Mapping pre-settlement landscape in southern Manitoba, Canada

Irene Hanuta, University of Manitoba

Abstract: Original Dominion Land Survey (DLS) township maps from the 19th century provide information to characterize pre-settlement surface conditions across the Canadian Prairies. The earliest township plans of the DLS in Manitoba are available beginning in 1871. A township plan covers a six-mile by six-mile square area and depicts topographical and hydrological features, and vegetation cover. Roads, trails and existing settlement are also mapped.

Township maps yield high spatial resolution environmental information and can be accurately dated. These maps were consulted to reconstruct pre-settlement landscape in part of southern Manitoba, including the mapping of locations and extent of wetlands in the 1870s. A Geographic Information System (GIS) was used to electronically capture, analyze and map historical landscape features from township maps. A total of 194 townships have been captured in the GIS. Landscape polygons have been classified as prairie lands, wooded areas, wetlands, scrub vegetation, or water. Streams and locations of springs have also been digitized. Township maps provide useful baseline information to assist tracking environmental changes through time and improve understanding of these natural or human-generated changes.

Introduction

Because instrumental measurements of natural phenomena cover a short period of Earth's history, a record of environmental change is often obtained from various proxy sources. Ice cores, geological and biological evidence, and historical records are some examples of proxy evidence (Bradley, 1999). Past environmental conditions provide valuable baseline information that can be used

for analysis of trends in natural processes, sensitivities to environmental changes and identification of extreme events. Using historical cartographic material, namely Dominion Land Survey (DLS) township maps from the 19th century, landscape cover change over the past century will be illustrated. A township covers a six-mile by six-mile square. The DLS township maps were produced at a scale of one inch to half a mile.

Historical Evidence of Environmental Conditions

The fundamental limitation of historical evidence is the brevity of the period of time in which it is available. However, the strengths of historical evidence lie in the accuracy with which it can be dated and the high resolution of the information it yields. Only ice core and tree ring data compare in quality with historical evidence in terms of accuracy of dating and resolution (Bradley, 1999).

Historical evidence is limited to primarily the last two centuries in the prairies. In prairie Manitoba, the DLS written records begin in the late 1800s. These records are suitable in providing a representation of conditions prior to mass European settlement and modification of landscape. For example, historical documents have been interpreted to reconstruct climate for the past 200 years by Alsopp (1977), Catchpole (1978), Rannie (1983; 1990) and Blair and Rannie (1994). Rannie (1999) recently completed a reconstruction of floods in the Red and Assiniboine Rivers over the past couple of centuries and has investigated prairie fire occurrence (Rannie, 2000). Watts (1960) produced a generalized distribution of pre-settlement vegetation for the prairies but did not use individual township maps. Instead vegetation information was found on maps compiled from township plans produced at scales of 1 inch to 4 miles or 1 inch to 6 miles. Archibold and Wilson (1980) consulted township maps to map percent cover of prairie, woods, scrub, marsh, open water and brule or burned land for each township in Saskatchewan. Tracie (1992) analyzed surveyors' field notebooks to map pre-settlement vegetation on a quarter section basis (1/4 of a mile) for a small area near Grand Prairie, Alberta. And, Joss and Wiseman (2000) utilized a GIS to reconstruct pre-

settlement land cover in the Riding Mountain National Park region of west central Manitoba.

Study Area

After an original DLS survey was completed, recorded land information was mapped onto a standardized, township base plan. Original Manitoba township plans, bound in volumes, are available at the Provincial Archives of Manitoba (PAM). ArcView GIS is used to digitize original township maps surface cover information, create a database of landscape information, and to analyze and map data. A total of 194 townships have been digitized in the Red River drainage basin region of southern Manitoba (Figure 1). Nearly 90% of the surveys in the study area occurred between 1872 and 1877.

