**STATEMENT OF**
**THOMAS W. SWETNAM**
**PROFESSOR OF DENDROCHRONOLOGY & WATERSHED MANAGEMENT**
**DIRECTOR OF THE LABORATORY OF TREE-RING RESEARCH, UNIVERSITY OF ARIZONA**

**BEFORE THE**
**UNITED STATES HOUSE OF REPRESENTATIVES**
**COMMITTEE ON NATURAL RESOURCES**
**SUBCOMMITTEE ON**
**NATIONAL PARKS, FORESTS, AND PUBLIC LANDS**
**APRIL 7, 2009**

**CONCERNING**

**THE IMPACTS OF CLIMATE CHANGE ON AMERICA'S NATIONAL PARKS**

Mr. Chairman and members of the Subcommittee, thank you for inviting me today to discuss the importance of America's National Parks in understanding climate change impacts, and the need to mitigate and adapt to these coming impacts on the "crown jewels" of our public lands system.

I am a scientist with more than 30 years of research and applications experience in National Parks, primarily in the western United States. My expertise is in the areas of forest ecosystems, fire history, insect outbreaks, and the effects of climate change. Although my research has basic aspects, it has largely focused on applications to management, such as the use of fire and forest history knowledge to guide ecological restoration of forest ecosystems. This work has been particularly useful in places like the giant sequoia groves in Sequoia, Kings Canyon and Yosemite National Parks in California and the ponderosa pine forests of the Rincon Mountain Wilderness in Saguaro National Park, near Tucson. In recent years, my research has focused primarily on climate change and its past and current effects on fires and insect outbreaks.

The main points of my statement are as follows:

- The coming climate-caused changes require landscape to regional-scale perspectives and management. These broad scales require much more effective collaboration among federal, state and private entities than has occurred before. Management challenges also require increased translational science capacity and partnerships between universities and federal agencies. I will briefly describe a landscape-scale collaboration in southern Arizona to illustrate some of the issues, needs, and potential.

- The National Parks are critically important areas for tracking and understanding climate change impacts on ecosystems and watersheds. The Parks include many of the least human-altered ecosystems on the planet. As such they provide a unique and valuable perspective on climate-caused changes that have occurred in the past and are occurring now. Moreover, because the Parks contain our most cherished biota and landscapes, the climate change effects on these living things and places are naturally of great concern to the American people.

- To carry out the needed science support for mitigation of and adaptation to climate change impacts in the National Parks, federal agencies and their science collaborators in the universities need to build basic science and translational science capacity. A very effective mechanism of science support within and for the National Parks is “place-based” science. I will describe examples of this model, and I recommend that it be broadly replicated and institutionally strengthened. Additional science capacity building is needed that will involve other approaches, including the National Park Service’s Monitoring Networks and Research Learning Centers, and coordination with the National Oceanic and Atmospheric Administration’s Regional Integrated Science and Assessment centers (RISAs).

**Landscape-Scale Management – Collaboration and Science Needed to Support It**

A common observation, as reflected in statements by witnesses who have testified earlier this year to this committee, is the need for better coordination and cooperation among the multiple federal and state agencies involved in managing our ecosystems and watersheds. This need arises because the impacts of climate change are broad scale; they do not follow administrative boundaries, and neither will effective mitigation and adaptation solutions. As temperatures continue to rise and droughts of greater severity occur in coming years and decades we may be challenged to assist re-location of plants and animals via migration corridors or direct transplantation to more suitable habitats.

Most of the necessary science, mapping, planning, and prioritization for adaptation is yet to be done. An approach that will be highly valuable is the development of climate change scenarios at the scale of bio-regions that can be used for planning and prioritizing in coordination among multiple agencies. I am encouraged to know that the National Park Service (NPS) is developing a strategic framework for action that has adaptation as a major component (Leigh Welling, NPS Climate Change Coordinator, personal communication). As part of this framework, NPS has already begun to develop a scenario-based approach for planning at the Park level. The first prototype workshop took place in Joshua Tree National Park in November 2007 and involved scientists, natural and cultural resource managers, and educators. Several other scenario workshops are being planned for 2009 and 2010, involving Assateague Island in the northeast, Wind Cave in the northern Prairies, and Yellowstone and Glacier National Parks in the Rocky Mountains. These efforts need to become more widespread and coordinated.

