

Climate Change Trends and Vulnerabilities, Big Cypress National Preserve, Florida

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Climate Trends for the Area within Park Boundaries

- Average annual temperature has increased at a statistically significant rate since 1950 (Table 1, Figure 1). Summer (June-August) temperature showed the greatest increase at $1.1 \pm 0.5^{\circ}\text{C}$ per century.
- Average total precipitation has increased since 1950, but the rate has not been statistically significant (Table 1, Figure 2).
- Although records suggest that climate change may have contributed to an increase in the intensity of North Atlantic hurricanes from 1970 to 2004 (Hoyos et al. 2006, Webster et al. 2006), the Intergovernmental Panel on Climate Change (IPCC 2013) has concluded that changing historical methods, incomplete understanding of physical mechanisms, and tropical cyclone variability prevent direct attribution of hurricane changes to climate change.
- If the world does not reduce emissions from power plants, cars, and deforestation by 40-70%, models project substantial warming and changes in precipitation (Table 1, Figure 3).
- For projected average annual precipitation, the climate models do not agree, with over half projecting increases, but many projecting decreases (Figure 3).
- Under the highest emissions scenario, models project 25-40 more days per year with a maximum temperature $>35^{\circ}\text{C}$ (95°F.) and 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).
- Projections of North Atlantic hurricanes under climate change do not agree on possible future hurricane trends (IPCC 2013).

Historical Impacts in the Everglades Region

- Climate change has raised sea level globally and along the Florida coast. [See NPS sea level report for the park from Maria Caffrey.]
- From 1984 to 2011, the area of mangroves on the Atlantic Coast at the latitude of the park increased 10% at the same time as a decrease in days colder than -4°C (25°F.) (Cavanaugh et al. 2014). The increase of mangroves at the northern end of their Florida coast range is consistent with climate change, but not yet attributed to it.

- Analyses of Audubon Christmas Bird Count data across the United States, including counts in Florida, 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 Everglades Region

- Under all emissions scenarios, climate change would continue to raise sea level globally and along the Florida coast (IPCC 2013). [See NPS sea level report for the park from Maria Caffrey.]
- Under a range of six climate change and sea level rise scenarios, hydrology and water supply would change substantially, and the groundwater table could rise (Obeysekera et al. 2014).
- Under the most extreme low and high precipitation climate change projections, inter-annual water level fluctuations in undisturbed ridge and slough landscapes in the Everglades in the next 40 years could exceed average measured fluctuations of the past 40 years, potentially altering major vegetation patterns (van der Valk et al. 2015).
- Vegetation modeling for Everglades National Park suggests that hydrological changes under climate change could more strongly affect the distributions and locations of tall sawgrass and pine savanna vegetation more than sawgrass, the most abundant vegetation type (Foti et al 2013). Sawgrass would tend to decrease under scenarios of decreased precipitation (Todd et al. 2012).
- Under high emissions, the region could become even more favorable to the growth of the invasive plant cogon grass (*Imperata cylindrica*) (Bradley et al. 2010).
- Under drier climate change scenarios, decreased water depths and reduced inundation duration in some areas of the Everglades could reduce peat and increase carbon emissions (Nungesser et al. 2014).
- Under high emissions, wildfire models project little change in fire frequencies (Moritz et al. 2012).
- Under drier climate change scenarios, decreased rainfall and more evapotranspiration could substantially reduce habitat suitability for wading birds and alligators (Catano et al. 2014). Climate change scenarios of increased rainfall could benefit aquatic prey and apex predators. (Catano 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	+0.8°C/century (1.4°F./century)		
precipitation	+9%/century		
Projected (compared to 1971-2000)			
Low emissions (IPCC RCP 4.5)			
temperature		+1.4°C (+2.5°F.)	+1.8°C (+3.2°F.)
precipitation		+2%	+4%
High emissions (IPCC RCP 6.0)			
temperature		+1.2°C (+2.2°F.)	+2.1°C (+3.8°F.)
precipitation		+4%	~0
Highest emissions (IPCC RCP 8.5)			
temperature		+1.8°C (+3.2°F.)	+3.3°C (+5.9°F.)
precipitation		+2%	-2%

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).

