

# ECONOMIC AND ENVIRONMENTAL IMPACTS OF CLIMATE CHANGE IN ARIZONA

by ROBERT REPETTO, PhD

Arizona's citizens and its economy are among America's most vulnerable to the growing adverse impacts of climate change. Climate change will have significant impacts on water resources and economic opportunities. Recent polling shows that the majority of voters in Arizona believe that state and federal governments should do more to address these impacts.<sup>1</sup> To reduce the threats and realize the opportunities posed by climate change, Arizona's leaders must support regional, national and international programs to reduce greenhouse gas emissions and accelerate a transition to clean energy.

## CLIMATE CHANGE'S IMPACT ON ARIZONA'S ENVIRONMENT

Climate change is already affecting Arizona's environment. Temperatures have risen by almost two degrees F in the past several decades, more rapidly than any other state in the lower 48 states, and are projected to continue increasing sharply by another three to five degrees F by 2050.<sup>2</sup> Rapid urbanization is exacerbating this trend by extending the urban heat island effect over larger areas and longer seasons, raising night-time temperatures by as much as 10 degrees compared to adjoining natural areas.<sup>3</sup> Heat waves of extraordinarily high summertime temperatures for extended periods of time are becoming more common.<sup>4</sup> The number of days with low night-time temperatures above 90 degrees has increased sharply in successive decades.<sup>5</sup>

### *Air and Water Quality Impact*

Air and water quality will suffer. Low river flows and higher water temperatures will raise water pollution concentrations. Ozone and smog concentrations will rise with higher air temperatures and growing energy use. Smoke from fires and dust from dry arid landscapes will raise particulate concentrations.

## *Water Scarcity*

Climate change is reducing precipitation, especially in the spring and early summer months, and these declines are projected to continue.<sup>6</sup> Runoff in the Colorado and other river systems that Arizona's water supply depend on for direct use and for groundwater recharge will decline by 20-40 percent by mid-century, exacerbating water supply shortages that are already evident. The Colorado River system is already overstretched and unable to meet future demand.<sup>7</sup> Reduced precipitation, increasing heat and evapotranspiration from soils and plants are making serious droughts a more frequent occurrence.<sup>8</sup>

In the past decade Arizona has been suffering from the worst drought in a century. Wildfires have increased in frequency and severity and will continue to do so as long as there are trees and other vegetation left to burn. Natural ecosystems, including Arizona's northern forests and its biodiversity hotspot (the Madrean Pine-Oak Woodlands) in the south, will be adversely affected by heat, drought, fire and proliferation of insect pests.

Adaptation to future water stresses in Arizona will be difficult and costly. Both groundwater and surface water resources are already over-allocated across much of the state. Increased population and economic growth will face water supplies that are already inadequate and diminishing with climate change, necessitating reallocations – largely out of agriculture – and different patterns of use. Yet, such changes are not determined by price and market signals. Water use in Arizona and throughout the Southwest is governed largely by administrative and judicial allocations involving private parties, local institutions, state, inter-state and federal authorities. Climate change will not only unsettle existing allocations, perhaps even the vital Colorado River Compact, but also introduce uncertainty into future allocation decisions, involving courts and government agencies in difficult conflicts.<sup>9</sup>

Urban water demand rises with increasing temperatures, as most water is used for outdoor watering. To meet the demand, water agencies will most likely be forced to consider costlier options as desalinization, waste water recycling and new diversions and storage projects to offset increasing shortages. Most of the supply enhancement projects under consideration, except conservation, are energy-intensive, but current energy supply options are themselves highly water-intensive, creating an escalating cost feedback loop.<sup>10</sup> Inevitably, climate change will sharply raise the cost of meeting future water demand.

## **CLIMATE CHANGE'S ECONOMIC IMPACT**

Climate change will have severe negative impacts on Arizona's economic drivers, as well as resulting in more costs for the state. A recent study by researchers at the Sandia National Laboratory considered impacts of precipitation declines on the half-dozen industries with the greatest water consumption (e.g., agriculture, utilities, mining, chemical manufacturing), sectors that make relatively small contributions to the state's GDP.<sup>11</sup> The study found that economic damages would be spread widely throughout the rest of the state's economy because of higher input costs, lower consumer incomes and spending, population changes and changes in the state's inter-regional competitiveness. Retail trade, food manufacturing and construction would be among the sectors most severely affected by these secondary effects but no sector would be unscathed. This study found Arizona to be among the nation's most vulnerable states, even though the full range of possible future heat, drought, and precipitation impacts was not considered, and optimistic assumptions about adaptation to future water shortages were included.

