Climate Change Summary, Harpers Ferry National Historical Park, USA

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Climate Trends for the Area within Park Boundaries

- Average annual temperature did not show a statistically significant change in the period 1950-2010 (Table 1, Figure 2). While temperatures have shown statistically significant increases across most of the world, the park lies adjacent to a region of the southeastern U.S. that is an anomaly due to increased precipitation, El Niño, and other factors (Portmann et al. 2009).
- Average total precipitation has increased since 1950, but the rate has not been statistically significant (Table 1, Figure 2). Autumn (September-November) precipitation has increased at a statistically significant rate of 51 ± 24% per century.
- If the world does not reduce emissions from power plants, cars, and deforestation by 40-70%, models project substantial warming and increases in precipitation (Table 1, Figure 3).
- The greatest temperature increases could occur in autumn (September-November). The greatest precipitation increases could occur in winter (December-February).
- Projections under the highest emissions scenario project 15-18 more days per year with a maximum temperature >35ºC (95ºF.) and an increase in 20-year storms (a storm with more precipitation than any other storm in 20 years) to once every 5-6 years (Walsh et al. 2014).

Historical Impact in the Region

- Analyses of Audubon Christmas Bird Count data across the United States, including counts in West Virginia, Maryland, and Virginia, 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 Vulnerabilities in the Region

- The combination of higher precipitation and increased frequency of large storms could lead to more river flooding (Horton et al. 2014).
- Under the highest emissions scenario, climate change could shift the ranges of numerous tree species northward, reducing potential densities of red maple (*Acer rubrum*) and chestnut oak (*Quercus prinus*) (Iverson et al. 2008).

- Under high emissions, hotter temperatures and increased precipitation will continue to make the park suitable for the invasive tree species tree-of-heaven (*Ailanthus altissima*) (Clark et al. 2014).

Table 1. Historical rates of change per century and projected future changes in annual average temperature and annual total precipitation (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. Because a rate of change per century is given, the absolute change for the 1950-2010 period will be approximately 60% of that rate. The table gives central values for the park as a whole. Figures 1-3 show the uncertainties.

	1950-2010	**2000-2050**	**2000-2100**
Historical			
temperature	-0.2ºC/century (-0.4ºF./century)		
precipitation	+19%/century		
Projected (compared to 1971-2000)			
Low emissions (IPCC RCP 4.5)			
temperature		+2.3ºC (+4.1ºF.)	+2.9ºC (+5.2ºF.)
precipitation		+8%	+10%
High emissions (IPCC RCP 6.0)			
temperature		+1.9ºC (+3.4ºF.)	+3.3ºC (+5.9ºF.)
precipitation		+7%	+10%
Highest emissions (IPCC RCP 8.5)			
temperature		+2.8ºC (+5ºF.)	+5ºC (+9ºF.)
precipitation		+9%	+14%

Figure 1. Historical annual average temperature for the area within park boundaries. Note that the U.S. weather station network was more stable for the period starting 1950 than for the period starting 1895. (Data: National Oceanic and Atmospheric Administration, Daly et al. 2008. Analysis: Wang et al. in preparation, University of Wisconsin and U.S. National Park Service).

