



## Climate Change, Water, and Risk: Current Water Demands Are Not Sustainable

Climate change will have a significant impact on the sustainability of water supplies in the coming decades. A new analysis, performed by consulting firm Tetra Tech for the Natural Resources Defense Council (NRDC), examined the effects of global warming on water supply and demand in the contiguous United States. The study found that more than 1,100 counties—one-third of all counties in the lower 48—will face higher risks of water shortages by mid-century as the result of global warming. More than 400 of these counties will face extremely high risks of water shortages.

The analysis by Tetra Tech—a highly-respected consulting firm used by the federal government, electric utility and other industries, finds that some states have an extreme or high risk to water sustainability, or are likely to see limitations on water availability as demand exceeds supply by 2050. These areas include parts of Arizona, Arkansas, California, Colorado, Florida, Idaho, Kansas, Mississippi, Montana, Nebraska, Nevada, New Mexico, Oklahoma, and Texas. In particular, in the Great Plains and Southwest United States, water sustainability is at extreme risk.

The report concludes that climate change will greatly increase the risk that water supplies will not be able to keep pace with withdrawals in

many areas of the United States. This conclusion has significant implications for future water management and climate change adaptation planning efforts. The pressure on public officials and water users, such as farmers, to manage demand and supply will be greatest in the areas facing these higher risks.

To be clear, the report was not intended to predict where water shortages will occur, but rather where they are more likely to occur. The goal of this analysis was to estimate future renewable water supply compared with water demand, assuming a business-as-usual scenario of growth in demand for electricity production and domestic use, both largely driven by population growth, with other demands remaining at their

For more information, please contact

**Theo Spencer** at  
212-727-4538  
tspencer@nrdc.org or

**Peter Altman** at  
202-289-2435  
paltman@nrdc.org



<http://www.nrdc.org/global-Warming/watersustainability/>

July 2010

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### Water Shortages Can Have Serious Impacts on Agriculture



The changes in the climate, precipitation and water availability could have implications for agricultural production including changes in crop yield, variations in plant tolerance, and prevalence of crop disease, weeds, and insect pests.<sup>1</sup> While detailed modeling of climate change impacts on crop production was beyond the scope of the Tetra Tech analysis, the potential scale of disruption can be appreciated simply based on the value of the top crops produced in the counties where

the risk of future water shortages rises. In 2007, the value of the top three crops produced in the at-risk counties identified in the Tetra Tech report exceeded \$105 billion. The Agricultural Carbon Markets Board has produced a set of fact sheets exploring the potential agricultural impacts more fully. <http://www.agcarbonmarkets.com/AboutUs.htm>

present levels. In addition to providing the most current analysis of these impacts, this report is also the most comprehensive quantitative assessment of water supply and demand under future climate scenarios performed to date.

### Evaluating Sustainability of Projected Water Demands in 2050 under Climate Change Scenarios

Tetra Tech performed an analysis for NRDC which combined water demand projections based on current growth trends with renewable water supply projections based on 16 leading climate models.

### New Water Sustainability Index Shows Projected Impacts of Climate Change

The report develops a new water supply sustainability index. The risk to water sustainability is based on the following criteria:

- 1) Projected water demand as a share of available precipitation;<sup>2</sup>
- 2) Groundwater use as a share of projected available precipitation;<sup>3</sup>
- 3) Susceptibility to drought;<sup>4</sup>
- 4) Projected increase in freshwater withdrawals;<sup>5</sup> and
- 5) Projected increase in summer water deficit.<sup>6</sup>

The risk to water sustainability for counties meeting two of the criteria are classified as “moderate,” while those meeting three of the criteria are classified as “high,” and those meeting four or more are classified as “extreme.” Counties meeting less than two criteria are considered to have low risk to water sustainability.<sup>7</sup>

In particular, counties at extreme risk for water shortages are most prevalent in the Great Plains and Southwest U.S., however none of the 48 states analyzed are unaffected. Counties throughout the Midwest and South—particularly Florida—are found to face

moderate to extremely high risk of water shortages. A relatively low number of counties in the Northeast and the Northwest are at risk.

