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Preface
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Preface

DRYLANDS: HOLOCENE CLIMATIC, GEOMORPHIC, AND CULTURAL CHANGE ON THE CANADIAN PRAIRIES

This Drylands special issue of *Géographie physique et Quaternaire* (*GpQ*) originates from the Great Plains Geomorphology and Environmental Change session, convened at the May 2002 annual meeting of the Geological Association of Canada / Mineralogical Association of Canada (GAC/MAC) in Saskatoon. Presentations at this session represented a convergence of research activities on the Canadian prairies including studies of flood hazards in the Red River basin, historical and Holocene drought on the Canadian prairies, and interdisciplinary geoarcheological investigations contributed by SCAPE (Study of Cultural Adaptations in the Prairie Ecozone) participants. The session was co-sponsored by the Canadian Geomorphology Research Group (CGRG), Geological Survey of Canada (GSC) and the International Geological Correlation Programme project (IGCP-413) on Understanding Future Dryland Changes from Past Dynamics.

Although for most Canadians, drylands may bring to mind the arid regions of the Sahel, western Australia, or American southwest, it is the term that accurately describes the Canadian prairies. Technically speaking, drylands include the dry subhumid, semi-arid and arid regions of the world where the ratio of annual precipitation to evapotranspiration (P: PE) is below 0.65, but not the desert, or hyper-arid, regions of the world where this ratio is below 0.03. Drylands cover nearly 40 % of the total land surface of the Earth. The Canadian prairies share much in common with other drylands of the world; they are a place of modest water supply, with less than that of forest regions but more than that of deserts, characterized by grassland, steppe and parkland, where dry-farming agriculture is an economic activity that dominates rural land use.

A common characteristic of dryland regions, where rainfall is typically less than about 500 mm per annum, is the variability in seasonal and annual precipitation. Paradoxically, this variation commonly results in either “too much or too little water”. The first volume in this issue centres on this theme, with papers divided into two sets. The first set of four papers deals with the hydrological reconstruction of river and lake basins on the Canadian prairies, and with flood reconstruction in the Red River and Assiniboine basins. The second set of three papers deals with the reconstruction of episodes of dune activity, and the implications for changing aridity on the Canadian prairies during the Holocene.

The first paper, by Last and Teller, attempts to unravel the complex Holocene history of Lake Manitoba, which has been influenced by differential isostatic uplift, variable river and groundwater inflow, and changing climate. The reconstruction of lake level changes through time is assisted by radiocarbon dating, and mineralogical, geochemical and lithostratigraphic analyses. The history of the lake basin begins with isolation from glacial Lake Agassiz at about 8500 BP and re-filling of the basin by 7700 BP, followed by re-routing of inflow from the Assinibone River by 4500 BP and later re-flooding in the late Holocene starting at about 3500 BP. The second paper, by Oetelaar, provides a reconstruction of the evolution of the Bow River Valley during the Holocene. In much the same manner as Last and Teller, the author finds that the history of incision and aggradation has been controlled by changes in rates of isostatic rebound, in base level, and in discharge into the drainage system. This history includes an early interval of aggradation between 11 500 and 10 000 BP resulting from multiple controls, followed by fluvial incision between 10 000 and 9000 BP in response to increased runoff, a second phase of aggradation originating as floodplain overbank deposits between 9000 and 5000 BP in response to increased sediment availability and reduced stream power, and a final phase of downcutting initiated around 5000 BP in response to wetter climatic conditions. Whereas change in fluvial and lacustrine systems has been significant during the Holocene, change in the latter part of the late Holocene appears to have been comparatively minor.

