



Impacts and Vulnerabilities of Climate Change in U.S. National Parks



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1. Historical impacts
2. Projected vulnerabilities
3. Climate change at Indiana Dunes National Lakeshore



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Scientific Procedures to Determine Historical Impacts

Gonzalez 2011 Issues in Science and Technology

Observation

Record changes, but no statistical analysis

Detection

Statistically significant departures from natural variability

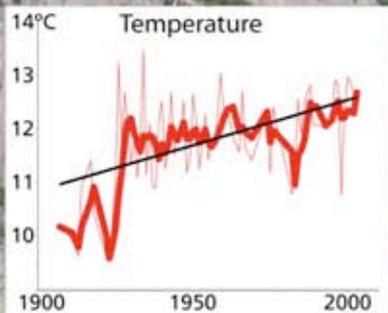
Attribution

Relative importance of different causal factors, from site selection, climate trends, or multivariate statistical analysis

Climate change has shifted plant and animal species upslope at Yosemite 1914-2006

Moritz et al. 2008 Science

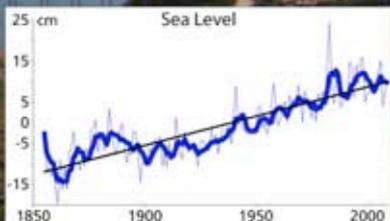
Millar et al. 2004 Arctic, Antarctic, and Alpine Research





Climate change has increased sea-level at the Golden Gate 1855-2004

Church and White 2006 Geophysical Research Letters





Climate change has reduced snowpack across the Western U.S. 1200-2006 AD

Pederson et al. 2011 Science





Climate has dominated all other factors in controlling the extent of wildfire in western U.S. forests 1916-2003

Little et al. 2009 Ecological Applications

Las Conchas Fire, July 4, 2011
Santa Clara Pueblo, north of Bandelier National Monument, New Mexico USA
photo K. Greer



Climate change doubled tree mortality in the western U.S. 1955-2007

van Mantgem et al. 2009 Science





Climate change shifted winter bird ranges northward $0.5 \pm 2.4 \text{ km y}^{-1}$ in 54 national parks and other areas 1975-2004

La Sorte and Thompson 2007 Ecology



Evening Grosbeak (*Coccothraustes vespertinus*)
photo M.J. Hopiak, Cornell Laboratory of Ornithology

Shenandoah National Park, Virginia USA
photo P. Gonzalez



Climate change has advanced spring warmth in 53 western national parks and other areas

Ault et al. 2011 Journal of Climate



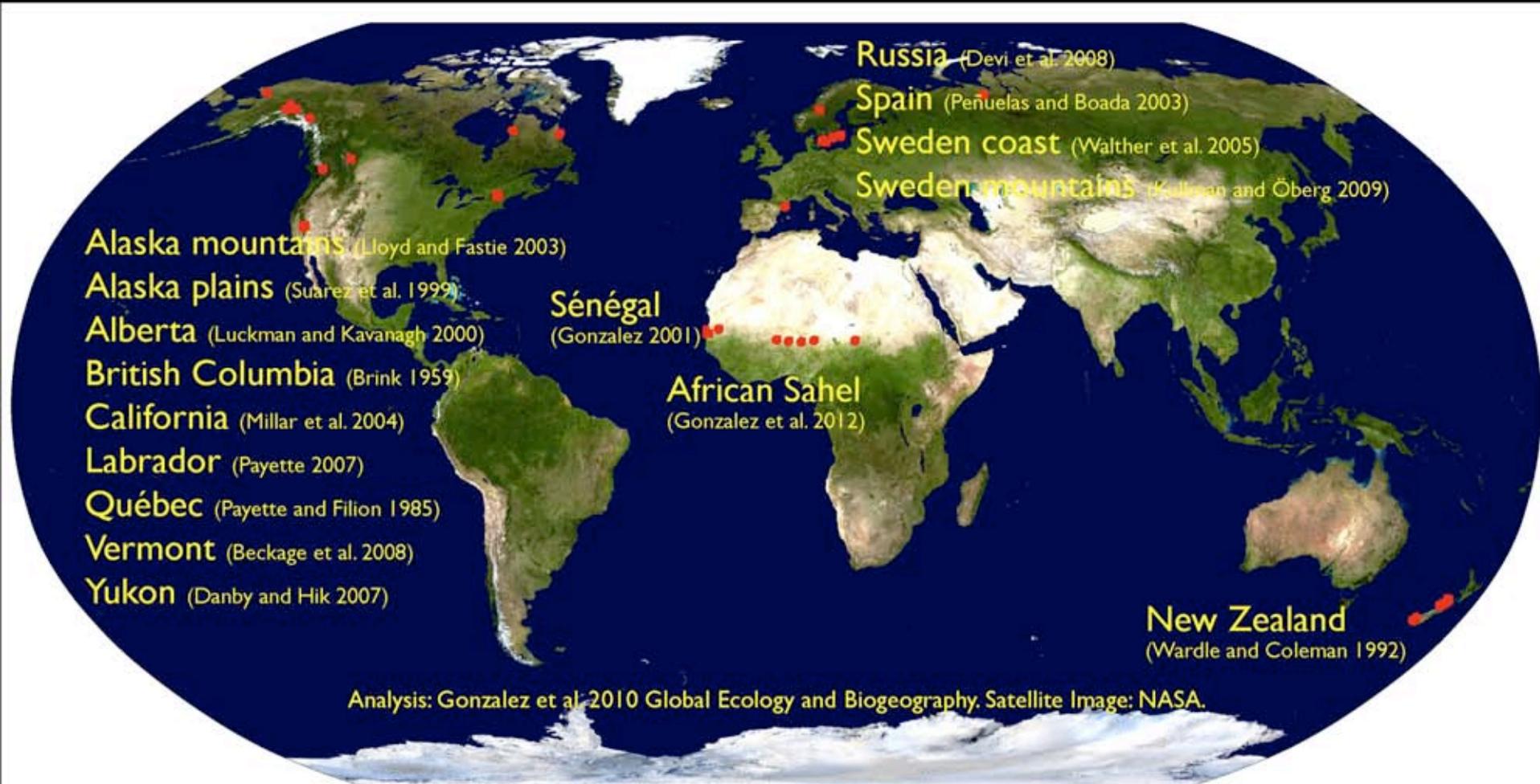


Climate change has shifted boreal forest into tundra in Noatak National Preserve

Suarez et al. 1999 Ecoscience



Climate change has shifted major vegetation zones globally



Historical Biome Shifts Due to Climate Change



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Climate Change may increase fire frequencies in Yellowstone National Park and its ecosystem 3-10x by 2100

IPCC Emissions Scenario A2

Westerling et al. 2011. Proceedings of the National Academy of Sciences of the USA.



