



Past and Future Climate Patterns

Introduction

Climate change has the potential to profoundly alter national parks, with potential impacts to vegetation, wildlife, and cultural resources (Monahan and Fisichelli 2014, Tercek et al. 2021). During this time of unprecedentedly rapid change (Intergovernmental Panel on Climate Change [IPCC] 2022), proactive management—planning that anticipates the future—is more likely to be successful than reactive management, which merely responds to crises as they arise. Proactive management plans depend on a clear understanding of both the changes that have occurred so far and what we might expect in the future. In this resource brief, we discuss historical climate patterns at Chickasaw National Recreation Area (NRA) and compare them to the range of conditions that we expect for the late 21st century, providing park managers with important insights for climate-change planning efforts.

Looking to the Future

Our discussion of the future is based on climate “projections.” Unlike weather “forecasts,” which typically extend only a few days to a few months into the future, climate projections, which are based on complex computer models of Earth’s atmosphere and geological systems, extend decades into the future. Climate projections are not meant to predict the temperature or rainfall on a particular day or month in the future, but they are skilled at capturing long-term (decades to centuries) trends in average annual and seasonal patterns that we might expect.

There are more than 40 climate projections available for Chickasaw NRA. They all call for some amount of future warming, but there is disagreement on whether precipitation will increase or decrease. As future warming interacts with changes in precipitation, it will change the amount of water that is available for plants and animals. A large amount of warming would greatly increase evaporation and transpiration (plant



Sunset over Veterans Lake at Chickasaw National Recreation Area. Photo: NPS / A. Ray.

water use), but less warming would require a smaller increase in precipitation to maintain historically normal moisture levels.

Summary of Future Climate at Chickasaw

- Climate projections, based on computer models of Earth’s atmosphere and geological systems, capture long-term trends in average annual and seasonal patterns.
- All climate projections for Chickasaw NRA call for future warming, but there is disagreement on whether precipitation will increase or decrease.
- Extremely warm temperatures (above 100°F) are expected to occur on more days per year compared to the past.
- The number of days per year below freezing is expected to decrease.
- The futures described here are likely to increase the frequency of drought, affect fire regimes, and alter the composition of plant communities at Chickasaw NRA.

In this resource brief, we have chosen two projections (out of >40) that capture the range of wettest (i.e., most biologically available water; also referred to as Wet Future) versus driest (i.e., least biologically available water; also referred to as Dry Future) conditions that are projected for the late 21st century (2070–2099). Note that the wettest future does not correspond to the future with the most precipitation.

Precipitation Patterns: Past and Future

Historical (1979–2022) precipitation did not have a clearly increasing or decreasing trend; instead, it had early and late wet periods that were interrupted by a drier-than-average period during the 1990s and 2000s (Figure 1, left). Future precipitation projections range from a roughly 50% decrease (Dry Future) to a 25% increase (Wet Future) relative to the historical average (Figure 1 [right], solid red and blue lines, respectively).

Temperature Patterns: Past and Future

Historical (1979–2022) temperatures did not have a

strong trend (Figure 2, left). The two future projections that we chose to highlight predict roughly 2–11°F of warming by late century compared to the historical average (Figure 2, right); mid-century (2040–2069) warming is also predicted, but the difference from historical values is lower (2–5°F).

Future warming would cause sharp decreases in the number of days per year below freezing. Under the milder Wet Future, the median number of days below freezing (53 days) would be similar to the most extreme count observed historically (49 days in 2017, Figure 3), and the warmer Dry Future projects approximately 12 days per year below freezing by the late 21st century (see Figure 3).

Extremely warm temperatures are projected to increase sharply in the future. The largest historical count of days per year above 100°F (96 days in 2011) is similar to the median count for the late-century Dry Future (103 days, Figure 4).

