Cooking Lake – The Disappearing Lake.

Introduction

In 1969, Government of Alberta Researcher, Edo Nyland, declared the lake system from Miquleon Lake to Hastings Lake a "dying watershed"[i]. His words were prophetic at the time. Today, Cooking Lake, once a large continuous lake over 5 metres (16 ft) deep, is less than 1 metre. It consists of two separate basins, a shallow south basin and a marsh like north basin. Extensive mudflats are appearing along the edge and within the southern portion of the lake. The question now is *"What is the future of Cooking Lake?"*

In the fall of 2020, a citizen volunteer project was formed in collaboration with Assistant Professor Greg King from the U of A, Augustana Campus (Camrose). The intent of the project was to examine the decline of water levels at Cooking Lake, Alberta. Cooking Lake was selected based on the amount of information available, however, it was hoped that the results of this work could be applied to other lakes in the Beaver Hills Biosphere in the future. The project was divided into two areas of research: 1) to examine the recorded history and possible causes of the decline, and 2) to determine if spruce tree growth rings could be used to document past changes in lake levels, potentially including times prior to settlement.

The project currently has three volunteers - Michael Boyd (M. ED-Ecological Sciences), Ken Quackenbush (P. Eng. Water Resource Mngmt) and Stefanie Pollock (M.Sc.-Biology). Many volunteer hours have been spent on this project to-date. The assistance of the Alberta Lake Management Society (ALMS), Alberta Environment (measuring water levels), the County of Strathcona, and the Strathcona County Museum and Archives has been greatly appreciated. Local landowners have been of great assistance, helping us locate and access sites for research and providing family photos or information about the lake. Thanks also to Dylan Reade who has shared invaluable history information.

This document provides a summary of work undertaken to-date, and interim findings. Work continues. Recommendations, future work needed and current data gaps are also identified.

Photos[1]

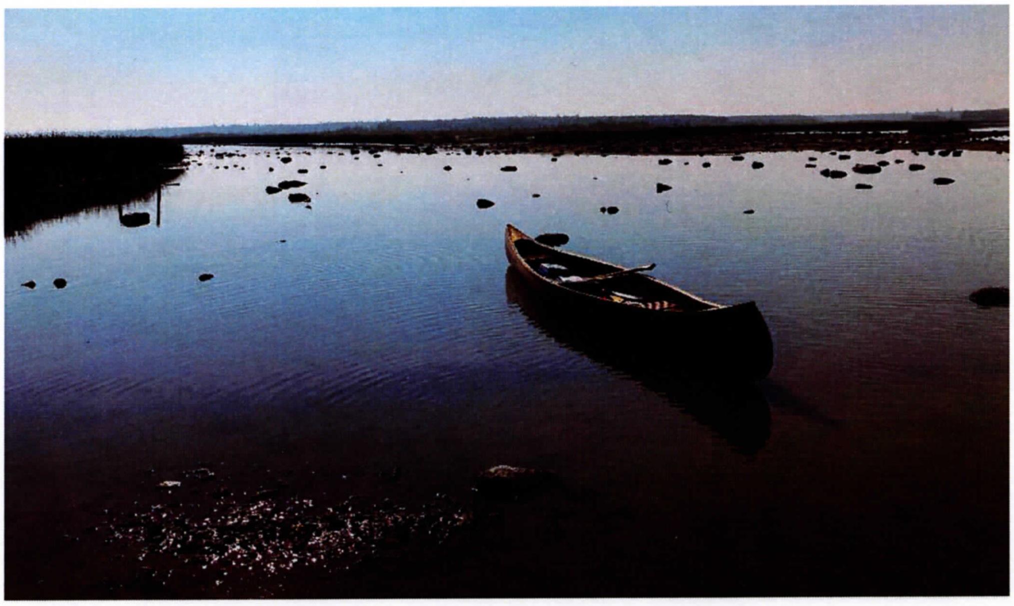

Photo 1: Inches of water where once there was feet (2022)

Photo 2: Mudflat at Plover Point (2022)

[1] All photos courtesy of K. Quackenbush unless otherwise noted.

