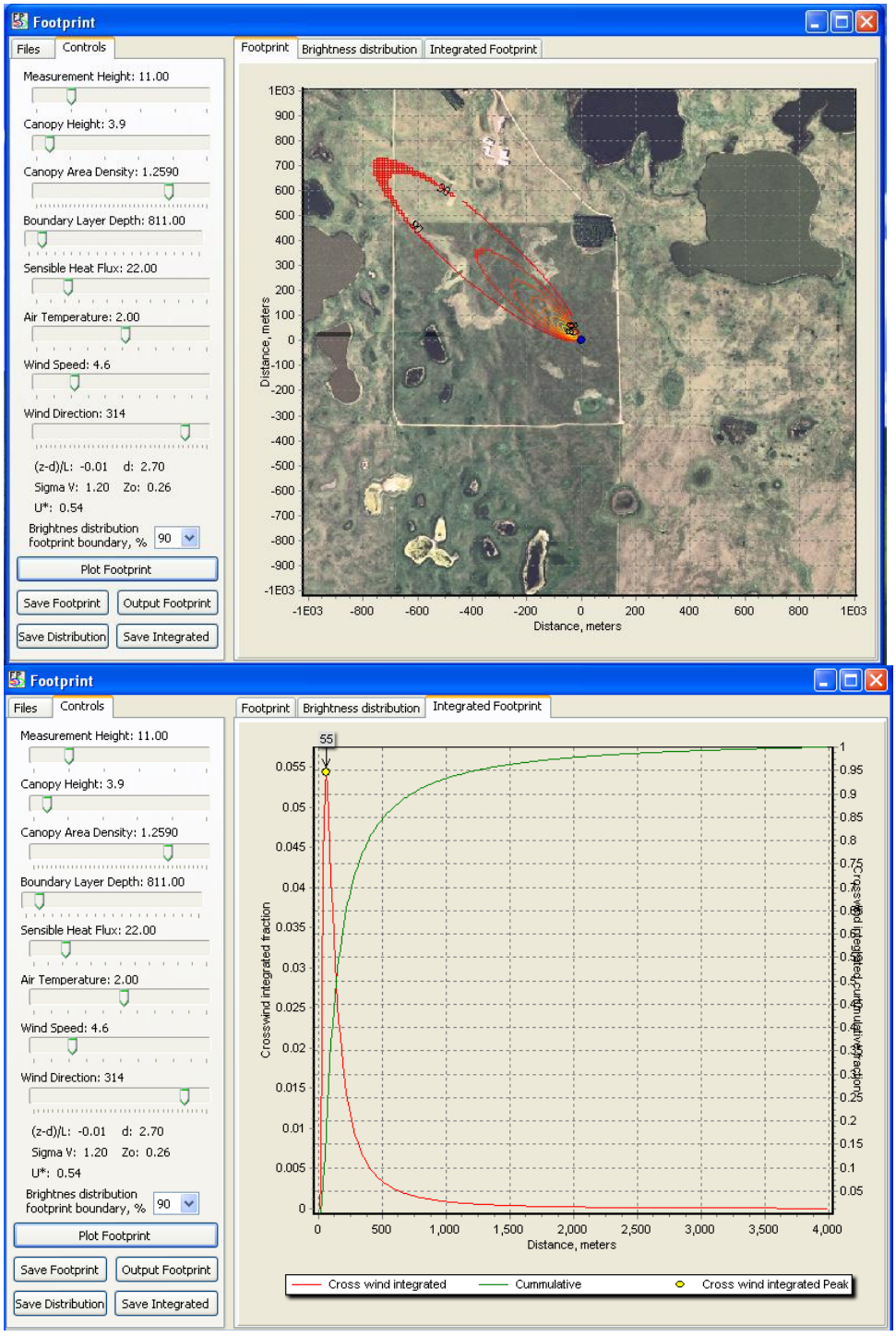


Figure 18. Winter daytime, mean wind speed

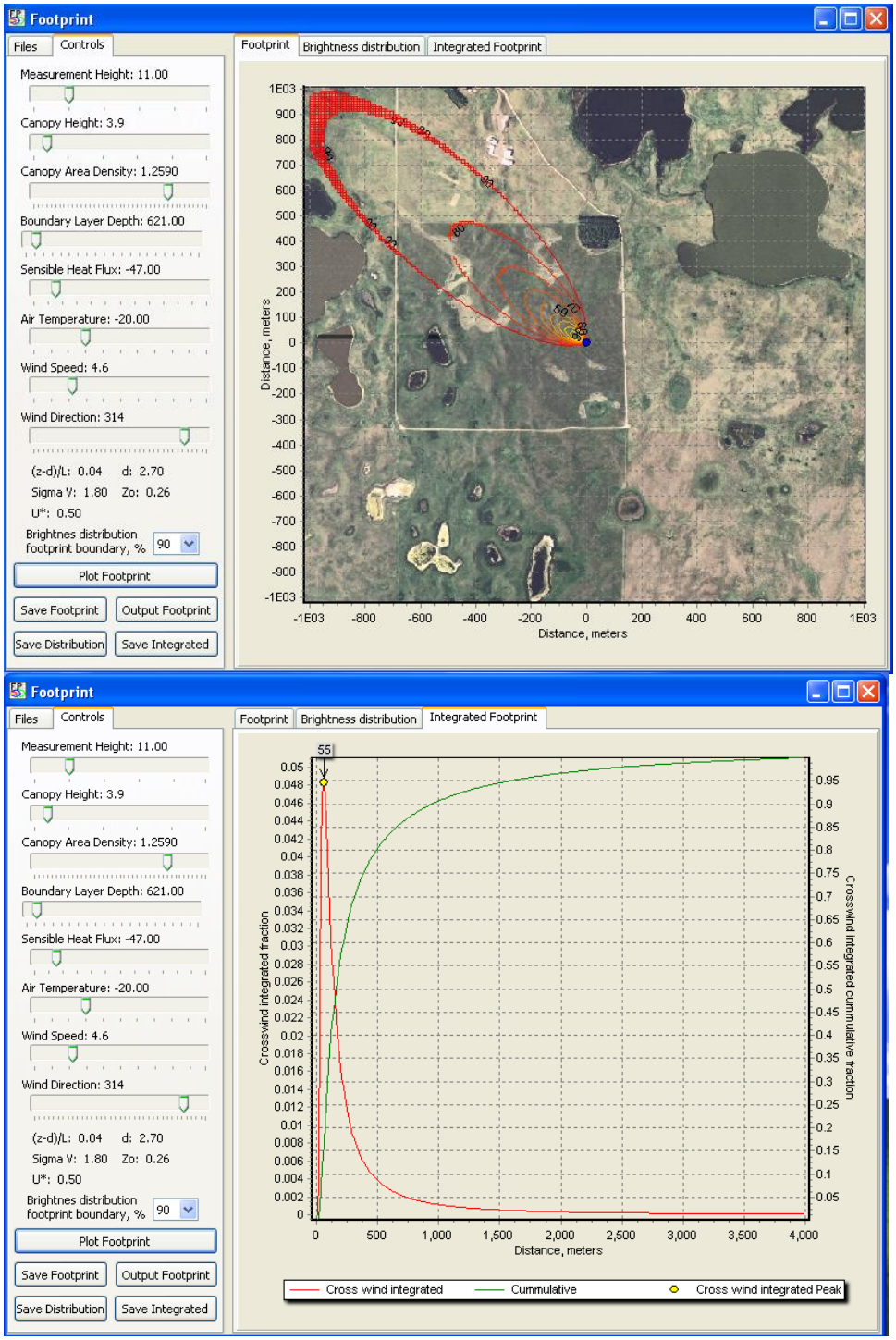


Figure 19. winter, nighttime, mean wind speed

3.4.6 Site design and tower attributes

According to wind roses, the prevailing wind direction blows from northwest and west (247° to 360°, clockwise from 247°, major airshed) and southeast (135° to 157°, clockwise from 135°, secondary airshed), which is consistent throughout the whole year. Tower should be placed to a location to best catch the signals from the airshed of the ecosystem in interest, which is restored native prairie. The candidate tower site was at 47.12761111, -99.24010833. After site visit, we moved tower location toward northwest for ~100 m to maximize the fetch area inside property boundary and the same management unit. The new tower location is at 47.12802, -99.24133.

Eddy covariance, sonic wind and air temperature **boom arms** orientation toward the southwest will be best to capture signals from all wind directions. **Radiation boom arms** should always be facing south to avoid any shadowing effects from the tower structure. An **instrument hut** should be outside the prevailing wind airshed to avoid disturbance in the measurements of wind and should be positioned to have the longer side parallel to frequent wind direction to minimize the wind effects on instrument huts and to minimize the disturbances of wind regime by instrument hut, and in this case, instrument hut should be positioned on the northeast side of tower and have the longer side parallel to SE-NW direction. The location of instrument hut is at 47.12811, -99.24113.

Canopy height of the restored native prairie was ~0.4 m by the time of FIU site characterization, but expects up to ~ 0.8-1m in summer. We require 4 **measurement layers** on the tower with top measurement height at 6 m, and remaining layers are 6 m, 3.5 m, 1 m, and 0.2 m, respectively, to best characterize the fluxes on the tower top and environmental conditions in profile.

DFIR (Double Fenced International Reference) will be at 47.12828, -99.24073, which is ~ 55 m away from tower. Closest power line is along the road on the east to tower, which is ~ 185 m away from DFIR. **Wet deposition collector** will collocate at the top of the tower. See AD 04 for further information and requirements for bulk precipitation collection and wet deposition collection.

The site layout is summarized in the table below. Assume the projected area of the tower is square. **Anemometer/temperature boom arm direction** is ***from*** the tower ***toward*** the prevailing wind direction or designated orientation. **Instrument hut orientation vector** is parallel to the long side of the instrument hut. **Instrument hut distance z** is the distance from the center of tower projection to the center of the instrument hut projection on the ground. The numbering of the **measurement levels** is that the lowest is level one, and each subsequent increase in height is numbered sequentially, in this case, level 4 being the upper most level at this tower site.

Table 6. Site design and tower attributes for Woodworth Advanced site.

0° is true north with declination accounted for. Color of Instrument hut exterior shall be tan to best match the surrounding environment.

Attribute	lat	long	degree	meters	notes
Airshed area			247° to 360° (major), 135° to 157°		Clockwise from first angle

			(secondary)		
Tower location	47.12802,	-99.24133	--	--	new site
Instrument hut	47.12811,	-99.24113			
Instrument hut orientation vector	--	--	145° - 325°		
Instrument hut distance z	--	--	--	18	
Anemometer/Temperature boom orientation	--	--	245°	--	
DFIR	47.12828,	-99.24073			
Height of the measurement levels					
Level 1				0.2	m.a.g.l.
Level 2				1.0	m.a.g.l.
Level 3				3.5	m.a.g.l.
Level 4				6.0	m.a.g.l.
Tower Height				6.0	m.a.g.l.

See AD 03 for technical requirement to determine the boom height for the bottom most measurement level.

Figure below shows the proposed tower location, instrument hut location, DFIR, airshed area and access road.

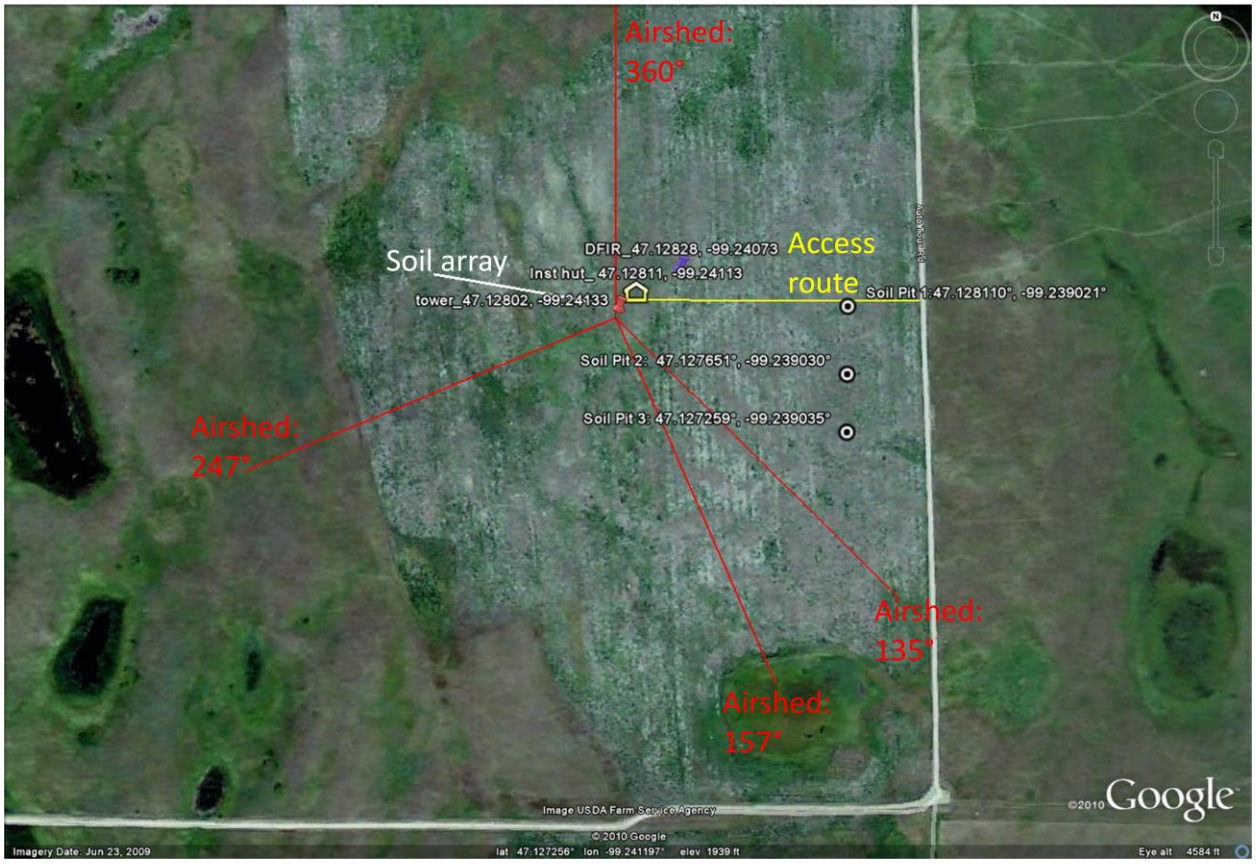


Figure 20. Site layout for Woodworth Advanced tower site.
i) Tower location is presented (red pin), ii) red lines indicate the airshed boundaries. Vectors 247° to 360° (clockwise from 247°) and 135° to 157° (clockwise from 135°) are the airshed areas that would have quality wind data without causing flow distortions, respectively. iii) Yellow line is the suggested access road to instrument hut. iv) Purple pin is DFIR location

Boardwalks. Ultimately, the decision to use a boardwalk will be, in part, based on owner's preferences. There are strong science requirements that minimize site disturbance to the surrounding area, which will be difficult to manage over a 30-y period. Traffic control is key to minimizing the site disturbance. Confining foot traffic to boardwalks minimizes site impact; this is particularly true in places where wear caused by foot traffic becomes noticeable and grows. For example, in places with snow part of the year, worn footpaths tend to have low places that collect water, or places where the snow pack becomes uneven causing personnel to walk farther and farther around the sides of the original path, causing the path to grow in width. This is a very common phenomenon. Here, FIU assumes that all conduits will be either buried, or placed inside the boardwalk such that it does not extend beyond the 36" (0.914 m). wide footprint. The boardwalk to access the tower is not on any side that has a boom.
Specific Boardwalks at Woodworth Advance site:

- Boardwalk is from the access dirt road to instrument hut, pending landowner decision
- Boardwalk from the instrument hut to the tower to intersect on north face of the tower
- Boardwalk to the soil array
- No boardwalk from the soil array boardwalk to the individual soil plots
- No boardwalk needed at DFIR site

- Boardwalk has to withstand managed burns and light grazing

The relative locations between tower, instrument hut and boardwalk can be found in the Figure below:

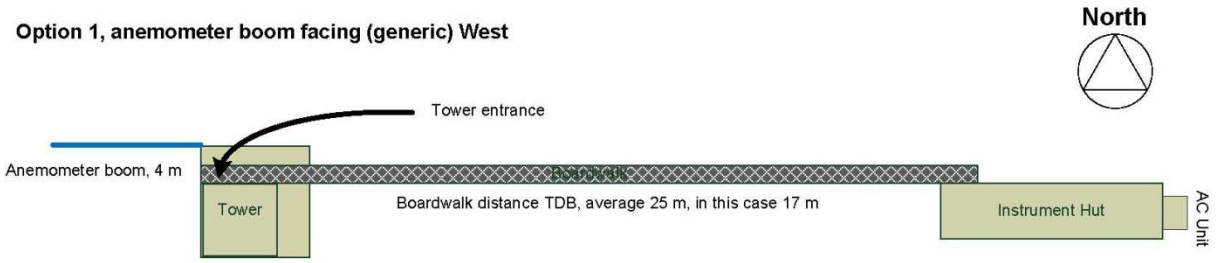


Figure 21. Generic diagram to demonstration the relationship between tower and instrument hut when boom facing west and instrument hut on the east towards the tower.

This is just a generic diagram. The actual layout of boardwalk (or path if no boardwalk required) and instrument hut position will be the joint responsibility of FCC and FIU. At Woodworth Advanced site, the boom angle will be 245 degrees, instrument hut will be on the northeast towards the tower, the distance between instrument hut and tower is ~18 m. The instrument hut vector will be SE-NW (145°-325°, longwise).

3.4.7 Information for ecosystem productivity plots

The tower at Woodworth Advanced site has been positioned to optimize the collection of the air/wind signals both temporally and spatially over the desired ecosystem (restored native prairie). Major airshed area at this site are from 247° to 360° (major, clockwise from 247°), 135° to 157° (secondary, clockwise from 135°), and 90% signals for flux measurements are in a distance of 900 m from tower, and 80% within 500 m. We suggest FSU Ecosystem Productivity plots are placed within the major airshed boundaries of 247° to 360° (clockwise from 247°) from tower.

3.5 Issues and attentions

A new tower location was selected (47.12802, -99.24133), which was ~100 m from the original location (47.12761111, -99.24010833), to reduce the effects of roads and areas outside the property on the airshed.

Plow lines and rock piles can be seen throughout the area surrounding the tower and are a result of recent, but now discontinued, agriculture at the site. The site has been re-seeded with native prairie plants once, but may be re-seeded again in order to achieve higher plant cover (60-70% bare ground during the site visit). The focus of this site is the restoration of the native prairie. Herbicide (Round-up) has been used to control non-native plants and it may be used again in the future. During the site visit many of the plants were germinating and it was often not possible to identify them, however, at least some non-native plants could be seen at the site. Due to the level of previous disturbance and the current management practices this site does not represent what most ecologists would consider “wildland”.

Prescribed burns and grazing may occur in the future as part of the management strategy for this site. NEON equipment should be designed to withstand managed fires and fencing or protective covers may be needed to prevent damage by cattle.

There are many small rocks (~2 cm diameter) and some larger cobbles in the soil, but this is not expected to be a major problem for the soil-based instruments.

Similar to the other sites in this domain, high winds can occur (e.g. >80 mph).

Information from the previous FIU site visit in 2008:

> Road Access is good (gravel), maintained during snow free periods. During winter, main road from Hwy 36 is only road Plowed. During winter will need 4X4 vehicle, and under worse case scenario may need a snow mobile. (Info source: Old FIU site visit report in 2008).
>
> The local science team from domain 9 did an excellent job preparing for the site visit and gave great insight into Woodworth Station. Three factors should be considered for construction: 1) The area is a water fowl production area and several ground nesting birds were found around the site, area will need to be surveyed before construction as not to damage any nests. 2) Grazing may be introduced into the area, additional protection should be place around the towers so cattle can not rub against towers or guy wires. 3) U.S. Fish and Wildlife crew would like the power line to be cut in and natural vegetation folded back down as to minimize the impact on the site. (Info source: Old FIU site visit report in 2008).
>
> Control burns (3-5 years), Tornados, Freeze events including ice storms, large hail storms, straight line winds that can exceed 80 mph, and lightning storms. Large temperature ranges -60 – 121. Potential grazing in the area. (Info source: Old FIU site visit report in 2008).
> The advance site is a restoration site which was burn, and had 2 years of round up treatment, then was reseeded with native grasses. The area is a water fowl production area and several ground nesting birds were found around the site, area will need to be surveyed before construction as not to damage any nests. Grazing may be introduced into the area. Control burns (3-5 years), Tornados, Freeze events including ice storms, large hail storms, straight line winds that can exceed 80 mph, and lightning storms. Large temperature ranges -60 – 121. (Info source: Old FIU site visit report in 2008).

4 DAKOTA COTEAU FIELD SCHOOL, RELOCATEABLE TOWER 1

4.1 Site description

The original Dakota Coteau Field School (DCFS) candidate Relocatable site was at 47.161°, -99.111° (Figure 22). After FIU site characterization, we microsited it ~350 m east at 47.16144°, -99.10653° to maximize tower fetch area on the SE and NW direction over pothole prairie, and minimize the impacts of lake (on west toward tower) on the tower climate measurements.

This site is just < 7 miles away from the Woodworth Advance site. We assumed the climate description for Woodworth Advance tower site above is also similar for this site, thus will not duplicate the same site description here.

Some general info about Dakota Coteau Field School can be found here http://www.ndsu.edu/fileadmin/www.ur.ndsu.edu/pdfs_-_examples/DakotaCoteau.pdf.

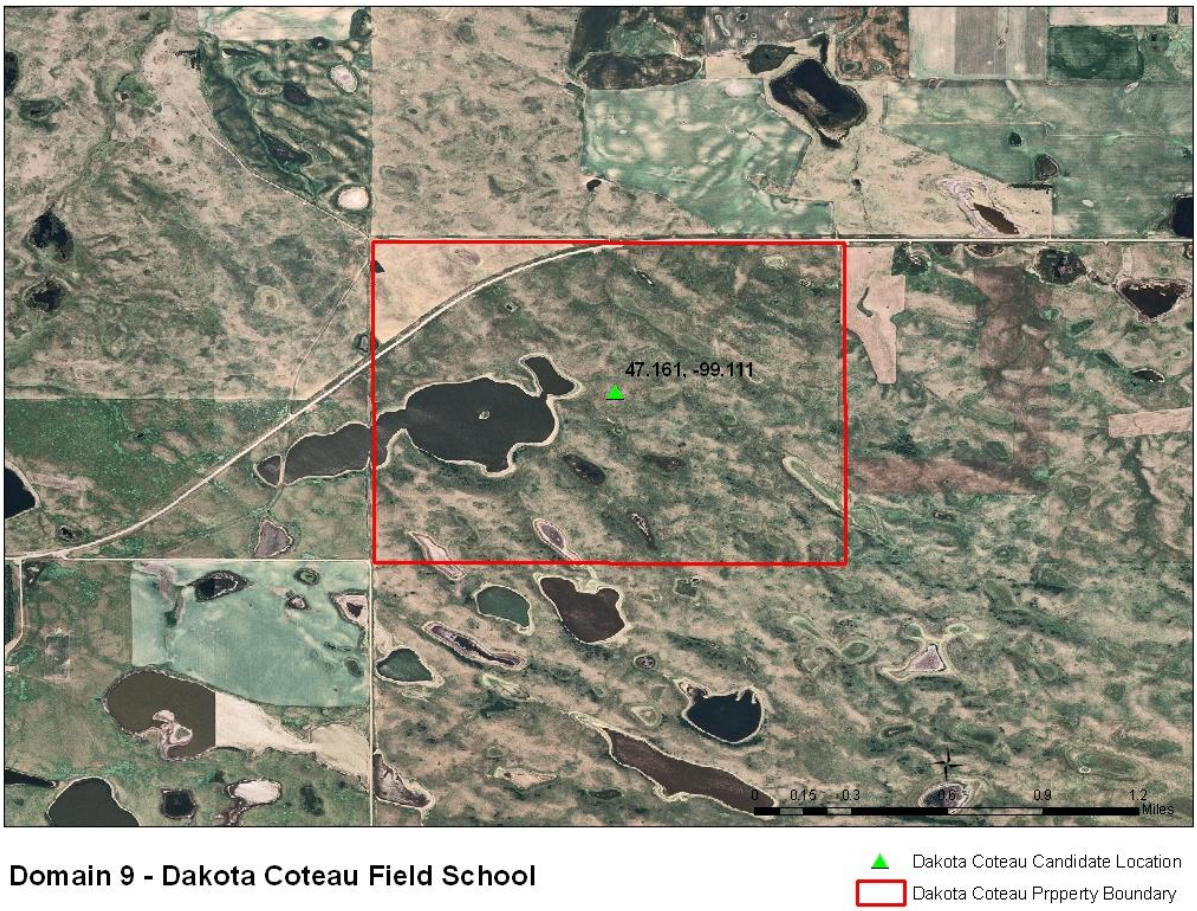


Figure 22. Property boundary of the DCFS and original candidate tower location.
Note that the tower was micro-sited since this image was made, actual tower location indicated below.

4.2 Ecosystem

Vegetation type and land cover information at this relocatable site are presented below:

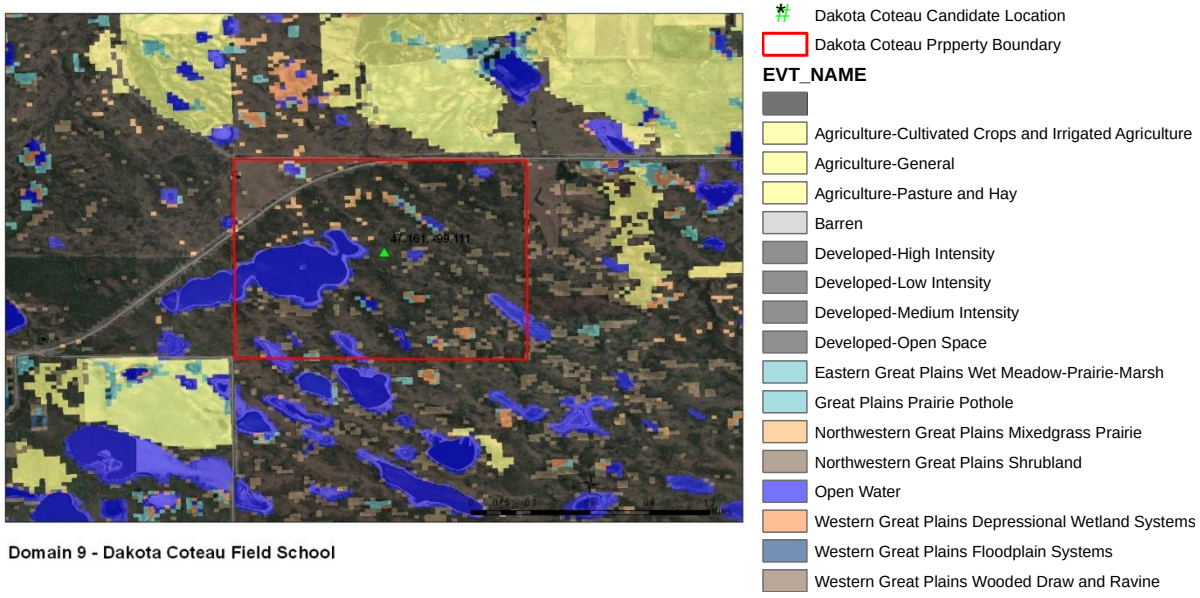


Figure 23. Vegetative cover map of DCFS relocatable site and surrounding areas (from USGS, http://landfire.cr.usgs.gov/viewer/viewer.htm), note that the tower was micro-sited since this graph was made, actual tower location indicated below.

Table 7. Percent Land cover information at DCFS relocatable site (from USGS, http://landfire.cr.usgs.gov/viewer/viewer.htm)

Vegetation Type	Area (km^2)	Percentage
No Data	1.89	72.63
Developed-Low Intensity	0.03	1.00
Developed-Open Space	0.03	1.24
Eastern Great Plains Wet Meadow-Prairie-Marsh	0.02	0.59
Great Plains Prairie Pothole	0.01	0.51
Northwestern Great Plains Mixedgrass Prairie	0.03	1.12
Open Water	0.39	14.93
Western Great Plains Depressional Wetland Systems	0.03	0.98
Western Great Plains Wooded Draw and Ravine	0.18	7.01
Total Area sq km	2.60	100.00

The ecosystem at this site is pothole prairie. Grass is ~0.4 m height, but many small shrubs are interspersed with height of 0.7 – 1.5 m and a density of ~ 150 ha^{-1} (Figure 24). A few tall shrubs (2 – 3 m) are also found. Landscape is very gentle rolling hills (30-40 m high) with ponds (ephemeral or permanent) in the valleys. Most ponds appear to be shallow since weeds grow almost to the center of the ponds. The average distance between ponds is ~ 200 m. Because of the ponds, there is a high abundance and diversity of mosquitoes. Birds are also abundant here, especially aquatic birds, e.g.

ducks, pelicans, etc. Rocky outcrops are intermittent at field, where large cobbles are visible on the soil surface. Agriculture land is visible to the north (~800 m from tower) and east (>1500 m from tower). The site is grazed at some times during the year, but not continuously, and the grazing intensity is lower than at the Northern Great Plains Research Lab site.

Figure 24. Ecosystem and surrounding environment at DCFS relocatable site.

Table 8. Ecosystem and site attributes for DCFS Relocatable site.

