Climate Change Trends for Planning at Capulin Volcano National Monument, New Mexico

Patrick Gonzalez
National Park Service
September 26, 2012

Historical Trends

From 1901 to 2002, mean annual temperature increased across North America (Figure 1; Gonzalez et al. 2010) and showed a statistically significant increase in the area that includes Capulin Volcano National Monument (NM) (Figure 2, Table 1). From 1901 to 2002, precipitation increased across most of North America (Figure 3; Gonzalez et al. 2010), although it showed no statistically significant trend in the Capulin Mountain area (Figure 4, Table 1). Analyses of causal factors attribute 20th century warming and precipitation changes to greenhouse gas emissions from vehicles, power plants, deforestation, and other human activities (Intergovernmental Panel on Climate Change (IPCC) 2007, Bonfils et al. 2008).

Future Projections

The Intergovernmental Panel on Climate Change (IPCC) has coordinated research groups to project possible future climates under defined greenhouse gas emissions scenarios (IPCC 2007). The three main IPCC greenhouse gas emissions scenarios are B1 (lower emissions), A1B (medium emissions), and A2 (higher emissions). Actual global emissions are on a path above IPCC emissions scenario A2 (Friedlingstein et al. 2010).

For the three main IPCC emissions scenarios, projected 21st century temperature in the Capulin Mountain area could increase four to eight times the amount of historical 20th century warming (Table 1, Mitchell and Jones 2005, Gonzalez et al. 2010). General circulation models (GCMs) of the atmosphere project decreased annual precipitation in the Capulin Mountain area under all three emissions scenarios (Table 1, Mitchell and Jones 2005, Gonzalez et al. 2010). For emissions scenario A2, the average projected change in annual precipitation is -17 ± 18%, with 14 out of 18 GCMs projecting decreases in precipitation (Figure 5; historical average from Mitchell and Jones 2005, Hijmans et al. 2005; projections from IPCC 2007, Tabor and Williams 2010, Conservation International; analysis by P. Gonzalez).

References

Bonfils, C., B.D. Santer, D.W. Pierce, H.G. Hidalgo, G. Bala, T. Das, T.P. Barnett, D.R. Cayan, C. Doutriaux, A.W. Wood, A. Mirin, and T. Nozawa. 2008. Detection and attribution of temperature changes in the mountainous western United States. Journal of Climate 21: 6404-6424.

Friedlingstein, P., R.A. Houghton, G. Marland, J. Hackler, T.A. Boden, T.J. Conway, J.G. Canadell, M.R. Raupach, P. Ciais, and C. Le Quéré. 201. Update on CO2 emissions. Nature Geoscience 3: 811-812.

Gonzalez, P., R.P. Neilson, J.M. Lenihan, and R.J. Drapek. 2010. Global patterns in the vulnerability of ecosystems to vegetation shifts due to climate change. Global Ecology and Biogeography 19: 755-768.

Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones, and A. Jarvis. 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978.

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007: The Physical Science Basis. Cambridge University Press, Cambridge, UK.

Mitchell, T.D. and P.D. Jones. 2005. An improved method of constructing a database of monthly climate observations and associated high-resolution grids. International Journal of Climatology 25: 693-712.

Tabor, K. and J.W. Williams. 2010. Globally downscaled climate projections for assessing the conservation impacts of climate change. Ecological Applications 20: 554-565.

Table 1. Historical and projected climate (mean ± standard deviation (SD)) trends for the area that includes Capulin Volcano NM (Mitchell and Jones 2005, IPCC 2007, Gonzalez et al. 2010). Climate projections for IPCC emissions scenarios B1 and A1B are calculated at 50 km spatial resolution (Gonzalez et al. 2010) and, for emissions scenario A2, at 4 km spatial resolution (data from Conservation International using method of Tabor and Williams (2010)). Note "century^{-1}" is the fractional change per century, so that -0.17 century^{-1} is a decrease of 17% in a century.

	mean	SD	units
Historical			
temperature 1901-2002 annual average	9.0	0.6	ºC
temperature 1901-2002 linear trend	0.6	2.0	ºC century^{-1}
precipitation 1901-2002 annual average	420	80	mm y^{-1}
precipitation 1901-2002 linear trend	0.07	0.66	century^{-1}
Projected			
IPCC B1 scenario (lower emissions)			
temperature 1990-2100 annual average	2.7	1.0	ºC century^{-1}
precipitation 1990-2100 annual average	-0.04	0.18	century^{-1}
IPCC A1B scenario (medium emissions)			
temperature 1990-2100 annual average	3.7	1.0	ºC century^{-1}
precipitation 1990-2100 annual average	-0.06	0.18	century^{-1}
IPCC A2 scenario (higher emissions)			
temperature 1990-2100 annual average	4.8	1.0	ºC century^{-1}
precipitation 1990-2100 annual average	-0.17	0.18	century^{-1}

Figure 1.