As we work to adapt or restore ecosystems to conditions that are more resilient to climate changes and related disturbances – such as wildfires and insect outbreaks – we will need to implement treatments (e.g., mechanical thinning of forests, eradication/control of invasive species, and prescribed fire) at landscape scales. By “landscape scales”, I mean entire watersheds and mountain ranges, typically extending over tens to hundreds of thousands of acres, i.e., the scales of National Parks, or networks of Parks. Examples from the landscapes where I live and work in southern Arizona (including Congressman Grijalva's district) serve to illustrate some of the issues and needs here:

The mountains and desert basins of southern Arizona are often referred to as the "Sky Islands". The mountains rise as "islands" of oak woodlands and conifer forests above a sea of grasslands and cactus-shrub deserts. Ecosystems that span these elevational gradients range from the low Sonoran deserts to the high montane forests. Most of these ecosystems are increasingly at risk of irreversible damage from a climate change-related disturbance: unnatural and uncharacteristic wildfire.

In the lowlands, the chief culprit is buffelgrass (*Pennisetum cilare*), an invasive species introduced into the Sonoran desert originally as forage for livestock. Buffelgrass has now spread widely throughout the Tucson Basin, including into Saguaro National Park. Buffelgrass is extremely flammable. The spreading clumps of buffelgrass are forming continuous patches hundreds of acres in size in some places, and they are carrying extraordinarily hot, running fires through the Sonoran desert. These fires kill most of the cactus and other native species because they are not adapted to such fires, which have never occurred with this severity or extent in these ecosystems before. Buffelgrass, in contrast, is highly adapted to fire and it re-sprouts prolifically.

This problem of widespread invasive species promoting unnatural wildfires is increasingly common in the American deserts and our National Parks. In addition to buffelgrass invasion in the Sonoran Desert, red brome, cheat grass and other invasive species are spreading prolifically in the Southwest and elsewhere, including National Parks in the Mohave and Great Basin deserts. In summer of 2005, invasive grasses fueled desert wildfires that approached a quarter of a million acres in central Arizona (the Cave Creek Fire Complex) and three-quarters of a million acres in southern Nevada.

The impacts of grass invasions and altered fire regimes in the deserts are many, looming and costly. They include threats to life and property in urban and exurban areas, significant economic losses (i.e., decreased property value, lost tourism revenues, and escalating weed control and fire suppression budgets), and compromises to biodiversity, protected lands and conservation initiatives. These fast-evolving threats are catching communities and fire departments off guard and ill prepared.

The connection with climate change is not entirely clear, but we know that higher CO2 levels will favor cheatgrass and red brome at the expense of native species, and that warmer winters will push buffelgrass higher in elevation and farther north. Our National Parks and Monuments are especially in peril, and save for a few valiant, grassroots efforts we seem to be losing this battle. One day, we may not only face a Glacier National Park without glaciers, but also a Joshua Tree National Park without Joshua trees and a Saguaro National Park without its iconic saguaro.

A growing concern is the potential spread of wildfires from the lowlands to the highlands, and vice versa. The mountain tops of the Sky Islands have already experienced several damaging wildfires. The 2002 Bullock Fire and the 2003 Aspen Fire in the Santa Catalina Mountains, for example, collectively burned more than 115,000 acres and destroyed about 300 homes and businesses in the town of Summerhaven. Similar events have occurred across the western U.S. in recent years, and it is increasingly evident that this rising trend in "megafire" occurrence is partly associated with warming temperatures, earlier arrival of spring, and drought conditions (Westerling et al. 2006).

