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LATE HOLOCENE ENVIRONMENTAL CHANGES IN SOUTHERN MANITOBA

(FIELD TRIP A2)

by

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LATE HOLOCENE ENVIRONMENTAL CHANGES IN SOUTHERN MANITOBA

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INTRODUCTION

The climatic, geomorphic and ecological changes that have occurred in North America during the last 25 000 years are nothing short of spectacular. The last glaciation, the greatest ecological catastrophe to befall Canada in recent geological time, culminated with the Wisconsinan glaciers reaching their maximum extent approximately 14 000 years ago. At that time, when the glacier terminus stood at the Bemis Moraine in Iowa (Mayewski *et al.*, 1981), Manitoba was entirely covered by ice, in places 2 to 3 kilometres thick. Ameliorating climate and the establishment of interglacial conditions over large parts of the world about 10 000 years BP, saw the rapid northward retreat of the ice margin down the Red River valley and into northern Manitoba. Glacial Lake Agassiz, at times over 200 metres deep, formed between the retreating ice margin and the high ground to the south, east and west. Lake Agassiz persisted for about 4000 years, from approximately 12 000 to 8000 years BP and occupied all of Manitoba below the Cretaceous Escarpment at various stages. The lake had a lasting effect on the geomorphology of the region. The flat fertile plain of the Red River valley was deposited in the basin of Lake Agassiz. The numerous beach deposits along the escarpment and elsewhere record successive lake levels. Water levels recorded by the beaches relate to differential isostatic uplift and step-wise drainage into the Gulf of Mexico, the Great Lakes and the Arctic Ocean before the lake finally emptied into Hudson Bay.

Fragmentary evidence from southwestern Manitoba suggests First Nations People occupied the area above the escarpment and the shores of Lake Agassiz during the early Holocene (10-8000 years BP). By approximately 8000 years BP, Lake Agassiz had regressed into northern Manitoba and the Red River clay plain had become permanently available for habitation for the first time since the onset of glaciation.

Climate and Vegetation

Pollen diagrams from Riding Mountain and Glenboro to the west (Ritchie, 1964; 1987), Kenora to the east (McAndrews, 1982) and Gypsumville to the north (Kuhry *et al.*, 1992) may be used to reconstruct the Holocene vegetation for the Red River valley of southern Manitoba.

Pollen diagrams from Riding Mountain (Fig. 1) and Glenboro in southwestern Manitoba indicate that a spruce (*Picea glauca*) dominated forest occupied the area in late glacial time from approximately 12 000 to 10 000 years BP. Approximately 9500 years BP, in response to a warmer and drier climate the spruce forest gave way to nonarboreal (NAP) taxa dominated by *Artemisia*, Gramineae, Ambrosieae and Chenopodiineae. The expanded prairie grassland, dominated by NAP, persisted through the early and mid-Holocene until about 5000 years BP, when oak and birch started to increase slowly until they reached their modern values 3000 years BP. Similarly, spruce and alder started to rise from negligible amounts in response to a cooler and wetter climate. The expansive early to mid-Holocene grassland decreased in area through the late-Holocene and is now only a vestige of its former extent.

The vegetational history of Hayes Lake near Kenora suggests the early spruce dominated forest changed to a pine, birch, poplar and alder forest after 10 000 years BP. An open, mixed woodland existed in the Kenora area during the early to mid-

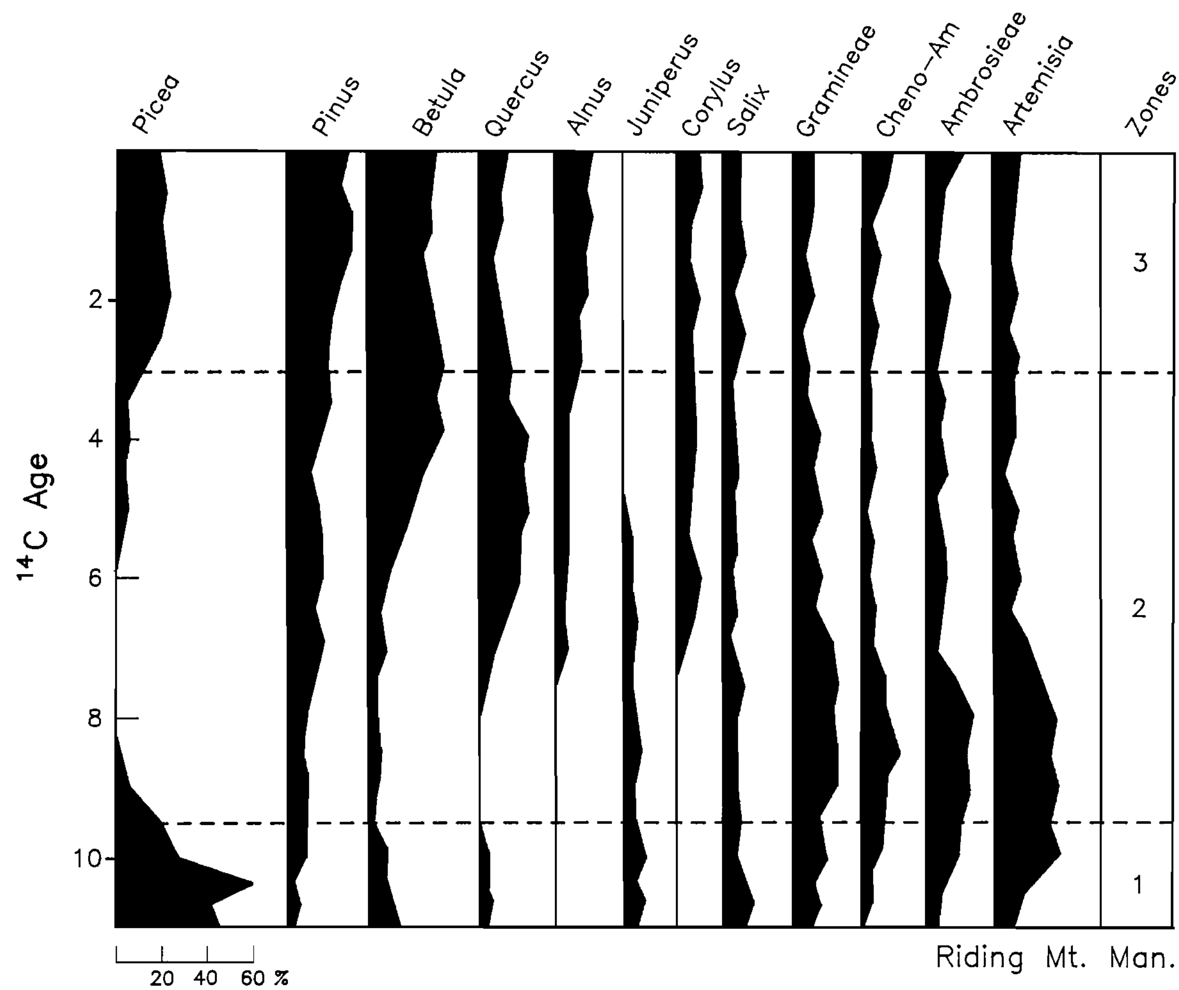

Figure 1. Abreviated pollen diagram for Riding Mountain (from Ritchie, 1976).

Holocene, while grassland was present to the west. Spruce and fir increased at the expense of alder after about 3600 years BP, in response to a cooling climate.

The Gypsumville core, with a basal radiocarbon date of only 4230 ± 100 years BP (AECV-1031C), is considerably shorter than either the Riding Mountain or the Hayes Lake cores. Grassland-parkland existed in the area prior to this date, but gave way to fen and boreal conifers in response to cooler and wetter conditions as indicated by the increase in spruce at the bottom of the core. The regional vegetation was probably open woodland, with spruce present in less abundance than in the southern mixed-wood boreal forest of today. The transition from fen to forested bog 1790 years BP represents terrestrialization and is not indicative of changing climatic conditions.

Available information from the three sites indicates an early spruce forest developed under cool, late glacial conditions. Then, in response to drier and warmer conditions after 9500 years BP, Ritchie (1976) and Shay (1976) conclude that prairie grassland extended as far east as the Red River, or to a northwest trending line running through the city of Winnipeg with deciduous and mixed forest to the northeast. Buchner (1981) and Kroker (per com 1995), on the other hand, believe that prairie probably extended east to the Winnipeg River. Frego and Staniforth's work (1986) on the distribution of brittle prickly-pear cactus in southeastern Manitoba suggests that grassland extended at least as far as the Winnipeg River in the mid-Holocene, leading to colonization of adjacent areas by cactus, a species traditionally inhabiting grasslands. This conclusion is supported by evidence of bison, a traditional grassland species, in mid-Holocene deposits in the Kenora (McAndrews, 1982), Winnipeg River (Buchner, 1981) and Gypsumville (Nielsen, unpublished) areas. The early to mid-Holocene climatic optimum lasted until 5000-3000 yrs BP, when the trend towards the present cooler and wetter conditions began (Fig. 2) (Ovenden, 1990).

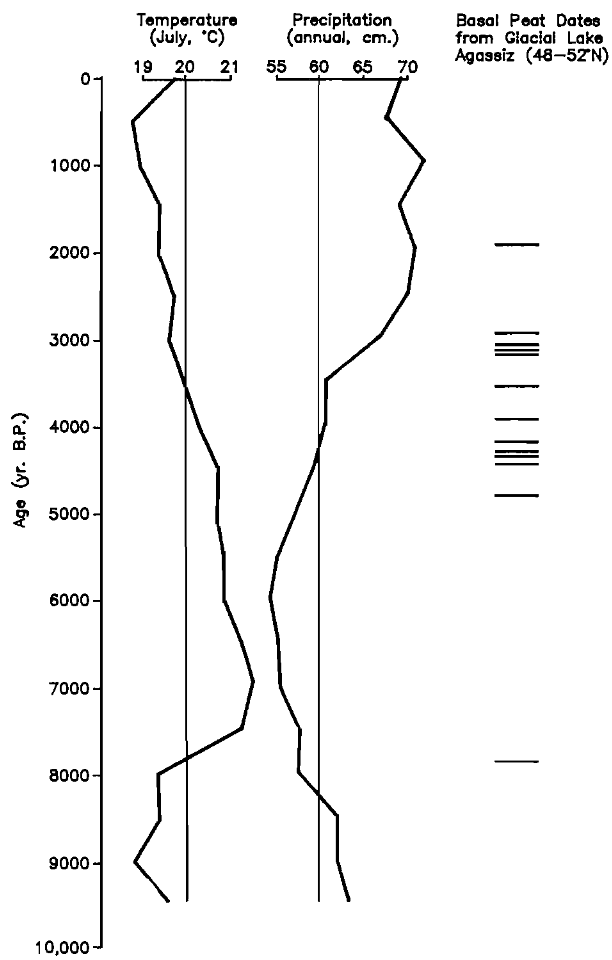

Figure 2. Holocene temperature and precipitation reconstruction for the southern part of the Lake Agassiz basin (from Ovenden, 1990).

Isostatic Uplift

Significant geomorphic changes have occurred in southern Manitoba in the last 8000 years, resulting from differential isostatic uplift. The most noticeable changes include the southward transgression of Lake Winnipeg, the rise in base level of the Red River and the shift in the course of the Assiniboine River.

Lake Winnipeg transgression

When Lake Agassiz drained, approximately 8000 years ago, large parts of what is now the North and South basins of Lake Winnipeg became subaerially exposed (Fig. 3). Seismic profiling and coring in the South Basin has revealed submerged shoreline features south of Hecla Island and evidence of subaerial conditions 4000 years ago northeast of Gimli (Lewis and Todd, 1996; Vance, 1996). The rise in water level during the Holocene is believed to have resulted from isostatic uplift of the sill in the north where Lake Winnipeg drains into the Nelson River. The rivers that drain into Lake Winnipeg today flowed across dry, clay plains and joined the Red River flowing north to Warren Landing and emptying into the Nelson River (Fig. 3). A chain of small lakes existed along the length of the Red River where flow was impeded by small topographic irregularities. As the sill in the north and ancillary sills farther south rose, Lake Winnipeg gradually expanded until it reached its present size. A 60 cm rise in its level in the last three hundred years is indicated by radiocarbon dating of submerged trees along the south shore. This finding implies the southward transgression of the lake is still occurring today (Nielsen and Conley, 1994).

