Climate Change Trends and Vulnerabilities, Big Bend National Park, Texas

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Climate Trends for the Area within Park Boundaries

- Temperature shows no statistically significant trend from 1950 to 2010, with some areas showing slight increases and others showing slight decreases (Figures 1, 3).
- Precipitation is increasing at a rate of 43% per century, but the trend is not statistically significant (Figures 2, 4).
- Analyses of atmospheric measurements and other data show that emissions from cars, power plants, and other human activities are causing climate change (IPCC 2013).
- If we do not reduce our emissions, models project substantial future warming, but show no agreement on whether precipitation may increase or decrease (Figures 5-7).

Past Impact

- Across the western U.S., climate controlled the extent of burned area from 1916 to 2003 (Littell et al. 2009).

Future Vulnerabilities

- The magnitude and frequency of water supply shortages in the lower Rio Grande watershed are severe, due to population growth, even before projecting effects of climate change. Reduced rainfall, snowfall in high elevations upriver, and increased evapotranspiration under climate change projections could reduce river flow (Bureau of Reclamation 2013).
- Germination of *Agave* and *Yucca* species showed reduced germination under hotter temperatures in the southern Chihuahua Desert (Pérez-Sánchez et al. 2011).
- Continued increases in precipitation may contribute to continued shrub encroachment in the Chihuahuan Desert, but decreased precipitation would tend to reduce shrub and grass productivity (Munson et al. 2013).
- Under emissions scenarios B1, A1B, and A2, three introduced fish species could expand their range in the Rio Grande River and tributaries: carp (Cyprinus carpio), white bass (Morone chrysops), and blue tilapia (Oreochromis aureus) (Cohen et al. 2013).
- Analyses of the potential distributions of 213 mammal species under a temperature increase

of 3.8ºC by 2011 (equivalent to emissions scenario A1B) project a possible loss of 12 species and influx of 22 species into Big Bend (Burns et al. 2003). One species vulnerable to local disappearance is the ringtail (*Bassaricus astutus*), while eight of the potential new species are rodents.

- Ranges of three bird species - Loggerhead shrike (Lanius ludovicianus), scaled quail (Callipepla squamata), and rock wren (Salpinctes obsoletus) – may shift from desert and grassland areas to shrubland under climate change and fire management (White et al. 2011).

Table. 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. We use the 1950-2010 rate of change because the weather station network was more stable for that period than for 1895-2010. 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, 2, 5, and 6 show the spatial variation. Figures 3, 4, and 7 show the uncertainties.

	1950-2010	**2000-2050**	**2000-2100**
Historical			
Temperature	-0.4ºC (0.7ºF.)/century		
Precipitation	+43%/century		
Projected (compared to 1971-2000)			
Low emissions (IPCC RCP 4.5)			
Temperature		+2ºC (3.6ºF.)	+2.6ºC (4.7ºF.)
Precipitation		1%	~0
High emissions (IPCC RCP 6.0)			
Temperature		+1.8ºC (3.2ºF.)	+3.1ºC (5.6ºF.)
Precipitation		-1%	-1%
Highest emissions (IPCC RCP 8.5)			
Temperature		+2.6ºC (4.7ºF.)	+4.8ºC (8.6ºF.)
Precipitation		~0	-2%

Figure 1.

