Climate Resource Brief – Grand Teton National Park

V4 – January 2024

Climate change has the potential to profoundly alter National Parks, with impacts to vegetation, wildlife, and cultural resources (Monahan and Fisichelli 2014, Tercek et al. 2021). During this time of unusually rapid change (IPCC 2022), proactive management is more likely to be successful than reactive management, which merely responds to crises as they arise. Proactive management depends on a clear understanding of both the changes that have occurred so far and what we might expect in the future. This resource brief discusses historical climate patterns at Grand Teton National Park and compares them to the range of conditions that we expect for the late 21st Century.

Our discussion of the future is based on climate "projections." Unlike weather "forecasts," which typically extend only a few days to a few months in the future, climate projections, which are based on complex computer models of the 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 capture long-term (decades to centuries) trends in average annual and seasonal patterns. There are over 40 climate projections available from a variety of universities and agencies around the world. Using complex mathematical models that include the effects of greenhouse gasses, ocean currents, clouds, and many other processes, they all project (calculate) some amount of future warming in Grand Teton National Park. Because of differences in how the projections model some of these processes, they disagree on whether precipitation will increase or decrease. In this resource brief, we have chosen two projections (Table 1) that span the range of driest (most soil moisture) to wettest (least soil moisture) conditions by the late 21st century (2070 – 2099). In Table 1, notice that the wettest projection has a decrease in precipitation while the driest projection has a slight increase in precipitation. The amount of water available in the ecosystem depends on the interaction between precipitation and temperature. Warmer temperatures draw more water out of the soil, making it unavailable. Despite its increase in precipitation, the driest projection will result in a lot more drought because it includes a lot of warming (14 degrees F by late century), which will cause a lot more water loss to evaporation and transpiration.

Table 1. Alternative future projections considered for Grand Teton National Park. Average annual temperature and total annual precipitation increases are calculated for 2070 – 2099 relative to 1981 – 2010. Historical data are GRIDMET. Future data are MACA, see Abatzoglou and Brown 2012, Abatzoglou (2013).

Name	T Increase	P Change
Wettest - (MRI-CGCM3 RCP 8.5)	6 (F)	-1.5 inches (5%)
Driest - (MIROC-ESM-CHEM RCP 8.5)	14 (F)	+0.6 inches (2%)

Temperature and Water Availability Patterns

Historical: During 1911 – 2022, daytime highs at Moran Junction did not have a strong trend (Figure 1, Top), but night-time lows had roughly 3 – 4 (F) warming (Figure 1, Bottom). Similar patterns were seen at other weather stations in the area, but Moran Junction had the longest record available.

The wettest projection called for about 6 (F) of warming in annual average temperature by late century (Figure 2). This would cause the length of the season with below-freezing temperatures to decrease by about 7 weeks (Figure 3).

The driest projection calls for about 14 (F) warming in annual temperatures (Figure 2) and a 14 week decrease in the freezing season (Figure 3) by late century.

The projected late century medians for number of days above 85 (F) (41, 76 days for the wettest, driest projections, respectively, is 2 - 3 times more than the longest historical count (20 days in 2003, Figure 3).