Red River base level

Radiocarbon dating of fluvial sediments indicates the Red and Assiniboine rivers were entrenched in the Lake Agassiz clay plain 7500 years BP, shortly after the drainage of Lake Agassiz (Nielsen *et al.*, 1993). The initial high gradient and unobstructed flow of the Red River prevented flooding of the river in the early Holocene (Fig. 4A). Differential isostatic uplift throughout the Holocene gradually decreased the gradient of the river (Fig. 4B). The rapids at Lockport rose in relation to the river upstream and became a bottle neck, causing flooding after about 5000 years BP. Climatic change and variable flow resulting from changes in the course of the Assiniboine River also affected hydrology and sedimentation along the Red River.

Evolution of the Assiniboine River

The Assiniboine River has a long and complex history that only now is beginning to be understood (Rannie *et al.*, 1989; Rannie, 1990). Rannie *et al.* (1989) concluded from a limited number of radiocarbon dates that immediately after the draining of Lake Agassiz, the Assiniboine River drained north into Lake Manitoba. About 3000 years BP, the river changed course, flowing east through the valley of the present La Salle River and joining the Red River in St. Norbert south of Winnipeg. The conclusion that the Assiniboine flowed through the La Salle is based on its meander geometry, which suggests that a significantly larger volume of water occupied the channel in the past than does today. Rannie *et al.* (1989) concluded the La Salle channel was abandoned about 1300 years BP, when the present Assiniboine channel was occupied for the first time. The cessation of drainage into Lake Manitoba in favour of eastward drainage may have resulted from gradual avultion and channel breaching during floods or ice-jams. The role of isostatic uplift is unknown, but diversion of the river from the north to the east, similar to the Saskatchewan River (McMartin, 1996), suggests it may have played a role.

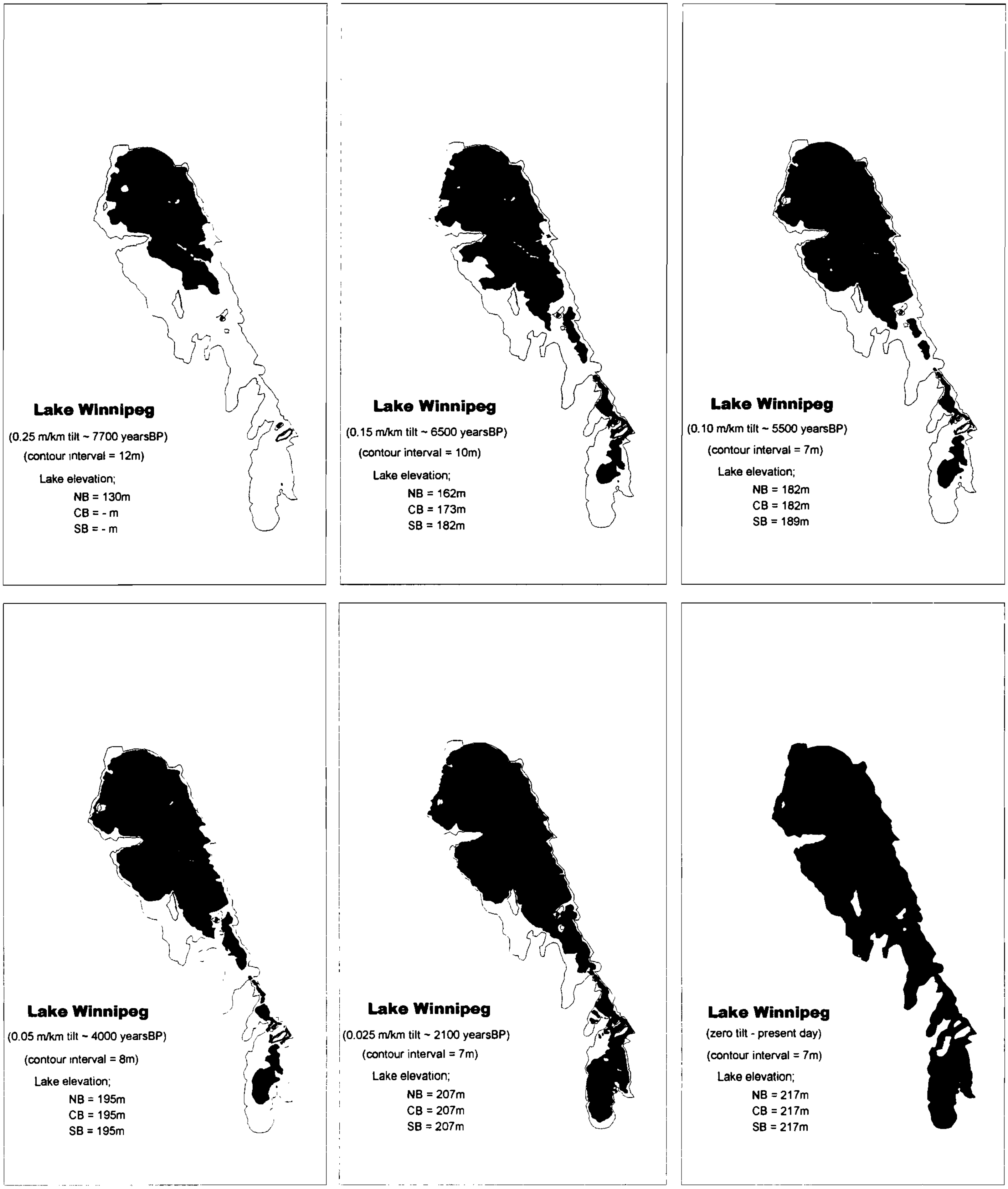

Figure 3. Speculative evolution of Lake Winnipeg since the draining of Lake Agassiz (7700 years BP) to the present as a result of isostatic tilting (Matile, unpublished).

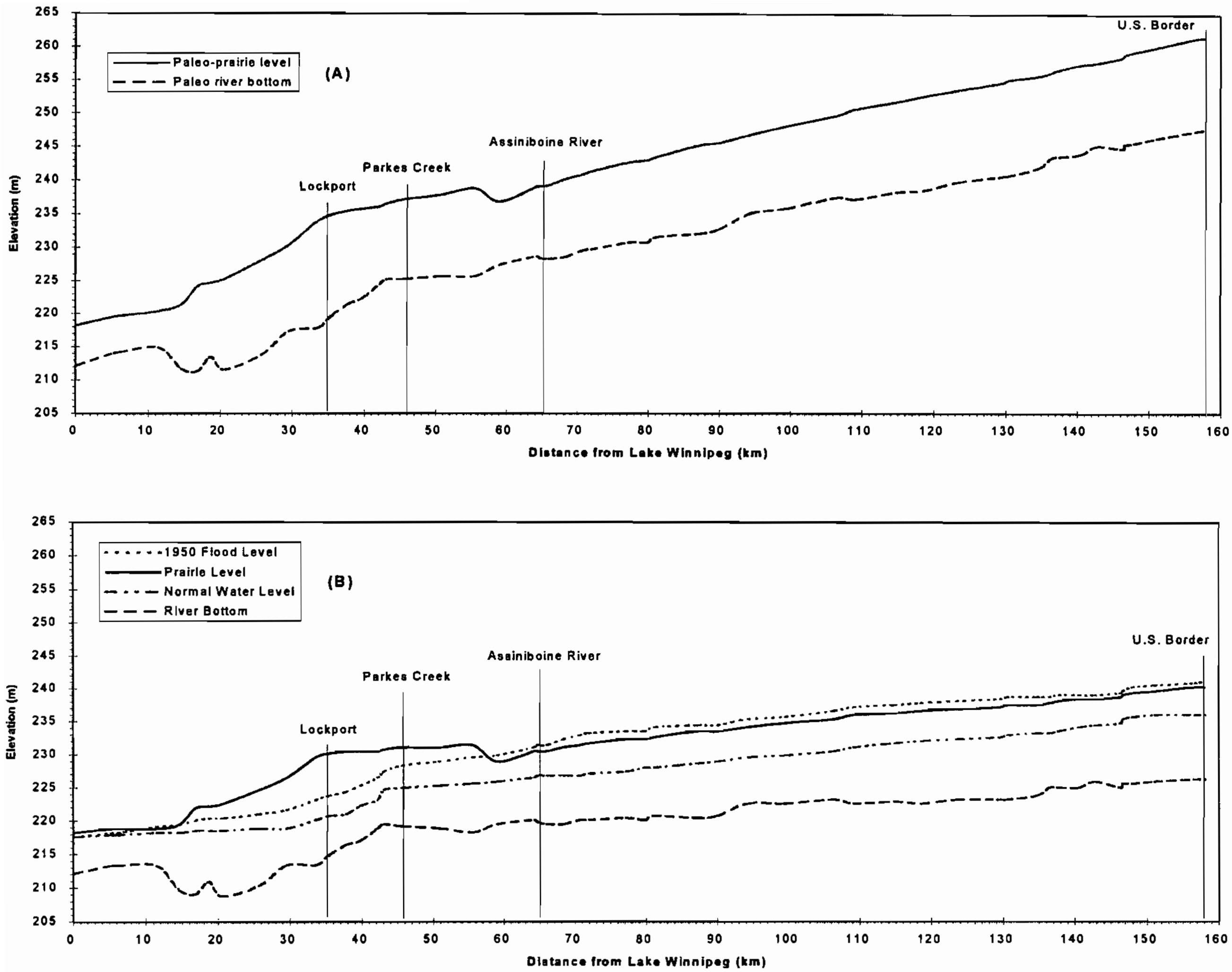

Figure 4. Assiniboine River profiles (A) immediately after the draining of Lake Agassiz (7700 years BP) and (B) today (Matile, unpublished). Data from Clark (1950).

Human Impact and Paleoenvironments

Humans have been an integral part of the natural environment of North America since their arrival from Asia via the Bering Land Bridge. Numbering approximately 30 million in the years immediately prior to European contact (Driver, 1969), Aboriginal people had considerable impact on the environment. The most obvious example is extinction of the Pleistocene megafauna of North America, 11 000 years BP, attributed by some to over-hunting. Evidence from southwestern and eastern North America also suggests that, when Europeans arrived, as much as 75% of the food consumed by the indigenous population was derived from cultivated plants, indicating that agriculture played a significant role in human subsistence (Driver, 1969). Slash and burn was the most common method of land clearance, but the magnitude of its impact on the natural environment is debatable.

Proof of anthropogenically induced burning is difficult to detect in the geological record, despite an abundance of ethnohistorical evidence (Spry, 1995). Burning on the prairies is known to have aided hunting by driving the bison herds. Burning also increased the quality of the grass which increased the carrying capacity for bison. When fodder was plentiful, the bison's reproductive rate rose. As well, other animals migrated into the burned area from the surrounding region, greatly increasing the number of animals available for hunting. The effect lasted for several years before the process had to be repeated. On the other hand, fires started by lightning were a common occurrence on the western plains and may have played an even larger role during the much drier mid-Holocene.

The frequency of charcoal in the geological record of the mid-Holocene, whether from natural or intentional causes, indicates the role fire has played in the development of the prairies. Although the prairie ecotone is determined largely by the amount of precipitation (Webb *et al.*, 1984), there is local evidence that the prairie boundary was in part determined by topographic obstacles preventing the spread of fires. The Precambrian shield in southeastern Manitoba, with its many rock outcrops and numerous lakes, would have acted as such a barrier. Increases in precipitation and a cooler climate in the late Holocene, together with the decreased size of bison herds and controlled fires, may have contributed to the prairie-boreal forest boundary moving gradually southwestwards.

Human impact on the natural environment of North America has accelerated since the arrival of Europeans in the 16th century, although this effect was not felt in southern Manitoba until the beginning of the 19th century. Early 19th century Europeans in the Red River valley rapidly deforested the river banks (Fig. 5) and began to cultivate the prairie grassland. The spread of farming across much of the prairies, the near extinction of the bison and the destruction or displacement of the indigenous population were the major impacts of European settlement on the natural environment of the Red River valley. The latter part of the 19th and the 20th centuries have witnessed a population explosion resulting in the loss of prairie habitat, the decline of species diversity, an increased sedimentation rate in rivers and lakes, drainage of wetlands and deforestation. On the other hand, prairie wild fires have been reduced, trees have extended their range along river valleys and riparian habitats have been re-established as the use of wood for heating has declined in the present century.