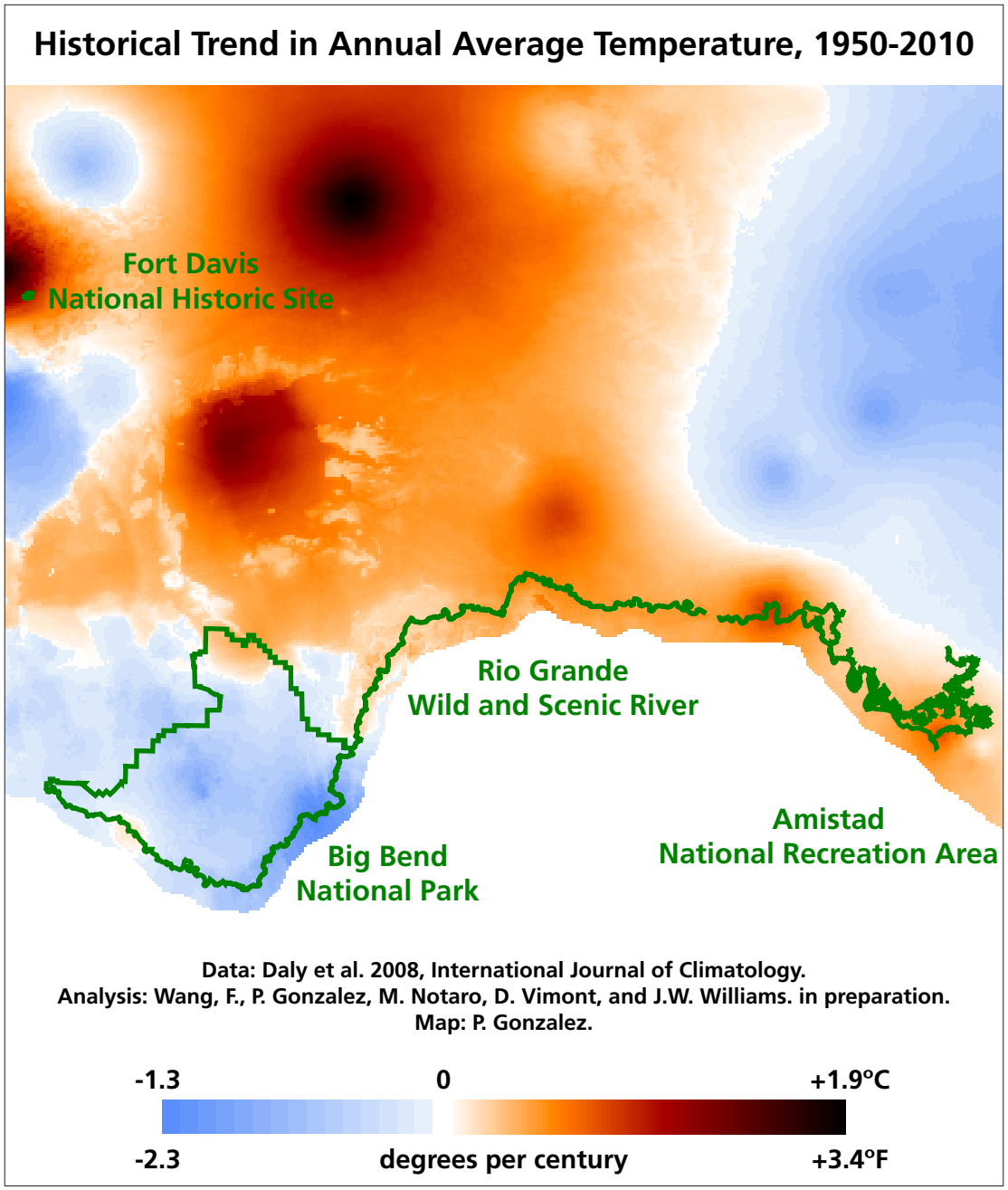

Historical Trend in Annual Average Temperature, 1950-2010
Fort Davis
National Historic Site
Rio Grande
Wild and Scenic River
Big Bend
National Park
Amistad
National Recreation Area
Data: Daly et al. 2008, International Journal of Climatology.
Analysis: Wang, F., P. Gonzalez, M. Notaro, D. Vimont, and J.W. Williams. in preparation.
Map: P. Gonzalez.
-1.3
0
+1.9°C
-2.3
degrees per century
+3.4°F

Figure 2.