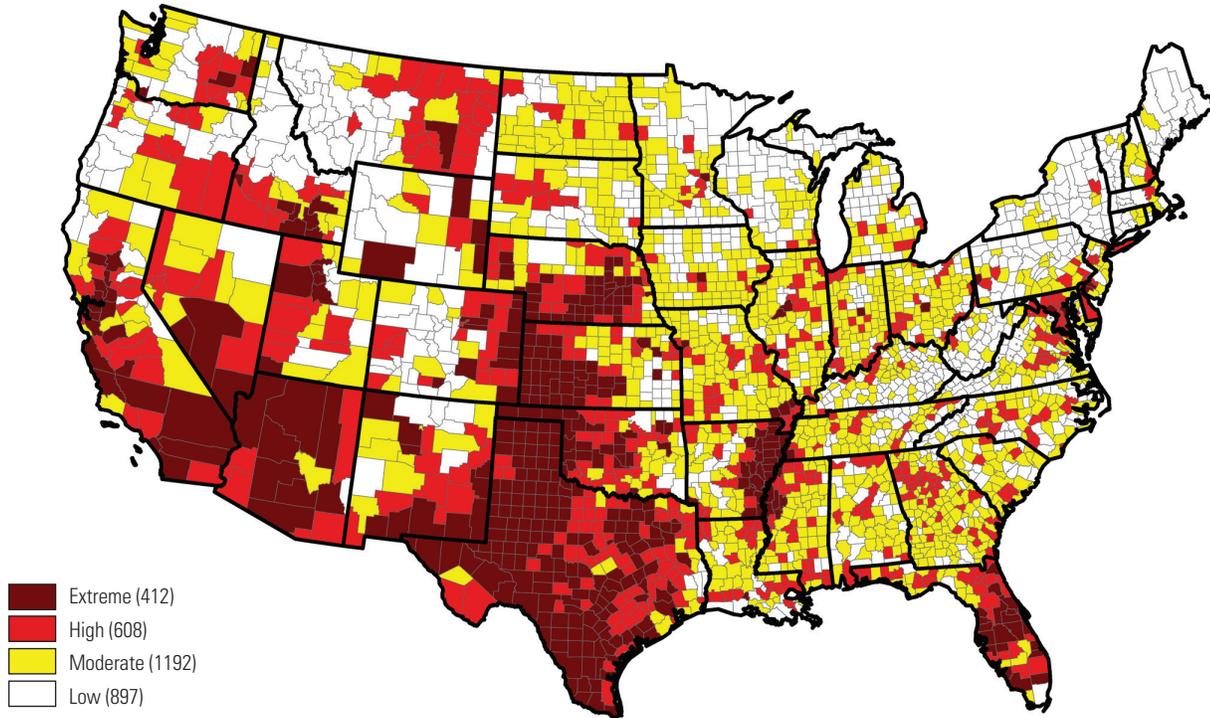
**Changes in Precipitation** Two of the principal reasons for the projected water constraints are shifts in precipitation and potential evapotranspiration (PET). Evapotranspiration is the sum of evaporative loss of water from the ground surface and transpiration losses through vegetation. PET is a calculated metric used to represent evapotranspirative losses under idealized conditions, where a full water supply is available for evapotranspiration. Together, changes in precipitation and potential evapotranspiration have significant effects on *available precipitation*, estimated as water falling either as rain or snow that would not be consumed by the potential evapotranspiration. Climate models project decreases in precipitation in many regions of the U.S., including areas that may currently be described as water short. Moreover, based on their projected temperature increases, potential evapotranspiration is also computed to increase. Generally, anticipated increases in PET range from 4 to 5 inches per year. Southern areas, however, may anticipate PET increases of as much as 5 to 6 inches per year.

The combination of decreased precipitation in some regions and increased PET in most regions indicates that many areas will face decreases in overall available precipitation, affecting their water supplies. Projected available precipitation will vary greatly depending on geographic region. It is expected to average less than 2 inches per year for many areas in the West, but more than 15 inches in the Northeast, Northwest, and South Atlantic regions. Projected decreases in available precipitation from historical records will also vary: most areas will experience only slight decreases—drops of less than 2.5 inches per year between 2005 and 2050—with some regions, such as east Texas, the Lower Mississippi Basin, California Central Valley, and the Southeastern U.S., experiencing decreases of more than 5 inches per year by 2050. (For maps detailing this individual impact, please see the full Tetra Tech report at [http://rd.tetratech.com/climatechange/projects/nrdc\\_climate.asp](http://rd.tetratech.com/climatechange/projects/nrdc_climate.asp))

