

YoungBear-Tibbetts, F.L., S. Nagy and A. Nelson. 2008. Lost City mounds management plan. Unpublished report for the University of Wisconsin Arboretum.

Mound Restoration Resources in Wisconsin

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Special Theme: Climate Change and Ecological Restoration

A GIS Analysis of Climate Change and Snowpack on Columbia Basin Tribal Lands

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A robust snowpack is the most important factor for the delivery of cool and consistent stream flows throughout the year in the Pacific Northwest, but it is at risk of depletion in an era of climate change. Most of the region's precipitation falls during the cool months between autumn and spring, historically as snow in upland areas. There it exists as a frozen reservoir that, as it melts, sustains flows during the dry months of late spring and summer. With increasing air temperatures anticipated from 21st century climate change, many of these upland areas in the Pacific Northwest may receive more rain and less snow, leading to increasing flooding during the winter months and lower stream flows during the summer months, when water is needed most for competing economic and ecological uses (Mote et al. 2003, ISAB 2007). The Indian tribes of the Columbia River Basin are interested in how these conditions may change because seasonal stream flows are critically important to salmon (*Oncorhynchus tshawytscha*, *O. keta*, *O. kisutch*, and *O. nerka*) and steelhead (*O. mykiss*), and they are also important to other traditional food resources of the tribes such as lamprey (*Lampetra tridentata*), sturgeon (*Acipenser transmontanus*), deer (*Odocoileus* spp.) and other big game, biscuit root (*Lomatium cous*) and other roots, and berries.

We performed an analysis using Geographic Information Systems (GIS) to project the changes to 21st century snow pack in the “ceded lands” of the Columbia River Basin where the member tribes of the Columbia River InterTribal Fish Commission have treaty hunting and fishing rights.

The use of GIS allows the landscape to be broken up into a grid of discrete cells, where historic climate data may be matched with projections of climate changes from general circulation models. We applied these data in a monthly model from an earlier study (Graves and Chang 2007) to project mean monthly precipitation and temperature over the landscape for future scenarios (2020s, 2050s, 2080s). We then used these climate projections to simulate future monthly snowpack accumulation and melt across the ceded lands of the tribes.

The results showed that many areas of importance to the tribes are very susceptible to loss of snowpack from small increases in air temperature (Figure 1). These areas have historically received the majority of their annual precipitation as snow, but because their mean winter temperatures are near or only slightly below the freezing mark (-2°C to $+1^{\circ}\text{C}$), incremental increases in air temperature projected by general circulation models (on average, a 2°C increase is projected by 2050, UWCIG 2007) will likely transition these areas from snow-dominated to a snow/rain transient precipitation regime during this century. Areas that are somewhat warmer during the winter months, with mean temperatures between $+1^{\circ}\text{C}$ and $+4^{\circ}\text{C}$, were also found to be vulnerable to loss of snowpack and may be expected to transition from a snow/rain transient regime to a rain-dominated one. Ecological changes within these zones will likely be influenced by climate change in conjunction with other natural and artificial disturbances, but plant and animal communities may be expected to migrate where possible in the direction of cooler temperatures (northward, to higher elevations, or upriver).

The most vulnerable areas studied are those that are closer to the Pacific Ocean and at moderate elevations. For example, the Deschutes River Basin of Oregon is located on the east side of the Cascade Mountains and receives a large proportion of its seasonal flow from snow, which supports upland forests of ponderosa and lodgepole pine (*Pinus ponderosa* and *P. contorta*), wet meadows, and juniper (*Juniperus* spp.) and sage (*Artemisia* spp.) rangelands. Mean winter season (November–March) temperatures in much of the upper basin are near or just below freezing ($+1^{\circ}\text{C}$ to -2°C), though, and therefore susceptible to snowpack losses from small increases in air temperature. Other areas, particularly