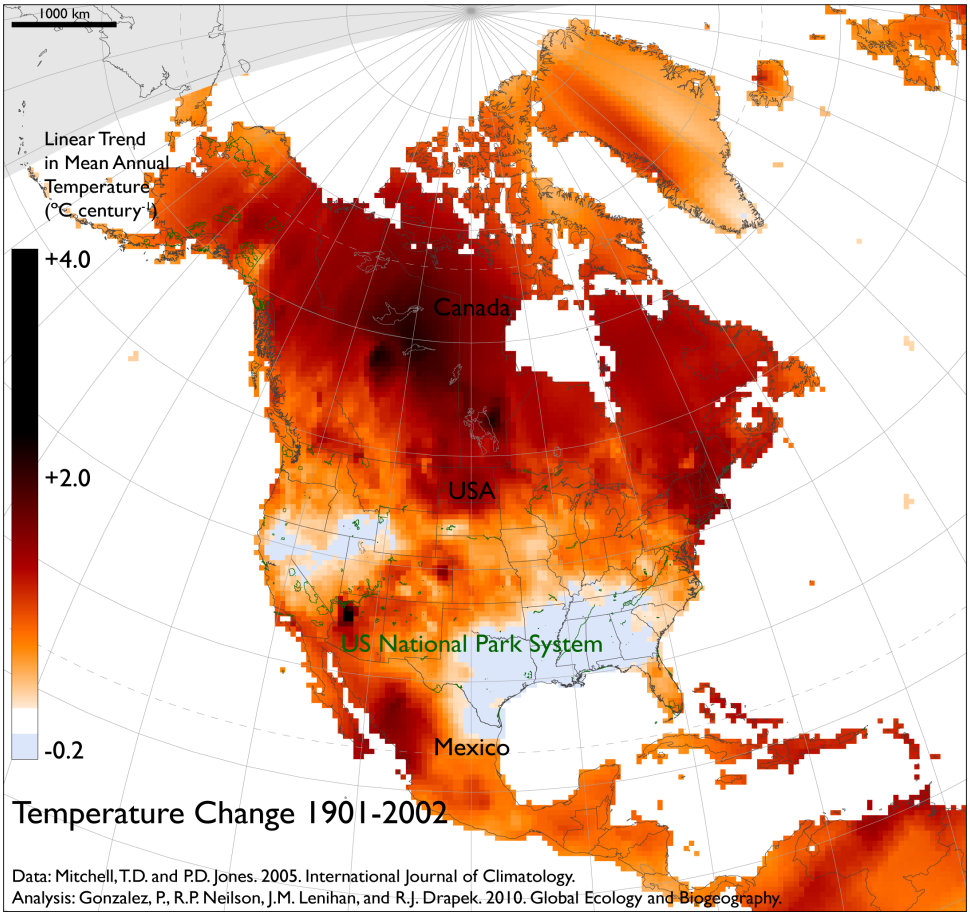


Figure 2.

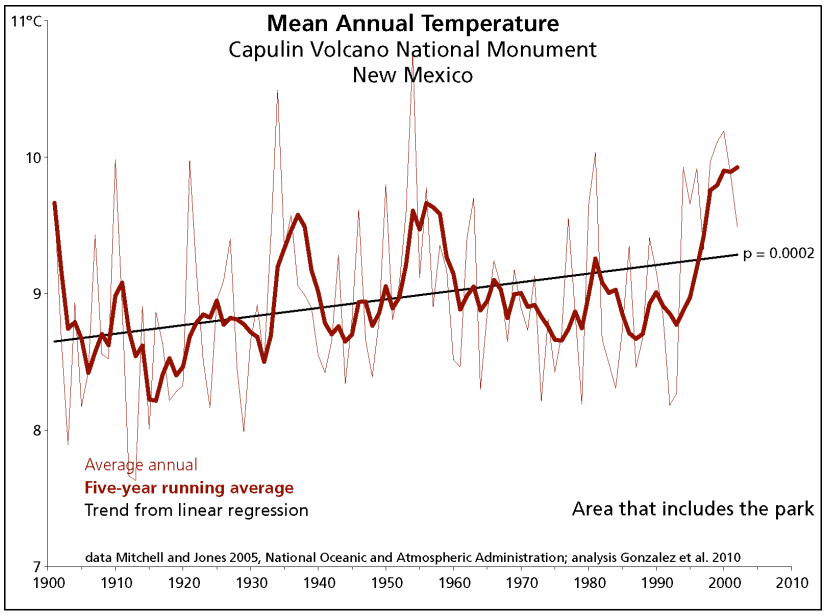


Figure 3.