Ecosystem attributes	Measure and units
Mean canopy height (grass)	0.4 m
Mean canopy height (shrub)[b]	1.5 m
Surface roughness (shrub)[a]	0.3 m
Zero place displacement height (shrub)[a]	1.0 m
Structural elements	Prairie grassland, shrubs intersperced
Time zone	Central time zone
Magnetic declination	5° 38' E changing by 0° 8' W/year

Note, [a] From field survey. [b] Although prairie grass is dominant vegetation type at site, shrubs has large impacts on the flow dynamics at ecosystem surface. Thus shrub height is used here for the purpose of tower design.

4.3 Soils

4.3.1 Description of soils

Soil data and soil maps (Figure 25) below for Dakota Coteau tower site were collected from 2.1 km^2 NRCS soil maps (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm) to determine the dominant

soil types in the larger tower foot print. This was done to assure that the soil array is in the dominant (or in the co-dominant) soil type present in the tower footprint.

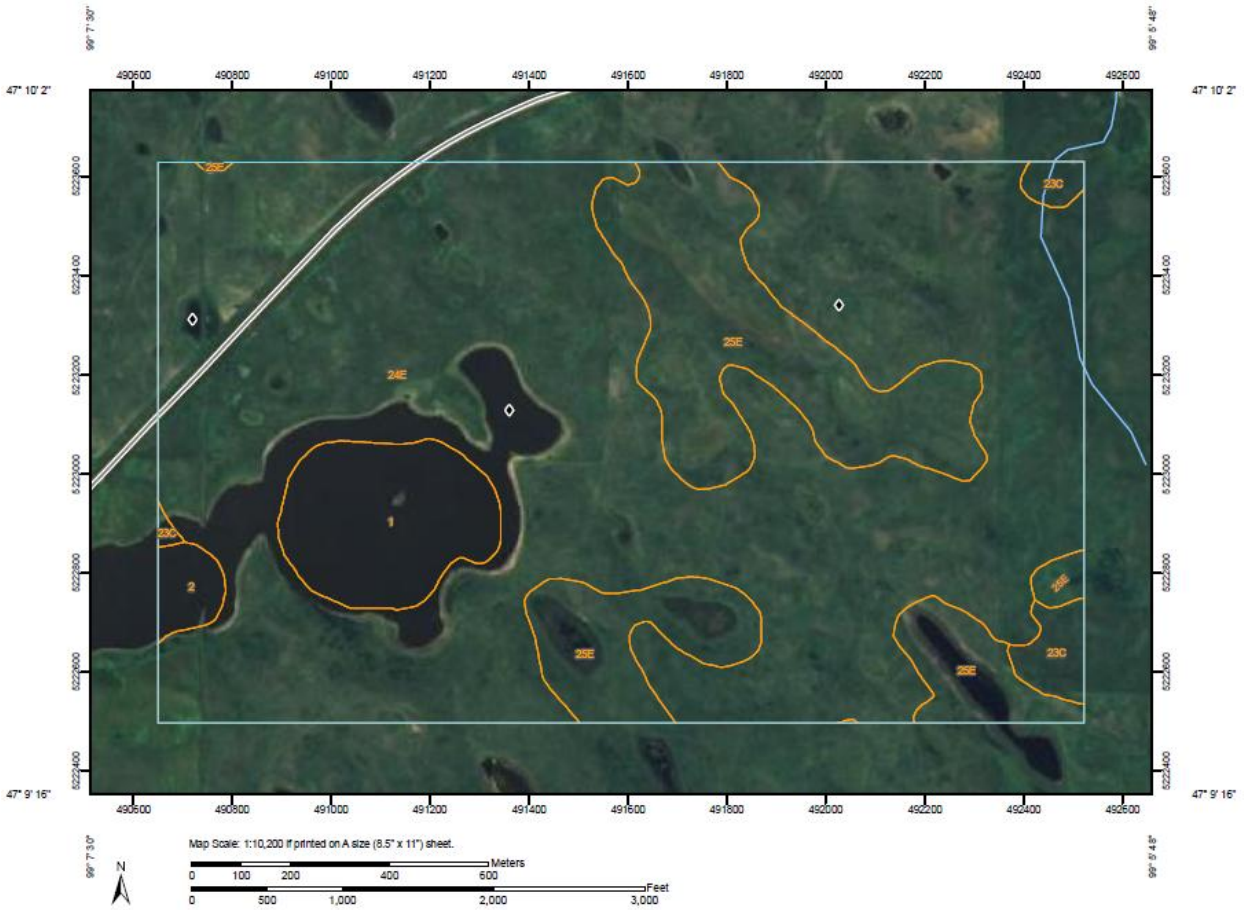


Figure 25. Soil map of the Dakota Coteau site and surrounding areas.

Soil Map Units Description: The map units delineated on the detailed soil maps in a soil survey represents the soils or miscellaneous areas in the survey area. The map unit descriptions in this report, along with the maps, can be used to determine the composition and properties of a unit. A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils. Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called non-contrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called

contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas. An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. All the soils of a series have major horizons that are similar in composition, thickness, and arrangement. Soils of a given series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. T he name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series. Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups. A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example. An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, are an example. Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example. Additional information about the map units described in this report is available in other soil reports, which give properties of the soils and the limitations, capabilities, and potentials for many uses. Also, the narratives that accompany the soil reports define some of the properties included in the map unit descriptions.

Table 9. Soil series and percentage of soil series within 2.1 km^2 at the Dakota Coteau site

Stutsman County, North Dakota (ND093)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
1	Southam silty clay loam, 0 to 1 percent slopes	30.0	5.7%
2	Parnell silty clay loam, 0 to 1 percent slopes	5.2	1.0%
23C	Barnes-Buse loams, 6 to 9 percent slopes	8.6	1.6%
24E	Barnes-Svea-Buse loams, 9 to 25 percent slopes	385.1	73.5%
25E	Barnes-Buse-Parnell complex, 0 to 35 percent slopes	95.4	18.2%
Totals for Area of Interest		**524.2**	**100.0%**

Stutsman County, North Dakota 23C—Barnes-Buse loams, 6 to 9 percent slopes: Map Unit Setting Elevation: 1,000 to 2,050 feet Mean annual precipitation: 16 to 20 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 140 days **Map Unit Composition** Barnes and similar soils: 52 percent Buse and similar soils: 24 percent Minor components: 24 percent **Description of Barnes Setting** Landform: Knolls Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear **Properties and qualities** Slope: 6 to 9 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 1 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Available water capacity: High (about 10.5 inches) **Interpretive groups** Land capability (nonirrigated): 3e Ecological site: Loamy (R055BY064ND) Other vegetative classification: Loam (G055BY100ND) **Typical profile** 0 to 7 inches: Loam 7 to 19 inches: Loam 19 to 37 inches: Loam 37 to 60 inches: Loam **Description of Buse Setting** Landform: Knolls Landform position (two-dimensional): Summit, shoulder Down-slope shape: Convex Across-slope shape: Convex Parent material: Fine-loamy till **Properties and qualities** Slope: 6 to 9 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 1 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Available water capacity: High (about 10.5 inches) **Interpretive groups** Land capability (nonirrigated): 4e Ecological site: Thin Loamy (R055BY068ND) Other vegetative classification: Limy Upland (G055BY400ND) **Typical profile** 0 to 8 inches: Loam 8 to 40 inches: Loam 40 to 60 inches: Loam **Minor Components Svea** Percent of map unit: 16 percent Landform: Rises Landform position (two-dimensional): Footslope Down-slope shape: Concave Across-slope shape: Linear Ecological site: Loamy Overflow (R055BY059ND) Other vegetative classification: Loam (G055BY100ND) **Hamerly** Percent of map unit: 3 percent Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Limy Subirrigated (R055BY058ND) Other vegetative classification: Subirrigated (G055BY700ND) **Tonka** Percent of map unit: 2 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Parnell** Percent of map unit: 1 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Ecological site: Wet Land (R055BY070ND) Other vegetative classification: Not suited (G055BY000ND)

Swenoda, well drained Percent of map unit: 1 percent Landform: Knolls Landform position (two-dimensional): Footslope Down-slope shape: Concave Across-slope shape: Linear Ecological site: Sandy (R055BY062ND) Other vegetative classification: Loam (G055BY100ND) **Renshaw** Percent of map unit: 1 percent Landform: Knolls Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear Ecological site: Shallow Gravel (R055BY063ND) Other vegetative classification: Very Droughty Loam (G055BY130ND)

Stutsman County, North Dakota 25E—Barnes-Buse-Parnell complex, 0 to 35 percent slopes: Map Unit Setting Elevation: 1,000 to 2,050 feet Mean annual precipitation: 16 to 20 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 140 days **Map Unit Composition** Barnes and similar soils: 33 percent Parnell, undrained, and similar soils: 24 percent Buse and similar soils: 18 percent Minor components: 25 percent **Description of Barnes Setting** Landform: Ridges Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear Parent material: Fine-loamy till **Properties and qualities** Slope: 15 to 25 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 1 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Available water capacity: High (about 10.5 inches) **Interpretive groups** Land capability (nonirrigated): 6e Ecological site: Loamy (R055BY064ND) Other vegetative classification: Steep Loam (G055BY109ND) **Typical profile** 0 to 7 inches: Loam 7 to 19 inches: Loam 19 to 37 inches: Loam 37 to 60 inches: Loam **Description of Parnell, Undrained Setting** Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Parent material: Alluvium **Properties and qualities** Slope: 0 to 1 percent Depth to restrictive feature: More than 80 inches Drainage class: Very poorly drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low (0.01 to 0.14 in/hr) Depth to water table: About 0 to 12 inches Frequency of flooding: None Frequency of ponding: Frequent Calcium carbonate, maximum content: 3 percent Gypsum, maximum content: 2 percent Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm) Available water capacity: High (about 10.6 inches) **Interpretive groups** Land capability (nonirrigated): 5w Ecological site: Wet Land (R055BY070ND) Other vegetative classification: Not suited (G055BY000ND) **Typical profile** 0 to 15 inches: Silty clay loam 15 to 22 inches: Silt loam 22 to 32 inches: Silty clay loam 32 to 55 inches: Silty clay 55 to 60 inches: Silty clay **Description of Buse Setting** Landform: Ridges Landform position (two-dimensional): Summit, shoulder Down-slope shape: Convex Across-slope shape: Convex Parent material: Fine-loamy till **Properties and qualities** Slope: 15 to 35 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 1 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Available water capacity: High (about 10.5 inches) **Interpretive groups** Land capability (nonirrigated): 7e Ecological site: Thin Loamy (R055BY068ND) Other vegetative classification: Not suited (G055BY000ND) **Typical profile** 0 to 8 inches: Loam 8 to 40 inches: Loam 40 to 60 inches: Loam **Minor Components Svea, well drained** Percent of map unit: 9 percent Landform: Knolls Landform position (two-dimensional): Footslope Down-slope shape: Concave Across-slope shape: Linear Ecological site: Loamy (R055BY064ND) Other vegetative classification: Loam (G055BY100ND) **Vallers** Percent of map unit: 6 percent Landform: Depressions, flats Down-slope shape: Concave, linear Across-slope shape: Concave, linear Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Hamerly** Percent of map unit: 6

percent Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Limy Subirrigated (R055BY058ND) Other vegetative classification: Subirrigated (G055BY700ND) **Tonka, undrained** Percent of map unit: 2 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Southam, undrained** Percent of map unit: 1 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Other vegetative classification: Not suited (G055BY000ND) **Sioux** Percent of map unit: 1 percent Landform: Ridges Landform position (two-dimensional): Shoulder, summit Down-slope shape: Convex Across-slope shape: Convex Ecological site: Very Shallow (R055BY069ND) Other vegetative classification: Not suited (G055BY000ND)

Stutsman County, North Dakota 24E—Barnes-Svea-Buse loams, 9 to 25 percent slopes: Map Unit Setting Elevation: 1,000 to 2,050 feet Mean annual precipitation: 16 to 20 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 140 days **Map Unit Composition** Barnes and similar soils: 40 percent Buse and similar soils: 23 percent Svea, well drained, and similar soils: 20 percent Minor components: 17 percent **Description of Barnes Setting** Landform: Ridges, hills Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear **Properties and qualities** Slope: 9 to 15 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 1 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Available water capacity: High (about 10.5 inches) **Interpretive groups** Land capability (nonirrigated): 4e Ecological site: Loamy (R055BY064ND) Other vegetative classification: Loam (G055BY100ND) **Typical profile** 0 to 7 inches: Loam 7 to 19 inches: Loam 19 to 37 inches: Loam 37 to 60 inches: Loam **Description of Buse Setting** Landform: Ridges Landform position (two-dimensional): Shoulder, summit Down-slope shape: Convex Across-slope shape: Convex Parent material: Fine-loamy till **Properties and qualities** Slope: 15 to 25 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 1 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Available water capacity: High (about 10.5 inches) **Interpretive groups** Land capability (nonirrigated): 7e Ecological site: Thin Loamy (R055BY068ND) Other vegetative classification: Limy Upland (G055BY400ND) **Typical profile** 0 to 8 inches: Loam 8 to 40 inches: Loam 40 to 60 inches: Loam **Description of Svea, Well Drained Setting** Landform: Ridges on hills Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear **Properties and qualities** Slope: 9 to 15 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 1 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Sodium adsorption ratio, maximum: 5.0 Available water capacity: High (about 10.9 inches) **Interpretive groups** Land capability (nonirrigated): 4e Ecological site: Loamy (R055BY064ND) Other vegetative classification: Loam (G055BY100ND) **Typical profile** 0 to 10 inches: Loam 10 to 19 inches: Loam 19 to 37 inches: Loam 37 to 60 inches: Loam **Minor Components Svea** Percent of map unit: 8 percent Landform: Rises Landform position (two-dimensional): Footslope Down-slope shape: Concave Across-slope shape: Linear Ecological site: Loamy Overflow (R055BY059ND) Other vegetative

classification: Loam (G055BY100ND) **Tonka, undrained** Percent of map unit: 2 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Southam, undrained** Percent of map unit: 2 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Other vegetative classification: Not suited (G055BY000ND) **Parnell, undrained** Percent of map unit: 2 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Ecological site: Wet Land (R055BY070ND) Other vegetative classification: Not suited (G055BY000ND) **Hamerly** Percent of map unit: 2 percent Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Limy Subirrigated (R055BY058ND) Other vegetative classification: Subirrigated (G055BY700ND) **Sioux** Percent of map unit: 1 percent Landform: Ridges Landform position (two-dimensional): Shoulder, summit Down-slope shape: Convex Across-slope shape: Convex Ecological site: Very Shallow (R055BY069ND) Other vegetative classification: Not suited (G055BY000ND)

Stutsman County, North Dakota 2—Parnell silty clay loam, 0 to 1 percent slopes: Map Unit Setting Elevation: 1,000 to 2,050 feet Mean annual precipitation: 16 to 20 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 140 days **Map Unit Composition** Parnell and similar soils: 75 percent Minor components: 25 percent **Description of Parnell Setting** Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Parent material: Alluvium **Properties and qualities** Slope: 0 to 1 percent Depth to restrictive feature: More than 80 inches Drainage class: Very poorly drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low (0.01 to 0.14 in/hr) Depth to water table: About 0 to 12 inches Frequency of flooding: None Frequency of ponding: Frequent Calcium carbonate, maximum content: 3 percent Gypsum, maximum content: 2 percent Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm) Available water capacity: High (about 10.6 inches) **Interpretive groups** Land capability (nonirrigated): 3w Ecological site: Wet Land (R055BY070ND) Other vegetative classification: Not suited (G055BY000ND) **Typical profile** 0 to 15 inches: Silty clay loam 15 to 22 inches: Silt loam 22 to 32 inches: Silty clay loam 32 to 55 inches: Silty clay 55 to 60 inches: Silty clay **Minor Components Tonka** Percent of map unit: 10 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Colvin** Percent of map unit: 8 percent Landform: Flats, depressions Down-slope shape: Linear, concave Across-slope shape: Linear, concave Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Vallers** Percent of map unit: 3 percent Landform: Depressions, flats Down-slope shape: Concave, linear Across-slope shape: Concave, linear Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Southam** Percent of map unit: 2 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Other vegetative classification: Not suited (G055BY000ND) **Hamerly** Percent of map unit: 2 percent Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Limy Subirrigated (R055BY058ND) Other vegetative classification: Subirrigated (G055BY700ND)

Stutsman County, North Dakota 1—Southam silty clay loam, 0 to 1 percent slopes: Map Unit Setting Elevation: 1,000 to 2,050 feet Mean annual precipitation: 16 to 20 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 140 days **Map Unit Composition** Southam and similar soils: 80 percent Minor components: 20 percent **Description of Southam Setting** Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Parent material: Alluvium **Properties and qualities** Slope: 0 to 1 percent Depth to restrictive feature: More than 80 inches Drainage class: Very poorly drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low (0.01 to 0.14 in/hr) Depth to water table: About 0 to 12 inches Frequency of flooding: None Frequency of ponding:

Frequent Calcium carbonate, maximum content: 15 percent Gypsum, maximum content: 2 percent Maximum salinity: Nonsaline to slightly saline (2.0 to 8.0 mmhos/cm) Sodium adsorption ratio, maximum: 2.0 Available water capacity: High (about 10.4 inches) **Interpretive groups** Land capability (nonirrigated): 3w Other vegetative classification: Not suited (G055BY000ND) **Typical profile** 0 to 16 inches: Silty clay loam 16 to 40 inches: Silty clay 40 to 60 inches: Silty clay **Minor Components Vallers** Percent of map unit: 6 percent Landform: Depressions, flats Down-slope shape: Concave, linear Across-slope shape: Concave, linear Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Parnell** Percent of map unit: 6 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Ecological site: Wet Land (R055BY070ND) Other vegetative classification: Not suited (G055BY000ND) **Minnewaukan** Percent of map unit: 3 percent Landform: Beaches Down-slope shape: Linear Across-slope shape: Linear Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND) **Hamerly** Percent of map unit: 3 percent Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Limy Subirrigated (R055BY058ND) Other vegetative classification: Subirrigated (G055BY700ND) **Lallie** Percent of map unit: 2 percent Landform: Depressions Down-slope shape: Concave Across-slope shape: Concave Ecological site: Wet Meadow (R055BY071ND) Other vegetative classification: Wet (G055BY900ND)

4.3.2 Soil semi-variogram description

The goal of this aspect of the site characterization is to determine the minimum distance between the soil plots in the soil array such that data farther apart can be considered spatially independent. The collected field data will be used to produce semivariograms, which is a geostatistical technique to characterize spatial autocorrelation between mapped samples of a quantitative variable (*e.g.*, soil property data in our case). In an empirical semivariogram, the average of the squared differences of a response variable is computed for all pairs of points within specified distance intervals (lag classes). The output is presented graphically as a plot of the average semi-variance versus distance class (Figure 26). For the theoretical variogram models considered here, the semivariance will converge on the total variance at distances for which values are no longer spatially auto-correlated (this is referred to as the range, Figure 26).

For the theoretical variograms considered here, three parameters estimated from the data are used to fit a semivariogram model to the empirical semivariogram. This model is then assumed to quantitatively represent the correlation as a function of distance (Figure 26), the range, the sill (the sill is the asymptotic value of semi-variance at the range), and the nugget (which describes sampling error or variation at distances below those separating the closest pairs of samples). The range, sill and nugget are estimated from theoretical models that are fitted to the empirical variograms using non-linear least squares methods.

The variogram analysis will be used, to determine the spatial scales at which we can consider soil measurements spatially independent. This characterization will directly inform the minimum distance between *i*) soil plots within each soil array, *ii*) the soil profile measurements, *iii*) EP plots, and *iv*) the microbial sampling locations. These data will directly inform NEON construction and site design activities.

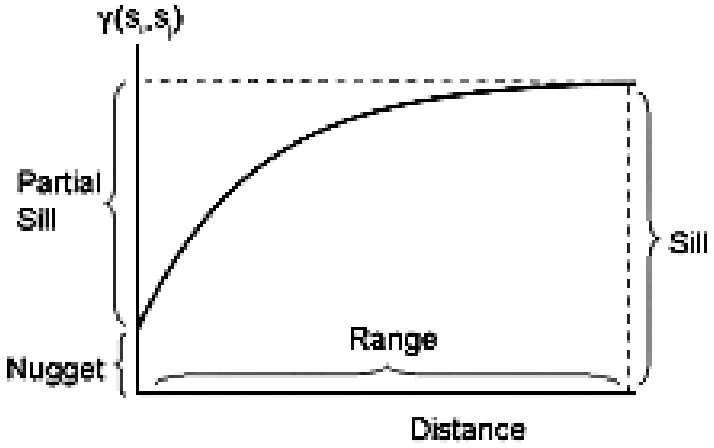


Figure 26. Example semivariogram, depicting range, sill, and nugget.

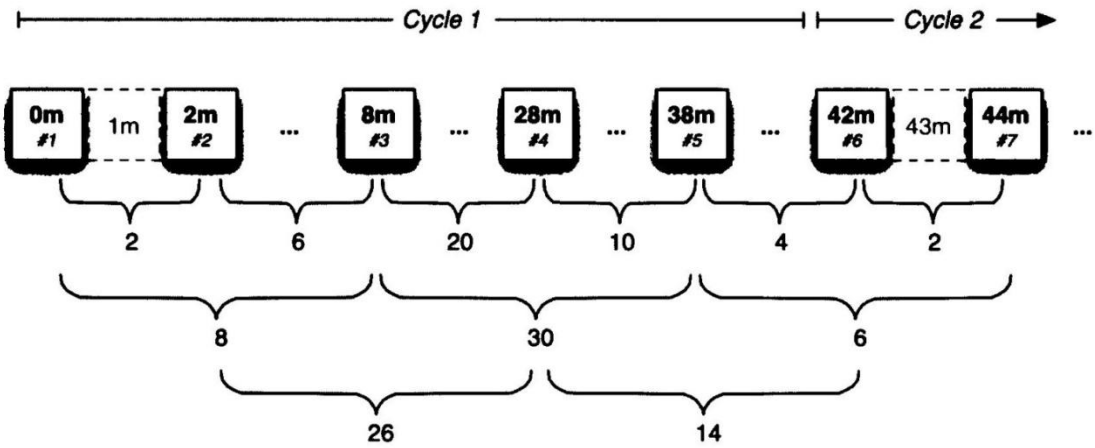


Figure 27. Spatially cyclic sampling design for the measurements of soil temperature and soil water content.

Field measurements of soil temperature (0-12 cm) and moisture (0-15 cm) were taken on 26 May 2010 at the Dakota Coteau site. The sampling points followed the spatially cyclic sampling design by Bond-Lamberty et al. (2006) (Figure 27). Soil temperature and moisture measurements were collected along three transects (210 m, 84 m, and 84 m) located in the expected airshed at Dakota Coteau. Details of how the airshed was determined are provided below. Soil temperature was measured with platinum resistance temperature sensors (RTD 810, Omega Engineering Inc., Stamford CT) and soil moisture was measured with time domain diaelectric sensors (CS616, Campbell Scientific Inc., Logan UT).

As well as measuring soil temperature and moisture at each sample point in Figure 27, measurements were also taken 30 cm in front and behind the sampling point along the axis of the transect. For example, at the 2 m sampling point, soil temperature and moisture was measured at 1.7 m, 2 m, and 2.3 m; this data is referred to as mobile data, since the measurements were taken at many different locations. In addition, soil temperature and moisture were continuously recorded at a single fixed location (stationary data) throughout the sampling time to correct for changes in temperature and moisture throughout the day.

Data collected were used for geospatial analyses of variograms in the R statistical computing language with the geoR package to test for spatial autocorrelation (Trangmar *et al.* 1986; Webster & Oliver 1989; Goovaerts 1997; Riberiro & Diggle 2001) and estimate the distance necessary for independence among soil plots in the soil array. To correct for changes in temperature and moisture over the sampling period, the stationary data was subtracted from the mobile data. In many instances a time of day trend was still apparent in the data even after subtracting the stationary data from the mobile data. This time of day trend was corrected for by fitting a linear regression. The data were further de-trended using elevation, slope, and aspect from a digital elevation map and the residuals were used for the semivariogram analysis. Soil temperature and moisture data, R code, graphs, and R output can be found at: P:\FIU\FIU_Site_Characterization\DXX\YYYYYYY_Characterization\Soil Measurements\Soil Data Analysis (where XX = domain number and YYYYYYY = site name).

4.3.3 Results and interpretation

4.3.3.1 Soil Temperature

Soil temperature data residuals, after accounting for changes in temperature in the stationary data, any remaining time of day trend, elevation, slope and aspect, were used for the semivariogram analysis (Figure 28). Exploratory data analysis plots show that there was no distinct patterning of the residuals (Figure 29, left graph) and directional semivariograms do not show anisotropy (Figure 29, center graph). An isotropic empirical semivariogram was produced and a spherical model was fitted using Cressie weights (Figure 29, right graph). The model indicates a distance of effective independence of 10 m for soil temperature.

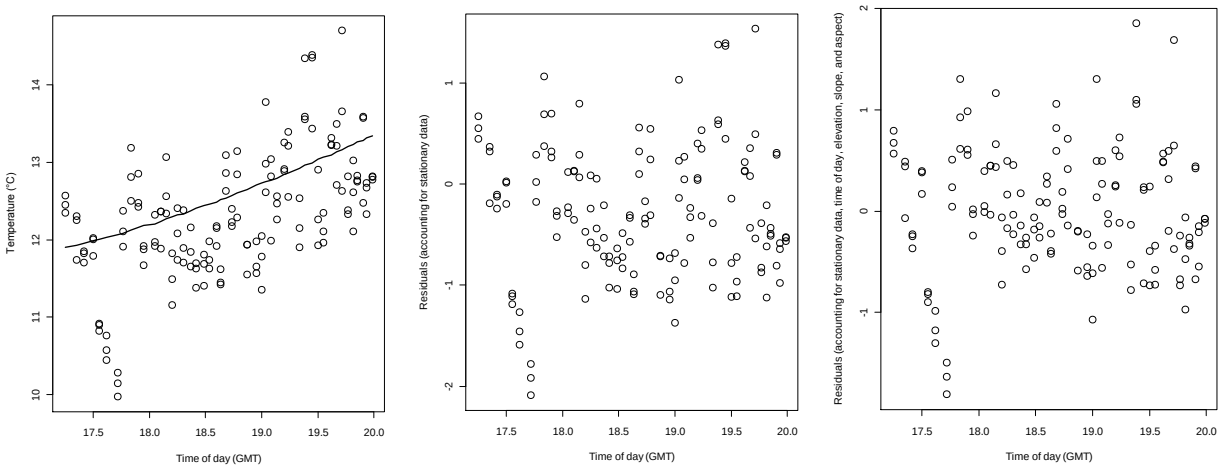


Figure 28. Left graph: mobile (circles) and stationary (line) soil temperature data. Center graph: temperature data after correcting for changes in temperature in the stationary data (circles) and a linear regression based on time of day (line). Right graph: residual temperature data after correcting for changes temperature in the stationary data and the time of day regression. Data in the right graph were used for the semivariogram analysis.

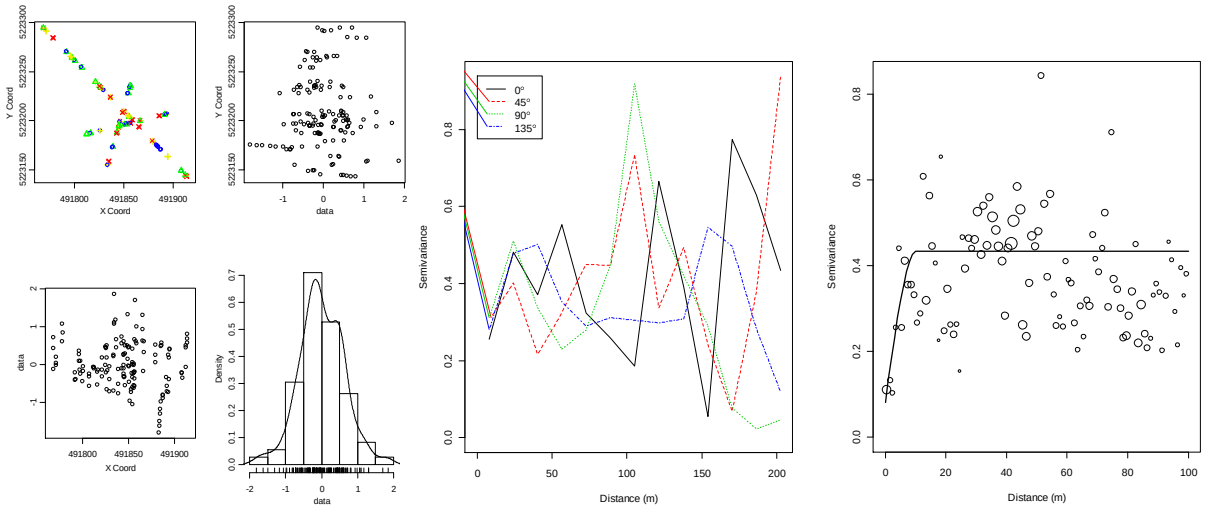


Figure 29. Left graphs: exploratory data analysis plots for residuals of temperature. Center graph: directional semivariograms for residuals of temperature. Right graph: empirical semivariogram (circles) and model (line) fit to residuals of temperature.

4.3.3.2 Soil water content

Soil water content data residuals, after accounting for changes in water content in the stationary data, any remaining time of day trend, elevation and aspect, were used for the semivariogram analysis (Figure 30. Exploratory data analysis plots show that there was no distinct patterning of the residuals (Figure 31, left graph) and directional semivariograms do not show anisotropy (Figure 31, center graph). An isotropic empirical semivariogram was produced and a spherical model was fitted using Cressie weights (Figure 31, right graph). The model indicates a distance of effective independence of 19 m for soil water content.