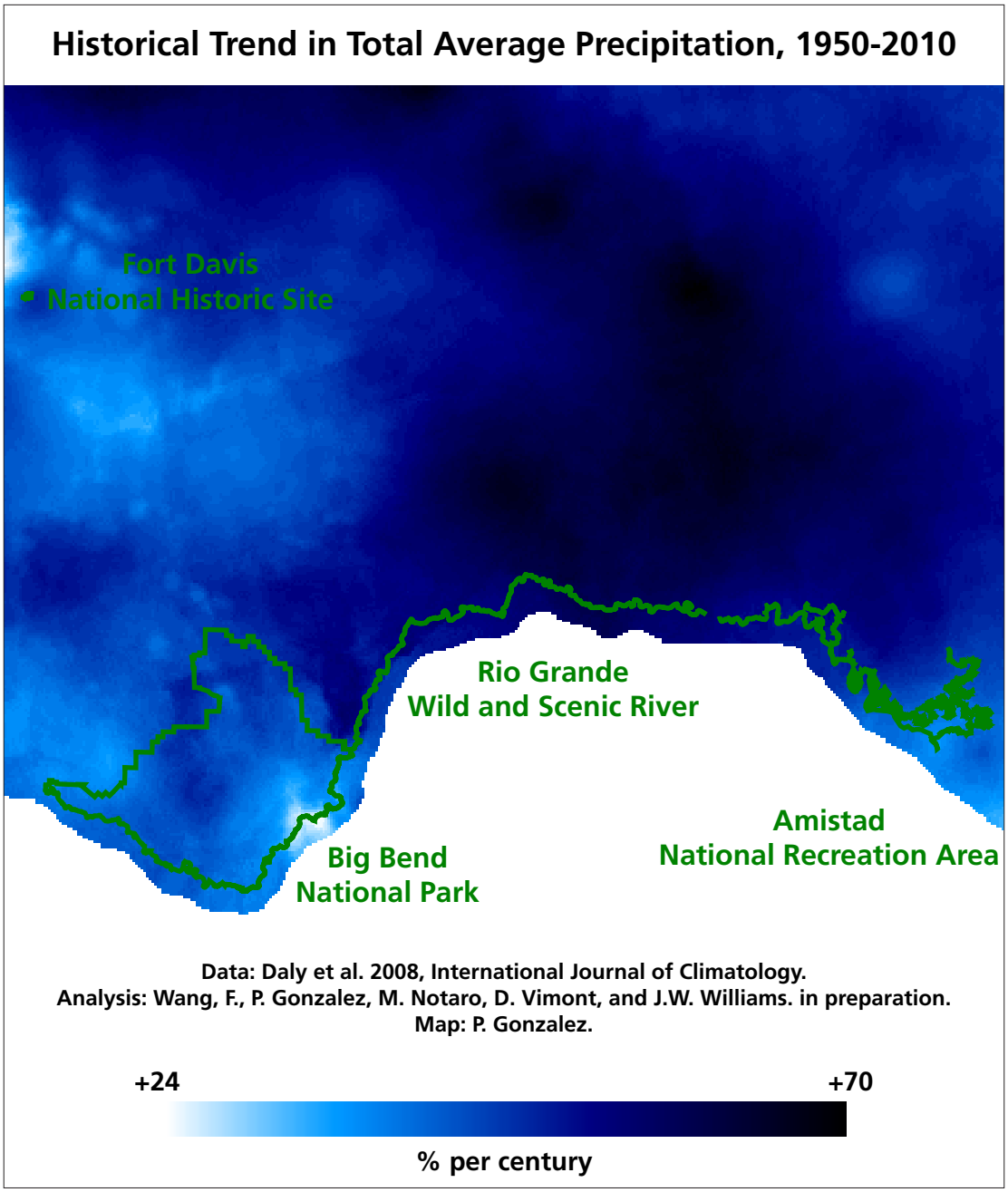

Historical Trend in Total Average Precipitation, 1950-2010
Fort Davis
National Historic Site
Rio Grande
Wild and Scenic River
Amistad
National Recreation Area
Big Bend
National Park
Data: Daly et al. 2008, International Journal of Climatology.
Analysis: Wang, F., P. Gonzalez, M. Notaro, D. Vimont, and J.W. Williams. in preparation.
Map: P. Gonzalez.
+24
+70
% per century