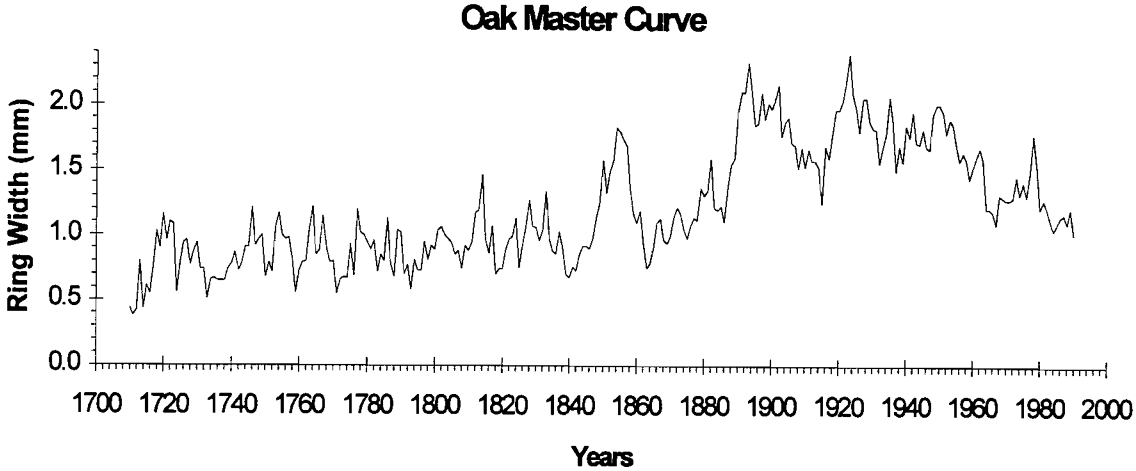

Figure 5. Tree-ring curve for oak (*Quercus macrocarpa*) for the Winnipeg area showing increased growth in the late 19th century as a result of deforestation and decreased competition among small trees. Curve is based on the analysis of nine trees.

Construction of the Red River Floodway and Portage Diversion have solved problems related to flooding of the Red River in the city of Winnipeg. The Portage Diversion will also prevent future changes in the course of the Assiniboine River. Regulation of the level of Lake Winnipeg by Manitoba Hydro in 1976 has reduced, though not eliminated, problems related to shoreline erosion. The spread of pollution, concerns about water quality and development of the shores of Lake Winnipeg are only some of the issues facing the inhabitants of the area at the beginning of the 21st century.

ENVIRONMENTAL SETTING OF THE RED RIVER VALLEY

Introduction

A major part of Manitoba's population is concentrated within the watershed of the Red River. The two largest urban centres along the river are Winnipeg (population > 625 000) and Selkirk (population ca. 10 000). Obviously, the greatest impact on water quality is exerted by Winnipeg. Its impact persists throughout the 100 km from the south perimeter of the city to the inflow at the South Basin of the lake.

Approximately 40 km north of Winnipeg, the Red River enters Lake Winnipeg forming a delta known as Netley Marsh. This area is composed of ca. 27 000 ha of wetland and ca. 14 000 ha of more elevated land used for agriculture, primarily cereal and forage crops. Netley Marsh contains a system of channels and lagoons, but the Red River enters Lake Winnipeg through 4 main distinct channels.

The sediments comprising much of this marsh originate from Lake Winnipeg; only a minor proportion have been deposited by the Red River. However, this area suffers from decades of accumulated garbage, some of which originates far upstream in southern and western Manitoba.

Hydrology

Flow rates in the Red and Assiniboine rivers fluctuate tremendously on a seasonal basis and are dominated by spring floods. At the U.S. border at Emerson, annual flows of the Red River average 96.4 cubic metres per second. Approximately 64% of the volume of the Red River at the south perimeter of Winnipeg consists of water from the United States. Average annual flows of the Red River at Lockport north of Winnipeg increase to 222 cubic metres per second due to a number of tributaries entering the Red River. The Assiniboine River, Omand's Creek, Sturgeon Creek, Bunn's Creek, La Salle River and Seine River join within or near the City of Winnipeg, while Cook's Creek, Netley Creek and Devil's Creek enter the river farther north. All of these tributaries contribute garbage, residential runoff, agricultural chemical residues and effluent from commercial activities. Many of these tributaries experience low flows during the summer; at these times pollution levels may reach extreme levels.

Water Quality

Water in the Assiniboine and Red rivers is used for irrigation. Many individual users west of Winnipeg draw water from the Assiniboine River for domestic consumption, as groundwater west of the city is saline and not potable. Red River water is used for cooling by Manitoba Sugar in Winnipeg and Manitoba Hydro in Selkirk.

The Locks at Lockport are a water level control structure maintaining higher water levels to the south. The Locks are sited at an area where large rapids once obstructed boat navigation on the Red River.

The water in the Red and Assiniboine rivers is naturally quite turbid, hence the name of the Red River, with most suspended solids arising from soil erosion and resuspension of bottom sediments. Suspended solids can be as high as 800 mg/L in the Red River, with pH ranging between 7.4 and 8.7.

Effluents into the Red and Assiniboine rivers from Winnipeg's three wastewater treatment plants are not disinfected. The largest contributor (about 70%) is the North End Water Pollution Control Centre, which has a primary treatment capacity of more than 800 million litres per day and a secondary capacity of ca. 500 million litres per day. Wastewater treatment in Winnipeg does not go beyond secondary treatment; effluents contain substantial amounts of microorganisms and thousands of dissolved materials. In many parts of the city, land drainage and wastewater are not segregated into separate sewers, with the result that during storms, overflows from combined sewers cannot be treated. This situation occurs 30 - 50 times a year.

Significant increases of bacteria, ammonia, total Kjeldahl nitrogen, nitrate, nitrite, phosphorus and the herbicide 2,4-D are seen north of Winnipeg. Downstream of Winnipeg, the Red River is not suitable for swimming or livestock watering. The nutrient input has a noticeable effect on Lake Winnipeg, particularly the South Basin. According to provincial data, while the Red River contributes only 6% of the total water influx into

Lake Winnipeg, this river annually contributes 59% of the total phosphorus and 33% of the total nitrogen. During the past decade, problems with noxious algal blooms and unacceptable bacterial levels have increased at Lake Winnipeg beaches in summer. Commercial fisherman have complained about declining catches, reduced quality and frequent entanglement of garbage in nets. Pollution-sensitive species such as freshwater mussels have also declined dramatically in many areas of the South Basin where they were formerly abundant; some species have not been found for several years. A study of lake sediment cores and records from the 1930s reveals that some species of gastropods which were historically present in the province, are now extinct in Manitoba.

Downstream from Winnipeg, the town of Selkirk uses the Red River to supplement well water for its domestic supply. Although water from two wells is the preferred source, if demand exceeds supply or well pump failure occurs, river water is used. During the past decade, at times as much as 60% of Selkirk's water supply consisted of Red River water. It must be heavily disinfected by chlorination and treatment with potassium permanganate. A smaller treatment plant at Sanford, southwest of Winnipeg, uses La Salle and diverted Assiniboine River water to serve several small communities.

Species Diversity

The impact of effluents is reflected dramatically in species diversity and composition of the aquatic communities in the river. Freshwater clams and mussels, for example, drop from 17 species south of Winnipeg to only 2 (*Anodonta grandis* and *Lampsilis radiata siliquoidea*) in the area north of the city to Lockport. Zooplankton composition also changes drastically, with a broad shift to heterotrophic, low oxygen forms, particularly protozoa. Only the most robust, pollution tolerant species of submerged macrophytes survive in this stretch of the river (*Potamogeton pectinatus* and *Ruppla maritima*). Diversity tends to increase again downstream of the Lockport Dam.

Chronic problems with toxicity are seen at a number of locations on the Red and Assiniboine rivers, as well as on their smaller tributaries. Zinc, copper and cadmium have been implicated. Some species of freshwater mussels accumulate tremendous quantities of cadmium and copper in the hearts and gills, particularly of younger individuals. Since 1991, decline of freshwater mussels has been further aggravated by commercial harvesting operations to obtain seed pearls for the Asian cultured pearl industry. The mussel populations are currently declining.

A total of 46 species of fish have been reported in the region of the Lockport Dam, with 50 recorded upstream of the dam. Species composition changes as one moves downstream; however, the fish are very mobile in the river. Some channel catfish marked in the Selkirk area have been recaptured in North Dakota. Because a fish lane is provided at the Lockport Dam, fish community differences are not as well-defined as planktonic or nektonic invertebrate populations which have more limited ranges, or for sedentary benthic organisms.

The Red River at Lockport is an important sport fishing area. However, frequently fish caught in the Red River show open sores, tumors or gross developmental abnormalities. Lockport fishing operators advise their clients to discard such fish. Provincial data have shown elevated levels of mercury in fish from the Red and Assiniboine rivers.

LAKE WINNIPEG SHORELINE EROSION

Lake Winnipeg is the twelfth largest fresh water lake in the world. It is divided into North and South basins by a relatively narrow constriction in the lake. Together the two basins have a surface area of approximately 24 000 sq. km. South Basin is used extensively for commercial and recreational purposes and has over 300 km of shoreline, much of which has developed into sandy beaches. These well-developed sandy beaches, particularly along the southern shore, have made it a popular location for cottages. However, fluctuations in water level arising from hydrologic variations in inflow, wind-induced setup, and barometric pressure, combined with wave action, causes extensive erosion in some areas. For example, along the southern shore of Lake Winnipeg (*i.e.*, Winnipeg Beach to Grand Beach) erosion rates in excess of 7 metres per year have been recorded, although a significant portion of this rate is likely due to just a few episodic storm events. To control erosion damage to their shoreline, property owners have attempted to stabilize their shoreline. Unfortunately, their efforts have met with varying degrees of success.

There are a variety of approaches that can be used to control shoreline erosion. These range from non-structural solutions, such as planting suitable vegetation to stabilize the foreshore and bluffs or artificial beach nourishment, to structural solutions, such as groynes, seawalls, or slope armouring. The success of these approaches depends not only on the soundness of the design and its suitability for a given environment, but also on its integration in a regional approach rather than just an individual solution. For example, a stretch of shoreline "protected" by a mixture of groynes, seawalls, and armouring is likely to be fraught with problems and these individual "solutions" will be in competition for sediment. These works can also induce increased erosion on adjacent unprotected properties. It should be remembered that a shoreline is not a location or a static object but rather a dynamic feature that moves in space and time. For this reason the best solution to the destruction of public property is not to build along beaches and shorelines which requires the shoreline to be fixed in time and space.

EXCURSION ROUTE

Purpose

The purpose of this trip is to examine evidence for (i) large scale changes in the environment due to climatic change and isostatic uplift and (ii) human-environment interactions along the Red River, north of Winnipeg and along the southwestern shore of Lake Winnipeg (Fig. 6).

Stop 1: Fluvial terrace on the Assiniboine River at the foot of Ruby Street.