Forest changes (e.g., fuel accumulations) due to a century of fire suppression and land uses (e.g., livestock grazing, logging, etc.) are also involved in this problem in many but not all forests. More than 35% of the area of the Bullock and Aspen Fires resulted in total or substantial canopy kill of the forest, leaving very large "canopy holes" which promote erosion of forest soils, and severe downstream watershed impacts. Although frequent, low severity, "surface fires" were a common and natural ecological process in our Southwestern ponderosa pine and mixed conifer forests in the past, these recent fires are burning uncharacteristically (and unnaturally) hot as "crown fires. The result is conversion of forest stands to shrublands or grasslands, and damaging effects on soils, habitats, and watershed values.

Landscape-scale collaborative efforts are underway in the Sky Islands, focusing on forest restoration that aims to mitigate and adapt to the climate change-related "shocks" of megafires. The "FireScape" collaborative is an approach that has been particularly effective at working at landscape scales in the multi-agency context. FireScape is a collaboration of the Coronado National Forest, The Nature Conservancy, Saguaro National Park, The University of Arizona and other partners to provide an umbrella for safe, ecologically sound, broad-scale, multi-party fire management. The first FireScape project was developed for the Huachuca Mountains of southeastern Arizona. This project is nearing the implementation phase.

A developing FireScape project for the Santa Catalina and Rincon Mountains surrounding Tucson has a focus on utilizing the mosaic of fuel conditions left by the recent Bullock and Aspen fires. The idea here is that the mosaic of low, moderate and high severity burned areas in the Bullock and Aspen Fires can be used as effective fuel breaks and opportunities for reintroducing prescribed fire and thinning treatments at landscape scales. This approach is likely to be safer, more cost effective, and ecologically sensitive than such treatments in unburned landscapes. In some areas the recent wildfires have effectively begun the restoration process of reducing fuel accumulations and forest stand densities. It is necessary, however, to follow up with treatments within the next decade or less, otherwise it is likely that the beneficial effects of the mosaic will be lost.

Both the buffelgrass and forest wildfire problems of southern Arizona, like similar climate change-related problems elsewhere in U.S., require landscape-scale thinking, effective translational science partnerships, and sustained implementation with follow through using science-based adaptive management. The buffelgrass efforts are exemplary of highly effective multi-jurisdictional coordination and planning to deal with a landscape-scale problem affected by climate, and analogous to many of the climate change problems we will be facing in years ahead. Space is limiting here to describe in detail the collaborative efforts that have gone into planning southern Arizona buffelgrass control and the landscape fire planning for the mountains, so I will refer here to web links where more information can be obtained: see Southern Arizona Buffelgrass Coordination Center at http://www.buffelgrass.org/, and http://www.fs.fed.us/r3/coronado/ under "FireScape on the Catalina and Rincon Mountains".

The key points I want to emphasize from these examples of landscape-scale, multi-agency management problems are the following:

1. Planning, collaboration, and implementation of restoration and climate-change adaptation programs at landscape-scales are essential. Both the Tucson Basin buffelgrass and Sky Islands FireScape examples cross numerous administrative boundaries and to be effective these projects must involve collaboration and coordination among federal, state, and county agencies, and with private land owners. Fundamentally, what is needed is support for the science, planning, and implementation of treatments and restoration work on the ground.

   In this regard, I wish to commend Congressman Grijalva for his vision and leadership in helping develop and pass the recent Forest Landscape Restoration Act. This is precisely the kind of federal support and leadership needed for landscape-scale restoration projects.

2. In addition to funding mechanisms for planning and implementation, we need to develop science support capacity. The Southern Arizona Buffelgrass Coordination Center (SABCC) and Sky Islands FireScape initiatives both point to the need for state-of-the-art decision support and expertise in geospatial tools for mapping and prioritizing treatments, and for modeling spread of invasive species and fire behavior at multiple scales. If we are going to engage in landscape-scale treatments and adaptation, we should do it with our best scientific understanding, and monitor the results in a scientific framework. University collaboration is highly valuable in this regard because it brings scientific expertise, creativity, and credibility, as well as educational and training value for young scientists and managers.

