DAVEY

Climate Change Projections for the United States Northern Great Plains

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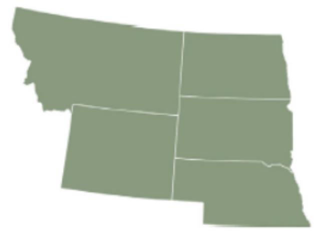
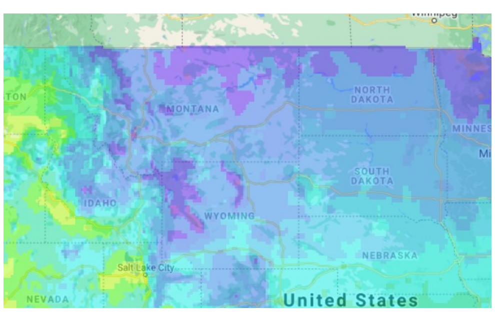


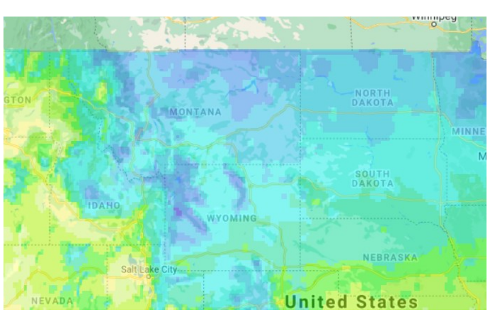
Image from Fourth National Climate Assessment

The Davey Climate Change Fact Sheet Series projects the future impacts of climate change in our industry over the next 30-70 years, with emphasis on changes in temperature, precipitation, storm intensity, tree health, pest pressure, wildfire, and worker stress. Temperatures across the U.S. are expected to increase between 3-11°F by the end of this century, with future patterns of greenhouse gas emissions providing the largest source of uncertainty. The Intergovernmental Panel on Climate Change (IPCC) predicts future climates based on modeling for different emissions scenarios, called "Representative Concentration Pathways (RCP)." This fact sheet focuses on changes expected to occur in the Northern Great Plains of the U.S. based on lower (RCP4.5) and higher (RCP8.5) emissions scenarios. Currently, global patterns of fossil fuel consumption correspond most closely with the high emission scenario, while the lower emission scenario will require significant mitigation measures yet to be implemented.

The climate is warming. The average annual temperature throughout the Northern Plains States has warmed over the last century, ranging from 1°F in Nebraska to as much as 3°F in parts of Wyoming. The number of extreme heat days in also increasing. For example, the number of days above 100°F is projected to double in Wyoming by the middle of this century, and over much of the region the number of very hot days (above 86°F) are projected to increase by an average of 31 and 46 over the 1980-2009 baseline under the lower and higher emissions scenarios, respectively. With increasing temperatures, plant hardiness zones are transitioning. By mid-century, mean minimum temperature will have increased by 3.6° and 10.8°F for nearly half of the region.



Current winter hardiness zones



Winter hardiness zones projected for end of century under the lower emission scenario

Precipitation is becoming more variable

Total precipitation is increasing in the eastern areas of the region while declining in the western areas. It is also becoming more variable. As summer droughts are projected to become more severe, flooding may also intensify as rainstorms also become more intense throughout the region. Average precipitation during winter and spring is projected to increase, with heavy downpours increasingly accounting for a greater proportion of all precipitation.