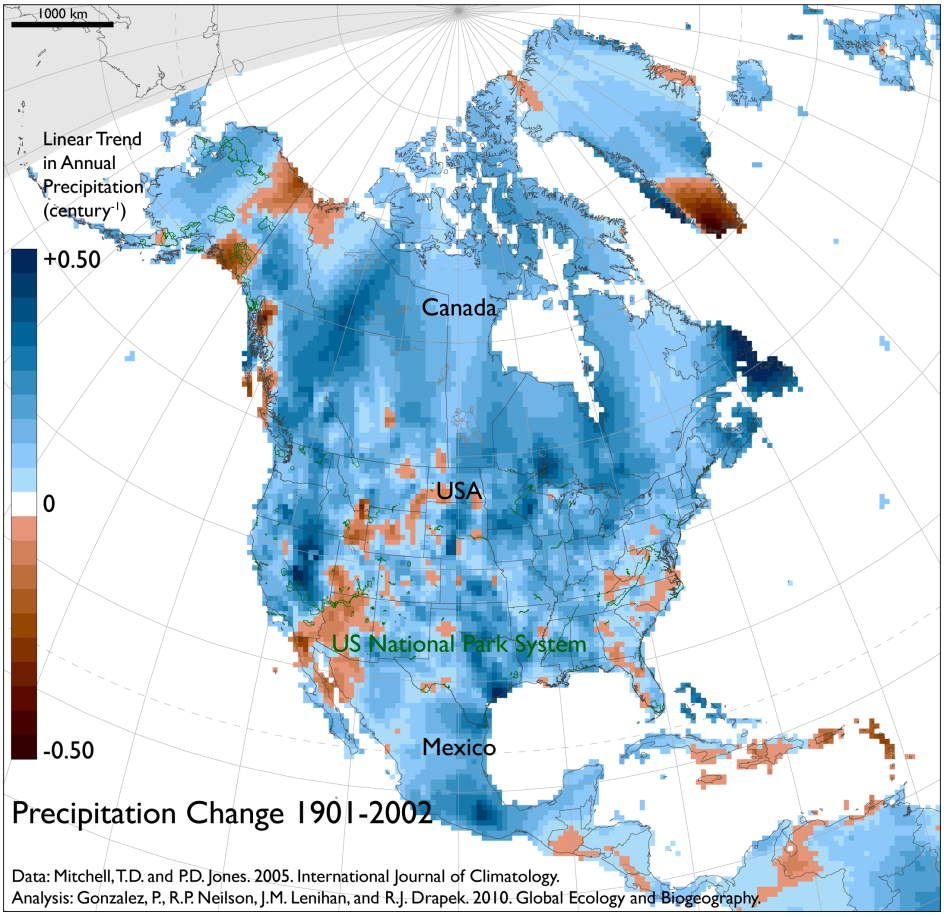


Figure 4.

