

Climate Change Trends and Vulnerabilities, Indiana Dunes National Lakeshore, Indiana

Patrick Gonzalez

Natural Resource Stewardship and Science, U.S. National Park Service, Washington, DC

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Climate Trends for the Area within Park Boundaries

- Temperature is increasing at a rate of up to 1.1° C (2° F.) per century, but the rate for the park as a whole is not statistically significant due to lower rates along the shore (Figures 1, 3).
- Precipitation is increasing at a rate of 18% per century for the park as a whole, 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 and increases in precipitation (Figures 5-7).

Ecological Vulnerabilities

- Field surveys found no Karner Blue butterflies (*Lycaeides melissa samuelis*) in summer 2013 along six routes (Ralph Grundel, U.S. Geological Survey, April 3, 2014). The population is vulnerable to complete disappearance under hotter temperatures due to acceleration of larval development and decreased fitness and a lack of wild lupines (*Lupinus perennis*), their food source (Grundel and Pavlovic 2007). A small laboratory population exists (Jessica Hellmann, University of Notre Dame, May 2, 2014), but it is genetically poorer than the wild population.
- Three Lake Michigan historical trends are consistent with climate change:
 - ice cover decrease 1973-2010 (Magnuson et al. 2000, Wang et al. 2012)
 - lake level decrease 1865-2007 (Hanrahan et al. 2009, 2010)
 - water temperature increase 1960-1992 (McCormick and Fahnenstiel 1999).

Future warming would leave the lake vulnerable to continued changes that may alter ranges of fish species, increase invasive species, and create more algae blooms (Pryor et al. 2014).

- One-fifth of the length of park lakeshore is very highly vulnerable to lake level changes (Figure 8; Pendleton et al. 2010).
- The vegetation of northern Indiana is highly vulnerable to a biome shift from temperate mixed to temperate broadleaf forest (Gonzalez et al. 2010).
- Climate change shifted the winter ranges of numerous bird species in the Midwest northward from 1975 to 2004 (La Sorte and Thompson 2007) and shifts could continue.

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 tables give 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	+0.3°C (0.5°F.)/century		
Precipitation	+18%/century		
Projected (compared to 1971-2000)			
Low emissions (IPCC RCP 4.5)			
Temperature		+2.5°C (4.5°F.)	+3.2°C (5.8°F.)
Precipitation		+7%	+8%
High emissions (IPCC RCP 6.0)			
Temperature		+2.0°C (3.6°F.)	+3.6°C (6.5°F.)
Precipitation		+6%	+9%
Highest emissions (IPCC RCP 8.5)			
Temperature		+3.1°C (5.6°F.)	+5.4°C (9.7°F.)
Precipitation		+8%	+11%

Figure 1.