Methods

Definitions of Terrestrial Landscape Categories:

All graphic and written descriptions of any landscape polygon on original township maps were placed into one of five landscape categories: Prairie, Wetland, Woodland, Scrub or Water. These category names are almost identical to original plans category names and similar to categories used by Archibold and Wilson (1980) and Hildebrand and Scott (1987). To assess consistency of landscape description terms used by different surveyors, content *analysis* of root words and phrases was undertaken. *Content analysis* refers to the derivation of scientific (quantitative) information from textual material through interpretation of meanings and grouping of similar words or phrases. Much uniformity existed among the root words used by surveyors to describe any particular landscape or environmental phenomenon. This consistency appeared over all the townships in the study area and from surveyor to surveyor. Numerous descriptive adjectives of root words also appeared. Because of the variability and number of adjectives accompanying root words, most of these descriptors were not used in determining classification of a feature.

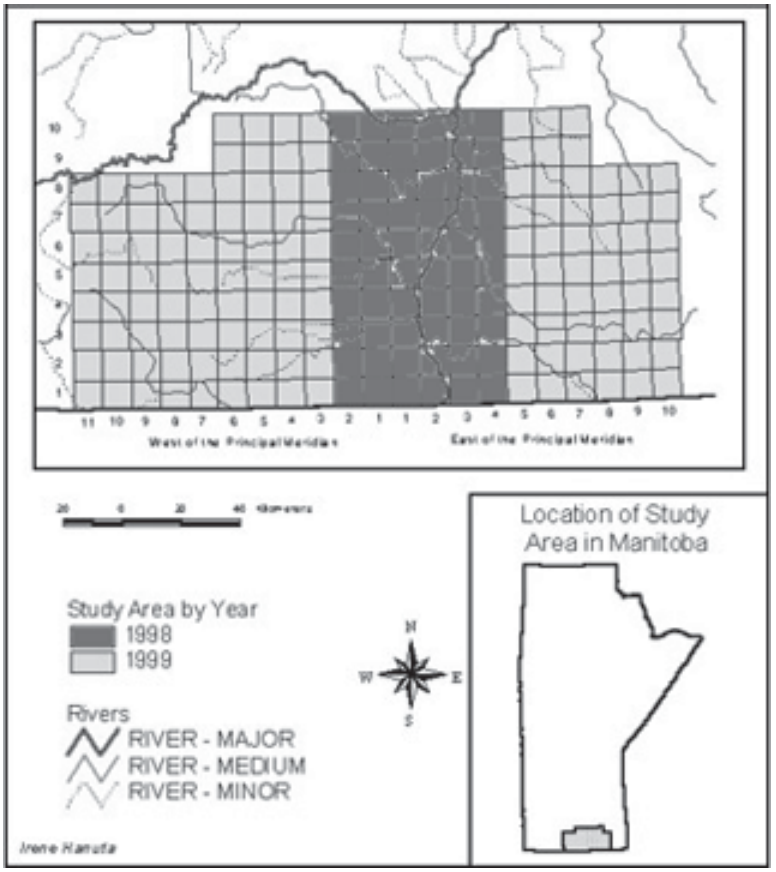

Figure 1: *Location of study area.*

Prairie Landscape Category: In a sample of 60 township plans in the study area, the most common root word to describe prairie was *prairie* (Appendix 1a). Written references to prairie on the sampled maps appeared 223 times. *Open prairie* was the most commonly used phrase, with *high prairie* and *low prairie* being the next most common. Of the four categories, the Prairie category also contained the most adjectives (20), individual words or phrases, to describe different types of prairie conditions (Appendix 1b).

Wetland Landscape Category: Many different root words described wetlands (Appendix 2a) while few descriptive adjectives were used **(**Appendix 2b). Some example root words include: *marsh, swamp, bog, slough* and *muskeg*. References to *hay marsh* or *hay land* were also placed in this category. *Marsh* and *hay land* were the most commonly used words to describe wetland areas.

Woodland Landscape Category: Dominant tree species were typically identified on township maps because supply and quality of timber was important for settlement purposes. The species identified most frequently in the Woodland category was *poplar* (Appendix 3a) found within and bordering the prairies. *Oak* was the next most commonly mentioned tree and was found in gallery forests along streams. No dominant adjectives accompanied the woodland root words. *Poplar Bluffs* were the most frequently mentioned features (Appendix 3b).