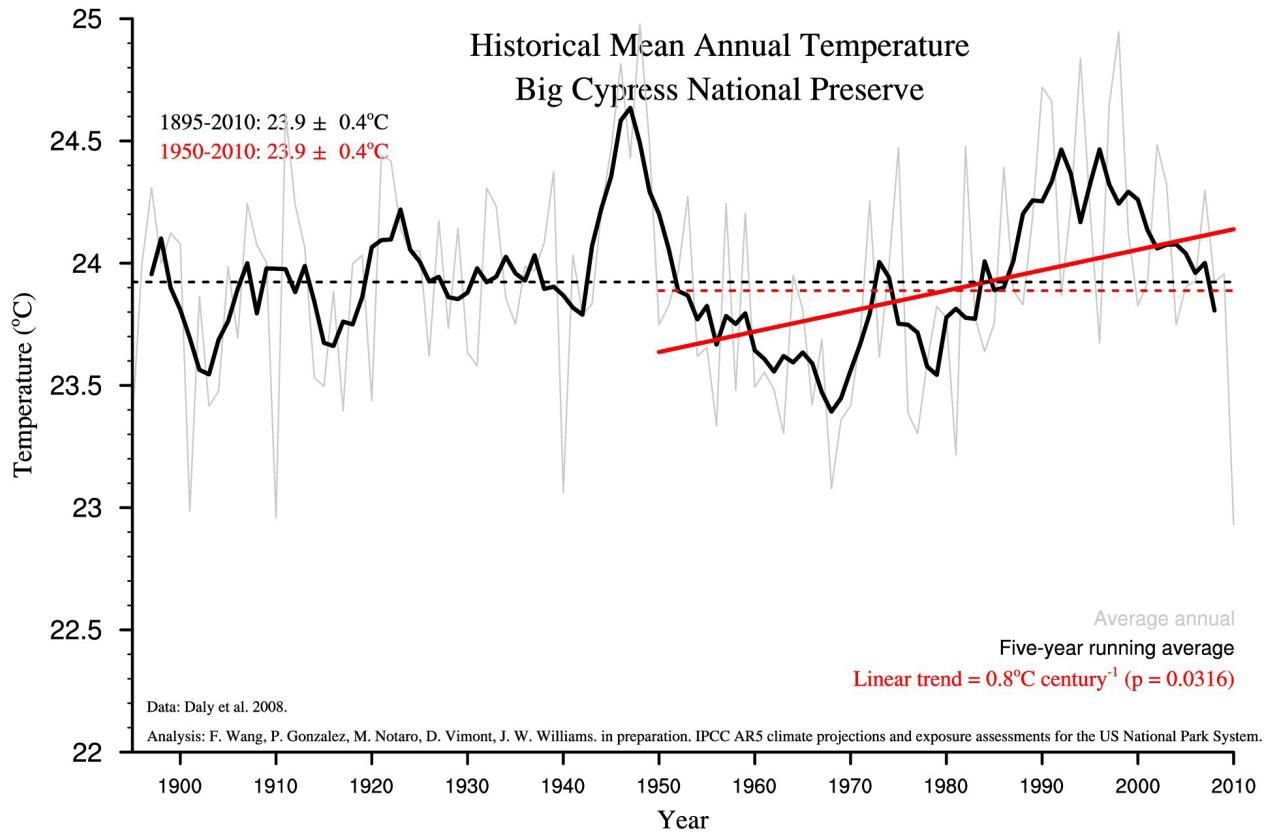


Figure 2. Historical annual total precipitation for the area within park boundaries. Note that the U.S. weather station network was more stable for the period starting 1950 than for the period starting 1895. (Data: National Oceanic and Atmospheric Administration, Daly et al. 2008. Analysis: Wang et al.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

