A Proposal for 2009 Wyoming
NASA Space Grant Consortium Undergraduate
Research Fellowship
Proposal

Long-Term Perspectives on the Effects of Climate Change on Southern Wyoming's and Northern Colorado's Water Resources

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Abstract

An increasing global concern is the availability and allocation of water. Water is necessary for human consumption and irrigation, but also increasingly necessary for energy production via uses such as the cooling of power plants. In western states, such as Wyoming, the policy deciding the current and future allocation of water has been based on weather data primarily from the past 30 to 100 yrs. This time span does not cover the full range of weather events that can occur because more severe droughts have taken place in the past few centuries and since the last ice age. Future climate change – both natural and human caused – could similarly produce large changes in water supply. By reconstructing past changes, I intend to improve understanding of the sensitivity of water resources to change. This work on past climate change will parallel one of NASA's primary science questions: how is the global Earth system changing?

Project goals include gaining a greater understanding of past climate changes, their patterns, and their impacts on hydrology. I aim to establish a record of drought that extends back 15,000 years and encompasses a broad range of possible climate variation in the economically-important Platte River watershed. To do so, I will collect and analyze lake-bottom sediment from two lakes in the upper headwaters area using techniques developed by Dr. Bryan Shuman. I am familiar with the processes of analysis and operation in Shuman's lab and the equipment necessary due to previous projects.

The other benefits for this project include the cooperation and partnership of researchers and professors in varying fields within the University of Wyoming. For example, Dr Tom Minckley (Botany) will use the lake-level histories from this region for comparison with floral and wildfire history to understand the role of drought in forest ecology.

Description of Proposed Research

Analysis of lake-bottom sediments has proved to be an effect way to determine past water levels and has been carried out over 120 years since Gilbert's analysis of The Great Salt Lake (Gilbert 1890) This method continues to be used effectively (e.g. Benson 2003; Shuman et al 2006). Small lakes have proven to be effective records of past climates (Benson 2003; Shuman et al 2006.). The lakes selected for this study, Little Windy Hill in southern Wyoming and lakes in the Big Creek Drainage of Colorado, have a specific geometry and composition like those of other lakes that have accurately reflected changing climates over time (Shuman et al., 2001; 2005). This method of reconstruction drought history has been correlated with other methods such as tree ring analysis and has been found to be accurate (McCabe and Wolock, 2007).

The two lakes of which I will be researching are Little Windy Hill and Big Creek Drainage lake. Little Windy Hill is located east of the Platte River Drainage in southern Wyoming, (Fig 1b) and the Big Creek Drainage is located to the west of the Platte River Drainage in northern Colorado,(Fig 1b) By studying these lakes and comparing our results other research from across the country, we can examine how larger scale episodes of water shortages and droughts, as well as local changes that directly impacted southern Wyoming and northern Colorado, have changed through time.

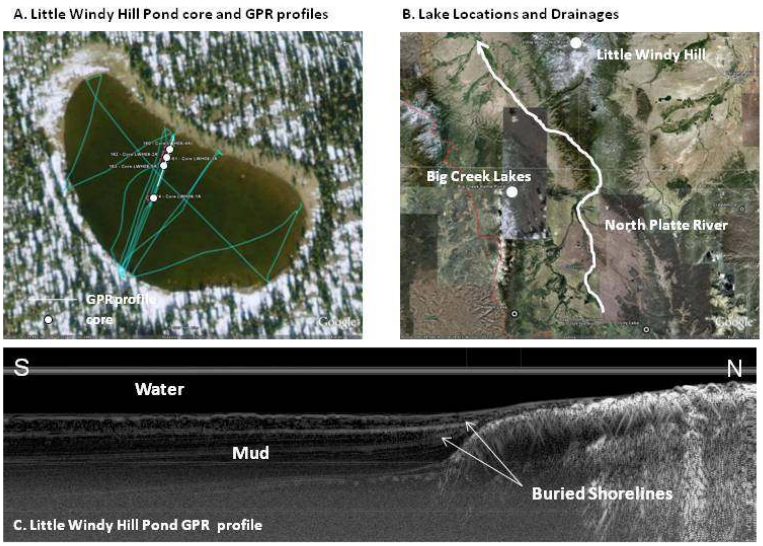

Figure 1: Little Windy Hill sample and ground-penetrating radar (GRP) profile locations (A), loction of Little Windy Hill and Big Creek Drainage Lakes (B), and GPR-based cross section showing buried shorelines (C).

Roles of Responsibilities

This project will be using the similar methods proposed and developed by Shuman, Digerfeldt (1986), and others. The samples from Little Windy Hill that I will be analyzing have been collected by Dr Bryan Shuman. The location of the core removal was decided by first taking Ground

Penetrating Radar (GPR) images of the lake bottom and reviewing the images to select points of interest, such as buried shorelines (Fig 1c). We assume that such features mark the past water levels of the lake. Cores were then collected near these features to confirm our interpretations. The existing sediment cores are about 1 to 2 meters in length and likely span ~15,000 yrs of lake history. Now, the proposed work is to gather additional cores from a comparable lake in the Big Creek Drainage in northern Colorado. We will then categorize and date the shore lines of these two lakes to obtain a history of each lake's water levels through time.