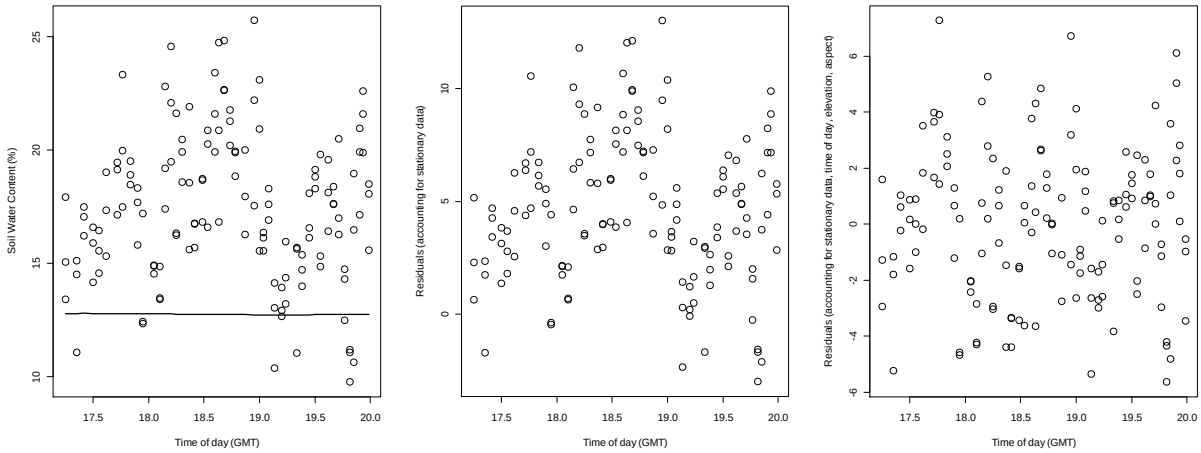


Figure 30. Left graph: mobile (circles) and stationary (line) soil water content data. Center graph: water content data after correcting for changes in water content in the stationary data (circles) and a linear regression based on time of day (line). Right graph: residual water content data after correcting for

changes water content in the stationary data and the time of day regression. Data in the right graph were used for the semivariogram analysis.

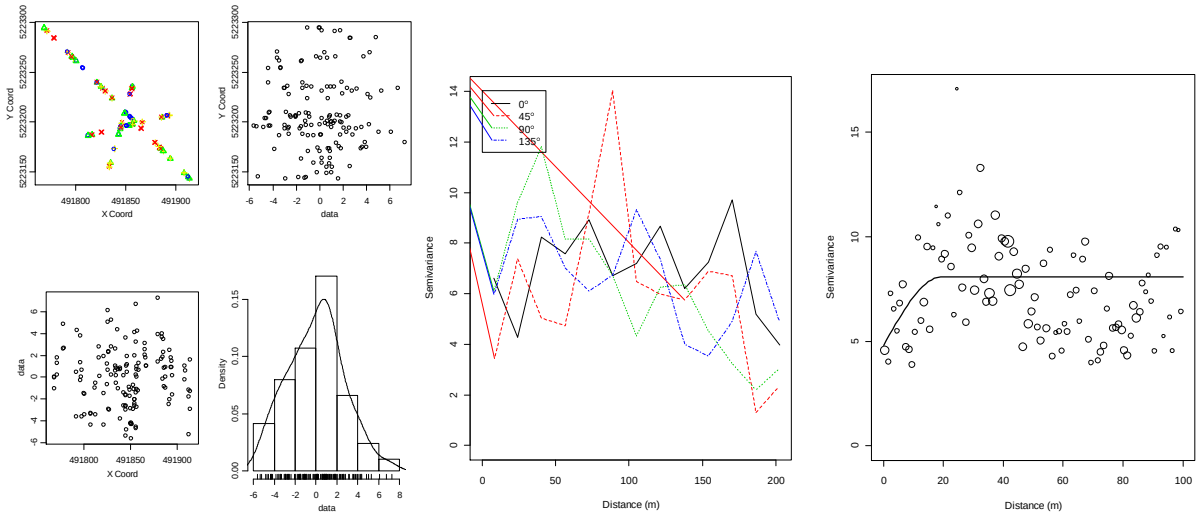


Figure 31. Left graphs: exploratory data analysis plots for residuals of soil water content. Center graph: directional semivariograms for residuals of water content. Right graph: empirical semivariogram (circles) and model (line) fit to residuals of water content.

4.3.3.3 Soil array layout and soil pit location

The minimum distance allowable between soil plots is 25 m to ensure a degree of spatial independence in non-measured soil parameters (i.e., other than temperature and water content) and the maximum distance allowable between soil plots is 40 m due to cost constraints. The estimated distance of effective independence was 10 m for soil temperature and 19 m for soil moisture. Based on these results and the site design guidelines the soil plots at Dakota Coteau shall be placed 25 m apart. The soil array shall follow the linear soil array design (Soil Array Pattern B) with the soil plots being 5 m x 5 m. The direction of the soil array shall be 310° from the soil plot nearest the tower. The location of the first soil plot will be approximately 47.161527°, -99.106682°. The exact location of each soil plot will be chosen by an FIU team member during site construction to avoid placing a soil plot at an unrepresentative location (e.g., rock outcrop, drainage channel, large tree, etc). The FIU soil pit for characterizing soil horizon depths, collecting soil for site-specific sensor calibration, and collecting soil for the FIU soil archive will be located at 47.164041°, -99.101067° (primary location); or 47.163093°, -99.101079° (alternate location 1 if primary location is unsuitable); or 47.163557°, -99.101089° (alternate location 2 if primary location is unsuitable). A summary of the soil information is shown in Table 10 and site layout can be seen in Figure 32.

Dominant soil series at the site: Barnes-Svea-Buse loams, 9 to 25 percent slopes. The taxonomy of this soil is shown below:
Order: Mollisols
Suborder: Udolls
Great group: Hapludolls-Calciudolls

Subgroup: Calcic Hapludolls-Pachic Hapludolls-Typic Calciudolls
Family: Fine-loamy, mixed, superactive, frigid Calcic Hapludolls-Fine-loamy, mixed, superactive, frigid Pachic Hapludolls-Fine-loamy, mixed, superactive, frigid Typic Calciudolls
Series: Barnes-Svea-Buse loams, 9 to 25 percent slopes

Table 10. Summary of soil array and soil pit information at Dakota Coteau. 0° represents true north and accounts for declination.

Soil plot dimensions	5 m x 5 m
Soil array pattern	B
Distance between soil plots: x	25 m
Distance from tower to closest soil plot: y	15 m
Latitude and longitude of 1st soil plot OR direction from tower	47.161527°, -99.106682°
Direction of soil array	310°
Latitude and longitude of FIU soil pit 1	47.164041°, -99.101067° (primary location)
Latitude and longitude of FIU soil pit 2	47.163093°, -99.101079° (alternate 1)
Latitude and longitude of FIU soil pit 3	47.163557°, -99.101089° (alternate 2)
Dominant soil type	Barnes-Svea-Buse loams, 9 to 25 percent slopes
Expected soil depth	>2 m
Depth to water table	>2 m

Expected depth of soil horizons	**Expected measurement depths***
0-0.18 m (Loam)	0.09 m
0.18-0.48 m (Loam)	[A]0.33 m
0.48-0.94 m (Loam)	[A]0.71 m
0.94-1.52 m (Loam)	1.23 m
1.52-2 m	[A]2 m

*Actual soil measurement depths will be determined based on measured soil horizon depths at the NEON FIU soil pit and may differ substantially from those shown here.
[A]current depths of the soil CO2

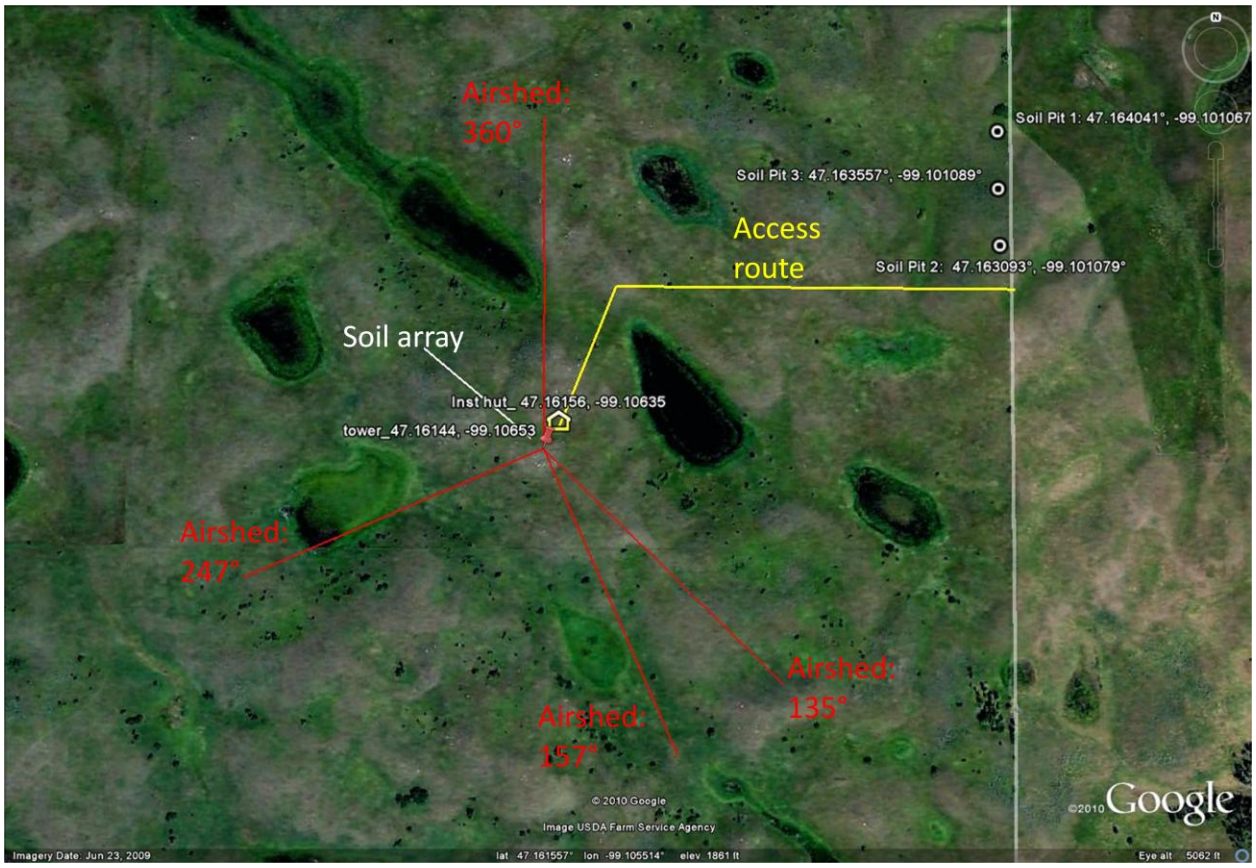


Figure 32. Site layout at Dakota Coteau showing soil array and location of the FIU soil pit.

4.4 Airshed

4.4.1 Seasonal windroses

Wind roses analytically determine and graphically represent the frequencies of wind direction and wind speed over a given timeseries. The orientation of the wind rose follows that of a compass (assume declination applied). When we describe the wind directions it should be noted that they are the cardinal direction that wind blows from. The directions of the rose with the longest spoke show wind directions with the largest frequency. These wind roses are subdivided into as 24 cardinal directions.

4.4.2 Results (graphs for wind roses)

Because Woodworth Advance tower site is only < 7 miles southwest to Dakota Coteau Field School (DCFS) Relocatable site, we assume the wind patterns at DCFS site are similar to those of Woodworth Advanced site above. Therefore, the windroses for Woodworth Advanced site above are the same set for DCFS relocatable site. We will not duplicate here.

4.4.3 Resultant vectors

Not available.

4.4.4 Expected environmental controls on source area

Two types of models were commonly used to determine the shape and extent of the source area under different and contrasting atmospheric stability classes. An inverted plume dispersion model with modeled cross wind solutions were used for convective conditions (Horst and Weil 1994). For strongly stable conditions, and Lagrangian solution was used (Kormann and Meixner 2001). The source area models where bounded by the expected conditions depict the extreme conditions. Convective conditions typically have strong vertical mixing between the ecosystem and atmosphere (surface layer). Stable conditions typically have long source area and associated waveforms. Convective turbulence is often characterized by short mixing scales (scalar) and moderate daytime wind speeds, *e.g.,* 1-4 m s^{-2}. Higher wind speeds, like those experienced over the Rockies, are often the product of mechanical turbulence with long waveforms. Because thermal stratification is very efficient in suppressing vertical mixing, stable conditions also have typically very long waveforms.

As a general rule, shorter and less structurally complex ecosystems have good vertical mixing during all atmospheric stabilities. Taller and more structurally complex ecosystems have well mixed upper canopies during the daytime, and can be decoupled below the canopy under neutral and stable conditions (e.g., Harvard Forest, Bartlett Experimental Forest, and Burlington Conservation Area). The type of turbulence (mechanical verse convective) and the physical attributes of the ecosystem control the degree of mixing, and the length and size of the source area.

Here, we use a web-based footprint model to determine the footprint area under various conditions (model info: http://www.geos.ed.ac.uk/abs/research/micromet/EdiTools/). Winds used to run the model and generate following model results are extracted from the wind roses. Vegetation information, temperature and energy information were either from the RFI document, previous site visit report, available data files or best estimated from experienced expert. Measurement height was determined from the Tower Height Info document provided by ENG group, then verify according to the real ecosystem structure after FIU site characterization at site. Runs 1-3 and 4-6 represents the expected conditions for summer and winter conditions, respectively, with maximum and mean windspeeds (daytime convective) and nighttime (stable atmospheres) conditions. The wind vector for each run was estimated from wind roses and is placed as a centerline in the site map included in the graphics. The width of the footprint was also estimated using the length between the isopleth of 80% cumulative flux and center line to calculate the angle from centerline. This information, along with distance of the cumulative flux isopleths and wind direction, will define the source area for the flux measurements on the top of the tower.

Table 11. Expected environmental controls to parameterize the source area model and associated results from DCFS Relocatable tower site.

Parameters	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	
Approximate season	summer			winter			Units
	Day (max WS)	Day (mean WS)	Night	Day (max WS)	Day (mean WS)	night	qualitative
Atmospheric stability	Convective	convective	Stable	Convective	convective	Stable	qualitative
Measurement height	6	6	6	6	6	6	m
Canopy Height	1.4	1.4	1.4	1.4	1.4	1.4	m
Canopy area density	1.3	1.3	1.3	0.8	0.8	0.8	m

Boundary layer depth	2100	2100	1000	800	800	650	m
Expected sensible heat flux	500	500	100	26	26	-55	W m^{-2}
Air Temperature	29	29	22	2	2	-20	°C
Max. windspeed	11	5.2	5.2	5.2	4.0	4.0	m s^{-1}
Resultant wind vector	300	300	145	290	290	150	degrees
Results							
(z-d)/L	-0.02	-0.14	-0.04	-0.01	-0.02	0.06	m
d	0.97	0.97	0.97	0.88	0.88	0.88	m
Sigma v	2.90	2.10	1.40	1.20	0.99	1.80	m^2 s^{-2}
Z0	0.09	0.09	0.09	0.11	0.11	0.11	m
u*	1.10	0.58	0.54	0.55	0.43	0.39	m s^{-1}
Distance source area begins	0	0	0	0	0	0	m
Distance of 90% cumulative flux	500	350	500	520	500	750	m
Distance of 80% cumulative flux	300	200	300	300	300	400	m
Distance of 70% cumulative flux	200	150	200	200	200	250	m
Peak contribution	45	35	45	35	35	35	m

4.4.5 Results (source area graphs)

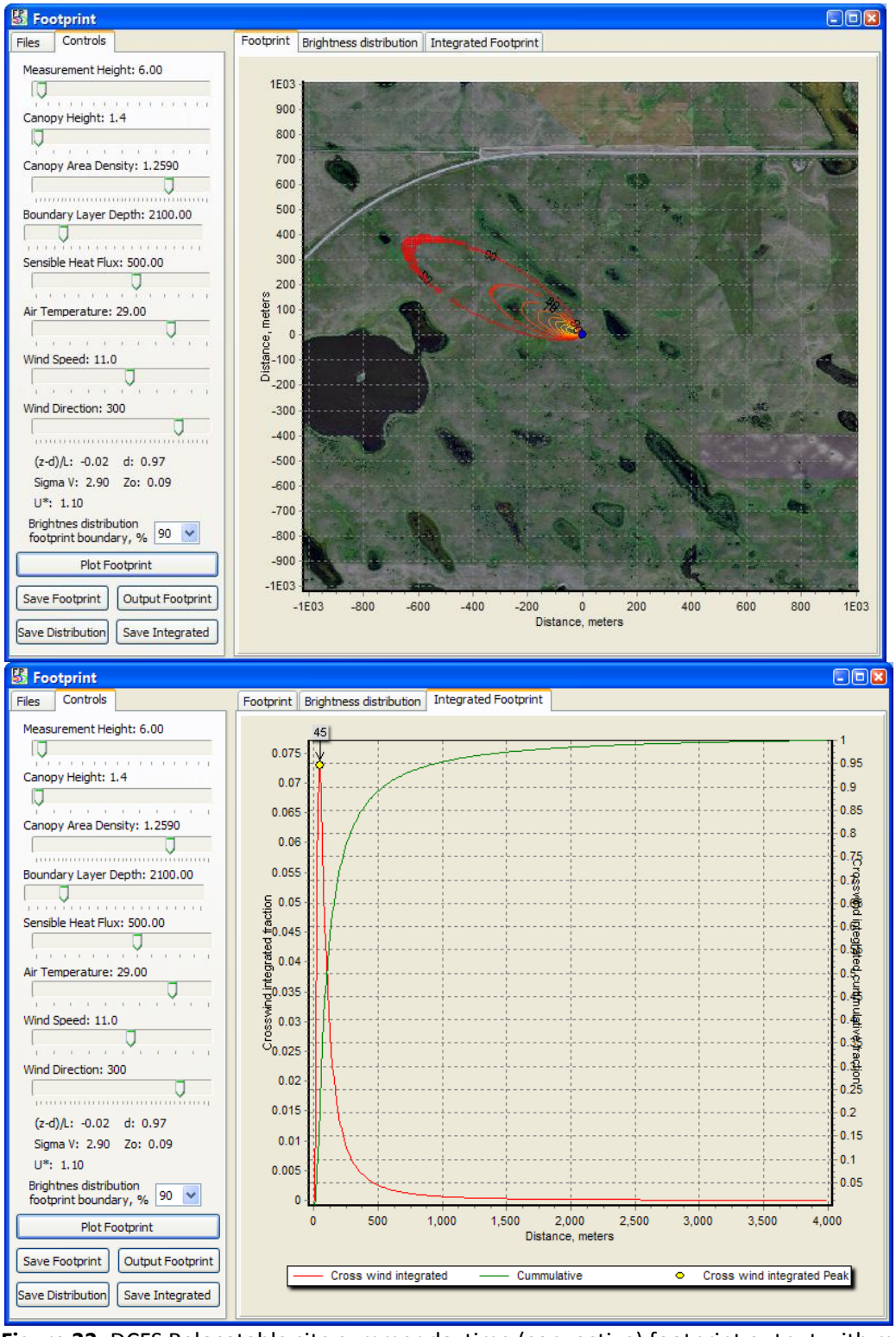


Figure 33. DCFS Relocatable site summer daytime (convective) footprint output with max wind speed

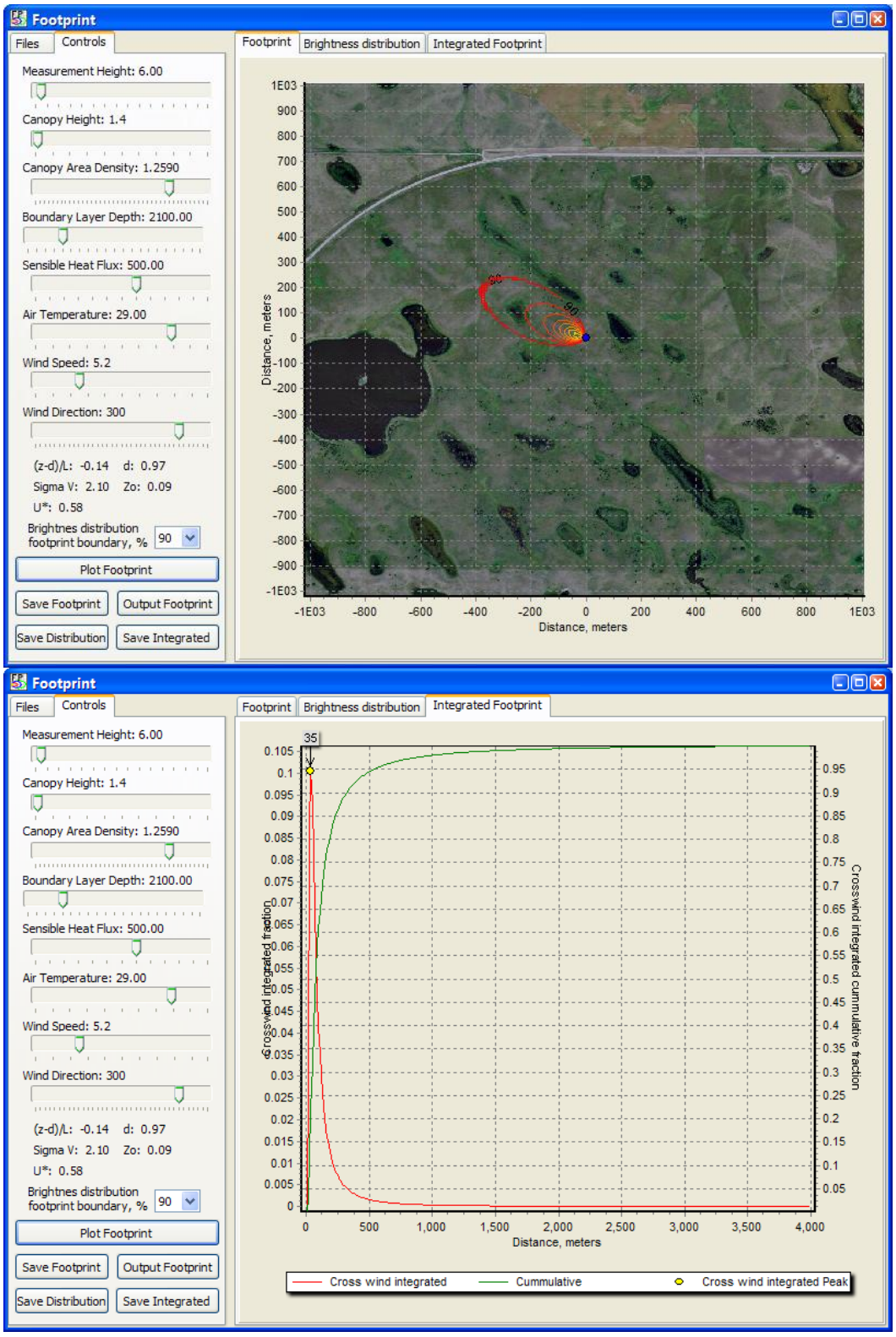


Figure 34. DCFS Relocatable site summer daytime (convective) footprint output with mean wind speed

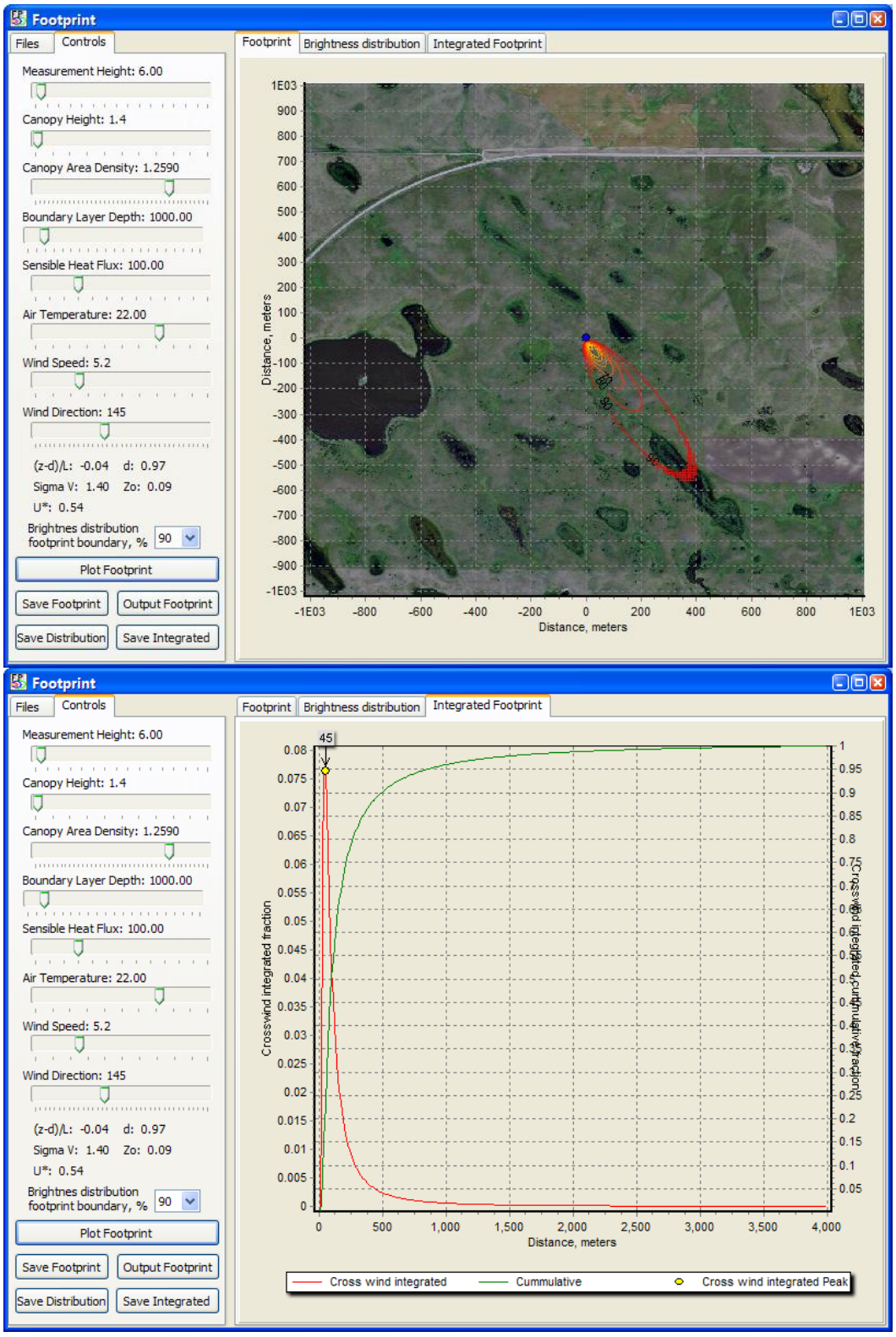


Figure 35. DCFS Relocatable site summer nighttime (stable) footprint output with mean wind speed.

