

MOUNTAIN VIEWS

The Newsletter of the Consortium for Integrated
Climate Research in Western Mountains
CIRMOUNT



Mount Whitney Sunrise, Alabama Hills © ElizabethCarmel.com

Informing the Mountain Research Community

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Above: "Silence, Last Twilight on an Unknown Lake, Johnson Peak", Yosemite National Park Woodcut on paper by Chiura Obata, 1930. Credit: © Yosemite Conservancy

Below: Stained glass window designed and rendered after Obata's image by Jessica Lundquist and Andrey Shcherbina, both of University of Washington, Seattle

Read about the contributing artists on page 42

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Volume 6, No 1, Spring 2012

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Front: Mount Whitney Sunrise, Alabama Hills

Back: Night Journey, Lake Tahoe



The Mountain Views Newsletter (MVN)

Connie Millar and Jeremy Littell, *Editors*

Welcome to Mountain Views, the biannual newsletter of the Consortium for Integrated Climate Research in Western Mountains (CIRMOUNT, www.fs.fed.us/psw/cirmount/). With this issue we begin our sixth year producing MVN and reporting news about climate research and climate adaptation relevant to mountains of western North America. CIRMOUNT is an informal grass-roots consortium comprising scientists, managers, policy makers, and others interested in climate science and ecosystem responses in our region. CIRMOUNT provides a forum to integrate and communicate research from diverse disciplines, and seeks to promote awareness of, and solutions to, societal issues arising from anthropogenic impacts on the climate and biophysical systems in mountain regions. *MVN* is one vehicle for our communication. We welcome your contributions.

We are proud this winter to recognize honors awarded to colleagues of our community. In December 2011, Jill Baron (USGS, Ft. Collins, CO) was elected President-Elect of the 11,000-member Ecological Society of America. Her position begins in summer 2012. Read an interview with Jill on page 34. The American Geophysical Union announced its class of 2012 Fellows in January 2012. Congratulations Dan Cayan (USGS and Scripps Institution of Oceanography, UCSD, La Jolla, CA) as a new AGU Fellow. His citation reads, "For pioneering cross-disciplinary contributions and leadership advancing understanding of hydroclimatic variation and change in western North America."

In 2004, CIRMOUNT launched its first *MtnClim* Conference. The sixth meeting, *MtnClim 2012*, convenes Oct 1-4, 2012 (with field trips before), in Estes Park, CO. A post-conference workshop for resource managers will be held on the afternoon of Oct 4. Read about plans for *MtnClim 2012* on page 36, follow updates at www.fs.fed.us/psw/mtnclim/, and join mountain-climate colleagues in the high Rockies this autumn. Deadline for registration, abstract submission, and lodging reservation is **July 20, 2012**.

The MtnClim Conferences alternate annually with our sister event, the Pacific Climate Workshop (PACLIM), which last convened in Pacific Grove, CA in March 2011. The next PACLIM Workshop will be March 3-6, 2013 at the Asilomar Conference Center, Pacific Grove, CA. Contact Scott Starratt, USGS, for information: sstarrat@usgs.gov.

CIRMOUNT also sponsors mountain-climate sessions at the annual Fall Meeting of the American Geophysical Union (AGU) in San Francisco. At the December 2012 AGU meeting, we convened a session entitled, "Climatic Water Deficit and Water Balance in Mountain Systems: Biophysics, Ecohydrology, and Impacts", CIRMOUNT's eighth year contributing to AGU. Find abstracts and copies of oral and poster presentations on the CIRMOUNT meeting archive web pages: www.fs.fed.us/psw/cirmount/meetings/archives.

In past issues, we have been striving to broaden the scope of *MVN* by adding new sections. *Brevia* are short overviews that summarize recent or in-press articles of wide interest; *Short Pieces* briefly describe new projects; *News and Events* include summaries of reports and announce meetings of interest; and *Mountain Visions* represents our effort to highlight the artistic sides of our research community. In this issue, we add yet another new section, *Did You See (Hear, Feel, Touch, Smell) It?* For this we invite brief articles that describe and depict unusual weather or climate events. For our first contributions to this section, see "The Sierran Flood (Rhymes with 'Flood') of Winter 2011-2012" (page 31) and "Frost Feathers" (page 33). We take this opportunity also to thank Barbara DeLuisi (NOAA) for original design of *MVN* and layout of all prior issues. We have transitioned layout to Diane Delany (USFS) with the current issue. Many thanks, Diane, for stepping up to this task so completely.

For many parts of the West, this felt like the year when autumn proceeded directly to spring, and winter forgot to happen. For those who did get winter, we hope you took some extra turns on fluffy white slopes, and at any rate, it will be fascinating this coming field season to experience the contrast with last year.

On behalf of the CIRMOUNT coordinators, we send our best for a productive spring 2012 – whether you had winter or not -- around mountains of the West.

— Connie and Jeremy

From Mountain Microclimates to the Macroecology of Tree Species Distributions in California

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¹*National Center for Ecological Analysis and Synthesis
University of California, Santa Barbara, California*

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Background and Introduction

Tree species ranges are shifting in response to global climate change (e.g. Lenoir et al. 2009). Species distribution models based on the empirical association of observed species localities and mapped climate variables are widely used to forecast shifts in species' ranges and extinction risk, but these models have well-known limitations (Wiens et al. 2009). The vulnerability of a species to climate change depends on many interacting factors, notably the extent of climate change the species is likely to experience, its demographic sensitivity to climate factors, and its coping capacity (e.g., physiological tolerance, ability to disperse to more suitable climatic conditions, phenotypic plasticity and genetic diversity) (Dawson et al. 2011).