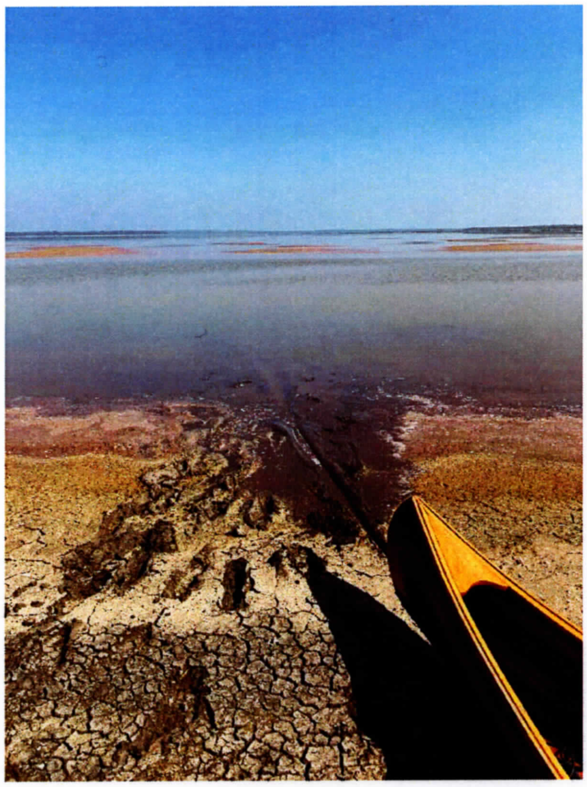

Photo 3: View across the south basin with mudflats in the distance (2022)

Photo 4: The north basin of Cooking Lake. Shallow marsh with no connection to the south basin, in the background. (2022)

Photo 5: Cooking Lake, 2020. Strathcona County Property Tax Assessment.

Photo 6: Cooking Lake, in the background, as it was in 1924. (oblique aerial photo Govt of AB). Note - Ministik Lake, also full of water, in the foreground.

History of Cooking Lake

The Beaver Hills watershed includes Miquelon Lake, Oliver, Joseph and Larry Lakes, Ministik Lake, Cooking Lake, Halfmoon and Antler Lakes, Hastings and Beaverhill Lake. In the past we believe the lakes were connected by streams that flowed intermittently, with surface run-off, or when the lake or lakes reached overflow conditions. Likely this would have been in the spring or during periods of heavy rainfall. Similarly ground water flows from the highest point at Miquelon down to the north and east. In the last century all these lakes have seen MAJOR declines in water levels and have become 'closed-basin lakes'. This is a condition common to the semi-arid climate of the prairies, not to boreal mixed wood forest that existed in the Beaver Hills Moraine.

Before settlers came, Cooking Lake was well known to local first nations as a place for fishing and hunting and is named after a Cree phrase which translates as "the Cooking Place". Today's landscape is not what it was when the first Government of Canada surveyor, Joseph Tyrrell, arrived in 1886. Tyrell described the Beaver Hills as,*"thickly wooded with balsam poplar and spruce….. and charming lakes with clear pure water"*.[ii] In the late 1800's and early 1900's a succession of fires swept the area. Land clearing, and timber mills removed any remaining old forest, leaving only a few remnants on islands.

In the 1890's and years of the early 1900's Cooking Lake became a popular destination for Edmontonians'. Development first started at what is today, the hamlet of South Cooking Lake. With the arrival of the railway at North Cooking lake in 1909 travel to the lake became easy and inexpensive. Hundreds of visitors would flock to the lake on weekends in the summer. Land was subdivided and cottage development expanded. Twelve (12) resorts were surveyed between 1911 and 1913. Many prominent lawyers, doctors, judges and businessmen came to own cottages at Cooking Lake.

Cooking Lake was thought to have reached its highest level in 1900 as a result of a 1-in-100-year summer rainfall. The exact depth of water that year is unknown but it exceeded the overflow level to Hastings Lake (achieved at a maximum depth of 5.9m or 19.6 ft). Regular measurements of water levels did not begin until the 1970's. Today, Cooking Lake is estimated to be at less than a metre in depth.