Figure 3. Temperature.
Historical and projected average annual average temperature for the area within park boundaries. For projections, each bar shows one standard deviation above and below the average of up to 33 climate models. (Data: Daly et al. 2008, IPCC 2013. Analysis: Wang et al. in preparation, University of Wisconsin and U.S. National Park Service).

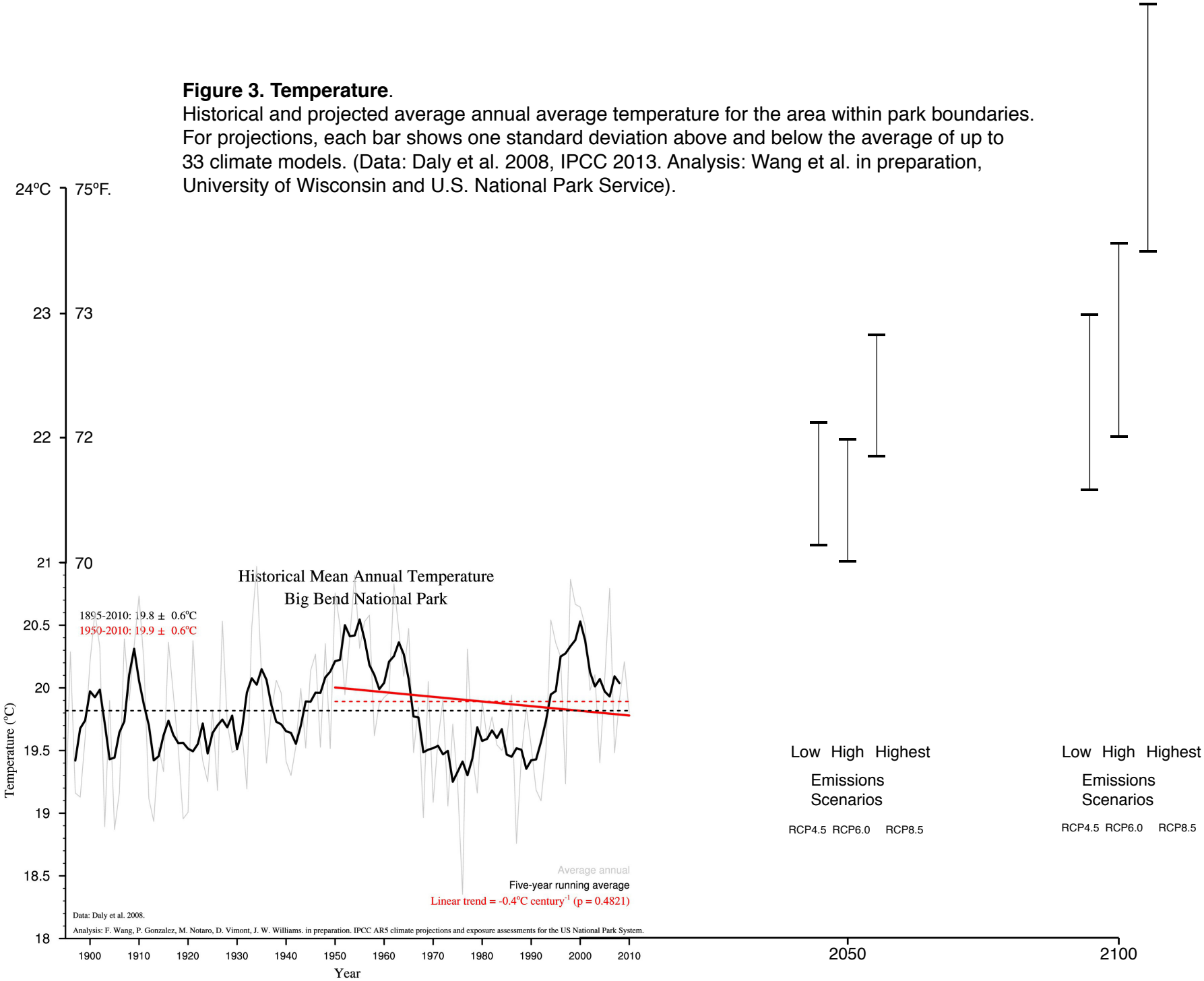


