# Soil composition and elevation along the forested dune ridge at the University Field Station

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## Introduction

The beach ridge separating Delta Marsh from Lake Manitoba was formed over 2,500 years ago as a result of erosion of material deposited at the mouth of the Assiniboine River (Teller and Last 1981). Variations in the beachfront morphology and ridge have occurred historically due to wind and wave action from the lake and, since around the turn of the century, to disturbance caused by cottage development and lake level regulation. The sand ridge is now mostly covered by a thin organic litter layer but there are several places where the sand is exposed. Composition of the forest canopy on the ridge was described by Mackenzie (1982) and numerous studies of the songbirds and other fauna have been conducted over the 30-year period since field station was established. In 1993, a student in the co-operative education program of the Environmental Science Program at the University of Manitoba, established 26 transects along the ridge between the mouths of the Assiniboine River Diversion and Cram Creek (Flynn 1993). The purpose of the transects was to provide information on tree distribution, soil disturbance, herbaceous plant cover, and penetrance of the canopy by solar irradiance, and to form a basis for long-term monitoring of potential ridge erosion. During the summer of 1996, many of these transects were re-visited to collect additional data, including the relative elevation of positions along each transect, the depth of the organic soil horizon, and the texture of the ridge soil.

## Materials and Methods

North-south transects, running from the shoreline of Lake Manitoba to the marsh beyond the tree canopy of the beach ridge, were established in 1993 (Fig. 1). The transects were located at about 100 m intervals, numbered consecutively from west to east, along the ridge. A wood stake was erected on each transect at the time of transect establishment, either at a point 60 meters south of the lake or at the end of the transect (Flynn 1993). The south-most stakes for transects 14 through 26 were relocated and used as the starting points for the 13 transects monitored in this study (Table 1). The UTM

Table 1. Comments on locations of stakes used to mark the south end of north-south transects along the forested dune ridge between the mouths of the Assiniboine River Diversion and Cram Creek. All stakes were located on the north side of the road along the forested ridge.

| Transect | Location |
|---|---|
| 14-20 | at approximately 100 m intervals, to the west of Wardle along the foot path |
| 21 | 135 m west of stake 22 |
| 22 | 115.5 m west of stake 23 |
| 23 | 107 m west of stake 24 |
| 25 | 96 m west of stake 26 |
| 24 | 92 m west of stake 25 |
| 26 | 75 m west from red gate at the corner of the summer road and the diversion road |

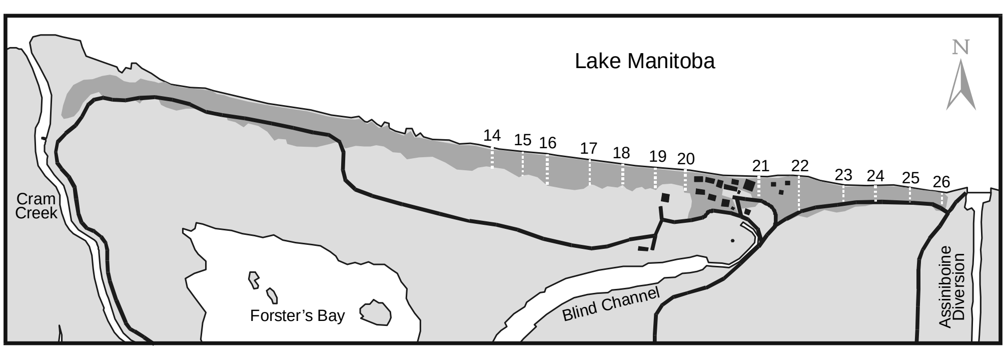


Figure 1. Locations of transects 14 to 26, established in 1993 along the forested beach ridge (indicated by darker shading), that were re-located and sampled in 1996.

Table 2. Univeral Transverse Mercator (UTM) coordinates (Zone 14, NAD83) of permanent stakes marking the north or south ends of selected transects along the forested beach ridge, as determined by a base-corrected Trimble GeoExplorer II GPS receiver. The coordinates are accurate to about 1 meter. All sites monitored in 1996 were positioned relative to the south stakes.

| Transect | End | Easting (meters) | Northing (meters) |
|---|---|---|---|
| 21 | south | 544,183 | 5,559,264 |
| 22 | south | 544,287 | 5,559,219 |
| 24 | north | 544,485 | 5,559,313 |
| 24 | south | 544,490 | 5,559,270 |
| 25 | south | 544,589 | 5,559,286 |

coordinates of several stakes were determined using a base-corrected GPS receiver (Table 2) although dense foliage prevented us from obtaining coordinates for all stakes.