Distinguishing wooded areas from the scrub category was sometimes difficult. Identified tree species, density of cover and indication of stand age aided classification. For instance, when species was provided with a clue that mature trees were present (*thick, grove*, or *bluff*), the Woodland category was applied. Often, in the written description of wooded landscape, several tree varieties were listed, or a list consisted of one or more tree varieties and other vegetation types. In the former case, with a list of multiple tree species such as *Oak, Ash & Poplar* or *Ash Basswood Oak*, the Woodland category was applied. In the latter case, vegetation type appearing first in a mixed list was used as the overall indicator of landscape. For example, with phrases such as *poplar & scattered willow* or *thick poplar, scrub oak & willow*, the Woodland category was also applied. It was assumed that the most visible or dominant species would take precedence in a list of multiple vegetation types.

Scrub Landscape Category: The Scrub category included vegetation described as a mixture of prairie grasses interspersed with immature woodland or bush-type vegetation. This category also included areas with a low tree distribution density. That is, if adjectives

such as *scattered, clumps,* or *scrub* preceded a tree species name, then the Scrub category was applied. *Willow* vegetation was commonly labelled on township plans and was classified as Scrub unless it was identified as *willow marsh* or *willow swamp*. Since willow can thrive in saturated soils, regions of willow brush could denote areas of lower elevations receiving runoff or prone to flooding. In the scrub designation, willows were the most common vegetation type (Appendix 4a). Accompanying adjectives to scrub terms varied greatly **(**Appendix 4b). Some typical descriptors were: *scattered, brush* and *thicket.*

Data Capture:

Data collection involved electronic capture, digitizing, of township maps' landscape features as polygons, lines or point symbols. *ArcView* GIS was employed to enter original township map information into electronic format. First, digital base maps were acquired for each of the townships of the study area. Second, the maps were "geo-referenced", that is, the "real world" coordinates of each township map were established. To geo-reference a township map, the four corners of each paper township map are correlated with the four corners of a spatially accurate digital township map. Next, using a portable digitizing tablet, landscape features were captured electronically by tracing the outlines of each feature within the township. Landscape features and water bodies were drawn as polygons, streams as line symbols and spring water sources as point symbols.

Figure 2 shows an example of a township plan captured electronically with *ArcView*. Two attributes, information about the feature, are captured for each feature as it is digitized to create a database of landscape information. For vegetation and water bodies, the first attribute, a classification code, is assigned to each feature identifying the landscape category. To ensure consistency in the database, all attribute data were entered using a form designed specifically for this project. The form, presenting landscape classification options in a list, is designed to appear once digitizing of a feature was completed. Assigning a classification to a feature was achieved by pointing and clicking on the appropriate

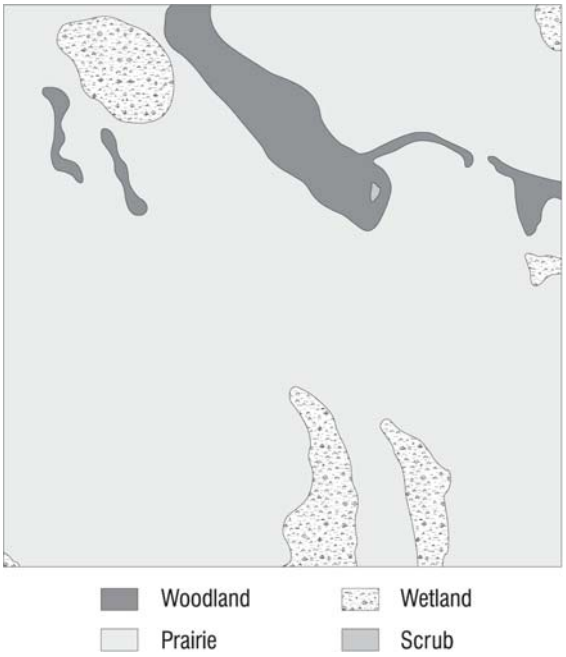

Figure 2: *Township plan captured elecronically using ArcView.*

classification on the form. This ensured classification consistency and that there were no typographical errors. The second attribute on the form allows the capture of any textual information relating to the landscape polygon in a space designated *Detailed Class*. The same process and a similar form were applied independently to a stream (line symbol) layer in the GIS database. Stream attributes included permanent or intermittent designations.