PART 1 – Weather, Water Levels and Water Quality

Weather Data – Cooking Lake and the Beaver Hills Biosphere (BHB)

Table 1 shows all the available weather stations in the Cooking Lake area. Edmonton provides the only continuous data set in the area with data from 1880 when measurements first started. However, recognition of the heat urban heat island effect[2] created by large cities suggest that it would be unwise to use Edmonton stations after 1943 (approximate[iii]) so they have been excluded. Previous studies of Cooking Lake in the 1970's used the Edmonton International

[2] The term was first coined by Manley in 1958 and effects both urban centres and immediate surrounding areas

Airport weather data. (see Appendix 1 for a full set of weather stations in or near the Beaver Hills Biosphere)

Table 1. ***Local Weather Stations in the Beaver Hills Biosphere***

Station Name	*Daily Readings*	*Climate ID*	*Data*
Beaver Hills West	1897 – 1908	3010558	Precip
North Cooking Lake	1918 - 1930	3014870	ADNoW
Cooking Lake (south)	1985 - 1994	3011854	ADNoW
Uncas	1995 – 2021	3016650	Precip
Hastings Lake	1977 - 1987	3013060	ADNoW
Ministik Lake[3]	1940 - 1951	3014560	Precip
Ministik Sanctuary	1961 - 1970	3014565	Precip
Ministik Research	1988	3014563	ADNoW
Edmonton	1880 - 1943	3012195	ADNoW

1) Notes: AD = all data; ADNoW = all data but no wind; Precip = precipitation only.

2) Climate stations may include some years with missing data.

3) While Edmonton is not "local' the time period before 1943 includes the oldest weather records in the region.

Weather stations are needed to monitor local weather conditions within the BHB. At present there are only three (3) active weather stations in the BHB – Uncas, Camrose, and Elk Island National Park. But Uncas only collects precipitation data. For the purpose of future monitoring and research, it is recommended that the Uncas station be upgraded to collect temperature data.

Effects of Weather Variation on Water Levels

Recent Water Levels[4]

In the past water levels at Cooking Lake were recorded first by Environment Canada and then assumed by Alberta Environment in the 1970's. The earliest measurements were taken in 1919 to 1922, and 1939 to 1941. No subsequent water levels were measured until 1950. Lake levels have been recorded on a yearly basis since 1956. A major study of lake levels previously undertaken by the Alberta Environment Planning Division in the early 1970's was reviewed. Our groups work with water levels included collecting past water level measurements, working with Alberta Environment to ensure water gauges were installed and read at Cooking Lake, and assisting ALMS in water quality sampling

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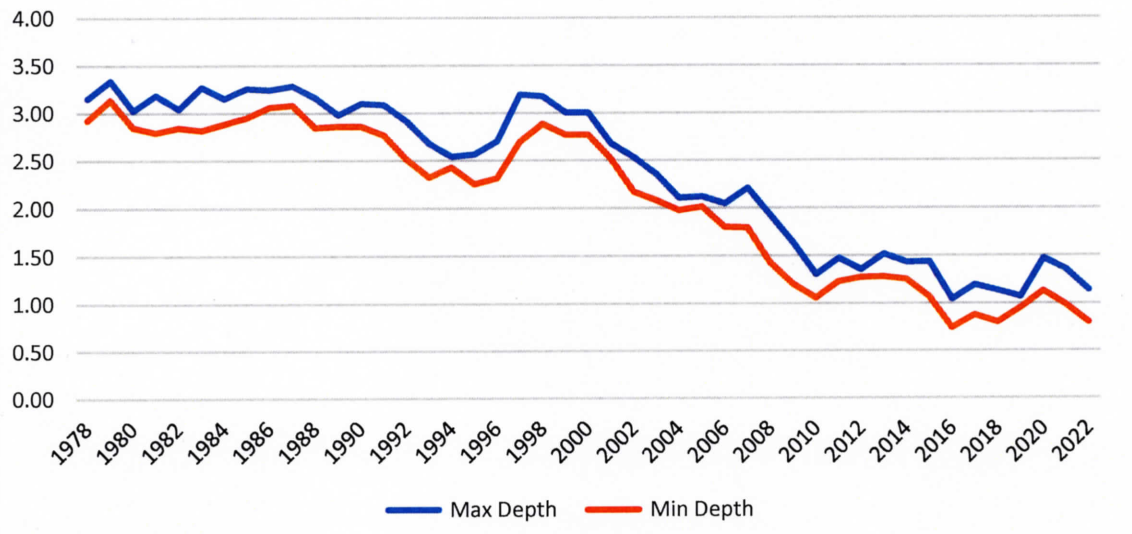
[3] Ministik lake is under review EC as the location given is not Ministik Lake

[4] For a discussion of historic water levels (1886 to 1977) see the later section

Water levels are traditionally presented in an elevation chart. Such presentations do not convey the impact of changing water levels on lake depth. Figure 1 depicts historic water depth in metres, in the south basin of Cooking Lake. It is calculated as the difference between summer water level recorded and the 733m (2405 ft) contour elevation of the south basin. The north basin is not connected to the south basin. The north basin consists of intermittent areas of water whose depth is unknown.

