Connecting Climate Change and Paleoclimate in the Pacific Northwest

By Christal Johnson, USFS Blue Mountains Area Ecology Program, christal.johnson@usda.gov

Background and Purpose

Reference conditions for forest restoration and management are often based on the pre-fire suppression era of about 1800-1910. However, this period occurred at the end of a Little Ice Age and was significantly cooler than the present climate, and cooler still compared to predicted future climate. In managing for climate change, it may be useful to have information about the ecological effects of historical warm periods such as the Medieval Climate Anomaly (MCA). The MCA was a period of warmer temperatures, drought, and increased fire activity that occurred about 1000-600 years before present (BP) over some portions of the world. Present climate change means that the future is also almost certain to have high temperatures and increases in drought and fire across most of the western United States, so the MCA could serve as a useful reference period for planning climate change adaptations. This brief will summarize available information on climate and vegetation in the MCA, and give recommendations for future climate change adaptation actions.

Climate Change

There are some differences between the climate change that is occurring today and past instances of climate change: present climate change is rapid, global, human-caused, and involves unprecedented levels of atmospheric CO_2. **Figure 1** shows the rapid and significant increase in global mean temperatures from 1880-2022. Although the MCA was a period of increased temperatures and disturbances, it is worth remembering that it is not an exact analogue for future climate change, because present rate and causes of climate change are unprecedented in the history of the world and will require vegetation to adapt more rapidly.