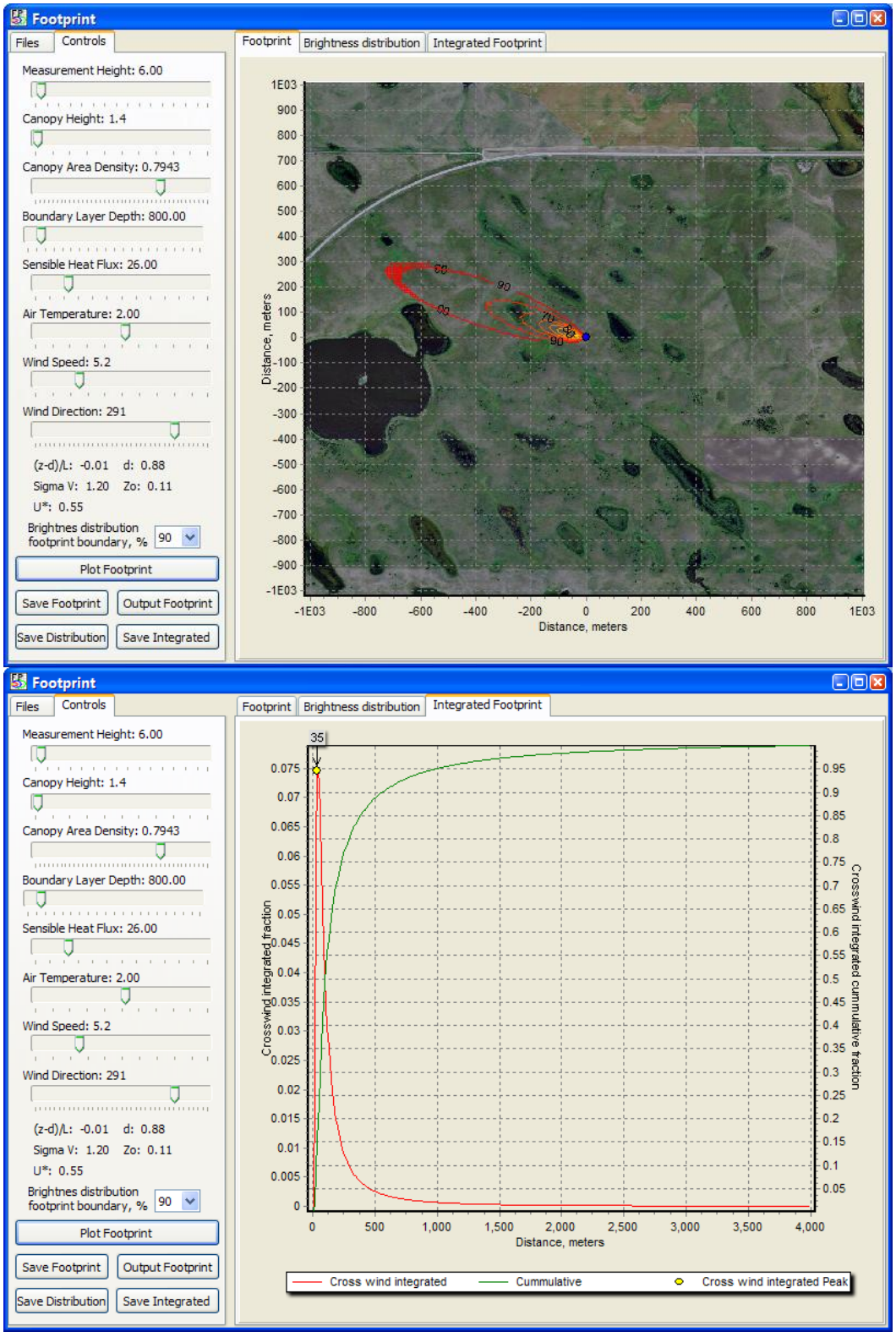


Figure 36. DCFS Relocatable site winter daytime (convective) footprint output with max wind speed

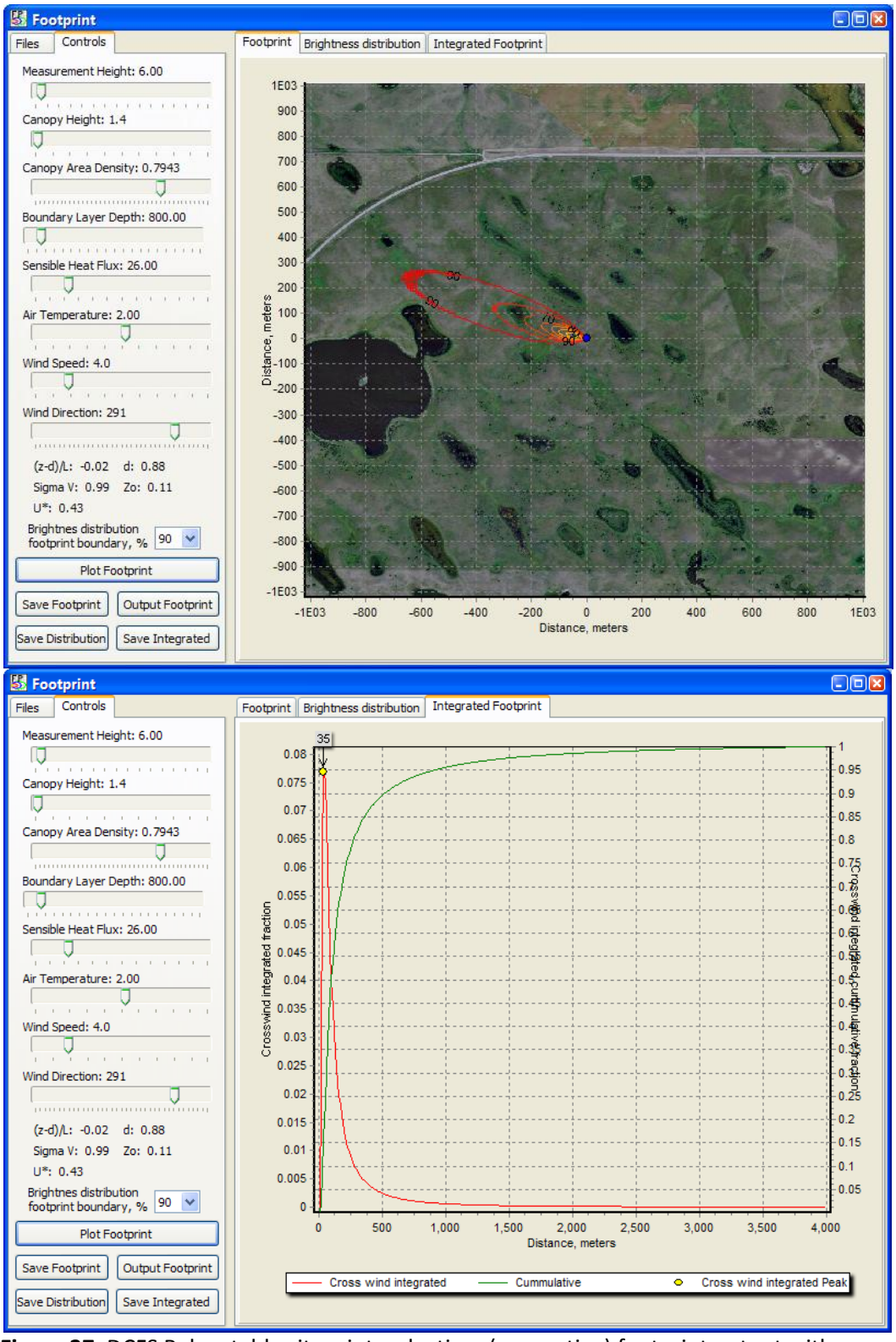


Figure 37. DCFS Relocatable site winter daytime (convective) footprint output with mean wind speed.

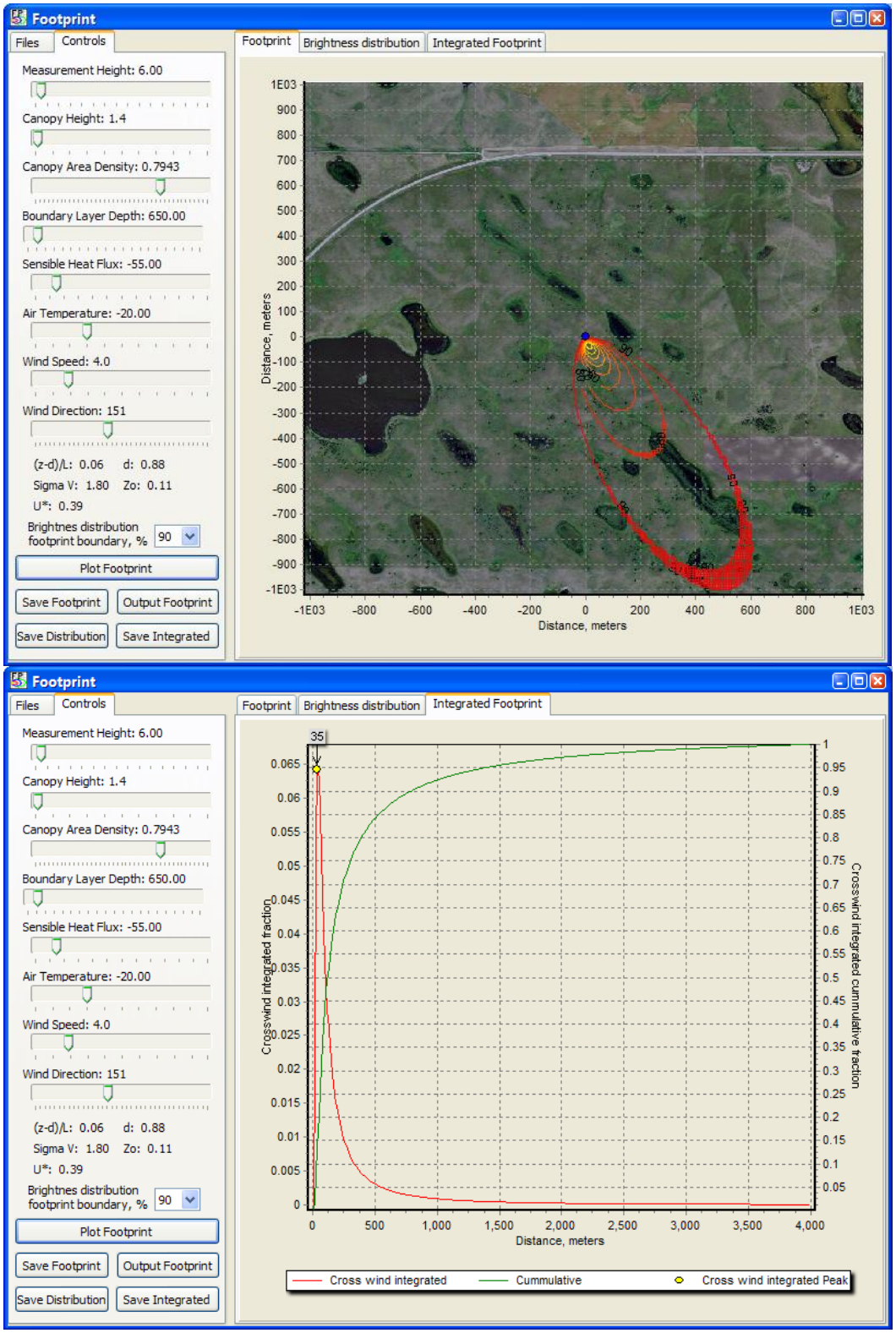


Figure 38. DCFS Relocatable site winter nighttime (stable) footprint output with mean wind speed.

4.4.6 Site design and tower attributes

According to wind roses, the prevailing wind direction blows from northwest and west (247° to 360°, clockwise from 247°, major airshed) and southeast (135° to 157°, clockwise from 135°, secondary airshed), which is consistent throughout the whole year. Tower should be placed to a location to best catch the signals from the airshed of the ecosystem in interest, which is pothole prairie ecosystem. The candidate tower site was at 47.161, -99.111. After site visit, we moved tower location toward ENE for ~350 m to maximize the fetch area on NW and SE direction and minimize the impacts of the lake (on the west to tower) on microclimate measurements on the tower. The new tower location is at 47.16144, -99.10653.

Eddy covariance, sonic wind and air temperature **boom arms** orientation toward the southwest will be best to capture signals from all major wind directions. **Radiation boom arms** should always be facing south to avoid any shadowing effects from the tower structure. An **instrument hut** should be outside the prevailing wind airshed to avoid disturbance in the measurements of wind and should be positioned to have the longer side parallel to frequent wind direction to minimize the wind effects on instrument huts and to minimize the disturbances of wind regime by instrument hut, and in this case, instrument hut should be positioned on the northeast toward tower and have the longer side parallel to NW-SE direction. Therefore, we decide the placement of instrument hut at 47.16156, -99.10635.

The ecosystem at this site is pothole prairie. Grass is ~ 0.4 m height, but many small shrubs intersprerced with height of 0.7 – 1.5 m. A few tall shrubs (2 – 3 m) are found. Although prairie grass is dominant vegetation type at site, shrubs has large impacts on the flow dynamics at ecosystem surface. Thus shrub height of 1.5 m is used here for the purpose of tower design. Therefore, we require 4 **measurement layers** on the tower with top measurement height at 6 m, and the remaining levels are 4.0 m, 1.5 m, and 0.3 m, respectively, to best characterize the fluxes on the tower top and environmental conditions in profile.

Secondary **precipitation collector** for bulk precipitation collection will be located the top of tower at this site. No **wet deposition collector** will be deployed at this site. See AD 04 for further information and requirements for bulk precipitation collection and wet deposition collection.

The site layout is summarized in the table below. Assume the projected area of the tower is square. **Anemometer/temperature boom arm direction** is ***from*** the tower ***toward*** the prevailing wind direction or designated orientation. **Instrument hut orientation vector** is parallel to the long side of the instrument hut. **Instrument hut distance z** is the distance from the center of tower projection to the center of the instrument hut projection on the ground. The numbering of the **measurement levels** is that the lowest is level one, and each subsequent increase in height is numbered sequentially.

Table 12. Site design and tower attributes for DCFS Relocatable site

0° is true north with declination accounted for. Color of Instrument hut exterior shall be tan to best match the surrounding environment.

Attribute	lat	long	degree	meters	notes
Airshed area			247° to 360°		Clockwise from

			(major), 135° to 157° (secondary)		first angle
Tower location	47.16144,	-99.10653	--	--	new site
Instrument hut	47.16156,	-99.10635			
Instrument hut orientation vector	--	--	145° - 325°		
Instrument hut distance z	--	--	--	19	
Anemometer/Temperature boom orientation	--	--	245°	--	
Height of the measurement levels					
Level 1				0.3	m.a.g.l.
Level 2				1.5	m.a.g.l.
Level 3				4.0	m.a.g.l.
Level 4				6.0	m.a.g.l.
Tower Height				6.0	m.a.g.l.

See AD 03 for technical requirement to determine the boom height for the bottom most measurement level.

Figure below shows the proposed tower location, instrument hut location, airshed area and access road.

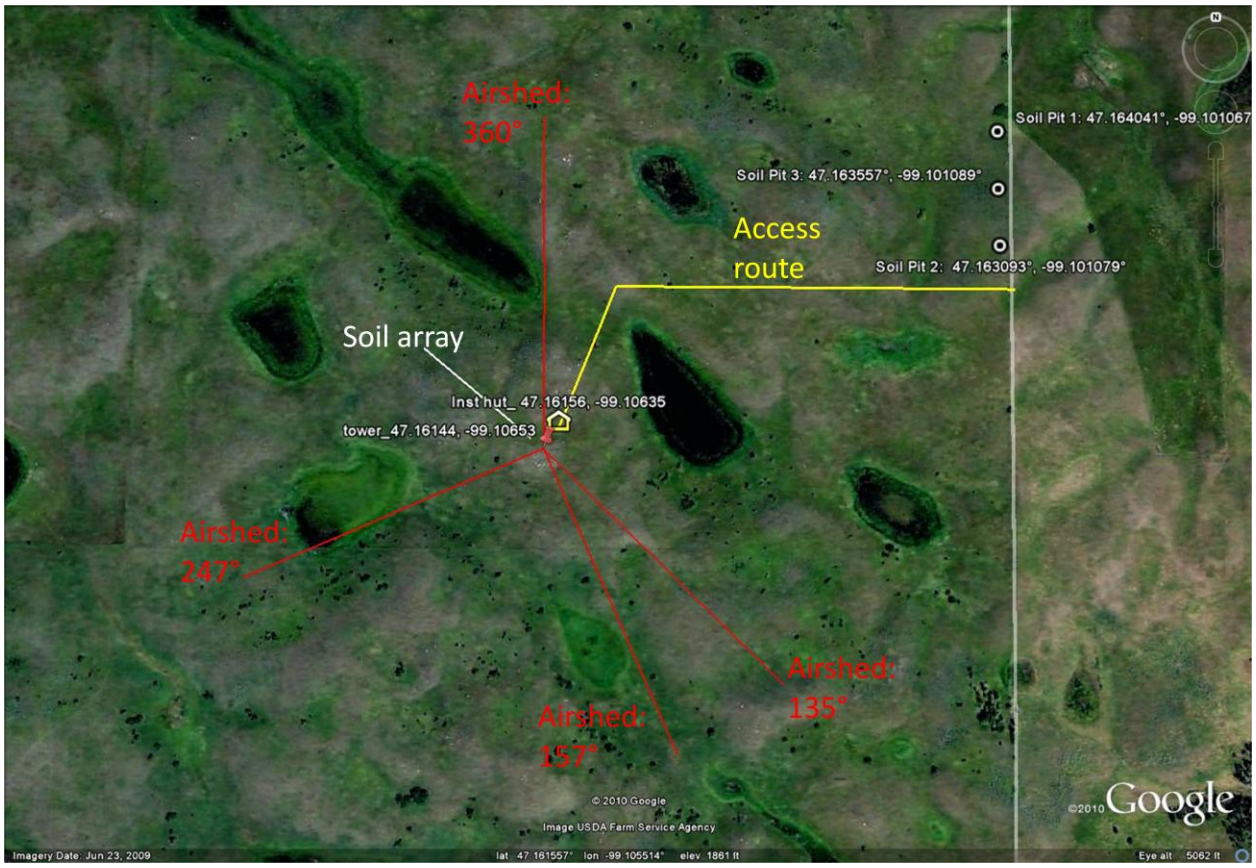


Figure 39. Site layout for DCFS Relocatable site.
i) new tower location is presented (red pin), ii) red lines indicate the airshed boundaries. Vectors 247° to 360° (major, clockwise from 247°) and 135° to 157° (secondary, clockwise from 135°) would have quality wind data without causing flow distortions, respectively. iii) Yellow line is the suggested access road to instrument hut.

Boardwalks. Ultimately, the decision to use a boardwalk will be, in part, based on owner's preferences. There are strong science requirements that minimize site disturbance to the surrounding area, which will be difficult to manage over a 30-y period. Traffic control is key to minimizing the site disturbance. Confining foot traffic to boardwalks minimizes site impact; this is particularly true in places where wear caused by foot traffic becomes noticeable and grows. For example, in places with snow part of the year, worn footpaths tend to have low places that collect water, or places where the snow pack becomes uneven causing personnel to walk farther and farther around the sides of the original path, causing the path to grow in width. This is a very common phenomenon. Here FIU assumes that all conduits will be either buried, or placed inside the boardwalk such that it does not extend beyond the 36' wide footprint. While the final design is not yet known, there are some general criteria that can be outlined. We assume that the boardwalk width is 36" (0.914 m). Material is not known, but must be fire proof, and in some locations the site is seasonally flooded and inundated with water. Boardwalks may also provide a scratching structure for grazing animals that in turn, would wear and unduly impact the site. Site by site evaluations must be done.
Specific boardwalks at the DCFS Relocatable site

- Boardwalk is from the access dirt road to instrument hut

- Boardwalk is required from the instrument hut to the tower to intersect on north face of the tower
- Soil array boardwalk is required, pending landowner decision.
- No boardwalk from the soil array boardwalk to the individual soil plots
- Boardwalk has to withstand light grazing

The relative locations between tower, instrument hut and boardwalk can be found in the diagram below:

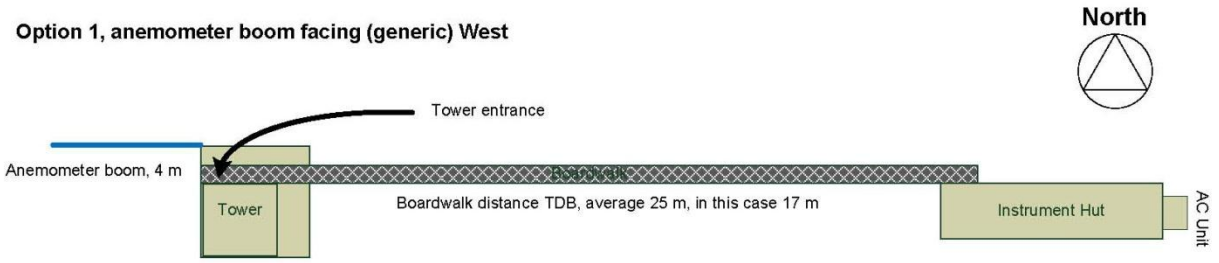


Figure 40 Generic diagram to demonstration the relationship between tower and instrument hut when boom facing west and instrument hut on the east towards the tower.

This is just a generic diagram. The actual layout of boardwalk (or path if no boardwalk required) and instrument hut position will be the joint responsibility of FCC and FIU. At DCFS Relocatable site, the boom angle will be 245 degrees, instrument hut will be on the northeast towards the tower, the distance between instrument hut and tower is ~19 m. The instrument hut vector will be SE-NW (145°-325°, longwise).

4.4.7 Information for ecosystem productivity plots

The tower at DCFS relocatable site has been positioned to optimize the collection of the air/wind signals both temporally and spatially over the desired ecosystem (pothole prairie ecosystem). Major airshed area at this site are from 247° to 360° (major, clockwise from 247°) and 135° to 157° (secondary, clockwise from 135°), and 90% signals for flux measurements are within a distance of 750 m from tower, and 80% within 400 m. We suggest FSU Ecosystem Productivity plots are placed within the boundaries of 247° to 360° (major, clockwise from 247°) from tower.

4.5 Issues and attentions

The initial tower location was only specified to 3 decimal places only (47.161, -99.111) and resulted in a large lake, ~140 m from the tower, in the dominant airshed. The tower location was moved to a new location (47.16144, -99.10653), which is further from the lake (~460 m) and the lake occupies a smaller part of the dominant airshed. The new location is closer to a road and also closer to power lines.

The suggested access route to the tower is south from Route 36/17th St SE and then west to the tower. A gate (or gates) will likely need to be added to the fence so that people and vehicles can get to the site

from the road. The landowners will have to approve this route. I f this route is not approved, access to the site can come from the SE but it will be >500 m longer.

There are many lakes/ponds (some possibly ephemeral) at the site, including around the tower (the closest lakes to the tower are ~80 m to the North, ~100 m to the East, and ~150 m to the west). This will complicate the tower flux measurements, but cannot be avoided since lakes and ponds are a major feature of praire pothole ecosystems.

The site is grazed at some times during the year, but not continuously, and grazing pressure is lower than at the Northern Great Plains Research Lab site. Protection of sensors on the lower level on the tower may be needed. Individual guards may also be needed to protect the tubes at soil plots.

Similar to the other sites in this domain, high winds can occur (e.g. >80 mph).

5 NORTHERN GREAT PLAINS RESEARCH LAB (NGPRL), RELOCATEABLE TOWER 2

5.1 Site description

The candidate relocatable tower site (46.76993, -100.9158) is located in Northern Great Plains Research Laboratory (NGPRL, Figure 41). After FIU site characterization, we microsited tower location ~40 m toward SE to the location of 46.76972, -100.91535 to keep more distance away from the cattle exclosures.

The Northern Great Plains Research Laboratory (NGPRL) in Mandan, ND, is one of more than 120 Agricultural Research Service (ARS) facilities in the U.S. The NGPRL was established by Congress on August 8, 1912 to respond to the needs of farmers and ranchers of the Northern Plains. Research began in 1914 on vegetables, shrubs, ornamentals, berries, fruits, wheat, flax, forages, grazing management, windbreaks and forestry. Research programs have changed significantly through the years to address the ever-changing needs of our customers. Programs to evaluate trees and shrubs for windbreaks, to develop methods to reclaim mine-land spoils and to examine the feasibility of dairy production in the Northern Great Plains have been replaced with new long-term research. Modern lines of research include global climate change, biofuel production, dryland cropping, forage production, and rangeland management. The current vision of the Laboratory is the development of economically and environmentally sustainable integrated crop and livestock management systems to help preserve the family farm. The mission of NGPRL is to develop environmentally sound practices and add value to agricultural systems in the Great Plains in terms of food, feed, and biomass by conducting team-focused, systems-oriented research and technology transfer (info source: http://www.ars.usda.gov/AboutUs/AboutUs.htm?modecode=54-45-00-00).

Many publications (especially soil and grazing studies) from research projects conducted at this location can be found on http://www.ars.usda.gov/Services/Services.htm?modecode=54-45-00-00 .

Soils are classified as Temvik-Wilton silt loam [FAO: Calic Siltic Chernozems; USDA: fine-silty, mixed, superactive, frigid typic, and PachicHaplustolls (Soil Survey Staff, 2008)]. The prairie site was historically grazed and hayed with no history of tillage. It is densely covered by grasses [*Bromus inermis (L.)* and *Poa pretensis (L.)*] and has remained undisturbed since 2005. The arable site has been managed for annual grain production for over 50 years but has not been tilled since 1992. Granular urea is broadcast (approximately 50 kg N ha^{-1}) each spring prior to planting. Soil properties measured in spring 2008 indicated that C, N, and pH were 42.0 g kg^{-1}, 3.8 g kg^{-1}, and 6.2, respectively, for prairie and 24.0 g kg^{-1}, 2.3 g kg^{-1}, and 5.7, respectively, for arable soils (info source: http://ddr.nal.usda.gov/dspace/bitstream/10113/34926/1/IND44250960.pdf).

Figure 41. Property boundary of the NGPRL and tower location.
Note that tower location has been changed since this map was made. See site layout mp for the new tower location.

5.2 Ecosystem

Vegetation and land cover around tower site and surrounding area are presented below:

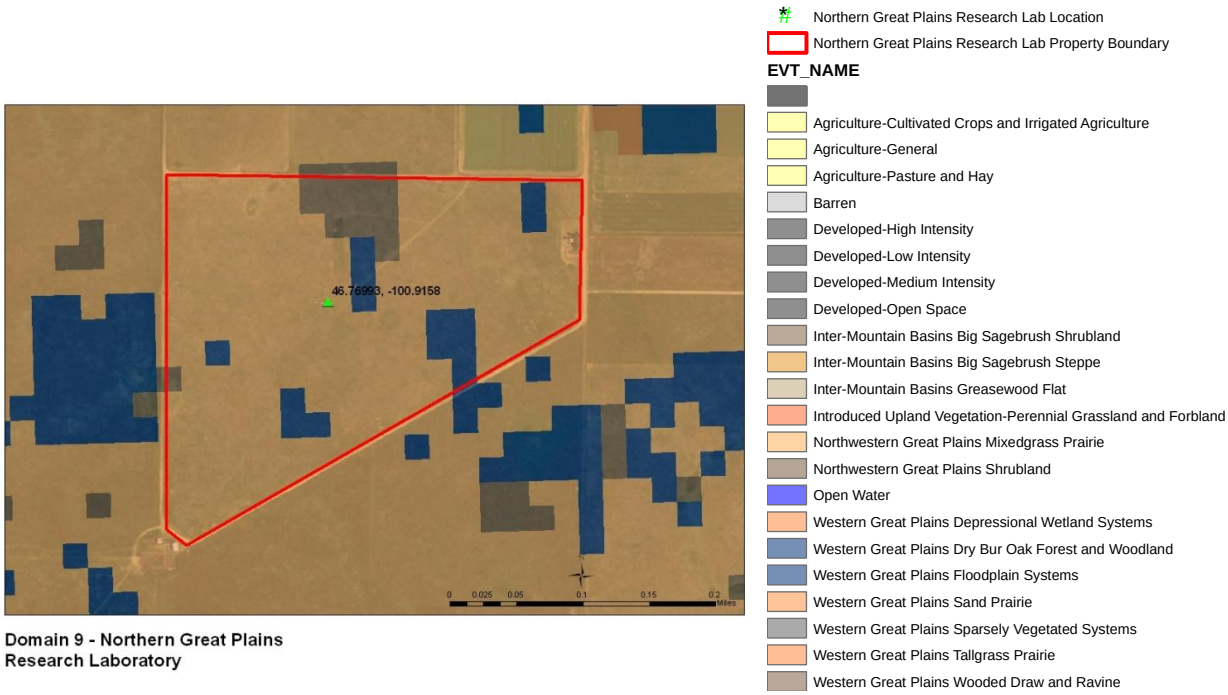


Figure 42. Vegetative cover map of NGPRL relocatable site and surrounding areas

(from USGS, http://landfire.cr.usgs.gov/viewer/viewer.htm)
Note that tower location has been changed since this map was made. See site layout mp for the new tower location.

Table 13. Percent Land cover information at NGPRL relocatable site (from USGS, http://landfire.cr.usgs.gov/viewer/viewer.htm)

Vegetation Type	**Area (km^2)**	Percent
Northwestern Great Plains Mixedgrass Prairie	0.14	89.47
Western Great Plains Floodplain Systems	0.01	5.79
Western Great Plains Wooded Draw and Ravine	0.01	4.74
Total Area sq Km	0.16	100.00

The ecosystem is grazed grassland around tower site and within tower airshed (Figure 43). Canopy height is ~0.4 m. Ground coverage is 100%. LAI is estimated to be ~ 2. Some small bushes are at site with height < 1 m. Several cattle exclosures are inside the field with height around 1 -1.2 m. The exclosure fences are just wires and very open for wind flows. We do not expect large impacts of the enclosures on local wind patterns. Surrounding fields are mostly grazed perennial grasslands, but also include some cropland (although the cropland areas can likely be converted to perennial grasslands if requested).

Table 14. Ecosystem and site attributes for NGPRL Relocatable site.

Ecosystem attributes	**Measure and units**
Mean canopy height[a]	0.4 m
Surface roughness[a]	0.05 m
Zero place displacement height[a]	0.2 m
Structural elements	Grazed grassland, homogenous
Time zone	Central time zone
Magnetic declination	6° 55' E changing by 0° 8' W/year

Note, [a] From field survey.

Figure 43. Grazed grassland is the dominant ecosystem type at NGPRL Relocatable site

5.3 Soils

5.3.1 Description of soils

Soil data and soil maps (Figure 44) below for NGPRL tower site were collected from 2.2 km^2 NRCS soil maps (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm) to determine the dominant soil types in the larger tower foot print. This was done to assure that the soil array is in the dominant (or in the co-dominant) soil type present in the tower footprint.

Figure 44. Soil map of the NGPRL Relocatable site and surrounding areas.

Soil Map Units Description: The map units delineated on the detailed soil maps in a soil survey represents the soils or miscellaneous areas in the survey area. The map unit descriptions in this report, along with the maps, can be used to determine the composition and properties of a unit. A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils. Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called non-contrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor

components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas. An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. All the soils of a series have major horizons that are similar in composition, thickness, and arrangement. Soils of a given series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series. Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups. A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example. An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example. An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, are an example. Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example. Additional information about the map units described in this report is available in other soil reports, which give properties of the soils and the limitations, capabilities, and potentials for many uses. Also, the narratives that accompany the soil reports define some of the properties included in the map unit descriptions.