Figure 1. Change in Depth (m) - Cooking Lake - South Basin. 1978 - 2022



Cooking Lake has undergone a steep decline in water depth since 1999. It reached a record low in 2016 of 0.7m. The depth in 2022 is 0.8m. A slight recovery in 2020 saw a rise of 0.18m likely as a result of the 658mm of total precipitation received that year. This was the third highest precipitation received since 1978. In years of very high precipitation the water level does rise but it is typically lost in the months that follow. High precipitation does not always create a net rise in water level, presumably due to high evaporation rates.

Precipitation

In examining precipitation and water levels for Cooking Lake, it was necessary to assemble as much local weather data as possible. Past studies have used Edmonton International Airport Data while ignoring local data. Using Hastings Lake, Cooking Lake and Uncas weather stations it was possible to create a continuous record of precipitation from 1978 to the present[5]. Monthly precipitation data was grouped on the basis of season, where winter is calculated from November of the year previous, to April of the current year and summer includes May thru

[5] In addition, historic data from earlier time periods was available for Edmonton (1800 – 1943), Beaver Hill West (1899-1907), North Cooking Lake (1919-1924, 1927 & 1928) and Ministik Sanctuary (1962-1969).

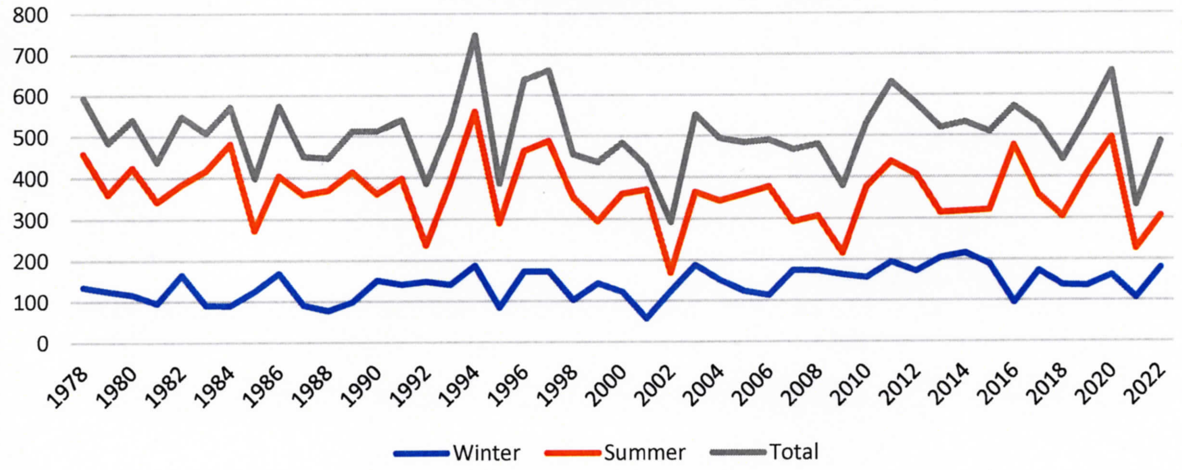
October. A seasonal approach directly reflects precipitation that will affect summer water levels. Table 2 and Figure 2 (below) provide summaries of precipitation based on local data.

Table 2. ***Seasonal Precipitation (mm) by Time Periods – Cooking Lake Local Stations***

Time Period (Local Data)	Weather station	Years of Data[6]	Winter Average (mm)	Summer Average (mm)	Year Total Average (mm)
1899 - 1908	Beaver Hills W	10	110.0	389.6	499.5
1918 - 1924	N Cooking Lake	6	115.5	293.4	409.0
1962 - 1969	Ministik Sanctuary	8	146.2	305.4	451.6
1985 - 1994	Hastings & Cooking Lk	10	132.9	376.8	509.7
1995 - 2004	Uncas	10	131.4	349.8	482.4
2005 - 2014	Uncas	10	169.0	340.5	509.5
2015 - 2022	Uncas	8	147.0	361.7	508.7
1978 - 2022	Hastings, Cooking, Uncas	45	140.6	365.2	506.0
1990 - 2022	Cooking Lk & Uncas	22	149.9	355.8	506.1

Source: Canada Environment and Natural Resources

Figure 2. ***Local Seasonal Precipitation (mm) Cooking Lake Area. 1978-2022***



Three significant dry periods have occurred since 1978, one in 2002, another in 2009 and again in 2021. In all cases the lake continued to decline with no persistent recovery. The lake may have reached a tipping point where warmer water temperatures in shallow water raise evaporation rates even further.