## *Impact on Agriculture and Ranching*

For some of the most vulnerable sectors of Arizona's economy, the direct damages from climate change are already being felt. Agriculture and ranching are facing increasing heat, drought, water shortages and pest damages that combine to reduce yields and productivity. In bad years, feed shortages force many ranchers to sell off herds at distressed prices, taking heavy losses.<sup>12</sup> Arizona farmers are heavily dependent on irrigation and even those with senior water rights are likely to face increasing shortages. More marginalized farmers, including Latinos and Native Americans, are more vulnerable because their access to crop insurance, credit, federal disaster relief and other institutional support is weaker.<sup>13</sup>

Although farming and ranching constitute only about two percent of the state GDP,<sup>14</sup> their importance to rural economies and associated industries is considerably larger, as is their political weight. Many Arizonan farmers and ranchers who hold senior water rights strongly resist water transfers to non-agricultural uses, even though urban and industrial water values are markedly higher than in most agricultural uses. There will be increasing pressure to transfer water out of agriculture toward industries that can afford to pay more for it<sup>15</sup> but there are legal, political and institutional impediments to these reallocations. Adaptation to supply constraints is unlikely to be smooth or economically efficient.<sup>16</sup>

## *Potential Loss of High Tech Manufacturing Industry*

Arizona's most dynamic and growth-generating sectors are also surprisingly vulnerable to climate change. Arizona was once a leader in high-tech manufacturing, which generated significant sales outside the state and many high-paying jobs within it. In 2005, the high-tech sector contributed five percent of state GDP,

four percent of employment and seven percent of earnings. If indirect effects are included, high-tech's contribution rises to 11, 10 and 13 percent, respectively. Yet, Arizona's lead in these industries has been eroding to the extent that Arizona is now not significantly above the average of all the states.<sup>17</sup> Most high-tech industries are "footloose": their location is not tied to local markets or to raw material supplies. High-tech firms must be able to attract and retain highly trained and educated executives, engineers and scientists, who typically have nation-wide choices of employment. For this reason, "quality of life" considerations enter strongly into locational decisions.<sup>18</sup>

**Though there has been a significant movement of economic activity toward the Sunbelt states in recent decades, growth of population and employment *within* the Sunbelt has been negatively associated with temperature, favoring metropolitan statistical areas with more moderate climates.**

resources, and cultural and educational opportunities. Prolonged summer heat in excess of 100 degrees and rising at times to 110 and 120 degrees is a deterrent rather than an attraction. For example, there is a marked hot-season drop-off of business travel to Arizona, measured by business segment hotel rooms sold during the summer months.<sup>19</sup> Climate change is likely to discourage movement into the state by footloose high-tech industries, research centers and corporate headquarters that are sensitive to quality of life issues. Though there has been a significant movement of economic activity toward the Sunbelt states in recent decades, growth of population and employment *within* the Sunbelt has been negatively associated with temperature, favoring metropolitan statistical areas with more moderate climates.<sup>20</sup>

Salient among these considerations are an attractive climate and scenery, outdoor recreation

## Damage to Tourism Industry

A substantial segment of Arizona's economy is the extremely climate-sensitive travel and tourism industry. Almost 37 million visitors in 2010 spent nearly \$18 billion on a wide variety of goods and services, generating more than 150,000 jobs, nearly \$5 billion in direct earnings, and \$3.5 billion in state and local taxes.<sup>21</sup> Eighty percent of this business is derived from out-of-state visitors, making tourism Arizona's leading export industry. Tourism also generated \$297 million in construction investment, more than 10 percent of all non-residential construction in Arizona in 2010. This investment supported 5,300 construction jobs with earnings of \$280 million in a weak economy. Including the earnings and employment of businesses supplying the tourism sector and the spending by employees in those businesses, the direct plus indirect contribution of tourism to the Arizona economy rises considerably, to 283,000 jobs with \$9.7 billion in annual earnings.<sup>22</sup>