In 1969, sewer excavations on the Assiniboine River terrace near the corner of Ruby Street and Palmerston Avenue exposed approximately 0.3 m of homogeneous, stiff blue clay at the bottom of a 10.7 m deep trench. The clay was overlain by a metre of pea gravel and crossbedded sand containing numerous articulated freshwater clams,

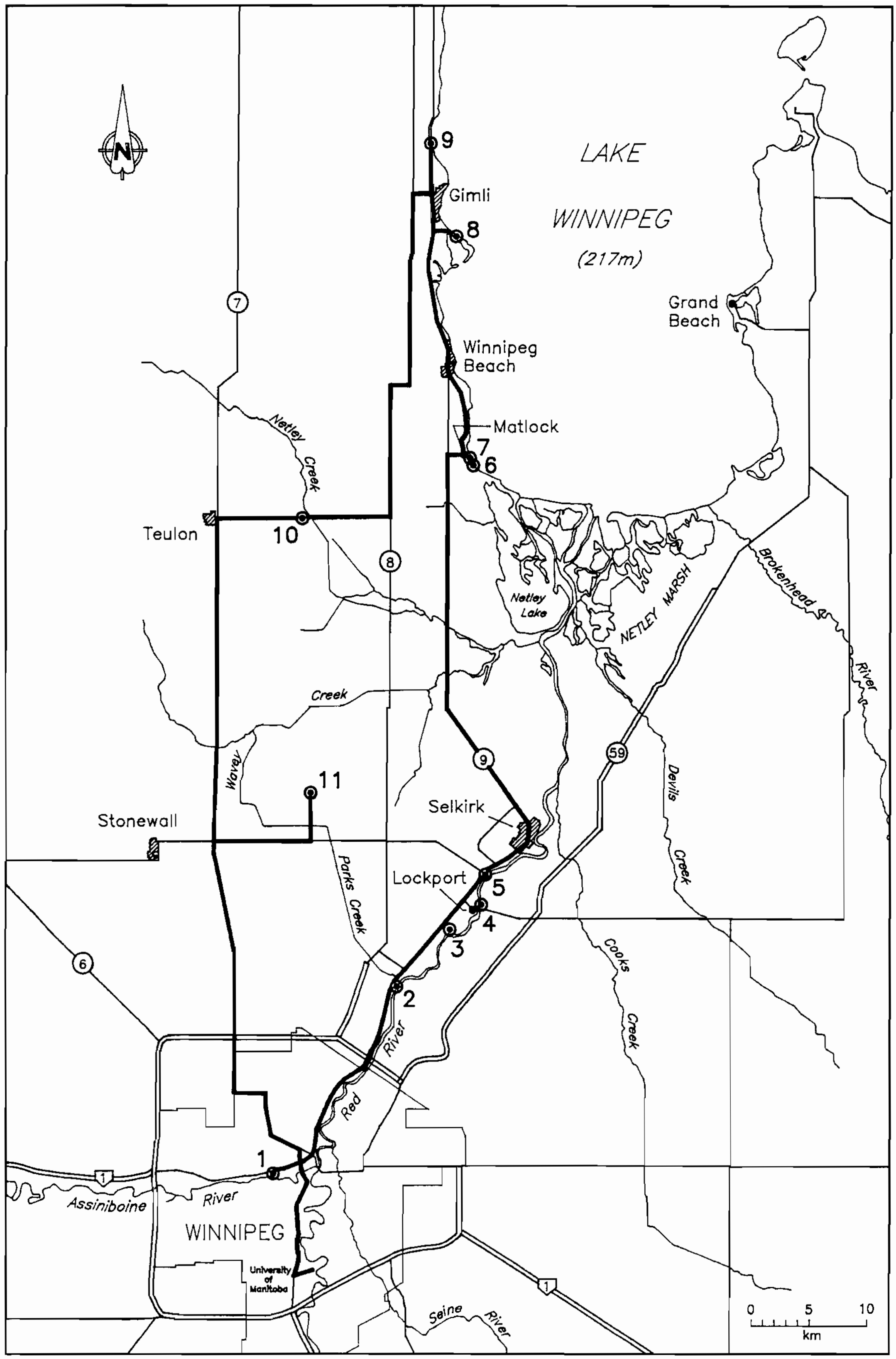

Figure 6. Excursion route and field trip stops.

pieces of wood and parts of a bison skeleton. The bison skull has tentatively been identified as *Bison antiquus occidentalis* (Fig. 7). In turn, the sand was overlain by very fine, laminated silty clay of undetermined thickness (G. Lammers, Museum of Man and Nature, unpublished field notes, 1969).

Figure 7. Bison skull (*Bison antiguus occindentalis*) from a sewer excavation on the Assiniboine River. Wood from the same site dated to 7490 ± 80 years BP.

The clay at the bottom of the trench was probably deposited in Lake Agassiz. The geomorphic setting, the lithostratigraphy and the presence of shells, wood and bison bones indicate the overlying sand, gravel and silt is probably a point bar deposit associated with the formation of the Assiniboine River terrace. A radiocarbon date of 7490 ± 80 years BP (GSC-4839) (Table 1) on the wood indicates the Assiniboine River had cut the present valley to a depth of over 10 m within a thousand years after the drainage of Lake Agassiz (Nielsen *et al.*, 1993). This interpretation of the radiocarbon date contradicts Rannie *et al.*, (1989) who concluded the present Assiniboine River valley was not cut or occupied until about 1300 years ago.

The archaeological record could, theoretically, provide information on the course of the Assiniboine River and the extent and impact of human activities in the Red River valley following the regression of Lake Agassiz. Unfortunately there are few excavated archaeological sites along either the Red or Assiniboine rivers from which dates have

TABLE 1. RADIOCARBON DATES

Site	Age(BP)	Lab No.	Depth (m)	Material	Reference
Blind Channel	4230±70	BGS-1851	?	Wood	This report
Kuypers Site	3950±120	BGS-1825	NA	Bone	"
Ruby Street	7490±80	GSC-4839	10.7	Wood	Nielsen et al., 1993
Wright Site	3560±100	BGS-926	1.4	Bone	Nielsen et al., 1993
	5000±100	BGS-921	3.4	Shells	"
	4980±125	BGS-920	4.5	Shells	"
	3625±70	BGS-1801	.75	Bone	This Report
	3940±80	BGS-1802	1.06	Bone	"
	4920±100	BGS-1803	1.40	Bone	"
	5330±80	BGS-1804	2.55	Bone	"
Lockport	470±270	S-2850	0.37	Charcoal	Buchner, 1989
	705±75	RIDDL-1273	0.57	Bone	"
	315±235	S-2852	0.63	Charcoal	"
	1005±280	S-2851	0.75	Charcoal	"
	595±80	RIDDL-1272	0.78	Bone	"
	620±105	GX-10866	0.82	Charcoal	"
	635±90	S-2849	0.83	Charcoal	"
	1185±255	S-2848	0.83	Charcoal	"
	1185±255	S-2854	0.93	Charcoal	"
	1410±290	GX-10865	1.42	Bone	"
	1095±250	S-2853	1.53	Charcoal	"
	2315±140	GX-10864	1.57	Bone	"
	2515±140	GX-10863	1.90	Bone	"
	3300±295	S-2847	2.10	Charcoal	"
Sans Souci	3600±80	BGS-1477	-	Soil	Nielsen and Conely, 1994
	1200±70	BGS-1478	-	Peat	"

been obtained. A new radiocarbon date of 3950 ± 120 years BP (BGS-1825) on faunal remains excavated by the University of Winnipeg in 1980 at the Kuypers Site, along the south bank of the Assiniboine River 1.8 km west of the Perimeter Highway, indicates that by 4000 years ago, groups of hunter/gatherers had established camps along the banks of the river. The site's large size, as evidenced by the lateral dispersal of artifacts across the now-cultivated fields, suggests that it was either inhabited by a large group of individuals, or re-occupied frequently throughout the years.

Data from the Kuypers Site is consistent with that obtained by The Forks Public Archaeology Project in 1993, where a dense cultural horizon indicated a fairly large encampment. However, no occupations at the Forks or along the Assiniboine River in general, date earlier than 4000 years BP. The radiocarbon dates, therefore, suggest the Assiniboine River flowed through and cut the valley 7500 years BP, then changed course and abandoned the valley until about 4000 years BP. At that time, the Assiniboine changed course again, reoccupying the old valley. During the intervening 3500 years, the river flowed north into Lake Manitoba via Willowbend and Blind Channels (Rannie *et al.*, 1989). A replotting of the location of Gilliland's 3375 ± 250 years BP (I-255) radiocarbon date, used by Rannie as evidence for the Assiniboine River not abandoning Blind Channel until almost 3000 years BP, shows it is not associated with this channel, but rather a later event. Also, a new radiocarbon date on a large oak log from Blind Channel gave an age of 4230 ± 70 years BP (BGS-1851), confirming the 4520 ± 60 years BP (TO-330) date obtained by Rannie *et al.* (1989).

Radiocarbon dating of Blind Channel, the Kuypers Site and The Forks suggests the present Assiniboine River channel has been occupied for only the last 4000 years. It seems unlikely that the Forks was a major meeting place prior to 4000 years ago.

Historic note

The Point Douglas area of Winnipeg was settled in the early 1800s by Scottish and French colonists. In the late 1800s, the area experienced an influx of Ukrainian immigrants. Many of Winnipeg's oldest structures can be found in this small area bordering the Red River. The Church of the Immaculate Conception and a nunnery combining a French school (now demolished) were constructed during 1850-1884 on land owned by the MacGregor family. This church became the Ukrainian Orthodox Church of St. Ivan Suchavsky in 1931.

This area contains Winnipeg's oldest Ukrainian church. St. Michael's Orthodox Parish on Disraeli Street near the river was organized in 1918. The building itself is older and was purchased when the parish came into existence. Later, St. Andrew's Ukrainian Catholic Church was built nearby on Euclid Avenue. It burned down in the early 1950s and was rebuilt farther west on Euclid. Holy Trinity Ukrainian Orthodox Cathedral at 1175 Main Street was built over several years in the 1960s. A Ukrainian cultural hall on Euclid, near Disraeli, was constructed in the 1920s. During its heyday it housed a library, theatrical and choral groups, business association and school. As Ukrainians began to move out of the area to newer and more affluent neighborhoods, the school was the last element to disappear, closing in 1964. The building was then sold and became a bingo hall.

Stop 2: Mid-Holocene overbank sedimentation and archaeology at the Wright Site.

The Wright Site is situated at what is now the largest and most prominent rapids on the Red River (Fig. 4). Sedimentation of bedload sand and gravel and overbank silt and clay started in this small meander scar approximately 5000 years ago, continuing for about two thousand years. Overbank sedimentation all but ceased about 3000 years BP (Table 1. Fig. 8). A gradual decrease in the gradient of the river resulting from isostatic rise to the north is believed to have increased the frequency of floods along the Red River to the south of the Wright site in the mid-Holocene (Fig. 4). Continued uplift brought the elevation of the terrace and adjacent prairie above all but the largest floods. For this reason, the frequency of floods affecting this site diminished in the latter part of the Holocene.

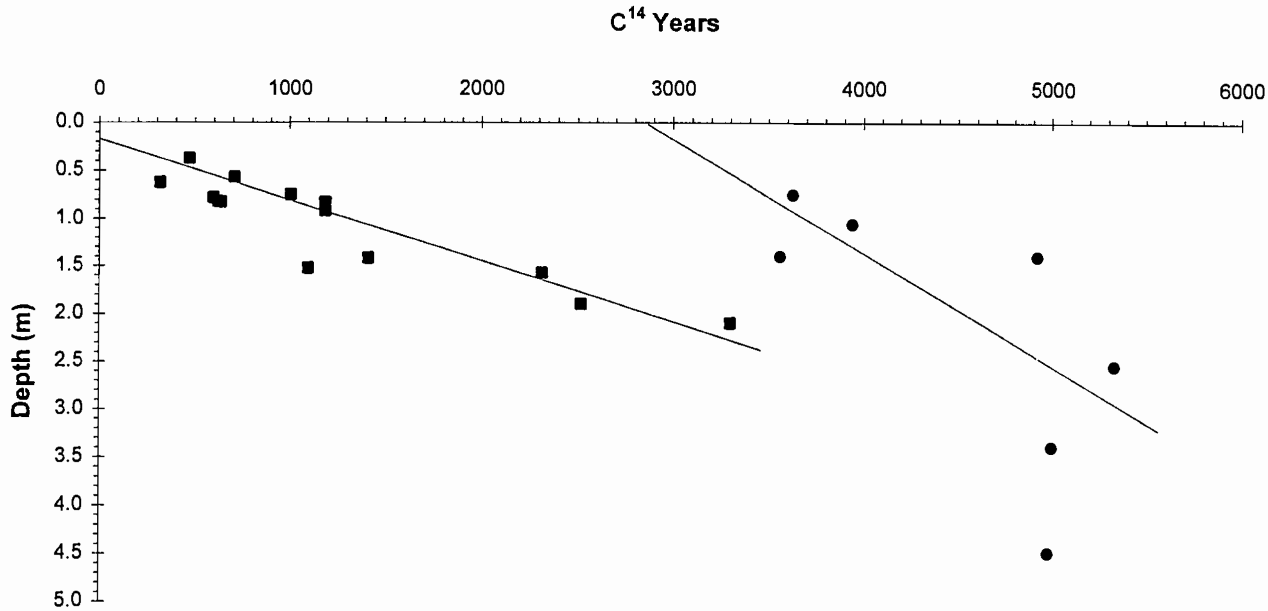

Figure 8. Plot of radiocarbon age vs depth for samples from the Wright Site (•) and Lockport (■).