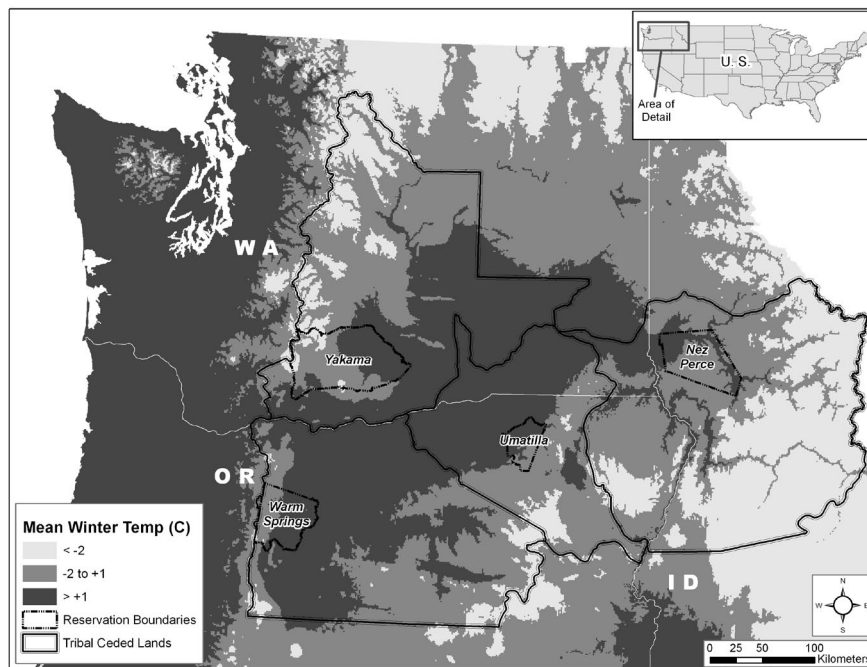


Figure 1. Mean winter (Nov–Mar) temperatures in the ceded lands of Columbia Basin Indian tribes. Analysis performed at the Columbia River InterTribal Fish Commission (CRITFC) with data obtained from the PRISM Group (2007). Areas shown with mean winter temperatures between -2°C and $+1^{\circ}\text{C}$ are likely the most at risk for loss of snowpack from near-term climate change, because air temperatures are projected to increase by about 2°C by 2050, potentially changing these areas from snow-dominated to rain-dominated.

the high-elevation mountains of Idaho, experience markedly colder winter temperatures and were found to be less susceptible to the effects of near-term climate change, because they will better produce and retain snow, even with moderate increases in air temperatures. For example, the Salmon River Basin drains an extensive mountainous wilderness in central Idaho, which consists of mixed conifer forests and alpine areas above tree line. Mean winter-season temperatures in most of this area are below -5°C , meaning that moderate increases in air temperature will not likely cause a significant shift of precipitation from snow to rain.

These findings demonstrate the importance of considering the watersheds of a region individually, because even though these watersheds may share many regional qualities, their unique characteristics such as elevation, distance from major water bodies, and other climate factors will influence how close they are to the freezing mark when precipitation falls and as snow melts, and therefore how susceptible they are to loss of their annual snowpack and how much the quantity and timing of stream discharge may change. Because a climate-change analysis in GIS can be conducted at a fine scale across a landscape (this study partitions the landscape into discrete 1.44 km^2 grid cells), the results may be aggregated at various watershed scales for interpretation (this study aggregates results to the major subbasins of the Columbia River Basin). These assessments will be helpful to the tribes of the Columbia Basin for planning to mitigate and adapt to the effects of climate change, and to prioritize watersheds for habitat protection and restoration. A full report is available at www.critfc.org/tech/08-05report.html. Readers who are interested in adapting this methodology for other areas may follow the approach outlined in this report, and may also contact the author with questions about its application.

References

- Graves, D. and H. Chang. 2007. Hydrologic impacts of climate change in the Upper Clackamas River Basin, Oregon, USA. *Climate Research* 33:143–158.
- Independent Scientific Advisory Board (ISAB). 2007. *Climate Change Impacts on Columbia River Fish and Wildlife*. Portland OR: Northwest Power and Conservation Council.
- Mote, P.W., E.A. Parson, A.F. Hamlet, W.S. Keeton, D. Lettenmaier et al. 2003. Preparing for climate change: The water, salmon, and forests of the Pacific Northwest. *Climatic Change* 61:45–88.
- PRISM Group, Oregon State University. 2007. 800-meter climate normals (1971–2000) gridded data, created May 2007. www.prismclimate.org
- University of Washington Climate Impacts Group (UWCIG). 2007. Projections for 21st century climate change. www.cses.washington.edu/cig/



Restoration in the Face of Climate Change: A Case Study from the Dorset Heaths

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The last few decades have seen the rapid development of techniques for restoring a range of habitats and much discussion on meanings of “success” in restoration projects and on setting realistic goals (Miller and Hobbs 2007). What has, as yet, received little attention is how the effectiveness of restoration techniques developed and tested under current climatic conditions may change as climate changes. In this article, we demonstrate the