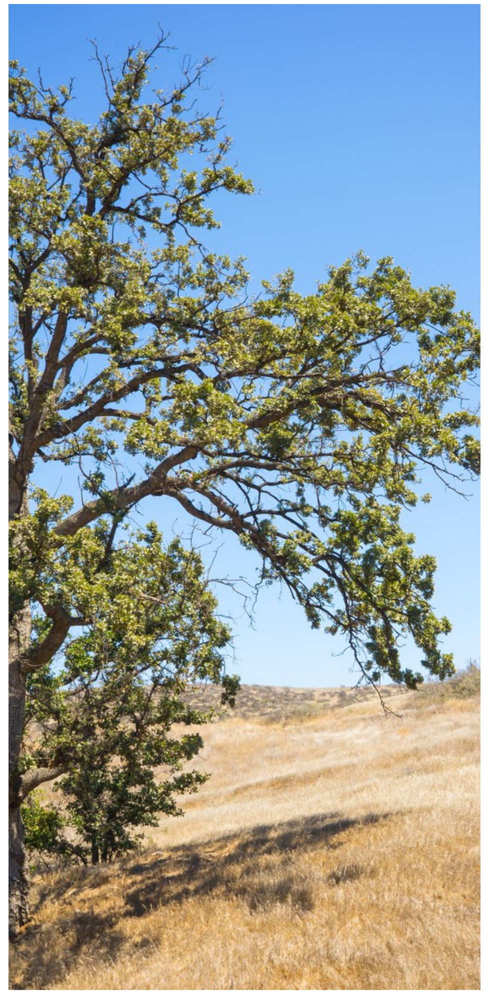
Already, a greater proportion of precipitation in winter is falling as rain resulting in decreased snowpack, which is increasing hydrological runoff and streamflow in winter and decreasing runoff in summer. For example, the amount of rain falling during the wettest four days of the year has increased about 15 percent in the Great Plains since 1970.

Water availability is declining

Summer drought, decreased snowpack, shrinking glaciers, and increased evapotranspiration in the Northern Great Plains have decreased the average flow rate of rivers and streams in recent decades. Recent research based on analyses of tree rings (dendrochronology) has found that severity of droughts in the Upper Missouri River basin in the early 21st Century is unprecedented in the last 100 years and probably in the last 1,000 years.

Furthermore, agricultural irrigation has depleted ground water in the High Plains Aquifer System on which the water supply of parts of the region, including Nebraska, are highly dependent. As these trends continue, limits on municipal water supplies may result in irrigation restrictions, which will present challenges for tree health maintenance when physiological demands for water are amplified by increasing temperatures and evapotranspiration.

As plant growth begins earlier in the spring and summers become hotter and extreme heat more frequent, soil is becoming drier as evapotranspiration increases. These trends will intensify stress experienced by trees resulting in their increased susceptibility to secondary pests such as wood-borers, vascular wilt and canker pathogens, especially in the southern portions of this region. Increased degree-day accumulation is resulting in insect pests increasing their reproductive rates and number of generations per year; warmer temperatures will also lead to new pest species migrating north into the region.



Changing forests: insect outbreaks and wildfire.

Forest productivity may increase in the northern portions of this region due to longer growing seasons and increased atmospheric carbon dioxide concentrations. However, forest composition is expected to shift as pines become less dominant and a warmer climate favor deciduous trees such as aspen.

Tree mortality has increased across the region due to more intense drought, increased forest fires, and expansive insect outbreaks. Warmer winters increase overwintering survival of mountain pine beetle, which in recent years has contributed to massive outbreaks of this bark beetle across much of the region resulting in widespread mortality of lodgepole and ponderosa pine. Mountain pine beetle is killing whitebark pine in high elevation forests in the Greater Yellowstone Ecosystem where severe outbreaks previously did not occur.

Warming and drying of the climate have increased wildfire frequency, intensity, and the length of the wildfire season, resulting in a doubling of the forest area that has burned throughout the western United States since 1984 . The greatest increases in wildfires have occurred in the northern Rocky Mountains and have been strongly linked to more arid fuels, increased spring and summer temperatures, and earlier spring snowmelt. This trend is projected to intensify in coming decades as the climate continues to become warmer and drier.

Sources:

Abatzogloua, J.T., and A.P. Williams. Impact of anthropogenic climate change on wildfire across western US forests. *Proceedings of the National Academy of Sciences* 113:11770–11775.