Table 15. Soil series and percentage of soil series within 2.2 km^2 at the NGPRL site

Morton County, North Dakota (ND059)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
12C	Amor-Cabba loams, 6 to 9 percent slopes	14.5	2.6%
15D	Cabba-Chama-Sen silt loams, 9 to 15 percent slopes	27.5	5.0%
15F	Cabba-Chama-Arnegard complex, 15 to 70 percent slopes	51.8	9.5%
26	Grail silty clay loam, 0 to 2 percent slopes	7.7	1.4%
27	Belfield-Grail silty clay loams, 0 to 2 percent slopes	22.5	4.1%
28	Belfield-Daglum silt loams, 0 to 2 percent slopes	13.6	2.5%
28B	Belfield-Daglum silt loams, 2 to 6 percent slopes	0.3	0.1%
31B	Regent-Janesburg complex, 0 to 6 percent slopes	0.2	0.0%
31C	Regent-Janesburg complex, 6 to 9 percent slopes	39.4	7.2%
35D	Moreau-Wayden silty clays, 9 to 15 percent slopes	18.7	3.4%
42F	Dogtooth-Janesburg-Cabba complex, 6 to 30 percent slopes	15.4	2.8%
76D	Zahl-Williams loams, 9 to 15 percent slopes	22.8	4.2%
77	Temvik-Wilton silt loams, 0 to 3 percent slopes	223.5	40.9%
77B	Temvik-Williams silt loams, 3 to 6 percent slopes	88.3	16.2%
Totals for Area of Interest		**546.2**	**100.0%**

Morton County, North Dakota 12C—Amor-Cabba loams, 6 to 9 percent slopes: Map Unit Setting Elevation: 1,650 to 3,600 feet Mean annual precipitation: 13 to 18 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 135 days **Map Unit Composition** Amor and similar soils: 39 percent Cabba and similar soils: 29 percent Minor components: 32 percent **Description of Amor Setting** Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Linear Parent material: Loamy residuum weathered from mudstone **Properties and qualities** Slope: 6 to 9 percent Depth to restrictive feature: 20 to 40 inches to paralithic bedrock Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.01 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 2 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Sodium adsorption ratio, maximum: 2.0 Available water capacity: Low (about 5.7 inches) **Interpretive groups** Land capability (nonirrigated): 3e Ecological site: Loamy (R054XY031ND) Other vegetative classification: Droughty Loam (G054XY120ND) **Typical profile** 0 to 8 inches: Loam 8 to 19 inches: Loam 19 to 31 inches: Loam 31 to 60 inches: Bedrock **Description of Cabba Setting** Landform: Ridges Landform position (two-dimensional): Shoulder Down-slope shape: Convex Across-slope shape: Convex Parent material: Fine-loamy residuum weathered from sedimentary rock **Properties and qualities** Slope:

6 to 9 percent Depth to restrictive feature: 10 to 20 inches to paralithic bedrock Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.01 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Gypsum, maximum content: 2 percent Maximum salinity: Nonsaline to very slightly saline (1.0 to 4.0 mmhos/ cm) Sodium adsorption ratio, maximum: 2.0 Available water capacity: Very low (about 2.5 inches) **Interpretive groups** Land capability (nonirrigated): 6e Ecological site: Shallow Loamy (R054XY030ND) Other vegetative classification: Not suited (G054XY000ND) **Typical profile** 0 to 3 inches: Loam 3 to 15 inches: Loam 15 to 60 inches: Bedrock **Minor Components Amor** Percent of map unit: 10 percent Landform: Pediments Down-slope shape: Convex Across-slope shape: Linear Ecological site: Loamy (R054XY031ND) Other vegetative classification: Droughty Loam (G054XY120ND) **Shambo** Percent of map unit: 9 percent Landform: Alluvial fans, stream terraces Down-slope shape: Linear Across-slope shape: Linear Ecological site: Loamy (R054XY031ND) Other vegetative classification: Loam (G054XY100ND) **Chama** Percent of map unit: 5 percent Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Linear Ecological site: Thin Loamy (R054XY038ND) Other vegetative classification: Limy Upland (G054XY400ND) **Cohagen** Percent of map unit: 3 percent Landform: Hills Landform position (two-dimensional): Shoulder Down-slope shape: Convex Across-slope shape: Linear Ecological site: Shallow Sandy (R054XY043ND) Other vegetative classification: Not suited (G054XY000ND) **Regent** Percent of map unit: 3 percent Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Savage** Percent of map unit: 2 percent Landform: Ridges Landform position (two-dimensional): Footslope Down-slope shape: Convex Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND)

Morton County, North Dakota 28—Belfield-Daglum silt loams, 0 to 2 percent slopes: Map Unit Setting Elevation: 1,650 to 3,600 feet Mean annual precipitation: 13 to 18 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 135 days **Map Unit Composition** Belfield and similar soils: 45 percent Daglum and similar soils: 32 percent Minor components: 23 percent **Description of Belfield Setting** Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Parent material: Clayey alluvium derived from sedimentary rock **Properties and qualities** Slope: 0 to 2 percent Depth to restrictive feature: 7 to 45 inches to natric Drainage class: Moderately well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.01 to 1.42 in/hr) Depth to water table: About 42 to 60 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Gypsum, maximum content: 5 percent Maximum salinity: Slightly saline to moderately saline (5.0 to 15.0 mmhos/cm) Sodium adsorption ratio, maximum: 20.0 Available water capacity: Very low (about 2.5 inches) **Interpretive groups** Land capability (nonirrigated): 2s Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Typical profile** 0 to 9 inches: Silt loam 9 to 12 inches: Silty clay loam 12 to 17 inches: Silty clay 17 to 24 inches: Silty clay loam 24 to 43 inches: Silty clay loam 43 to 60 inches: Clay loam **Description of Daglum Setting** Landform: Alluvial flats Down-slope shape: Concave Across-slope shape: Linear Parent material: Clayey alluvium **Properties and qualities** Slope: 0 to 2 percent Depth to restrictive feature: 4 to 20 inches to natric Drainage class: Moderately well drained Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 1.42 in/hr) Depth to water table: About 42 to 60 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 25 percent Gypsum, maximum content: 5 percent Maximum salinity: Slightly saline to moderately saline

(5.0 to 15.0 mmhos/cm) Sodium adsorption ratio, maximum: 20.0 Available water capacity: Very low (about 1.1 inches) **Interpretive groups** Land capability (nonirrigated): 4s Ecological site: Claypan (R054XY021ND) Other vegetative classification: Claypan (G054XY800ND) **Typical profile** 0 to 7 inches: Silt loam 7 to 8 inches: Silt loam 8 to 18 inches: Clay 18 to 32 inches: Clay loam 32 to 47 inches: Clay loam 47 to 60 inches: Clay **Minor Components Daglum** Percent of map unit: 8 percent Landform: Alluvial flats Down-slope shape: Concave Across-slope shape: Linear Ecological site: Claypan (R054XY021ND) Other vegetative classification: Claypan (G054XY800ND) **Savage** Percent of map unit: 5 percent Landform: Alluvial flats Down-slope shape: Convex Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Grail** Percent of map unit: 5 percent Landform: Alluvial flats Down-slope shape: Concave Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Rhoades** Percent of map unit: 3 percent Landform: Alluvial flats Down-slope shape: Concave Across-slope shape: Concave Ecological site: Thin Claypan (R054XY033ND) Other vegetative classification: Not suited (G054XY000ND) **Regent** Percent of map unit: 2 percent Landform: Pediments Down-slope shape: Convex Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND)

Morton County, North Dakota 28B—Belfield-Daglum silt loams, 2 to 6 percent slopes Map Unit Setting Elevation: 1,650 to 3,600 feet Mean annual precipitation: 13 to 18 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 135 days **Map Unit Composition** Belfield and similar soils: 43 percent Daglum and similar soils: 35 percent Minor components: 22 percent **Description of Belfield Setting** Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Parent material: Clayey alluvium derived from sedimentary rock **Properties and qualities** Slope: 2 to 6 percent Depth to restrictive feature: 7 to 45 inches to natric Drainage class: Moderately well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.01 to 1.42 in/hr) Depth to water table: About 42 to 60 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Gypsum, maximum content: 5 percent Maximum salinity: Slightly saline to moderately saline (5.0 to 15.0 mmhos/cm) Sodium adsorption ratio, maximum: 20.0 Available water capacity: Very low (about 2.5 inches) **Interpretive groups** Land capability (nonirrigated): 2e Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Typical profile** 0 to 9 inches: Silt loam 9 to 12 inches: Silty clay loam 12 to 17 inches: Silty clay 17 to 24 inches: Silty clay loam 24 to 43 inches: Silty clay loam 43 to 60 inches: Clay loam **Description of Daglum Setting** Landform: Alluvial fans Down-slope shape: Concave Across-slope shape: Linear Parent material: Clayey alluvium **Properties and qualities** Slope: 2 to 6 percent Depth to restrictive feature: 4 to 20 inches to natric Drainage class: Moderately well drained Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 1.42 in/hr) Depth to water table: About 42 to 60 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 25 percent Gypsum, maximum content: 5 percent Maximum salinity: Slightly saline to moderately saline (5.0 to 15.0 mmhos/cm) Sodium adsorption ratio, maximum: 20.0 Available water capacity: Very low (about 1.1 inches) **Interpretive groups** Land capability (nonirrigated): 4s Ecological site: Claypan (R054XY021ND) Other vegetative classification: Claypan (G054XY800ND) **Typical profile** 0 to 7 inches: Silt loam 7 to 8 inches: Silt loam 8 to 18 inches: Clay 18 to 32 inches: Clay loam 32 to 47 inches: Clay loam 47 to 60 inches: Clay **Minor Components Farland** Percent of map unit: 7 percent Landform: Alluvial fans, alluvial flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Loamy (R054XY031ND) Other vegetative classification: Loam (G054XY100ND) **Grail** Percent of map unit: 6 percent Landform: Alluvial fans Down-slope shape: Linear Across-slope shape: Concave Ecological site:

Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Rhoades** Percent of map unit: 5 percent Landform: Alluvial flats Down-slope shape: Concave Across-slope shape: Concave Ecological site: Thin Claypan (R054XY033ND) Other vegetative classification: Not suited (G054XY000ND) **Reeder** Percent of map unit: 3 percent Landform: Pediments Down-slope shape: Convex Across-slope shape: Linear Ecological site: Loamy (R054XY031ND) Other vegetative classification: Droughty Loam (G054XY120ND) **Slickspots** Percent of map unit: 1 percent Landform: Alluvial fans, alluvial flats Down-slope shape: Concave Across-slope shape: Concave Other vegetative classification: Not suited (G054XY000ND)

Morton County, North Dakota 27—Belfield-Grail silty clay loams, 0 to 2 percent slopes: Map Unit Setting Elevation: 1,650 to 3,600 feet Mean annual precipitation: 13 to 18 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 135 days **Map Unit Composition** Belfield and similar soils: 49 percent Grail and similar soils: 26 percent Minor components: 25 percent **Description of Belfield Setting** Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Parent material: Clayey alluvium derived from sedimentary rock **Properties and qualities** Slope: 0 to 2 percent Depth to restrictive feature: 7 to 45 inches to natric Drainage class: Moderately well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.01 to 1.42 in/hr) Depth to water table: About 42 to 60 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Gypsum, maximum content: 5 percent Maximum salinity: Slightly saline to moderately saline (5.0 to 15.0 mmhos/cm) Sodium adsorption ratio, maximum: 20.0 Available water capacity: Very low (about 2.4 inches) **Interpretive groups** Land capability (nonirrigated): 2s Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Typical profile** 0 to 9 inches: Silty clay loam 9 to 12 inches: Silty clay loam 12 to 17 inches: Silty clay 17 to 24 inches: Silty clay loam 24 to 43 inches: Silty clay loam 43 to 60 inches: Clay loam **Description of Grail Setting** Landform: Swales Down-slope shape: Linear Across-slope shape: Concave Parent material: Clayey alluvium derived from sedimentary rock **Properties and qualities** Slope: 0 to 2 percent Depth to restrictive feature: More than 80 inches Drainage class: Moderately well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.01 to 1.42 in/hr) Depth to water table: About 42 to 60 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Gypsum, maximum content: 2 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Sodium adsorption ratio, maximum: 2.0 Available water capacity: High (about 10.6 inches) **Interpretive groups** Land capability (nonirrigated): 2c Ecological site: Loamy Overflow (R054XY023ND) Other vegetative classification: Overflow (G054XY500ND) **Typical profile** 0 to 5 inches: Silty clay loam 5 to 10 inches: Silty clay loam 10 to 24 inches: Silty clay 24 to 52 inches: Silty clay loam 52 to 60 inches: Silty clay loam **Minor Components Savage** Percent of map unit: 7 percent Landform: Alluvial flats Down-slope shape: Convex Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Daglum** Percent of map unit: 6 percent Landform: Alluvial flats Down-slope shape: Concave Across-slope shape: Linear Ecological site: Claypan (R054XY021ND) Other vegetative classification: Claypan (G054XY800ND) **Farnuf** Percent of map unit: 4 percent Landform: Alluvial flats, terraces Down-slope shape: Linear Across-slope shape: Linear Ecological site: Loamy (R054XY031ND) Other vegetative classification: Loam (G054XY100ND) **Arnegard** Percent of map unit: 2 percent Landform: Alluvial fans Down-slope shape: Linear Across-slope shape: Linear Ecological site: Loamy Overflow (R054XY023ND) Other vegetative classification: Loam (G054XY100ND) **Straw, rarely flooded** Percent of map unit: 2 percent Landform: Flood plains Down-slope shape: Linear Across-slope shape: Concave Ecological site: Loamy Overflow (R054XY023ND) Other vegetative classification: Overflow

(G054XY500ND) **Lawther** Percent of map unit: 2 percent Landform: Alluvial flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Regent** Percent of map unit: 2 percent Landform: Pediments Down-slope shape: Convex Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND)

Morton County, North Dakota 15F—Cabba-Chama-Arnegard complex, 15 to 70 percent Slopes: Map Unit Setting Elevation: 1,650 to 3,600 feet Mean annual precipitation: 13 to 18 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 135 days **Map Unit Composition** Cabba and similar soils: 40 percent Chama and similar soils: 22 percent Arnegard and similar soils: 10 percent Minor components: 28 percent **Description of Cabba Setting** Landform: Ridges Landform position (two-dimensional): Shoulder Down-slope shape: Convex Across-slope shape: Convex Parent material: Fine-silty residuum weathered from sedimentary rock **Properties and qualities** Slope: 15 to 70 percent Depth to restrictive feature: 10 to 20 inches to paralithic bedrock Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.01 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Gypsum, maximum content: 2 percent Maximum salinity: Nonsaline to very slightly saline (1.0 to 4.0 mmhos/ cm) Sodium adsorption ratio, maximum: 4.0 Available water capacity: Very low (about 2.5 inches) **Interpretive groups** Land capability (nonirrigated): 7e Ecological site: Shallow Loamy (R054XY030ND) Other vegetative classification: Not suited (G054XY000ND) **Typical profile** 0 to 3 inches: Silt loam 3 to 15 inches: Silt loam 15 to 60 inches: Bedrock **Description of Chama Setting** Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Linear Parent material: Fine-silty residuum weathered from siltstone **Properties and qualities** Slope: 15 to 35 percent Depth to restrictive feature: 20 to 40 inches to paralithic bedrock Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.01 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 2 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Sodium adsorption ratio, maximum: 4.0 Available water capacity: Moderate (about 6.6 inches) **Interpretive groups** Land capability (nonirrigated): 7e Ecological site: Thin Loamy (R054XY038ND) Other vegetative classification: Not suited (G054XY000ND) **Typical profile** 0 to 4 inches: Silt loam 4 to 8 inches: Silt loam 8 to 34 inches: Silt loam 34 to 60 inches: Bedrock **Description of Arnegard Setting** Landform: Swales Landform position (two-dimensional): Toeslope Down-slope shape: Concave Across-slope shape: Linear Parent material: Loamy alluvium derived from sedimentary rock **Properties and qualities** Slope: 15 to 25 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 20 percent Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm) Available water capacity: High (about 10.6 inches) **Interpretive groups** Land capability (nonirrigated): 6e Ecological site: Loamy Overflow (R054XY023ND) Other vegetative classification: Steep Loam (G054XY109ND) **Typical profile** 0 to 13 inches: Loam 13 to 36 inches: Loam 36 to 60 inches: Loam **Minor Components Amor** Percent of map unit: 10 percent Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Linear Ecological site: Loamy (R054XY031ND) Other vegetative classification: Steep Loam (G054XY109ND) **Regent** Percent of map unit: 10 percent Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Linear Ecological site: Clayey (R054XY020ND)

Other vegetative classification: Clayey Subsoil (G054XY210ND) **Wayden** Percent of map unit: 3 percent Landform: Ridges Landform position (two-dimensional): Shoulder Down-slope shape: Convex Across-slope shape: Convex Ecological site: Shallow Clayey (R054XY028ND) Other vegetative classification: Not suited (G054XY000ND) **Flasher** Percent of map unit: 3 percent Landform: Hills, ridges Landform position (two-dimensional): Summit, shoulder Down-slope shape: Linear, convex Across-slope shape: Convex Ecological site: Shallow Sandy (R054XY043ND) Other vegetative classification: Not suited (G054XY000ND) **Janesburg** Percent of map unit: 2 percent Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Convex Ecological site: Claypan (R054XY021ND) Other vegetative classification: Claypan (G054XY800ND)

Morton County, North Dakota 15D—Cabba-Chama-Sen silt loams, 9 to 15 percent slopes: Map Unit Setting Elevation: 1,650 to 3,600 feet Mean annual precipitation: 13 to 18 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 135 days **Map Unit Composition** Cabba and similar soils: 38 percent Chama and similar soils: 26 percent Sen and similar soils: 16 percent Minor components: 20 percent **Description of Cabba Setting** Landform: Ridges Landform position (two-dimensional): Shoulder Down-slope shape: Convex Across-slope shape: Convex Parent material: Fine-silty residuum weathered from sedimentary rock **Properties and qualities** Slope: 9 to 15 percent Depth to restrictive feature: 10 to 20 inches to paralithic bedrock Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.01 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Gypsum, maximum content: 2 percent Maximum salinity: Nonsaline to very slightly saline (1.0 to 4.0 mmhos/ cm) Sodium adsorption ratio, maximum: 4.0 Available water capacity: Very low (about 2.5 inches) **Interpretive groups** Land capability (nonirrigated): 6e Ecological site: Shallow Loamy (R054XY030ND) Other vegetative classification: Not suited (G054XY000ND) **Typical profile** 0 to 3 inches: Silt loam 3 to 15 inches: Silt loam 15 to 60 inches: Bedrock **Description of Chama Setting** Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Linear Parent material: Fine-silty residuum weathered from siltstone **Properties and qualities** Slope: 9 to 15 percent Depth to restrictive feature: 20 to 40 inches to paralithic bedrock Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.01 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 2 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Sodium adsorption ratio, maximum: 4.0 Available water capacity: Moderate (about 6.6 inches) **Interpretive groups** Land capability (nonirrigated): 6e Ecological site: Thin Loamy (R054XY038ND) Other vegetative classification: Limy Upland (G054XY400ND) **Typical profile** 0 to 4 inches: Silt loam 4 to 8 inches: Silt loam 8 to 34 inches: Silt loam 34 to 60 inches: Bedrock **Description of Sen Setting** Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Linear Parent material: Fine-silty residuum weathered from siltstone **Properties and qualities** Slope: 9 to 15 percent Depth to restrictive feature: 20 to 40 inches to paralithic bedrock Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.01 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 2 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Sodium adsorption ratio, maximum: 4.0 Available water capacity: Moderate (about 7.3 inches) **Interpretive groups** Land capability (nonirrigated): 4e Ecological site: Loamy (R054XY031ND) Other vegetative classification: Droughty Loam (G054XY120ND) **Typical profile** 0 to 6 inches: Silt loam 6

to 17 inches: Silt loam 17 to 34 inches: Silt loam 34 to 60 inches: Bedrock **Minor Components Vebar** Percent of map unit: 5 percent Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Linear Ecological site: Sandy (R054XY026ND) Other vegetative classification: Not suited (G054XY000ND) **Arnegard** Percent of map unit: 4 percent Landform: Swales Landform position (two-dimensional): Toeslope Down-slope shape: Concave Across-slope shape: Linear Ecological site: Loamy (R054XY031ND) Other vegetative classification: Loam (G054XY100ND) **Cabba** Percent of map unit: 4 percent Landform: Rises Down-slope shape: Convex Across-slope shape: Convex Ecological site: Shallow Loamy (R054XY030ND) Other vegetative classification: Not suited (G054XY000ND) **Janesburg** Percent of map unit: 3 percent Landform: Hills Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear Ecological site: Claypan (R054XY021ND) Other vegetative classification: Claypan (G054XY800ND) **Golva** Percent of map unit: 2 percent Landform: Ridges Landform position (two-dimensional): Footslope Down-slope shape: Linear Across-slope shape: Linear Ecological site: Loamy (R054XY031ND) Other vegetative classification: Loam (G054XY100ND) **Maschetah** Percent of map unit: 2 percent Landform: Ridges Landform position (two-dimensional): Footslope Down-slope shape: Linear Across-slope shape: Linear Ecological site: Thin Loamy (R054XY038ND) Other vegetative classification: Limy Upland (G054XY400ND)

Morton County, North Dakota 42F—Dogtooth-Janesburg-Cabba complex, 6 to 30 percent: slopes Map Unit Setting Elevation: 1,650 to 3,600 feet Mean annual precipitation: 13 to 18 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 135 days **Map Unit Composition** Dogtooth and similar soils: 33 percent Janesburg and similar soils: 22 percent Cabba and similar soils: 20 percent Minor components: 25 percent **Description of Dogtooth Setting** Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Concave Across-slope shape: Concave Parent material: Clayey residuum weathered from shale **Properties and qualities** Slope: 6 to 25 percent Depth to restrictive feature: 2 to 4 inches to natric; 20 to 40 inches to paralithic bedrock Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Gypsum, maximum content: 5 percent Maximum salinity: Slightly saline to moderately saline (5.0 to 16.0 mmhos/cm) Sodium adsorption ratio, maximum: 25.0 Available water capacity: Very low (about 0.4 inches) **Interpretive groups** Land capability (nonirrigated): 7s Ecological site: Thin Claypan (R054XY033ND) Other vegetative classification: Not suited (G054XY000ND) **Typical profile** 0 to 2 inches: Silt loam 2 to 8 inches: Silty clay 8 to 13 inches: Silty clay 13 to 21 inches: Silty clay 21 to 60 inches: Bedrock **Description of Janesburg Setting** Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Convex Parent material: Clayey residuum weathered from shale **Properties and qualities** Slope: 6 to 25 percent Depth to restrictive feature: 2 to 13 inches to natric; 20 to 40 inches to paralithic bedrock Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Gypsum, maximum content: 5 percent Maximum salinity: Slightly saline to moderately saline (5.0 to 15.0 mmhos/cm) Sodium adsorption ratio, maximum: 20.0 Available water capacity: Very low (about 2.1 inches) **Interpretive groups** Land capability (nonirrigated): 6s Ecological site: Claypan (R054XY021ND) Other vegetative classification: Claypan (G054XY800ND) **Typical profile** 0 to 8 inches: Silt loam 8 to 10 inches: Silt loam 10 to 21 inches: Silty clay 21 to 26 inches: Silt loam 26 to 60 inches: Bedrock **Description of Cabba Setting** Landform: Ridges Landform position (two-dimensional): Shoulder Down-slope shape: Convex Across-slope shape: Convex Parent material: Fine-loamy residuum weathered from

sedimentary rock **Properties and qualities** Slope: 9 to 30 percent Depth to restrictive feature: 10 to 20 inches to paralithic bedrock Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.01 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Gypsum, maximum content: 2 percent Maximum salinity: Nonsaline to very slightly saline (1.0 to 4.0 mmhos/ cm) Sodium adsorption ratio, maximum: 2.0 Available water capacity: Very low (about 2.5 inches) **Interpretive groups** Land capability (nonirrigated): 7e Ecological site: Shallow Loamy (R054XY030ND) Other vegetative classification: Not suited (G054XY000ND) **Typical profile** 0 to 3 inches: Loam 3 to 15 inches: Loam 15 to 60 inches: Bedrock **Minor Components Moreau** Percent of map unit: 7 percent Landform: Ridges Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Wayden** Percent of map unit: 4 percent Landform: Ridges Landform position (two-dimensional): Shoulder Down-slope shape: Convex Across-slope shape: Convex Ecological site: Shallow Clayey (R054XY028ND) Other vegetative classification: Not suited (G054XY000ND) **Amor** Percent of map unit: 3 percent Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Linear Ecological site: Loamy (R054XY031ND) Other vegetative classification: Droughty Loam (G054XY120ND) **Chama** Percent of map unit: 3 percent Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Linear Ecological site: Thin Loamy (R054XY038ND) Other vegetative classification: Not suited (G054XY000ND) **Ekalaka** Percent of map unit: 3 percent Landform: Hills, ridges Landform position (two-dimensional): Footslope Down-slope shape: Concave Across-slope shape: Linear Ecological site: Sandy Claypan (R054XY027ND) Other vegetative classification: Claypan (G054XY800ND) **Regan, occasionally flooded** Percent of map unit: 3 percent Landform: Drainageways Down-slope shape: Linear Across-slope shape: Concave Ecological site: Saline Lowland (R054XY024ND) Other vegetative classification: Saline (G054XY895ND) **Slickspots** Percent of map unit: 2 percent Landform: Alluvial fans, alluvial flats Down-slope shape: Concave Across-slope shape: Concave Other vegetative classification: Not suited (G054XY000ND)

Morton County, North Dakota 26—Grail silty clay loam, 0 to 2 percent slopes: Map Unit Setting Elevation: 1,650 to 3,600 feet Mean annual precipitation: 13 to 18 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 135 days **Map Unit Composition** Grail and similar soils: 49 percent Minor components: 51 percent **Description of Grail Setting** Landform: Alluvial flats Down-slope shape: Linear Across-slope shape: Concave Parent material: Clayey alluvium derived from sedimentary rock **Properties and qualities** Slope: 0 to 2 percent Depth to restrictive feature: More than 80 inches Drainage class: Moderately well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.01 to 1.42 in/hr) Depth to water table: About 42 to 60 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Gypsum, maximum content: 2 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Sodium adsorption ratio, maximum: 2.0 Available water capacity: High (about 10.6 inches) **Interpretive groups** Land capability (nonirrigated): 2c Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Typical profile** 0 to 5 inches: Silty clay loam 5 to 10 inches: Silty clay loam 10 to 24 inches: Silty clay 24 to 52 inches: Silty clay loam 52 to 60 inches: Silty clay loam **Minor Components Grail** Percent of map unit: 20 percent Landform: Alluvial flats Down-slope shape: Concave Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Belfield** Percent of map unit: 10 percent Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Clayey

(R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Savage** Percent of map unit: 7 percent Landform: Alluvial flats Down-slope shape: Convex Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Lawther** Percent of map unit: 7 percent Landform: Alluvial flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Farland** Percent of map unit: 5 percent Landform: Alluvial flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Loamy (R054XY031ND) Other vegetative classification: Loam (G054XY100ND) **Regent** Percent of map unit: 2 percent Landform: Pediments Down-slope shape: Convex Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND)

Morton County, North Dakota 35D—Moreau-Wayden silty clays, 9 to 15 percent slopes: Map Unit Setting Elevation: 1,650 to 3,600 feet Mean annual precipitation: 13 to 18 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 135 days **Map Unit Composition** Moreau and similar soils: 42 percent Wayden and similar soils: 22 percent Minor components: 36 percent **Description of Moreau Setting** Landform: Ridges Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Linear Parent material: Clayey residuum weathered from calcareous shale **Properties and qualities** Slope: 9 to 15 percent Depth to restrictive feature: 20 to 40 inches to paralithic bedrock Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 20 percent Gypsum, maximum content: 5 percent Maximum salinity: Very slightly saline to slightly saline (4.0 to 8.0 mmhos/cm) Sodium adsorption ratio, maximum: 4.0 Available water capacity: Low (about 5.2 inches) **Interpretive groups** Land capability (nonirrigated): 6e Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Typical profile** 0 to 6 inches: Silty clay 6 to 13 inches: Silty clay 13 to 35 inches: Silty clay 35 to 60 inches: Bedrock **Description of Wayden Setting** Landform: Ridges Landform position (two-dimensional): Shoulder Down-slope shape: Convex Across-slope shape: Convex Parent material: Clayey residuum weathered from shale **Properties and qualities** Slope: 9 to 15 percent Depth to restrictive feature: 10 to 20 inches to paralithic bedrock Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 30 percent Gypsum, maximum content: 5 percent Maximum salinity: Nonsaline to moderately saline (2.0 to 16.0 mmhos/cm) Sodium adsorption ratio, maximum: 4.0 Available water capacity: Very low (about 2.4 inches) **Interpretive groups** Land capability (nonirrigated): 6s Ecological site: Shallow Clayey (R054XY028ND) Other vegetative classification: Not suited (G054XY000ND) **Typical profile** 0 to 3 inches: Silty clay 3 to 7 inches: Silty clay 7 to 15 inches: Silty clay 15 to 60 inches: Bedrock **Minor Components Regent** Percent of map unit: 10 percent Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Janesburg** Percent of map unit: 8 percent Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Convex Ecological site: Claypan (R054XY021ND) Other vegetative classification: Claypan (G054XY800ND) **Cabba** Percent of map unit: 7 percent Landform: Ridges Landform position (two-dimensional): Shoulder Down-slope shape: Convex Across-slope shape: Convex Ecological site: Shallow Loamy (R054XY030ND) Other vegetative classification: Not suited (G054XY000ND) **Wabek** Percent of map unit: 3 percent Landform: Ridges on terraces Landform position (two-dimensional): Summit, shoulder Down-slope

shape: Convex Across-slope shape: Linear Ecological site: Very Shallow (R054XY035ND) Other vegetative classification: Not suited (G054XY000ND) **Farland** Percent of map unit: 3 percent Landform: Hills Landform position (two-dimensional): Footslope Down-slope shape: Concave Across-slope shape: Linear Ecological site: Loamy (R054XY031ND) Other vegetative classification: Loam (G054XY100ND) **Lawther** Percent of map unit: 3 percent Landform: Alluvial fans Down-slope shape: Linear Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Reeder** Percent of map unit: 2 percent Landform: Ridges Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Linear Ecological site: Loamy (R054XY031ND) Other vegetative classification: Droughty Loam (G054XY120ND)

