GEOARCHAEOLOGY OF BOREAL FOREST DUNE-WETLAND COMPLEXES
PROJECT SUMMARY

Introduction

Stabilized aeolian (i.e., windblown) sand dune fields in the Boreal Forest ecoregion of northwestern Canada contain hundreds of pre-European contact archaeological sites. These sites yield significant artifact assemblages, but their chronological and environmental context is largely unknown due to a lack of organic materials that can be radiocarbon dated. Without this information it is difficult to understand how humans used these unique landscapes through time. Here we develop a new geoarchaeology-based approach to assessing the temporal and paleoecological context of aeolian archeological sites in the Boreal Forest. This approach focuses on interdune basins; sediment traps that are more likely to contain datable material than dune ridgetops, where most study has been undertaken. The main objectives of the research program are: 1) to determine how Boreal Forest interdune sedimentary sequences developed through time, and 2) to evaluate the potential preservation of datable archaeological sites in interdune settings. This will be achieved by conducting archaeological survey and developing spatiotemporal models of peatland expansion and dune reactivation in interdune basins at two sites in northern Alberta: The Smoky River near Grand Prairie, Alberta and Lesser Slave Lake, Alberta. The models will be developed using a blend of geophysical (ground penetrating radar), geochronological (radiocarbon and luminescence dating) and archaeological methods (survey, artifact analysis).

The absence of datable material in boreal aeolian sites is partially attributable to archaeological survey patterns. Most survey to date has focused on dune ridgetops, a topographic setting that favours erosion of sediment and the development of acidic soils that accelerate organic decay. Our research switches focus to interdune basins, the low-lying terrain between dune ridgetops. These areas serve as sediment traps, where organic and mineral sediment collects, rather than erodes. The lower topographic setting also promotes wetter soil conditions that aid the preservation of organic material. Interdune basins in the Great Plains and Great Lakes regions have yielded datable archaeological sites and paleoenvironmental sequences that span at least the last 6,000 years. Boreal Forest dune sites in Alaska have also yielded dated paleosol (i.e., buried, ancient soils) sequences and archaeological sites from 12,500 years ago. Despite this potential, there has been no systematic geoarchaeological study of interdune deposits in the boreal forest of northwestern Canada.

This research will have an impact within the archaeological community by providing the first formal assessment of the potential of interdune areas to contain sites. This can in turn inform cultural resource management (CRM) field practice, which is largely focused on a limited subset of raised landform types. It is currently unknown if significant sites located in settings like interdune basins are being impacted. Broadening the coverage of archaeological assessment will increase certainty in regulatory decisions. CRM professionals owe this to the development of archaeology and more importantly, to the descendants of the Indigenous groups that left their archaeological signature on the landscape. A clearer understanding of interdune depositional processes will also provide and assessment of how sensitive boreal dune-wetland complexes are to present and future climate change. Uses of our data in this manner can help determine land management practices and the impact of climate change on the archaeological record in these settings.

Funding and Personnel

The project is funded by a SSHRC Insight Development Grant and will run from July 2023 to July 2025. The project is led by Robin Woywitka (Physical Sciences, MacEwan University) in collaboration with Alberto Reyes (University of Alberta), Liam Wadsworth (University of Alberta), Krista Gilliland (Western Heritage Inc.) and Vincent Jankunis (Ember Archaeology Ltd.). One MSc and three undergraduate researchers will participate in the research (Table 1).

Methods

The Smoky River and Lesser Slave Lake dune areas were selected because they are rich in dune ridgetop archaeological sites, have well developed peatlands in interdune basins and are located in settings that have a high likelihood of preserving reactivation events. In the case of the Smoky River dunes, the selected interdune basins are enclosed and occur on the lee side of large dunes, ensuring an ample potential sediment supply. The interdune chronology derived in this study can also be tied back to the age of the initial stabilization of these dunes is known from luminescence dating (ca. 14,000 years ago; Wolfe et al. 2004). The Lesser Slave Lake dunes are located in two sites: one on the modern eastern shore of Lesser Slave Lake and another on an ancient lake margin farther east of the lake. These dune fields have elevated potential for preserving dune reactivations because they have a rejuvenating sediment supply from the lake margins. An additional aspect of this site is that reactivations can be tied to lake level fluctuations, a process that can affect the preservation and erosion of archaeological sites on the margins of Lesser Slave Lake (Le Blanc 2004). No previous dating has been done for these dunes, so luminescence analysis of dune stabilization is proposed here as part of the interdune geochronology work.
The work will be completed in three components, outlined below.

Component 1: Archaeological survey of interdune peatland margins. We will perform a systematic survey of the margins of the three interdune basins placing shovel tests on transects from the foot of the dune slope into the wetland until shovel tests infill with water. The number of transects and test holes will be determined based on field conditions. The goal of this phase is to assess the potential for sites located in interdune basins that can be detected with traditional archaeological methods.