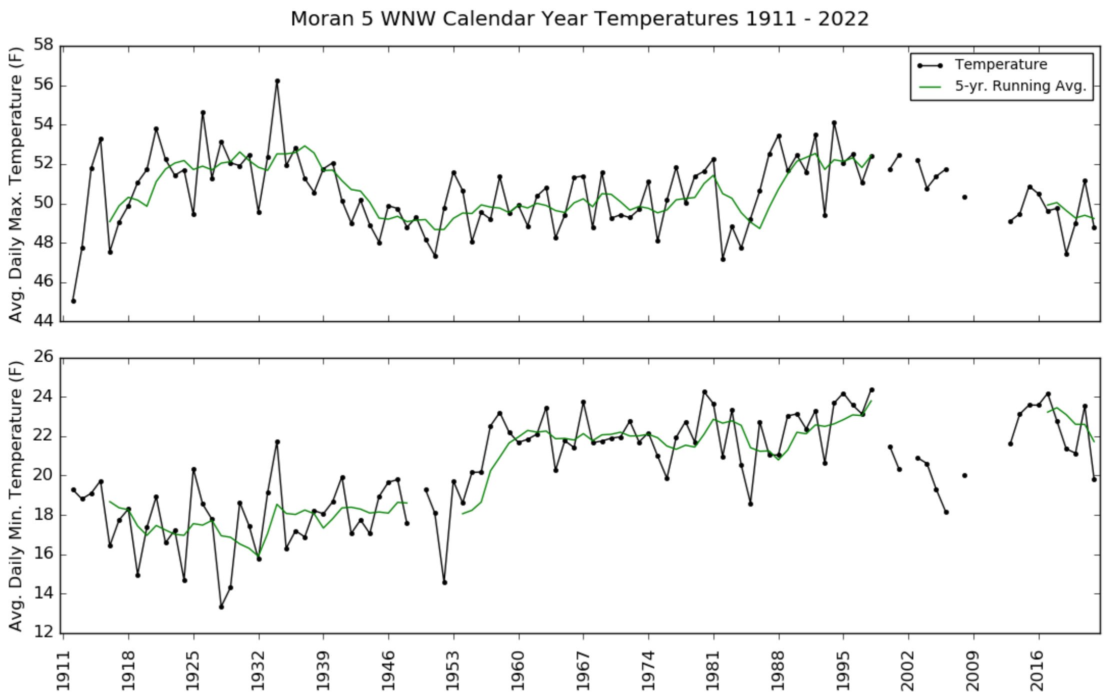

Figure 1. Temperature trends at the Moran Junction weather station 1911 - 2022. Blanks are years with data insufficient for calculating an average. Top: Annual averages of daily high temperatures. Bottom: Annual averages of night-time low temperatures.

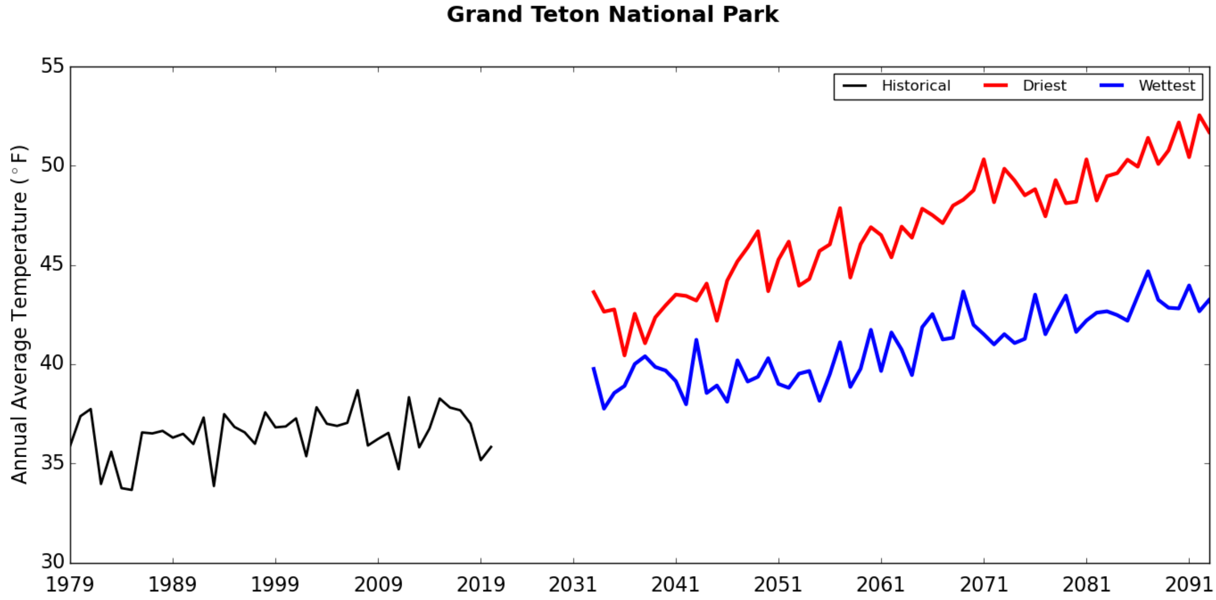

Figure 2. Historical annual average temperatures (annual average of daily average temperatures) and two future projections that bracket the range of driest vs. wettest futures at Grand Teton National Park. Data for this graph and those that follow are for the park centroid (43.82, -110.71), which is near Leigh Lake. Data source citations = Abatzoglou (2012, 2013).