Conant, R.T., D. Kluck, M. Anderson, A. Badger, B.M. Boustead, J. Derner, L. Farris, M. Hayes, B. Livneh, S. McNeeley, D. Peck, M. Shulski, and V. Small. 2018. Northern Great Plains. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 941–986. doi:10.7930/NCA4.2018.CH22.

Lian, X., S. Piao, L.Z.X. Li, Y. Li, C. Huntingford, P. Ciais, A. Cescatti, I.A. Janssens, J. Peñuelas, W. Buermann, A. Chen, X. Li, R.B. Myneni, X. Wang, Y. Wang, Y. Yang, Z. Zeng, Y. Zhang, T.R. McVicar. 2020. Summer soil drying exacerbated by earlier spring greening of northern vegetation. *Science Advances* 2020; 6: eaax0255.

Logan, J.A, W.W. MacFarlane, and L. Willcox. 2010. Whitebark pine vulnerability to climate-driven mountain pine beetle disturbance in the Greater Yellowstone Ecosystem. *Ecological Applications* 20:895-902.

Martin, J.T., G.T. Pederson, C.A. Woodhouse, E.R. Cook, G.J. McCabee, K.J. Anchukaitis, E.K. Wise, P.J. Ergerg, L. Dolanh, M. McGuirei, S. Gangopadhyayi, K.J. Chase, J.S. Littell, S.T. Gray, S. St. George, J.M. Friedman, D.J. Sauchyn, J.-M. St-Jacques, and J. King. 2020. Increased drought severity tracks warming in the United States' largest river basin. *Proceedings of the National Academy of Sciences* 117:11328-11336.

Mathews, S.N., L.R. Iverson, M.P. Peters, and A.M. Prasad. 2018. Assessing potential climate change pressures across the conterminous United States: mapping plant hardiness zones, heat zones, growing degree days, and cumulative drought severity throughout this century (https://www.fs.fed.us/nrs/pubs/rmap/rmap_nrs9.pdf)

Overpeck, J.T., and B. Udall. 2020. Climate change and the aridification of North America. *Proceedings of the National Academy of Sciences* 117:11856-11858.

Sanford, W.E. and D.L. Selnick. 2013. Estimation of evapotranspiration across the conterminous United States using a regression with climate and land-cover data. *Journal of the American Water Resources Association,* 49:217-230.

Taylor, R., D.A. Herms, J. Cardina, and R. Moore. 2018. Climate change and pest management: unanticipated consequences of trophic dislocation. *Agronomy,* 8, 7; DOI:10.3390/agronomy8010007.

U.S. Environmental Protection Agency. EPA's Climate Change Indicators in the United States (https://www.epa.gov/climate-indicators).

United States Environmental Protection Agency. What climate change means for Nebraska. EPA 430-F-16-029, August 2016.

United States Environmental Protection Agency. What climate change means for Wyoming. EPA 430-F-16-052, August 2016.

van Vuuren, D.P., J. Edmonds, M. Kainuma, K. Riahi, A. Thomson, K. Hibbard, G.C. Hurtt, T. Kram, V. Krey, J.-F. Lamarque, T. Masui, M. Meinshausen, N. Nakicenovic, S.J. Smith, and S.K. Rose. 2011. The representative concentration pathways: an overview. *Climatic Change* 109:5-31. https://doi.org/10.1007/s10584-011-0148-z.

Weed, A.S., M.P. Ayres, and J.A. Hicke. 2013. Consequences of climate change for biotic disturbances in North American forests. *Ecological Monographs* 83:441-470.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam. 2006. Warming and earlier spring increase western U.S. forest wildfire activity. *Science* 313:94-943.

Williams, A.P., E.R. Cook, J.E. Smerdon, B.I. Cook, J.T. Abatzoglou, K. Bolles, S.H. Baek, A.M. Badger, and B. Livneh. 2020. Large contribution from anthropogenic warming to an emerging North American drought. *Science* 368:314-318.