Table 1. Summary of project funding and personnel

Geoarchaeology of Boreal Forest Dune-Wetland Complexes			
Funding			
Source	SSHRC Insight Development Grant		
Duration	Two years (starting June 1, 2023)		
Amount	Year 1: $37,155	Year 2: $30,839	Total: $67,994
Team			
Member	**Affiliation**	**Role**	**Tasks**
Robin Woywitka	MacEwan University	Lead	Research lead, student supervision
Alberto Reyes	University of Alberta	Co-applicant	RC dating, wetland modeling, student supervision
Krista Gilliland	Western Heritage	Collaborator	IRSL dating
Vince Jankunis	Ember Archaeology	Collaborator	Archaeology
Liam Wadsworth	U of A	Collaborator	GPR
MSc Student	U of A / MacEwan	HQP	Wetland modeling
Undergrad Student	MacEwan University	HQP	Fieldwork / IRSL
Undergrad Student	MacEwan University	HQP	Fieldwork/Artifact Analysis
Undergrad Student	MacEwan University	HQP	Fieldwork / GPR

Component 2: Geophysical modeling of interdune basins. In order to create accurate models of lateral peatland expansion, it is necessary to understand underlying basin topography. Peatlands do not always expand in a uniform manner from central nucleation zones; lateral expansion may be impeded by bumps or depressions on the basin surface and surface

gradients. Knowing the shape of the basin is therefore necessary to design a sampling strategy that accurately reflects expansion in time and space. This will also inform what type and age of archaeological sites might be found at the mineral-peat interface. We propose imaging basin morphology using a 100Mhz rough terrain antennae (RTA) ground penetrating radar (GPR) system. This system and frequency enabled Shulba (2021) to successfully image the basin topography of a peat-submerged basin near Mariana Lakes, Alberta. We will conduct the GPR survey in winter, with the instrument mounted on a sled so that surface roughness is as low as possible during data collection. Image analysis will be completed using the open source RGPR software.

Component 3: Stratigraphy and geochronology of interdune deposits. Peat cores will be collected using a "Belarus" coring equipment (Shotyk and Noernberg, 2020). Coring transects will extend from nucleation depressions identified in Component 1 to the margins of the peatland. Expansion rates will be derived from basal radiocarbon ages extracted from the peat cores. Plant macrofossils for dating will be selected from as near the peat-mineral sediment interface as possible. Radiocarbon analysis will be completed at the A.E. Lalonde Accelerated Mass Spectrometry (AMS) laboratory. Samples will be prepared using standard physical and acid-base-acid pre-processing procedures. Standard AMS dating techniques will be used to measure the radiocarbon age. Radiocarbon ages will be calibrated using the most recent version of OxCal (Bronk-Ramsey, 2001). Expansion rates will also be modeled in Oxcal, using Bayesian methods (Bronk-Ramsey, 2009). This process increases the reliability of individual ages, and allows the user leverage a priori information, such as stratigraphic order, to increase the accuracy of sedimentation and expansion rates (Bronk-Ramsey, 2009).

Reactivation episodes will be detected by examining peat cores for sandy interbeds. Because peat and sand have very distinct visual, magnetic and density signatures, measurements of these factors can be used to differentiate organic and mineral sediment. A Geotek Core Scanner at the Permafrost Archives Laboratory, University of Alberta will be used to derive image, magnetic susceptibility and bulk density data for a subset of the cores obtained in the field.

At both Lesser Slave Lake sites samples for portable Optically Stimulated (pOSL) and full OSL dating will be obtained from dune crests in light-safe conditions. Environmental samples for the calculation of dosimetry will be collected. The pOSL samples will be taken at 5cm intervals and stratigraphic coherence of luminescence properties will be used to determine the placement of the optimal sample for full OSL dating. Selection of quartz or feldspar targets will be made upon initial evaluation of the sample at the University of St. Andrews luminescence lab. Luminescence measurements will be made using a Risø TL-OSL DA-20 reader. Dose rate calculation will follow (Durcan et al., 2015).

Student Roles

Undergraduate Research Assistant #1: This student will provide assistance in the archaeological aspects of the project. They will participate in the planning and execution of the archaeological survey of interdune peatland margins in the summer of Year 1. During this activity they will learn how to design a sampling program, manage field logistics, keep archaeological field records, use Global Positioning Satellite (GPS) technology to record field data, and use Geographic Information Systems (GIS) to create spatial data that meet the requirements of the Archaeological Survey of Alberta. During the Fall Term of Year 1, this student will complete artifact analysis and cataloging, and assist in writing the archaeological permit report.