We face a number of challenges in developing more realistic models to assess species vulnerability to climate change, notably:

- Individual plants, which are the atomic units of species ranges, grow in microclimates. Those microclimates and associated thermal and soil moisture regimes, are especially complex and poorly modeled in mountainous terrain (Dobrowski 2011) (Fig. 1).
- Grids of historical and forecasted future climate variables are too coarse to represent the local climates and microclimates that govern species distribution and abundance.
- We have limited understanding of the relationship between multiple scales of climate variation and species' population dynamics and resulting range dynamics.
- For most species, we do not know how geographic patterns of genetic diversity could influence species' vulnerability to changing climate (Sork et al. 2010).

Knowledge of the biophysical conditions associated with initial establishment and how those conditions vary across the landscape are critical to understanding the implications of ongoing climate change for tree species distributions (e.g., Clark et al. 1999, Ibanez et al. 2007). Many studies investigating the potential responses of tree species to climate change rely on temperature tolerances inferred from ecotonal or range boundaries (reviewed by Smith et al. 2009). Field trials using seeds of different



Figure 1. Topographic variation in microclimate and soils support vegetation mosaics such as the blue oak and valley oak woodlands on south facing slopes and canyon live oak and mixed conifer forests on north facing slopes (left side of image) on Tejon Ranch, Tehachapi Mountains, California. Photo: F. Davis.

geographic provenance provide a more consistent basis for investigating microclimatic and genetic controls on tree species establishment.

Microsite conditions determine plant seed germination, establishment and growth, but local and landscape-level patterns of suitable habitats and disturbance such as fire may regulate population distributions and abundances. Those patterns in turn regulate gene flow and colonization processes that may ultimately drive emergent macro-scale patterns of species migration and range shifts. Coupling climate and ecological processes across such a broad range of scales and ecological levels of organization remains one of the central challenges in ecology and climate change biology (Levin 1992, Levin 2000).

Over the past several years a multidisciplinary working group met at the National Center for Ecological Analysis and Synthesis (www.nceas.ucsb.edu) to investigate strategies for producing finer-scale climate models and more biologically realistic species

distribution models. Last year we obtained funding through the National Science Foundation's Macrosystems Biology program for a 5-year collaborative research project entitled "Do microenvironments govern macroecology?" Our main research questions are:

- What is the distribution of microenvironments in mountain landscapes under current climate?
- How might climate change affect tree species occupancy of microenvironments?
- How are the macroscale dynamics of species distribution and abundance, and range shifts due to climate change related to microenvironments?

The project team members are listed in Table 1. This article provides a brief overview of our research approach and current project status.

Study Sites

We are measuring microclimate and tree seedling establishment in foothill and montane sites in two neighboring ecoregions and seed zones: the southern Sierra Nevada and the western Tehachapi Mountains in California (Fig. 2). Our Sierran sites include the San Joaquin Experimental Range (37°5' N, 119°43' W, 210-520 m elevation, www.fs.fed.us/psw/ef/san_joaquin/) and Teakettle Experimental Forest (36°58' N, 119°1' W, elevation 2000-2800 m), www.fs.fed.us/psw/ef/teakettle/). Our low (34°59' N, 118°43' W, 750-930 m) and high (34°58' N, 118°35' W 1600-1700 m) elevation sites in the Tehachapi Range are located on the Tejon Ranch, where we are fortunate to have the cooperation of the land

owner (Tejon Ranch Company, www.tejonranch.com) and the Tejon Ranch Conservancy (www.tejonconservancy.org/).

Microclimate Measurement

We located study sites in order to characterize a spectrum of microclimate conditions in blue oak woodland at low elevations and mixed conifer forest at high elevations. At each site we are monitoring air temperatures at 10 cm above ground surface and, for a subset of locations, at 2 m above the surface using an array of 18-43 HOBO® (Onset, www.onsetcomp.com) dataloggers spanning approximately 2 km (Fig. 3). These "landscape arrays" will be used to estimate mean surface temperature at the scale of available coarse climate grids and at the scale of a dynamic regional climate model (1-3 km²) that we are using to downscale global climate models. Within each site we have also deployed dense grids of 20 temperature loggers in six 0.25 ha areas on north slopes, south slopes and valley floors. These dense arrays will be used to estimate local temperature variability and the mean surface temperature at the 30 m scale of digital terrain data that we are using for heuristic downscaling of coarse climate

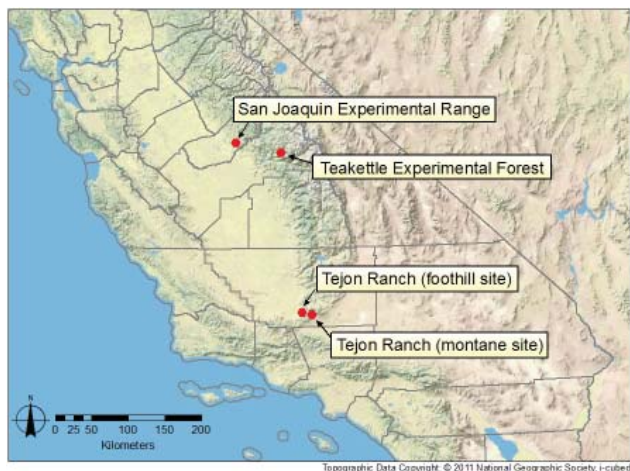


Figure 2. Locations of field sites in California. San Joaquin and Teakettle experimental forest are the foothill and montane sites, respectively, in the Sierra Nevada Mountains. Within the Tehachapi Mountain Range, both the foothill and montane sites are located on Tejon Ranch.



Figure 3. Temperature sensors deployed at a foothill site, Tejon Ranch, in southern California. Photo: A. Shepard.

grids (Flint and Flint 2011). Thus far we have deployed approximately 160 loggers at each of the four study sites that are recording temperatures at 10 minute intervals.

At each site, we have also installed 3 weather stations (north slope, south slope, and valley floor) and are monitoring precipitation, wind, insolation, temperature, relative humidity and soil moisture. These stations are co-located with experimental common gardens, described below.