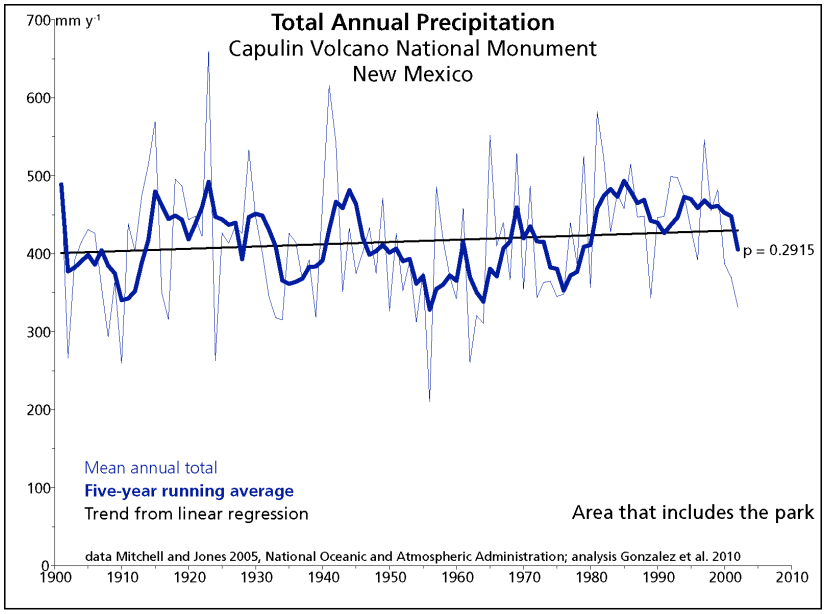
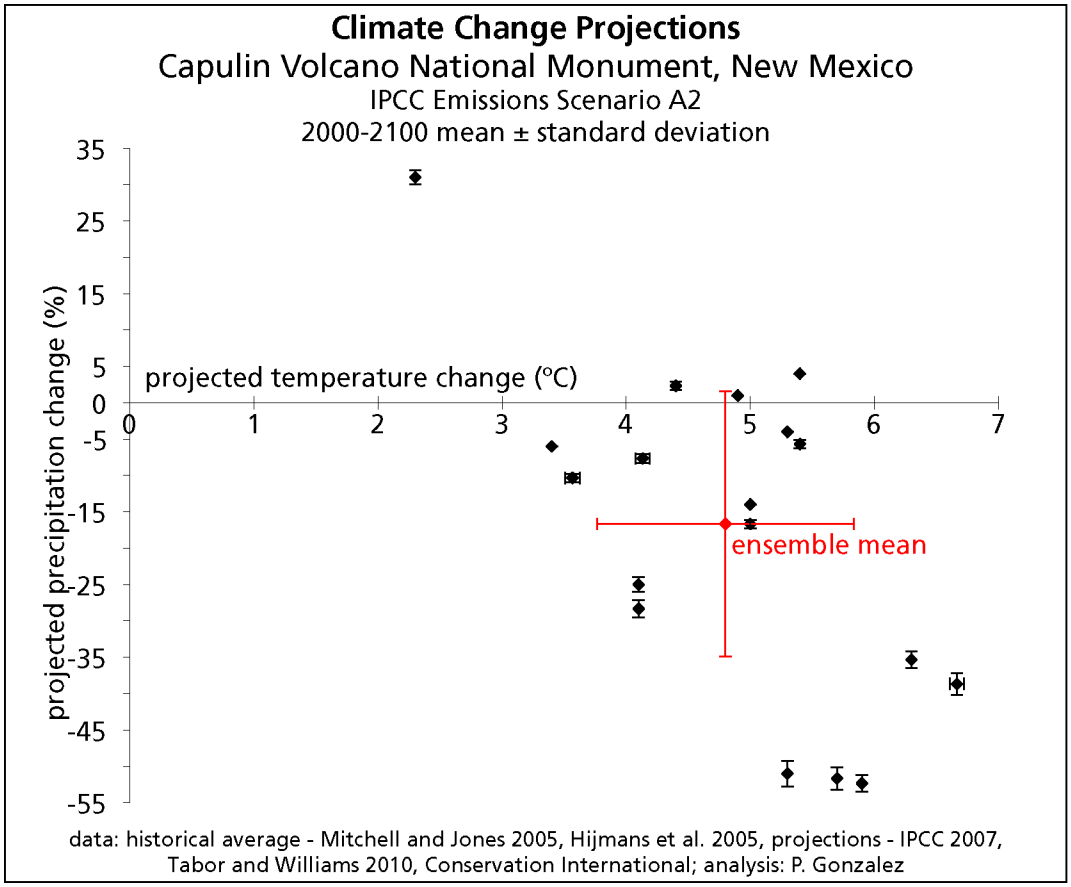


Figure 5.


Climate Change Projections
Capulin Volcano National Monument, New Mexico
IPCC Emissions Scenario A2
2000-2100 mean ± standard deviation
projected precipitation change (%)
35
25
15
5
0
-5
-15
-25
-35
-45
-55
projected temperature change (°C)
0
1
2
3
4
5
6
7
ensemble mean
data: historical average - Mitchell and Jones 2005, Hijmans et al. 2005, projections - IPCC 2007,
Tabor and Williams 2010, Conservation International; analysis: P. Gonzalez