Climate-change-induced wildfires may alter Yellowstone forests

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This is a healthy lodgepole pine with multiple cones. Credit: Erica A. H. Smithwick

Climate change in the Greater Yellowstone Ecosystem will increase the frequency of wildfires and alter the composition of the forests by 2050, according to a team of ecologists who modeled the effects of higher temperatures on fire occurrence.

"We are following the long-term effects of fire in the Yellowstone area and encountering some lessons and surprises that challenge the way we think about fire in the area," said Erica A. H. Smithwick, assistant professor of geography and ecology, Penn State, and principle investigator on the project. "Yellowstone National Park is the first national park in the world and is now a wonderful natural laboratory for

studying natural processes."

The Greater Yellowstone Ecosystem is centered around Yellowstone National Park but encompasses about 20 million acres in Wyoming, Montana and Idaho and includes Grand Teton National Park, many national forests and a small amount of private land. The forests in this area are predominantly lodgepole pine but also include Douglas fir, Ponderosa pine, whitebark pine, spruce-fir and aspen.

Using historic records of fires in the Yellowstone area and coupling that information with a number of existing climate models, the researchers report today (July 25) in the Proceedings of the National Academy of Sciences that the climate-linked fire system is a tipping element that may change the flora, fauna and ecosystem quality in this landscape and could point to similar changes in other subalpine or boreal forests.

Historically, fires occur in the lodgepole forests in the Yellowstone area about once every 100 to 300 years. These fires are 'stand replacing fires' because the entire forest is destroyed by fire and then regrows. Unlike areas of the southwest where understory brush and organic material increases the chance of major fires, fire in this area is mostly dependent on temperature, relative humidity and drought conditions.

Unlike other coniferous trees, lodgepole pine create pinecones very slowly and the cones stay on the trees. On some trees, the cones require the heat of a fire to open and release their seeds.

"The vegetation really needs about 90 years to fully recover," said Smithwick, "although there would probably be some cones at 15 years and more at 30 and 60 years. We need to know more about the forest's capacity to recover rapidly under frequent fire conditions."

Historically, large fire years were associated with moderate -- 2 degrees

Fahrenheit -- changes in temperature, but changes in future temperatures are expected to exceed these values on a regular basis. The rate of fires is already increasing in the western U.S. Using the historical fire-climate relationships between 1972 and 1999 as a guide, the three global climate models provided consistent results through the year 2099.

The researchers found that "warmer-than-average temperatures were a necessary but not sufficient condition for predicting extreme fire years" but that moisture deficit and summer precipitation were also important. Although the variability of day-to-day winds is not included in the models, they too would play a part in fire frequency and size.

"What surprised us about our results was the speed and scale of the projected changes in fire in Greater Yellowstone," said Anthony Westerling, professor of environmental engineering and geography, University of California, Merced. "We expected fire to increase with increased temperatures, but we did not expect it to increase so much or so quickly. We were also surprised by how consistent the changes were across different climate projections."

In the simulations, years with no major fires, which are common historically, became rare approaching 2050 and almost non-existent between 2050 and 2099. Between 2005 and 2034 the fire interval drops below 30 years in parts of the landscape, and by 2099 climatic condition are such that fire is the norm.

Of course with a more frequent fire regime, there could be insufficient fuel for fires to persist.

"In these model we don't consider what the vegetation will do under these changing regimes," said Smithwick. "The forest has been stable for thousands of years, but it looks like it will face changes by 2050."

These changes would also alter the fire regime because some areas might become more permanent grasslands or forests of other trees, such as Ponderosa pine, might emerge. Long before the fire regimebecomes more frequent, the vegetation and possibly the animals in the area may have to adapt to severe fire events.

Smithwick is not suggesting that fire policy in Yellowstone should shift, and she is certain that the park with its geysers and mud pots will still remain, but climate change will bring changes to the forests and perhaps to the human and animal uses of the park.

"The lodgepole pine has surprised us over and over, so maybe it will be resilient enough to persist," she said.

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