Microclimate data will be analyzed to model temperature, precipitation and soil moisture fields across our study sites to better understand microenvironmental variation in relation to tree species distribution and abundance. The data will also be used to test

the efficacy of different methods for interpolating weather station data and for downscaling outputs of global climate models using dynamic regional climate models and statistical approaches.

Microclimate Controls on Tree Species Establishment

Our study focuses on 5 tree species: blue oak (*Quercus douglasii*), black oak (*Q. kelloggii*), ponderosa pine (*Pinus ponderosa*), Jeffrey pine (*P. jeffreyi*), and gray pine (*P. sabiniana*). Gray pine and blue oak are overstory dominants of the foothill zone, and ponderosa pine, Jeffrey pine and black oak are dominant species of the lower-montane and mid-montane zones.

At each site, we installed six gardens that have been fenced above and below ground to exclude large ungulates (cattle, deer, feral pigs) and rodents (Figs. 4 and 5). Seeds of the five tree species were collected from the study sites in Sierras and the Tehachapis to gauge regional genetic differences in climate responses. Seeds from all species-region collections (10) were planted into every common garden in the fall of 2011. Seedling establishment and growth will be followed for several years to compare germination and growth rates in different seed zones, life zones, and microclimates within life zones. Separate cohorts of seeds will be planted in subsequent study years to account for inter-annual climate variation.



Figure 4. Field crew planting seeds into a common garden within an enclosure at Tejon Ranch, in Southern California. Photo: A. Shepard.

Our garden trials will be used to identify relevant bioclimatic variables, parameterize species distribution models, and ultimately to help parameterize spatially explicit population and landscape simulation models. The landscape simulation models will be used to link fine scale climate variation and local population dynamics to landscape and regional patterns of species distribution under alternative climate scenarios.



Figure 5. Common garden with a weather station within an enclosure at Teakettle Experimental Forest, in the California Sierra Nevada Mountains. Photo: L. Sweet.

We will make all of our project data available via a public web portal that is now under development. Please contact Frank Davis (fd@bren.ucsb.edu) if you are interested in learning more about the project or see opportunities for collaboration.

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Table 1. The Microscale to Macroecology (m2M) research team

Name	Institution	Primary Role
Frank Davis	UC Santa Barbara	PI: microclimate monitoring, field experiments, climate response functions
John Dingman	Earth Research Institute, UC Santa Barbara	Postdoctoral researcher: geographical analysis, climate mapping and model downscaling
Alan Flint	US Geological Survey, California Water Science Center, Sacramento	Collaborator: microclimate monitoring and modeling, climate model downscaling
Lorraine Flint	US Geological Survey, California Water Science Center, Sacramento	Collaborator: geographic analysis, climate model downscaling
Janet Franklin	School of Geographical Sciences, Arizona State University	Co-PI: species distribution models, landscape simulation models
Alex Hall	Department of Atmospheric and Oceanic Sciences, UCLA	co-PI: dynamic regional climate modeling, climate model downscaling
Lee Hannah	Conservation International	Co-PI: microclimate monitoring, species distribution modeling
Sean McKnight	Earth Research Institute, UC Santa Barbara	Researcher: microclimate monitoring, field experiments, geographical analysis
Max Moritz	Department of Environmental Science, Policy and Management, UC Berkeley	Co-PI: fire ecology, landscape simulation models
Malcolm North	USDA Forest Service, Pacific Southwest Research Station	Collaborator: forest ecology, field experiments, climate response functions
Kelly Redmond	Western Regional Climate Center, Desert Research Institute, University of Nevada, Reno	Co-PI: microclimate monitoring and modeling, climate model downscaling
Helen Regan	Department of Biology, UC Riverside	Co-PI: population ecology, landscape simulation models
Peter Slaughter	Earth Research Institute, UC Santa Barbara	Researcher: data management
Anderson Shepard	Earth Research Institute, UC Santa Barbara	Researcher: microclimate monitoring, field experiments
Lynn Sweet	Earth Research Institute, UC Santa Barbara	Postdoctoral researcher, field experiments, species distribution models
Alexandra Syphard	Conservation Biology Institute, San Diego CA	Co-PI: landscape ecology, landscape simulation models

How Large (in the scheme of things) are Precipitation Extremes in California's Mountains?

F. M. Ralph¹ and M. D. Dettinger²

¹NOAA/ESRL, Physical Sciences Division, Boulder, Colorado

²U.S. Geological Survey, Scripps Institution of Oceanography, La Jolla, California

Extreme precipitation events frequently batter the mountains of the Western US, fueled by a variety of large-scale meteorological processes and enhanced (relative to surrounding lowlands) by the orographic uplift that occurs when storms blow up and over the mountainous terrains. The bigger storms can result in landslides and erosion, thick disabling snowpacks, and widespread flooding in both the mountain reaches and down below, and so such storms are high on our lists of dangerous extremes. In a recently accepted article for the Map Room section of the Bulletin of the American Meteorological Society (Ralph and Dettinger, in press), we used the major winter storm of mid December 2010 as a reason to explore the question: Are our biggest western storms really as big, or bigger, than storms elsewhere in the country?

To answer this question in the most straightforward possible way, we analyzed historical precipitation records from thousands of long-term weather stations across the US, and defined a very simple categorization of 3-day precipitation totals that allows direct comparison and characterization of the largest recorded events at each station, in absolute terms. The categorization of any given precipitation event at any given station is simply based on whether the 3-day precipitation total was greater than 200 mm of (rainfall category, R-Cat, 1), greater than 300 mm (R-Cat 2), greater than 400 mm (R-Cat 3), and so on. Three-day totals were used because many of the most damaging storm impacts require sustained rains to really get rolling. Also, when we did the analyses with 2-day totals the numbers of extremes being categorized fell by about half and when we did them with 4-day totals, we found that the fourth day contributed, on average, less than 5% of the storm totals anyway.