Figure 4. Precipitation.
Historical and projected annual total precipitation for the area within park boundaries.
For projections, each bar shows one standard deviation above and below the average of up to 33 climate models. (Data: Daly et al. 2008, IPCC 2013. Analysis: Wang et al. in preparation, University of Wisconsin and U.S. National Park Service).

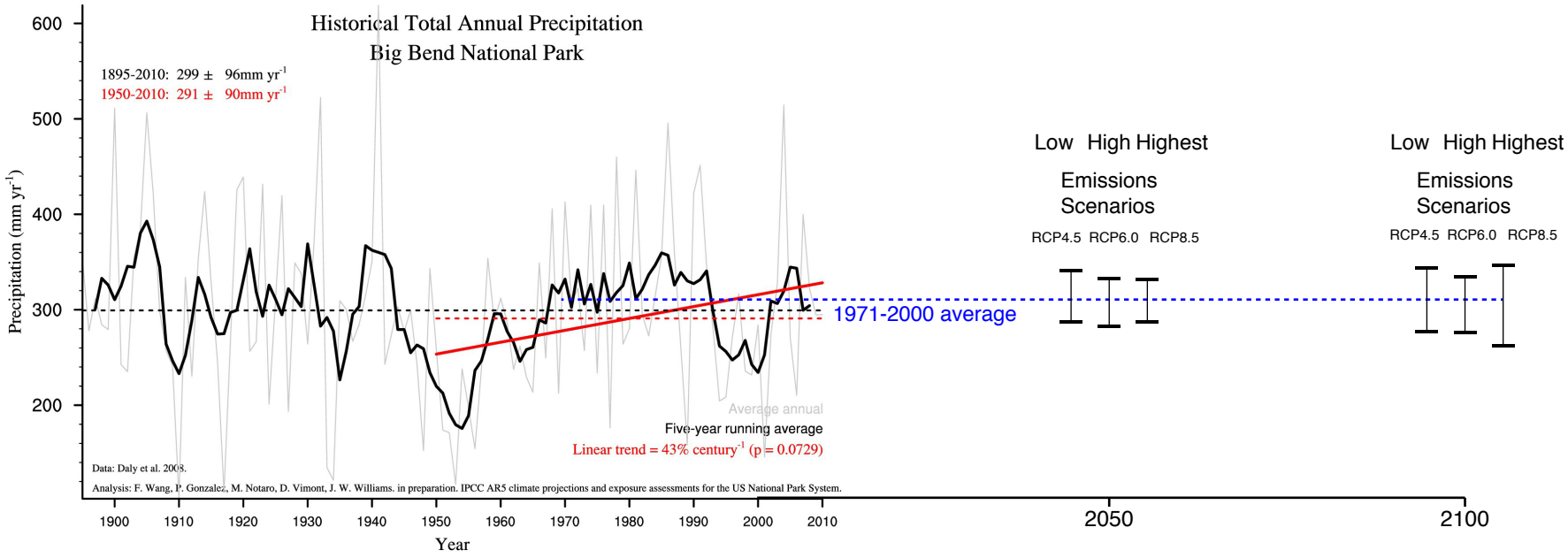


Figure 5.