Recent experience confirms that visitation is highly sensitive to climate and its effects. Controlling for other influences, drought reduces visits to some national parks by seven percent.<sup>23</sup> During the 1999–2003 period, when lake levels fell 2.1 percent at Mead and 5.4 percent at Powell, those changes reduced visits to Glen Canyon by half a million visitors and reduced spending by \$32 million. At Lake Powell, there were almost a million fewer visitors and \$28 million less in tourist spending. Tourism statistics show that for every one percent drop in the reservoir level, visits to Lake Powell fall by five percent.<sup>24</sup> Reduced river flows and deterioration of riparian habitats undermines fishing, rafting, boating and other water-based activities. Forest fires are also a deterrent.<sup>25</sup>

**Tourism statistics show that for every one percent drop in the reservoir level, visits to Lake Powell fall by five percent.**

According to the U.S. Forest Service, there are 182 communities bordering federal lands in Arizona and New Mexico that are at risk of forest fires.<sup>26</sup> Many of these towns host second home developments, which make up more than six percent of all residences in Arizona.<sup>27</sup> Arizona's ski facilities are also vulnerable. Rising winter temperatures, less precipitation falling as snow, and increasing water scarcity will shorten the ski season, perhaps drastically, especially at the Arizona SnowBowl where snowmaking possibilities are limited. The lack of snow will hurt not only the ski operations but also the value of second homes and other real estate developments around the ski areas.

Skiing, fishing and other outdoor recreational activities will suffer from climate change. Forty percent of Arizonans surveyed engage in sport and fitness exercises and 25 percent enjoy outdoor recreation.<sup>28</sup> More than two-thirds of the golfers on the state's 421 courses are residents, many of them retirees who have relocated to Arizona. Golfing makes an important economic contribution, estimated in 2004 at \$3.4 billion, counting direct, indirect and induced golf-related spending. The higher prices commanded by houses in golfing developments amount to a premium of over \$2 billion.<sup>29</sup> However, water scarcity has already forced golf courses to reduce consumptive water use significantly, in part by restricting the area of turf. Climate change will make further restrictions inevitable. The lack of assured sustainable water supplies may even constrain future residential real estate and golf course resort developments. A more threatening effect is that golfing becomes a less appealing sport when temperatures rise to uncomfortably hot levels. Fewer rounds of golf are played and green fees fall in the hot spring and summer months. As the duration and intensity of the hot season increases, golf clubs revenues will suffer. The demand for membership will fall, hurting finances and making it difficult for older members to sell without taking losses.

## *Less Desirable Retirement Destination*

The broader impact of climate change will be a decline in Arizona's attractiveness as a retirement destination, which has always been based largely on its warm and dry climate. Retirees moving to Arizona make important economic contributions. In 2000, more than 20 percent of the population had been living in another state five years earlier. More than half the population was born in another state. Since retirees' incomes are not based on employment earnings, they bring a stable source of spending from outside the states. In 2000, 27 percent of the population was receiving social security benefits.<sup>30</sup> In Maricopa and Pima counties, subject to the widening heat island over urban and suburban population centers, life throughout much of the year will become increasingly uncomfortable and even unhealthy for seniors venturing outdoors.

## *Electricity Costs*

Electricity generating costs will also increase for several reasons. Low-cost hydroelectric production will fall with the reduced runoff from the Colorado River. Cooling water required for coal, gas, nuclear, and solar thermal generating plants will become scarcer and more costly. Non-conventional oil and gas production is extremely water-intensive and will face limits on availability. Because hotter weather boosts the photochemical reactions that create atmospheric smog and because urban areas are already out of compliance with existing national ozone standards, which may be tightened substantially, coal-fired power plants will have to install expensive controls on nitrogen oxide emissions, an ozone precursor in order to keep operating.

Climate change will also raise the summer peak in electricity demand and extend it through a longer air conditioning season, when it accounts for 70 percent of household electricity consumption. Meeting summer peak demand is nearly twice as costly as meeting off-peak requirements and considerably more costly than meeting the lower cool season peak demand. Under heat and drought conditions, peak summer generating costs can rise to 30-50 cents per kwh. Ironically, the main objection to policies limiting greenhouse gas emissions is that they will raise energy costs but in Arizona energy costs will also increase if such policies are not enacted and climate change goes unchecked.