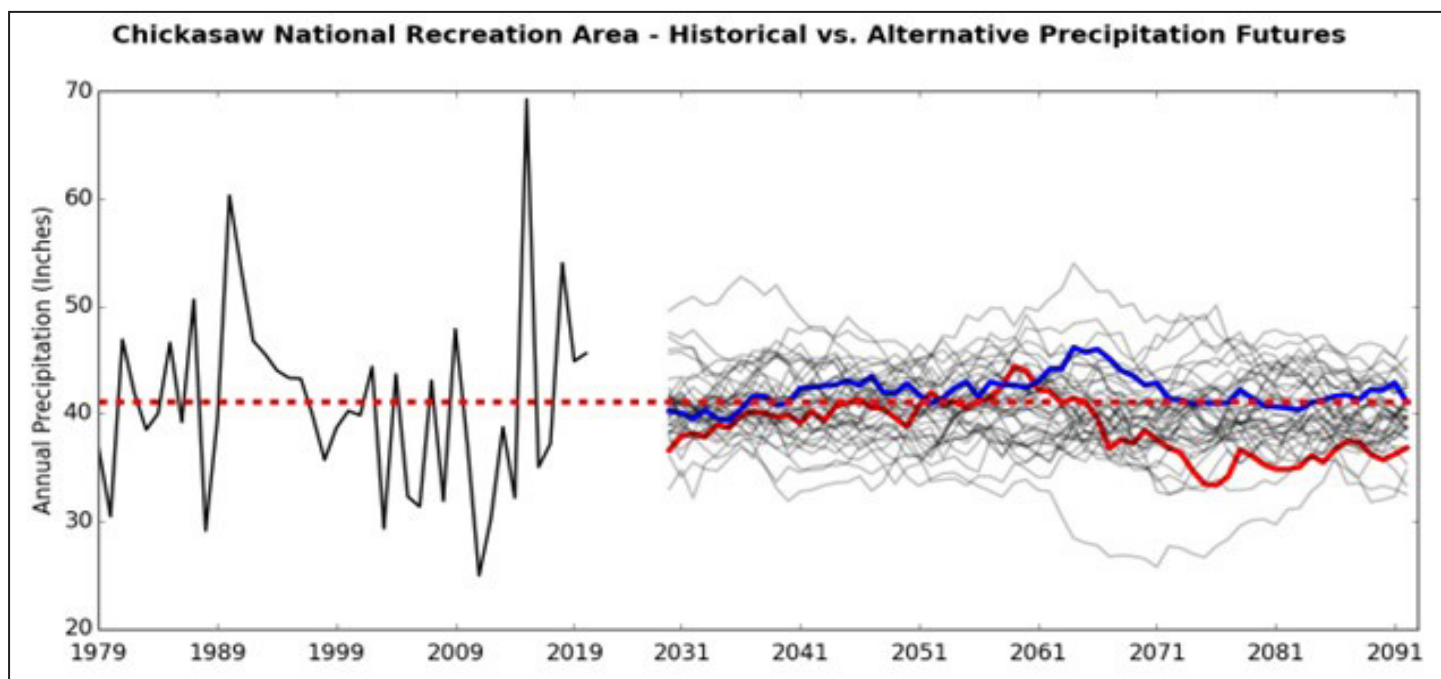


Figure 1. Historical annual precipitation (1979–2022, left) compared to 40 future projections of annual precipitation (right) at Chickasaw National Recreation Area. The dashed red line shows the historical average of annual precipitation. Future time series have been smoothed with a 10-year moving average to make the patterns clearer. The wettest (Wet Future, shown in blue here and below) and driest (Dry Future, shown in red here and below) futures fall within the range of all ($n=40$) forecasted futures (gray lines). The Wet Future represents the one with the most soil moisture or biologically available water, and the Dry Future represents the one with the least biologically available water. Notably, the Wet Future does not correspond to the future with the most precipitation. Historical data are taken from GRIDMET gridded data, and future data are produced using the MACA down-scaling method (Abatzoglou and Brown 2012, Abatzoglou 2013).