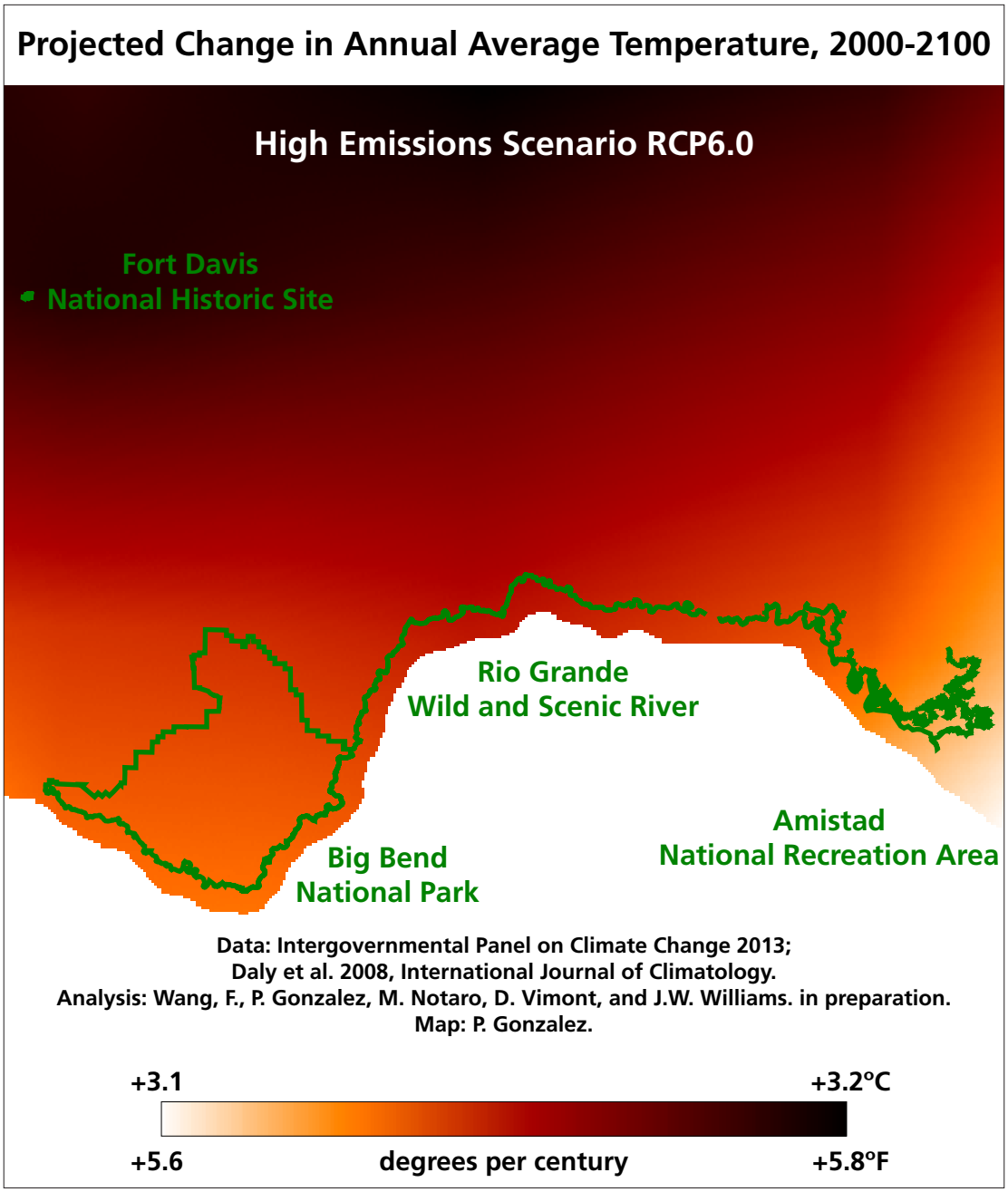
