Reconstruction of Fire History and its Connection to the Arrival of Spruce from Windmill Lake, Interior Alaska

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Background

Understanding the controls on forest fire frequency and intensity is critical to predicting future fire regimes under a changing climate. Climate and vegetation influence fire, but fires themselves influence vegetation, and possibly climate as well (Lloyd et al., 2006). A previous study on a lake sediment core from Dune Lake in interior Alaska documented that charcoal abundance (a proxy for fire) increased at the same time as pollen from black spruce (*Picea mariana*) (Lynch et al., 2003), suggesting a causal relationship. This was unexpected as black spruce typically grow in moist conditions. In addition, charcoal abundance did not increase when white spruce (*Picea glauca*) (which prefers drier conditions) expanded several millennia earlier.

Our study presents results of a pollen and charcoal analysis from Windmill Lake to assess whether a similar pattern is present at a site that is ~100 km to the SE of Dune Lake, and in the Alaska Range, which has slightly different vegetation and is more influenced by weather systems from the north Pacific.

Figure 1. Google Maps areal view ofWindmill Lake and the surrounding area

Methods

In June, 2023, the studied cores were retrieved in 1 m intervals or less by Dr. Nancy Bigelow with UAF graduate students Reyce Bogardus and Sara Datson, along with Sarah Stehn (NPS). Upon return to the lab, the cores were stored at ~+5C, split, and described. In January, 2024, 1 cc samples were taken along cores 2, 3 and 4 of Windmill E in 8 cm intervals. 16 samples were taken and processed for pollen using methods slightly modified from Faegri and Iverson, (1989). A known quantity of exotic pollen was added at the beginning of processing and the samples were stained to make counting easier. A small portion of the pollen sample was placed onto a microscope slide to be counted to at least 100 terrestrial grains. To calculate pollen concentration, the exotic pollen was counted at the same time. 9 of 16 samples were counted. Pollen id's were made by comparison with the in-house pollen reference collection as well as a published atlas (McAndrews et al. 1973). Charcoal samples were taken alongside the pollen at ~3 cc using syringes. To disaggregate the samples and to whiten the organic matter, the samples were soaked in a weak bleach (7.5%) and sodium pyrophosphate (10%) solution and sieved at 125 microns. The entire processed charcoal sample was poured into a petri dish and the charcoal fragments were counted

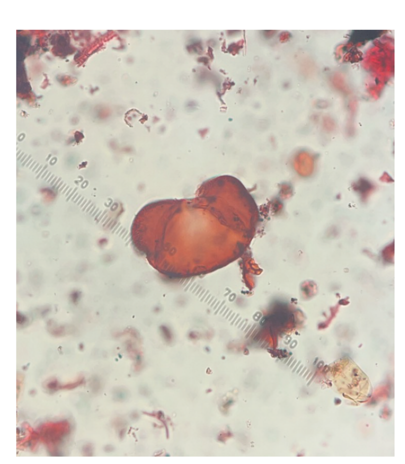

Figure 2.*Picea* under the microscope in oneof the counted samples

Figure 3. Dr. Nancy Bigelow with one of the retreived cores out in the field

Results

In the 9 samples counted, 6 of them contained *Picea*, both *P. mariana* (black) and *P. glauca* (white). The deeper samples contain higher concentrations of *Betula* (birch) and Pediastrum (an alga). *Picea* concentration and charcoal counts increase up-core. *Picea* concentration (grains/cm3) reaches its peak just above 265 cm, whereas charcoal concentration (fragments/cm3) has a peak at ~245 cm. *Alnus* arrived at the same time as *Picea.* The most common herbs and forbes present are *Cyperaceae* (sedges) and *Poaceae* (grasses). *Betula*, *Picea*, *Alnus*, *Populus*, and *Salix* are the most common for the trees and shrubs category.