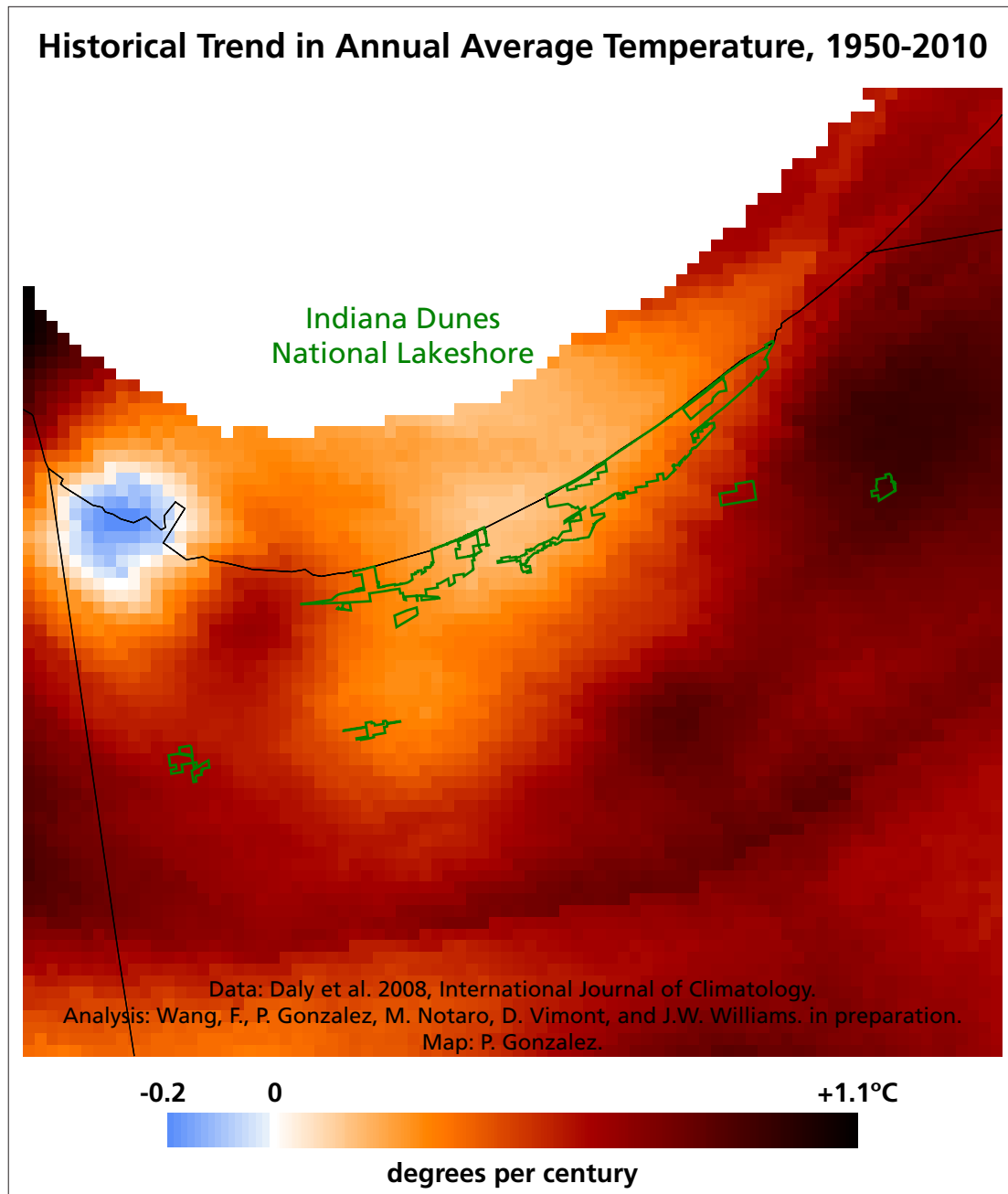


Figure 2.