The subsequent two papers focus on aspects of floodplain evolution and flooding in Manitoba. First, is a study by Brooks of floodplain chronology and vertical sedimentation rates along the Red River. Unlike the longer recorded history of other prairie basins, cores retrieved along a section of the Red River reveal that the oldest floodplain deposits are of mid-Holocene age, suggesting that most meanders have experienced only a single sequence of lateral channel migration. Lateral channel migration rates along the Red River are significantly lower than those of rivers associated with higher energy sand- and gravel-bed rivers. As well, vertical sedimentation rates of overbank deposits along meanders have generally decreased in the late

Holocene, although a marked increase in modern sedimentation rates may be the result of increased fluvial erosion due to the introduction of European agricultural practices beginning in the 19thcentury. Second, St. George and Nielsen describe how they have used tree-ring evidence to develop paleoflood records of the Red and Assiniboine rivers in Manitoba. Tree-ring evidence documents high flood modes for the lower Red River basin during the mid-1700s, the early to mid-1800s, and the latter half of the 20th century. Although records for the Assiniboine River and the American portion of the Red River are developed from fewer trees, they suggest that severe floods along these rivers have coincided, albeit infrequently, in the past 500 years. From these papers we find that, although the basic morphology of the Red River basin has changed little during the latter half of the Holocene, it remains highly susceptible to severe flooding.

The subsequent three papers focus on records of sand dune activation and stability on the prairies and the reconstruction of associated arid and humid climatic episodes during the Holocene. First, Lian *et al.* describe how optical stimulation luminescence dating of K-feldspar grains is used to determine the time of eolian deposition on the Canadian prairies. Accurate optical ages ranging from 150 years to more than 11 ka are determined with precision typically better than 10 % at 2σ. Subsequently, Wolfe, Huntley and Ollerhead test the accuracy of optical dating technique and develop a record of sand dune activation and stability for the Brandon Sand Hills, Manitoba. "Zero-age" samples are found to have an uncertainly of ± 40 years, whereas ages of modern dune samples are consistent with expectations. Similarly, optical ages of late Holocene dune sands are consistent with published radiocarbon ages from similar sand dunes in the Canadian prairies (and adjacent portions of the United States). Episodes of sand dune activation in the Brandon Sand Hills are identified at about 2.0 ka, 3.1 to 4.0 ka, and prior about 5.2 ka, interspersed with intervening episodes of soil formation and landscape stability. Lastly, Wolfe, Ollerhead and Lian combine the derived optical ages of Lian *et al.*, with published optical and radiocarbon ages to develop a chronology of dune activation for much of the southern Canadian prairies. In south-central Saskatchewan, infilling of the Qu'Appelle River Valley by sand dunes is documented for the period between 5.7 ka and 215 years ago, and cliff-top eolian deposition is documented at about 5.2 ka and prior to 2.7 ka. Published ages from sites across the prairies provide evidence for sand dune activity in both the early and late Holocene. Evidence of mid-Holocene sand dune activity is rarely observed. An absence of mid-Holocene eolian deposits is interpreted as a result of extensive eolian reworking during that time, in response to mid-Holocene aridity, rather than due to extensive eolian re-working in the late Holocene. The authors speculate that mid-Holocene eolian deposits may be preserved within some as yet uninvestigated depositional basins on the southern Canadian prairies, and at sites near the boreal forest ecozone-prairie ecozone boundary.

The second volume of this Dryland Issue is focused on the issue of drought, and on the paleoenvironmental contexts associated with Holocene cultural occupations within the prairie ecozone. Presently, the most arid regions of the prairies experience, on average, dry sub-humid conditions ($0.65 \geq$ P:PE ≥ 0.50), although they frequently experience semi-arid conditions ($0.50 \geq$ P:PE ≥ 0.35) during times of drought. It is this variability in the prairie climate that is of primary interest to paleoecological investigators and to those studying future climate change. The authors of the first two papers in this second volume of the Drylands Issue explore the issues of drought and aridity on the Canadian prairies from these two perspectives.

In the first paper, Beaudoin discusses the identification and characterization of drought and aridity in postglacial paleoecological records from the Northern Great Plains. Although paleoenvironmental records have been used to extend the record of drought history derived from the instrumental record, few studies have explicitly defined drought in the context of Holocene climatic variability. Beaudoin reviews the operational definitions of drought, and evaluates proxy records with regard to their utility in distinguishing between drought and aridity. She concludes that drought is a short-term phenomenon of usually less than five years, and mostly less than two years. Conversely, longer sustained dry intervals lasting more than a decade reflect a shift to aridity. She notes that many paleoecological investigators use the term drought inappropriately, to describe arid intervals derived from proxy records. Beaudoin suggests that high-resolution (*i.e.* annual to sub-decadal) paleoenvironmental proxies from tree-ring and some lake records are suitable for investigating drought history, whereas most lake-records sampled at lower resolution (*i.e.* decadal to sub-century) are more suitable for investigating changing aridity.