[6] Based on data available

Evaporation

Cooking Lake has lost an estimated 2.1 metres (6.9 feet) in depth since 1978. This loss may be attributed to higher summer temperatures, wind and increased rates of evaporation. As the lake becomes shallower water temperatures rise increasing evaporation rates. Dryer soil conditions in the Cooking Lake watershed also mean that more precipitation is absorbed by the soil leaving less to runoff into the lake during periods of snowmelt or rainfall. It was observed in 2022 that the Cooking Lake water level would rise when it rained. But in the days following rainfall, no further increase occurred suggesting there was no prolonged run-off from surrounding areas and that the water rose simply from the rain falling on the lake. (*N.B. This was the first year we had a local observer watching water level and weather)*. Diminished run-off from surface areas may also be reduced by very dry soil conditions.

Evaporation data is being examined and will be reported when available.

In the mean time here is our understanding of the key factors that determine the summer evaporation rate of water.

1. <u>Temperature of water</u>: The water molecules move faster as water warms. The faster the molecules move the more easily they can escape the water surface.
2. <u>Temperature of air</u>: As the air above the water warms it has the capacity to have a greater amount of moisture evaporated into the air. A combination of warm water and warm air will evaporate the most water.
3. <u>Wind speed</u>: A higher wind helps remove moisture that has evaporated from the water. This helps the relative humidity stay unsaturated near the water surface. When the air is saturated the amount of moisture that evaporates into the air is minimized. Higher winds will continue to supply drier air from aloft to the water surface and this allows for a greater amount of evaporation. A higher wind also churns the water (waves, splashing) and this helps lead to a greater surface area in which evaporation can occur from the water surface.
4. <u>Dry air:</u> Dry air will help generate more evaporation especially if the air is warm and dry. There is a higher capacity to evaporate moisture into the air as the air dries. Once the air is saturated then the evaporation rate is minimized. Air with a low relative humidity is optimum for moisture to evaporate into it.
5. <u>Sunlight:</u> Direct sunlight will lead to more evaporation. The direct photons of light increase the motion of the water molecules it strikes giving them a better chance to evaporate

Source: https://www.theweatherprediction.com/habyhints2/470/

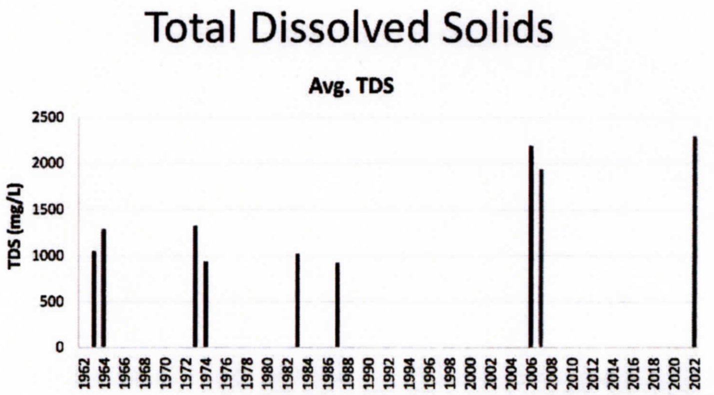
It can be concluded that the shallower the water in a lake becomes, the more it warms in the summer and the higher the evaporative rate. Combining this with increased temperatures and wind, a shallow lake like Cooking Lake, may not recover without **extremely** high precipitation and/or human intervention.

Water Quality (information provided by the Alberta Lake Management Society)

In 2022 our study group connected with the Alberta Lakes Management Society (ALMS). We were able to assist them with water sampling at Cooking Lake, Hastings Lake and Ministik Lake during the winter of 2021/22 and the summer of 2022.