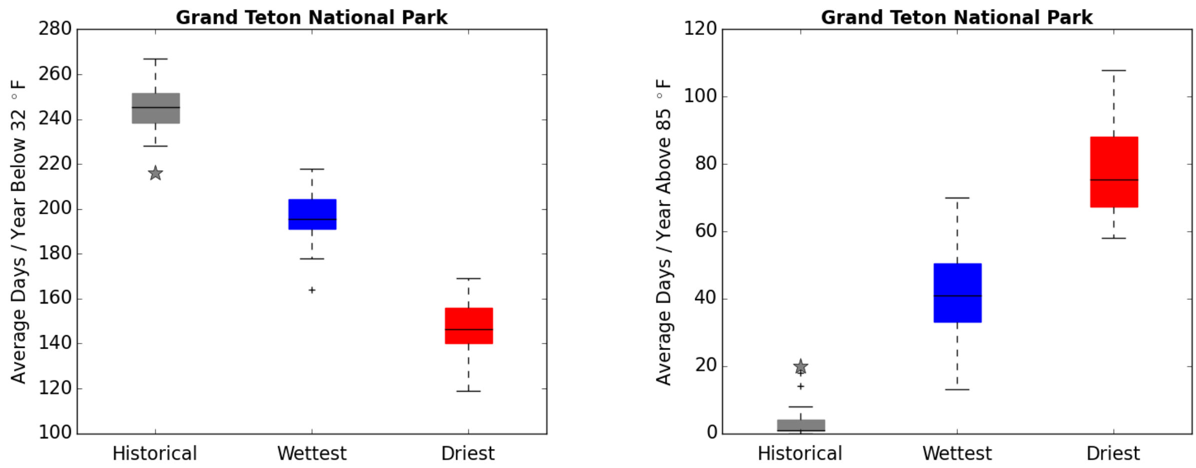

Figure 3. Left: Annual number of days per year below freezing, with historical compared to two future projections (see Table 1) in the late 21st Century (2070 - 2099). The gray star marks the smallest count during 1979 – 2022 (216 days in 2015). Right: Annual number of days above 85 F, with historical values compared to the late 21st Century. The gray star marks the greatest count during 1979 – 2022 (20 days in 2003). Data sources are the same as in Figure 2.

There were no clear historical trends in precipitation during 1911 – 2022 (Figure 4), but future summers in Grand Teton National Park will likely be drier than historical summers. In the future, July and August will likely continue to be the months with the lowest precipitation (Figure 5, Figure 6), but all of the alternative projections, even those with annual precipitation increases, show lower than historical soil moisture during at least some of the warmest months (April – October; Figure 6) because warming summer temperatures will increase evaporation and transpiration (AET;plant water use; Figure 6) above historical levels.

Extension of the growing season

The length of the growing season can be estimated by Actual Evapotranspiration (AET), which is the amount of water that can be either evaporated or transpired (used by plants) each day (Tercek et al. 2023). AET is calculated from equations that use temperature and precipitation as inputs, and it is greater than zero only during times when it is relatively warm (generally above 40 F) and water is available in the soil – the same conditions needed for plants to grow. By looking at changes in the seasonal patterns of when AET is greater than zero, we can track changes in the growing season length.