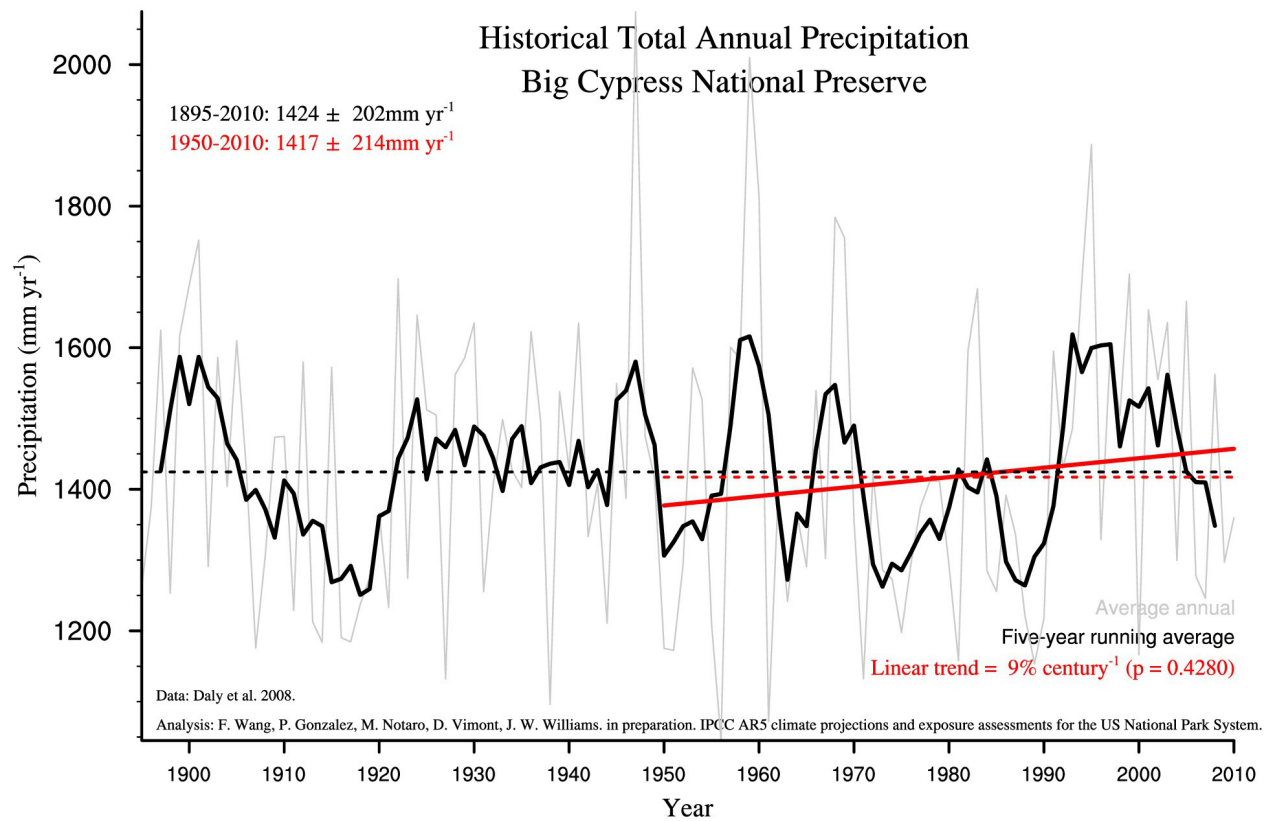
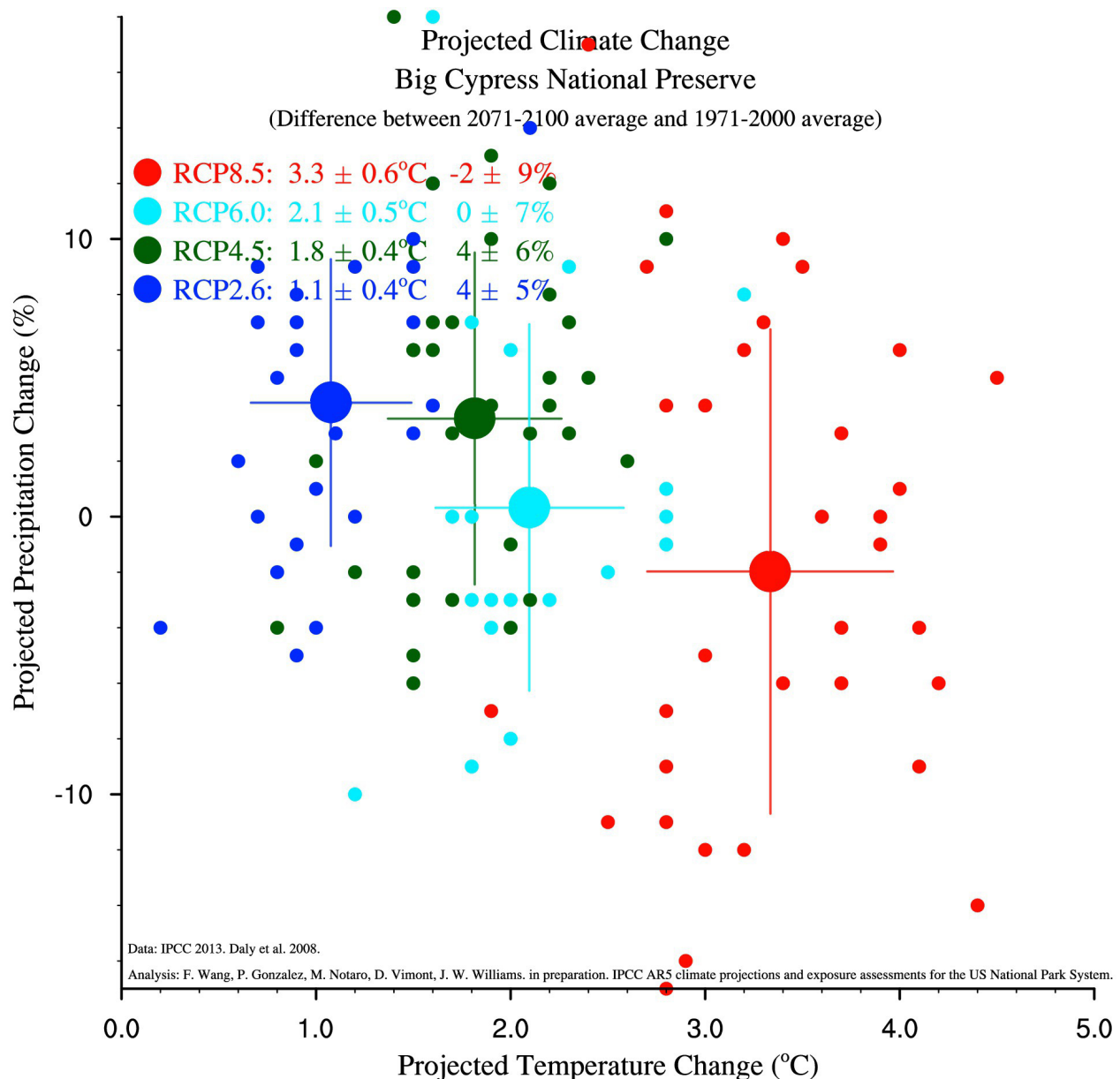


Figure 3. Projections of future climate for the area within park boundaries. Each small dot is the output of a single climate model. The large color dots are the average values for the four IPCC emissions scenarios. The lines are the standard deviations of each average value. (Data: IPCC 2013, Daly et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



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