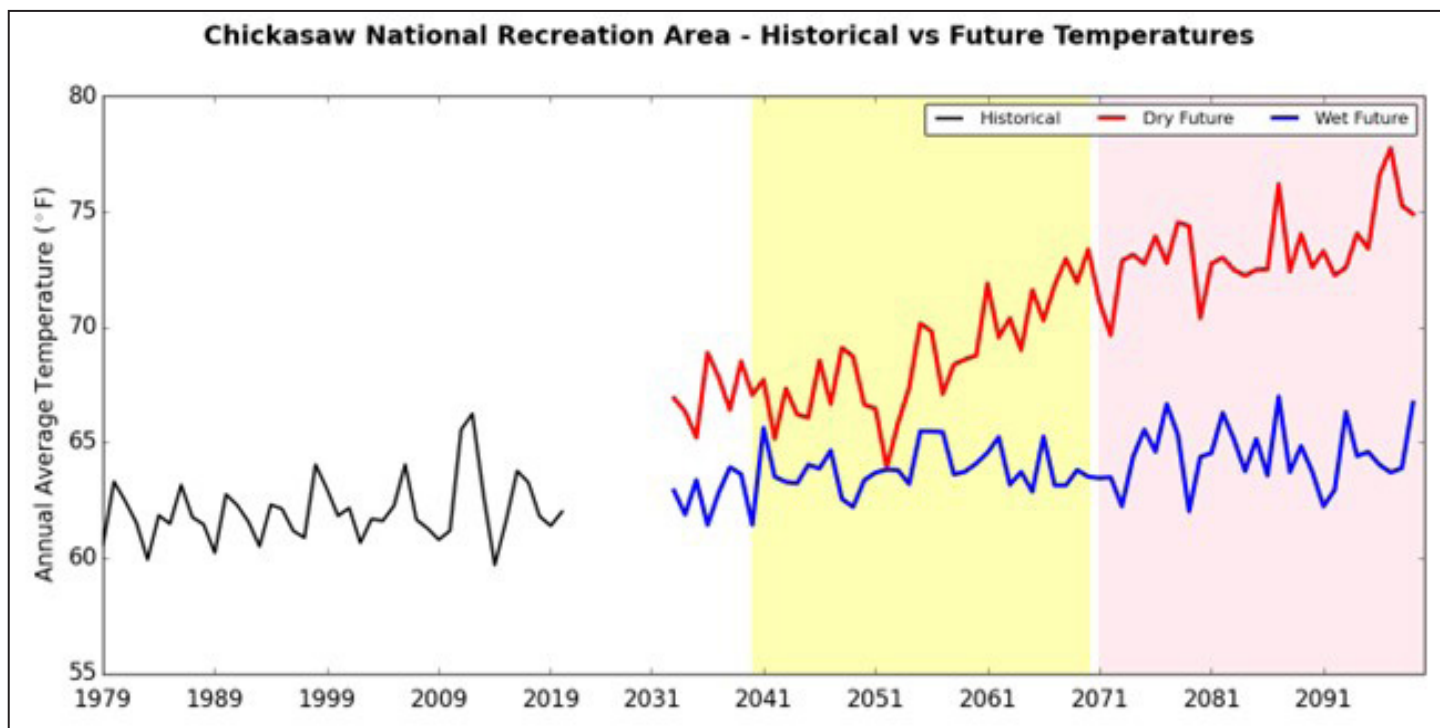


Figure 2. Historical average annual temperatures (black) and two temperature projections (red {top} and blue) that bracket the range of driest vs. wettest futures at Chickasaw National Recreation Area. Mid-century (2040–2069) projections are highlighted in yellow, and late-century (2070–2099) projections are highlighted in pink. Historical data are from GRIDMET. The Wet Future is MACA downscaled MRI-CGCM3 RCP 4.5, and the Dry Future is HadGEM2-CC365 RCP 8.5. Data sources are from the UC Merced Climatology Lab (<https://www.climatologylab.org/datasets.html>), Abatzoglou and Brown (2012), and Abatzoglou (2013).