3. Both the SABCC and FireScape programs have great potential to be national models of adaptation and mitigation of climate change-related impacts on federal, state, and private lands.

**The Value of National Parks and Other Federal Lands for Tracking and Understanding Climate Change**

There are many uncertainties about future climate change impacts on ecosystems and watersheds. Much of what we have learned about the effects of past and recent climate variations and change on ecosystems has come from studies conducted within the National Parks and National Forests. In the future, we need to continue and expand monitoring of climate and ecosystems within Parks, because these places offer some of the best landscapes to study climate-driven changes with the least amount of human land-use effects. Furthermore, the rationale for the Parks was, and is, that these are the places we care the most about in terms of protecting and preserving these wonders for the enjoyment by people, now and in the future.

There are two examples of climate change impacts in National Parks and Forests that I want to bring to your attention to illustrate the value of federal lands, and long-term monitoring data that comes from them. The first is a study of forest fire activity on federal lands in the western U.S. that I coauthored in the journal *Science* in 2006 with Dr. Tony Westerling of University of California, Merced and colleagues at the Scripps Institute, University of California, San Diego (Westerling et al. 2006). We used wildfire occurrence records primarily from National Forests and Parks in the eleven western states. We restricted our analyses to the period after 1970 and to fires larger than 200 hectares (about 1,000 acres) because this was the most complete and reliable type and period of documentary record.

We found a nearly 7-fold increase in area burned during the recent 17 year period from 1987 to 2003 compared to the earlier 17 year period from 1970 to 1986. This change was significantly correlated with rising spring and summer temperatures across this region, and the years with greatest numbers of large fires were consistently associated with years when spring arrived earlier, as measured by peak runoff dates in rivers. From locations of the large fires in different elevations and forest types, and patterns of spatial/temporal moisture deficits, it was apparent that warming climate was the key driver overall, and especially in some regions (e.g., the Northern Rockies). Both forest changes (fuel accumulations) and warming combined were likely important in other regions (e.g., the Southwest).

The second example is a recent paper published by a group of scientists working in western forests, led by U.S. Geological Survey scientists located at Sequoia and Kings Canyon National Parks. Drs. Philip van Mantgem and Nathan Stephenson and their colleagues gathered long-term forest monitoring data from 76 forest plots across the western U.S (van Mantgem et al. 2009). Using data from more than 58,000 monitored trees they found that 86% of the plots showed increasing tree mortality rates over the period from about 1955 to 2007. The mortality rates doubled over periods ranging from 17 to 29 years in different plots and sub-regions during the studied time period. Mortality rates increased regardless of sub-region, elevation, tree size (age), species, or type of natural fire regime characteristic to the forests. The authors concluded that climate change (warming and drought) in the western U.S., and consequent physiological and ecological stresses on trees, was most likely the dominant factor leading to increased tree mortality rates.

Both of these studies illustrate the power of long-term monitoring data sets from National Parks and Forests for detecting and tracking climate change impacts. Neither of the studies could have been conducted without the existence of these federal units, and sustained dedication of scientists and managers who have carried out the monitoring and record keeping over many years. In addition to the national policy implications and the public educational values of such broad-scale studies, the results from local monitoring data sets have importance for management of individual National Parks and Forests.

Another important value of our Parks and Forests is that they are great places to teach our citizens about climate change and to directly engage them in the necessary monitoring and science. For example, federal agencies and the academic community are collaborating in an exciting national monitoring initiative, the USA-National Phenology Network (www.usanpn.org). Phenology is the study of the timing of events in the annual life cycle of plants and animals, including things like budburst, first bloom and leafout in plants and emergence, migration and hibernation in animals. A number of recent studies have shown that these biological events can serve as sensitive indicators of climate change effects on ecosystems. In essence, the NPN can serve as an early warning and monitoring system of climate change.