The exposed section is mainly buff coloured silt and clayey silt deposited by overbank sedimentation during flooding. The thick, black, well-developed chernozem soil at the top of the section indicates there has been no appreciable overbank sedimentation through the last three millennium of the Holocene (Fig. 9A). Minor paleosols near the top of the section indicate that a few, relatively recent large floods reached the top of the bank, but these may be considered anomalous events.

The Wright Site is an example of successive prehistoric occupation of an area adjacent to the Red River. Four new radiocarbon dates of 3600, 3900, 4900 and 5300 years BP were recently obtained on bone from depths of 0.75 m, 1.06 m, 1.40 m and 2.55 m below the surface in addition to the three previously published dates (Table 1). The most distinctive feature of the Wright Site is a series of hearths, created by camping or cooking fires, eroding from the riverbank at various depths (Fig. 9B). Artifacts diagnostic of the Middle and Late Historic periods have also been recovered from the cultivated field on the upper river terrace of the Wright Site. These historic

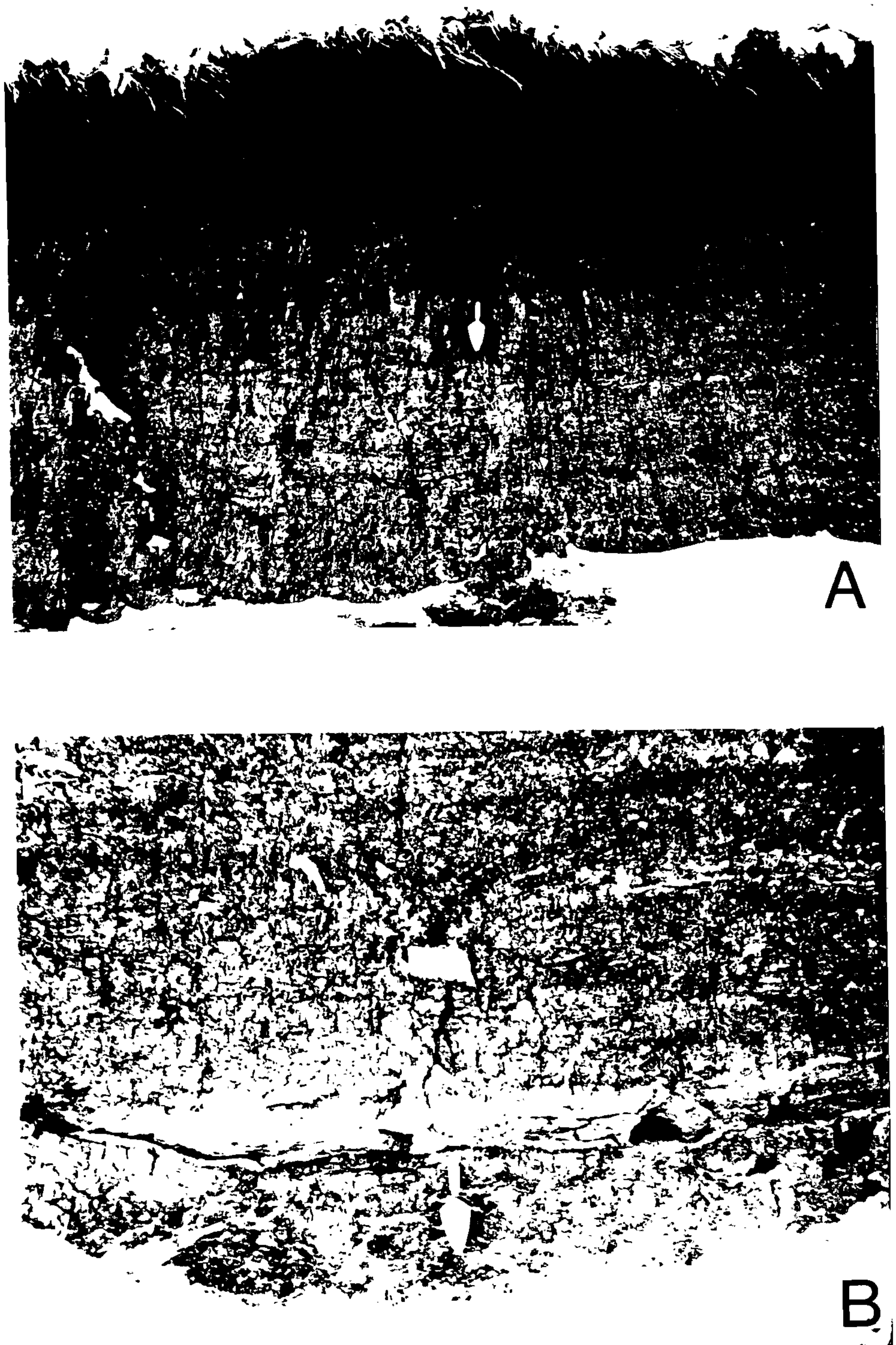

Figure 9. (A) Charcoal layers in overbank sediments at the Wright Site. Note the thick black soil at the top of the section. (B) Hearth and charcoal layers in overbank sediments at the Wright Site. The light coloured layer above the trowel is the result of burning of the clay.

deposits relate to homesteads that were constructed after 1840 and occupied until about 1920.

The natural feature that would have attracted Aboriginal people to this particular location is the nearby rapids. Large catches of fish could be expected, particularly during annual spawns. The fluvial dynamics of this section of the Red River during the Middle Prehistoric Period may also have attracted animals and, in turn, the hunters who sought them. The range of radiocarbon dates indicates a time period associated with a climate that was warmer and drier than at present.

Thin, discontinuous layers of charcoal interspersed with overbank sediments are common along the Red River. These charcoal deposits are attributed to man-made camp fires or prairie fires, started accidently by natural causes such as lightning or set deliberately by Aboriginal hunters. The numerous charcoal layers at this particular site of repeated human occupation indicate that the fires were probably campfires made by Aboriginal hunters or fishers. The estimated 15 to 20 charcoal layers deposited during the 2000 years of sedimentation recorded at the Wright Site suggests a recurrence interval of at least one fire per century.

Stop 3: St. Andrews Church.

Anthropogenic modification of the environment is perhaps best demonstrated between 1821 and 1870, the Middle Historic Period. Although established between 1812 and 1817, it wasn't until the 1821 amalgamation of the Hudson's Bay and North West companies that the Red River Settlement expanded significantly. About 15% of the redundant labour force made its way to the Settlement, where the Hudson's Bay Company (HBC) offered land grants to its former employees. In this manner, river lots surrounding the original core of the Red River Settlement were cleared and homesteaded. Retired Orkney men and Scots of the HBC settled with their families in areas that eventually became the parishes of St. Paul and St. Andrews.

By the time Manitoba entered Confederation in 1870, settlement along the west bank of the Red River stretched upstream from the present-day Selkirk area to the forks of the Red and Assiniboine rivers. Large tracts of the east bank had also been cleared and homesteaded. The most obvious result of expanded settlement was destruction of the river bottom forest (Fig. 10), as clearly indicated by the growth release observed in tree-rings in the middle and late 1800s (Fig. 5).

The first church at St. Andrews on the Red, a log structure, was built in 1831 by Reverend William Cockran. Standing just east of the present-day stone edifice, it was soon too small to accommodate an increasing congregation. The foundation of the stone church was laid in 1845 and the structure, built of locally quarried limestone, was completed in 1850 (Fig. 10). These quarries survive today as large marshes adjacent to the riverbank, downstream of the church. The cemetery surrounding the church contains numerous gravestones also manufactured from local dolomitic limestone. These markers, primarily dating from the mid-1840s to mid-1860s, were supplanted by gravestones imported from eastern Canada and the United States. The earliest markers were wooden and have long-since disappeared. The St. Andrews on the Red Cemetery contains approximately 2000 unmarked burials.

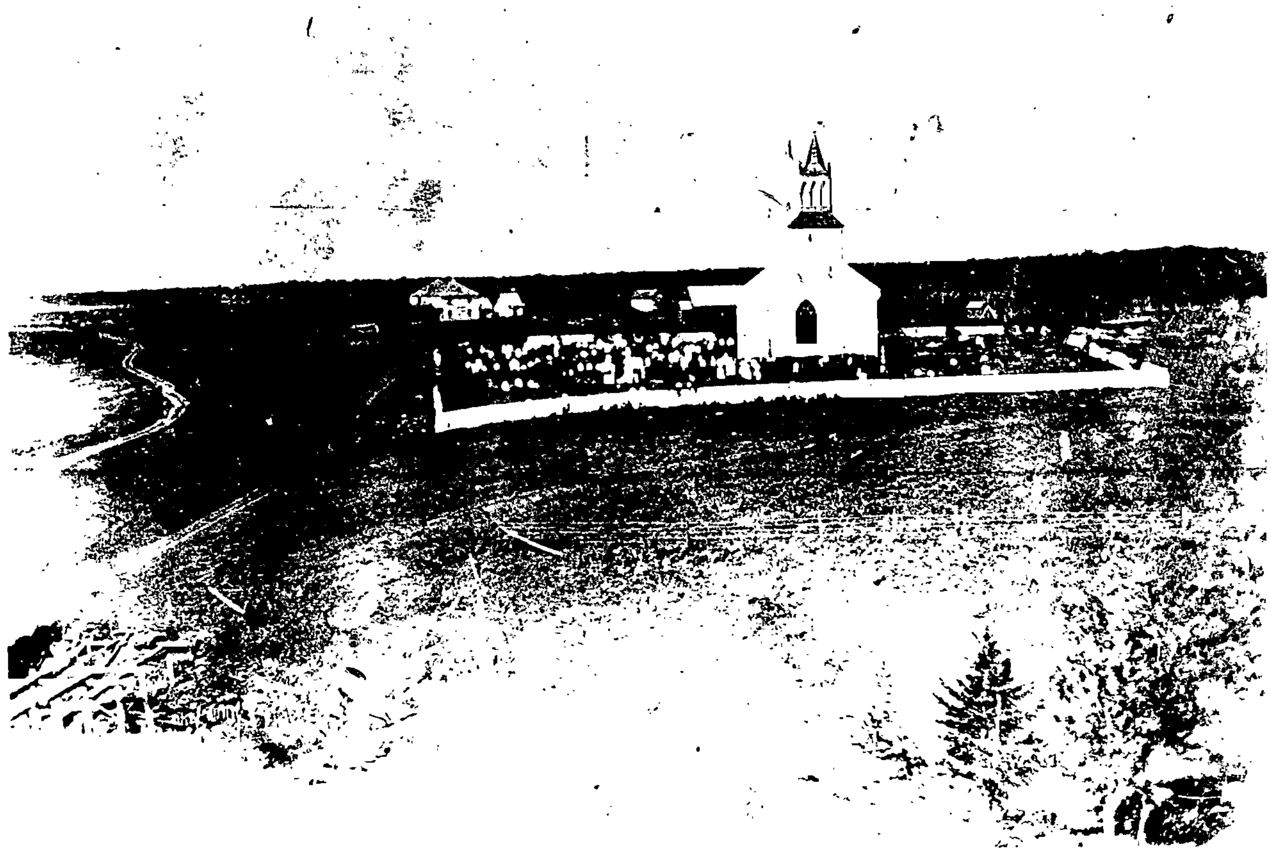

Figure 10. St. Andrews Church and Rectory viewed from the north in 1899. Note the absence of trees and the Red River to the left. Courtesy of Manitoba Archives.