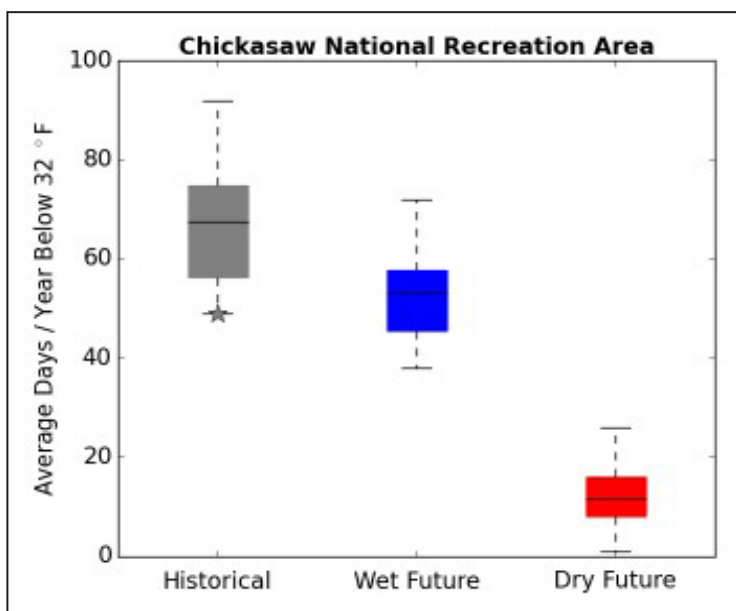


Figure 3. Annual number of days per year with minimum temperatures below freezing. The gray star marks the lowest historical count (49 days) in 2017. This historical extreme is very similar to the median of the Wet Future (53 days, horizontal line in middle of blue boxplot) by late century. The median Dry Future count (12 days) is less than one-fourth of the historical median. Data sources: Abatzoglou and Brown (2012), Abatzoglou (2013).

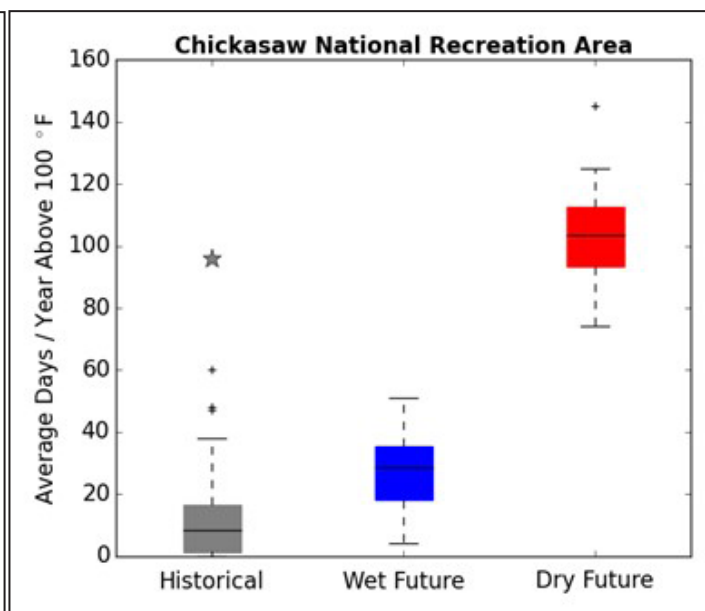


Figure 4. Annual number of days per year with temperatures above 100°F. The gray star marks the highest historical count (96 days in 2011). This historical count is similar to the late-century Dry Future median (103 days, horizontal line in red boxplot). The late-century Wet Future median (28 days) is double the historical median (14 days). Data sources: Abatzoglou and Brown (2012), Abatzoglou (2013).

Moisture Availability: Will Plants have Access to the Water they Need?

The future is quite likely to be warmer, but will it be wetter or drier? At first this might seem like a difficult question to answer, as future projections for Chickasaw NRA show either an increase or a decrease in precipitation. This can be discouraging because it seems as though the future is so uncertain that it is impossible to make plans. However, the future is more certain than one might think after looking at Figure 1.