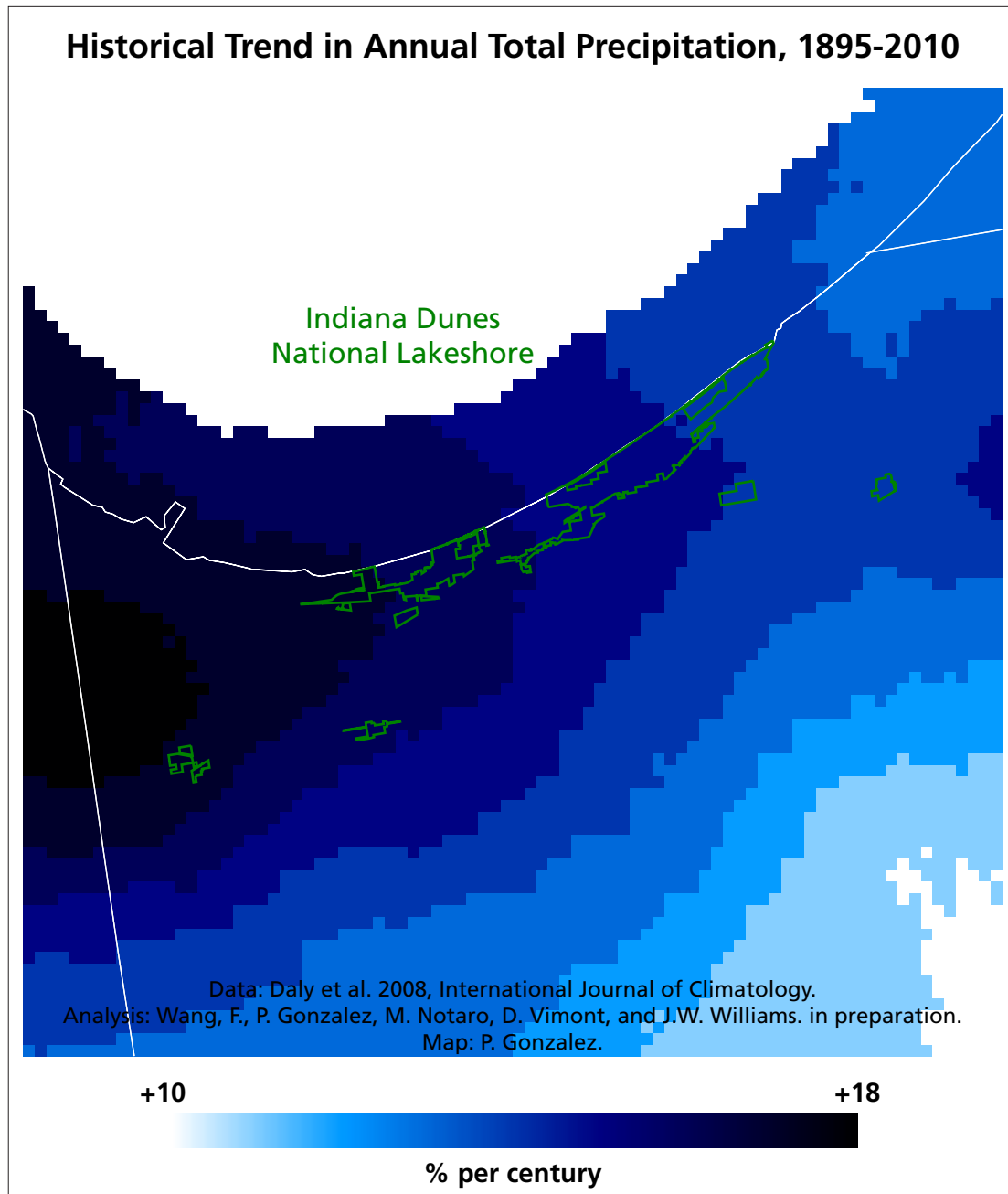


Figure 3. Temperature.

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).