1) Cooking Lake has water quality information that spans back to the 60s, but is fairly patchy (many missing years)
2) The total dissolved solids (TDS) levels indicate that the lake has become more-salty in recent years *(possibly affected by decreasing water level)*
3) The lake shows variability of nutrients and algae growth over the period where we have data,
3) Recent winter monitoring indicates higher levels of nutrients and chloride under the ice compared to data from the 1970s, also directly related to reduced volume. There is also no sequestering or purging of nutrients within closed-basin lakes.
4) Compared to lakes in the Cooking Lake Moraine, Cooking is saltier but not the saltiest, has high levels of nutrients, and high but not the highest levels of algae,
5) Cooking Lake, like other lakes in the Cooking Lake Moraine, has little to no oxygen under the ice in the winter

Figure 3. Cooking Lake Total Dissolved Solids 1963 to 2022



Comparison

- Antler: 250 mg/L (2020)
- Half Moon: 243 mg/L (2020)
- Hastings: 1,325 mg/L (2022 – preliminary)
- Miquelon: 14,000 mg/L (2021)

Source: ALMS, 2022

Recommendations from ALMS:

- Examine surrounding lake water chemistry (especially lakes in watershed and Beaverhills region
- Find water quality data from missing years •
- Explore the relationship between water level change and water quality •
- Continue to work with ALMS for water quality monitoring

In the Beaver Hills Biosphere other lakes have been sampled by ALMS for water quality. These include Halfmoon Lake, Antler and Miquelon. That data is not presented here.

Groundwater

The role of groundwater in regards to lake levels remains to be explored. We would note that the 2019 Antler Lake Watershed Management Plan[iv] reported that the Cooking Lake Groundwater Observation station showed "*substantial periodic fluctuation, with highest levels recorded in the early 1970s and a large period of rise between 1988-1990, followed by a long period of decline from late 1990s until 2018*[7]". We have noted elsewhere a similar decline in Cooking Lake water levels after 1990. The decline of a large body lake such as Cooking Lake, which may act as groundwater recharger, should be of concern. The same report recommended further investigation to identify groundwater level trends in the region. We are not aware of any being conducted to-date.

Without a hydrologist, our study group is limited in our ability to investigate and interpret groundwater changes in the Cooking Lake area. Sources of information (reports and data sets) have been identified and will be examined. Further information will be reported in future updates.

Historical Water Levels

Information on water levels prior to 1950 is scarce. The only early measurements available are daily ones from 1919 to 1922 and single measures for 1939, 1940 and 1941. Work is continuing to try and fill the gaps using other sources. A timeline of observations made by local residents and recorded in published local histories has been prepared. Estimates from the 1977 study, aerial photos, early surveys and historic photographs[8] are being examined to fill in some of the gaps.

It would be very useful to obtain stories about the lakes of the BHB from Indigenous peoples, particularly ones related to pre-settlement times. This is a time when little is known about the lakes and climate conditions.

It is hoped that analysis of spruce tree rings may assist in understanding past changes in lake levels.

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[7] Pp.33 &34

[8] Past water edges can be located by overlaying modern photos of historic photographed locations around the lake. Elevations were then estimated using current GNSS technology.

Archaeological Information

Local landowners are important contributors to our research, whether it be identifying sites for tree coring, old log cabins, locating old family photos and information on cottages and lake levels. Occasionally they have identified past Indigenous peoples' campsites. I do not believe any of these have been investigated by archeologists. Sites are reported to the Alberta Historical Resources Branch, but the BHB may want to track these sites and consider a joint archaeological project with local Indigenous peoples.

PART 2 – Tree Rings and Climate (G. King)

Tree Ring Analysis

Tree-ring analysis, also known as dendrochronology, is the science that utilizes the analysis of annual radial growth of trees to date and interpret past events, particularly climatic trends. In this project we make use of wood located in historic buildings (some of the oldest structures in the Beaver Hills Biosphere – providing a link between the environmental and human history of this landscape) to develop a longer-term perspective on changes in precipitation and lake levels.

Our research has collected about 70 samples from several different cabins constructed from white spruce around Cooking Lake. All cores were collected from the basal end of logs to ensure as many rings as possible were included, and secondly, we cored only along the rounded edges of the log (and through bark, when possible) to capture the outermost rings and thus determine the year(s) the trees were harvested. Samples are then processed at the U of A, Augustana Campus facilities and rings are digitally measured. These ring width measurements were then used for the essential principle of dendrochronology – cross-dating.

Cross-dating is the procedure of matching ring width variations among trees that have grown in nearby areas, allowing us to assign an exact calendar year to each ring. Basically, we are looking at the synchrony of ring width patterns as it is expected that trees of the same species from the same area would respond to regional climate in the same way.

Our challenge was that to anchor our historic timbers chronology we needed to locate and sample living trees that were old enough to overlap with the cabin timbers. Local forests were all presumed to be younger than the structures due to historic fires and logging. However, local history research revealed islands that had avoided the large fires that took place in the late 1800s and early 1900s.

