Testimony of
William deBuys, Ph.D.
before the
Senate Committee on
Energy and Natural Resources

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Chairman Bingaman, thank you for the opportunity to appear before you to examine the current and future impacts of climate change on the Intermountain West, focusing on drought, wildfire frequency and severity, and ecosystems. My name is William deBuys. I am a historian and have published seven books dealing with the land and people of the Southwest. For the past four and a half years I have made a particular study of the effects of climate change in the region, which resulted in a book published by Oxford University Press last year entitled *A Great Aridness: Climate Change and the Future of the American Southwest.*

My work on climate change focused on the Southwest, defined broadly. This hearing addresses the "Intermountain West" which, by any definition, overlaps the Southwest extensively, but the experience of some northern portions of the Intermountain West may differ from the rest of the region, if, as expected, "wet places get wetter and dry places drier" in the changed climate of the future.

To speak specifically of the Southwest, one scientist whom I interviewed summarized its environmental future in five words: "drought, dust, and dead trees."
[DROUGHT]

Let me begin with drought.

Certainly the current drought has caught people's attention: thousands of new high temperature records have been set; by mid-summer a larger portion of the country was in a state of drought than at any time since the 1950s; and more counties have been declared agricultural disaster areas than ever before.

Of course, there have always been droughts. What is different now is that our droughts are hotter. Drs. David Breshears, Craig Allen, and colleagues have shown that the drought of the early 2000s was 1º to 1.5ºC hotter than the drought of the 1950s. Because greater heat means greater evaporation, our droughts have become effectively more arid than comparable droughts of the past, placing greater heat and water stress on vegetation of all kinds, from agricultural crops to forest trees.

Even so, “drought” may be a misnomer. Drought is exceptional. We don’t say that the Sahara Desert is experiencing drought: the Sahara is dry by nature, not by exception. A strong body of research suggests that the climate of the Southwest is moving to a new base state similar to the drought conditions of the 1950s and ‘30s. Droughts and wet periods will still occur, but they will be superimposed on this new base state. In time, what we currently conceive as drought will be understood as the new normal.

The implications for water resources are severe. A widely cited study by a team led by Chris Milly of the Geophysical Fluid Dynamics Laboratory in Princeton predicted that the Southwest will experience declines of surface streamflow on the order of 10-30% by mid-century. (Surface streamflow is the yield of rivers and streams; it is the water, apart from groundwater, that is available for human use.) Given that southwestern water resources are already fully or even over-allocated, such an extreme diminution of supply will undermine the well-being of the region in profound ways.

Predictions like those of the streamflow study are based on climate modeling, which is as sophisticated as any science being conducted in the world today. Although the science of climate modeling is difficult for the average citizen to understand, the predictions that emanate from it appear to be holding up well, except in one important respect: the changes are happening faster than predicted.

For example, in 2007 the Intergovernmental Panel on Climate Change predicted our region would warm approximately 4°C by the end of this century. We appear to be already about 0.8°C along that journey, almost a quarter of the way, but seven-eighths of the century still lie before us. Clearly, if temperatures increase at a linear rate, or faster, we are on track to exceed the 4°C target.

These temperatures, however, are *means*. There is reason to expect that the heated, more energetic climate of the future will produce *extreme* temperatures that are proportionately even larger, and the extremes will shape our world even more profoundly than the means, triggering yet more forest fires, water shortages, crop failures, and even waves of human mortality. Bear in mind that approximately 50,000 human deaths were attributed to the European heat wave of 2003.

[DUST]

A word about dust. Higher temperatures and increased water stress will trigger the exposure of more soil to the air, as vegetation dies back, farmlands are fallowed, and forests and woodlands are consumed by fire. Combined with the fierce winds of a more energetic atmosphere, and with inevitably high levels of soil-disturbing human activity, this is a recipe for dust storms. In recent years Phoenix has suffered periodic dust storms of unprecedented magnitude. Lacking a name for them, Phoenix has borrowed a word from Arabic, and now *haboob* has entered the regional lexicon.

Atmospheric dust does more than make life uncomfortable for residents of the region. Deposited on mountain snowpack, dust lowers albedo (reflectance), promotes the absorption of heat from sunlight, and significantly accelerates the melting of accumulated snow, lowering natural storage and increasing the vulnerability of downstream farms and communities to shortages.