The pika is vulnerable to losing its habitat from warming in Great Basin National Park and other areas

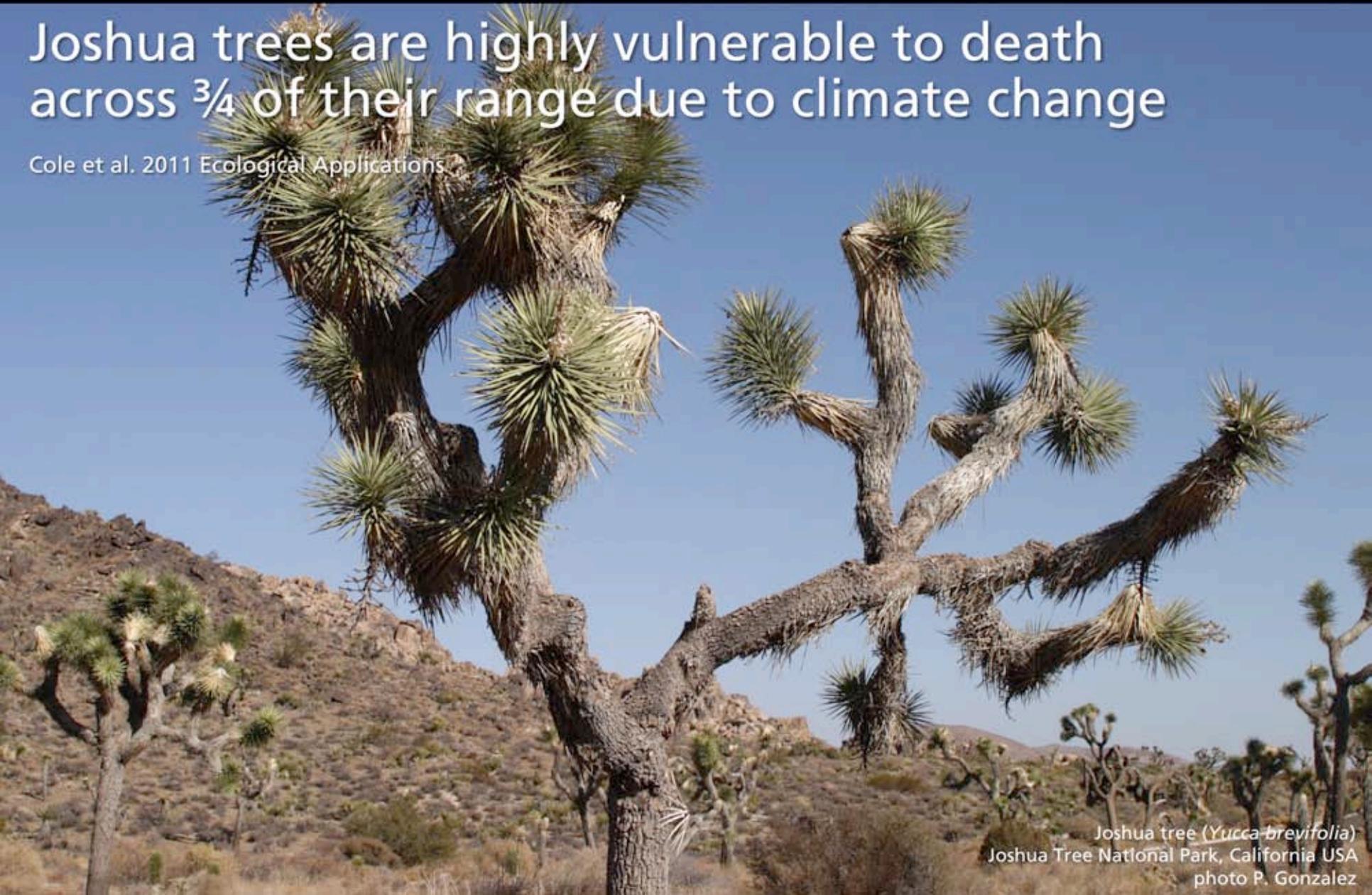
Beever et al. 2011 Global Change Biology





Joshua trees are highly vulnerable to death across $\frac{3}{4}$ of their range due to climate change

Cole et al. 2011 Ecological Applications



Joshua tree (*Yucca brevifolia*)
Joshua Tree National Park, California USA
photo P. Gonzalez



Coastal ecosystems are vulnerable to increased erosion from sea-level rise and storm surges