From these locations we were able to collect cores and cross-sections from a total of ~ 40 living and recently dead trees. These samples once dated, generate a 50+ year overlap period that we could use to anchor the Spruce Lodge timbers. A statistical comparison between all of the living trees and the historic timbers revealed a very good series intercorrelation between all of the trees of 0.65 – this means that across the entire time period, there is a synchronous ring width response and that the cabin timbers were local and could be used to create a complete chronology (see Figure 1 below).

At this point we have a master chronology for the area that spans just over 300 years with good sample depth back about 220 years to 1800. This represents a unique opportunity in east-Central Alberta to answer questions about the regional environmental history and the potential fluctuations of the lakes during this time with few written records.

Figure 4. Overlap of Ring Widths – Living Trees and Spruce Cabins

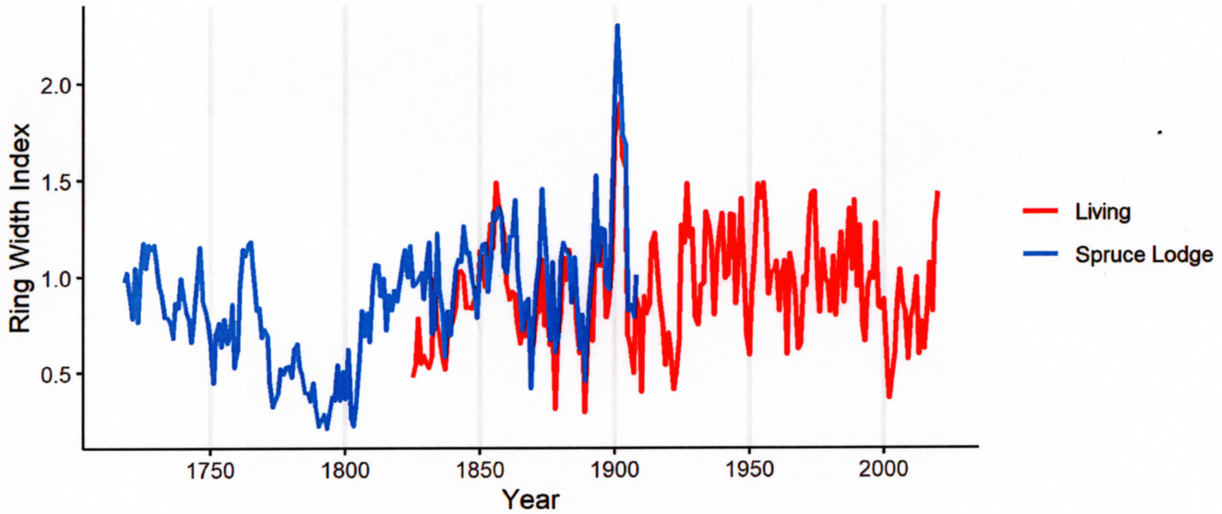

Figure 3. *The overlap of measured ring-widths between living white spruce samples and historic white spruce samples (here collected from a single cabin, Spruce Lodge). When other historic samples are added to this, the patterns remain.*

Preliminary work has been conducted showing a connection between ring-widths and precipitation. Exploratory analysis to reconstruct annual precipitation from the tree-rings was also undertaken. This is still preliminary and no inferences can be made at this stage in the project, but it allows a very early look into what might be possible with this data

The next steps for the tree-ring parts of this project are to solidify the connections between tree-ring and climate data, look for improvements in our reconstruction skill, and continue to expand the number of cabins and historical timbers that we can sample to potentially extend this record.

Part 3 – Interim Recommendations and Areas of Future Study

Recommendations:

- That the Beaver Hill Biosphere work with the North Saskatchewan Watershed Alliance (NSWA), Strathcona County and other counties to prepare a Watershed Management Plan for the BHB Sub-Watershed.
- Incorporate the Beaverhill Lake, Ramsar (*Convention on Wetlands, 1971*) into the sub-basin scope.
- Obtain Watershed Planning and Advisory Council (WPAC) support (funding and expertise) to update state of the watershed and commission a technical review of recommendations presented in the 1977 Cooking Lake Area Study.
- Request that the Uncas weather station be upgraded to collect temperature data
- Continue working with ALMS for water quality monitoring. Examine surrounding lake water chemistry (especially lakes in watershed and Beaver Hills region)
- Obtain hydrological assistance to help with groundwater data interpretation
- Meet with the BHB Research Committee to present and discuss results.
- Discuss with BHB the possibility of obtaining Indigenous stories of the lakes.