Historic note

In 1993, the Historic Resources Branch of Manitoba Culture, Heritage and Citizenship conducted an archaeological impact assessment around the perimeter of the church building in anticipation of foundation repairs. A work space of roughly 6.0 m was required. Because the boundaries of the cemetery relative to the church were unknown, an electromagnetic ground conductivity survey was undertaken. This study indicated that two unmarked burials lay in the work space at the northeast corner of the church. The two individuals, one an adult male and the other an infant were exhumed in 1993 and their remains analyzed by physical anthropologists at the University of Winnipeg. Associated artifacts and coffin hardware were analyzed by staff of the Historic Resources Branch, who also conducted historical and genealogical research. Wood fragments from the coffins were identified as white pine (*Pinus strobus*), red pine (*Pinus resinosa*) and spruce (*Picea* sp.). Using dendrochronology, the dates of the burials were estimated as after 1859 for the infant and after 1871 for the adult (Fig. 11). These various analyses indicate that the 9- to 15-month-old infant suffering from a congenital blood disorder, was buried between 1860 and 1890. The elderly male was buried sometime after 1890.

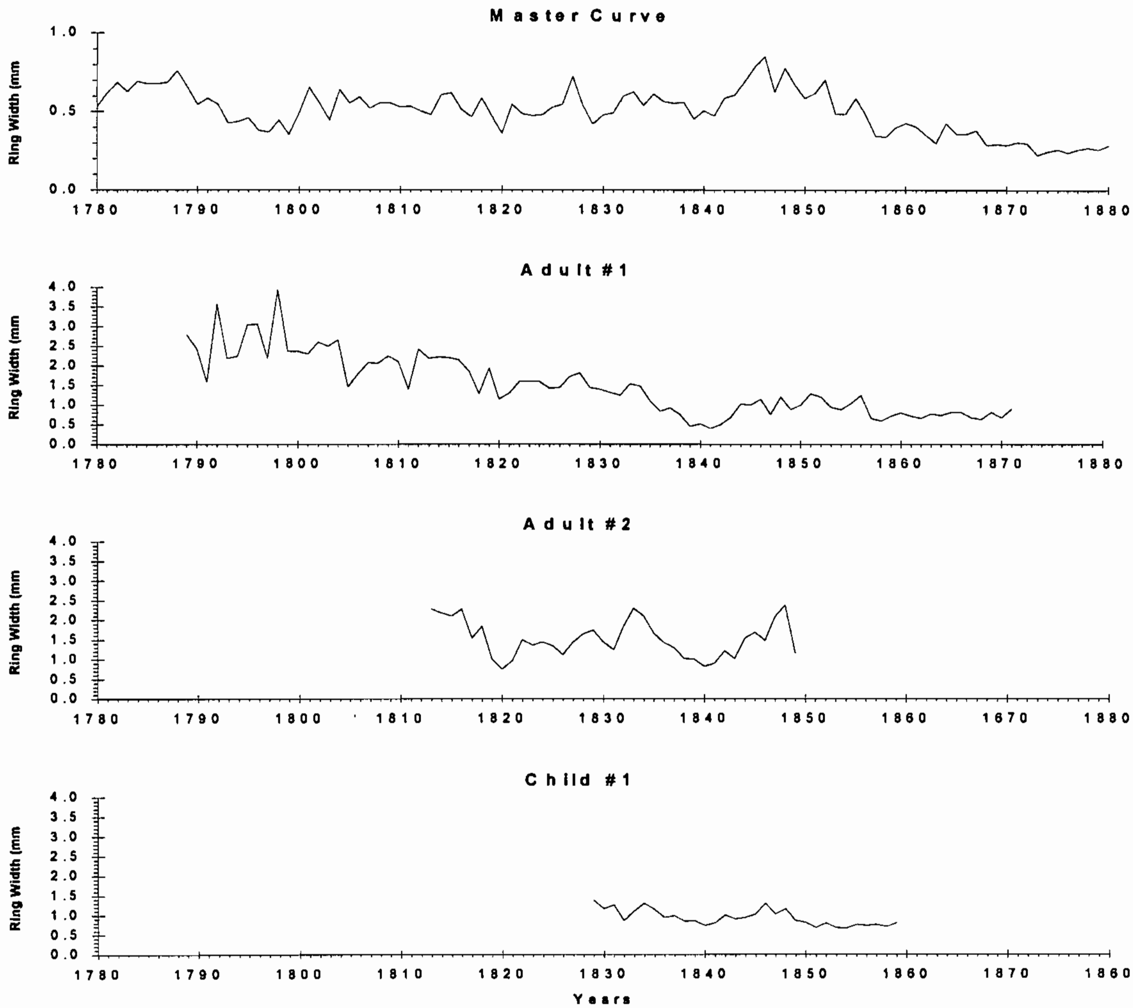

Figure 11. Tree-ring dating of two coffins from St. Andrews cemetary. The coffin boards are cross-dated with a master curve for red pine anchored in 1992 from Granite Lake, Ontario.

From church and genealogical records, these two were identified as Harriet Anderson and her grandfather, James Anderson. Harriet had died in October 1865 at age nine months. James, who had died in January 1896, was 86 years old at time of death. Both were reinterred in 1994 when church repairs were completed. James Anderson's father, also James, had moved into St. Andrew's parish after years of service with the Hudson's Bay Company. He retired in 1821 from Brandon House on the Assiniboine River. The family farm was on lot 98, on the west bank of the Red River, just upstream of the Lockport Dam.

Stop 4: Alluvial terrace and archaeology at Lockport.

First reported by Donald Gunn in 1866, the Lockport Site has been the scene of archaeological excavations for 120 years. The Lockport Site is unique for Manitoba in that it is deeply stratified; approximately eight cultural occupations are present containing the remains of at least four distinct cultures spanning the last 3000 years. Rapids in the Red River at this location provided, as they do today, an excellent fishing location. The site is further distinguished by containing the earliest known evidence for farming on the Canadian prairies (Fig. 12). As well, the northernmost expression of pre-European horticulture on the North American continent was recovered from the excavations. Corn kernels found in occupation levels radiocarbon dated to 1400 A.D. were associated with underground storage pits and hoes made from bison shoulder blades. Some of the storage pits were up to 2 metres deep. Pottery styles diagnostic of Aboriginal farming communities of the upper Mississippi and Missouri river valleys were also recovered. The onset of the Little Ice Age during the fifteenth century is thought to have ended Aboriginal horticulture at Lockport.

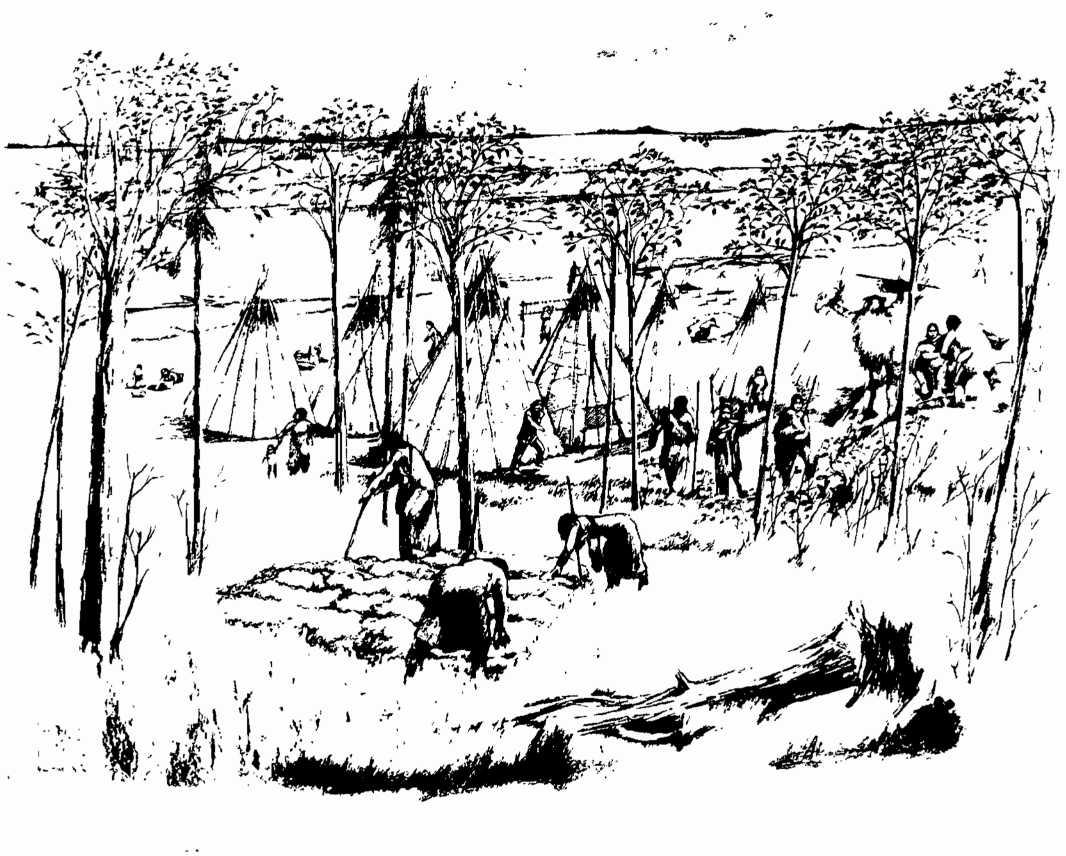

Figure 12. Artist's rendition of a garden being prepared at Lockport. Note the Red River in the background. Courtesy of Manitoba Culture, Heritage and Citizenship.

The sediments exposed along the banks of the river are similar to the overbank sediments observed at the Wright Site. Radiocarbon dating by Buchner (1981) indicates overbank sedimentation has been uniform and continuous throughout the last

3000 years (Fig. 8), unlike that observed at the Wright Site. The lower elevation and the location of the Lockport Site below the rapids may account for the differences in the timing and duration of sedimentation between the two sites.

Stop 5: Lunch at Lower Fort Garry.

Lower Fort Garry was built by order of Governor Simpson to replace Upper Fort Garry. The 1826 flood had seriously damaged the original establishment and construction of a new facility downstream of the Forks was thought a more viable alternative than rebuilding. Simpson chose an area on the west bank of the Red River at the downriver end of Pelican Rapids. This was an attractive site because it was elevated and building materials were readily available on the east bank. Construction of the Big House, or Officer's Quarters, began in the fall of 1830 and was completed by 1832. Other structures, such as the retail store and store houses, were constructed opposite and adjacent to the Big House in the 1830s and 1840s.

Trade at Upper Fort Garry, however, was too well-established to successfully transfer to the lower fort. Therefore, during the first years of its existence, the lower fort remained open primarily to benefit settlers living nearby. During the 1850s, the lower fort gradually became the major provisioning centre for the western Canadian fur trade. This period also coincided with increased industrial and agricultural activities at the fort; ship building facilities and an experimental farm were also operated during the 1850s.

Construction of the rail line in the 1880s diminished the role of Lower Fort Garry as a distribution centre; its importance decreased during the 1880s and 1890s and the fort was officially closed in 1911.

Stop 6: Shoreline erosion and lake level rise at Sans Souci.

Located north of Selkirk, Sans Souci means "carefree". The name was given by a Mr. Callaede to a park on his estate.