Pendleton et al. 2010 Journal of Coastal Research





Coral reefs are vulnerable to bleaching and acidification

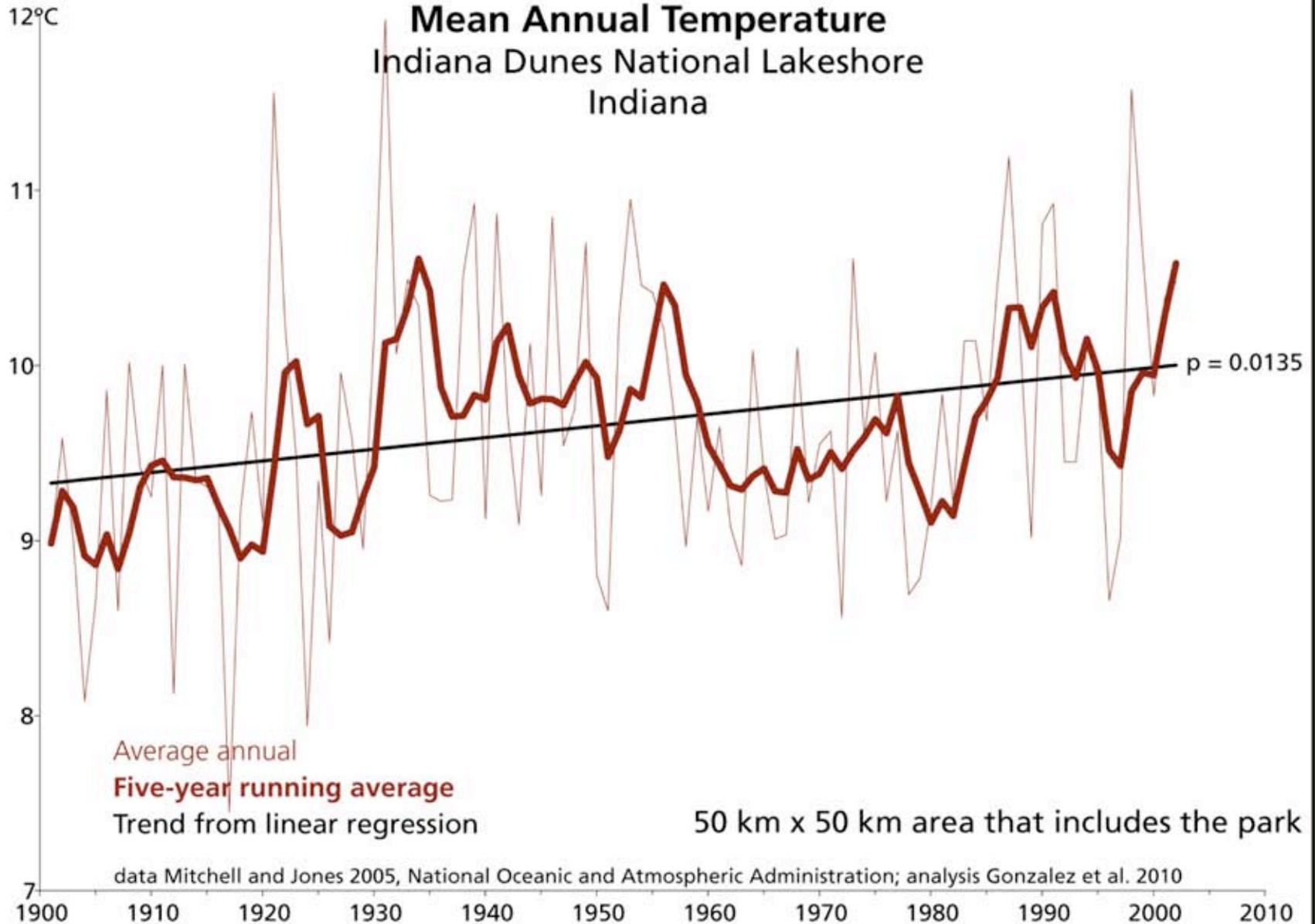
Hoegh-Guldberg et al. 2007 Science





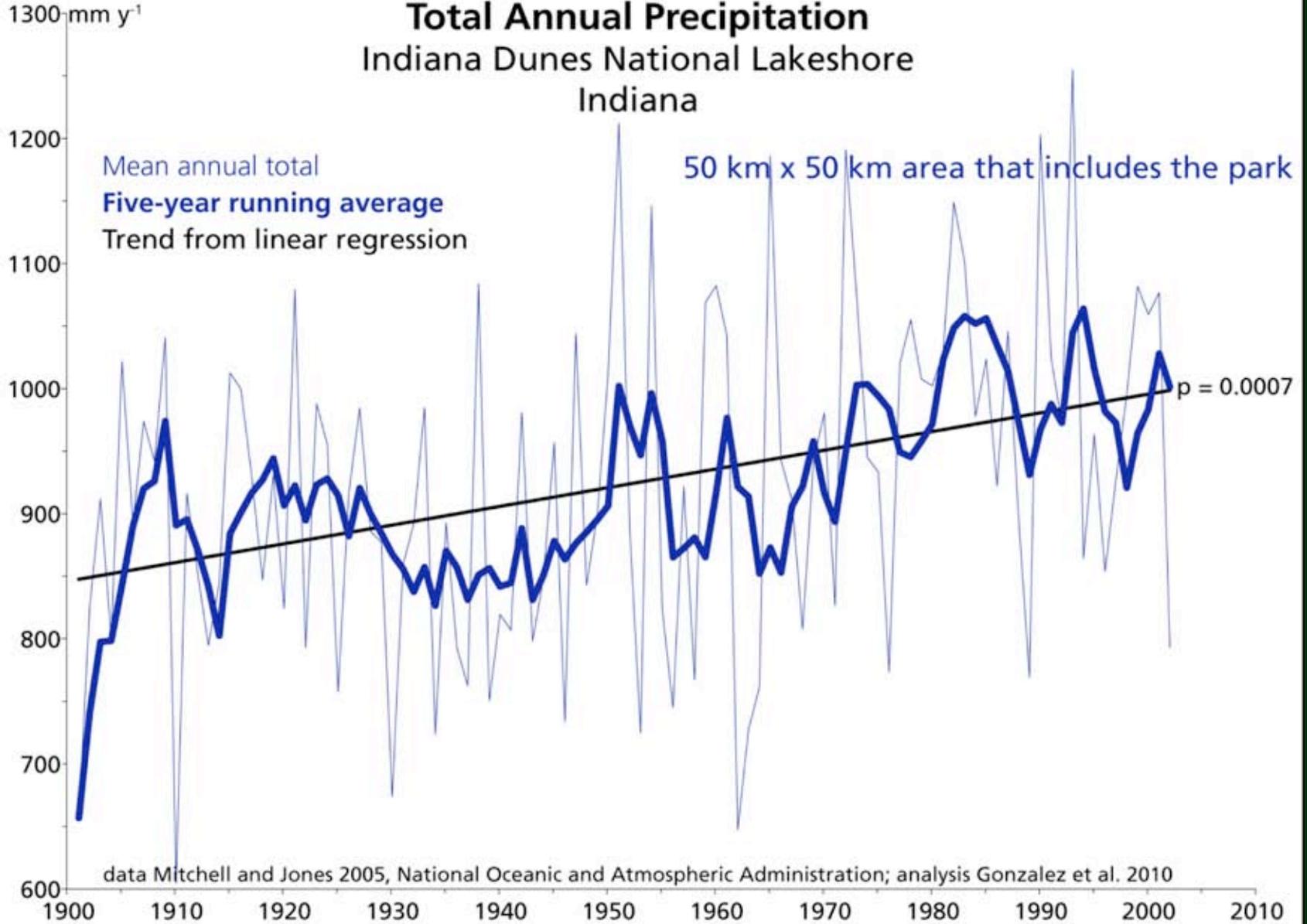