Historical patterns of extreme-precipitation reports as labeled by these R-Cats showed, first, that the most extreme precipitation events historically have been concentrated in near-coastal states (Fig. 1). While R-Cat 1 and 2 site events have occurred in most states, the clear majority of R-Cat 3 and 4 site events have been in California, Texas, and in the southeastern states. In the West, those R-Cat 3 and R-Cat 4 events are also clearly restricted to the Coastal Ranges and western Sierra Nevada of California. Not surprisingly, those extreme events were from winter storms (inset to Fig. 1), and usually they are orographically enhanced

storms. In order to understand the storm mechanisms more broadly, we identified storm “episodes” categorized by the largest R-Cat value achieved anywhere west, or east, of 105°W in each 3-day period. Evaluation of meteorological conditions during R-Cat episodes showed that, during all 17 episodes that met or exceeded the R-Cat 2 threshold from 1997-2005 and during 44 of 48 R-Cat 3 and 4 episodes from 1950-2008, an atmospheric river (Ralph and Dettinger, 2011) was making landfall on the west coast. Atmospheric rivers (ARs) are long, narrow zones within extratropical cyclones that contain large quantities of water vapor and strong winds, and are responsible for > 90% of all atmospheric water vapor transport in midlatitudes (Zhu and Newell, 1998). They are 1000s of km long and, on average, only 400 km wide (Ralph et al. 2004), with 75% of the water vapor transport occurring below 2.25 km altitude (Ralph et al. 2005a). ARs produce extreme precipitation because they transport such large and sustained quantities of water vapor (typically about 10 Mississippi River’s worth, lasting from hours to a few days) and because they set up almost ideal conditions for producing heavy orographic rains and flooding when they encounter mountains (Ralph and Dettinger 2011, Neiman et al. 2011, and references therein). In contrast, the only other comparable historical precipitation maxima above R-Cat 3 thresholds in the US—those in Texas and the southeast—were summertime events, arising from tropical storms and hurricanes (roughly half of the events) and other mechanisms like Mesoscale Convective Systems.

Thus, 3-day precipitation extremes associated with landfalling ARs in the Coastal Ranges and Sierra Nevada of California have historically been heavier than extreme storms anywhere else in the country outside the southeast US, and they are comparable with even those often-hurricane-fueled storms. And, yes, the big storm of 17-22 December 2010 was in this league, producing more than 670 mm (26 inches) of precipitation in the San Bernadino Mountains of southern California and 3-5 m (10-15 ft) of snowpack in the southern Sierra Nevada. The storm also penetrated far into the intermontane west, dumping 432 mm (17.0 inches), causing serious flooding, in the mountains of southern Utah over 5 days between 18-23 December. In terms of 3-day precipitation totals, it reached R-Cat 3 levels in southern California and R-Cat 2 levels in Utah!