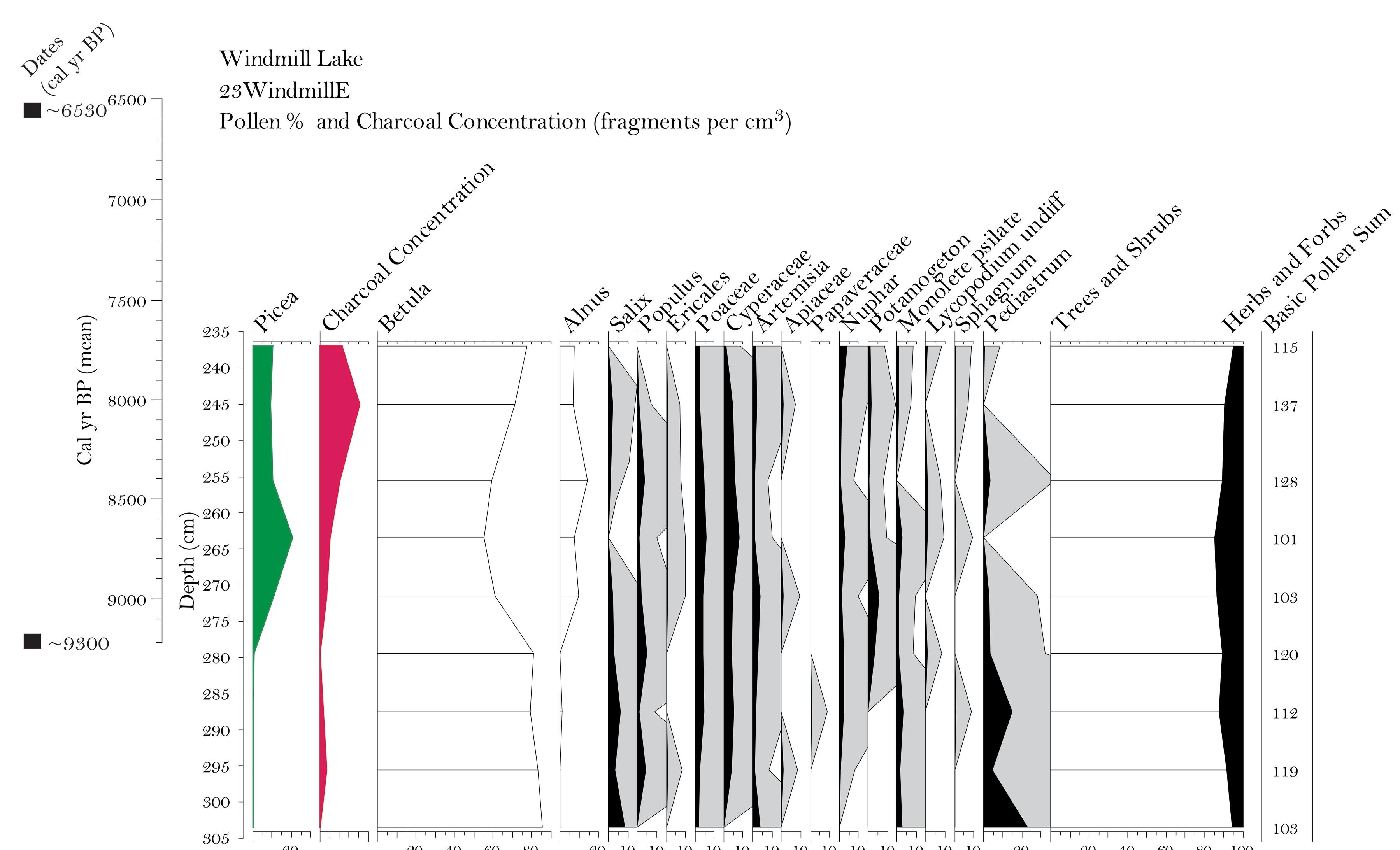

Figure 4: Pollen diagram with charcoal and Picea highlighted using the Tilia program. Gray shading indicates 10x exageration