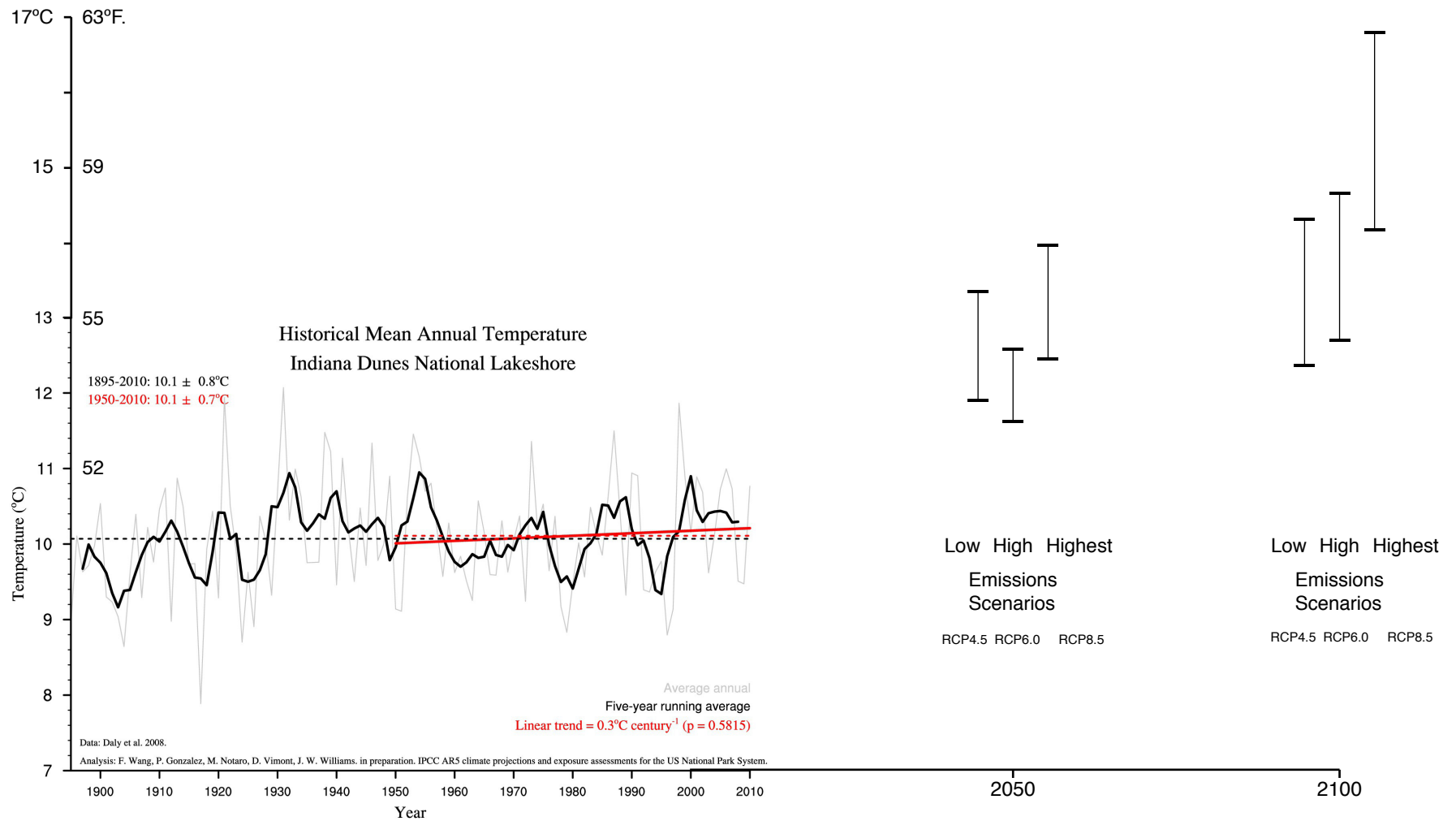


Figure 4. Precipitation.

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).