MAXIMUM 3-DAY PRECIPITATION TOTALS AT US COOP STATIONS, 1950-2008

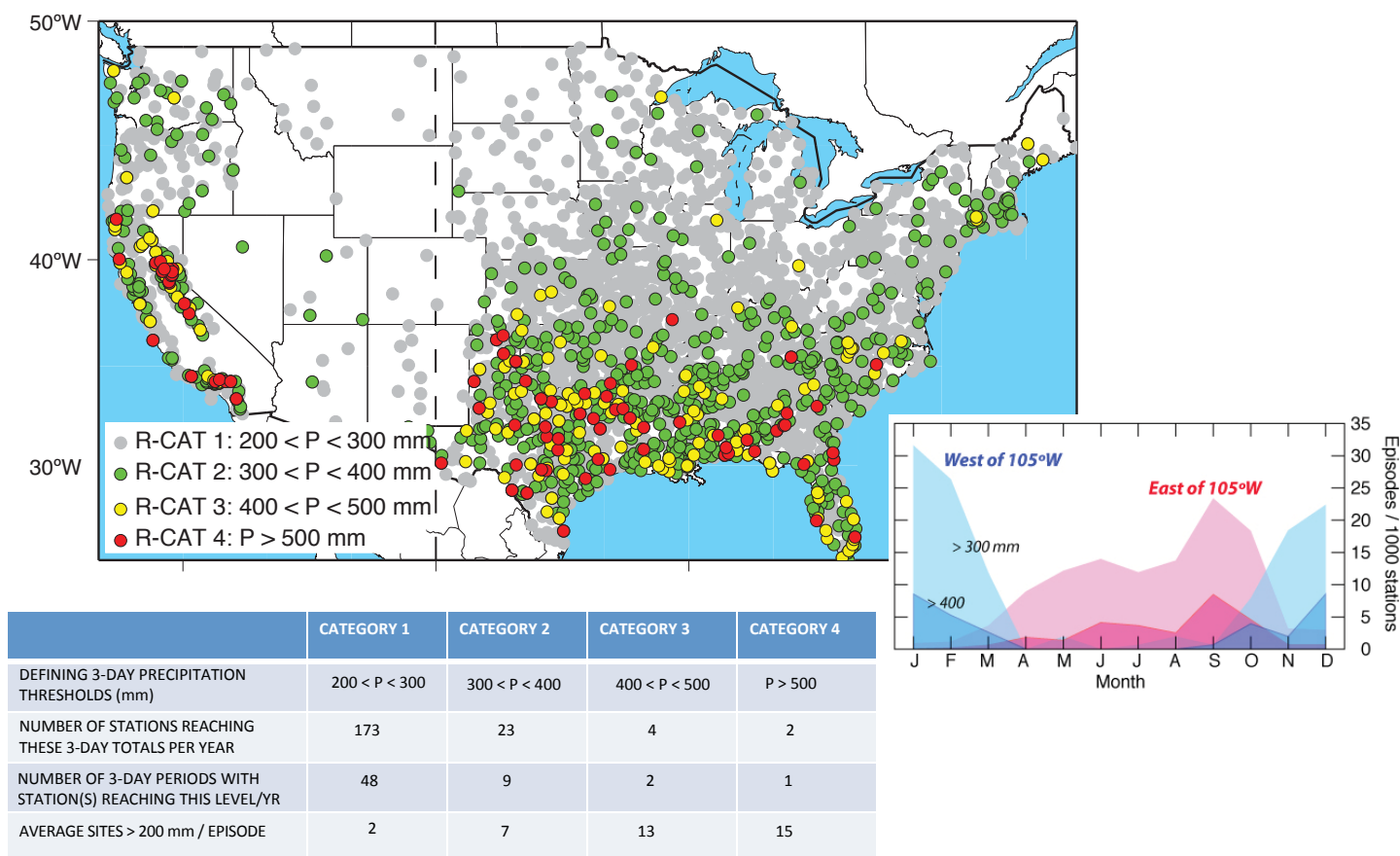


Figure 1. Historical maximum 3-day precipitation totals from 5877 long-term NWS cooperative weather observer stations across the conterminous US, with (inset) the numbers of 3-day episodes achieving the highest precipitation totals, east and west of 105°W, by month of year, and (table) frequency of occurrence nationally. 105°W was used based on the natural break between the two distributions at R-Cat 3 and 4 (figure).

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Adapting to a Changing Climate in the Sky Island Region

Louise Misztal
Sky Island Alliance, Tucson, Arizona

The arid southwest is among the fastest warming regions in the world; parts have already warmed more than 1°C (2°F) relative to average 20th century temperatures. Nestled in the heart of this rapid warming is the Sky Island region of southeastern Arizona, southwest New Mexico and northern Mexico (Fig. 1). The Sky Island mountain ranges, known collectively as the Madrean Archipelago, are truly unique in the western U.S. They harbor some of the highest biological diversity in North America, including a multitude of species at the edge of their range. The Sky Islands span the gap between the Rocky Mountains and the Sierra Madre in Mexico and overlap the boundary between the Sonoran and Chihuahuan deserts (Fig. 2). Partly due to their isolated character, with high-elevation forested terrain surrounded by intervening lowland desert and grassland, climate change is one of the greatest long-term threats facing the region. Between 1991 and 2006 the mean annual temperature rose 1.1°C and 0.6°C (1.9°F and 1.2°F) in Arizona and New Mexico, respectively (Robles and Enquist, 2010). The effects of this dramatic warming are being felt in the form of increased wildfire activity, changes in the timing of species' life cycle events, and ecological changes in habitat. To further complicate matters, climate change is interacting with other stressors such as decadal scale drought, human land use, habitat fragmentation, and complex ecosystem interactions to create measurable and sometimes drastic changes in the region.

Like many other mountainous areas in the west, the Madrean Archipelago supports a number of species that may wink out

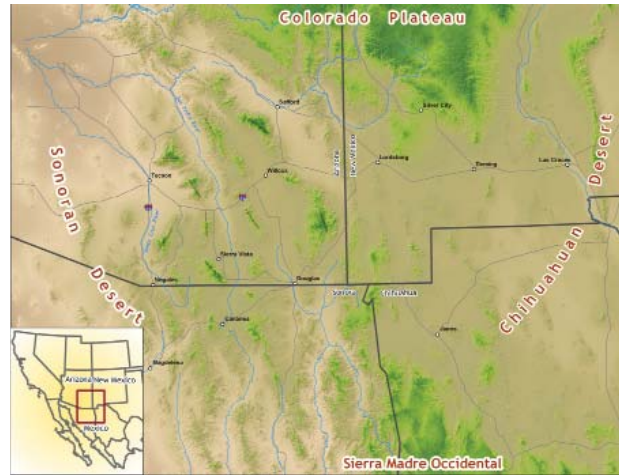


Figure 1. Map of Sky Island Region. Photo: Sky Island Alliance.

due to their reliance on high elevation habitat that is disconnected from similar habitat to the north or their dependence upon climate niches that cease to exist. It also hold interesting secrets, such as deep shaded canyons where species like Douglas fir (*Pseudotsuga menziesii*) and Arizona cypress (*Cupressus arizonica*) occur at remarkably low elevations. Such habitats offer a glimmer of hope as likely climate refugia for a variety of plant and animal species.

Sky Island Alliance is a conservation organization dedicated to the protection and restoration of the rich natural heritage of native species and habitats in the Sky Island region. Faced with the reality of rapidly increasing impacts such as the catastrophic



Figure 2. Sierra La Madera, Sonora Mexico. Photo: Chip Hedgecock.

fires that wracked the Coronado and Apache-Sitgreaves National Forests in 2011, and a persistent drought that has caused long-reliable water sources to dry up, we realize that climate change is affecting all that we work to protect and restore.

In an effort to respond to dramatic changes in the region, Sky Island Alliance initiated a project to improve natural resource management and stewardship in order to ensure ecosystem resilience. It has become clear to conservation, scientific, and resource management communities that protecting wildlife and ecosystems in the face of climate change will require new ways of thinking about land management and natural systems. In 2009 Sky Island Alliance began working to develop and promote implementation of adaptive land management strategies and policies that address climate impacts through an initiative called *Adapting to a Changing Climate in the Sky Island Region*. With a focus on natural resource managers and planners, conservation organizations, scientists, and landowners, we are working to build capacity to utilize climatic information and climate change predictions in decision making, build a network and forum for exchange of science and for discussions of climate change adaptation strategies, collaboratively develop on-the-ground adaptation strategies that can immediately be undertaken, engage trained volunteers in critical monitoring and restoration efforts to help build resilient systems, and engage the public in supporting climate change adaptation strategies undertaken by managers. Principle components of the project include a climate change adaptation survey, a series of climate change adaptation workshops and the formation of the Arizona Climate Change Network.

Climate Change Adaptation Survey

Prior to creating regional adaptation workshops, we wanted to better understand the current state of knowledge and the most effective and accessible structure to use. We conducted a survey with personnel from federal and local government agencies, non-governmental organizations, universities, research institutes and private landowners. The questions focused on how people gather climate information and use it in their work, key climate change threats and resource limitations to responding to those threats, and ways in which Sky Island Alliance could contribute to implementation of adaptation responses.