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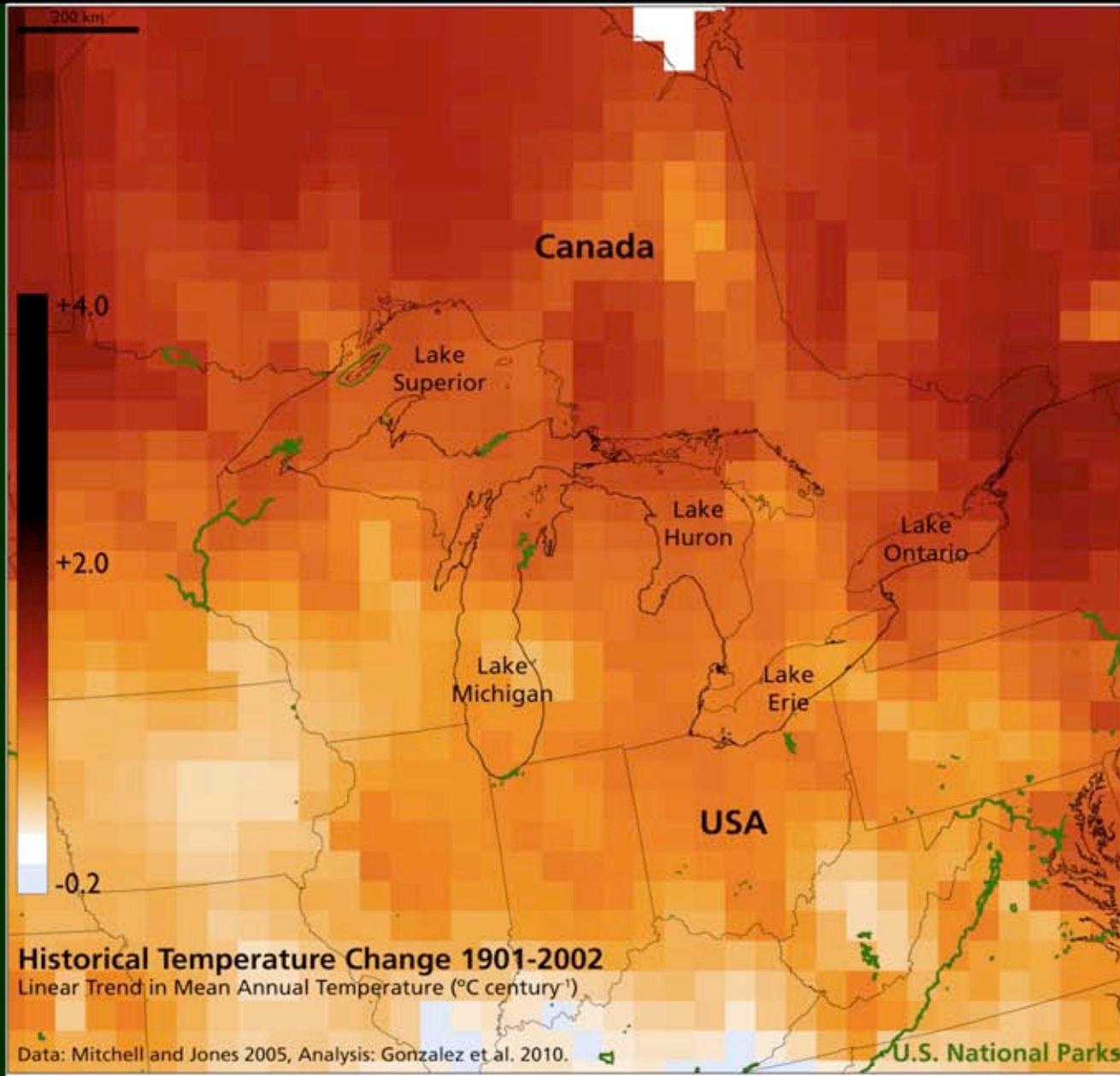
1. Historical impacts
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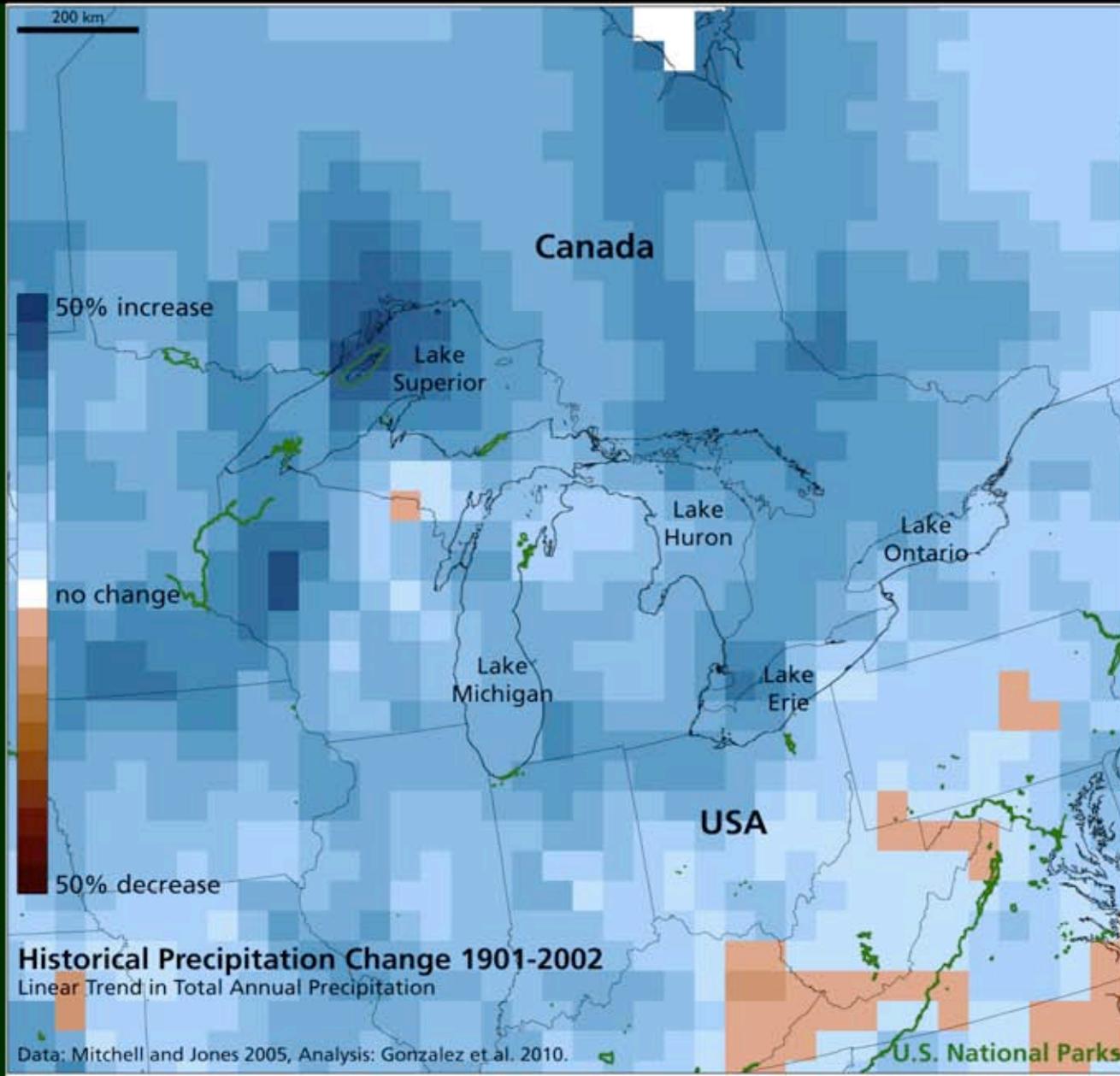