Analysis By: Cedar Hanger

Figure 5a.*Picea*

Figure 6a.*Betula*

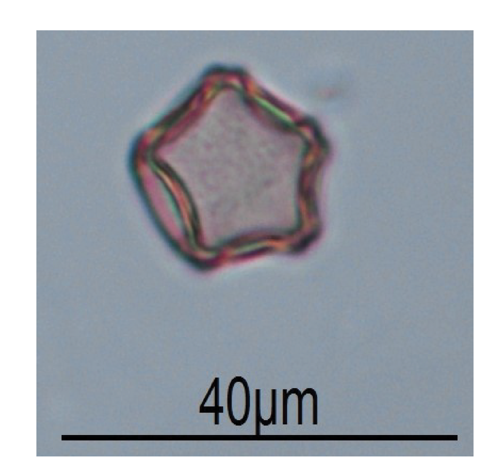

Figure 7a.*Alnus*

Figure 5b.*Picea*

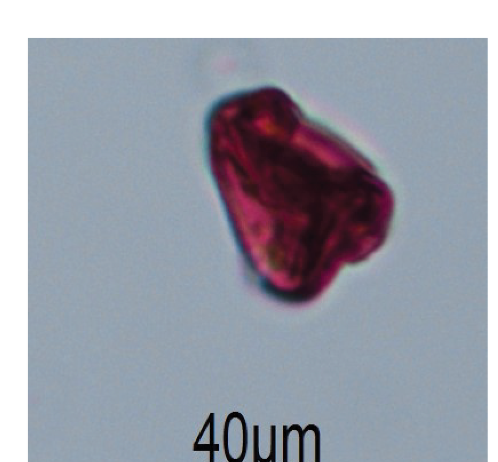

Figure 6b.*Betula*

Figure 7b.*Alnus*

Discussion

The data indicates an increase in fire frequency when *Picea* arrives in the region. This is consistent with findings from other studies of lakes done in the Interior, such as Dune Lake. Earlier pollen data from Windmill showed that black spruce, *Picea mariana*, and white spruce, *Picea glauca*, arrived at the same time (Bigelow, N. H., Edwards, M. E. (2001). Due to the arrival of both spruce types at the same time, it is unclear whether the increase in fire frequency in this region was caused by black, or white spruce.

Future Research

Increasing the pollen counts to 300 terrestrial grains is planned. In addition, identification of white spruce (*Picea glauca*) and black spruce (*Picea mariana*) pollen grains will be attempted. Finally, counting the rest of the uncounted samples to complete the pollen analysis. We are also awaiting the results of the C14 dates to come back from the lab. Other analyses on the core could be performed as well, such as LOI (Loss on Ignition), or perhaps more pollen sampling and counting.

References

Lloyd, A. H., Edwards, M. E., Finney, B. P., Lynch, J. A., Barber, V., and Bigelow, N. H. (2006). Holocene development of the Alaskan boreal forest. In "Alaska's Changing Boreal Forest." (F. S. Chapin, M. W. Oswood, K. V. Cleve, L. A. Viereck, and D. L. Verbyla, Eds.), pp. 62-78. Oxford University Press, Oxford.

Lynch, J. A., Clark, J. S., Bigelow, N. H., Edwards, M. E., and Finney, B. P. (2003). Geographic and temporal variations in fire history in boreal ecosytems of Alaska. Journal of Geophysical Research 108 (D1), 8-1 to 8-17.

Bigelow, N. H., and Edwards, M. E. (2001). A 14,000 yr paleoenvironmental record from Windmill Lake, central Alaska: Lateglacial and Holocene vegetation in the Alaska Range. Quaternary Science Reviews 20, 203-215.

Faegri, K., and Iversen, J. (1989). "Textbook of Pollen Analysis." John Wiley & Sons, Chichester.

McAndrews, J. H., Berti, A. A., and Norris, G. (1973). "Key to the Quaternary Pollen and spores of the Great Lakes Region." Royal Ontario Museum, Toronto.

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- Sara Datson

Figure 8. Coring on the floating platform with Sara Datson and Dr.Nancy Bigelow

Figure 9. Coring

Figure 10. Traveling the lake