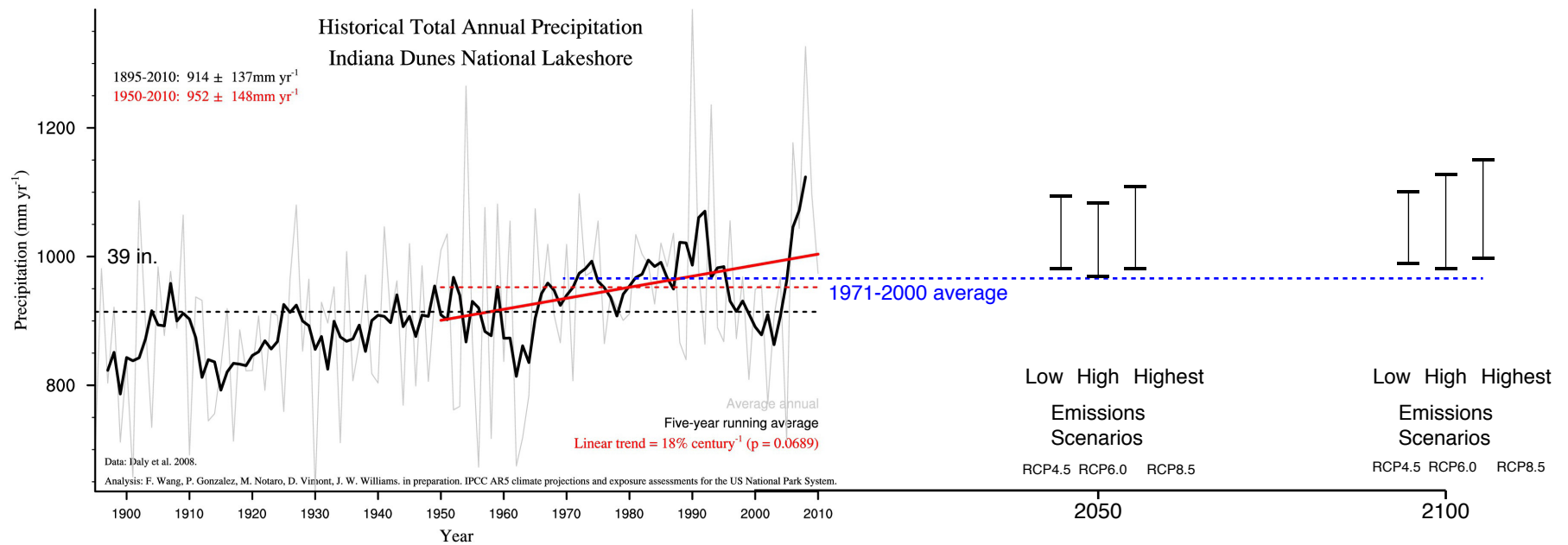


Figure 5.