Total Annual Precipitation Indiana Dunes National Lakeshore Indiana







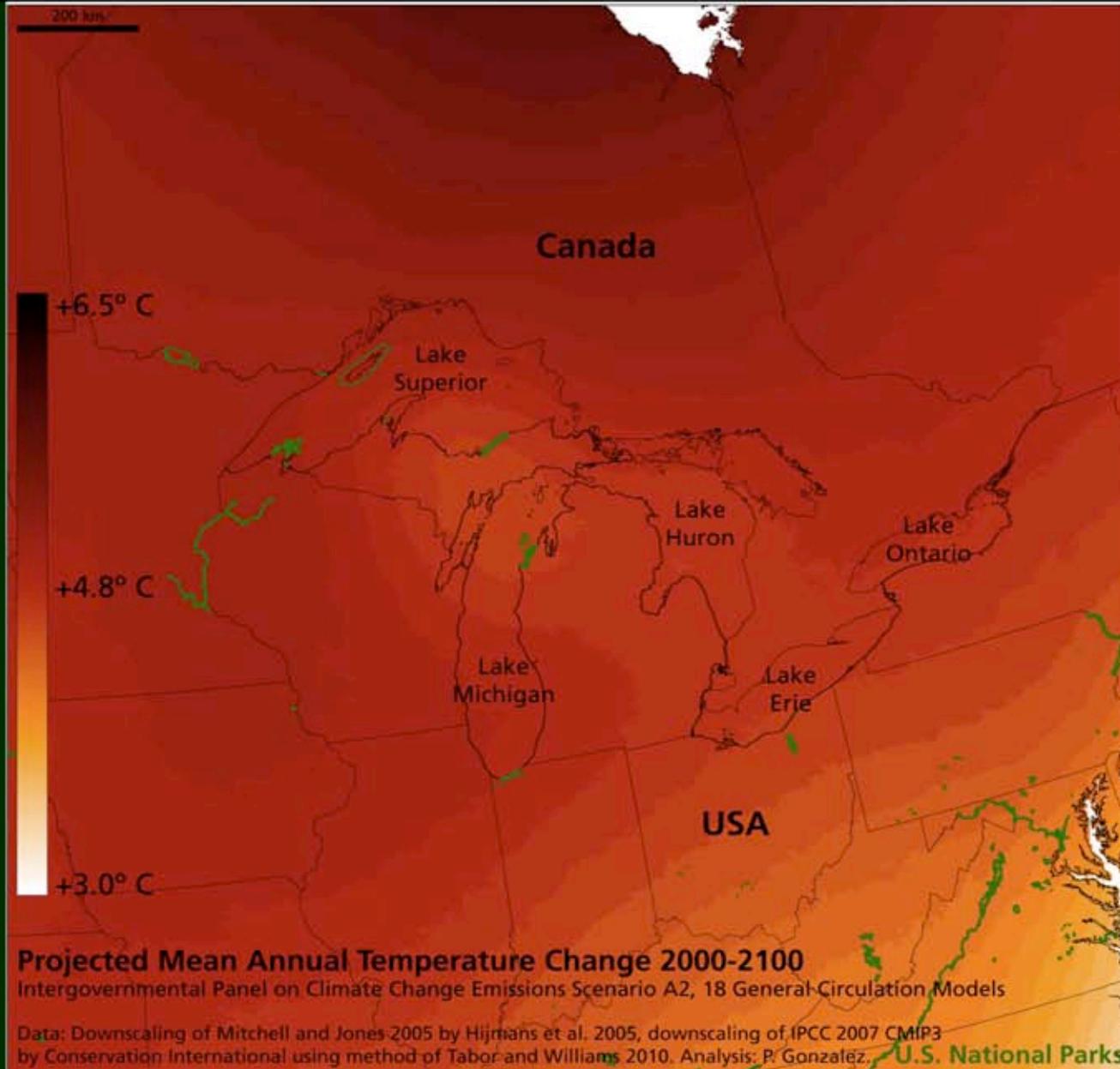


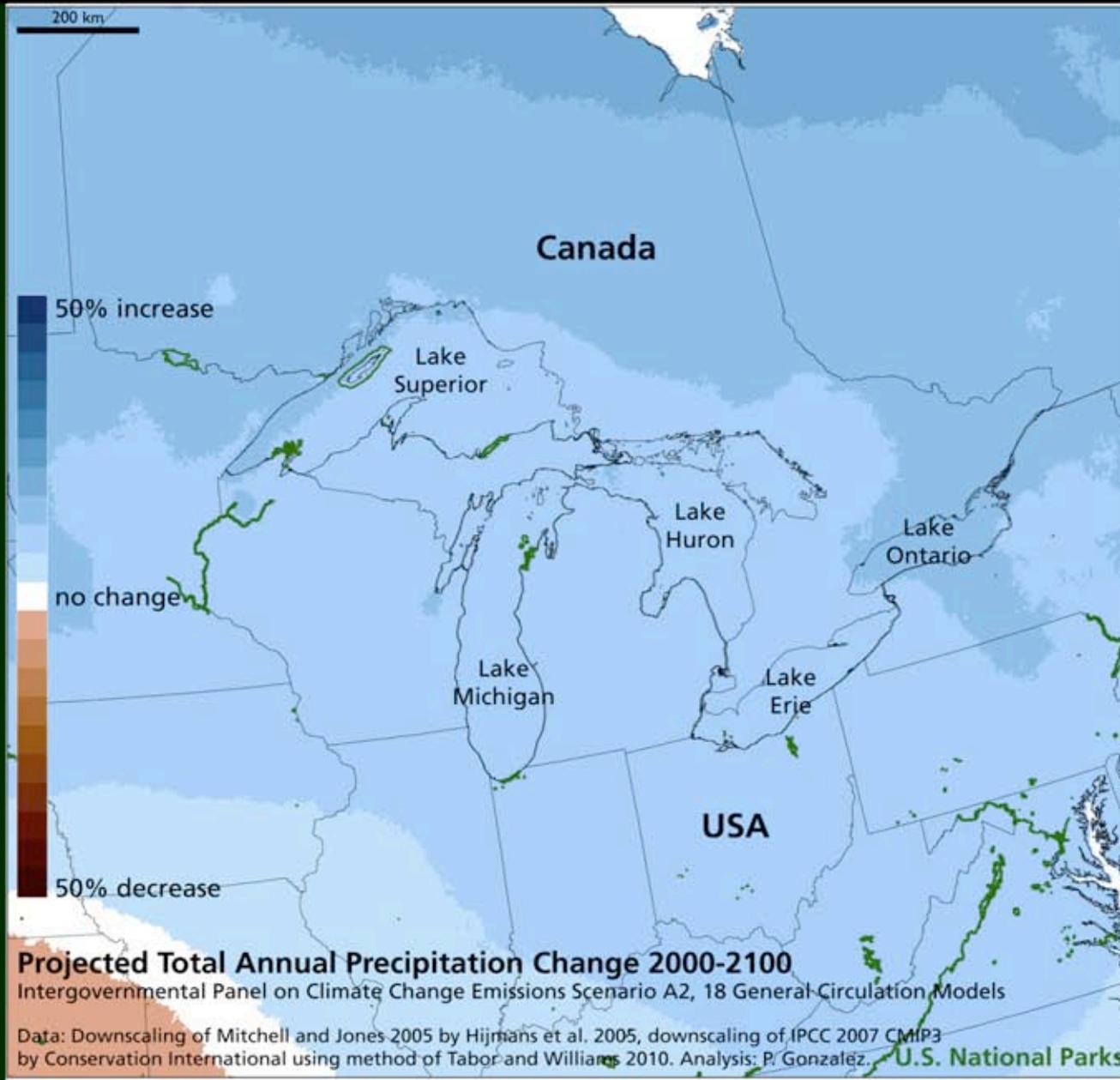
Lake Michigan trends consistent with climate change: ice cover decrease 1973-2010 lake level decrease 1865-2007 water temperature increase 1960-1992

ice: Magnuson et al. 2000 Science, Wang et al. 2012 Journal of Climate

lake: Hanrahan et al. 2010 Journal of Great Lakes Research, Hanrahan et al. 2010 Geophysical Research Letters