Areas of Future Study:

- Summarize water level and chemistry data for other lakes in the BHB watershed – subject to data availability
- Summarize groundwater data obtained to-date
- Locate data on long-term changes in soil aridity
- Continue examining aerial photos, surveys and historic records for information on water levels and stream connections between lakes.
- Obtain additional core samples from live spruce and old log cabins.

Appendix 1:

Climate Stations in the Biosphere[9]			Lat/Long	Data
Station Name	***Daily Readings Available***	***Climate ID***		
Beaver Hills West	1897 – 1908	3010558	53°32'00.000" N / 112°32'00.000" W	Precip
North Cooking Lake	1918 - 1930	3014870	53°26'00.000" N 113°11'00.000" W	ADNoW
Cooking Lake (south)	1985 - 1994	3011854	53°26'00.000" N 113°07'00.000" W	ADNoW
Uncas	1995 – 2021	3016650	53°30'00.000" N / 113°02'00.000" W	Precip
Hastings Lake	1977 - 1987	3013060	53°23'00.000" N 112°53'00.000" W	ADNoW
Ministik Lake[10]	1940 - 1951	3014560	53°26'00.000" N 116°41'00.000" W	Precip
Ministik Sanctuary	1961 - 1970	3014565	53°22'00.000" N 113°02'00.000" W	Precip
Ministik Research	1988	3014563	53°21'00.000" N 112°58'00.000" W	ADNoW
Hay Lakes RS [11]	1967 - 1970	3073073	58.73 N 118.68W	ADNoW
New Sarepta AGCM	2007 - 2021	3014795	53°15'44.009" N 113°09'54.006" W	ADNoW
Elk Island Pk	1966 - 1975	3012277	53°31'00.000" N 112°54'00.000" W	ADNoW
Elk Island Nat. Pk	1981 - 2021	3012275	112°52'05.000" W 53°40'58.000" N	AD
Elk Island siding	1980 - 1982	3012278	53°47'00.000" N 112°59'00.000" W	ADNoW
Lamont	1980 - 1993	3013PFD	53°46'00.000" N 112°51'00.000" W	ADNoW
Tofield North	1974 - 2014	3016494	53°33'00.000" N 112°45'00.000" W	ADNoW
Camrose a	1928 - 1941	3011239	53°02'00.000" N 112°48'00.000" W	ADNoW
Camrose b	1946 - 2021	3011240	53°03'00.000" N 112°49'00.000" W	ADNoW
Camrose 2	1947 - 2016	3011241	52°57'00.000" N 112°48'00.000" W	ADNoW

[9] Environment and Natural Resources Canada https://climate.weather.gc.ca
[10] Ministik lake is under review EC as the location given is not Ministik Lake
[11] large amount of missing data

Edmonton Climate Stations			Lat/Long	Data
Edmonton	1880 - 1943	3012195	53°33'00.000" N 113°30'00.000" W	ADNoW
Edmonton City Centre A[12]	1937 - 2005	3012208	53°34'24.000" N 113°31'06.000" W	AD
Edmonton Blatchford	1996 - 2021	3012209	53°34'23.008" N 113°31'00.010" W	ADNoW
Edmonton Intnl Airport A	1961 - 2012	3012205	53°19'00.000" N 113°35'00.000" W	AD
Edmonton Intnl Airport A	2012 - 2022	3012216	53°18'36.000" N 113°34'46.000" W	AD
Edmonton Intnl Airport CS	1999-2022	3012206	53°18'24.002" N 113°36'21.009" W	AD

Notes: AD = all data; ADNoW = all data but no wind; Precip = precipitation only.
Climate station year range may include some years with missing data.

Location wrong

[12] From 1961 snow value reduced in the calculation of total precipitation. Snow on grd noted from 1947 on.

References:

[i] Nyland, E. This Dying Watershed. Alberta Lands, Forests, Parks, Wildlife. 1996 22-38

[ii] Tyrrell, J.B. Report on a Part of Northern Alberta. Geological and Natural history Survey of Canada. 1887 44E

[iii] Adamowski and Prokaph. Assessing the impacts of the urban heat island effect on streamflow patterns in Ottawa, Canada. J. of Hydrology 496 (2013) 225-239.

[iv] NSWA. Antler Lake Watershed Management Plan. 2019