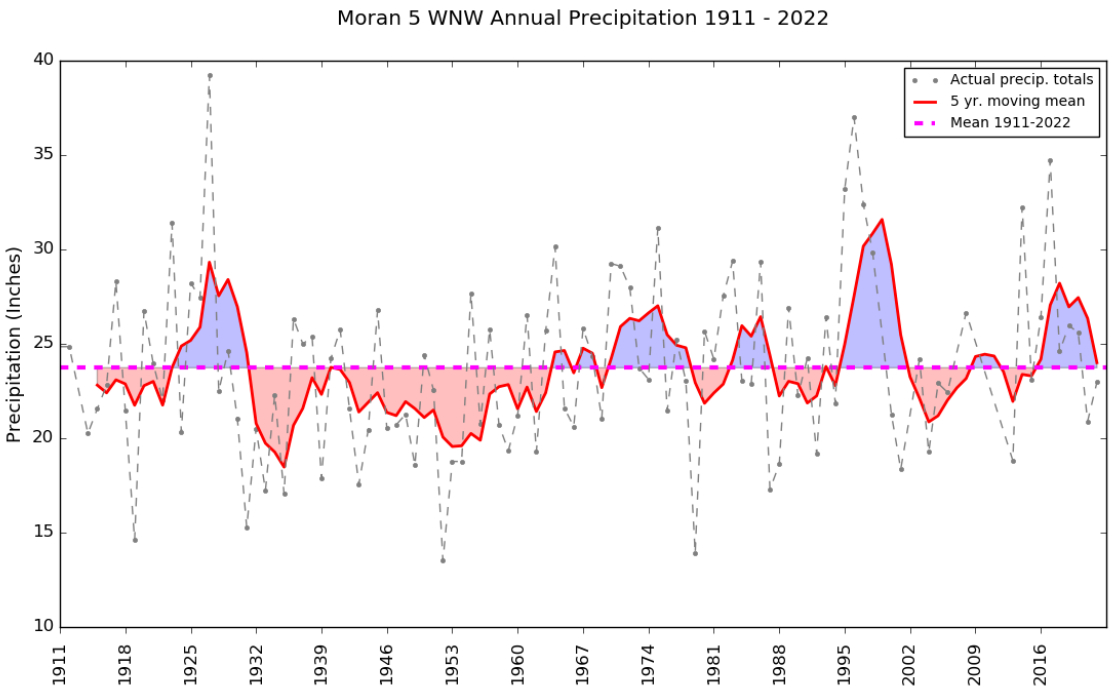

Figure 4. Annual precipitation 1943 – 2022 at the Moran Junction weather station. The dashed magenta line is the period average (23.7 inches).

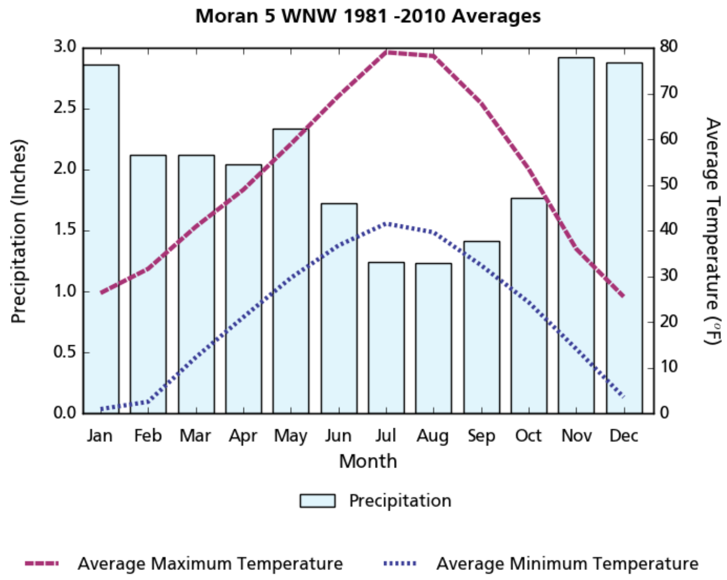

Figure 5. 1981 – 2010 seasonal patterns in temperature and precipitation at Moran Junction. July - August had the least precipitation. The values in this graph are official national weather service normals (30-year averages).

Figure 6 (Top Panel) shows that by late 21st Century, the growing season (time when AET > 0) will begin as much as 2 months earlier in the driest projection --March rather than May (red line, top panel, Figure 6). In contrast, the wettest projection, which projects less warming, shows only a month's earlier start to the season (Figure 6). Interestingly, the driest projection (red line, top panel figure 6) calls for a slight depression in plant growth later in the season as soil moisture becomes depleted (middle panel, Figure 6). Many of the other projections not shown here have seasonal bumps in precipitation, such as shown for the driest projection, but they have little effect on AET (top panel of Figure 6).