Morton County, North Dakota 31B—Regent-Janesburg complex, 0 to 6 percent slopes: Map Unit Setting Elevation: 1,650 to 3,600 feet Mean annual precipitation: 13 to 18 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 135 days **Map Unit Composition** Regent and similar soils: 38 percent Janesburg and similar soils: 28 percent Minor components: 34 percent **Description of Regent Setting** Landform: Pediments Down-slope shape: Convex Across-slope shape: Linear Parent material: Clayey residuum weathered from shale **Properties and qualities** Slope: 0 to 6 percent Depth to restrictive feature: 20 to 40 inches to paralithic bedrock Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Gypsum, maximum content: 5 percent Maximum salinity: Nonsaline to slightly saline (0.0 to 8.0 mmhos/cm) Sodium adsorption ratio, maximum: 4.0 Available water capacity: Moderate (about 7.3 inches) **Interpretive groups** Land capability (nonirrigated): 2e Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Typical profile** 0 to 10 inches: Silty clay loam 10 to 26 inches: Silty clay 26 to 39 inches: Silty clay loam 39 to 60 inches: Bedrock **Description of Janesburg Setting** Landform: Pediments Down-slope shape: Linear Across-slope shape: Convex Parent material: Clayey residuum weathered from shale **Properties and qualities** Slope: 0 to 6 percent Depth to restrictive feature: 2 to 13 inches to natric; 20 to 40 inches to paralithic bedrock Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Gypsum, maximum content: 5 percent Maximum salinity: Slightly saline to moderately saline (5.0 to 15.0 mmhos/cm) Sodium adsorption ratio, maximum: 20.0 Available water capacity: Very low (about 2.1 inches) **Interpretive groups** Land capability (nonirrigated): 4s Ecological site: Claypan (R054XY021ND) Other vegetative classification: Claypan (G054XY800ND) **Typical profile** 0 to 8 inches: Silt loam 8 to 10 inches: Silt loam 10 to 21 inches: Silty clay 21 to 26 inches: Silt loam 26 to 60 inches: Bedrock **Minor Components Belfield** Percent of map unit: 9 percent Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Reeder** Percent of map unit: 9 percent Landform: Pediments Down-slope shape: Convex Across-slope shape: Linear Ecological site: Loamy (R054XY031ND) Other vegetative classification: Droughty Loam (G054XY120ND) **Dogtooth** Percent of map unit: 7 percent Landform: Pediments Down-slope shape: Concave Across-slope shape: Concave Ecological site: Thin Claypan (R054XY033ND) Other vegetative classification: Not suited (G054XY000ND) **Savage** Percent of map unit: 4 percent Landform: Alluvial fans, alluvial flats Down-slope shape: Convex Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Moreau** Percent of map unit: 4 percent Landform: Pediments Down-slope shape: Convex Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative

classification: Clayey Subsoil (G054XY210ND) **Chama** Percent of map unit: 1 percent Landform: Pediments Down-slope shape: Convex Across-slope shape: Linear Ecological site: Thin Loamy (R054XY038ND) Other vegetative classification: Limy Upland (G054XY400ND)

Morton County, North Dakota 31C—Regent-Janesburg complex, 6 to 9 percent slopes: Map Unit Setting Elevation: 1,650 to 3,600 feet Mean annual precipitation: 13 to 18 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 135 days **Map Unit Composition** Regent and similar soils: 32 percent Janesburg and similar soils: 31 percent Minor components: 37 percent **Description of Regent Setting** Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Linear Parent material: Clayey residuum weathered from shale **Properties and qualities** Slope: 6 to 9 percent Depth to restrictive feature: 20 to 40 inches to paralithic bedrock Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Gypsum, maximum content: 5 percent Maximum salinity: Nonsaline to slightly saline (0.0 to 8.0 mmhos/cm) Sodium adsorption ratio, maximum: 4.0 Available water capacity: Moderate (about 7.3 inches) **Interpretive groups** Land capability (nonirrigated): 3e Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Typical profile** 0 to 10 inches: Silty clay loam 10 to 26 inches: Silty clay 26 to 39 inches: Silty clay loam 39 to 60 inches: Bedrock **Description of Janesburg Setting** Landform: Hills Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear Parent material: Clayey residuum weathered from shale **Properties and qualities** Slope: 6 to 9 percent Depth to restrictive feature: 2 to 13 inches to natric; 20 to 40 inches to paralithic bedrock Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Gypsum, maximum content: 5 percent Maximum salinity: Slightly saline to moderately saline (5.0 to 15.0 mmhos/cm) Sodium adsorption ratio, maximum: 20.0 Available water capacity: Very low (about 2.1 inches) **Interpretive groups** Land capability (nonirrigated): 6s Ecological site: Claypan (R054XY021ND) Other vegetative classification: Claypan (G054XY800ND) **Typical profile** 0 to 8 inches: Silt loam 8 to 10 inches: Silt loam 10 to 21 inches: Silty clay 21 to 26 inches: Silt loam 26 to 60 inches: Bedrock **Minor Components Regent** Percent of map unit: 12 percent Landform: Pediments Down-slope shape: Convex Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Belfield** Percent of map unit: 6 percent Landform: Flats Down-slope shape: Linear Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Dogtooth** Percent of map unit: 6 percent Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Concave Across-slope shape: Concave Ecological site: Thin Claypan (R054XY033ND) Other vegetative classification: Not suited (G054XY000ND) **Savage** Percent of map unit: 4 percent Landform: Alluvial fans Down-slope shape: Convex Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Moreau** Percent of map unit: 4 percent Landform: Ridges Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Linear Ecological site: Clayey (R054XY020ND) Other vegetative classification: Clayey Subsoil (G054XY210ND) **Wayden** Percent of map unit: 3 percent Landform: Ridges, rises on pediments Landform position (two-dimensional): Shoulder Down-slope shape: Convex Across-slope shape: Convex Ecological site: Shallow Clayey (R054XY028ND) Other vegetative classification: Not suited (G054XY000ND) **Chama** Percent of map unit: 2 percent Landform: Hills, ridges Landform position (two-dimensional): Backslope

Down-slope shape: Convex Across-slope shape: Linear Ecological site: Thin Loamy (R054XY038ND) Other vegetative classification: Limy Upland (G054XY400ND)

Morton County, North Dakota 77B—Temvik-Williams silt loams, 3 to 6 percent slopes: Map Unit Setting Elevation: 1,650 to 3,600 feet Mean annual precipitation: 13 to 18 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 135 days **Map Unit Composition** Temvik and similar soils: 50 percent Williams and similar soils: 16 percent Minor components: 34 percent **Description of Temvik Setting** Landform: Rises Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Linear Parent material: Fine-silty loess over till **Properties and qualities** Slope: 3 to 6 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 20 percent Gypsum, maximum content: 2 percent Sodium adsorption ratio, maximum: 5.0 Available water capacity: High (about 11.3 inches) **Interpretive groups** Land capability (nonirrigated): 2e Ecological site: Loamy (R054XY031ND) Other vegetative classification: Loam (G054XY100ND) **Typical profile** 0 to 7 inches: Silt loam 7 to 24 inches: Silt loam 24 to 44 inches: Clay loam 44 to 60 inches: Clay loam **Description of Williams Setting** Landform: Rises Landform position (two-dimensional): Backslope, summit Down-slope shape: Linear Across-slope shape: Linear Parent material: Fine-loamy till **Properties and qualities** Slope: 3 to 6 percent Surface area covered with cobbles, stones or boulders: 0.0 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 20 percent Gypsum, maximum content: 2 percent Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm) Sodium adsorption ratio, maximum: 5.0 Available water capacity: High (about 10.7 inches) Interpretive groups Land capability (nonirrigated): 2e Ecological site: Loamy (R054XY031ND) Other vegetative classification: Loam (G054XY100ND) **Typical profile** 0 to 6 inches: Silt loam 6 to 10 inches: Clay loam 10 to 15 inches: Clay loam 15 to 24 inches: Clay loam 24 to 36 inches: Clay loam 36 to 60 inches: Clay loam **Minor Components Wilton** Percent of map unit: 21 percent Landform: Swales Landform position (two-dimensional): Footslope Down-slope shape: Linear Across-slope shape: Concave Ecological site: LOAMY OVERFLOW (R054XY020SD) Other vegetative classification: Overflow (G054XY500ND) **Max** Percent of map unit: 5 percent Landform: Rises Landform position (two-dimensional): Backslope, summit Down-slope shape: Convex Across-slope shape: Linear Ecological site: Loamy (R054XY031ND) Other vegetative classification: Loam (G054XY100ND) **Zahl** Percent of map unit: 3 percent Landform: Rises Landform position (two-dimensional): Summit, shoulder Landform position (three-dimensional): Rise Down-slope shape: Convex Across-slope shape: Convex Ecological site: Thin Loamy (R054XY038ND) Other vegetative classification: Limy Upland (G054XY400ND) **Bryant** Percent of map unit: 3 percent Landform: Rises Down-slope shape: Linear Across-slope shape: Linear Ecological site: Loamy (R054XY031ND) Other vegetative classification: Loam (G054XY100ND) **Flaxton** Percent of map unit: 2 percent Landform: Rises Landform position (two-dimensional): Footslope, toeslope Down-slope shape: Concave Across-slope shape: Linear Ecological site: Sandy (R054XY026ND) Other vegetative classification: Loam (G054XY100ND)

Morton County, North Dakota 77—Temvik-Wilton silt loams, 0 to 3 percent slopes: Map Unit Setting Elevation: 1,650 to 3,600 feet Mean annual precipitation: 13 to 18 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 135 days **Map Unit Composition** Temvik and similar soils: 51

percent Wilton and similar soils: 38 percent Minor components: 11 percent **Description of Temvik Setting** Landform: Rises Down-slope shape: Convex Across-slope shape: Linear Parent material: Fine-silty loess over till **Properties and qualities** Slope: 0 to 3 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 20 percent Gypsum, maximum content: 2 percent Sodium adsorption ratio, maximum: 5.0 Available water capacity: High (about 11.3 inches) **Interpretive groups** Land capability (nonirrigated): 2c Ecological site: Loamy (R054XY031ND) Other vegetative classification: Loam (G054XY100ND) **Typical profile** 0 to 7 inches: Silt loam 7 to 24 inches: Silt loam 24 to 44 inches: Clay loam 44 to 60 inches: Clay loam **Description of Wilton Setting** Landform: Flats Down-slope shape: Linear Across-slope shape: Concave Parent material: Fine-silty loess over fine-loamy till **Properties and qualities** Slope: 0 to 3 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 20 percent Gypsum, maximum content: 2 percent Sodium adsorption ratio, maximum: 5.0 Available water capacity: High (about 11.4 inches) **Interpretive groups** Land capability (nonirrigated): 2c Ecological site: Loamy (R054XY031ND) Other vegetative classification: Loam (G054XY100ND) **Typical profile** 0 to 8 inches: Silt loam 8 to 27 inches: Silt loam 27 to 60 inches: Clay loam **Minor Components Williams** Percent of map unit: 9 percent Landform: Rises Landform position (two-dimensional): Backslope, summit Down-slope shape: Linear Across-slope shape: Linear Ecological site: Loamy (R054XY031ND) Other vegetative classification: Loam (G054XY100ND) **Grassna** Percent of map unit: 2 percent Landform: Swales Down-slope shape: Linear Across-slope shape: Concave Ecological site: Loamy Overflow (R054XY023ND) Other vegetative classification: Overflow (G054XY500ND)

Morton County, North Dakota 76D—Zahl-Williams loams, 9 to 15 percent slopes: Map Unit Setting Elevation: 1,650 to 3,600 feet Mean annual precipitation: 13 to 18 inches Mean annual air temperature: 39 to 45 degrees F Frost-free period: 120 to 135 days **Map Unit Composition** Zahl and similar soils: 45 percent Williams and similar soils: 21 percent Minor components: 34 percent **Description of Zahl Setting** Landform: Hills, ridges Landform position (two-dimensional): Shoulder, summit Down-slope shape: Convex Across-slope shape: Convex Parent material: Fine-loamy till **Properties and qualities** Slope: 9 to 15 percent Surface area covered with cobbles, stones or boulders: 0.0 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 20 percent Gypsum, maximum content: 2 percent Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm) Sodium adsorption ratio, maximum: 1.0 Available water capacity: High (about 10.3 inches) **Interpretive groups** Land capability (nonirrigated): 6e Ecological site: Thin Loamy (R054XY038ND) Other vegetative classification: Limy Upland (G054XY400ND) **Typical profile** 0 to 5 inches: Loam 5 to 20 inches: Clay loam 20 to 60 inches: Clay loam **Description of Williams Setting** Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Linear Across-slope shape: Linear Parent material: Fine-loamy till **Properties and qualities** Slope: 9 to 15 percent Surface area covered with cobbles, stones or boulders: 0.0 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 20 percent Gypsum,

maximum content: 2 percent Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm) Sodium adsorption ratio, maximum: 5.0 Available water capacity: High (about 10.5 inches) **Interpretive groups** Land capability (nonirrigated): 4e Ecological site: Loamy (R054XY031ND) Other vegetative classification: Loam (G054XY100ND) **Typical profile** 0 to 6 inches: Loam 6 to 10 inches: Clay loam 10 to 15 inches: Clay loam 15 to 24 inches: Clay loam 24 to 36 inches: Clay loam 36 to 60 inches: Clay loam **Minor Components Max** Percent of map unit: 15 percent Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Linear Ecological site: Loamy (R054XY031ND) Other vegetative classification: Loam (G054XY100ND) **Bowbells** Percent of map unit: 10 percent Landform: Swales Landform position (two-dimensional): Toeslope Down-slope shape: Concave Across-slope shape: Linear Ecological site: Loamy (R054XY031ND) Other vegetative classification: Loam (G054XY100ND) **Reeder** Percent of map unit: 3 percent Landform: Ridges Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Linear Ecological site: Loamy (R054XY031ND) Other vegetative classification: Droughty Loam (G054XY120ND) **Wabek, gravelly** Percent of map unit: 2 percent Landform: Ridges Landform position (two-dimensional): Shoulder, summit Down-slope shape: Convex Across-slope shape: Linear Ecological site: Very Shallow (R054XY035ND) Other vegetative classification: Not suited (G054XY000ND) **Cabba** Percent of map unit: 2 percent Landform: Ridges Landform position (two-dimensional): Shoulder Down-slope shape: Convex Across-slope shape: Convex Ecological site: Shallow Loamy (R054XY030ND) Other vegetative classification: Not suited (G054XY000ND) **Chama** Percent of map unit: 2 percent Landform: Hills, ridges Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Linear Ecological site: Thin Loamy (R054XY038ND) Other vegetative classification: Not suited (G054XY000ND)

5.3.2 Soil semi-variogram description

The goal of this aspect of the site characterization is to determine the minimum distance between the soil plots in the soil array such that data farther apart can be considered spatially independent. The collected field data will be used to produce semivariograms, which is a geostatistical technique to characterize spatial autocorrelation between mapped samples of a quantitative variable (*e.g.*, soil property data in our case). In an empirical semivariogram, the average of the squared differences of a response variable is computed for all pairs of points within specified distance intervals (lag classes). The output is presented graphically as a plot of the average semi-variance versus distance class (Figure 45). For the theoretical variogram models considered here, the semivariance will converge on the total variance at distances for which values are no longer spatially auto-correlated (this is referred to as the range, Figure 45).

For the theoretical variograms considered here, three parameters estimated from the data are used to fit a semivariogram model to the empirical semivariogram. This model is then assumed to quantitatively represent the correlation as a function of distance (Figure 45), the range, the sill (the sill is the asymptotic value of semi-variance at the range), and the nugget (which describes sampling error or variation at distances below those separating the closest pairs of samples). The range, sill and nugget are estimated from theoretical models that are fitted to the empirical variograms using non-linear least squares methods.

The variogram analysis will be used, to determine the spatial scales at which we can consider soil measurements spatially independent. This characterization will directly inform the minimum distance between *i*) soil plots within each soil array, *ii*) the soil profile measurements, *iii*) EP plots, and *iv*) the

microbial sampling locations. These data will directly inform NEON construction and site design activities.

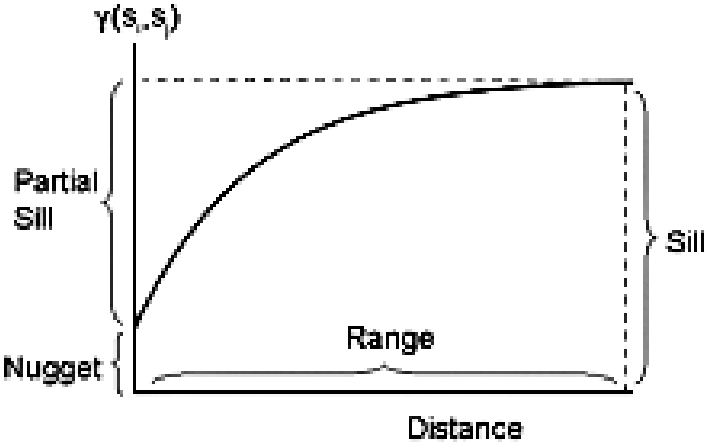


Figure 45. Example semivariogram, depicting range, sill, and nugget.

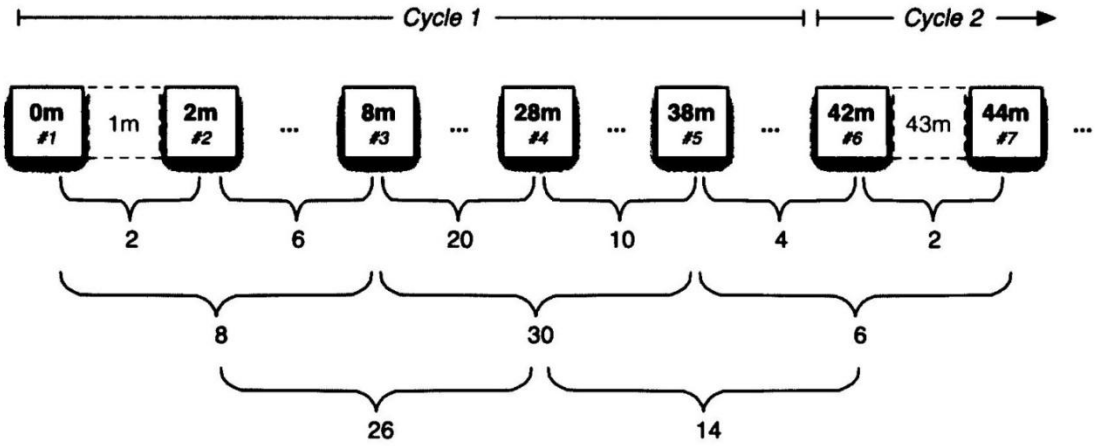


Figure 46. Spatially cyclic sampling design for the measurements of soil temperature and soil water content.

Field measurements of soil temperature (0-12 cm) and moisture (0-15 cm) were taken on 25 May 2010 at the Northern Great Plains Research Lab (NGPRL) site. The sampling points followed the spatially cyclic sampling design by Bond-Lamberty et al. (2006) (Figure 46). Soil temperature and moisture measurements were collected along three transects (210 m, 84 m, and 84 m) located in the expected airshed at NGPRL. Details of how the airshed was determined are provided below. Soil temperature was measured with platinum resistance temperature sensors (RTD 810, Omega Engineering Inc., Stamford CT) and soil moisture was measured with time domain diaelectric sensors (CS616, Campbell Scientific Inc., Logan UT).

As well as measuring soil temperature and moisture at each sample point in Figure 46, measurements were also taken 30 cm in front and behind the sampling point along the axis of the transect. For example, at the 2 m sampling point, soil temperature and moisture was measured at 1.7 m, 2 m, and 2.3

m; this data is referred to as mobile data, since the measurements were taken at many different locations. In addition, soil temperature and moisture were continuously recorded at a single fixed location (stationary data) throughout the sampling time to correct for changes in temperature and moisture throughout the day.

Data collected were used for geospatial analyses of variograms in the R statistical computing language with the geoR package to test for spatial autocorrelation (Trangmar *et al.* 1986; Webster & Oliver 1989; Goovaerts 1997; Riberiro & Diggle 2001) and estimate the distance necessary for independence among soil plots in the soil array. To correct for changes in temperature and moisture over the sampling period, the stationary data was subtracted from the mobile data. In many instances a time of day trend was still apparent in the data even after subtracting the stationary data from the mobile data. This time of day trend was corrected for by fitting a linear regression. Soil temperature data were further de-trended using elevation, slope, and aspect from a digital elevation map and the residuals were used for the semivariogram analysis. Soil temperature and moisture data, R code, graphs, and R output can be found at: P:\FIU\FIU_Site_Characterization\DXX\YYYYYYY_Characterization\Soil Measurements\Soil Data Analysis (where XX = domain number and YYYYYYY = site name).

5.3.3 Results and interpretation

5.3.3.1 Soil Temperature

Soil temperature data residuals, after accounting for changes in temperature in the stationary data, any remaining time of day trend, elevation, slope and aspect, were used for the semivariogram analysis (Figure 47). Exploratory data analysis plots show that there was no distinct patterning of the residuals (Figure 48, left graph) and directional semivariograms do not show anisotropy (Figure 48, center graph). An isotropic empirical semivariogram was produced and a spherical model was fitted using Cressie weights (Figure 48, right graph). The model indicates a distance of effective independence of 8 m for soil temperature.

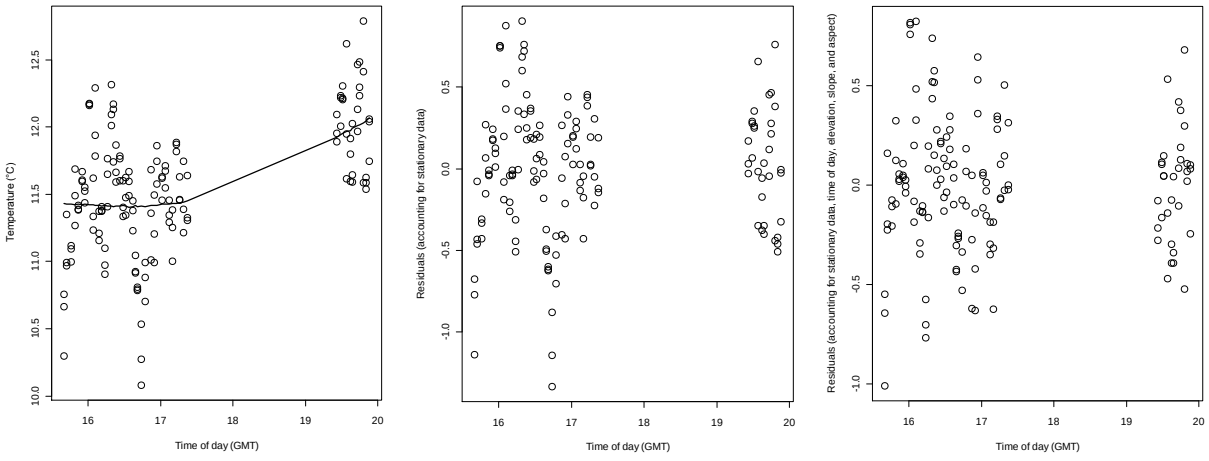


Figure 47. Left graph: mobile (circles) and stationary (line) soil temperature data. Center graph: temperature data after correcting for changes in temperature in the stationary data (circles) and a linear

regression based on time of day (line). Right graph: residual temperature data after correcting for changes temperature in the stationary data and the time of day regression. Data in the right graph were used for the semivariogram analysis.

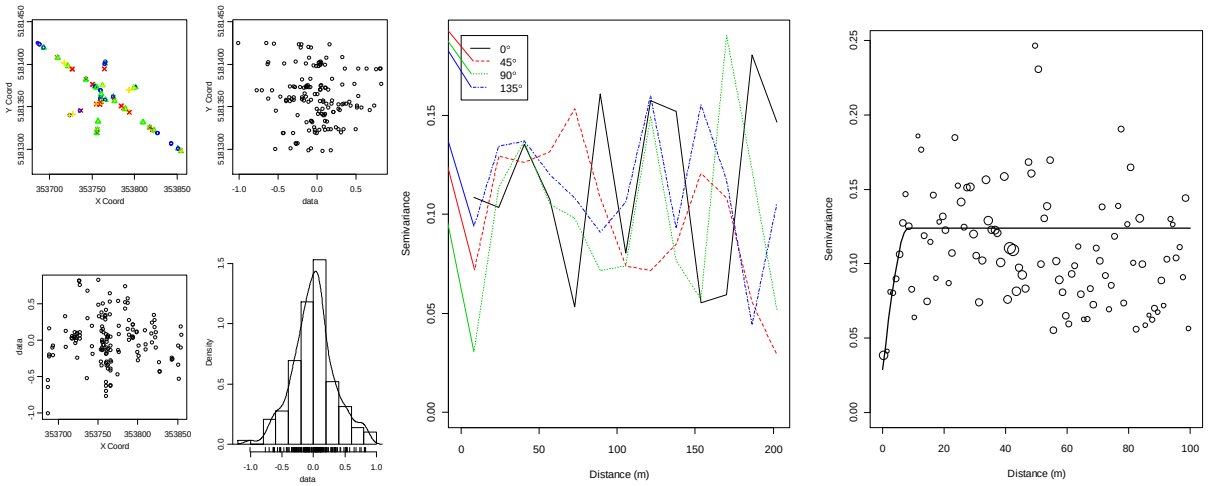


Figure 48. Left graphs: exploratory data analysis plots for residuals of temperature. Center graph: directional semivariograms for residuals of temperature. Right graph: empirical semivariogram (circles) and model (line) fit to residuals of temperature.

5.3.3.2 Soil water content

Soil water content data residuals, after accounting for changes in water content in the stationary data and any remaining time of day trend, were used for the semivariogram analysis (Figure 49). Exploratory data analysis plots show that there was no distinct patterning of the residuals (Figure 50, left graph) and directional semivariograms do not show anisotropy (Figure 50, center graph). An isotropic empirical semivariogram was produced and a spherical model was fitted using Cressie weights (Figure 50, right graph). The model indicates a distance of effective independence of 4 m for soil water content.

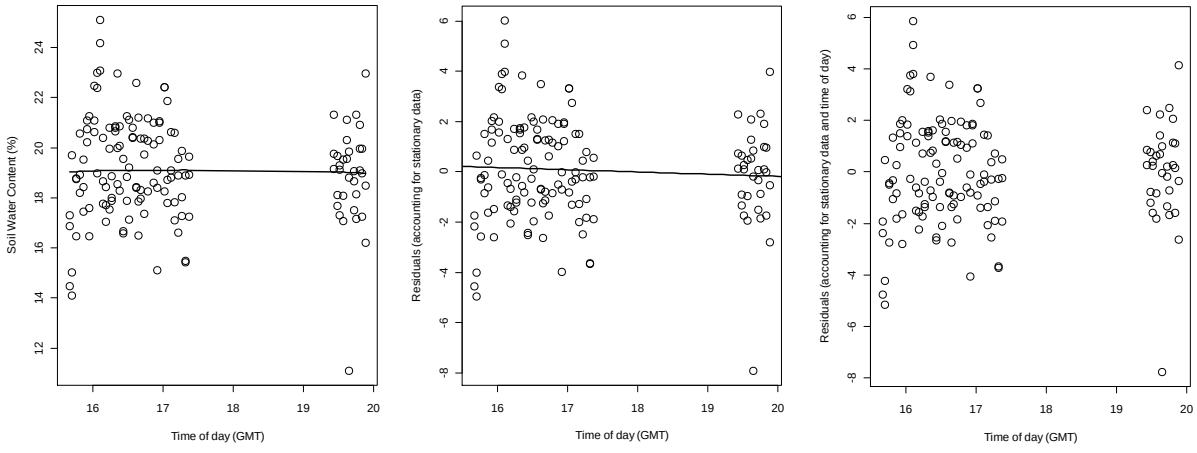


Figure 49. Left graph: mobile (circles) and stationary (line) soil water content data. Center graph: water content data after correcting for changes in water content in the stationary data (circles) and a linear regression based on time of day (line). Right graph: residual water content data after correcting for changes water content in the stationary data and the time of day regression. Data in the right graph were used for the semivariogram analysis.