One way for us to adapt to climate change is to integrate phenological observations and models with climatic forecasts. There are not enough scientists and technicians to do this routine monitoring everywhere on the continent, so large-scale programs like USA-NPN will also have to rely on “citizen scientists”. What better place to start these efforts than in our National Parks?

The key points I wish to emphasize from these examples are the following:

1. The National Parks and other federal lands are particularly valuable for monitoring, detecting, and tracking climate change.

2. Recent studies have begun to detect and describe probable, widespread climate change impacts in western National Parks and Forests, specifically increasing numbers of large forest fires and increasing tree mortality rates. These are broad-scale patterns, and the trends and primary causes of changes are different in some locations and sub-regions.

3. The National Parks and Forests can play a key role in public education about climate change and in carrying out broad-scale monitoring. Engaging people directly in observing climate change responses (e.g., the USA-NPN) is one approach. Programs such as the NPS’s Research Learning Centers will also be essential in these endeavors.

**The Value of Place-Based Science, and the Need for Expansion of Translational Science Capacity**

During the past several decades of conducting applied research in National Parks and National Forests, one of the most effective models I have seen of translational science is a “place-based” approach, where scientists and their support teams are located at National Parks. There is a long tradition of federal agency scientists being located at research branch offices or laboratories on or near university campuses (e.g., USGS and USFS laboratories). These university-located laboratories have clearly been a huge benefit to applied science. However, the particular niche of a place-based scientist located at a National Park (or a Forest Service Supervisor's Office or Ranger District) is relatively rare. In the western U.S., there may be as few as a dozen or so such USGS lead scientists located in "Field Stations" within or very near National Parks, and fewer in the eastern U.S.

The productivity and positive impacts of these relatively few place-based scientists are remarkable. The van Mantgem et al. *Science* paper on tree mortality is a case in point. The lead authors, van Mantgem and Stephenson, are place-based, USGS scientists at Sequoia National Park. Another great example of scientific leadership and impact of place-based science is the Western Mountain Initiative (see http://www.cfr.washington.edu/research.fme/wmi/). This is a collaboration of USGS and U.S. Forest Service scientists working on climate change impact topics in the western U.S. Three of the principal investigators on this team are place-based scientists at National Parks and three are in federal laboratories located at or near universities. The values of place-based science are well illustrated by the example of my colleague, Dr. Craig Allen, at Bandelier National Monument in northern New Mexico (see http://www.fort.usgs.gov/resources/spotlight/place/).

To summarize, the key values of place-based science include:

1. Place-based scientists can interact with on-site with managers on a daily basis, resulting in more effective communication, application, and follow-through of relevant science.

2. Place-based scientists can more effectively lead on proposing, conducting, arranging, overseeing, facilitating, and communicating the needed local research and monitoring.

3. Place based-scientists can act as a bridge between research and management, working to identify the information needs of management problems, secure external research funding, foster collaborations with outside institutions to conduct needed research, and communicate research findings quickly and effectively to local managers and the public.

4. Place-based scientists develop substantial expertise in the ecology of their particular landscape. Eventually this allows them to become information brokers of the deep-rooted institutional knowledge that comes from being in a place long enough to learn its lessons and grow familiar with its natural and cultural rhythms and history.

5. Place-based science, involving scientists and their teams located within National Parks, is a very effective model and it should be replicated. Currently, most of these scientists at Parks are USGS employees, but some of them started out as NPS researchers and they were eventually transferred to the USGS. The relationship of these scientists as translational-science support for local Parks and regional networks of Parks should be more formally defined and institutionalized in agreement between USGS and NPS, with the goal of sustaining the high quality and increasingly important work they conduct.