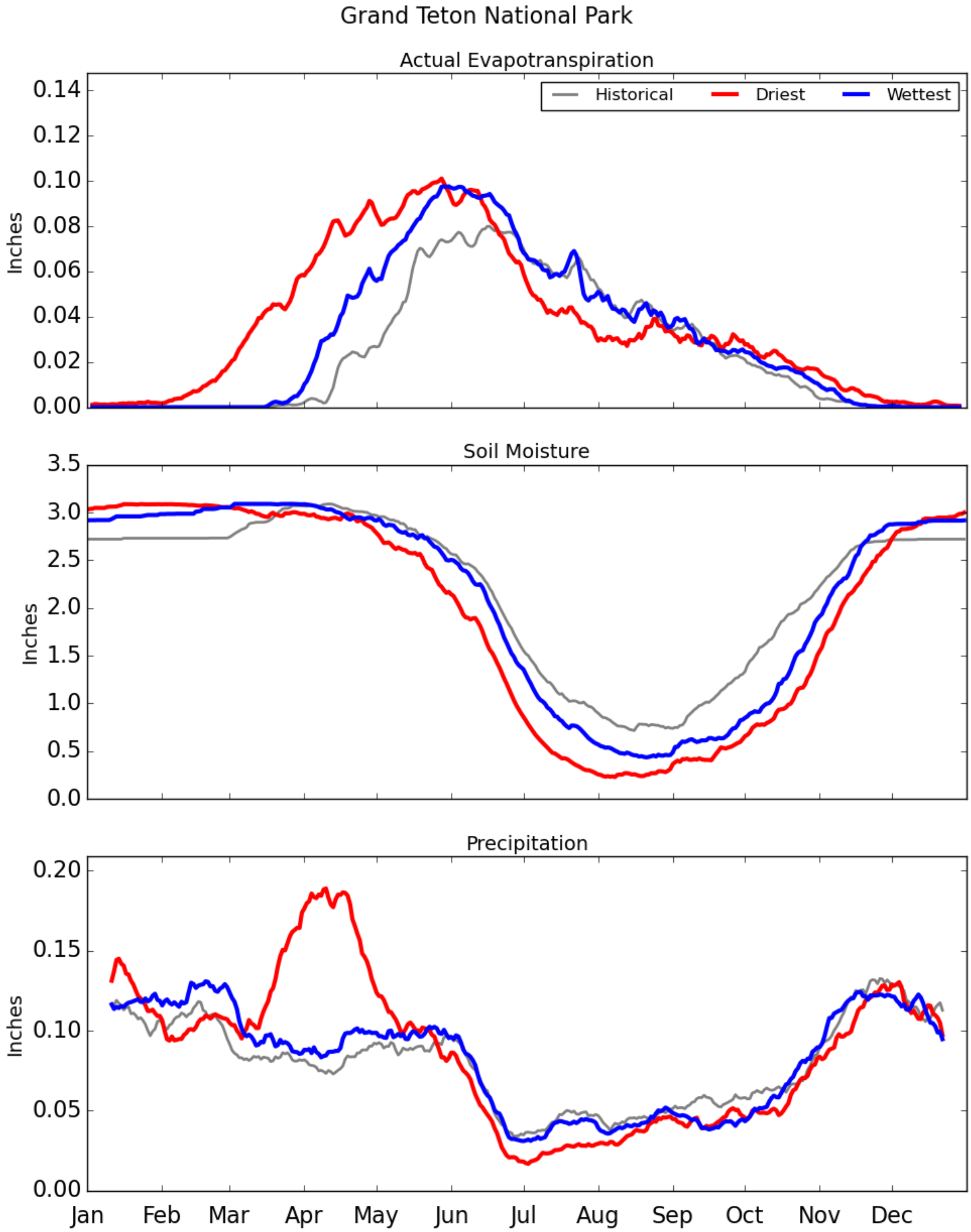

Figure 6. Historical (1981 - 2010) seasonal patterns in Actual Evapotranspiration (combined evaporation and plant water use), soil moisture, and precipitation compared to Late 21st Century (2070 - 2099) seasonal patterns. Data sources are the same as in earlier figures. Data source = Tercek et al. (2021), Tercek et al (in press).

Changes in Snow Pack

Future warming is likely to greatly reduce the length of snowcover season but have less of an effect on peak snowpack depth (Figures 7, 8). Under the wettest projection, the winter might be only 1/3 as long as we are used to, but the amount of snow that accumulates during this brief window might be comparable to historical levels. On the other hand, the driest projection calls for peak snow levels to decrease by 50% or more, at least in the lower elevations (right side of maps shown), with winters that are roughly 1/6 the length of the historical season.