A thick sequence of fine textured sediments comprising Lake Agassiz and late Holocene muds are exposed on the lower foreshore at Sans Souci during periods of low water. The Lake Agassiz sediments, exposed at the north end of the beach, consist mainly of nonfossiliferous 'buff' coloured silty clay with large inclusions of ice-rafted till blocks. Iceberg turbate similar to this has been described for areas west of Sans Souci by Nielsen (1989). The upper part of the Lake Agassiz sequence appears to be devoid of iceberg turbate suggesting that the water depth may have been too low for bergs before the final draining of the lake. A prominent southeastward dipping unconformity separates the light coloured Lake Agassiz sediments from the overlying late Holocene organic-rich mud. Infilled desiccation cracks that form polygons 16 to 30 cm in diameter, occur in the top of the Lake Agassiz sediments directly under the unconformity (Fig. 13). Ellis and Shafer (1928) and Christiansen (1959) describe similar features in the Red River Valley and in the Swift Current area in Saskatchewan, and attribute them to desiccation. They believe cracks in the ground open during periods of drought and are subsequently infilled by wind blown topsoil that forms the black wedge or polygon in the otherwise light coloured sediment. A sample of the wedge-filling organic-rich topsoil was radiocarbon dated at 3600 $\pm$ 80 years BP (BGS-1477) (Table

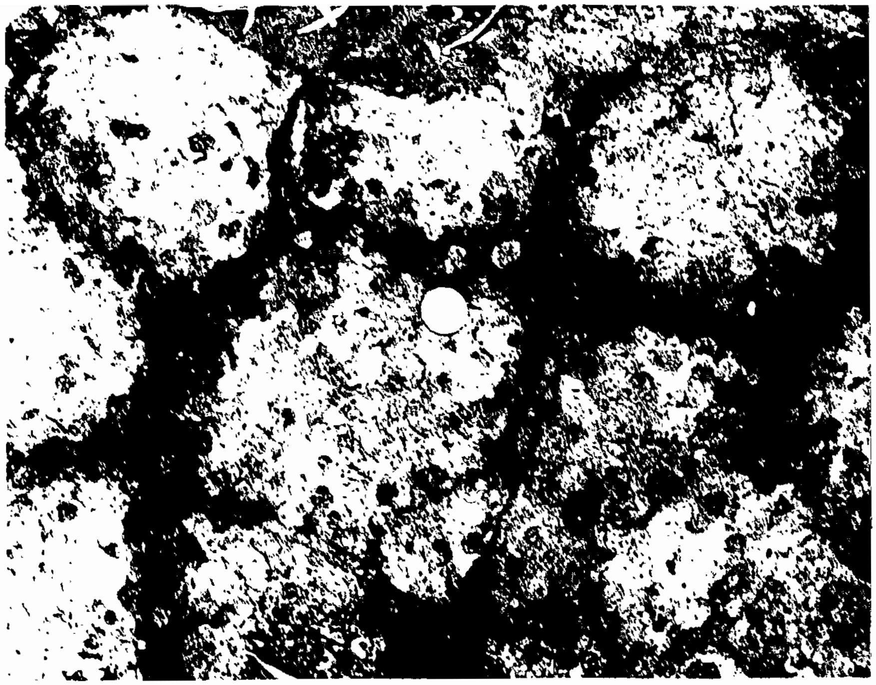

Figure 13. Desiccation cracks in Lake Agassiz sediments exposed on the foreshore at Sans Souci. The black topsoil in the desiccation cracks was dated at 3600 ± 80 years BP.

Figure 14. Marsh facies peat exposed on the foreshore of Lake Winnipeg at Sans Souci during low water. Bulk peat sample dated at 1200 ± 70 years BP.

1) indicating the cracks formed in a subaerial environment during the later part of the much drier mid-Holocene. The late Holocene marsh sediments above the unconformity thicken to the southeast where the unconformity dips below the level of the lake. Consequently only about 50 cm of marsh sediment is exposed on the foreshore (Fig. 14). A sample of fibrous plant material from the lowest exposed marsh sediments at an elevation of approximately 216.9 m asl gave a radiocarbon date of 1200 ± 70 years BP (Table 1) and is the minimum date for the transgression of Lake Winnipeg to this level.

Stop 7: Offshore breakwater and shore protection at Matlock.

Located near the southern end of the South Basin of Lake Winnipeg, the Matlock shoreline is a potentially high energy environment. Winds from the northeast have approximately a 100 km fetch over which to act. Although the relatively shallow nature of the lake limits the development of offshore waves, relatively large wind-driven setups (in excess of 1 m) significantly increase the region of wave inundation.

The shoreline consists of predominantly low sand beaches densely populated with cottages. The annual rate of erosion in this area is typically less than 0.3 m. Littoral drift is from north to south. There is a significant accumulation of sediment near Chalet Beach to the south of Matlock. To mitigate shoreline erosion property owners attempt to "protect" their shoreline. Figure 15 shows a style of seawall that is quite common along the Matlock shoreline. Relative to other methods, this type of shoreline protection is not particularly robust and not very effective. The riprap is typically placed on top of the native material without an underlying filter layer. As a result, the riprap settles into the underlying material allowing the erosion process to continue. During large storms the timbers snap or are overturned.

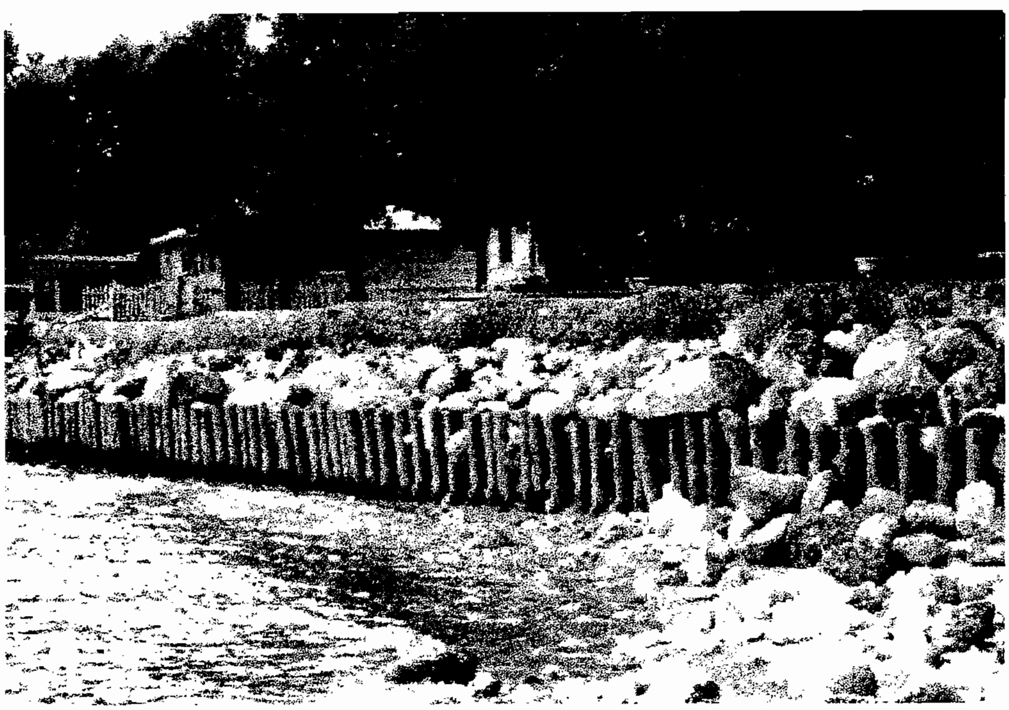

Figure 15. Matlock style of shoreline "protection". Timbers are driven into the beach face and backfilled with graded riprap material. Note the gabion baskets behind the riprap, further reinforcing this property.

This method of shoreline protection suffers the disadvantages of both riprap protection and a seawall. The presence of riprap eliminates the presence of a "beach" while the timber and riprap combination increases wave reflection and enhances scouring.

Figure 16 shows an aerial view of the Matlock shoreline. The section of property seen in Figure 15 is located to the right of the breakwater. The breakwater was built many decades ago to modify the offshore wave field and control shoreline erosion. The relative size of the breakwater and its distance from the shore virtually precludes it from having any affect on the neighboring shoreline. However, the present condition of the breakwater indicates that it has stood the test of time on Lake Winnipeg.

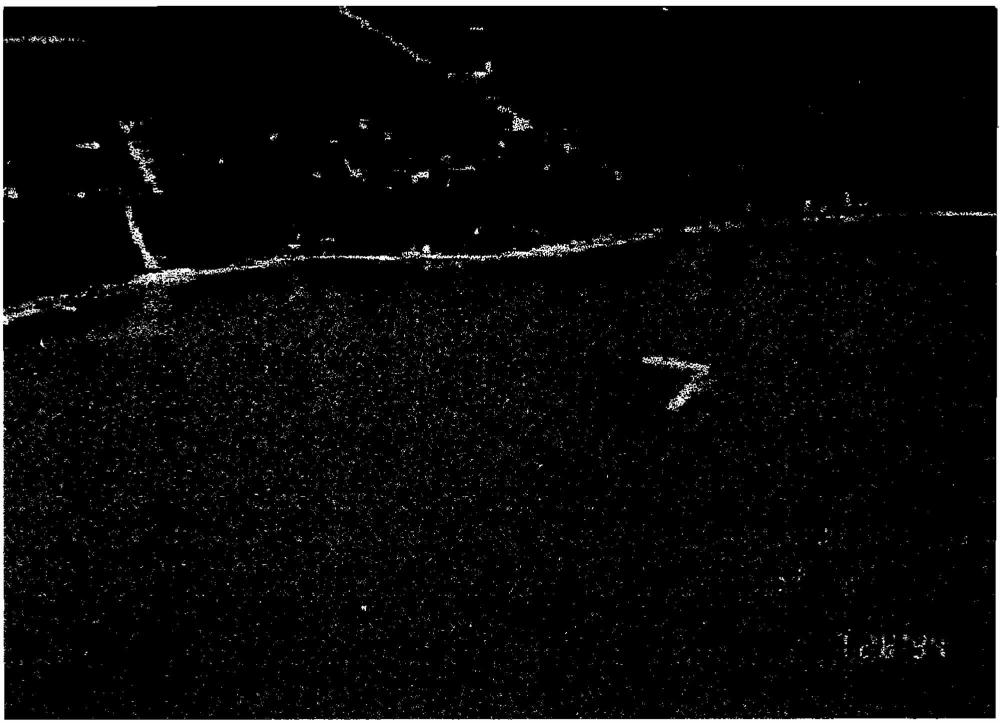

Figure 16. Breakwater just offshore of the Matlock shoreline. The look out pier can be seen at the end of the road cutting across the picture.

Stop 8: Transgressive barrier beach at Willow Point.

Willow Point is the most prominent feature along the west side of the South Basin of Lake Winnipeg. The point is located south of the town of Gimli. Forbes and Frobel (1996) note the point itself consists of a boulder shoal, presumably developed by winnowing of shallow till or other coarse glacial sediments. Anchored to this headland is a transgressive barrier on the north side with a relatively protected, sediment starved, thin marsh/lagoon on the south side. The point is connected to the western shore by a narrow causeway. Figure 17 shows the riprap placed to the north side of the causeway to protect this fragile strip of land from wave attack. The causeway was nearly breached in October of 1993 following a storm that lasted more than two days, with winds reaching nearly 80 kph.

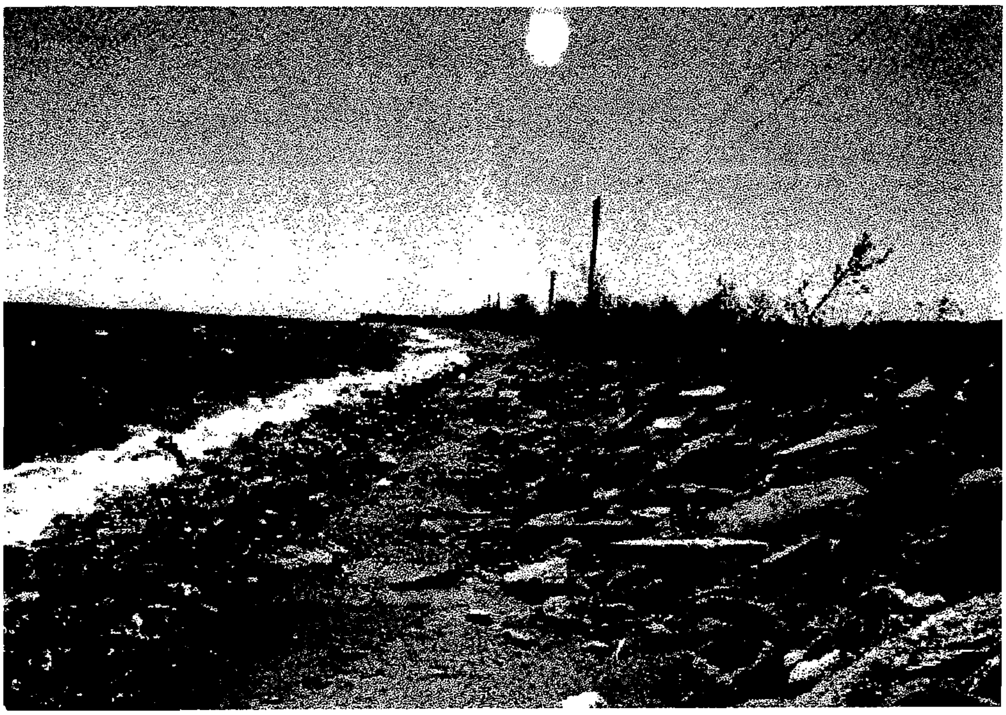

Figure 17. North side of Willow Point causeway looking east towards Lake Winnipeg.