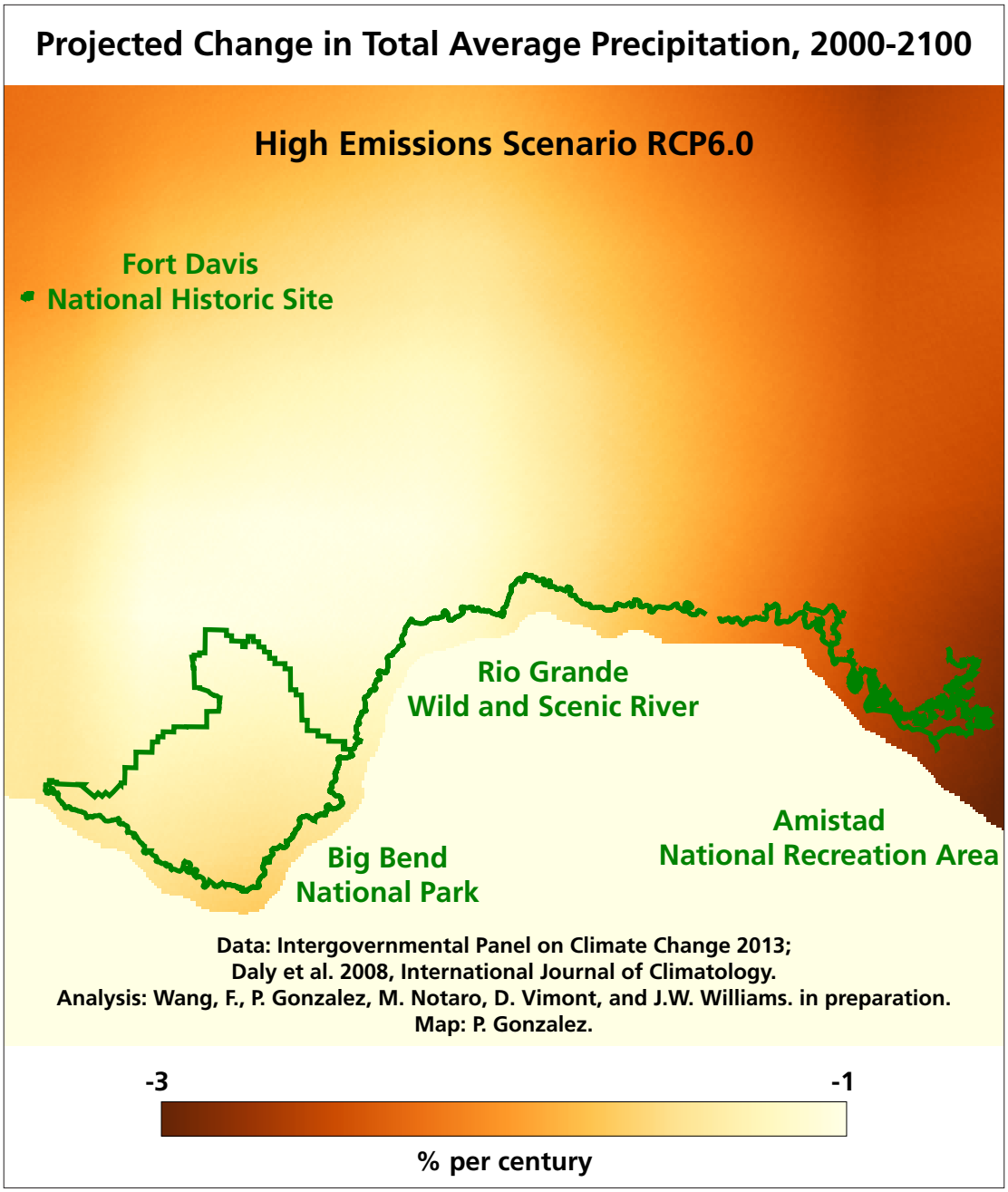