A compass was followed from each reference stake, northward to the lake and southward to the marsh, marking each 10 m interval with yellow survey tape tied to a ground point. At each of these points, the elevation above sea level was found. All elevations were measured using a Wild NA20 survey level starting from a benchmark elevation of 249.7 m above sea level at stake 21 near Mallard Lodge.

Soil samples were collected every 10 m along each transect. The top litter layer (O horizon) was cleared using a small shovel, exposing the soil below. A 30 cm deep hole was dug with a gardening trowel and the depth of the soil horizons, determined by color change, was measured. Soil was collected carefully from each horizon and placed in a plastic bag. On return to the lab, soil bags were refrigerated at 4°C until analyses were done. The soil analyses, which occurred within the following 24 hours, consisted of the determination of pH, conductivity and percentages of organic material, sand, silt, and clay. Measurements for the uppermost soil stratum are reported here; data for other strata may be obtained from the University Field Station (Delta Marsh).

A saturation paste was made from each soil sample using distilled water. Approximately 15 mL of soil was added to a 25 mL beaker that had been doubly rinsed with distilled water. Distilled water was added until a thick, yet flowing, consistency was reached. More soil and distilled water were added until the volume of the paste reached about 20 mL. This was left to stand for 1 hour. Then, any water that collected on the surface was decanted or, if the paste had stiffened, more distilled water was added. The pH of the saturation paste was determined using a Accumet/Fisher meter and the conductivity was measured using a Corning M90 meter.

Crucibles of known tare weight were half filled with a soil subsample and dried at 100°C for four hours then weighed. The crucibles were placed in a 400°C muffle furnace for four hours to remove organic matter then reweighed. The inorganic residue in the crucible was cooled then ground using a mortar and pestle. This material was sieved through the 270 sifter with 53 µm mesh. Sand particles did not pass through the mesh and these were weighed. The four weight measurements for each sample were used to calculate the % organic content

Table 3. Elevation (meters above sea level) along 13 transects perpendicular to the forested beach ridge separating Lake Manitoba from Delta Marsh, 1996. Sites listed as S were located marsh-ward from the southern permanent stake marking the transect; sites listed as N were located lake-ward from the stake. Elevations are relative to a geodetic benchmark (249.7 m) situated east of Mallard Lodge.

| Position | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40S | | | | | | | | | | | 248.4 | | |
| 30S | | | 247.9 | | | | 248.6 | | 248.4 | | 248.7 | 248.3 | |
| 20S | | | 248.2 | | | | 248.6 | | 248.4 | | 248.6 | 248.5 | |
| 10S | | | 249.2 | | | | 249.0 | | 248.5 | 248.2 | 248.9 | 248.6 | |
| Stake | 248.3 | 248.5 | 248.7 | 248.6 | 248.6 | 249.6 | 248.5 | 248.4 | 248.5 | 248.4 | 249.3 | 248.7 | 248.8 |
| 10N | 248.0 | 248.7 | 249.0 | 248.0 | 248.4 | 248.7 | 248.6 | 248.3 | 248.8 | 248.9 | 250.2 | 248.9 | 248.9 |
| 20N | 249.0 | 251.5 | 249.1 | 248.6 | 247.9 | 248.5 | 249.0 | 248.8 | 249.1 | 249.1 | 248.9 | 250.5 | 249.9 |
| 30N | 251.5 | 249.6 | 249.1 | 248.7 | 248.2 | 248.9 | 249.4 | 249.6 | 249.4 | 249.3 | 248.6 | 251.1 | 250.7 |
| 40N | | | 248.3 | 249.1 | 248.3 | 249.3 | 249.3 | 249.6 | 249.8 | 249.1 | 249.5 | 250.1 | 251.3 |
| 50N | | | | 250.0 | 248.6 | 249.4 | | | | | | | |
| 60N | | | | 248.6 | 248.7 | 247.8 | | | | | | | |
| 70N | | | | | 249.0 | | | | | | | | |
| 80N | | | | | 251.5 | | | | | | | | |
| 90N | | | | | 249.2 | | | | | | | | |
| 100N | | | | | 247.8 | | | | | | | | |

(weight loss on ignition of dry sample), % sand (weight retained on sieve), and %silt+clay (weight of inorganic residue minus sand fraction) of the soil.