water: McCormick and Fahnenstiel 1999 Limnology and Oceanography



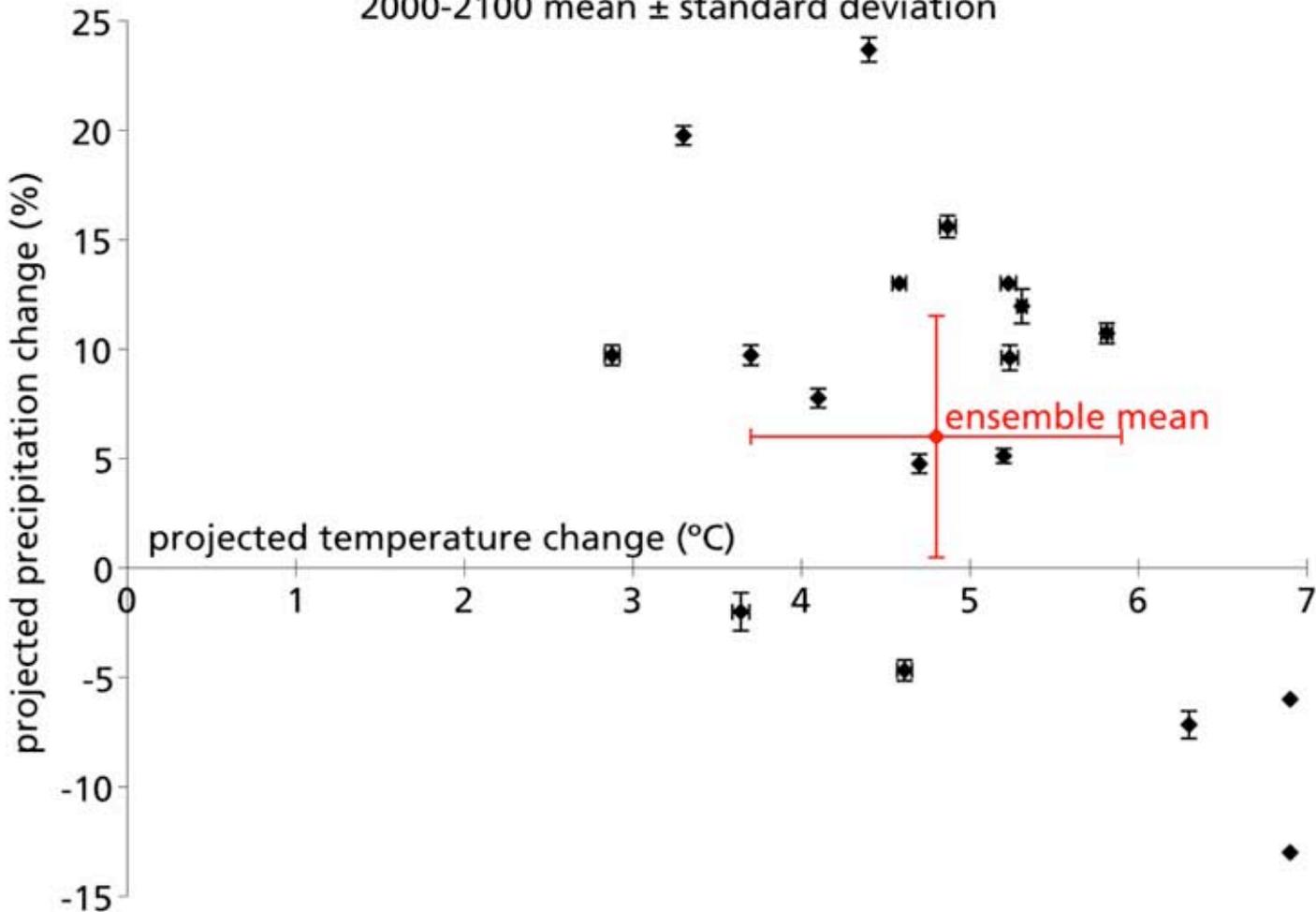




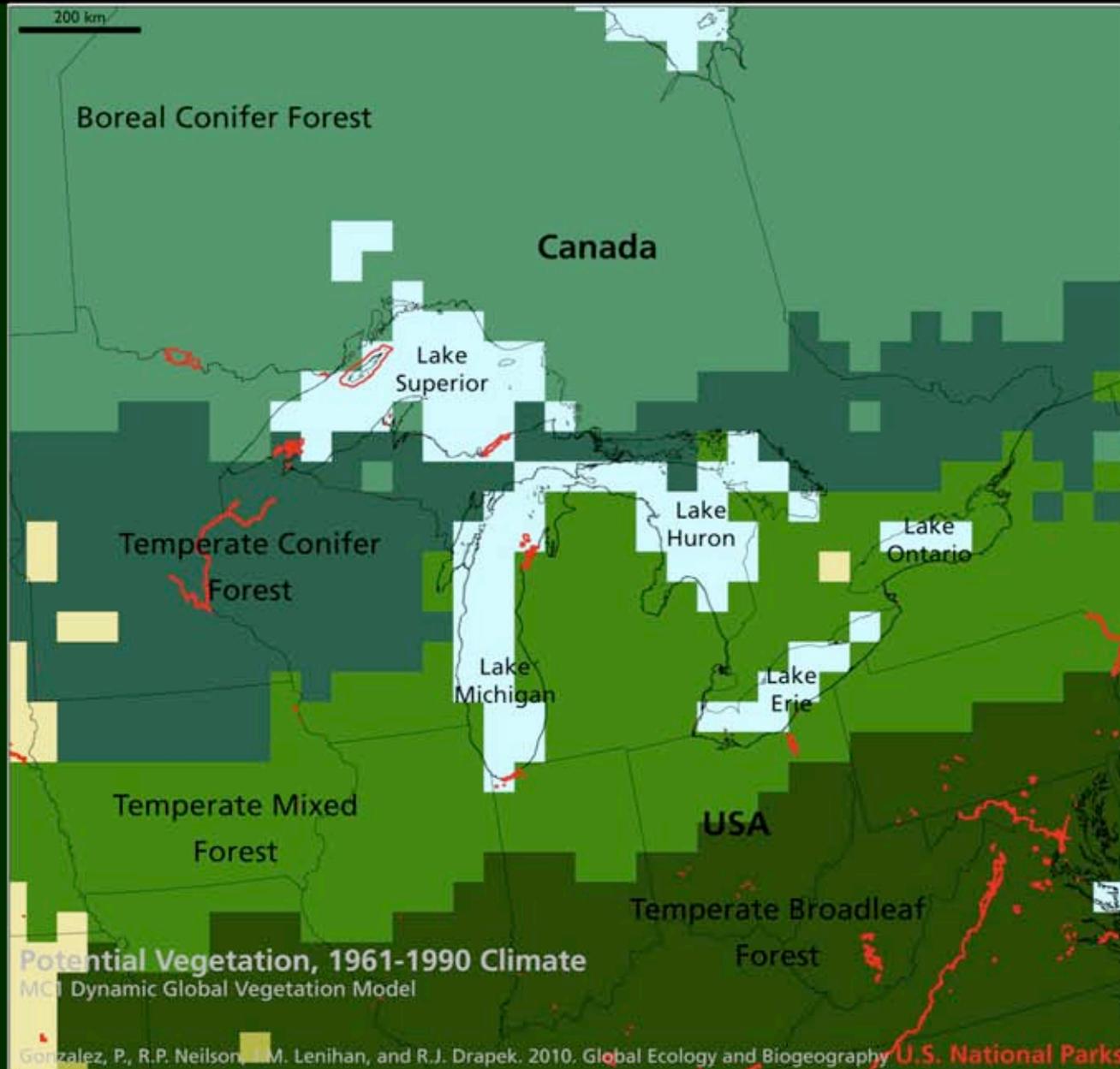
Climate Change Projections