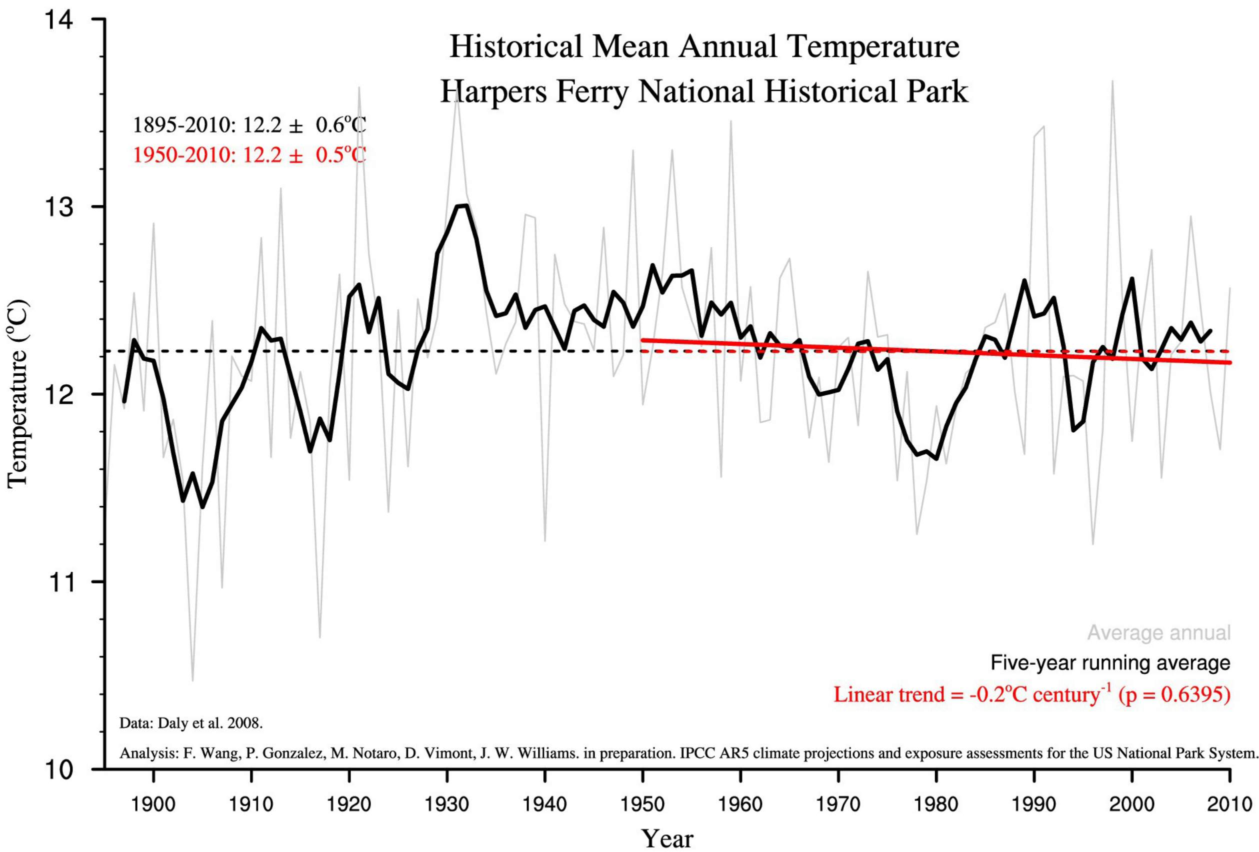


Figure 2. Historical annual total precipitation for the area within park boundaries. Note that the U.S. weather station network was more stable for the period starting 1950 than for the period starting 1895. (Data: National Oceanic and Atmospheric Administration, Daly et al. 2008. Analysis: Wang et al. in preparation, University of Wisconsin and U.S. National Park Service).