[DEAD TREES]

The fearsome increase in the destructiveness of forest fires throughout the region is well known. The drought of the early 2000s bred fires that set records in Arizona, New Mexico, and Colorado for both size and damage. The past two years have seen almost all of those records broken by still larger and more destructive fires. A century of misguided management that included the suppression of all fire contributes prodigiously to the fire danger we face today, but climate is equally influential: we know that fire season is now at least two and a half months longer than it was thirty years ago and fire behavior, driven by high winds and higher temperatures, is becoming ever more extreme.

A comparison of the Cerro Grande fire of 2000 and the Las Conchas fire of 2011, which ignited in adjacent, nearly identical areas in the Jemez Mountains, bears consideration. The Cerro Grande fire burned approximately 43,000 acres over the course of two weeks. Most observers thought its like would not be seen soon again, at least not in the same location, but last year the Las Conchas fire burned 43,000 acres, equaling the achievement of Cerro Grande, *in its first fourteen hours*. Ultimately more than 150,000 acres were consumed.

Fire is not the only threat to our forests. Insect outbreaks, like the bark beetle irruption of the early 2000s in Arizona and New Mexico that killed pines across an area twice the size of Delaware, will doubtless become more frequent, for the simple reason that warmer temperatures favor increased insect reproduction.

We can also expect heat and moisture stress, alone, without the intervention of fire or insects, to kill large numbers of trees, as they did last year, when between 2 and 10 percent of all the trees in Texas succumbed.

It is important to note that western forests account for 20 to 40 percent of all carbon sequestration in the United States. If, as now seems likely under the assault of climate change, we are to lose the greater part of our forests to fire, insects, and heat death, our forest lands will at some point become net emitters of atmospheric carbon, instead of storehouses, thereby intensifying buildup of greenhouse gases. Similarly, because drought inhibits the ability of plants of all kinds to conduct photosynthesis and absorb carbon dioxide, prolonged drought will also contribute to warming. These kinds of feedbacks (like the better known release of methane from thawing permafrost) have the potential to plunge us ever more rapidly into an overheated, much altered future.

[ATTRIBUTION STUDIES]

How sure can we be that these changes are the result of anthropogenic climate change and not simply manifestations of natural variability?

Actually, we are progressively achieving a very high degree of certainty.

Climate science has passed a threshold. The modeling studies on which it long depended did not permit the attribution of climate change as a cause of specific events. A scientist, asked about a certain drought or rash of forest fires, might say, “If climate change is occurring, this is the kind of event our models tell us to expect,” but he or she could not say, “Climate change caused this.”

Lately this limitation has diminished. A new sub-set of climate investigations, termed “attribution studies,” is emerging, which uses statistical analysis to determine the probable occurrence of specific weather events, with and without the contributing influence of climate change. The Bulletin of the American Meteorological Society recently published a small collection of such studies, including one asserting that climate change made last year’s drought and heat wave in Texas twenty times more likely.

A team led by James Hansen of NASA’s Goddard Institute for Space Studies goes further. According to their analysis, the probability that the 2011 heat wave in Texas or the 2010 heat wave in Russia would occur without the influence of climate change was less than 0.2 percent. One way of interpreting this figure is to say that neither event should have occurred more often than once in five centuries. The team further found that similar, highly unlikely events now cover, not 0.2 percent of Earth's surface, as was the case during the reference period of 1951-1980, but approximately 10 percent. This extreme anomaly, they say, can only be explained by climate change.

[ACTION RECOMMENDATIONS]

Given what we know, what should we do?

First and foremost, we must act to limit the magnitude of the changes still ahead. This means moving to limit and reduce greenhouse gas emissions with the utmost urgency. To shirk this responsibility is to steal the atmospheric resources of future generations and to assure suffering and instability throughout the world. It is that simple.

Second, we must adapt to the changes that cannot be prevented. This means establishing and living within drought-resilient water budgets, community by community, across the region. Presently the Lower Basin of the Colorado River, chiefly the states of Arizona and California, operates at an annual deficit of 18 percent. This is to say that the Lower Basin over-drafts its account by withdrawing from Lake Mead 1.2 to 1.4 million acre-feet more than its allocation of 7.5 million acre-feet. Such behavior is unsustainable under any circumstances. In an era of climate change and declining river flow, it is irrational and dangerous.