Chickasaw NRA is likely to get drier in future summers because warmer temperatures will use up any extra precipitation. This can be seen in Figure 5, where the Wet Future projects late-century soil moisture (biologically available moisture) slightly drier than the historical average (middle panel, compare blue and gray lines), even though there is a marginal increase in predicted precipitation (bottom panel, blue and gray lines). Since the Wet Future does not yield increased soil moisture, there is little change in warm-season actual evapotranspiration, which is an index of plant water use and growth (top panel, blue and gray lines). Meanwhile, the Dry Future projection (red lines) shows marked decreases in warm-season plant water use (top panel) and soil moisture (middle panel), which is not surprising given the projected decreases in precipitation (bottom panel).

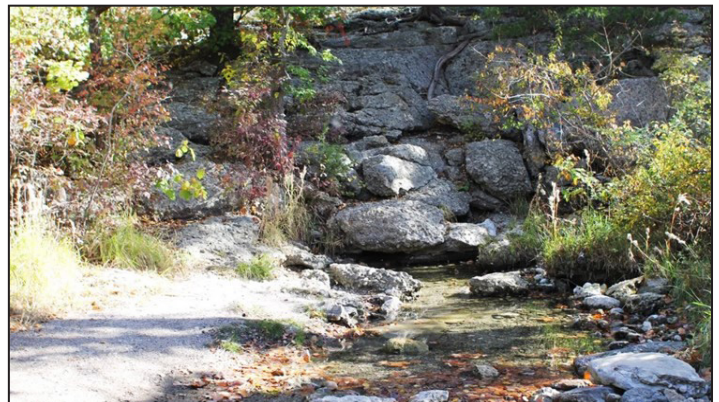
Conclusions and Implications: What does all this mean for Chickasaw NRA?

Future projections for Chickasaw NRA call for 2–11°F of warming, relative to the historical average, by the late 21st century. Future precipitation projections are mixed, calling for either increases or decreases. Despite the uncertainty in the precipitation projections, summers in the future are likely to be drier as only one of the available 40 climate futures projects soil moisture levels similar to the historical averages.

The climate futures described here are likely to affect fire regimes, increase the frequency of drought, and alter the composition of vegetation communities in Chickasaw NRA's grasslands and forests. Lower soil moisture is predicted to shift the species composition of grasslands at Chickasaw and across Oklahoma away

from tallgrasses and towards shorter, more drought-tolerant grasses (Manier et al. 2019), including invasive bluestems like *Bothriochloa ischaemum*. The proportion of warm-season grasses will increase at the expense of cool-season grasses (Belesky and Malinowski 2016). Native plant communities could face chronic drought stress, leaving them less resilient in the face of disturbance and invasive species (Wilsey et al. 2018). Finally, drought has reduced flows in many springs at Chickasaw NRA. In 2022, Antelope Springs ran dry—something that has happened just 24 times since 1902. The projections for a drier future described here may contribute to future declines in groundwater discharge that ultimately affect springs, streams, and other groundwater-dependent water bodies at Chickasaw.

This resource brief was intended to help resource managers better understand how the climate is likely to change at Chickasaw NRA, consider adaptations to climate impacts, and support planning that will reduce risks and vulnerabilities to park resources.



Antelope Springs in Chickasaw National Recreation Area (top and bottom). The springs, which are an important source of water for Travertine Creek, ran dry in 2022 (see bottom). NPS photos.