## *Rising Health Care Costs*

Climate change will place additional stresses on Arizona's health care system, which is already constrained by rising costs.<sup>31</sup> Nearly one in five Arizonans are dependent on Arizona's Medicaid equivalent (AHCCCS) and an additional 19 percent have no health insurance at all.<sup>32</sup> Asthma attacks and allergies will be exacerbated by higher air pollution levels, including ozone, particulates from dust and wildfires, and higher pollen counts that start earlier in the spring. Higher ozone and particulate levels are reliably linked to increased mortality and morbidity. Among the elderly, stroke and heart attack increase with rising heat.<sup>33</sup> People with chronic heart or lung diseases are twice as likely to suffer heat stroke during a heat wave. Heart disease accounted for 24 percent of deaths in Arizona in 2005, while stroke caused five percent of deaths.<sup>34</sup>

In the past decade, a six percent increase in heat-related mortality was observed for each one degree F rise in the heat index and mortality also rose with the duration of the heat wave.<sup>35</sup> Between 1999 and 2009, the percentage of annual deaths occurring during the hot April to September months rose from 45 to 49 percent and heat-related dispatches of medical emergency teams climb sharply in the summer months, averaging more than nine a day in Phoenix alone.<sup>36</sup> Low-income households are much more vulnerable to these health effects because the high cost of electricity prevents them from using air conditioning more consistently.<sup>37</sup> Unless climate change is brought under control, Arizona's health costs will continue to rise rapidly and the state's citizens will suffer.

# THE WAY FORWARD

---

Given the impact that climate change will have on Arizona's economy and citizens, the state's leaders should support regional, national and international efforts to reduce greenhouse gas emissions along with measures specific to Arizona itself. Arizona is positioned to benefit substantially from a transition to clean renewable energy. Its solar potential is the finest in the country. Arizona could become a world leader in solar technology, generating tens of thousands of high-paying jobs and billions of dollars in export earnings beyond the state's borders. The National Renewable Energy Lab has estimated that Arizona has the potential for 2.5 gigawatts of concentrating solar electricity, able to generate 5.8 gigawatt hours of electricity, more than in any other state in the nation.<sup>38</sup> Little of this potential has yet been realized.

There are already national, state and utility level incentives in place to make use of this enormous potential, including Arizona's Renewable Portfolio Standard, which mandates a 15 percent share of renewable generation by 2025.<sup>39</sup> A recent study has produced a roadmap by which the state can stimulate solar investment and accelerate the pace of installation and simultaneously develop the supporting manufacturing and research capabilities.<sup>40</sup> A key stimulus to rapid development would be a regional or national policy that sets a price on carbon dioxide emissions through either an emission fee or a cap-and-trade regime applied to the electric utility sector. Such a policy would equalize the cost structure so that solar power could compete economically in intra-state and regional markets. With the cost disadvantage neutralized, solar's other advantages of stable operating costs and low pollution would lead to rapid deployment. It is in Arizona's economic interest to support national and regional policies of this kind.