Adaptation will require water conservation that is both extensive and intensive, but (this is the hard part) the water saved by conservation must be managed in a way that contributes to drought resilience, and does not merely fuel continued land development and population growth, with consequent hardening of demand, as is typically the case.

In addition to crafting realistic water budgets, every interrelated group of water-users should develop enforceable shortage-sharing agreements and, where applicable, prepare for transfers of water from agriculture to municipalities in advance of the inevitable emergencies.

Where our forests are concerned, we must find ways to reverse the penetration of residential housing into landscapes vulnerable to fire, and we must continue fuel-reduction efforts, especially at the wildland-urban interface and in areas of high biodiversity, with redoubled energy.

Many other actions might be recommended--in all areas of policy and management from agriculture to wildlife--but none is more important than the purpose implicit in this hearing, which is to build public understanding of the seriousness of the challenges we face. As a society, we must first agree on the facts of climate change in order to achieve consensus on how to respond to them. These facts are to be seen all around us, if only we open our eyes. No set of facts will be more determinative of the future of our land and society, and no set of facts calls on us more emphatically for informed, deliberate, and immediate action.

I thank the chairman and his committee for the opportunity to discuss these matters.

[GRAPHIC 1]
Graphics 1 and 2 are taken from James Hansen, Makiko Sato, and Reto Ruedy, "Perceptions of Climate Change: the New Climate Dice."
http://fractual.co.za/Documents/Hansen_20120105.pdf.
This material, which became available on the internet in the autumn of 2011, has since been incorporated in Hansen, et al., "Perception of Climate Change," Proceedings of the National Academy of Sciences, August 6, 2012, doi: 10.1073/pnas.1205276109, http://www.pnas.org/content/early/2012/07/30/1205276109.abstract

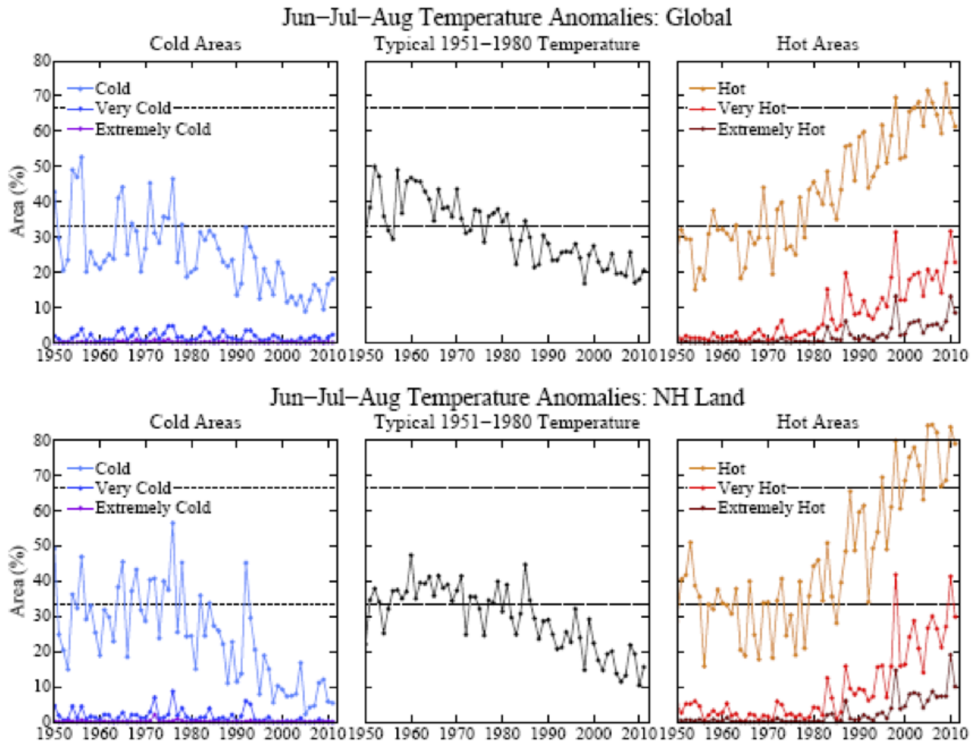

Fig. 5. Area of the world covered by temperature anomalies in the categories defined as hot (> 0.43σ), very hot (> 2σ), and extremely hot (> 3σ), with analogous divisions for cold anomalies. These anomalies are relative to 1951-1980 climatology with σ from the detrended 1981-2010 data, but results are similar for the alternative choices for standard deviation.