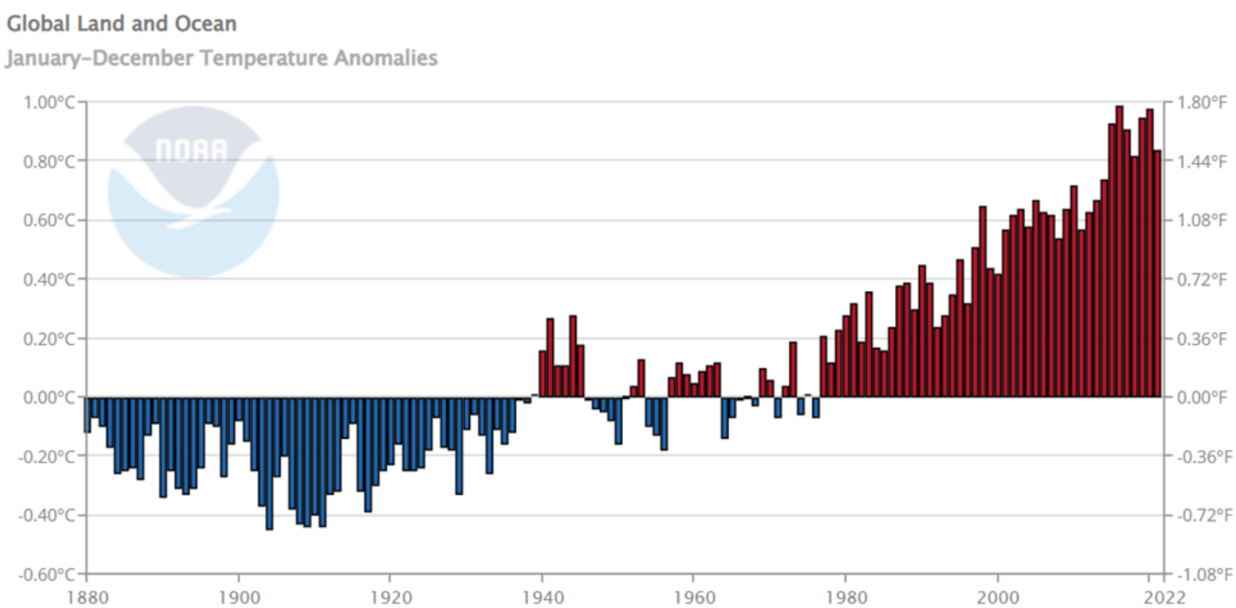


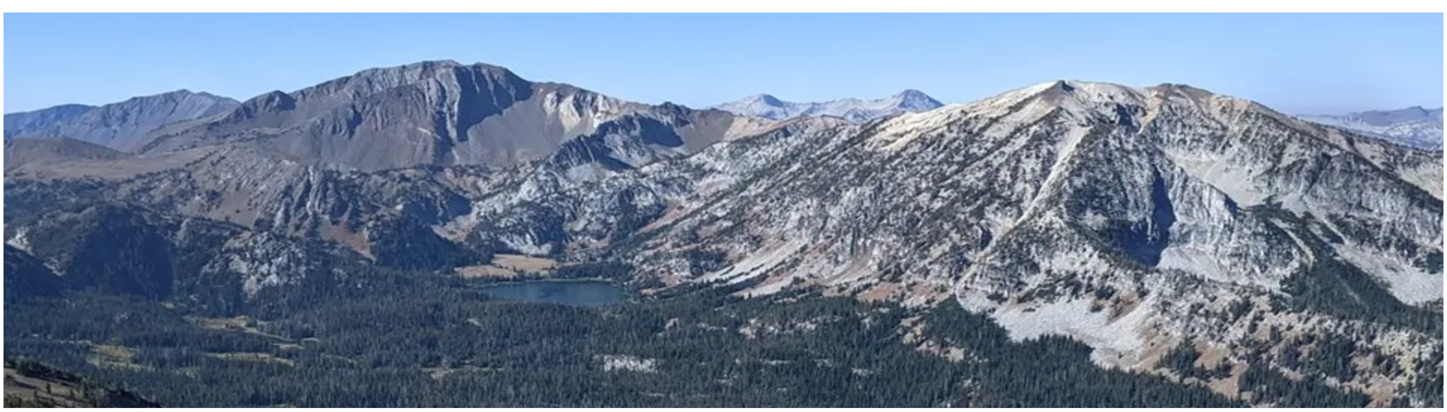
Figure 1. Global temperature anomalies from 1880-2022. Source: NOAA National Centers for Environmental information, Climate at a Glance: Global Time Series, published February 2022, retrieved on February 23, 2022 from https://www.ncdc.noaa.gov/cag/

A high-severity burn area shortly after the Green Ridge Fire on the Umatilla National Forest, 2021. High severity fire was more common during the MCA and will likely be more common in the future.

The Medieval Climate Anomaly

Although the MCA was not a global phenomenon, paleoecology records suggest that much of the western United States was impacted by increased temperature, drought, and/or fire during the MCA. Impacts of the MCA may have included:

- Increased fire severity, frequency, and area burned. Increases in fire were large in some areas, with a 260% increase in sites burned per century in northern Colorado, associated with a temperature increase of just 0.5˚C (0.9˚F) (Calder et al. 2015). Impacts of this included more trees burned (Walsh et al. 2010), higher post-fire erosion (Pierce et al. 2004), and shifts towards more open forest structure (Colombaroli & Gavin, 2010). Increases in fire may have been moderated by fuel availability, with fewer fires in more fuel-limited systems such as sagebrush ecotones (Nelson & Pierce 2010), and less fire activity towards the end of the MCA when fuels may have been more limited due to previous fires (Calder et al. 2015).
- Compositional shifts towards more drought-tolerant and more shade-intolerant vegetation, in response to increased drought and/or fire (Lucas & Lacourse 2013, Whitlock et al. 2011, Colombaroli & Gavin, 2010).
- Range shifts or local extinctions due to temperature changes. Range shifts were observed mainly in high-elevation tree species that were able to establish at even higher elevations as temperatures warmed (Rochner et al. 2021, Briles et al. 2011). Local extinctions occurred in temperature-sensitive species such as the American pika (Millar et al. 2014).



Under warmer temperatures, high-elevation areas (like this one in the Wallowa Mountains) tend to see treelines move to higher elevations. Rocky areas with sparse vegetation may serve as fuel breaks as fires increase in response to warmer and dryer conditions.

Adapting to Future Climate Change

The changes observed during the MCA are likely to occur in the future as the climate once again warms. Future changes may even be more severe than during the MCA, due to more rapid and potentially larger changes in temperature, coupled with lower ecosystem adaptability. Human activities and an increasingly large human footprint have caused alteration of natural disturbance regimes, loss of habitat connectivity and quality, and declines in biodiversity, which can make ecosystems more vulnerable (Watson et al. 2018). In the western United States, the biggest impact of climate change may be changes in fire regimes, which may lead to loss of forest in some areas where trees fail to regenerate due to dry climate conditions and large patches of high-severity fire. Although the future will be challenging and some change will be unavoidable, there are several strategies that land managers can employ to help climate adaptation, resistance, and resilience.