## ENDNOTES

---

1. Western Resource Advocates, A Clean Energy Strategy for Arizona, Boulder, CO, 2007.
2. U.S. Global Change Research Program (USGCRP), 2009. Global Climate Change Impacts in the United States, T.R. Karl, J.M. Melillo, and T.C. Peterson, (eds.). Cambridge University Press.
3. Wittlinger, Sally. 2011, "The Urban Heat Island: Jeopardizing the Sustainability of Phoenix", Policy Points, Vol 3(3); July.
4. U.S. Climate Change Science Program (CCSP), 2008a. *Weather and Climate Extremes in a Changing Climate*. T.R. Karl, et al. (eds.). Department of Commerce, NOAA's National Climatic Data Center, Washington, D.C.
5. Wittlinger, supra note 3.
6. U.S Dept. of the Interior, Bureau of Reclamation, 2011, *Reclamation: Managing Water in the West*, Denver, CO.
7. *Rethinking the Future of the Colorado River: Draft Interim Report of the Colorado River Governance Initiative*, University of Colorado Law School, December, 2010.
8. Ellis, Andrew W., G.B. Goodrich, G.M. Garfin, 2009, "A Hydro-Climatic Index for Examining Patterns of Drought in the Colorado River Basin", International Journal of Climatology.
9. Brickey, Carolyn, Engel, K., Jacobs, K., Matter, J., Luecke, D.F., Miller, M.L., Overpeck, J., & Udall, B., 2010, "How to Take Climate Change into Account: A Guidance Document for Judges Adjudicating Water Disputes", Environmental Law Reporter, Vol 40(12); 11215-11228.
10. Western Resource Advocates, 2010, *Protecting the Lifeline of the West*, Boulder CO.
11. Backus, Gerge, T. Lowry, D. Warren, M. Ehlen, G. Klise, V. Loose, L. Malczynski, R. Reinert, K. Stamber, V. Tidwell, V. Vargas, & A. Zagonel, 2009, "Assessing the Near-Term Risk of Climate Uncertainty: Interdependencies Among the U.S. States," Sandia National Laboratory.
12. Eakin, Hallie & D. Liverman, 1997, "Drought and Ranching in Arizona: A Case of Vulnerability," University of Arizona, Tempe.
13. Vasquez, Leon, 2009,
14. Mortensen, J.R., 2004. *Economic impacts from agricultural production in Arizona*. University of Arizona, Tucson: Department of Agricultural and Resource Economics.
15. Ackerman, Frank, Stanton, E., 2011, "The Last Drop: Climate Change and the Southwest Water Crisis," Stockholm Environmental Institute, Somerville, MA.
16. Eden, Susanna et al., 2008, "Agricultural Water to Municipal Use: The Legal and Institutional Context for Voluntary Transfers in Arizona," Envirotech Publications.
17. Rex, Tom, 2007, "High-Tech Activities in Arizona: 2007 Update, Seidman Research Center," Arizona State University.
18. Decker, Jill & J.L. Crompton, 1993, "Attracting Footloose Companies: An Investigation of the Business Location Decision Process," Journal of Professional Services Marketing, Vol. 9(1).
19. Arizona Office of Tourism, 2010, *2010 Arizona Group Business Lodging Demand - % Change*.
20. Hoffman, Dennis & T. Hogan, 2007, "Sunbelt Growth and the Knowledge Economy," W.P. Carey School of Business, Arizona State University.
21. Arizona Dept. of Tourism, 2011, *Arizona Tourism in 2010*, Arizona Governor's Conference on Tourism, July 14, 2011.
22. Dean Runyan Associates, 2011, *Arizona Travel Impacts, 1998-2010*, Arizona Dept. of Tourism.
23. Owen, Gigi, 2008, "Tourism and Recreation, Southwest Climate Change Network," accessed at <http://www.southwestclimatchange.org/impacts/people/tourism-and-recreation>.
24. Owen, Gigi, 2008, "Tourism and Recreation, Southwest Climate Change Network," accessed at <http://www.southwestclimatchange.org/impacts/people/tourism-and-recreation>.
25. Morehouse B., G. Frisvold, R. Bark-Hodgins, "How Can Tourism Research Benefit from Multi-Disciplinary Assessments of Climate Change: Lessons from the U.S. Southwest" Matzarakis, A., C.R. de Freitas, D. Scott, 2007. Developments in Tourism Climatology
26. [http://www.urbanclimate.net/cctr/ws3/report/dTcl\\_2007\\_morehouseetal.pdf](http://www.urbanclimate.net/cctr/ws3/report/dTcl_2007_morehouseetal.pdf).
27. U.S. Census Bureau, "Arizona 2000: Census 2000 Profile," Issued August 2002, [www.census.gov/prod/2002pubs/c2kprof00-az.pdf](http://www.census.gov/prod/2002pubs/c2kprof00-az.pdf).
28. Neelam C. Poudyala, Donald G. Hodges, and H. Ken Cordell, "The Role of Natural Resource Amenities in Attracting Retirees: Implications for Economic Growth Policy," *Ecological Economics* 68 (2008): 240-48.
29. Schmitz, Troy G., 2006, "Economic Impacts and Environmental Aspects of the Arizona Golf Industry," Morrison School of AgriBusiness and Resource Management.
30. U.S. Census Bureau, *Arizona 2000: Census 2000 Profile*, Issued August 2002, [www.census.gov/prod/2002pubs/c2kprof00-az.pdf](http://www.census.gov/prod/2002pubs/c2kprof00-az.pdf).
31. Anderson, Bell, 2009, "Weather-Related Mortality: How Heat, Cold and Heat Waves Affect Mortality in the US," *Epidemiology*, Vol 20(2).
32. Kaiser Family Foundation, *Arizona – Kaiser State Health Facts*, <http://www.statehealthfacts.org/mfs.jsp?rgn=4&rgn=1>.
33. Glua, Alessandra, M. Abbas, N. Murgia, & F. Corea, 2010, "Climate and Stroke: A Controversial Association", International Journal of Biometeorology, Vol54(1-3).
34. Centers for Disease Control, "Arizona: Burden of Chronic Disease," 2008, [www.cdc.gov/chronicdisease/states/pdf/arizona.pdf](http://www.cdc.gov/chronicdisease/states/pdf/arizona.pdf).
35. Yip, Fuyuen et al., 2008, "The Impact of Excess Heat Events in Maricopa County, Arizona: 2000-2005", International Journal of Biometeorology, Vol 52(8).
36. Golden, Jay, D. Hartz, A. Brazel, G. Lubert & P. Phelan, 2008, "A biometeorology Study of Climate and Heat-Related Morbidity in Phoenix from 2000 to 2006," International Journal of Biometeorology Vol 52:471-480.
37. Chow, Winston, W-C Chuang & P. Gober, 2011, "Vulnerability to Extreme Heat in Metropolitan Phoenix: Spatial, Temporal and Demographic Dimensions," The Professional Geographer. Vol 63 (1-3).
38. Department of Energy, *Report to Congress: Assessment of Potential Impact of Concentrating Solar Power for Electricity Generation*, February 2007 [www.nrel.gov/csp/troughnet/pdfs/41233.pdf](http://www.nrel.gov/csp/troughnet/pdfs/41233.pdf).
39. Department of Energy, *States with Renewable Portfolio Standards*, [http://apps1.eere.energy.gov/states/maps/renewable\\_portfolio\\_states.cfm](http://apps1.eere.energy.gov/states/maps/renewable_portfolio_states.cfm).
40. Navigant Consulting, Inc., 2007, *Arizona Solar Electric Roadmap Study*, Arizona Dept. of Commerce, Phoenix.