This analysis will be done through several methods with initial focus on density and radiocarbon dating. Followed be additional research in Loss of Ignition and Grain Size analysis. A description of each method follows.

Methods:

1.) **Multi Sensor Core Logger (MSCL)**- Geotek MSCL will be used to determine density, and magnetic susceptibility of each centimeter of the cores. This data will be used to detect shoreline features.
2.) **Imaging:** MSCL will then be implemented to capture high definition images of the cores which will be used to capture the changes in the sediment type
3.) **Loss of Ignition (LOI)**: Sub samples of the cores will be put through an LOI test. An LOI test consists of weighing the samples, burning them at 550 Degrees C (in a controlled environment), and then weighing them again. The difference in weight represents the amount of organic material present. By looking at the amount of organic material present we can determine the depth of water at the time of deposition. This is due to wave action near the shore which washes the less dense organic material out to deeper water to settle.
4.) **Grain Size**: By passing each sample through a series of sieves, I will determine the ratio of grain sizes within a sample. This ratio of grain sizes lets us know about the amount of wave energy at the core location in the past. Samples representing deep water contain only fine materials, where as sand and other large particles of deposited where waves break along the shoreline.
5.) **Radiocarbon Dating**: I will use extracted pieces of wood, charcoal and other organic remains to date layers within the core with radiocarbon analysis.
6.) **Assisting Collaborators**: While gathering samples for my research, I will also remove samples from the core to be used by collaborating research teams. I will be removing samples to undergo charcoal and pollen analysis by Dr Tom Minckley of the Botany Dept at UW.

By combining the data from each of these methods, we will reconstruct the water level history in the Platte River Drainage area. This will be used to determine how the availability of water at this drainage has changed over time. With each significant fall of water level we can conclude there was a drought event. Using radiocarbon dating, we can find out when, and for how long each one of these events occurred.

The results of this project will also be used to correlate with projects of a similar nature to establish a continental-scale perspective on past droughts (e.g. Shuman and Finney 2006). Such analysis can thus be used to bolster the planning needs of water managers by extending information on drought beyond the last 30 yrs to the last 15,000 yrs.

Timeline

May: Start of project by beginning analysis of existing Little Windy Hill sediment. Collect all Geotek MSCL data. Analysis data to determine areas of ancient shorelines and thus past lake level drops assumed to be drought events.

June: Extract sediment samples from core at boundaries of drought events. Extract terrestrial wood/charcoal samples from the sediment to be sent for radiocarbon dating. Funding for dating will be provided through Dr Shuman's NSF grant.

July: Gather cores from Big Creek Drainage and analyze with Geotek MSCL to obtain data on past shore lines. Collect sediment samples of layers of interest and sample for radiocarbon dating.

August: Use additional methods such as LOI and grain size analysis to confirm any initial conclusions that the data suggests up to this date. Gather all data and analyze it to find general trends and produce conclusions.

References

Benson, L. 2003. Western Lakes. In *Developments in Quaternary Science, Volume 1: The Quaternary Period in the United States*, edited by A. Gillespie, S. Porter and B. Atwater. Amsterdam: Elsevier.

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McCabe, G. J., and D. M. Wolock (2007), Warming may create substantial water supply shortages in the Colorado River basin, Geophys. Res. Lett., 34, L22708, doi:10.1029/ 2007GL031764.

Shuman, B., J. Bravo, J. Kaye, J. A. Lynch, P. Newby, and T. Webb III, (2001). Late-Quaternary water-level variations and vegetation history at Crooked Pond, southeastern Massachusetts. *Quaternary Research* 56: 401-410.

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Shuman, B., P. Newby, J. Donnelly, A. Tarbox, and T. Webb III. (2005). A record of late Quaternary moisture-balance change and vegetation response in the White Mountains, New Hampshire. *Annals of the American Association of Geographers* 95 (2): 237-248.

Award Request

I am requesting $5,000 for this project. This money will be used in the following ways in order to support this research. The radiocarbon dating is crucial to this study for that is what gives us the time ranges in which these past event occurred. Without them we have no way of knowing the time or extent of each event in the climate variation.

Budget For Summer of 2009:

Wages at $8.75 for 400 hours	$3500
Radiocarbon Dating 5 Samples	$1500
Total:	$5000

Cost Sharing:

Additional funding for radiocarbon dating if necessary will be provided through Dr Shuman's National Science Foundation Grant. This NSF grant will also cover any supplies or travel costs for this project.

Dr Shuman's anticipated time commitment:

(5 hrs per week)(10 weeks) = 50 hours

*Plus one week of field work full time = 35 hours