The most frequently identified climate change threat to the region was water scarcity and drought, which was subsequently reinforced by findings and results from the workshops. Other high-ranking threats included human pressures on ecosystems,

and invasive or non-native species. Some of the most pressing current needs were a framework for dealing with uncertainty, translation of science, and effective communication among colleagues, partners and stakeholders. Because Sky Island Alliance maintains a large corps of trained volunteers, we asked respondents to identify ways in which volunteers could assist them in their work. Monitoring native and invasive vegetation and wildlife, and ground-truthing data emerged as top responses.

Climate Adaptation Workshops

Sky Island Alliance's climate change adaptation work largely focuses on helping natural resource managers integrate climate change into the work they are already doing. Ideally, climate change considerations would be ever-present as plans and management decisions are made and on-the-ground approaches implemented. To address this issue we worked with partners including NOAA-funded Climate Assessment for the Southwest (CLIMAS), the Udall Foundation's U.S. Institute for Environmental Conflict Resolution, EcoAdapt, the University of Arizona's Institute of the Environment and School of Natural Resources and the Environment to develop and convene a workshop series focused on development and implementation of adaptation strategies for the region.

We convened the first two workshops of the series in 2010 and 2011, *Climate Change Adaptation in the Arid Southwest: A Workshop for Land and Resource Management* and *Between a Rock and a Hot Place: Climate Adaptation and Resource Management in the Sky Island region*. The workshops collectively drew 150 participants representing 36 different entities (including agencies, organizations, tribes, universities and private landowners) from across the region. We initially focused on reviewing and sharing climate change information and identifying vulnerabilities, initial adaptation strategies, and opportunities to work together across boundaries. This laid a solid groundwork for the second workshop where we delved much deeper into vulnerabilities and adaptation strategies for specific ecosystems of the Sky Island region (Table 1).

Water resources were a focal point at both workshops and emerged as having high vulnerability and high priority. Participants felt that inventorying the location and condition of water resources and identifying restoration activities to keep flow in streams will help them respond to decreases in available water, and to cascading effects on species and ecosystems. Managers desire to maintain water where it currently exists or, if possible, to restore it to where it historically existed. Collecting spatial

information about resources such as springs and seeps, and identifying appropriate restoration locations and activities will be necessary to make this possible. In response to these findings, Sky Island Alliance worked with a variety of federal state and county agency partners and other interested parties to develop a spring and seep inventory assessment project for the region. The project is moving forward this year and will be collecting crucial information on 50 springs and seeps largely through trained volunteers, and will be developing tools for managers across jurisdictions to access spatial and biological information about springs. This information will increase our understating of the location and condition of springs and will be used to prioritize restoration and protection efforts in the region (Fig. 3).

Other themes emerged from the workshops that will be key to successful adaptation in the region. Responding to climate change will require coordination on the management of shared resources, including cooperation and information sharing related to monitoring and data collection. Incorporating non-stationarity into decision-making and planning emerged as a large challenge that will be an ongoing. Participants feared that management targets may be lost no matter what they do, and that difficult questions about prioritization will have to be answered. This last issue will certainly be an ongoing challenge as all of the organizations and entities managing resources in the Sky Island region work within the realities of climate change. It is one of many issues we will seek to continue to address in our third workshop set to be convened in 2013.



Figure 3. Sycamore Spring in the Huachuca Mountains, AZ
Photo: Trevor Hare.

Conclusions

The essence of the initiative Sky Island Alliance launched in 2009 was to create a conversation about climate change in the Sky Island region. As an organization that has long taken a holistic look at the species and ecosystems of the entire 70,000-square-mile Sky Island region, we decided to approach climate change adaptation from a regional perspective. Regional climate change adaptation workshops have been a framework for the conversation and a tool to begin to make paradigm shifts to incorporate consideration of climate change into the work of

Table 1. Select Workshop Findings for Sky Island Ecosystems

Ecosystem	Threat	Vulnerabilities	Adaptation Strategy
Madrean Forest	Increased temperature Warmer & drier winters Increase in summer precipitation variability	Forest health and function Increased fire risk Loss of soil and potential for forest regeneration Increased insect infestations	Initiate a process to manage the Sky Island region at a landscape scale through the National Environmental Policy Act (NEPA)
Semi-desert Grassland	Increasing dry winters Increase in temperatures Variability in precipitation events Changes in Seasonality	Decreased ability to continue and use practices Less viable ranching soil loss and erosion Lack of community concern regarding climate change and effects on grasslands	Work together to cultivate resilient, native seed sources to prepare for likely flooding and soil loss associated with climate change impacts in the region

managing and protecting natural resources. Identification and long-term implementation of adaptation strategies will require communication and cooperation across agencies and sectors. Sky Island Alliance is working to make these strategies a reality by garnering commitments from appropriate decision makers to see the strategies through and provide necessary support to their field staff to ensure full implementation. For agencies managing public lands, implementation of forward-looking strategies will also require public support. Sky Island Alliance will continue to build that support in various ways, including providing a corps of trained volunteers to assist in implementing critical monitoring and restoration projects.

It is now well accepted and understood that cross-boundary and landscape level cooperation is an essential component of climate change adaptation. This continues to be a field with a lot of questions and few answers, but it is evolving rapidly. Although the agencies, organizations, private citizens, and researchers in the Sky Island region have an uncertain path ahead, we are well on our way to discovering that path together. Building a community of managers, scientists, conservation organizations and landowners in the region that share a common understanding of the dynamics at work and common goals and strategies for addressing them will help ensure a robust future for species and ecosystems. In the long run, we hope that this framework can serve as a model for those outside of the region who struggle with the many challenges and threats posed by climate change. More information about Adapting to a Changing Climate in the Sky Island Region and workshops can be found at www.skyislandalliance.org/climatechange.htm

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BREVIA

Climate Change, Mountain Hydrology, and Water Resources in the Oregon Cascades

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Nolin, A. W. In press. Perspectives on climate change, mountain hydrology, and water resources in the Oregon Cascades, USA. Mountain Research and Development, 32(suppl).