## **ABOUT DĒMOS**

Dēmos is a non-partisan public policy research and advocacy organization founded in 2000. Headquartered in New York City, Dēmos works with policymakers around the country in pursuit of four overarching goals—a more equitable economy with widely shared prosperity and opportunity; a vibrant and inclusive democracy with high levels of voting and civic engagement; an empowered public sector that works for the common good; and responsible U.S. engagement in an interdependent world.

## **ABOUT THE AUTHOR**

Robert Repetto is author of the 2011 book “America’s Climate Problem: The Way Forward.” He is a Senior Fellow in the United Nations Foundation’s climate and energy program. Previously, he was Professor in the Practice of Economics & Sustainable Development at the Yale University School of Forestry and Environmental Studies. Before that, he was a Senior Fellow of the Tim Wirth Chair at the University of Colorado and an advisor to Stratus Environmental Consulting, in Boulder, Colorado. He was a Pew Fellow at the Marine Policy Center of the Woods Hole Oceanographic Institute, and for fifteen years was vice president of the World Resources Institute in Washington, DC. Earlier in his career, he was an Associate Professor in economics and public health at Harvard University, and before that an advisor on economic planning in Indonesia, Bangladesh and India.

# Dēmos

### **DĒMOS**

220 Fifth Avenue, 2nd Floor  
New York, New York 10001  
Phone: (212) 633-1405  
Fax: (212) 633-2015  
[www.demos.org](http://www.demos.org)

### **DĒMOS MEDIA**

Lauren Strayer  
Associate Director of Communications  
[lstrayer@demos.org](mailto:lstrayer@demos.org)  
(212) 389-1413