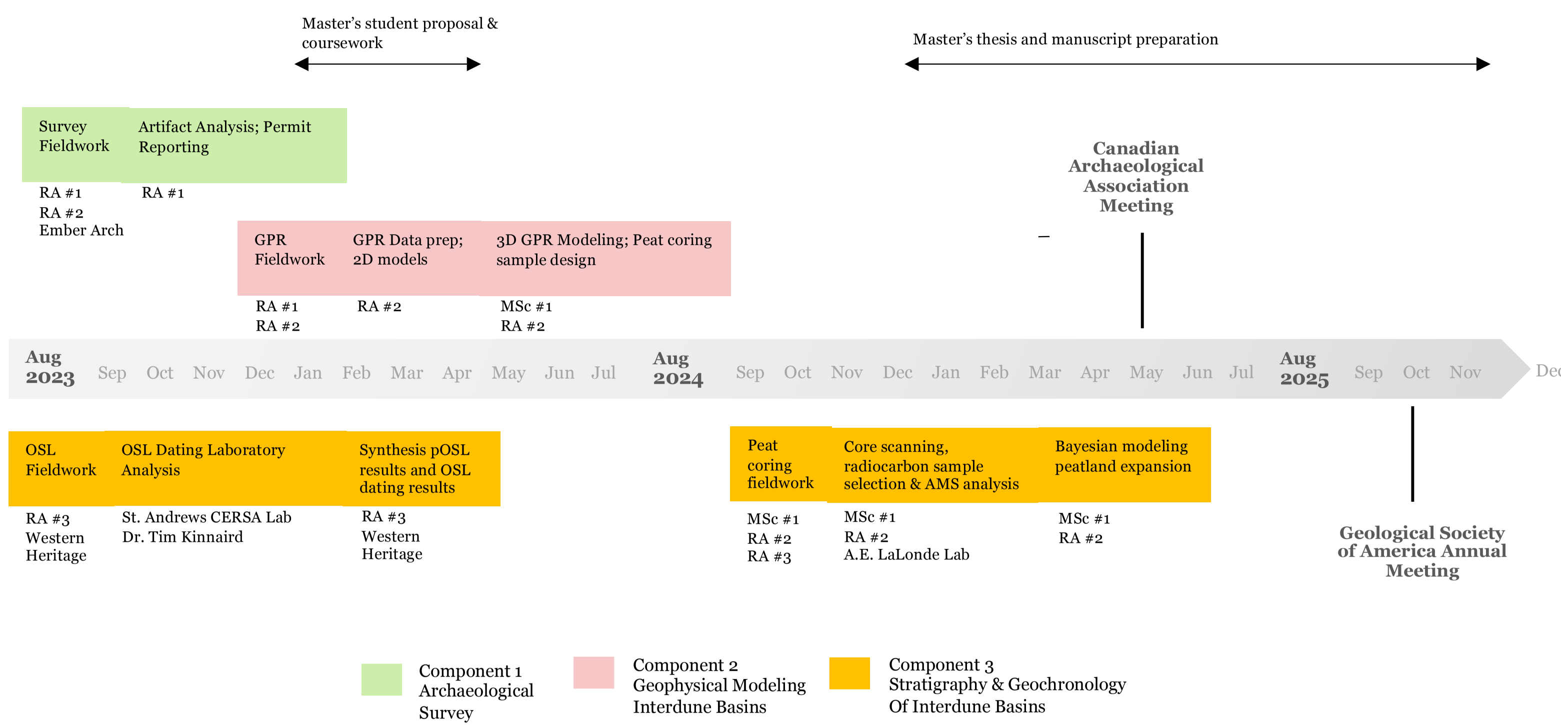
Undergraduate Research Assistant #2: This student will provide assistance in the ground penetrating radar (GPR) field surveys and data analysis. In the summer and fall of Year 1, they will assist myself and Dr. Gilliland in planning the survey layout, in-field data interpretation, and field data collection. During the latter portion of Fall Term of Year 1 they will prepare the GPR data for the 3D analysis that will be commenced in January of Year 2 by Masters Student #1. This will include filtering the data and creating 2D analyses that will help guide the design of the 3D model. This work provides hands-on experience with geophysical data from the field collection phase to image interpretation phase.

Undergraduate Research Assistant #3: This student will provide assistance in peatland expansion modeling. Their work will commence in the summer of Year 1 and continue through the Winter term of Year 2. They will aid in collecting pOSL and OSL samples in the summer of Year 1, and analyze the pOSL and OSL results through to the Winter term of Year 2. In summer of Year 2 they will assist in peat coring and radiocarbon sample extraction.

Masters Student #1. This student will join the team in January of Year 2. Their thesis will focus on the modeling of peatland expansion in interdune areas using GPR and geochronological data. They will write their proposal and take classes in Winter Term, Year 2 and begin 3D modeling of the GPR data collected and pre-processed in Year 1. In the summer of Year 2 they will design and execute a peat coring program. Fall Term Year 2 will be spent modeling peat expansion using Oxcal and GIS software. Thesis writing will take up the remainder of the project time.

Project Timeline

Geoarchaeology of Boreal Forest Dune-Wetland Complexes in Alberta, Canada



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