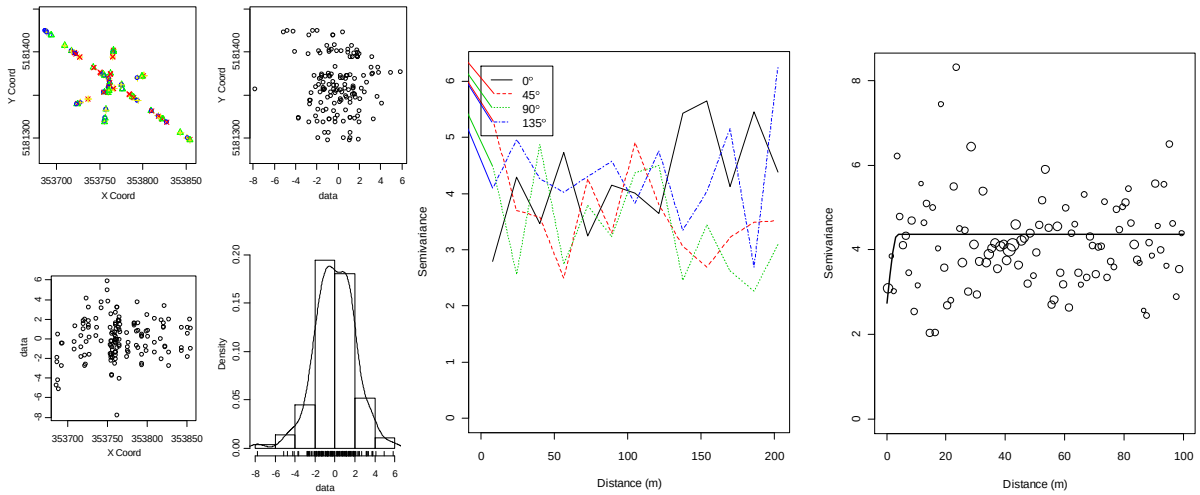


Figure 50. Left graphs: exploratory data analysis plots for residuals of soil water content. Center graph: directional semivariograms for residuals of water content. Right graph: empirical semivariogram (circles) and model (line) fit to residuals of water content.

5.3.3.3 Soil array layout and soil pit location

The minimum distance allowable between soil plots is 25 m to ensure a degree of spatial independence in non-measured soil parameters (i.e., other than temperature and water content) and the maximum distance allowable between soil plots is 40 m due to cost constraints. The estimated distance of effective independence was 8 m for soil temperature and 4 m for soil moisture. Based on these results and the site design guidelines the soil plots at NGPRL shall be placed 25 m apart. The soil array shall follow the linear soil array design (Soil Array Pattern B) with the soil plots being 5 m x 5 m. The direction of the soil array shall be 315° from the soil plot nearest the tower. The location of the first soil plot will be approximately 46.769837, -100.915447. The exact location of each soil plot will be chosen by an FIU team member during site construction to avoid placing a soil plot at an unrepresentative location (e.g., rock outcrop, drainage channel, large tree, etc). The FIU soil pit for characterizing soil horizon depths, collecting soil for site-specific sensor calibration, and collecting soil for the FIU soil archive will be located at 46.768462°, -100.918309° (primary location); or 46.768054°, -100.918304° (alternate location 1 if primary location is unsuitable); or 46.768983°, -100.918329° (alternate location 2 if primary location is unsuitable). A summary of the soil information is shown in Table 16 and site layout can be seen in Figure 51.

Dominant soil series at the site: Temvik-Wilton silt loams, 0 to 3 percent slopes. The taxonomy of this soil is shown below:
Order: Mollisols

Suborder: Ustolls
Great group: Haplustolls
Subgroup: Typic Haplustolls-Pachic Haplustolls
Family: Fine-silty, mixed, superactive, frigid Typic Haplustolls-Fine-silty, mixed, superactive, frigid Pachic Haplustolls
Series: Temvik-Wilton silt loams, 0 to 3 percent slopes

Table 16. Summary of soil array and soil pit information at Northern Great Plains Research Lab. 0° represents true north and accounts for declination.

Soil plot dimensions	5 m x 5 m
Soil array pattern	B
Distance between soil plots: x	25 m
Distance from tower to closest soil plot: y	15 m
Latitude and longitude of 1st soil plot OR direction from tower	46.769837, -100.915447
Direction of soil array	315°
Latitude and longitude of FIU soil pit 1	46.768462°, -100.918309° (primary location)
Latitude and longitude of FIU soil pit 2	46.768054°, -100.918304° (alternate 1)
Latitude and longitude of FIU soil pit 3	46.768983°, -100.918329° (alternate 2)
Dominant soil type	Temvik-Wilton silt loams, 0 to 3 percent slopes
Expected soil depth	>2 m
Depth to water table	>2 m

Expected depth of soil horizons	**Expected measurement depths***
0-0.18 m (Silt loam)	0.09 m
0.18-0.61 m (Silt loam)	[A]0.40 m
0.61-1.12 m (Clay loam)	[A]0.87 m
1.12-1.52 m (Clay loam)	[A]1.32 m

*Actual soil measurement depths will be determined based on measured soil horizon depths at the NEON FIU soil pit and may differ substantially from those shown here.
[A]current depths of the soil CO2

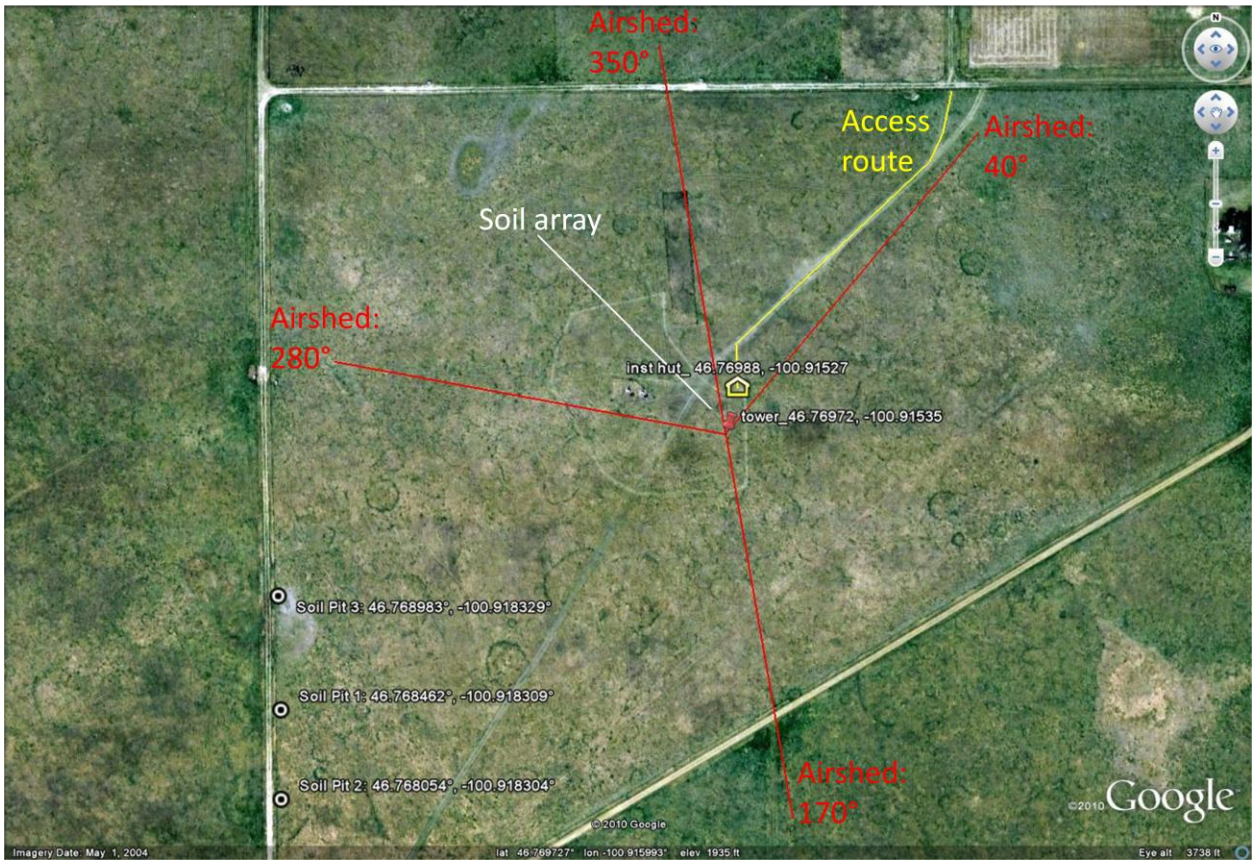


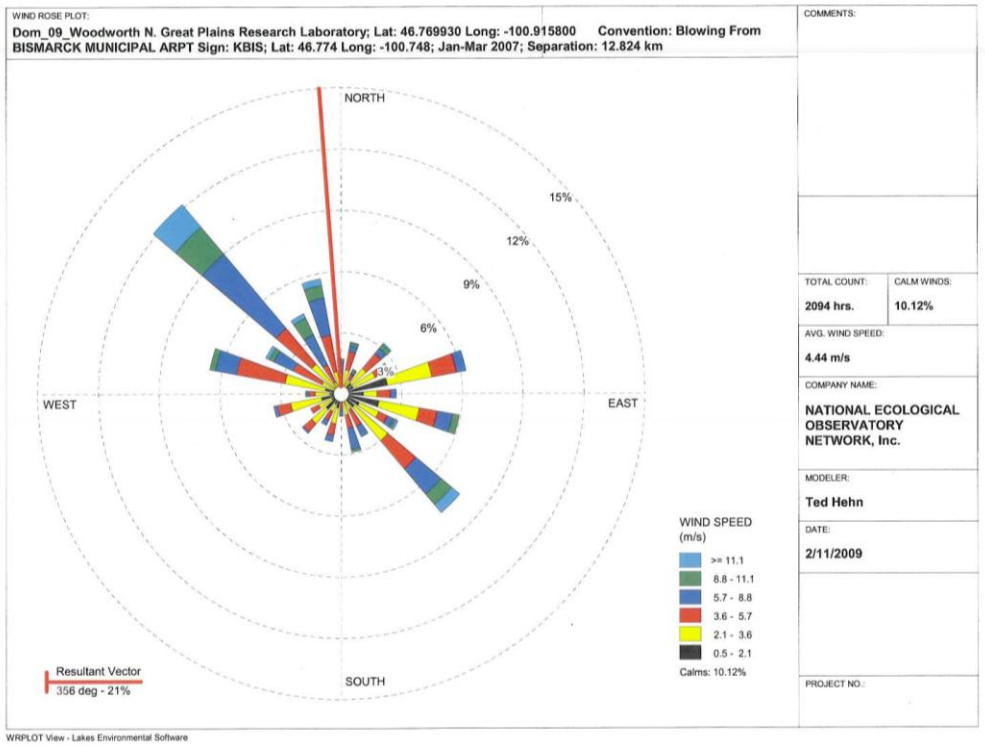
Figure 51. Site layout at NGPRL showing soil array and location of the FIU soil pit.

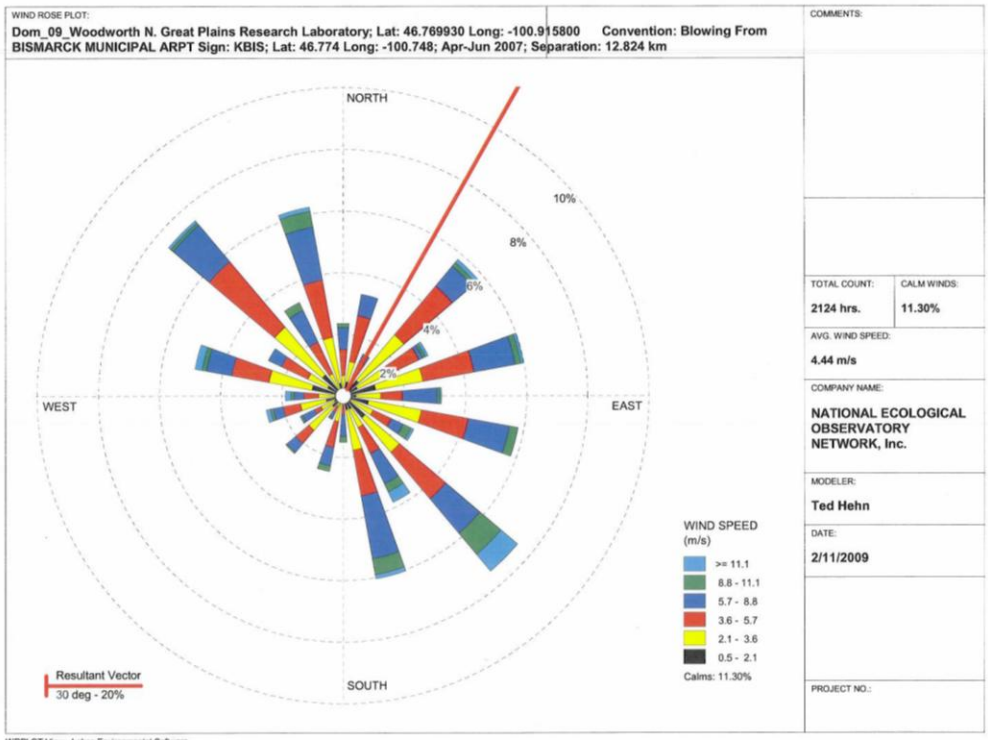
5.4 Airshed

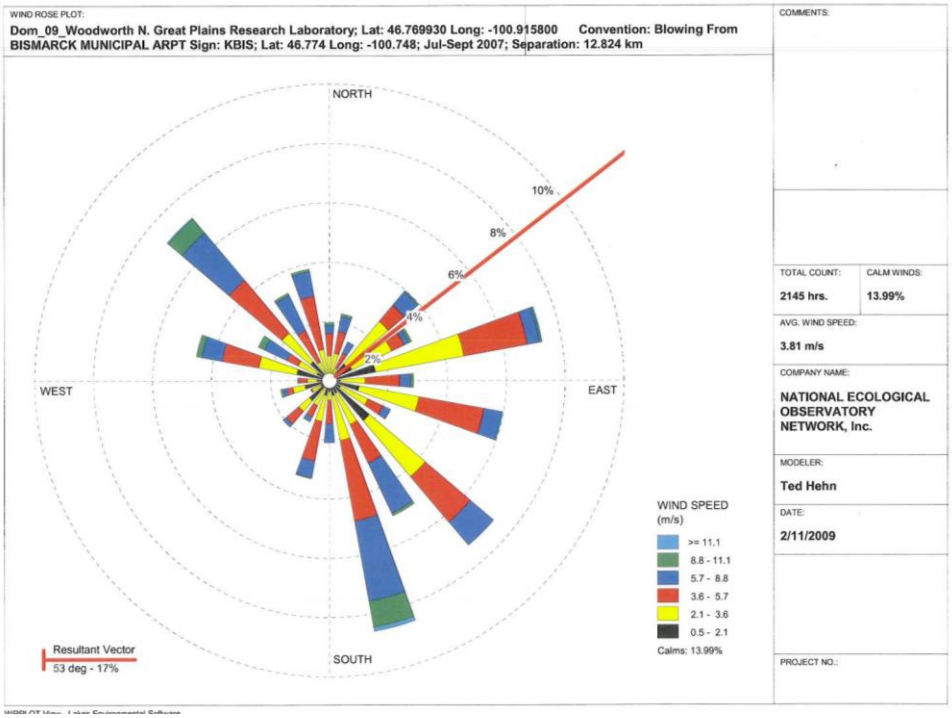
5.4.1 Seasonal windroses

Wind roses analytically determine and graphically represent the frequencies of wind direction and wind speed over a given timeseries. Data used to generate windroses were 2007 data set from Bismarck Municipal airport (46.744°, -100.748°), which is about 13 km away to NEON relocatable tower site. The orientation of the wind rose follows that of a compass (assume declination applied). When we describe the wind directions it should be noted that they are the cardinal direction that wind blows from. The directions of the rose with the longest spoke show wind directions with the largest frequency. These wind roses are subdivided into as 24 cardinal directions.

5.4.2 Results (graphs for wind roses)







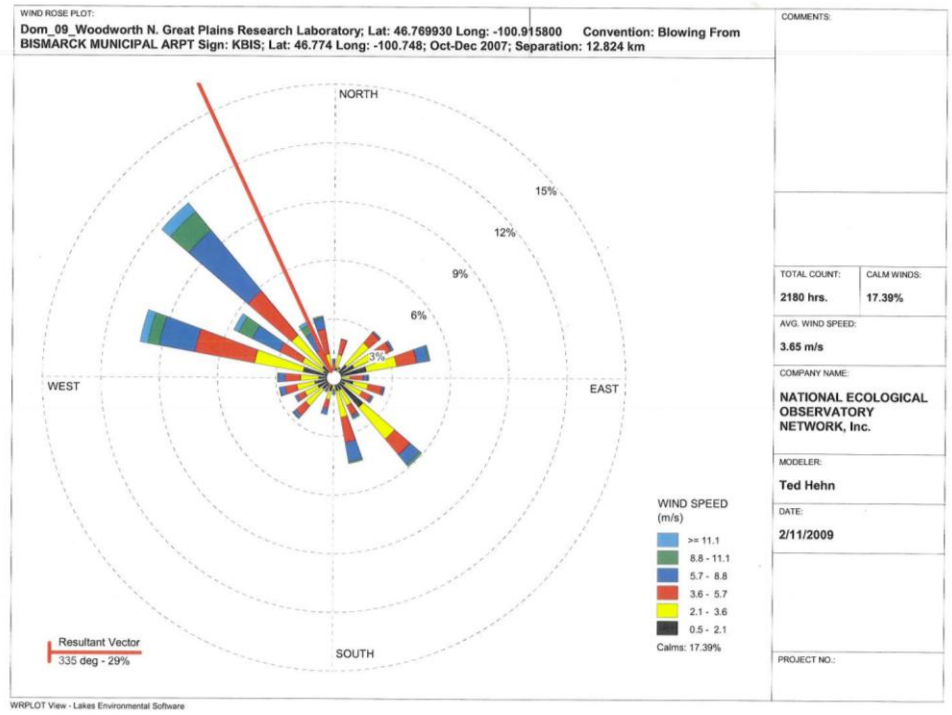


Figure 52. Windroses for NGPRL Relocatable tower site
Wind roses based on the 2007 data from Bismarck Municipal airport (46.744°, -100.748°), which is about 13 km away to NEON relocatable tower site. Panels (from top to bottom) are for Jan-Mar, Apr-Jun, Jul-Sept, and Oct-Dec.

5.4.3 Resultant vectors

Table 17. The resultant wind vectors from Bismarck Municipal airport using hourly data in 2007.

Quarterly (seasonal) timeperiod	Resultant vector	% duration
January to March	356°	21
April to June	30°	20
July to September	53°	17
October to December	335°	29
Annual mean	13.5°	na.

5.4.4 Expected environmental controls on source area

Two types of models were commonly used to determine the shape and extent of the source area under different and contrasting atmospheric stability classes. An inverted plume dispersion model with modeled cross wind solutions were used for convective conditions (Horst and Weil 1994). For strongly stable conditions, and Lagrangian solution was used (Kormann and Meixner 2001). The source area models where bounded by the expected conditions depict the extreme conditions. Convective conditions typically have strong vertical mixing between the ecosystem and atmosphere (surface layer). Stable conditions typically have long source area and associated waveforms. Convective turbulence is often characterized by short mixing scales (scalar) and moderate daytime wind speeds, *e.g.,* 1-4 m s^{-2}. Higher wind speeds, like those experienced over the Rockies, are often the product of mechanical turbulence with long waveforms. Because thermal stratification is very efficient in suppressing vertical mixing, stable conditions also have typically very long waveforms.

As a general rule, shorter and less structurally complex ecosystems have good vertical mixing during all atmospheric stabilities. Taller and more structurally complex ecosystems have well mixed upper canopies during the daytime, and can be decoupled below the canopy under neutral and stable conditions (e.g., Harvard Forest, Bartlett Experimental Forest, and Burlington Conservation Area). The type of turbulence (mechanical verse convective) and the physical attributes of the ecosystem control the degree of mixing, and the length and size of the source area.

Here, we use a web-based footprint model to determine the footprint area under various conditions (model info: http://www.geos.ed.ac.uk/abs/research/micromet/EdiTools/). Winds used to run the model and generate following model results are extracted from the wind roses. Vegetation information, temperature and energy information were either from the RFI document, previous site visit report, available data files or best estimated from experienced expert. Measurement height was determined from the Tower Height Info document provided by ENG group, then verify according to the real ecosystem structure after FIU site characterization at site. Runs 1-3 and 4-6 represent the expected conditions for summer and winter conditions, respectively, with maximum and mean windspeeds (daytime convective) and nighttime (stable atmospheres) conditions. The wind vector for each run was estimated from wind roses and is placed as a centerline in the site map included in the graphics. The width of the footprint was also estimated using the length between the isopleth of 80% cumulative flux and center line to calculate the angle from centerline. This information, along with distance of the cumulative flux isopleths and wind direction, will define the source area for the flux measurements on the top of the tower.

Table 18. Expected environmental controls to parameterize the source area model based on the wind roses for Bismarck Municipal airport, and associated results for NGPRL Relocatable tower site.

Parameters	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Run 6**	
Approximate season	summer			winter			Units
	Day (max WS)	Day (mean WS)	Night	Day (max WS)	Day (mean WS)	night	qualitative
Atmospheric stability	Convective	convective	Stable	Convective	convective	Stable	qualitative
Measurement height	6	6	6	6	6	6	m
Canopy Height	0.5	0.5	0.5	0.3	0.3	0.3	m
Canopy area density	2	2	2	0.8	0.8	0.8	m
Boundary layer depth	2100	2100	1000	800	800	650	m
Expected sensible heat flux	500	500	100	22	22	-55	W m^{-2}
Air Temperature	29	29	22	2	2	-20	°C
Max. windspeed	11	3.8	3.8	11	3.8	3.8	m s^{-1}
Resultant wind vector	120	120	120	320	320	320	degrees
Results							
(z-d)/L	-0.05	-0.71	-0.20	0.00	-0.06	0.50	m
d	0.37	0.37	0.37	0.19	0.19	0.19	m
Sigma v	2.50	1.90	1.00	1.70	0.75	1.70	m^2 s^{-2}
Z0	0.03	0.03	0.03	0.02	0.02	0.02	m
u*	0.85	0.35	0.31	0.81	0.29	0.20	m s^{-1}
Distance source area begins	0	0	0	0	0	30	m
Distance of 90% cumulative flux	700	300	450	1000	750	2000	m
Distance of 80% cumulative flux	400	200	300	520	400	1200	m
Distance of 70% cumulative flux	300	120	200	400	300	750	m
Peak contribution	65	35	55	75	75	115	m

5.4.5 Results (source area graphs)

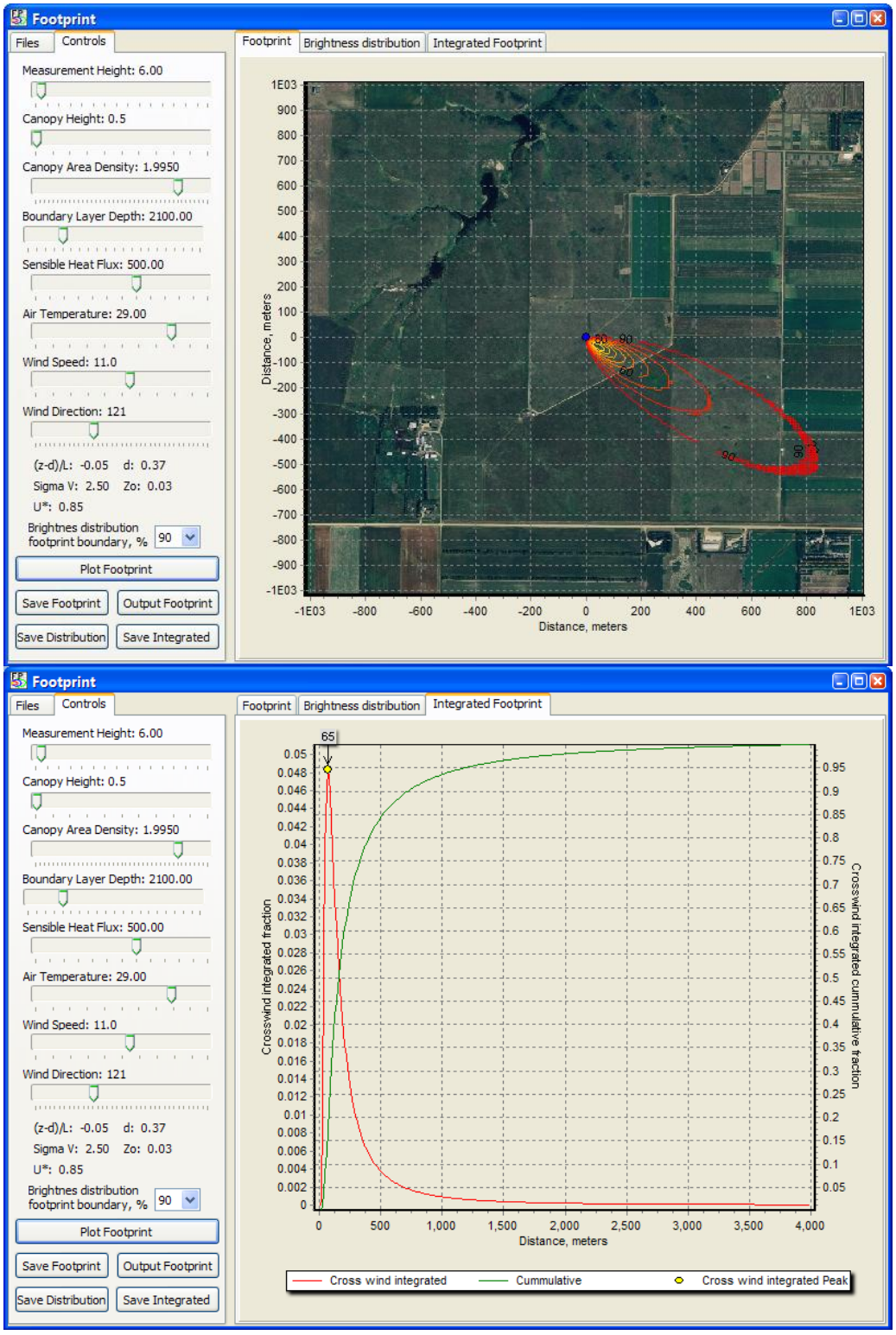


Figure 53. NGPRL Relocatable site summer daytime (convective) footprint output with max wind speed

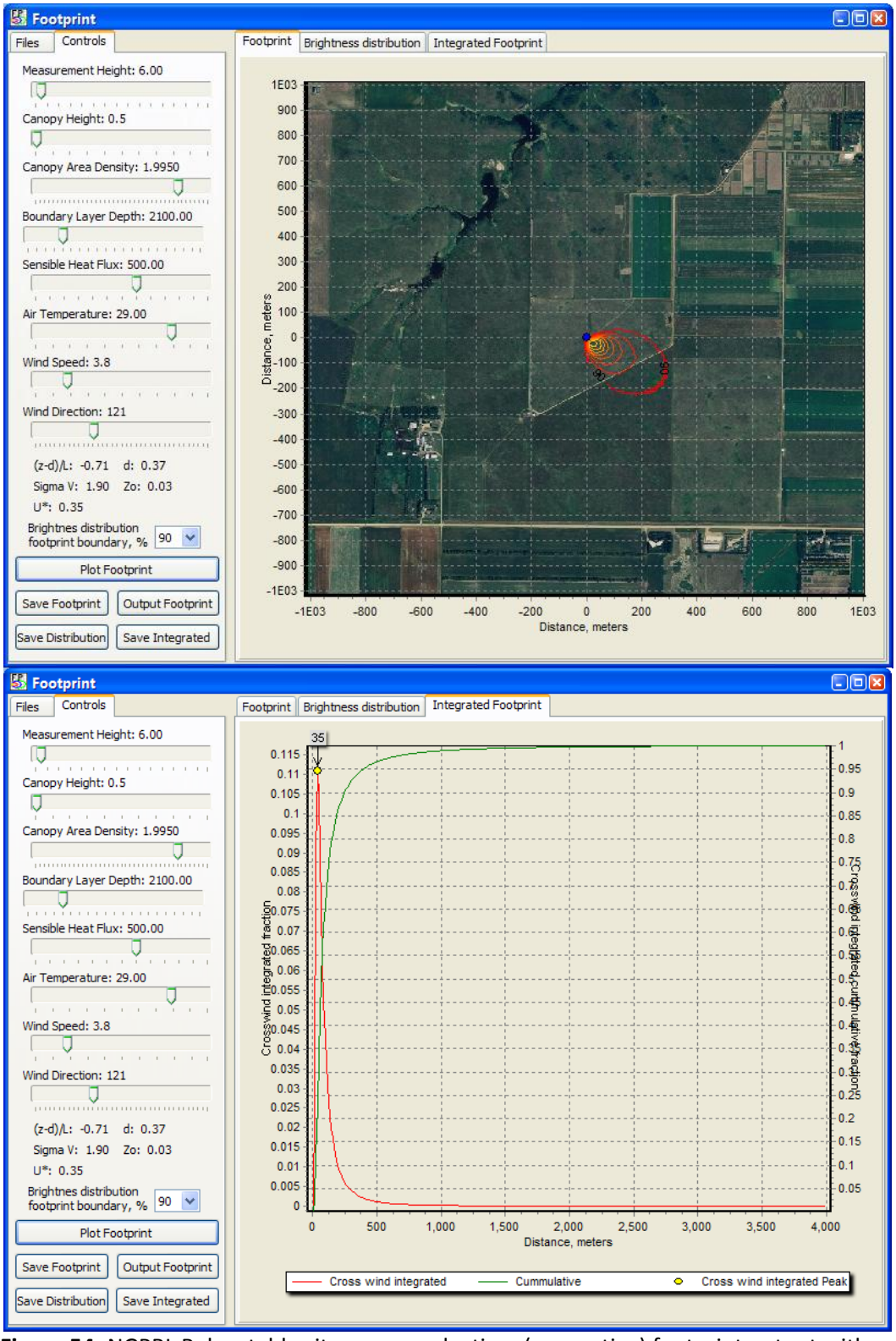


Figure 54. NGPRL Relocatable site summer daytime (convective) footprint output with mean wind speed

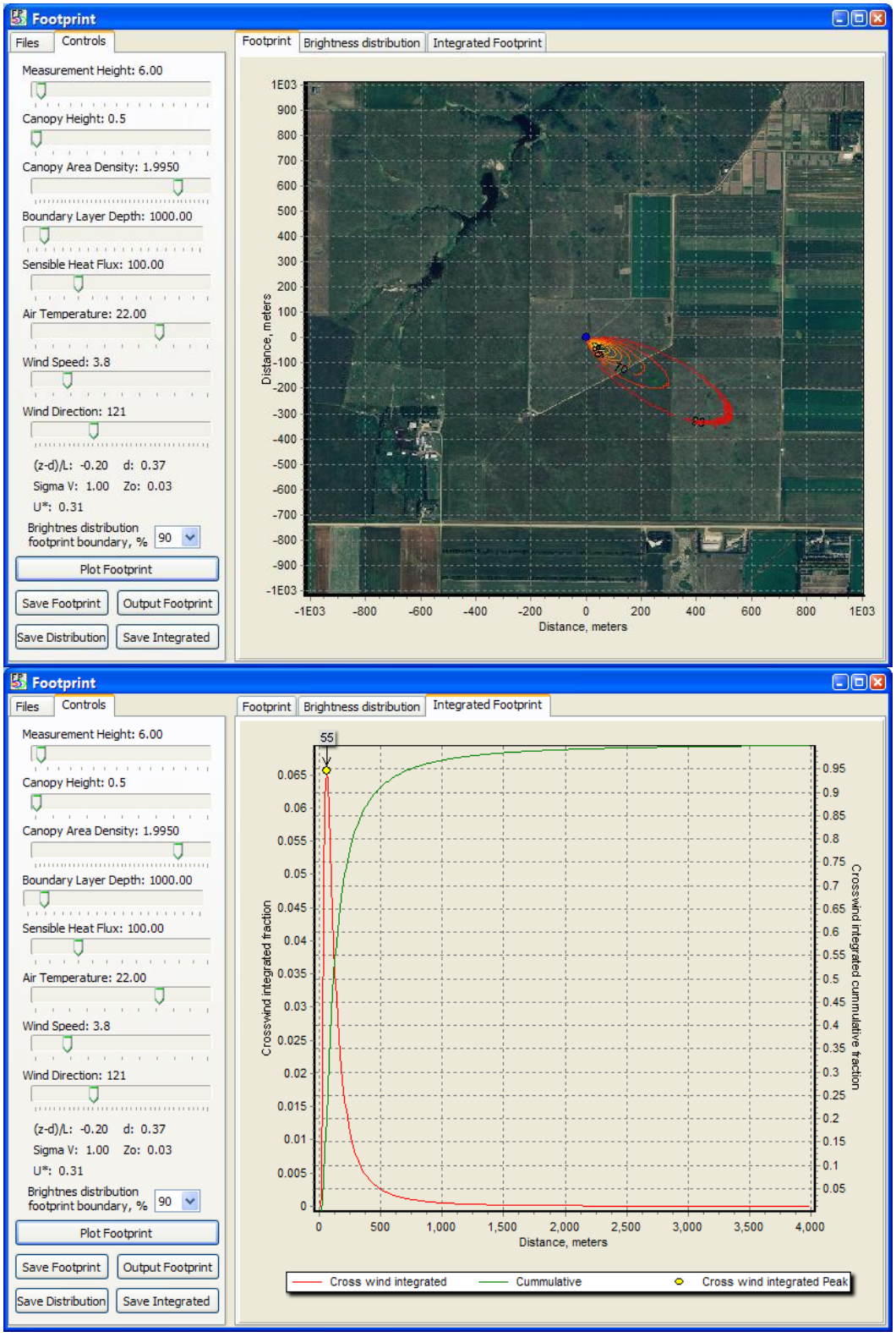


Figure 55. NGPRL Relocatable site summer nighttime (stable) footprint output with mean wind speed.