Water, as the fundamental linkage across the biosphere and as the essential resource for human society, is the ubiquitous connection for virtually all aspects of the mountain social-environmental system. Water flows downhill while demographic and policy impacts flow uphill. Using the Oregon Cascades as an example, this paper presents perspectives on the complex factors affecting present-day and future streamflow in snow-dominated mountain watersheds, the need to develop watershed classification schemes and improve our monitoring of these complex linkages, and an innovative modeling framework that explicitly integrates changing ecohydrologic factors and socio-ecological issues affecting water scarcity in the region.

The focus of this perspectives paper is the Oregon Cascades mountain range (Fig. 1) where geology, vegetation, and climate influence streamflow patterns within watersheds. Even the wettest parts of this mountain system experience seasonal drought since over 70% of annual precipitation falls from November to March and only a small fraction falls during the July-September period. In the upland portions of these mountain watersheds, at least half of the annual mountain precipitation falls as snow (Serreze et al., 1999) although much of this snow is close to the melting point and is at risk of converting to rainfall with only a 2°C winter temperature increase (Nolin and Daly, 2006). Geology determines which watersheds are surface runoff-dominated and which are groundwater-dominated. The McKenzie River Basin, Oregon has been the focus of several studies that examine the interactions of geology and climate on seasonal low flows (Tague and Grant, 2009, and references therein). This watershed is representative of many in the western Cascades in terms of size, elevation range, snowfall, and land use. It is characterized by highly permeable and porous young basalt geology in its headwaters that provides substantial groundwater recharge. Unlike surface runoff dominated basins, where summer low flows are nearly always closed, declining snowpacks will likely result in lower late summer flows in the groundwater-dominated basins. Looking to the future, snowpack model results show that with warmer winters the greatest reductions in snowpack will occur in the primary groundwater recharge zone of the McKenzie (Fig. 2) and model results suggest that this groundwater-dominated watershed will experience an increase in mid-winter peak flow and reduced summer low flows (Jefferson et al., 2008). Thus, this system will likely experience an increased probability of flood and drought over a single water year.

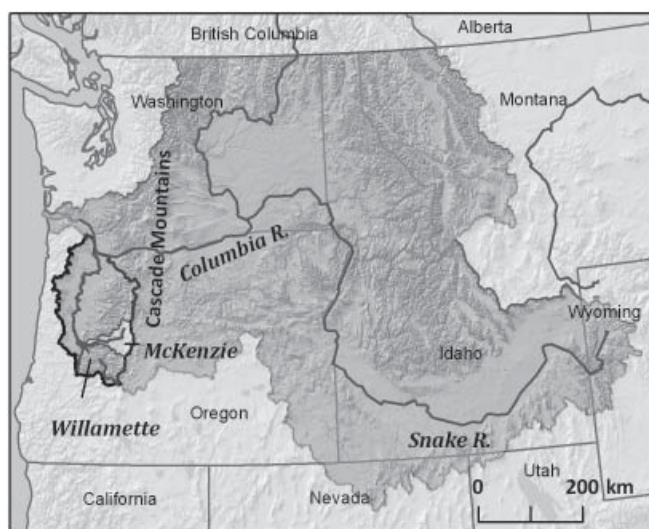


Figure 1. Location of the study area showing the Columbia, Willamette, and McKenzie River Basins.

The linkage between climate, vegetation, and streamflow is also relevant at the watershed scale. Snowpack provides water for vegetation and also imparts thermal controls. While snow remains on the ground, soils remain cold since available energy must

first contribute to warming and melting the snowpack. Once the snowpack melts and soil temperatures increase, photosynthesis in the coniferous forest increases and hence its water use increases. Declining snowpacks have been well documented at lower elevations in the Oregon Cascades. Earlier spring thaw appears to account for a decline in spring season streamflow at a long-term ecological research site in Oregon (Moore, 2010). The runoff ratio (streamflow normalized by precipitation) was reduced 19-41% over a period of five decades during which time the winter temperature also increased and snow water equivalent also declined by 8 mm yr^{-1} from 1941-2010. This suggests that earlier snowmelt causes forests to “wake up” earlier resulting in decreased springtime streamflow. Reduced snowpacks also lead to declines in soil moisture making forests more vulnerable to extensive wildfires (Westerling et al., 2006) and possibly affecting the lifespan and composition of forests (van Mantgem et al., 2009). This suggests that climate-water-vegetation connections function in multiple ways: affecting phenology and water use, increasing forests’ vulnerability to wildfires, and affecting the age structure of forests. These changes are primarily concentrated in the mountain regions yet affect water yield and other ecosystem services (such as carbon sequestration) that are important to lowland populations downstream.

Numerous studies are undertaken each year that attempt to address the water resource impacts of climate change. Few of them, however, consider the representativeness of the monitoring systems from which they derive their data. Moreover, when we consider future climate impacts on watersheds, our monitoring systems may be even more lacking. What is needed is an objective and comprehensive means of characterizing watersheds in terms of their physiographic and climatological parameters so that we can optimize our sampling strategies for present-day and future climate conditions. Watershed similarity indices and classification schemes (e.g. Wolock et al., 2004; Winter, 2001; Sivapalan et al., 1987) are very useful for ungauged basins and regions of sparse measurements since they can be used to identify (a) watersheds that are similar to those where more intensive monitoring and model calibration work has been performed and (b) watersheds that are hydrologically sensitive but not yet included in a monitoring or modeling scheme. Previous work in hydrologic classification has focused on abiotic parameters such as watershed topology, geology, and climate. I suggest that ecohydrologic classification of watersheds could be achieved by combining a hydrologic classification of watersheds with an ecoregions classification (e.g., Omernik, 1987; Omernik, 1995). Some watersheds may be hydrologically and ecologically similar but have very different degrees of human community stability