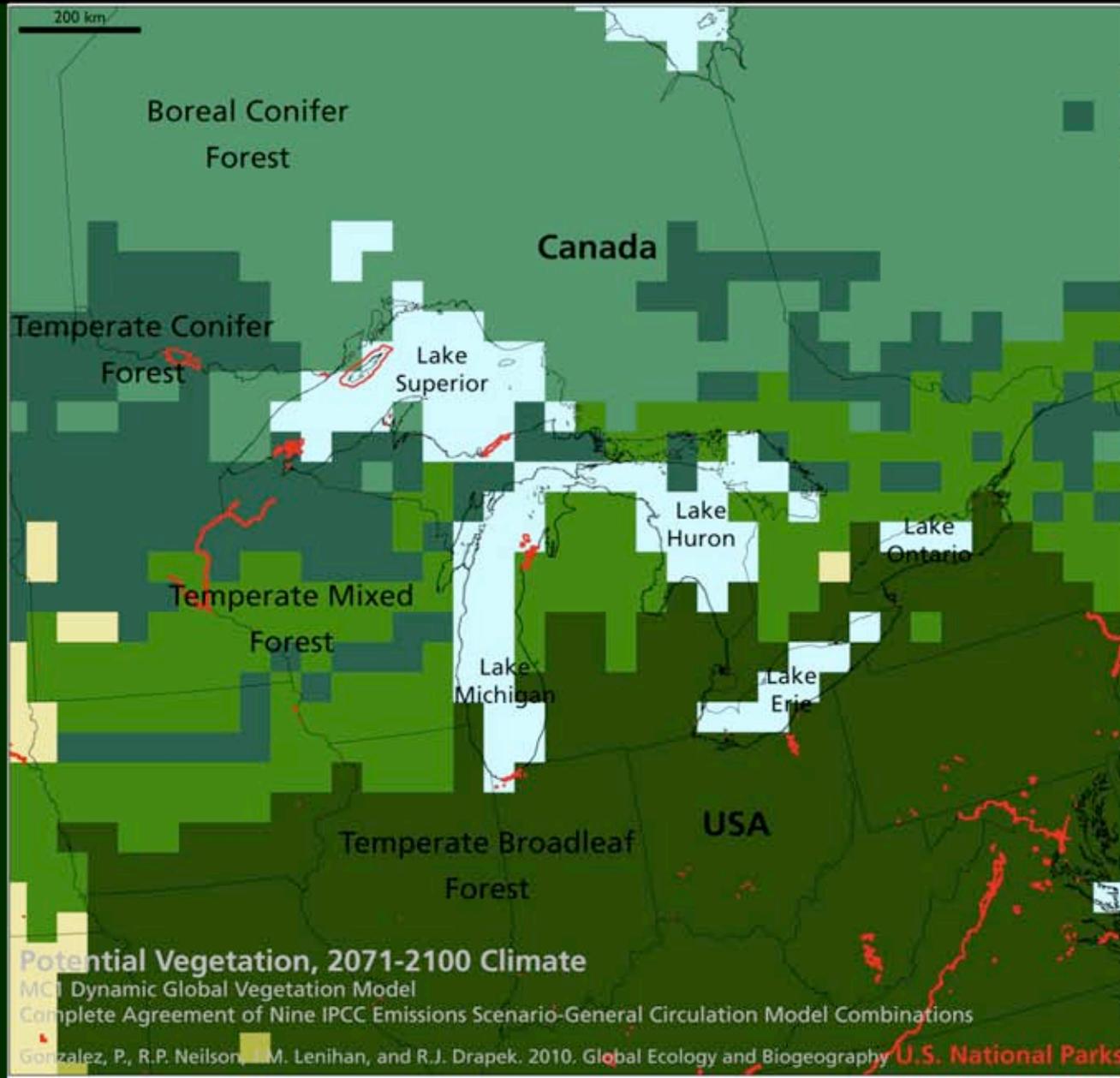
Indiana Dunes National Lakeshore, Indiana

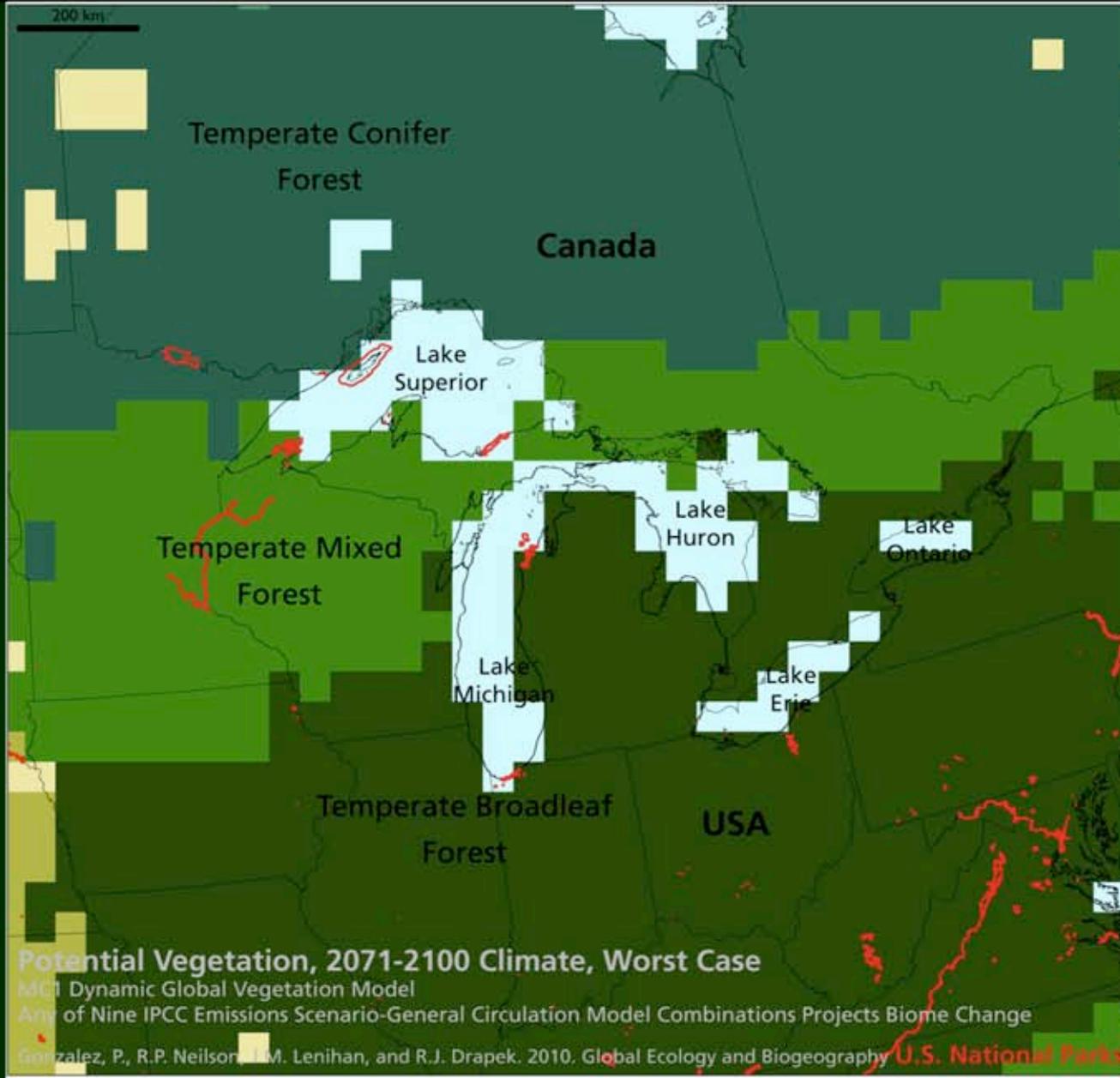
IPCC Emissions Scenario A2
2000-2100 mean \pm standard deviation