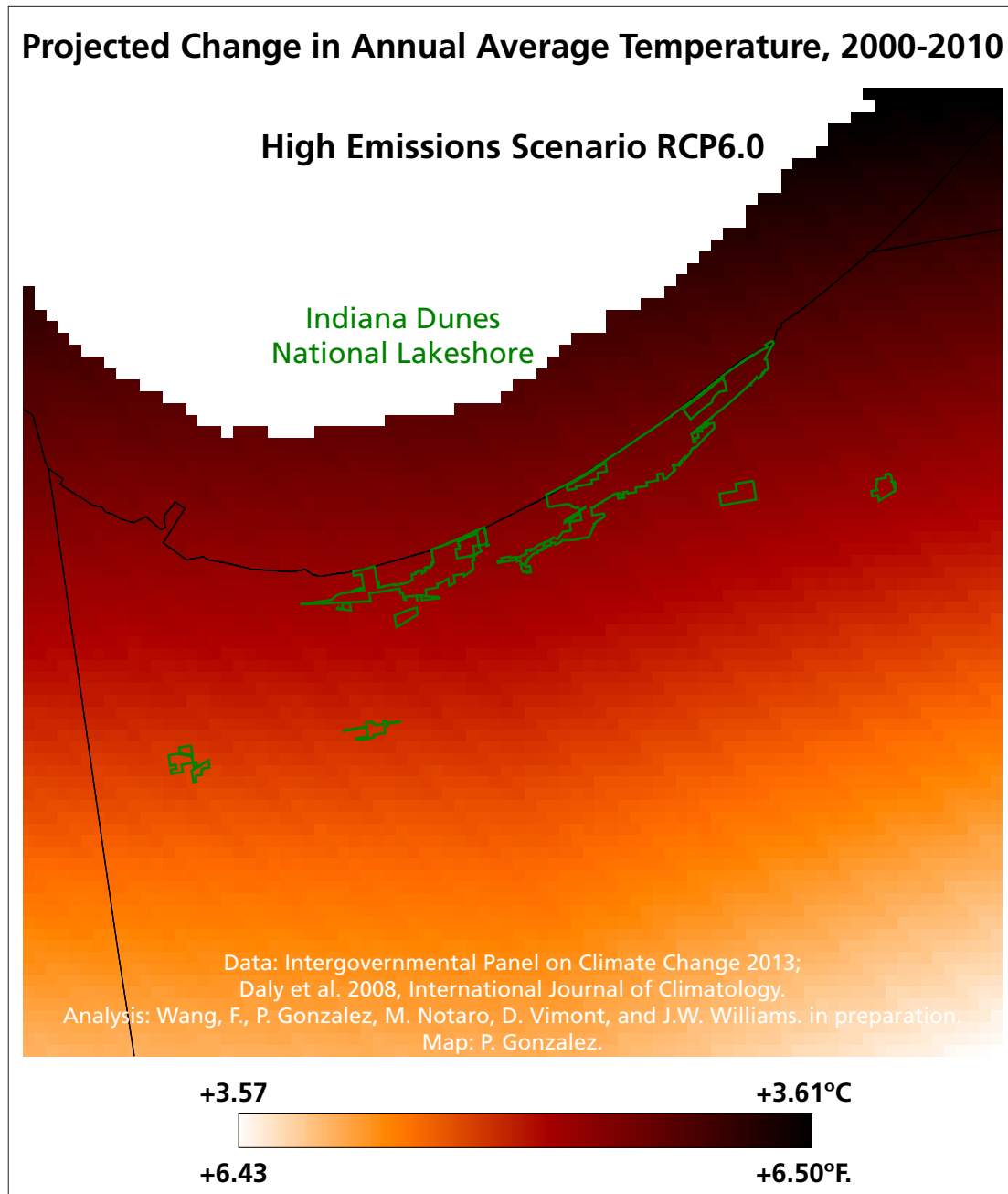


Figure 6.