In addition to place-based science as described above there is need for support of other models of translational science. For example, I am aware that the National Park Service is currently developing a concept for “Bio-Regional Mitigation and Adaptation Planning Units” to coordinate scenario and adaptation planning efforts for Parks (Leigh Welling, NPS Climate Change Coordinator, personal communication). The Units would be strategically placed to utilize existing field resources, such as the “Inventory and Monitoring Networks” and the “Research Learning Centers”. They would also coordinate with other entities, such as the NOAA RISAs, the USGS Field Stations and state and local governments. The bio-regional, landscape approach is critical for providing managers with relevant, up-to-date scientific information and for ensuring climate change efforts are dynamic, flexible and consistent across DOI and within other agencies

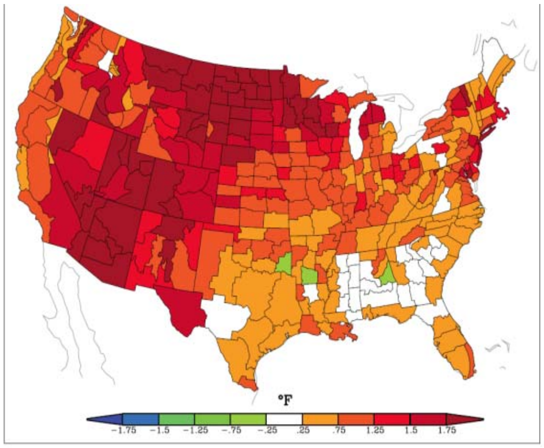
To be effective, the Units would need to have scientific, resource management, and adaptation planning staff. Resource and planning staff would use shared information to build defensible and comprehensive scenarios that are integrated into a Resource Adaptation Plan for each park. Tangible results would be a list of response actions to climate change designed to reduce susceptibility of vulnerable species, ecosystems, or historic assets to harm or loss. Such actions could include documenting and inventorying historic sites that will be submerged, protecting additional species, adapting park infrastructure, identifying and protecting refugia and corridors, or transplantation and relocation of resources in extreme cases.

The final science and management initiative I wish to bring to your attention is a very dynamic consortium of federal and university scientists called CIRMOUNT (Consortium of Integrated Climate Research in Western Mountains) who came together in the early 2000s to coordinate and converse on the issues of climate change impacts in western North American mountains. Monitoring, conducting integrated research, communicating science among disciplines, and promoting policy-relevant databases are among the goals of CIRMOUNT. Climate change impacts on National Parks and other federal lands are a common focus of this consortium. This group has organized multiple symposia in the past decade on climate impacts on ecosystems, water resources and people. The meetings and initiatives include managers and policy makers as well as scientists. I encourage anyone interested in climate change impacts in the west to visit their website (http://www.fs.fed.us/psw/cirmount/), get on the mailing list for the newsletter (*Mountain Views*), and attend one of the biennial meetings. It is my hope that CIRMOUNT will be sustained in coming years by establishment of a central office in support of this dynamic organization and their important work.

**References cited:**

van Mantgem, P. J., N. L. Stephenson, J. C. Byrne, L. D. Daniels, J.F. Franklin, P.Z. Fulé, M. E. Harmon, A. J. Larson, J. M. Smith, A. H. Taylor, T. T. Veblen. 2009. Widespread increase of tree mortality rates in the Western United States. *Science* 323-521-523.

Westerling, A. L., H. G. Hidalgo, D. R. Cayan, and T. W. Swetnam. 2006. Warming and earlier spring increase western U.S. wildfire activity. *Science* 313:940-943.