1) Identify, restore, and maintain areas that may provide refugia from fire and/or climate change. This may include wetlands and riparian areas, and non-forested areas that serve as natural fuel breaks.
2) Use thinning, prescribed fire, and managed wildfire to reduce forest density and promote conditions that are resistant to drought and fire.
3) Prioritize restoration and protection based on values at risk. Areas such as rare habitat, biodiversity hotspots, and wildland-urban interface may be protected with fuel breaks and restoration efforts.
4) Facilitate species shifts towards more suitable future environments. This may mean increasing habitat connectivity, or even facilitating migrations for species that are losing habitat more quickly than they can relocate.
5) Consider future climate in all planting decisions. This may mean allowing conversion to non-forested states at hot and dry sites, or altering planting densities and species compositions to be suitable for hotter and dryer conditions.

Wet areas (like the Duck Lake Research Natural Area on the Wallowa-Whitman National Forest) can serve as climate refugia, remaining cooler and wetter than the surroundings as the climate changes. However, many of these areas are in need of restoration to maximize their ecological benefits.

Heavens Gate Lookout Tower in early October on the Wallowa-Whitman National Forest. Future increases in minimum temperatures will mean less snowpack and earlier snowmelt at sites like this, translating into lower water availability later in the year.

Suggested Resources

Halofsky, J. E., Peterson, D. L., & Harvey, B. J. (2020). Changing wildfire, changing forests: the effects of climate change on fire regimes and vegetation in the Pacific Northwest, USA. *Fire Ecology*, *16*(1), 1-26.

Climate Change Adaptation Library for the Western United States, http://adaptationpartners.org/library.php

References

Calder, W. J., Parker, D., Stopka, C. J., Jiménez-Moreno, G., & Shuman, B. N. (2015). Medieval warming initiated exceptionally large wildfire outbreaks in the Rocky Mountains. *Proceedings of the National Academy of sciences*, *112*(43), 13261-13266.

Colombaroli, D., & Gavin, D. G. (2010). Highly episodic fire and erosion regime over the past 2,000 y in the Siskiyou Mountains, Oregon. *Proceedings of the National Academy of Sciences*, *107*(44), 18909-18914.

Lucas, J. D., & Lacourse, T. (2013). Holocene vegetation history and fire regimes of Pseudotsuga menziesii forests in the Gulf Islands National Park Reserve, southwestern British Columbia, Canada. *Quaternary Research*, *79*(3), 366-376.

Millar, C. I., Heckman, K., Swanston, C., Schmidt, K., Westfall, R. D., & Delany, D. L. (2014). Radiocarbon dating of American pika fecal pellets provides insights into population extirpations and climate refugia. *Ecological Applications*, *24*(7), 1748-1768.

Pierce, J. L., Meyer, G. A., & Timothy Jull, A. J. (2004). Fire-induced erosion and millennial-scale climate change in northern ponderosa pine forests. *Nature*, *432*(7013), 87-90.

Rochner, M. L., Heeter, K. J., Harley, G. L., Bekker, M. F., & Horn, S. P. (2021). Climate-induced treeline mortality during the termination of the Little Ice Age in the Greater Yellowstone Ecoregion, USA. *The Holocene*, *31*(8), 1288-1303.

Walsh, M. K., Whitlock, C., & Bartlein, P. J. (2010). 1200 years of fire and vegetation history in the Willamette Valley, Oregon and Washington, reconstructed using high-resolution macroscopic charcoal and pollen analysis. *Palaeogeography, Palaeoclimatology, Palaeoecology*, *297*(2), 273-289.

Watson, J. E., Evans, T., Venter, O., Williams, B., Tulloch, A., Stewart, C., ... & Lindenmayer, D. (2018). The exceptional value of intact forest ecosystems. *Nature ecology & evolution*, *2*(4), 599-610.

Whitlock, C., Briles, C., Fernandez, M., & Gage, J. (2011). Holocene vegetation, fire and climate history of the Sawtooth Range, central Idaho, USA. Quaternary Research, 75(1), 114-124. doi:10.1016/j.yqres.2010.08.013