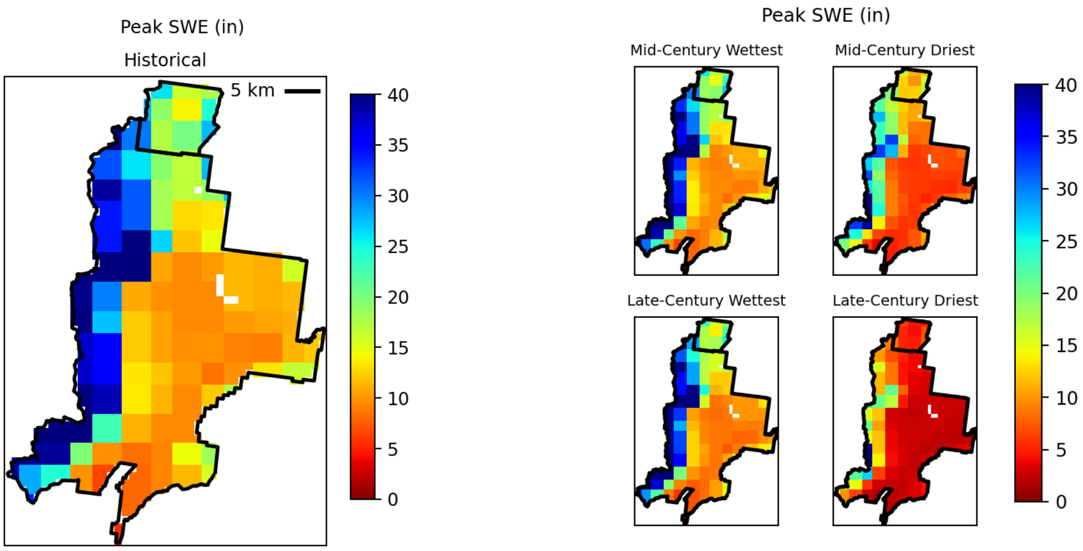

Figure 7. Historical (1981 – 2010) average peak Snow Water Equivalent (SWE) compared to mid-century (2040 – 2069) and late-century (2070 – 2099) for two future projections under the RCP 8.5 "business as usual" scenario in Grand Teton National Park. The wettest projection has about 6 (F) warming by late century and the driest has 14 (F). Data citations = Tercek et al 2021, Tercek et al. 2023. White within the park boundary are missing data. The Teton mountain range runs top to bottom along the left side of each map. Lower elevations are on the right.

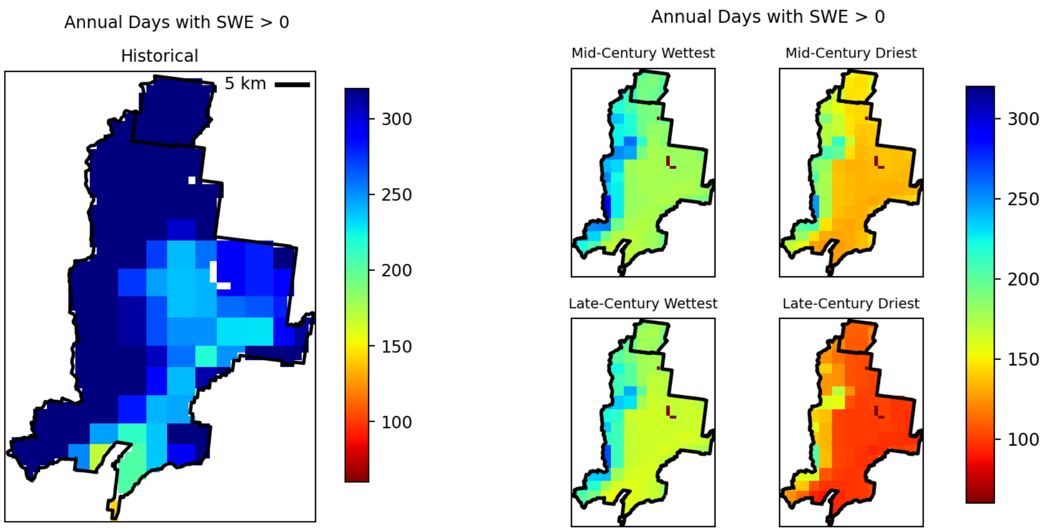

Figure 8. Historical (1981 – 2010) average annual days with snow cover (SWE > 0) compared to mid-century (2040 – 2069) and late-century (2070 – 2099) for two future projections under the RCP 8.5 "business as usual" scenario in Grand Teton National Park. Data citations are the same as Figure 7.

Conclusions

The future in Grand Teton National Park will quite likely be warmer. Despite any potential increases in precipitation, it will likely be drier during at least some of the warmest months of the year (April – October). The exact months that are drier within this period varies among future projections. The season with snow cover will be shorter, and the growing season will be longer, driven by warmer spring temperatures. This is not necessarily good news for all plants. Cold-adapted species could be pushed out by competitors from lower elevations that are able to use the additional months of growth to monopolize space. Some of these new species will probably be non-native or weedy such as cheatgrass. Drier summertime soils would also put shallower-rooted plants at a disadvantage against deeper-rooted shrubs and trees. It is difficult to predict all the cascading biological effects of these climate changes, but it is likely that plant and animal communities will be dramatically different by the end of the century.

Future vulnerability assessments will look at how these projections may impact park plant and animal species such as sagebrush.

Literature Cited

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