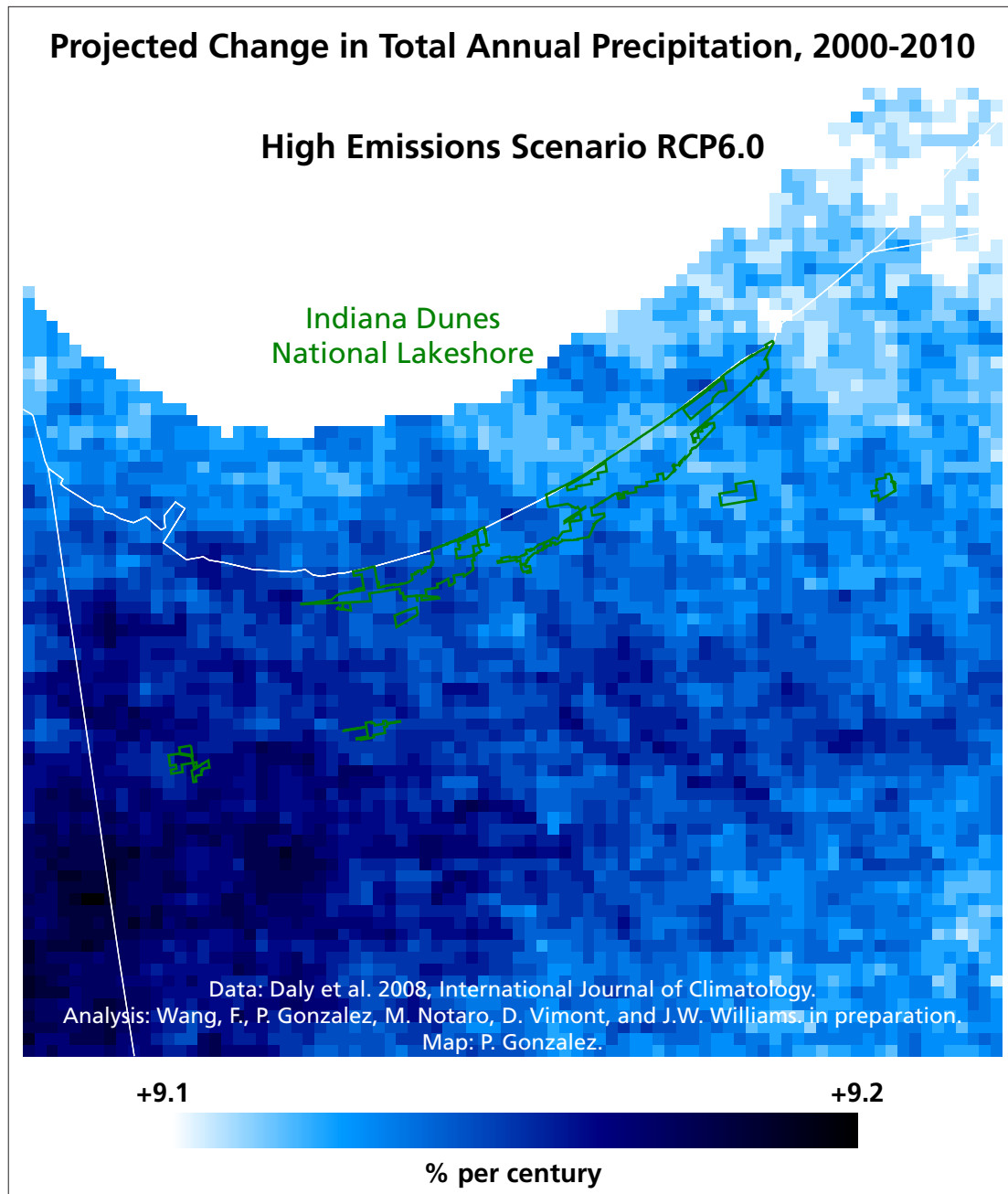


Figure 7. Projections of future climate for the area within park boundaries. The large black dot is the current combination of temperature and precipitation. Each small dot is the output of a single climate model. The large color dots are the average values for the four IPCC emissions scenarios. The 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).