Comparing Reconstructed Landscape with Modern Environmental Monitoring Data

After large-scale European agricultural settlement, many land use changes occurred: agricultural crops replaced prairie grasslands; major drainage schemes were initiated and woods were cleared. Instrumental data sources used to compare 19th and 20th century

landscape include digital air photographs or othophotographs, classified satellite imagery from the Prairie Farm Rehabilitation Association (PFRA) and the Manitoba Forest Resource Inventory (FRI) interpreted air photography. Spatial analyses can be conducted with a GIS, overlaying and comparing the 19th century reconstructed landscape with some modern resources documenting surface conditions. This type of analysis is useful for tracking changes over time.

Figure 3a shows an area in southwestern Manitoba with a small prairie pothole lake, Lizard Lake. This lake contained water and was surrounded by wetland when it was surveyed in the later summer of 1872. When re-surveyed in 1917, water levels were much lower and Lizard Lake was labeled as *hay marsh* on the township plan. Another survey in 1919 mapped this lake as dry land. The area enclosed in the box on Figure 3a is depicted in Figure 3b, an orthophotograph from 1995 with the reconstructed 1872 lake and wetland boundaries superimposed. Open water area for the lake has contracted and a portion of the former marsh is cultivated. A former lakeshore scar is also visible. Two areas of woods present in the 1872 survey have been cleared.

Figure 4a illustrates a portion of a "Great Hay Marsh". This soggy terrain was surveyed between June and August 1872. The field notebook report cautioned: "Cattle and horses cannot cross these parts except in the month of August, and then some spots must be avoided". The surveyor speculated on the formation of this vast wetland: "The marsh is produced by the water of the Riviere aux Islets de Bois [Boyne River] having no channel through the Marsh to connect it with the Scratching River [Morris River], and until such channel is made these wet lands will be useless except for grazing and hay". The industrious surveyor did recommend and plot a path for a drainage channel through this extensive wetland. Construction of this drainage channel and much of its original, proposed route did occur more than 30 years later resulting in the Norquay Channel. Figure 4b highlights part of this former wetland. Not a trace of the wetland appears on the 1995 orthophotograph.

Township 3, Range 3 East (Figure 5a) contained some forest cover in the 19th century comprised primarily of oak, elm and ash, which was of "large size" along the Roseau River. Other trees