In the second paper, Sauchyn *et al.* reveal that modern climate normals are not representative of the full range of potential climatic conditions, even in the absence of increased CO_2-induced global warming. Rather, the climate of the 20th century was anomalous in terms of the absence of sustained drought, and that of the climate normal period 1961-1990 was, perhaps, the most benign of the past 750 years. Using the Canadian Global Circulation Model (C-GCM) forecasts, an approximately 50 % increase in the area of sub-humid climate and a pronounced area of semi-arid climate could occur by the 2050s. The authors suggest that an additional effect of global warming may be to return the prairie climate to former conditions in which aridity persisted for intervals of decades or more.

The final five papers in this Drylands Issue are derived from the SCAPE project. This is an interdisciplinary project examining indigenous cultural response to changes in the climate and ecology of the Canadian prairies during the Holocene. From a geomorphic perspective, the pretext of the project is that human groups have used some locales, characterized by greater geomorphic complexity within the Canadian prairies, more so than the surrounding grasslands. Locales such as sand hills, meltwater channels, glacial moraines and bed-rock controlled uplands, by virtue of their geomorphic and topographic complexity, exhibit ecological complexity and include wide ranges of resources of potential use by human groups. As well as understanding the ways environmental conditions in these locales influenced indigenous cultures, an important goal of the project is to

decipher the impact human groups had on their environment. Past human groups should not be considered passive observers in these locales. At various times in the past, they foraged and hunted, built homes and prepared fields for horticulture, and promoted prairie fires to manage the movement of bison herds. Therefore, the role of anthropogenic activities must be considered when causal mechanisms for paleoclimatic and paleoenvironmental change observed in proxy-records are investigated. The SCAPE project focuses on four ecologically complex, and archeologically-rich localities within the Canadian prairies, for the purpose of reconstructing the natural and cultural landscape in these areas. These areas are the confluence of the North and South Saskatchewan rivers in Saskatchewan, the Tiger Hills in west-central Manitoba, the Cypress Hills in southern Alberta and Saskatchewan and the Glacial Lake Hind Basin of southwestern Manitoba. The following papers present SCAPE research conducted to date in the Cypress Hills and the Glacial Lake Hind Basin.

The Cypress Hills rise more than 600 m above the surrounding plains and contain an abundance of natural resources including water, forests and wildlife. One of the focus sites for SCAPE researchers within the Cypress Hills is the Stampede archeological site. This is a thick archeological deposit, situated on an alluvial fan within the Elkwater meltwater channel along the northwestern flank of the Cypress Hills. The site contains multiple occupational levels starting at about 7200 BP. The first paper, by Robertson, describes a study to investigate the stratigraphy and geomorphic history of the Cypress Hills in the vicinity of the Elkwater meltwater channel for the purpose of identifying locations with the potential to contain archeological sites similar to the Stampede site. Robertson finds that meltwater channels, and other fluvial channels along the flanks of the Cypress Hills appear to have experienced intermittent deposition of sediment transported from upslope, alternating with episodes of landscape stability and soil formation. She further concludes that the abundance of archeological material encountered in these settings suggests they were indeed attractive to indigeneous groups, and that the Stampede site may not be unique. The second paper, by Wiseman *et al.*, investigates the Holocene paleoenvironmental history of Elkwater Lake. Elkwater Lake is located within the Elkwater meltwater channel. They conclude that the lake formed no earlier than 9440 BP as result of impoundment by one of two large landslides west of the present-day lake, and that its highest early Holocene elevation was attained prior to 7245 BP when an outlet was established at the northeast end of the lake at Feleski Creek. During the mid-Holocene the lake became a closed-basin as water levels dropped. The northeastern outlet was cut-off by the deposition of an alluvial fan between 7245 to 5000 BP, within which the Stampede archeological site is situated. A subsequent outlet was established during a second highwater stand in the late Holocene, through the present-day outlet of Ross Creek. The authors suggest that, owing to the close proximity to the lakeshore, the Stampede archeological site was probably an attractive site for human occupation during and after the fan aggraded during the mid- to-late Holocene.