## Results

The topography of the forested beach ridge is highly irregular, consisting of undulating sand hills amongst depressions. Consequently, although elevation was usually lowest at the southern end of each transect (about 248.4 m asl), it did not increase consistently as one proceeded northward (Table 3). The maximum elevation on these transects was 251.5 m. Depending on the orientation of a sampling site with respect to local topography (exposed hilltop versus protected depression), the depth of the uppermost soil horizon varied from 1 to 30 cm (mean = 12 cm; Table 4). Soils were generally circumneutral (Table 5) with little spatial variability, although those samples collected nearest the lakeshore were more alkaline (pH 8-9). Soil conductivity was variable, with no apparent relationship with position along the transects (mean = 324 mS/cm; Table 6). Highest conductivity values tended to occur at sites with the lowest elevations. Organic matter content (% total dry weight) was highest on the marsh (south) ends of the transects and it generally decreased lake-ward (Table 7). Mean organic matter content was 13%. As expected, sand was the largest constituent of the soil, contributing an average of 78% of total soil mass and up to 100% in some samples (Table 8). The silt and clay fractions comprised the remaining 9% of soil mass although values as high as 38% were found at the marsh end of some transects (data not shown).

Table 4. Depth of the uppermost soil stratum (cm) along 13 transects perpendicular to the forested beach ridge separating Lake Manitoba from Delta Marsh, 1996.

| Position | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40S | | | | | | | | | | | 17 | | |
| 30S | | | 7 | | | | 7 | | 18 | | 23 | 2 | |
| 20S | | | 5 | | | | 9 | | 13 | | 15 | 4 | |
| 10S | | | 20 | | | | 5 | | 14 | 30 | 6 | 8 | |
| Stake | 10 | 8 | 8 | 17 | 9 | 22 | 7 | 21 | 10 | 8 | 16 | 6 | 4 |
| 10N | 7 | 9 | 6 | 6 | 5 | 21 | 7 | 17 | 6 | 9 | 7 | 3 | 13 |
| 20N | 3 | 30 | 4 | 5 | 30 | 2 | 4 | 4 | 4 | 9 | 11 | 3 | 6 |
| 30N | 30 | 6 | 7 | 6 | 10 | 6 | 18 | 1 | 1 | 5 | 8 | 30 | 3 |
| 40N | | | 30 | 5 | 7 | 5 | 30 | 6 | 1 | 2 | 6 | 30 | 30 |
| 50N | | | | 30 | 5 | 3 | | | | | | | |
| 60N | | | | 30 | 3 | 30 | | | | | | | |
| 70N | | | | | 10 | | | | | | | | |
| 80N | | | | | 6 | | | | | | | | |
| 90N | | | | | 30 | | | | | | | | |
| 100N | | | | | 30 | | | | | | | | |

Table 5. pH of the uppermost soil horizon along 13 transects perpendicular to the forested beach ridge separating Lake Manitoba from Delta Marsh, 1996.

| Position | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40S | | | | | | | | | | | 7.9 | | |
| 30S | | | 8.1 | | | | 6.3 | | 6.9 | | 7.4 | 7.6 | |
| 20S | | | 7.1 | | | | 6.7 | | 6.7 | | 6.9 | 7.3 | |
| 10S | | | 7.1 | | | | 6.7 | | 7.0 | 6.8 | 6.8 | 6.5 | |
| Stake | 6.9 | 6.8 | 6.8 | 7.1 | 7.6 | 6.9 | 6.7 | 6.8 | 6.7 | 7.6 | 6.8 | 6.0 | 6.3 |
| 10N | 6.7 | 6.3 | 6.3 | 8.4 | 7.4 | 6.9 | 7.0 | 6.8 | 7.1 | 6.9 | 6.6 | 6.0 | 5.8 |
| 20N | 5.9 | 7.1 | 6.5 | 7.1 | 7.0 | 6.9 | 7.0 | 6.6 | 6.8 | 6.1 | 7.0 | 6.5 | 6.2 |
| 30N | 7.4 | 6.5 | 6.6 | 7.2 | 7.1 | 7.3 | 7.5 | 6.7 | 6.8 | 6.3 | 6.5 | 7.4 | 6.1 |
| 40N | | | 9.0 | 7.4 | 7.3 | 7.1 | 7.6 | 6.8 | 7.0 | 6.8 | 6.7 | 7.4 | 7.2 |
| 50N | | | | 7.4 | 7.3 | 7.5 | | | | | | | |
| 60N | | | | 9.0 | 7.1 | 8.2 | | | | | | | |
| 70N | | | | | 7.3 | | | | | | | | |
| 80N | | | | | 7.1 | | | | | | | | |
| 90N | | | | | 7.3 | | | | | | | | |
| 100N | | | | | 9.0 | | | | | | | | |

Table 6. Conductivity (mS/cm) of the uppermost soil horizon along 13 transects perpendicular to the forested beach ridge separating Lake Manitoba from Delta Marsh, 1996.