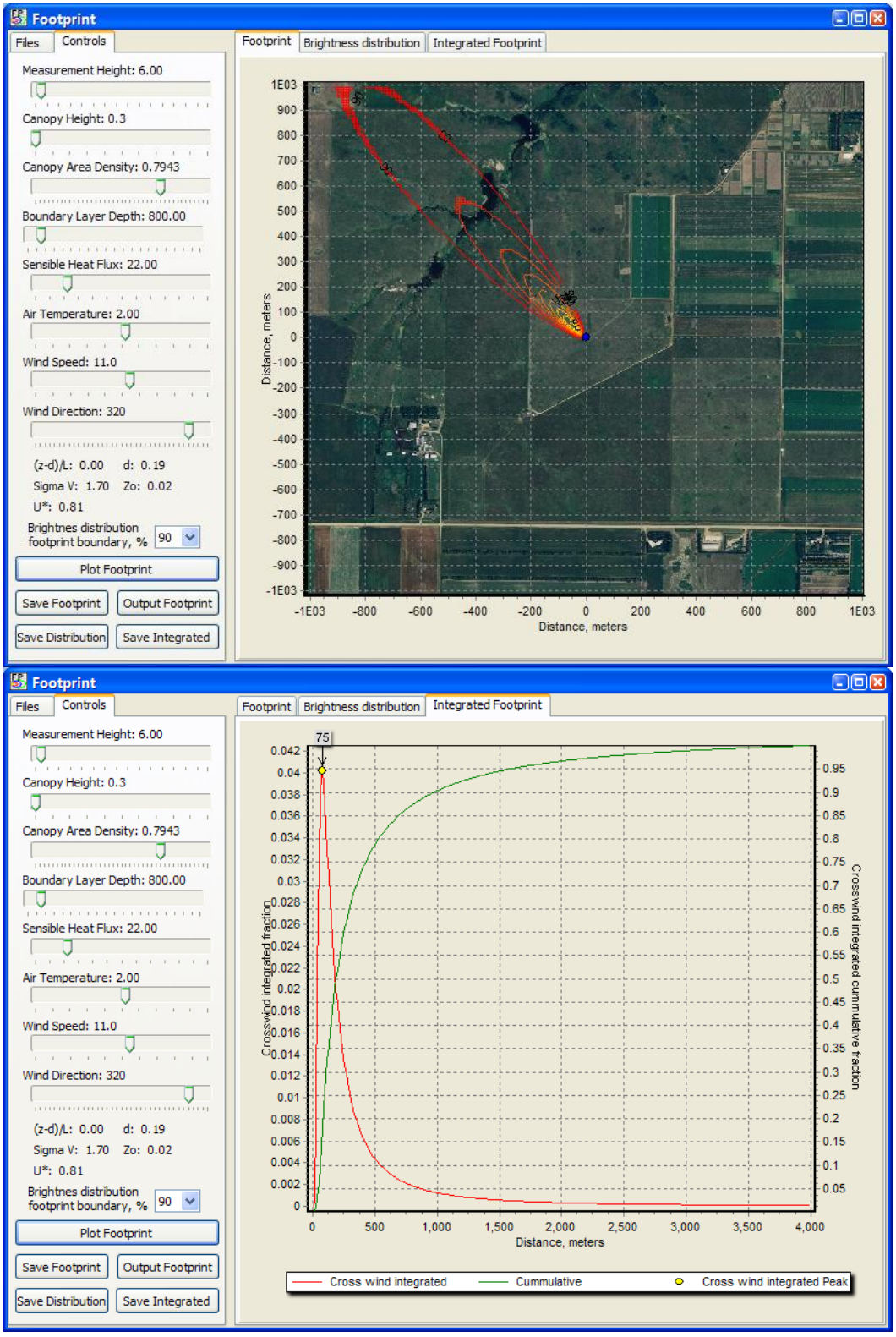


Figure 56. NGPRL Relocatable site winter daytime (convective) footprint output with max wind speed

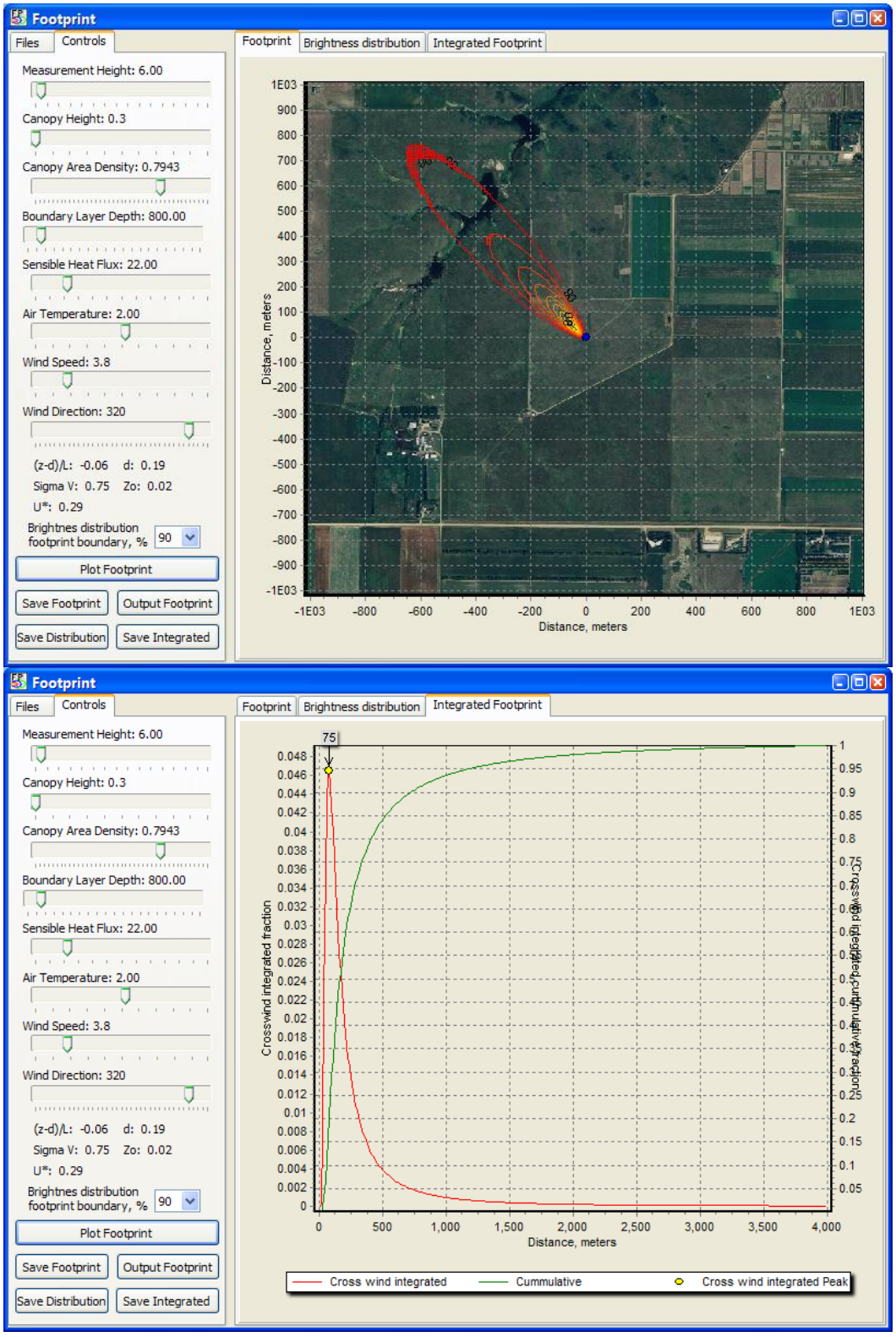


Figure 57. NGPRL Relocatable site winter daytime (convective) footprint output with mean wind speed.

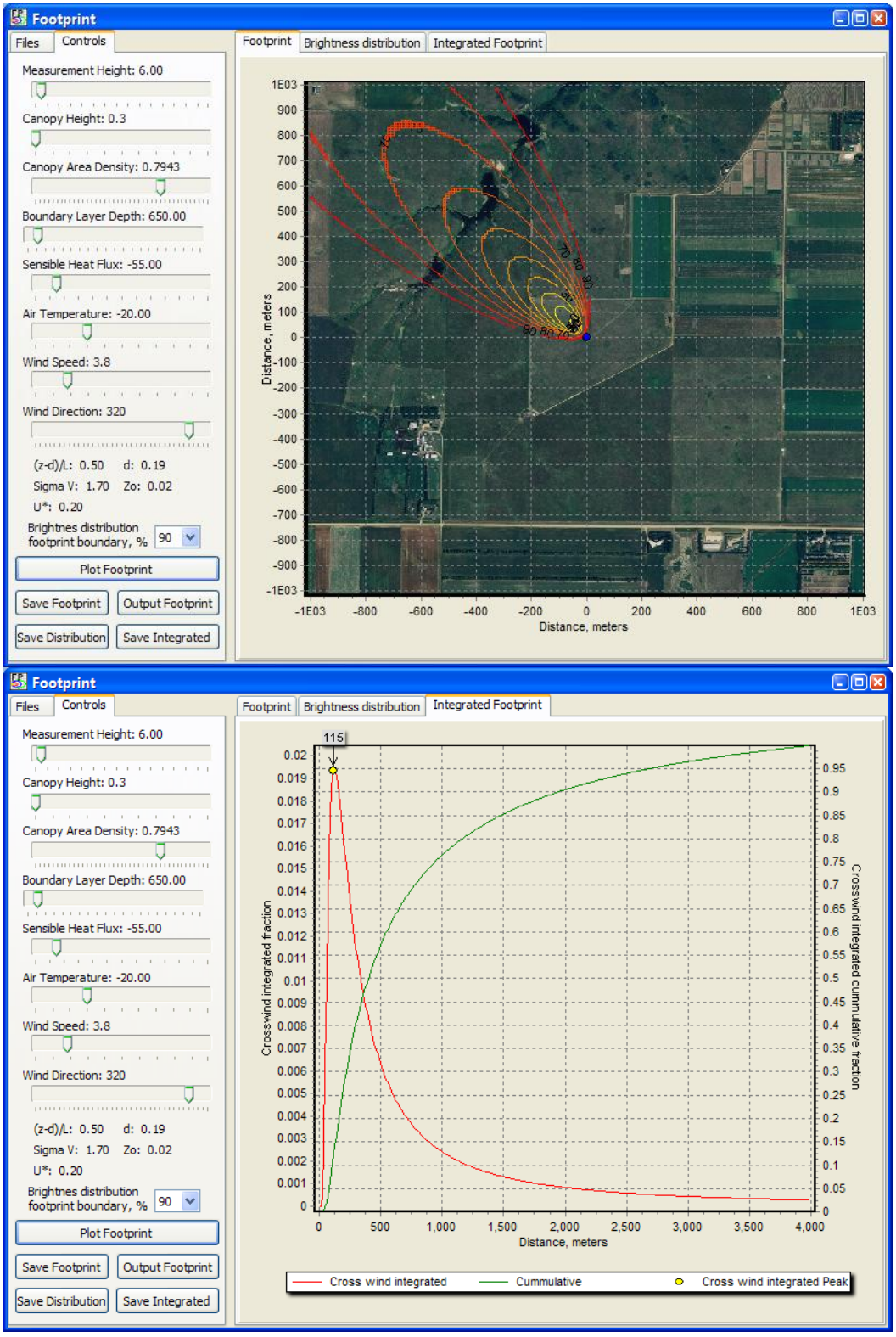


Figure 58. NGPRL Relocatable site winter nighttime (stable) footprint output with mean wind speed.

5.4.6 Site design and tower attributes

According to wind roses, the prevailing wind airshed for the tower is from 280° to 350° (clockwise from 280°). Secondary airshed is from 40° to 170° (clock wise from 40°), but with higher frequency from 70° to 140° (clock wise from 70°). The tower should be placed to a location to best catch the signals from the airshed of the ecosystem in interest, which is grazed grassland. Tower location was at 46.76993, -100.9158. After FIU site characterization, we microsted tower location ~40 m toward SE to the location of 46.76972, -100.91535 to keep some distance away from the cattle enclosures. Because the enclosure fences (1-1.2 m tall) are just wires and very open for wind flows, although two cattle enclosures are inside major airshed, with a distance of 40 m away, we do not expect large impacts of the enclosures on local wind patterns that will be measured at tower.

Eddy covariance, sonic wind and air temperature **boom arms** orientation toward the southwest will be best to capture signals from all major wind directions. **Radiation boom arms** should always be facing south to avoid any shadowing effects from the tower structure. An **instrument hut** should be outside the prevailing wind airshed to avoid disturbance in the measurements of wind and should be positioned to have the longer side parallel to frequent wind direction to minimize the wind effects on instrument huts and to minimize the disturbances of wind regime by instrument hut, and in this case, instrument hut should be positioned on the NNE toward tower and have the longer side parallel to SE-NW direction. This is a short statue grassland ecosystem. We require the placement of instrument hut at 46.76988, -100.91527. The distance between the tower and the instrument hut is ~ 19 m.

The ecosystem is grazed grassland around tower site and within tower airshed. Canopy height is ~0.4 m. Some small bushes are presented at site with height < 1 m. We require 4 **measurement layers** on the tower with top measurement height at 6 m, and remaining levels are at 3.5 m, 1 m and 0.3 m, respectively, to best characterize the fluxes on the tower top and environmental conditions in profile.

Secondary **precipitation collector** for bulk precipitation collection will be located the top of tower at this site. **Wet deposition collector** will be collocated at the tower top. See AD 04 for further information and requirements for bulk precipitation collection and wet deposition collection.

The site layout is summarized in the table below. Assume the projected area of the tower is square. **Anemometer/temperature boom arm direction** is ***from*** the tower ***toward*** the prevailing wind direction or designated orientation. **Instrument hut orientation vector** is parallel to the long side of the instrument hut. **Instrument hut distance z** is the distance from the center of tower projection to the center of the instrument hut projection on the ground. The numbering of the **measurement levels** is that the lowest is level one, and each subsequent increase in height is numbered sequentially.

Table 19. Site design and tower attributes for NGPRL Relocatable site

0° is true north with declination accounted for. Color of Instrument hut exterior shall be tan to best match the surrounding environment.

Attribute	lat	long	degree	meters	notes
Airshed			280° to 350° (major)		Clockwise from first angle

			40°to 170° (secondary)		
Tower location	46.76972,	-100.91535	--	--	new site
Instrument hut	46.76988,	-100.91527			
Instrument hut orientation vector	--	--	135°-315°		
Instrument hut distance z	--	--	--	19	
Anemometer/Temperature boom orientation	--	--	220°	--	
Height of the measurement levels					
Level 1				0.3	m.a.g.l.
Level 2				1.0	m.a.g.l.
Level 3				3.5	m.a.g.l.
Level 4				6.0	m.a.g.l.
Tower Height				6.0	m.a.g.l.

See AD 03 for technical requirement to determine the boom height for the bottom most measurement level.

Figure below shows the proposed tower location, instrument hut location, airshed area and access road.

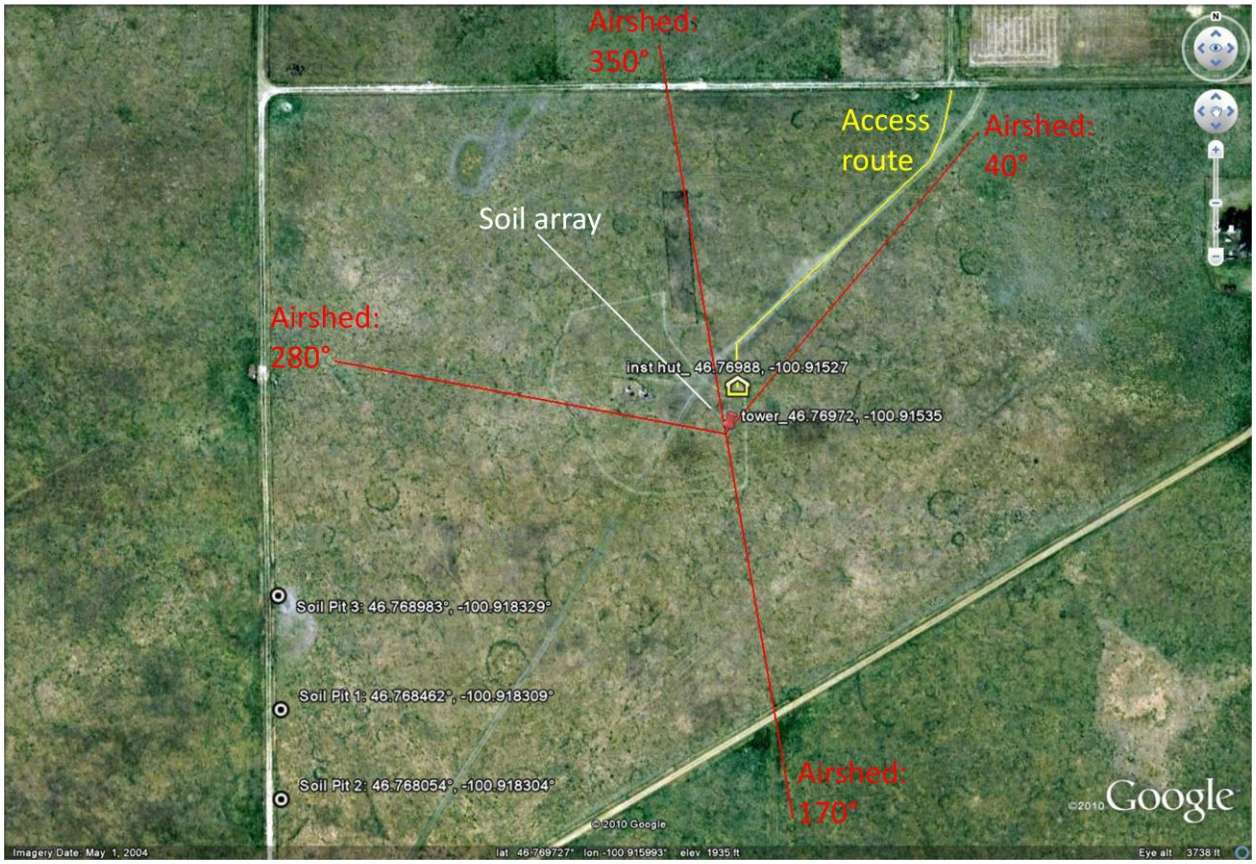


Figure 59. Site layout for NGPRL Relocatable site.

i) new tower location is presented (red pin), ii) red lines indicate the airshed boundaries. Vectors 280^{o} to 350^{o} (major airshed, clockwise from 280^{o}) and 40^{o} to 170^{o} (secondary airshed, clockwise from 40^{o}) would have quality wind data without causing flow distortions, respectively. iii) Yellow line is the suggested access road to instrument hut.

Boardwalks. Ultimately, the decision to use a boardwalk will be, in part, based on owner's preferences. There are strong science requirements that minimize site disturbance to the surrounding area, which will be difficult to manage over a 30-y period. Traffic control is key to minimizing the site disturbance. Confining foot traffic to boardwalks minimizes site impact; this is particularly true in places where wear caused by foot traffic becomes noticeable and grows. For example, in places with snow part of the year, worn footpaths tend to have low places that collect water, or places where the snow pack becomes uneven causing personnel to walk farther and farther around the sides of the original path, causing the path to grow in width. This is a very common phenomenon. Here FIU assumes that all conduits will be either buried, or placed inside the boardwalk such that it does not extend beyond the 36" wide footprint. While the final design is not yet known, there are some general criteria that can be outlined. We assume that the boardwalk width is 36" (0.914 m). Material is not known, but must be fire proof, and in some locations the site is seasonally flooded and inundated with water. Boardwalks may also provide a scratching structure for grazing animals that in turn, would wear and unduly impact the site. Site by site evaluations must be done. Since there is a relatively high density of cattle at this site, we suggest using gravel paths to access the site, rather than boardwalk.
Specific boardwalks at this site:

- Gravel path from the access dirt road to instrument hut, pending landowner decision
- Boardwalk (not gravel path) from the instrument hut to the tower to intersect on north face of the tower, pending landowner decision
- No boardwalk or gravel path to soil array or individual soil plots.
- Boardwalk has to withstand grazing

The relative locations between tower, instrument hut and boardwalk can be found in the diagram below:

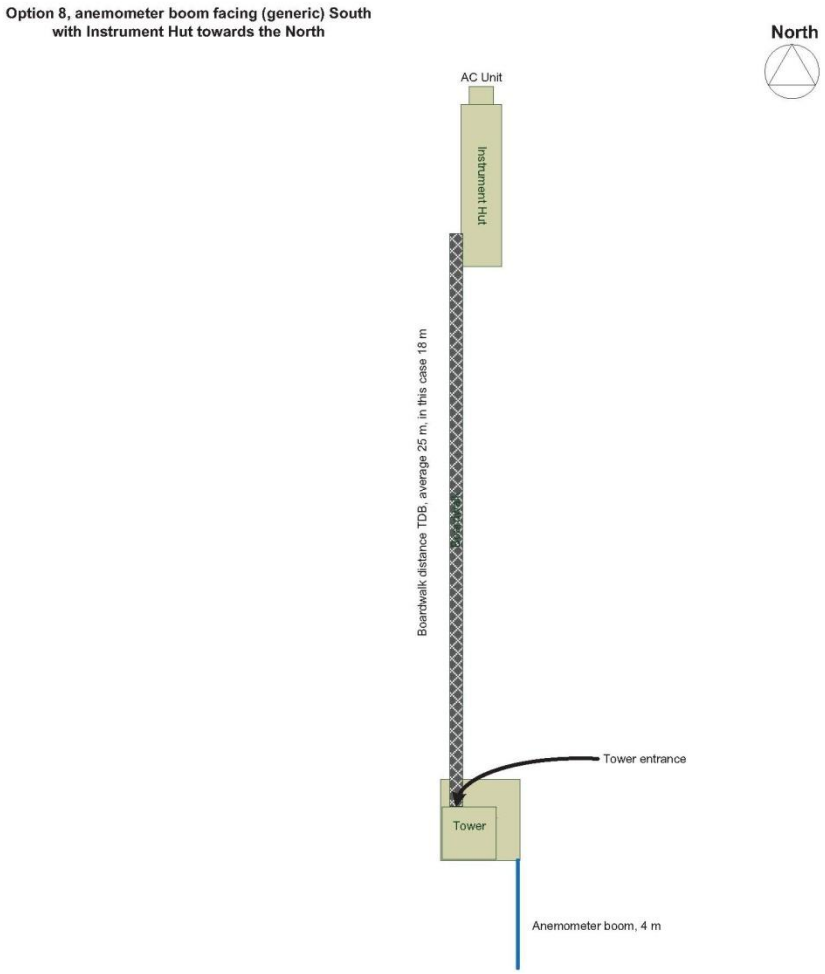


Figure 60. Generic diagram to demonstration the relationship between tower and instrument hut when boom facing south and instrument hut on the north towards the tower.

This is just a generic diagram when boom facing south and instrument hut on the north towards the tower. The actual design of boardwalk (or path if no boardwalk required) and instrument hut position will be joint responsibility of FCC and FIU. At NGPRL Relocatable site, the boom angle will be 220 degrees, instrument hut will be on the northeast towards the tower, the distance between instrument hut and tower is ~19 m. The instrument hut vector will be SE-NW (135°-315°, longwise).

5.4.7 Information for ecosystem productivity plots

The tower has been positioned to optimize the collection of the air/wind signals both temporally and spatially over the desired ecosystem (grazed grassland). Major airshed at this site is from 280^o to 350^o (clockwise from 280^o), and secondary airshed is from 40^o to 170^o (clockwise from 40^o) with higher frequency from 70^o to 140^o (clockwise from 70^o). Most of the time throughout of the year, 90% signals for flux measurements are within a distance of 750 m from tower, and 80% within 500 m. Therefore, we suggest FSU Ecosystem Productivity plots are placed within the major tower airshed boundaries of 280^o to 350^o (clockwise from 280^o) and second airshed boundaries of 70^o to 140^o (clockwise from 70^o).

5.5 Issues and attentions

Field for tower location is very small (less than 510 m on N-S and E-W direction). Therefore, the fetch area will extend into surrounding fields, including different management types of cropland, which will increase the uncertainty for the flux signal interpretation. S. Kronberg and R. Phillips said that the arable cropland study in the field north of the tower is scheduled to end in 2010 and that it would be possible to seed the 15 acres back to perennial grass in spring 2011. If this occurs, all the surrounding fields will be managed grasslands (i.e., similar to the field with the NEON tower), although grazing intensity and timing will differ among these fields. This will help to simplify the interpretation of the flux signals.

Two cattle enclosures are inside major airshed with enclosure fences height of 1-1.2 m. Because enclosure fences are just wires and very open for wind flows, and with distances > 40 m away from tower, we do not expect large impacts of the enclosures on local wind patterns that will be measured at tower.

This is active grazing site. Protection of sensors on the lower level on the tower may be needed. Individual guards may also be needed to protect the tubes at soil plots.

Since there is a relatively high density of cattle at this site, we suggest using gravel paths to access the site rather than boardwalk, which are more likely to injure the cattle and affect their behavior.

Gusty winds can reach 60 mph at this site.

It can be very muddy on the dirt road and may be difficult to drive following heavy rains.

Electric fences are around the field to prevent cattle from escaping.

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