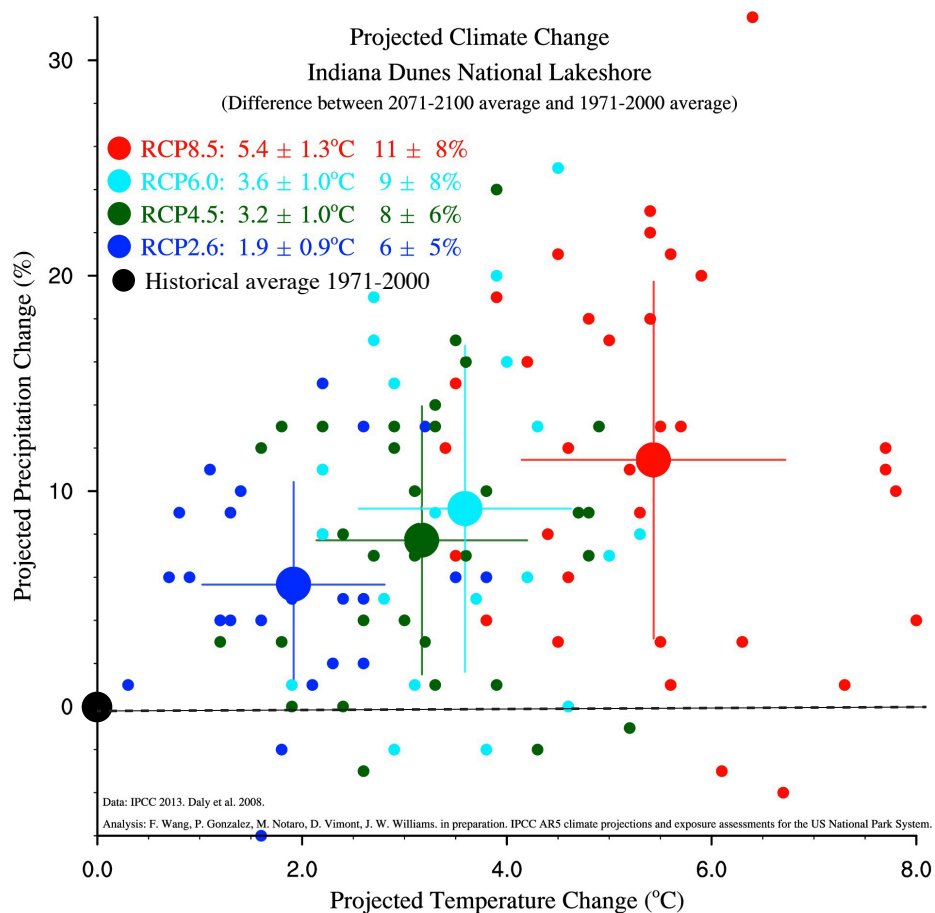
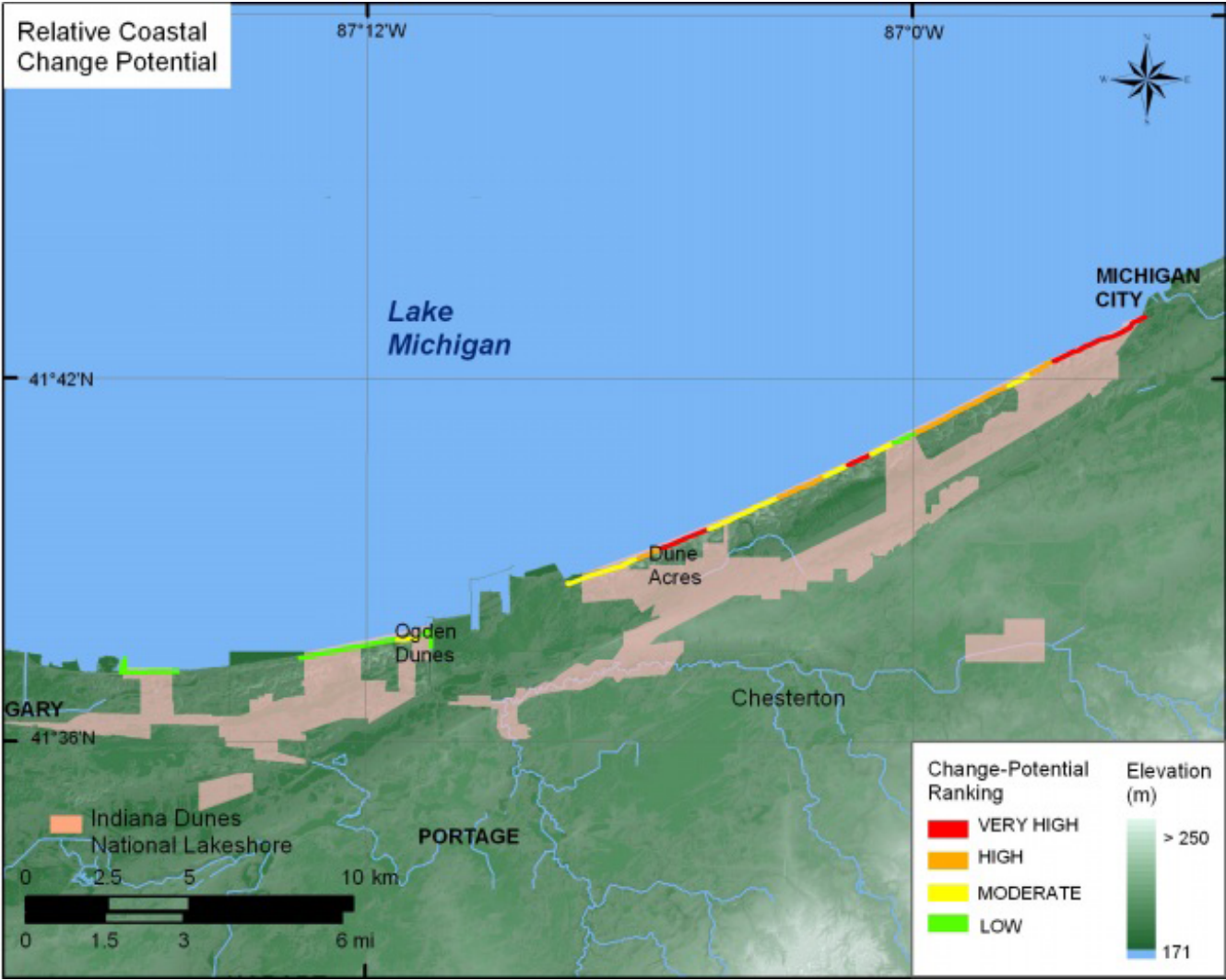


Figure 8. Vulnerability of the coastline of Indiana Dunes National Lakeshore to lake level change (Pendleton et al. 2010).



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