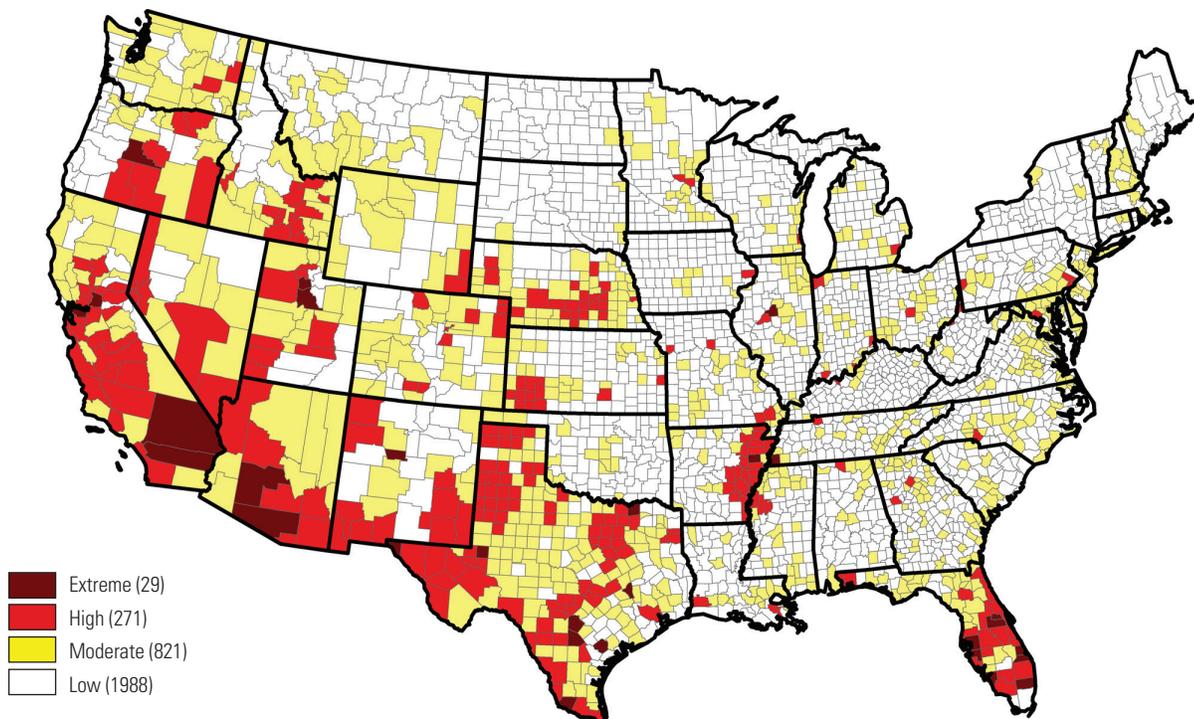
**Changes in Water Withdrawals** Increases in water withdrawals, from groundwater, lakes, rivers, streams, and manmade structures like dams, are also a primary reason for increasing vulnerability. The three categories of water use with the greatest demand are agricultural use, power plant cooling, and domestic use. Under the business-as-usual scenario assumed in this analysis, total water demand is projected to increase by as much as 12.3 percent between 2000 and 2050. Demand for municipal use and electric cooling is projected to grow along with the U.S. population, while use for irrigation, livestock, aquaculture and mining is assumed to remain at the same levels as 2005, as withdrawals in those sectors have remained relatively flat in the last two decades.

The analysis found that total freshwater withdrawals in 2030 and 2050 are anticipated to be significant in the major agricultural and urban areas throughout the nation. For this analysis, the volumes of freshwater withdrawal at the county level were normalized to the county area and represented in inches per

### Water Supply Sustainability Index (2050)



### Water Supply Sustainability Index (2050) No Climate Change Effects



### Methodology

For the purpose of this analysis, we project future water demand and supply. Demand is projected based upon a business-as-usual scenario of continued population growth and associated energy and cooling water needs. Supply—or available precipitation—is estimated from current and future temperature and precipitation scenarios, obtained from an ensemble of global climate models. The analysis then compares future demand to future supply to provide an initial assessment of water resources sustainability across the nation—resolved at the county level, the best resolution for water use information—and helps identify areas most likely to be adversely impacted by increasing water demand and climate change. For a much more detailed description of methodology, please go to [http://rd.tetrattech.com/climatechange/projects/nrdc\\_climate.asp](http://rd.tetrattech.com/climatechange/projects/nrdc_climate.asp).

year, such that they could be compared with estimates of available precipitation. Total freshwater withdrawals in 2030 and 2050 will be between 0.2 to 0.5 inches per year, with some areas in the West showing water demand of 1 to 5 inches. Some areas in California, Texas and the Lower Mississippi River basin show projected water demand of more than 10 inches per year. These withdrawals will differ significantly from 2005 levels, with anticipated decreases in much of the Great Plains and increases in some areas in the South, Southeast, and Western regions of the U.S. Overall, water demand in most regions is projected to increase 0.1 inches per year, with a few areas showing growth in demand of up to 3 inches per year. Expressed as a percentage, water withdrawal will grow by 25 percent in many areas of the U.S. including the arid Arizona/New Mexico area, the populated areas in the South Atlantic region, Florida, the Mississippi River basin, and Washington DC and surrounding regions.