**More Rapid Warming in the West**

**2003 to 2007 5-Year Average Temperatures Compared to 20th Century Averages**

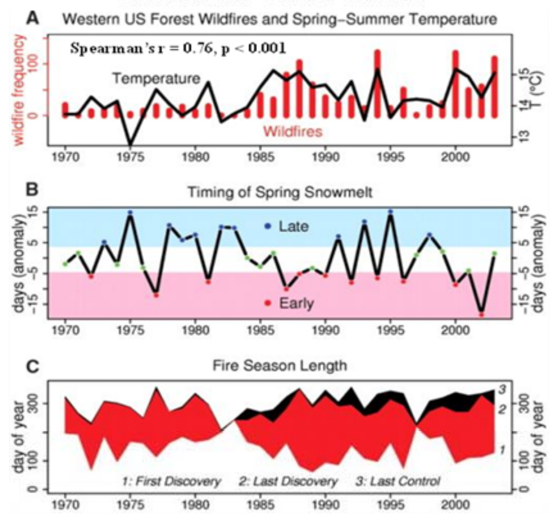
| | |
|---|---|
| Planet | +1.0°F |
| Western United States | +1.7°F |
| Colorado River Basin | +2.2°F |
| Arizona | +2.2°F |
| California | +1.1°F |
| Colorado | +1.9°F |
| Idaho | +1.8°F |
| Montana | +2.1°F |
| Nevada | +1.7°F |
| New Mexico | +1.3°F |
| Oregon | +1.4°F |
| Utah | +2.1°F |
| Washington | +1.4°F |
| Wyoming | +2.0°F |

The western U.S. is the epicenter of warming in the lower 48 states in the past decade. Map and table from Saunders et al. March 2008. Hotter and Drier: The West's Changed climate, RMCO, NRDC. http://www.nrdc.org/globalWarming/west/west.pdf

## Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity

A. L. Westerling,[1,2]* H. G. Hidalgo,[1] D. R. Cayan,[1,3] T. W. Swetnam[4]

18 AUGUST 2006 VOL 313 SCIENCE



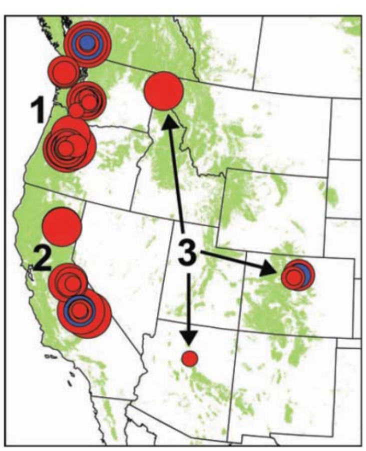


The numbers of large forest fires (>200 hectares) occurring in the western US has been rising, and this pattern is related to warming temperatures (graph A), and more early spring years in recent decades (graph B). The fire season has also lengthened more than 70 days in recent decades (graph C.)

## Widespread Increase of Tree Mortality Rates in the Western United States

Phillip J. van Mantgem,[1]*†‡ Nathan L. Stephenson,[1]*† John C. Byrne,[2] Lori D. Daniels,[3] Jerry F. Franklin,[4] Peter Z. Fulé,[5] Mark E. Harmon,[6] Andrew J. Larson,[4] Jeremy M. Smith,[7] Alan H. Taylor,[8] Thomas T. Veblen[7]

SCIENCE VOL 323 23 JANUARY 2009



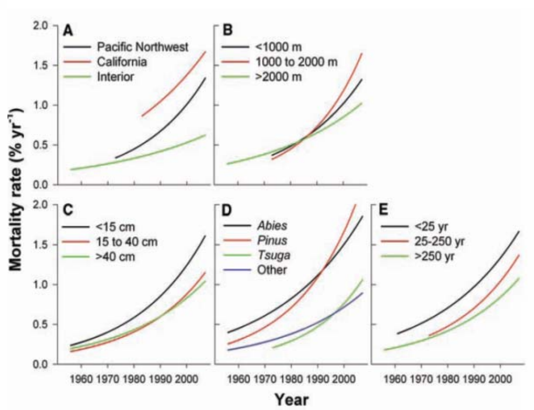




**Fig. 2.** Modeled trends in tree mortality rates for (**A**) regions, (**B**) elevational class, (**C**) stem diameter class, (**D**) genus, and (**E**) historical fire return interval class.

Tree mortality rates have increased in forest monitoring plots across the West (red circles on the map). Rising tree mortality rates are evident among all sub-regions (A), elevations (B), tree size classes (C), species (D), and forests of different natural fire frequencies (E). Warming climate and droughts are the probable causes.