CLIMATE CHANGE & DROUGHT

Climate change is making droughts more likely to occur - and more severe when they do - in parts of the United States. While the US is no stranger to drought, climate change has exacerbated drought conditions so that when droughts occur, it is in a hotter climate and, in some cases, with lower precipitation.

- Snow cover in the Northern Hemisphere has declined significantly over the past 90 years, largely driven by climate change (Najafi et al. 2016).
- Warmer temperatures associated with climate change have intensified the severity of droughts, particularly in areas already suffering from water scarcity (Weiss et al. 2009; Williams et al. 2019).
- Climate change can even be detected on some of the droughts in the early twentieth-century (1900-1950) (Marvel et al. 2019).

HOW DOES CLIMATE CHANGE EXACERBATE DROUGHT?

Climate change has exacerbated drought in parts of the US primarily by decreasing the snowpack and already small amount of water available in streams and soils. Most droughts are driven by natural variability in precipitation. Climate change-driven hotter temperatures, however, melt snowpack earlier, evaporate water in streams and lakes, and evaporate water from soils, turning what would have been a moderate drought into a much more severe drought. In some limited cases, there is also evidence that climate change is changing rainfall patterns, blocking rain from reaching areas in need of water. These combined effects have made what may have been moderate droughts severe or exceptional instead.

WHY DROUGHTS MATTER

There are many types of 'droughts', ranging from agricultural drought - when there is insufficient water or soil moisture to meet agricultural demands - to hydrological drought - a shortage in water resources, including groundwater and rivers. Ultimately, we care about droughts when there is not enough water to meet needs. Droughts can have huge social and economic effects; the 2018 Southwest and Southern Plains drought cost $3 billion (NOAA NCEI 2019). Beyond the effects on agriculture and water availability, drought can also increase wildfire risk. Desiccated vegetation from drought is a perfect fuel for fires, so when fires start, they can burn more intensely and over larger areas.

"THE DOUBLE WHAMMY OF RISING TEMPERATURES AND SHIFTING RAIN AND SNOWFALL IS BEING FELT ALL OVER CALIFORNIA, FROM THE DRY HILLSIDES THAT HAVE BEEN BURNING WITH INCREASED FREQUENCY AND INTENSITY TO THE DEPLETED RIVERS, AQUIFERS AND RESERVOIRS OUR COMMUNITIES DEPEND ON FOR DRINKING WATER AND IRRIGATION, TO THE PROLIFERATION OF HARMFUL ALGAL BLOOMS AND RISING SALINITY IN OUR FRESHWATER ECOSYSTEMS.

CLIMATE CHANGE FINGERPRINTS ARE EVERYWHERE, AND WE ARE WORKING TO MANAGE CURRENT IMPACTS WHILE PREVENTING EVEN WORSE ONES FROM OCCURRING."

- Laurel Firestone,
California State Water Resources Control Board

REGIONAL BREAKDOWN

Climate change has the largest effect on drought in the Western US, west of the Appalachian Mountains, where it has expanded semi-arid conditions (Chan and Wu 2015). Here, a combination of hot temperatures and, in some areas, a lack of precipitation has led to or exacerbated droughts over the past decade.

WHAT CAN WE LEARN FROM THE HOT & DRY CALIFORNIA DROUGHT?

California's infamous 2011-2017 drought was made worse by climate change; scientists have identified telltale climate fingerprints on the drought's hottest and driest years (2011-2014) (AghaKouchak et al. 2014). These 'hot droughts' are now twice as likely to occur in California due to climate change, just from higher temperatures drying out soil and evaporating water (Diffenbaugh et al. 2015). Record-high temperatures made the 2012-2014 drought 36 percent worse (Griffin and Anchukaitis 2014), and were responsible for 8-27 percent of drier soil (Williams et al. 2015).

These hot temperatures also significantly reduced California's snowpack, which provides the state with much of its water. It is very likely (>80 percent chance) that climate change made the 2014 CA drought worse by reducing the snowpack and causing earlier snowmelt, leaving streams dry by summer (Shukla et al. 2015). Over 2011-2015, climate change reduced California's snowpack by 25 percent (Berg and Hall 2017).

The effect on precipitation is less clear. There is, however, some limited evidence that the low precipitation in 2013 and 2014 could be linked to climate change (Seager et al. 2017), partly by having made the 'ridiculously resilient ridge' - which blocked rain from reaching California - twice as likely (Swain et al. 2014). Ultimately, whether or not climate change 'blocks' precipitation, it has significantly exacerbated drought in California simply from hotter temperatures.

The effects seen in California can be seen in much of the Western US.

THE COLORADO RIVER

Streamflow in the Colorado River is decreasing due in large part to warmer temperatures that cause evaporation and early snowmelt (McCabe et al. 2017, Udall and Overpeck 2017). The river's annual average streamflow is decreasing by around 9 percent per degree Celsius (1.8 degrees Fahrenheit) of warming and warmer temperatures are responsible for half of the 16 percent decrease in flow in the Colorado River between 2000 and 2017 (Milly and Dunne 2020).

HOT GROUND FROM THE NORTHERN GREAT PLAINS TO TEXAS

In semi-arid environments - including the Southwest and large portions of the Great Plains - hotter temperatures can dry out land. Those warmer temperatures made the 2017 Great Plains (the Dakotas and Montana) drought 50 percent more likely (Hoell et al. 2019). Climate change also made the 2011 Texas drought more likely to occur; specifically, it greatly increased the frequency of hot temperatures by an order of magnitude and likely decreased precipitation totals (Rupp et al. 2012). Climate change has made extreme precipitation deficits (like those in the Central US in summer 2012) three to four times more likely (Rupp et al. 2017).

"HOT DROUGHTS" IN THE SOUTHWESTERN US

Just like California, climate change is leading to 'hot droughts' in the US Southwest, with warming increasing the severity of droughts particularly since 2000 (Weiss et al. 2009). This region has been in perpetual drought conditions since 2000; while the low rain and snowfall is mostly due to natural variability, climate change-driven warming has significantly exacerbated that drying (Lehner et al. 2018). In 2018, hotter temperatures decreased the snowpack water content by 20 percent and reduced vegetation greenup - a proxy for rangeland conditions (Williams et al. 2019).

SNOW & STREAMFLOW IN THE MOUNTAINOUS WESTERN US

The mountainous Western US is heavily dependent on a good winter snowpack. Climate change has led to fewer snow days, a lower overall snowpack, and early snowmelt: this has caused earlier runoff (streamflow), leaving late spring and early summer without water. At least half of this low late-winter snowpack and the earlier runoff is due to warmer temperatures (Pierce et al. 2008; Barnett et al. 2008). These increases in hot temperatures - particularly daytime winter temperatures - are driven by climate change (Bonfils et al. 2008). The largest effect on snowpack and number of snow days is in the Northwest (Das et al. 2009), where warm temperatures have significantly reduced snowpack (Fosu et al. 2017; Mote et al. 2016).

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