Estimated water withdrawal as a percentage of available precipitation is generally less than 5 percent for the majority of the Eastern United States, and less than 30 percent for the majority of the Western United States. But in some arid regions (such as Texas, the Southwest, and California) and agricultural areas, water withdrawal is greater than 100 percent of the available precipitation. In other words, in many places, water is already used in quantities that exceed supply (see detailed maps at [http://rd.tetrattech.com/climatechange/projects/nrdc\\_climate.asp](http://rd.tetrattech.com/climatechange/projects/nrdc_climate.asp)). This situation may be possible if one region pipes water from other regions or takes more water from underground aquifers that is “recharged” through rain, snowmelt and other sources.

But as this analysis highlights, the impacts of climate change will greatly increase the number of areas where renewable water supply will be lower than withdrawal, therefore increasing the number of areas vulnerable to future water shortages. This vulnerability may be most pronounced in regions like Texas and the Great Plains, where changes in precipitation and increases in

temperature will mean that projected evapotranspiration will exceed rain and snowfall (precipitation). In these regions there will not be any available precipitation at *all*.

### The Future of Water Management for Sustainability

This analysis shows that climate change will have significant impacts on water supplies throughout the country in the coming decades, with over 1,100 counties facing greater risks of water shortages due to the effects of climate change.

While water management and climate change adaptation plans will be essential to lessen the impacts, they cannot be expected to counter the effects of a warming climate. One reason is that the changes may simply outrun the potential for alternatives such as modifying withdrawals, increasing water use efficiency, increased water recycling, enhancing groundwater recharge, rainwater harvesting and inter-basin or inter-county transfers to make up for water deficits. The widespread nature of the risk of water shortages may also limit the effectiveness of local solutions—such as acquiring more water from a neighboring county or basin—since many other localities will be trying to get control of the same resource.<sup>8</sup>

Further, the pressure on water supplies will not cease in 2050. If climate warming continues to increase, we can expect the risks of water shortages to increase with it. There is no way to truly manage the risks exposed by this report other than taking the steps necessary to slow down and reverse the warming trend. Doing so requires Congressional action and global leadership.

<sup>1</sup> Based on information from USDA and the US Global Change Research Program. (2009). Climate Change Impacts by Sector: Agriculture. Retrieved from <http://globalchange.gov/publications/reports/scientific-assessments/us-impacts/climate-change-impacts-by-sector/agriculture>.

<sup>2</sup> Extent of development of available renewable water: greater than 25 percent of available precipitation is used (calculated based on projected water demand and available precipitation in 2050). The larger the fraction of available precipitation that is used to meet human needs, the greater the risk to supply when this quantity changes.

<sup>3</sup> Sustainable groundwater use: ratio of groundwater withdrawal to available precipitation is greater than 25% (based on current groundwater withdrawal). Greater withdrawals may be indicative of unsustainable use of aquifers.

<sup>4</sup> Susceptibility to drought: Summer deficit is greater than 10 inches, and this water requirement must be met through stored surface water, groundwater withdrawals, or transfers from other basins. In estimating irrigation demand in June, July and August, it was assumed that irrigation needs are proportional to monthly deficit in available precipitation (P–PET). Summer deficit is defined as the amount by which withdrawal exceeds available precipitation in June, July, and August, typically the three warmest months of the year that correspond to increased municipal, thermoelectric cooling, and irrigation demand.

<sup>5</sup> Growth in water demand: The increase of total freshwater withdrawal between 2000 and 2050 is more than 20 percent. Growth in water demand is driven largely by population growth and the need for new thermoelectric generation. Growth in population is based on the business as usual scenario. This scenario uses population growth at the county level between 2000 and 2008 to project county level populations in 2050. The electricity growth is the projection made by the Department of Energy to 2030, extrapolated to 2050.

<sup>6</sup> Summer deficit increases more than 1 inch between 2005 and 2050.

<sup>7</sup> Two of the principal reasons for the projected water constraints are shifts in precipitation and potential evapotranspiration (PET). Evapotranspiration is the sum of evaporative loss of water from the ground surface and transpiration losses through vegetation. PET is a calculated metric used to represent evapotranspirative losses under idealized conditions, where a full water supply is available for evapotranspiration. Together, changes in precipitation and potential evapotranspiration have significant effects on *available precipitation*, estimated as water falling either as rain or snow that would not be consumed by the potential evapotranspiration.

<sup>8</sup> Sources of data: This report uses the most up-to-date comprehensive data on water use in the U.S., released in December 2009. Collected every 5 years by the U.S. Geological Survey (USGS) as part of the National Water Use Information Program, these surveys were first conducted in 1950, and the most recent survey available is for 2005. The 2005-2050 timeframe was chosen for this analysis because it is within the time horizon of most major infrastructure planning activities, especially infrastructure related to water resources and energy production.