The final three papers focus on paleoenvironmental and lifeway reconstructions in the Glacial Lake Hind Basin and the Tiger Hills of southwestern Manitoba. The first paper, by Running *et al.*, provides an overview of stratigraphy and paleoenvironmental reconstruction derived from a section exposed in a Souris River cutbank in the Lauder Sand Hills of the Glacial Lake Hind Basin. The section provides the most complete postglacial stratigraphic section in the basin, and one of the only exposures of mid-Holocene dune deposits in the prairie ecozone. It includes two distinctive eolian units, separated by a fluvial unit with multiple buried soil profiles ranging in age from 5.5 to 3.2 ka BP, and underlain by low-energy fluvial and glaciolacustrine sediments that record the recession of Glacial Lake Hind and the establishment of the Souris River between 10.5 and 6.7 ka BP. The lower eolian unit records dune slipface deposits indicative of net sand-moving winds from the west-southwest, in contrast to the dominant present-day winds originating from the northwest. The upper eolian unit is up to 7 m thick, and records multiple blowout-and-fill sequences suggestive of episodic stabilization and reactivation during the late Holocene, with orientations conformable with present-day transporting winds. Interpretations from this section suggest that early inhabitants of that area may have focused on exploiting wetlands and wet meadows until about 9.2 ka BP, and a dune-dominated landscape thereafter.

In the second paper, by Wallace, stratigraphic investigations are undertaken within several dune fields in the Oak Lake region of the basin. Lithologic sections reveal eolian sand sheets and dune deposits, up to 7 m thick, underlain by a sequence of unconsolidated sediments consisting of coarse-to-fine sand and black shaley gravels of fluvial origin or silty-clay lacustrine sediments. The eolian sediments can be divided, based on lithologic and pedologic characteristics, into a basal eolian unit containing organic laminations but without buried soil profiles, and an upper eolian unit without organic laminations but containing multiple buried soil profiles. Three radiocarbon ages obtained near the base of the upper eolian unit are similar to those derived from other dunes in southwestern Manitoba, and are indicative of late Holocene eolian activity. Orientations expressed by the surface morphology indicate migration of dunes towards the southeast, consistent with modern wind directions, suggesting the most recent dunes formed under a climatic regime similar to that experienced at present. Wallace concludes that, in general, the lithologic units he observes in a number of dune fields across the Glacial Lake Hind Basin are lithologically and chronologically consistent with those observed at Flintstone Hill.

The final paper, by Nicholson *et al.*, provides a reconstruction of the lifeways of the Vickers focus people. These were a northern Great Plains people who first appear in the archeological record of southwestern Manitoba by about AD 1400. Evidence of the Vickers focus people has been found in southwestern Manitoba in two widely scattered clusters. The earlier, eastern cluster of sites is found within the glacial moraine uplands of the Tiger Hills, whereas later, western cluster of sites (*ca.* AD 1500) is found within the Lauder Sand Hills of the Glacial Lake Hind Basin. Despite the apparent geomorphic differences between these two areas, both are characterized by ecological complexity, and similarities in local site selection preferences exist. In both locales, Vickers Focus people exhibited a preference for ecologically complex, resource-rich areas within the Aspen

parkland ecotone, near small pothole water sources, and in the eastern cluster, close proximity to well-watered soils on southern exposures; the later suggesting a lifeway supported, in part, by horticulture. It appears that the Vickers focus people may have shifted from foraging/horticultural subsistence in the Tiger Hills to intensified foraging in the Lauder Sand Hills, but they retained a preference for sites associated with ecologically complex settings. In particular, they preferred ecologically complex settings located away from major streams, lakes and other travel routes, potentially as an avoidance strategy to reduce chance encounters with neighbouring groups.

In all, these papers provide insight into Holocene geomorphic processes, climate and cultural change in the Canadian prairies. Whereas much of the emphasis of this research is on the past, it is clear that the potential for significant environmental and geomorphic change in the future exist, and that cultural adaptations to climate change will continue within Canada's drylands.

As a final word, we are appreciative of the staff at *GpQ* for the consideration, professionalism and timeliness that they have shown in preparing this Drylands Issue.

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