

Climate Change Summary, Fort Laramie National Historic Site, Wyoming

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Climate Trends for the Area within Park and Preserve Boundaries

- **Temperature** While average annual temperature across the western U.S. has been increasing, annual temperature in the park showed no statistically significant change in the period 1950-2010 (Table 1). Average temperature for the month of March increased at the statistically significant rate of $4.2 \pm 1.6^{\circ}\text{C}$ ($7.6 \pm 2.9^{\circ}\text{F.}$) per century.
- **Precipitation** Total annual precipitation increased in the period 1950-2010, but the rate was not statistically significant (Tables 1).
- **Projections** If the world does not reduce emissions from power plants, cars, and deforestation by 40-70%, models project substantial warming and precipitation increases (Table 1, Figure 1).
- **Aridity** Even if precipitation increases, temperature increases may overcome any cooling effects of increased precipitation, leading to increased evapotranspiration and overall aridity.
- **Extreme heat** Projections under the highest emissions scenario project an increase of 10 to 20 more days per year with a maximum temperature $>35^{\circ}\text{C}$ (95°F.) (Kunkel et al. 2013).
- **Extreme storms** Projections under the highest emissions scenario project an increase in 20-year storms (a storm with more precipitation than any other storm in 20 years) to once every 6-10 years (Walsh et al. 2014).

Historical Impact in the Region Attributed to Human Climate Change

- **Bird range shifts** Analyses of Audubon Christmas Bird Count data across the United States, including counts in Wyoming, detected a northward shift of winter ranges of a set of 254 bird species at an average rate of 0.5 ± 0.3 km per year from 1975 to 2004, attributable to human climate change and not other factors (La Sorte and Thompson 2007).

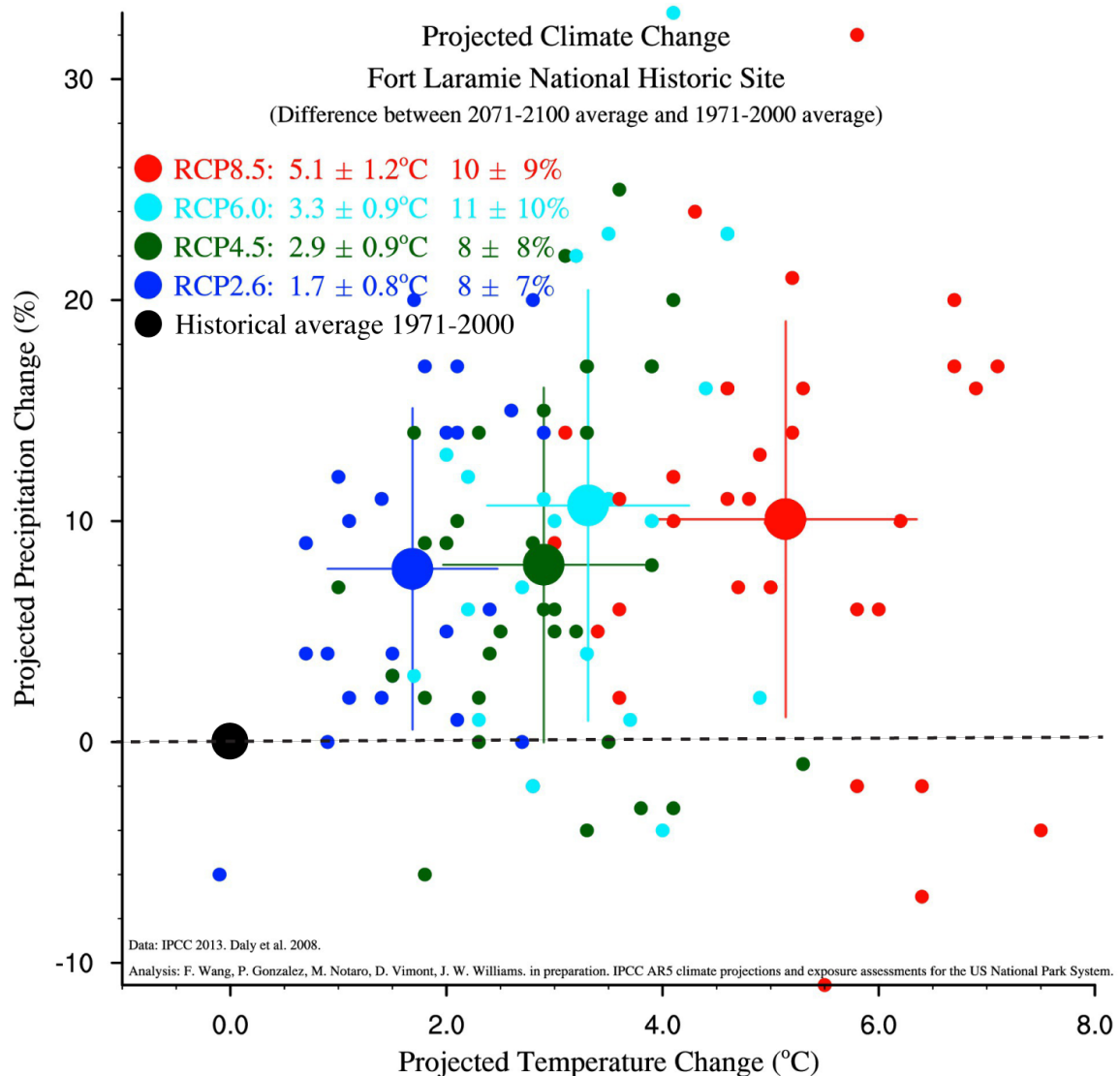
Future Vulnerability in the Park

- **River flooding** Under all emissions scenarios, more intense rains can contribute to more flooding (Shafer et al. 2014).

Table 1. Historical rates of change and projected future changes per century in annual average temperature and annual total precipitation for the park as a whole (data Daly et al. 2008, IPCC 2013; analysis Wang et al. in preparation). The table gives the historical rate of change per century calculated from data for the period 1950-2010. The U.S. weather station network was more stable for the period starting 1950 than for the period starting 1895. The table gives central values with standard errors (historical) and standard deviations (projected).

	1950-2010	2000-2100
Historical		
temperature	-0.2 ± 0.5°C per century (-0.4 ± 0.9°F.)	
precipitation	+18 ± 12% per century	
Projected (compared to 1971-2000)		
Reduced emissions (IPCC RCP2.6)		
temperature	+1.7 ± 0.8°C per century (+3.1 ± 1.4°F.)	
precipitation	+8 ± 7% per century	
Low emissions (IPCC RCP4.5)		
temperature	+2.9 ± 0.9°C per century (+5.2 ± 1.6°F.)	
precipitation	+8 ± 8% per century	
High emissions (IPCC RCP6.0)		
temperature	+3.3 ± 0.9°C per century (+5.9 ± 1.6°F.)	
precipitation	+11 ± 10% per century	
Highest emissions (IPCC RCP8.5)		
temperature	+5.1 ± 1.2°C per century (+9.2 ± 2.2°F.)	
precipitation	+10 ± 9% per century	

Figure 1. Projections of future climate for the area within Fort Laramie National Historic Site. Each small dot is the output of a single climate model. The large color dots are the average values for the four IPCC emissions scenarios and the historical baseline. The lines are the standard deviations of each average value. (Data: IPCC 2013, Daly et al. 2008; Analysis: Wang et al. in preparation, University of Wisconsin and U.S. National Park Service).



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