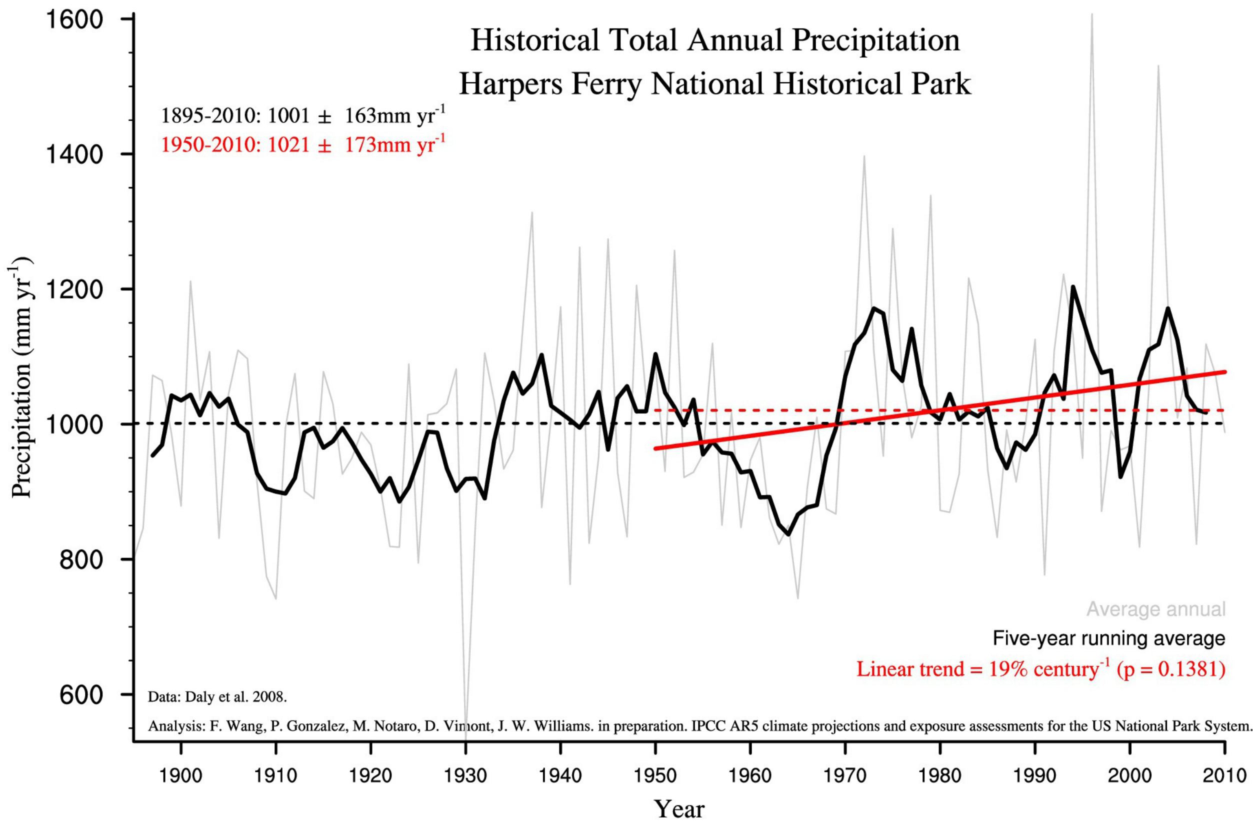
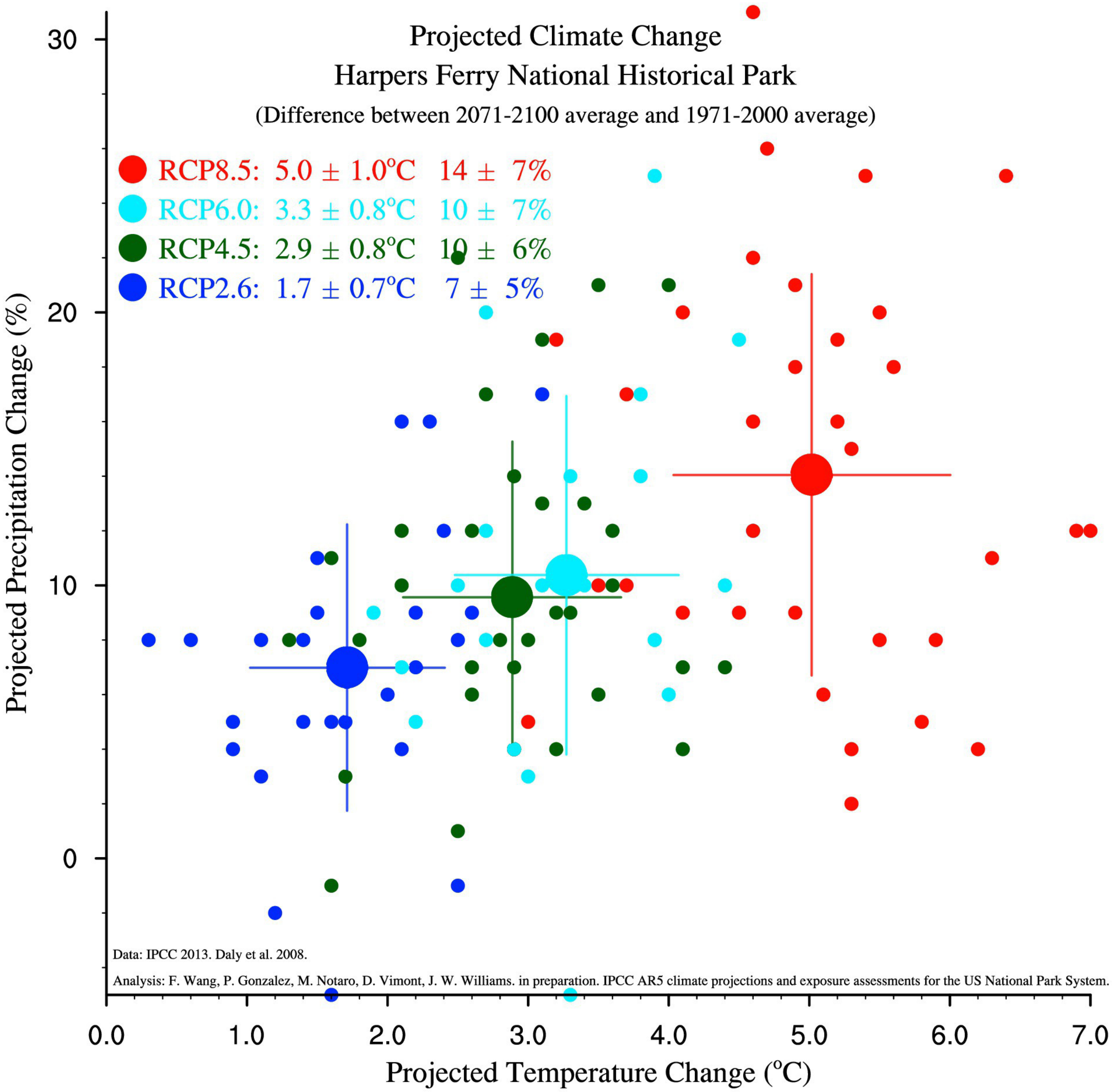


Figure 3. Projections of future climate for the area within park boundaries. Each small dot is the output of a single climate model. The large color dots are the average values for the four IPCC emissions scenarios. The lines are the standard deviations of each average value. (Data: IPCC 2013, Daly et al. 2008; Analysis: Wang et al. in preparation, University of Wisconsin and U.S. National Park Service).



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