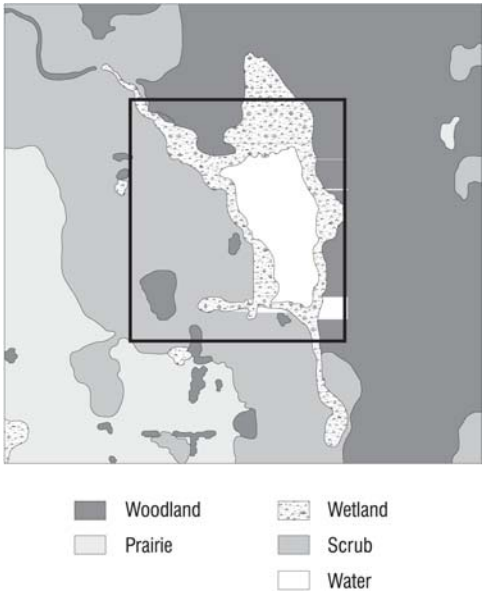

Figure 3a: *Lizard Lake, southwestern Manitoba.*

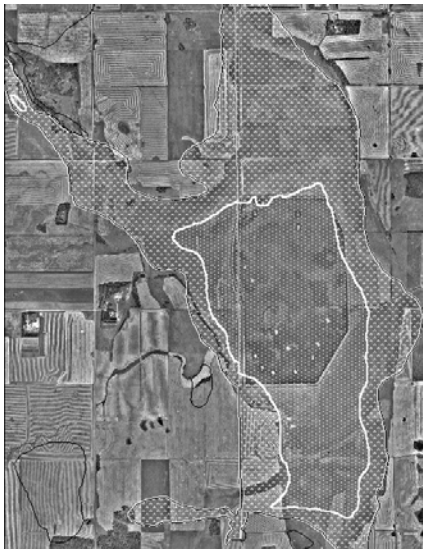

Figure 3b: *Orthophotograph of Lizard Lake, 1995.*

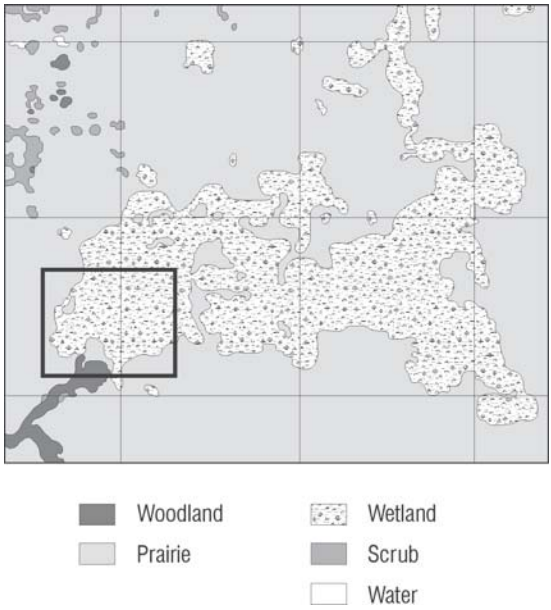

Figure 4a: *Portion of the "Great Hay Marsh."*

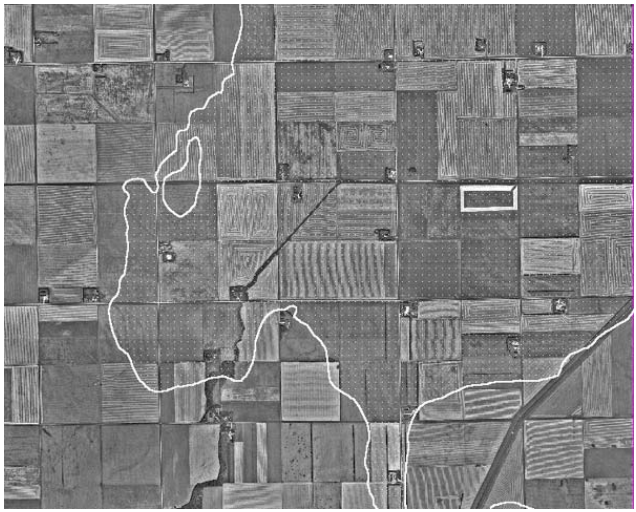

Figure 4b: *Orthophoto of Figure 4a (boxed area, lower left). White line indicates boundary of the "Great Hay Marsh."*

identified along the river were basswood, maple, balm of gilead (balsam), poplar and willow. On June 5, 1872 the depth of the Rosseau was recorded at 18 feet. The surveyor reported the river teeming with fish: "buffalo fish, channel cat, both very large 10 to 35 pounds and easily caught. Also: pike, goldeyes and shiners". Figure 5b shows the same township in 1995 based on the FRI air photograph classified data. Practically all of the timber has been cleared and the land now classified as agricultural.

Summary

Original DLS township maps, field notebooks and other archival data can be valuable proxies in characterizing landscape in the recent past. The DLS plans are particularly useful for providing some very detailed baseline landscape data because of their systematic nature and the short time span over which they were conducted. Township maps yield high spatial resolution information (township level and even section level) and can be accurately dated. Utilizing a GIS to capture individual township data and to generate maps produces a digital database of landscape information that has potential future uses for other applications such as hydrological modeling or energy budget studies. The 19th century reconstructed landscape can be compared with instrumental media used today, such as air photographs or classified satellite imagery to evaluate changes over the past century. Changes can be graphically represented and also be quantified in the GIS through spatial analysis functions.