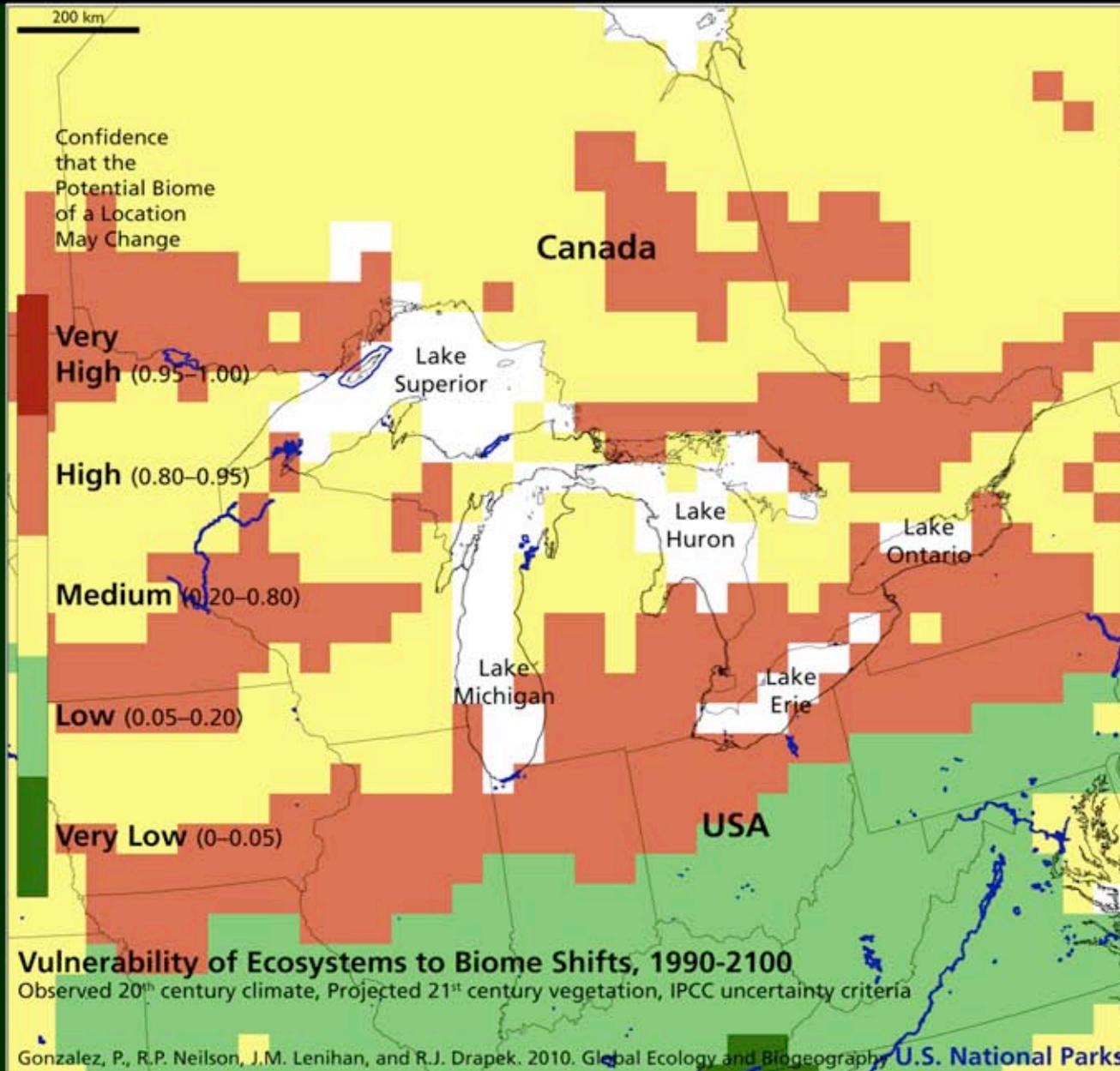


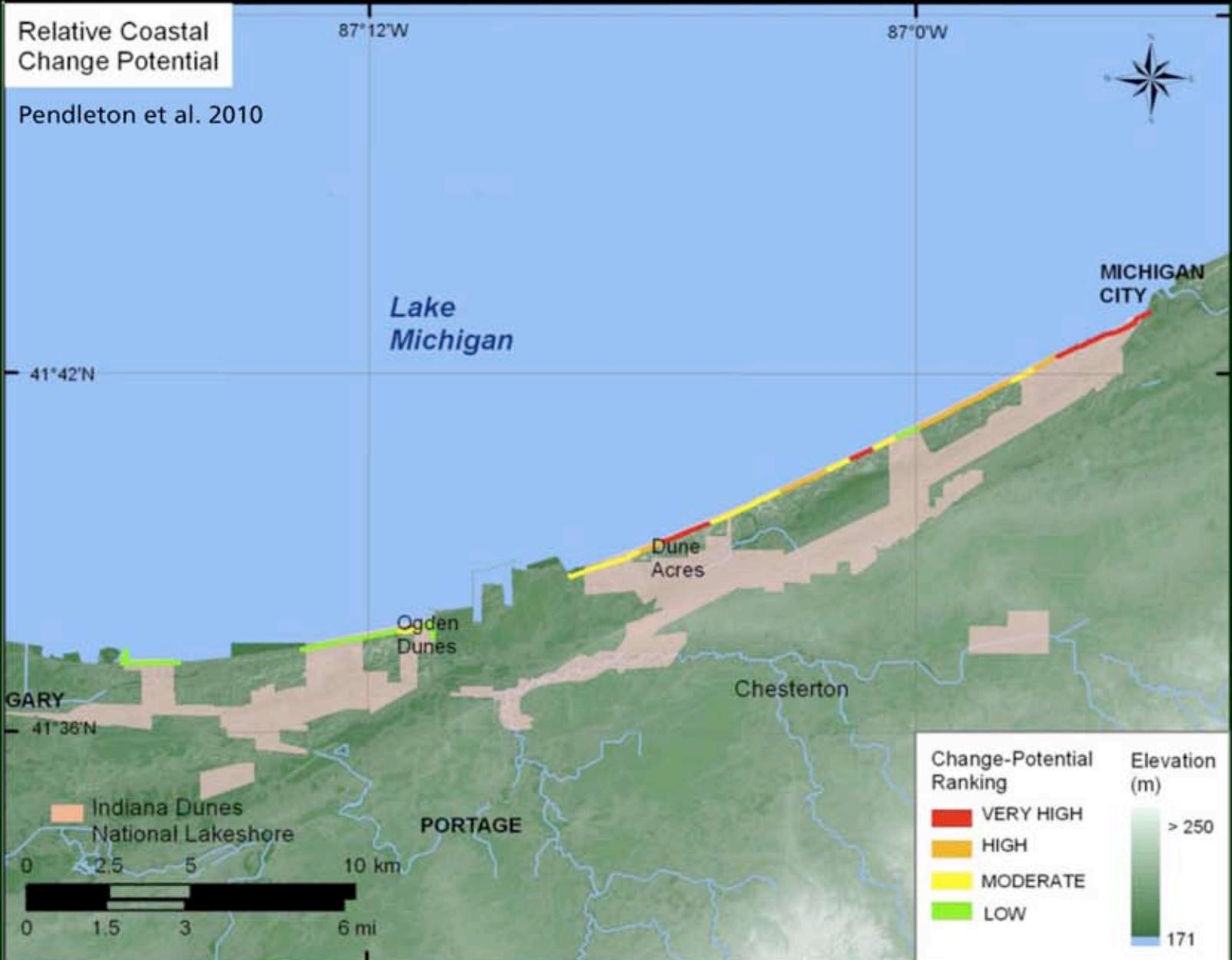
data: historical average - Mitchell and Jones 2005, Hijmans et al. 2005, projections - IPCC 2007, Tabor and Williams 2010, Conservation International; analysis: P. Gonzalez











Take Personal Action to Reduce Climate Change

- Walk, bike, or take public transit
- If you own a car, keep tires well inflated
- Recycle and use recycled products
- Turn down heating and air conditioning
- Install or buy renewable energy
- Eat local produce
- Plant native trees