The erosion of the causeway was likely exacerbated by the construction of the Gimli breakwater, which interrupts the southward drift of littoral material. The causeway is the only land link to the headland and is therefore vital to the extensive residential development on the north face of the point. Although the shoreline on the north face of Willow Point is relatively dynamic, the general absence of protective works suggests it is relatively stable.

Stop 9: Shoreline erosion north of Gimli.

Some of the highest rates of erosion around the southern basin of Lake Winnipeg occur along the shoreline just north of Gimli (Fig. 18). Figure 19, just north of Gimli, shows the 3 to 4 m high cliffs that are typical of the area.

The predominant mechanism of erosion occurs when waves undercut steep cliffs, followed by a large slump which is then readily washed away. Erosion rates of 3 to 4 m/yr are typical for this area. The cliffs in this region consist primarily of glaciolacustrine sediments fronted by narrow beaches consisting of sand and gravel. Since this photograph was taken, the property owner has dumped solid fill material at the base of the cliff to try and reduce the undercutting by waves.

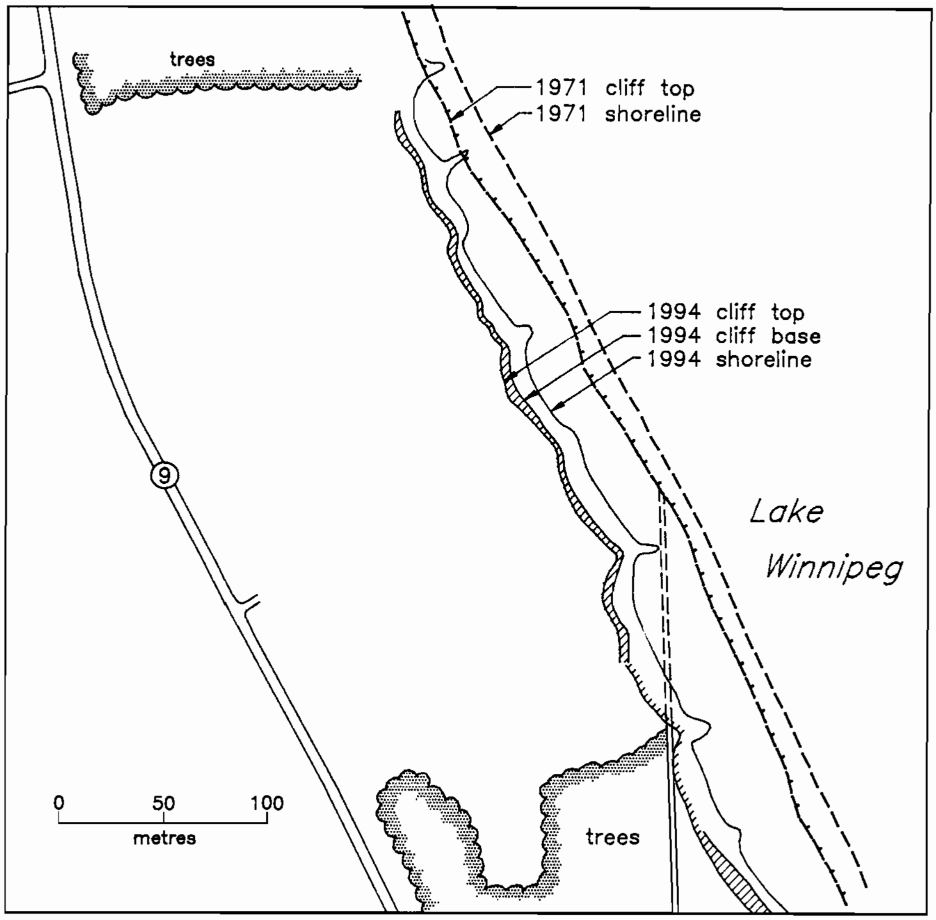

Figure 18. Location of the 1971 and 1994 Lake Winnipeg shorelines north of Gimli (from Forbes and Frobel, 1996).

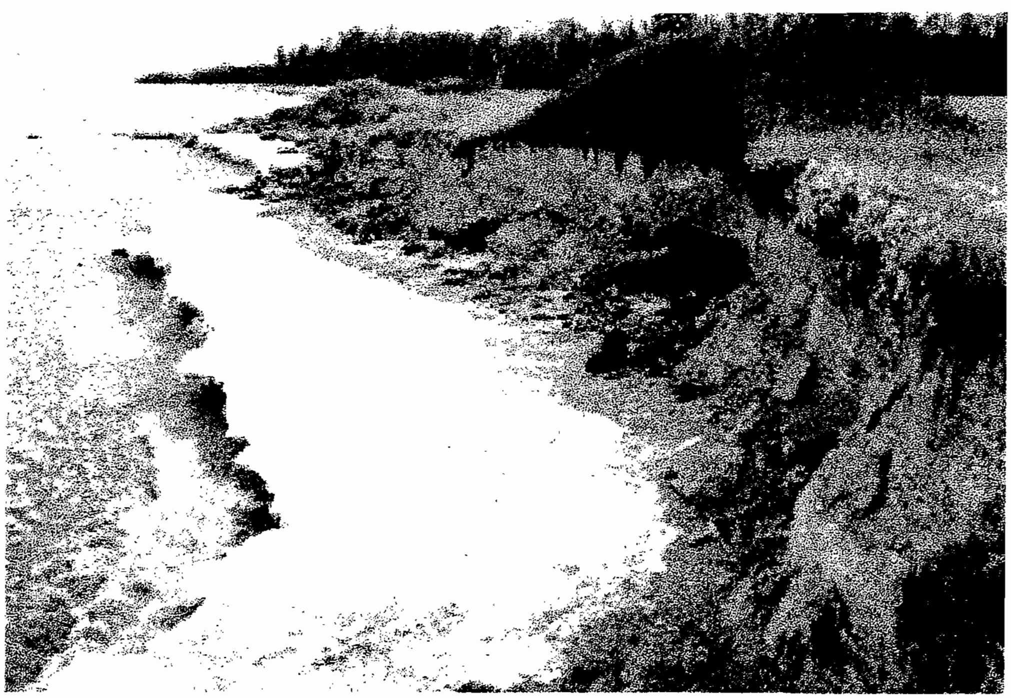

Figure 19. Eroding cliffs north of the town of Gimli. View looking south.

Stops 10 and 11: St. Andrews Bog - a drained wetland.

The Red River Valley has poor natural drainage as the result of the high clay content of the soil and the flat topography of the Lake Agassiz clay plain. Without drainage and flood protection, an estimated 60% of the land would be subject to periodic swamping. In the Red River Valley, wetlands have been reduced to only about 1% of their former extent through a variety of drainage channels established during the last hundred years (Fig. 20).

Oak Hammock Marsh is a small remnant of a much larger wetland known as “St. Andrews Bog” or “The Bog” that existed southeast of Teulon a century ago (Fig. 20). Mr. E. C. Callery, who surveyed Township No. 15, Range 3 east of the principal meridian in 1873 reports

"The face of the Country in this Township is generally low and level with very rich soil, being a strong clay mixed with loam, there is a large quantity of the best quality of Hayland. There is very little timber in this Township. There are groves of small poplar with some scattered oak.

Part of a very extensive Marsh runs through the centre of the Township, which is not passable for Cattle or Horses, the greater part of it could not be surveyed as it was too deep in places to get through, where it was possible to run lines and plant the posts, I have made a survey."

Except for the 250 hectares comprising Oak Hammock Marsh, the 47000 hectares of "The Bog" was drained for agricultural land in the early part of the twentieth century. One of these drainage ditches can be seen at Stop 10.

If time permits, a short visit will be made to Oak Hammock Marsh (Stop 11) on the return to Winnipeg. Ducks Unlimited Canada has developed Oak Hammock Marsh since the early 1970s. The marsh supports hundreds of thousands of staging waterfowl and provides habitat for a wide range of plants and animals. The marsh is a time capsule reminiscent of what much of the Red River Valley must have been like before the middle of the last century.

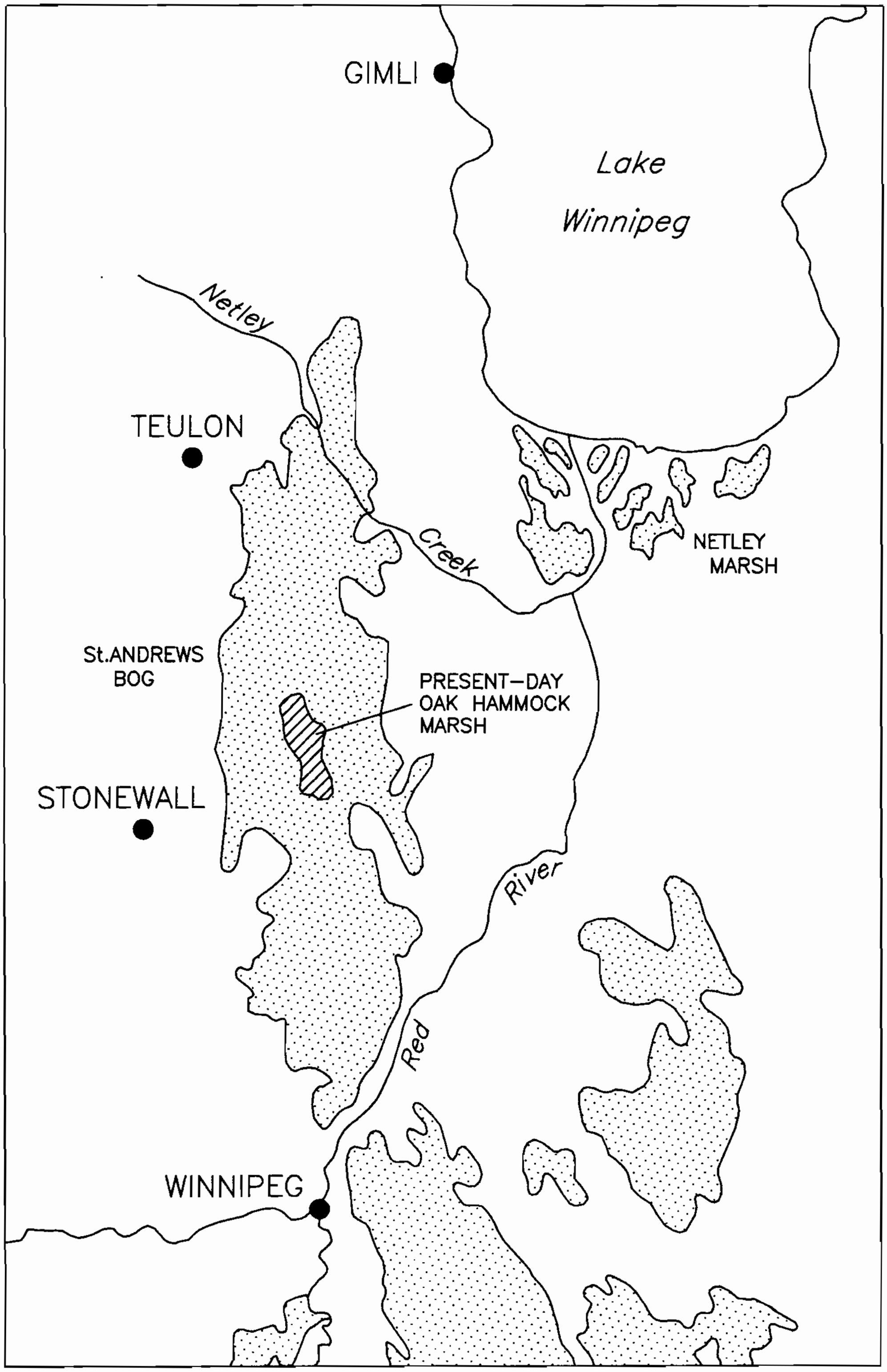

Figure 20. Distribution of wetlands in the lower Red River Valley in the late 19th century.

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NOTES

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