Projected Change in Annual Average Temperature, 2000-2100
High Emissions Scenario RCP6.0
Fort Davis
National Historic Site
Rio Grande
Wild and Scenic River
Amistad
National Recreation Area
Big Bend
National Park
Data: Intergovernmental Panel on Climate Change 2013;
Daly et al. 2008, International Journal of Climatology.
Analysis: Wang, F., P. Gonzalez, M. Notaro, D. Vimont, and J.W. Williams. in preparation.
Map: P. Gonzalez.
+3.1
+3.2°C
+5.6
degrees per century
+5.8°F

Figure 6.


Projected Change in Total Average Precipitation, 2000-2100
High Emissions Scenario RCP6.0
Fort Davis
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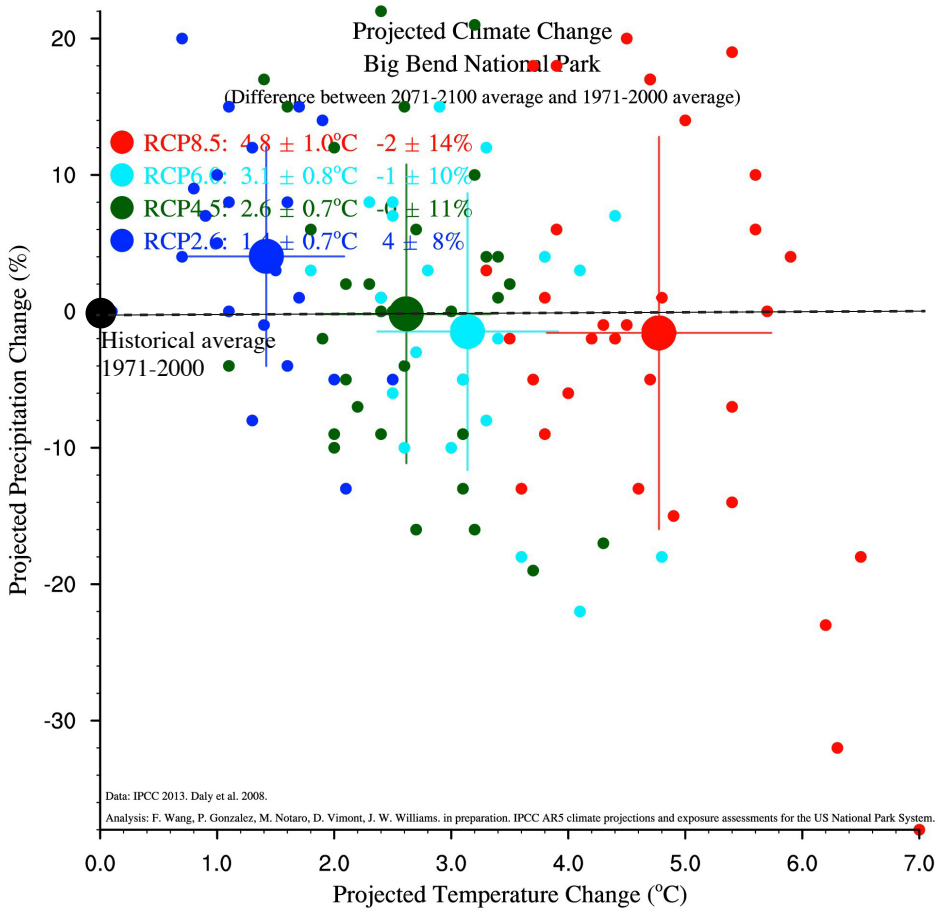
Daly et al. 2008, International Journal of Climatology.
Analysis: Wang, F., P. Gonzalez, M. Notaro, D. Vimont, and J.W. Williams. in preparation.
Map: P. Gonzalez.
-3
-1
% per century

Figure 7. Projections of future climate for the area within park boundaries. The large black dot is the current combination of temperature and precipitation. 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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