Acknowledgements

I must thank Dr. Harvey Thorleifson, Geological Survey of Canada and Dr. Erik Nielsen, Manitoba Geological Survey who were instrumental in activating this research through genuine interest, enthusiasm and initial funding. Also thanks to Mr. Bob Halliday, with R. Halliday and Associates who was so influential in assisting with funding to continue this research. My gratitude to

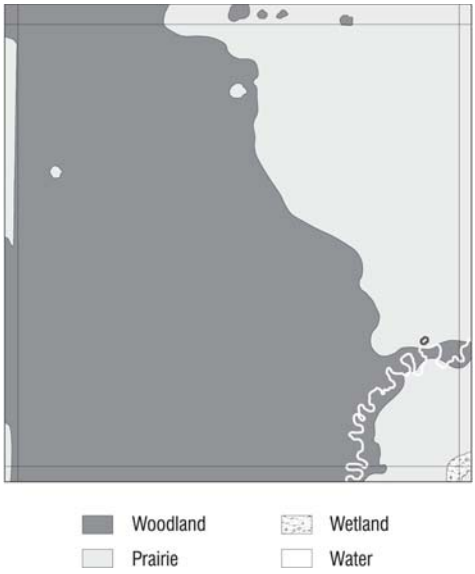

Figure 5a: *Township 3, Range 5E, 19th century.*

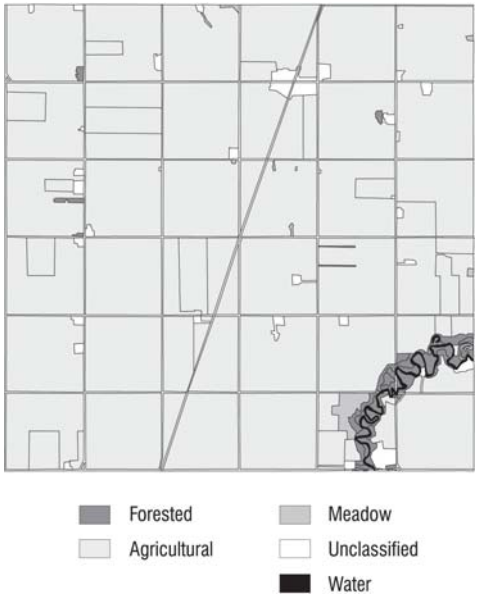

Figure 5a: *Township 3, Range 5E, 1995.*

the Provincial Archives of Manitoba, especially Chris Kotecki, for access to the original township maps and field notebooks. Thanks to John Teillet for assistance in preparing graphics. And, finally, I am happy to have Dr. Jim Gardner as my thesis advisor.

References

ALSOPP, T.R. 1977 *Agricultural weather in the Red River basin of southern Manitoba over the period 1800 to 1975* (Downsview: Atmospheric Environment Service, Report Number CLI-3-77)

ARCHIBOLD, O.W. and WILSON, M.R., 1980 'The natural vegetation of Saskatchewan prior to agricultural settlement' *Canadian Journal of Botany* 58(19), 2031-42

BLAIR, D. and RANNIE, W.F. 1999 'Wading to Pembina: 1849 spring and summer weather in the valley of the Red River of the north and some climatic implications', *Great Plains Research* 4, 3-26

BRADLEY, RAYMOND S. 1999 *Paleoclimatology: Reconstructing Climates of the Quaternary* Second Edition (London: Academic Press Limited)

CATCHPOLE, A.J.W. 1978 'Historical evidence of climatic change in western and northern Canada in Climatic Change in Canada' Syllogeus No. 26, *Climatic Change in Canada* edited by C.R. Harrington (Ottawa: National Museums of Canada) 17-60