Amplification:

"A normal distribution of variability has 68 percent of the anomalies falling within one standard deviation of the mean value. The tails of the normal distribution … decrease quite rapidly so there is only a 2.3% chance of the temperature exceeding +2σ, where σ is the standard deviation, and a 2.3% chance of being colder than -2σ. The chance of exceeding +3σ is only 0.13% for a normal distribution of variability, with the same chance of a negative anomaly exceeding -3σ."

From James Hansen's August 3 op-ed, "Climate Change is Here--and Worse than We Thought," in the Washington Post:

Extremely hot weather events [>+3σ] "used to be exceedingly rare. Extremely hot temperatures covered about 0.1 to 0.2 percent of the globe in the base period of our study, from 1951 to 1980. In the last three decades, while the average temperature has slowly risen, the extremes have soared and now cover about 10 percent of the globe."

[GRAPHIC 2]
This graphic provides a spatial depiction of the data presented in Graphic 1.

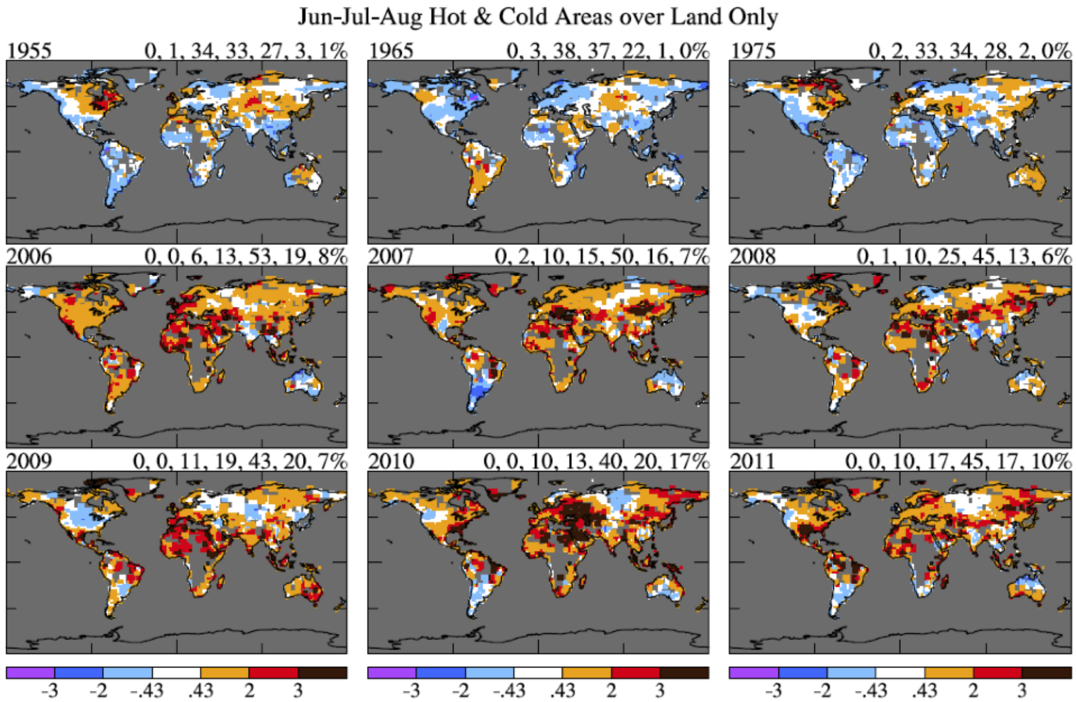

Fig. 6. Jun-Jul-Aug surface temperature anomalies over land in 1955, 1965, 1975 and 2003-2011 relative to 1951-1980 mean temperature in units of the local standard deviation of temperature. The numbers above each map are the percent of surface area covered by each of the categories in the color bar.

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