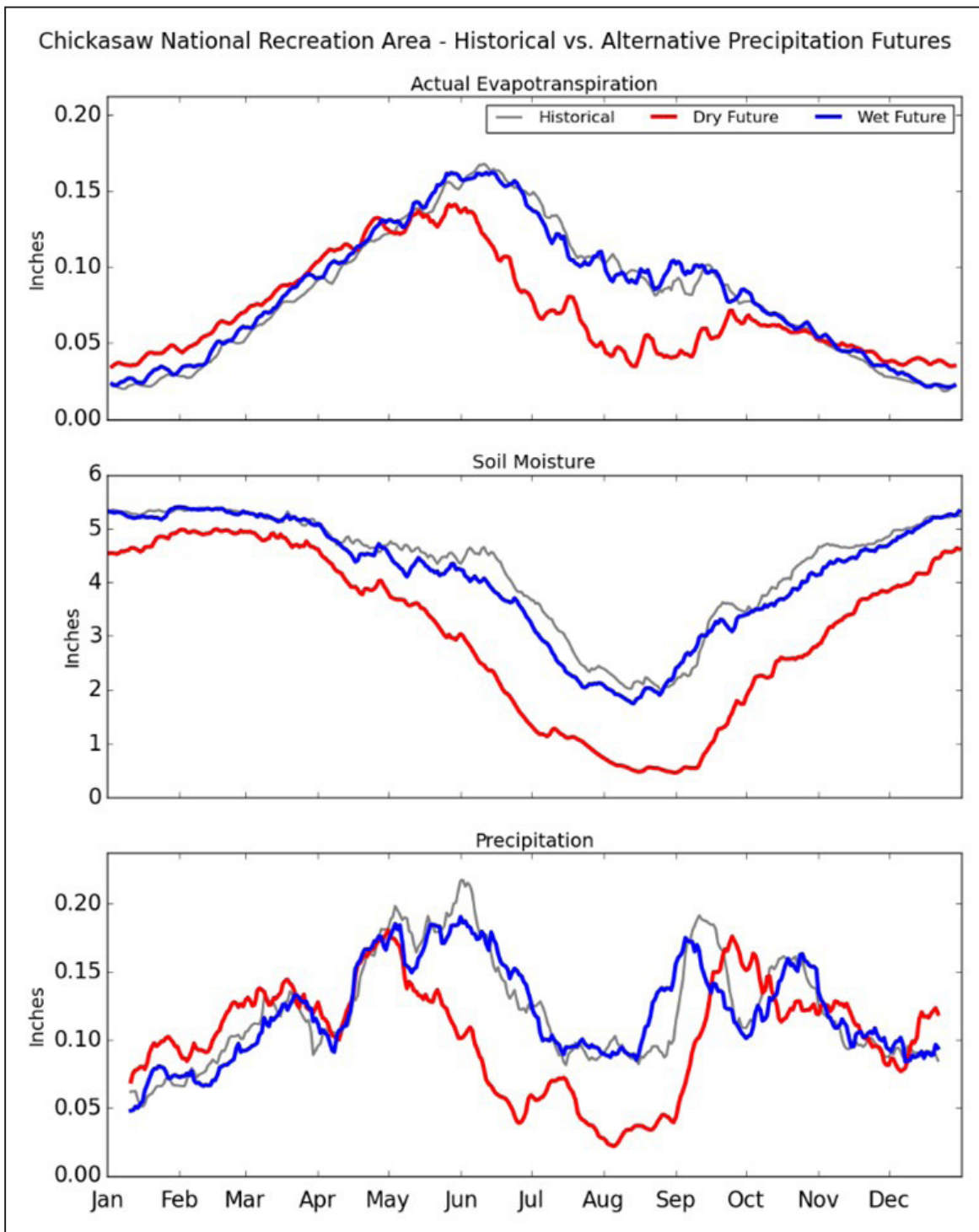


Figure 5. Historical (1981–2010) seasonal patterns (gray lines) in actual evapotranspiration, soil moisture, and precipitation compared to the wettest (Wet Future, blue) and driest (Dry Future, red) projected late 21st century (2070–2099) seasonal patterns. Data sources for precipitation are the same as in earlier figures. Data sources for AET and soil moisture: Tercek et al. (2021, 2023).

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Lemon beebalm (*Monarda citriodora*) and other plants in a mixed grass prairie at Chickasaw National Recreation Area. This scene will likely look different in a future with lower soil moisture, which is predicted to shift the species composition in grasslands. NPS photo.

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