JOSS, B. and WISEMAN, D. 2000 *A GIS-based Methodology for Landcover Reconstruction Utilizing Dominion Land Survey Township Diagrams* Paper presented, Canadian Association of Geographers Prairie Division and Association of North Dakota Geographers Annual Meeting, 29 September – 1 October, 2000, Devils Lake, North Dakota

RANNIE, W.F. 1999 *Hydroclimate, Flooding and Runoff in the Red River Basin Prior to 1870* (Geological Survey of Canada Open File 3705)

RANNIE, W.F. 1990 'Change in frost season characteristics in Winnipeg, 1872-1988' *Climatological Bulletin* 24, 168-77

RANNIE, W.F. 1983 'Breakup and freezeup of the Red River at Winnipeg, Manitoba, Canada in the 19th Century and some climatic implications' *Climatic Change* 5, 283-96

TRACIE, C.J. 1992 'Pre-settlement vegetation in a mixed prairie woodland area of northern Alberta: A reconstruction from surveyors' notes' *The Canadian Geographer* 36 (3), 260-66

WATTS, F.B. 1960 'The natural vegetation of the southern Great Plains of Canada' *Geographical Bulletin* 14: 25-43

Appendix

Appendix 1a:

Prairie Landscape Category and Root Words Assigned

PRAIRIE	**Frequency of Root Words**
Prairie	223
Grass	4
Field	2

Appendix 1b:

Prairie Landscape Category and Descriptive Words (Adjectives) Accompanying Root Words

PRAIRIE	**Frequency of Descriptor (Adjective)**
Open	66
High	44
Low	29
Dry	24
Level	22
Rolling	13
Clear	6
Good	6
Excellent	4
Undulating	4
Flat	3
Hard	3
Rich	3
Poor	2
Ridge	2
Wet	2
Burnt	1
Fair	1
Inferior	1
No. 1	1

Appendix 2a:
Wetland Landscape Category and Root Words Assigned

WETLAND	Frequency of Root Words
Marsh	73
Hay*	67
Weeds	39
Slough	3
Bog	3
Meadow/Beaver Meadow	3
Swamp	2
Wet Land	1
Muskeg	1
Coteau	1

*includes Hay Land, Hay Marsh, Hay Ground, Hay Swamp, Hay Grass

Appendix 2b:
Wetland Landscape Category and Descriptive Words (Adjectives) Accompanying Root Words

WETLAND	Frequency of Descriptor (Adjective)
Good (Hay Land)	9
Tall (Weeds)	6
Wet	5
Low	4
Burnt	2
Dense	1
Dry	1
Fine	1
Great	1
Floating (Bog)	1

Appendix 3a:
Woodland Landscape Category and Root Words Assigned

WOODLAND	**Frequency of Root Words**
Poplar	171
Oak	77
Elm	12
Ash	7
Balm of Gilead (Balsam)	7
Trees	7
Woods/Woodland	4
Basswood	2
Maple	1
Tamarack	1
Timber	1
Windfall	1

Appendix 3b:
Woodland Landscape Category and Descriptive Words (Adjectives) Accompanying Root Words

WOODLAND	**Frequency of Descriptor (Adjective)**
Bluff	11
Small	8
Thick	8
Grove	6
Burned/Burnt	5
Dry	3
Dense	2
Green	2
Line of	2
Principally	2
Thinly	2
Dead	1
Fallen	1
Islands	1
Thicket	1

Appendix 4a:
Scrub Landscape Category and Root Words Assigned

SCRUB	**Frequency of Root Words**
Willow	170
Scattering/ Scattered Poplar	9
Brush	5
Scattered Trees/Timber	3
Scattering Oak	2
Scrub Oak	1
Oak and Poplar Clumps	1

Appendix 4b:
Scrub Landscape Category and Descriptive Word (Adjectives) Accompanying Root Words

SCRUB	Frequency of Descriptor (Adjective)
Scattered	67
Brush	21
Thicket	12
Clumps	7
Dry	5
Thick	5
Burnt	4
Large	4
Scrub	3
Dense	2
Green	2
Few	2
Bush	1
Fire killed	1
Low	1
Line of	1
Small	1