| Position | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40S | | | | | | | | | | | 1394 | | |
| 30S | | | 1339 | | | | 53 | | 303 | | 1194 | 2 | |
| 20S | | | 924 | | | | 304 | | 208 | | 411 | 1780 | |
| 10S | | | 47 | | | | 201 | | 317 | 532 | 226 | 315 | |
| Stake | 317 | 205 | 213 | 295 | 327 | 220 | 222 | 533 | 187 | 485 | 104 | 254 | 688 |
| 10N | 207 | 313 | 203 | 1036 | 7 | 278 | 97 | 284 | 268 | 182 | 307 | 292 | 211 |
| 20N | 176 | 70 | 490 | 255 | 1796 | 241 | 3 | 167 | 202 | 5 | 71 | 248 | 324 |
| 30N | 45 | 196 | 276 | 354 | 906 | 221 | 38 | 177 | 282 | 263 | 207 | 29 | 294 |
| 40N | | | 132 | 140 | 1206 | 3 | 41 | 332 | 609 | 265 | 252 | 35 | 49 |
| 50N | | | | 58 | 8 | 134 | | | | | | | |
| 60N | | | | 146 | 290 | 425 | | | | | | | |
| 70N | | | | | 180 | | | | | | | | |
| 80N | | | | | 98 | | | | | | | | |
| 90N | | | | | 42 | | | | | | | | |
| 100N | | | | | 89 | | | | | | | | |

Table 7. Organic matter content (% dry mass) of the uppermost soil horizon along 13 transects perpendicular to the forested beach ridge separating Lake Manitoba from Delta Marsh, 1996.

| Position | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40S | | | | | | | | | | | 11 | | |
| 30S | | | 58 | | | | 18 | | 8 | | 15 | 46 | |
| 20S | | | 48 | | | | 25 | | 12 | | 14 | 23 | |
| 10S | | | 1 | | | | 3 | | 7 | 35 | 16 | 17 | |
| Stake | 7 | 4 | 8 | 5 | 9 | 4 | 17 | 10 | 6 | 9 | 7 | 25 | 41 |
| 10N | 9 | 3 | 17 | 37 | 18 | 4 | 16 | 9 | 9 | 12 | 22 | 16 | 25 |
| 20N | 17 | 1 | 14 | 17 | 15 | 13 | 5 | 8 | 8 | 10 | 2 | 19 | 10 |
| 30N | 0 | 6 | 38 | 30 | 39 | 9 | 1 | 6 | 11 | 15 | 14 | 1 | 4 |
| 40N | | | 0 | 8 | 19 | 4 | 0 | 10 | 23 | 9 | | 0 | 2 |
| 50N | | | | 1 | 32 | 3 | | | | | | | |
| 60N | | | | 1 | 9 | 0 | | | | | | | |
| 70N | | | | | 8 | | | | | | | | |
| 80N | | | | | 1 | | | | | | | | |
| 90N | | | | | 0 | | | | | | | | |
| 100N | | | | | 0 | | | | | | | | |

Table 8. Sand content (% dry mass) of the uppermost soil horizon along 13 transects perpendicular to the forested beach ridge separating Lake Manitoba from Delta Marsh, 1996.

| Position | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40S | | | | | | | | | | | 51 | | |
| 30S | | | 31 | | | | 67 | | 77 | | 54 | 48 | |
| 20S | | | 44 | | | | 62 | | 76 | | 70 | 61 | |
| 10S | | | 97 | | | | 94 | | 81 | 35 | 62 | 63 | |
| Stake | 82 | 88 | 81 | 87 | 84 | 84 | 71 | 59 | 87 | 77 | 88 | 52 | 43 |
| 10N | 85 | 85 | 73 | 53 | 71 | 78 | | 64 | 80 | 80 | 68 | 75 | 61 |
| 20N | 78 | 99 | 86 | 77 | 68 | 80 | 91 | 86 | 87 | 78 | 95 | 71 | 79 |
| 30N | 99 | 90 | 53 | 65 | 47 | 86 | 99 | 89 | 83 | 82 | 74 | 99 | 90 |
| 40N | | | 100 | 87 | 76 | 91 | 100 | 85 | 67 | 83 | | 99 | 97 |
| 50N | | | | 98 | 55 | 96 | | | | | | | |
| 60N | | | | 99 | 87 | 100 | | | | | | | |
| 70N | | | | | 87 | | | | | | | | |
| 80N | | | | | 98 | | | | | | | | |
| 90N | | | | | 99 | | | | | | | | |
| 100N | | | | | 99 | | | | | | | | |

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