Modeled Loss of Snow Water Equivalent (April 1)
Winter with Average SWE - 2040s projected climate

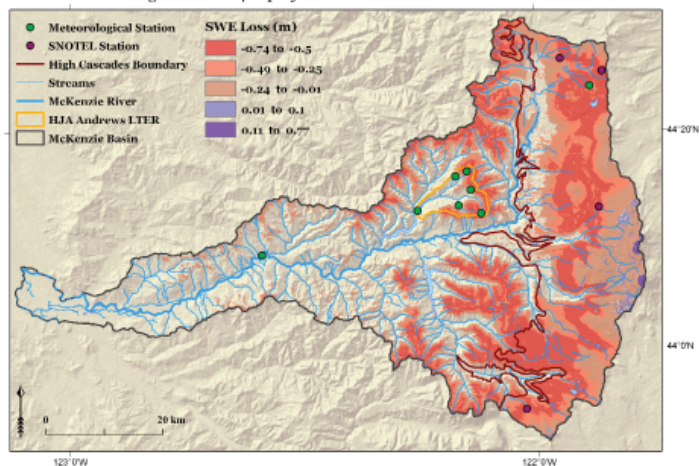


Figure 2. Modeled loss of snow water equivalent (April 1) for projected climate in the 2040s. The volume of snowpack storage loss is 0.6 km^3 , most of which is in the groundwater recharge zone in the High Cascades basalt.

and resilience. If we want to explicitly consider resilience and the impacts of water scarcity on ecosystem services, our watershed typology should also consider the human dimension. For this, we might incorporate the framework of complex social-environmental systems developed by Ostrom (2009) in which she identified variables that promote self-organizing sustainable resource use.

The demands for integrated understanding of hydrologic, ecologic and social-environmental impacts of climate change in mountain watersheds means that we need to consider not only physical parameters but also biotic and human elements in our sampling strategies. The final topic in this perspectives paper touches on integrated and interactive modeling of climate change and land use impacts on the hydrologic, ecologic and human components in mountain watersheds. Documenting and assessing vulnerability is a key first step but modeling allows us to diagnose sensitivities and explore alternative strategies. In the modeling realm, the traditional approach to assessing watershed scale impacts of climate change on water resources has been to rely on water resources planning models (e.g. Leavesley et al., 1996; Yates et al., 2008), but these typically neglect the effects and feedbacks of the human and/or ecosystem components. In the area of decision-support modeling of landscape change, approaches have been based on the paradigm of “predict-then-act” (Hulse et al., 2008), which combines information about changing land use and water resources with optimal economic and ecosystem services outcomes so that managers may identify

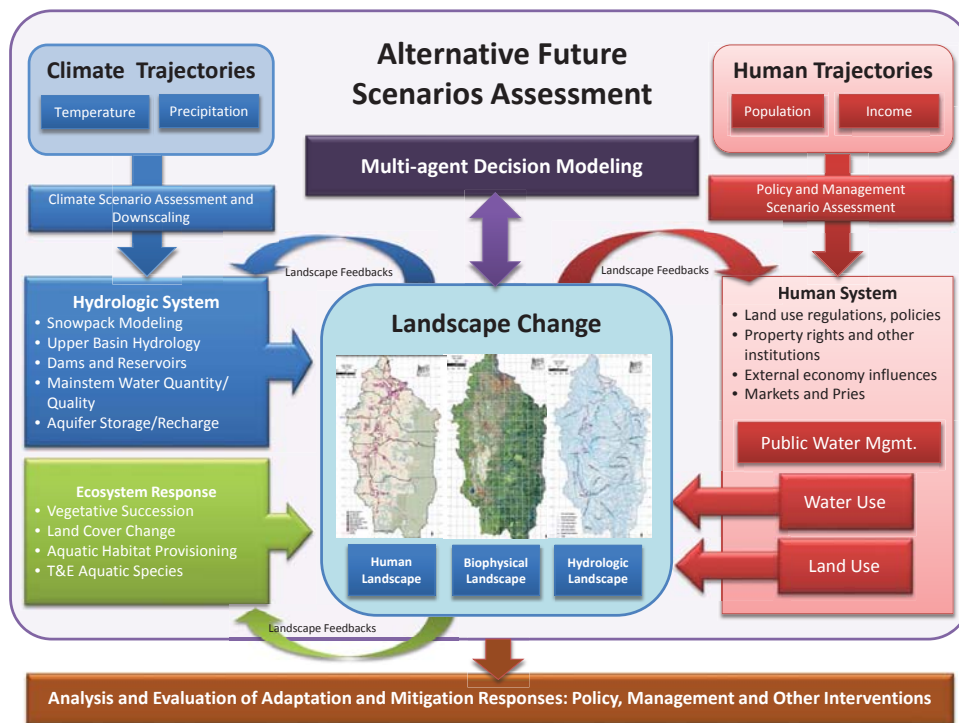


Figure 3. Diagram of the Envision model.

a “best” scenario and follow a course of action by which to attain it. However, such models do not incorporate feedbacks between land use, water, management, and decision-making and the result is that optimal outcomes may be unstable when there is large uncertainty in one or more of the landscape components. Moreover, they do not shed light on policies that may lead to more sustainable futures. A new decision support approach referred to by Hulse et al. (2008) as “explore-then-test” seeks to identify those strategies that produce good, though perhaps not optimal, outcomes for a wide range of possible future scenarios. It is the connectivity of landscape elements (vegetation, geology, water, etc.) as well as the multiple forcings (climate change, land cover disturbance, land use change) and feedbacks that create non-linear and threshold effects across watersheds. Bolte et al. (2006) have developed a modeling framework called “Envision” that connects process-based hydrologic and ecosystem models with socio-economic models and agent-based decision-making (Fig. 3). This integrative modeling approach represents a new paradigm because it allows scientists and managers to “envision” the rich complexity of landscape patterns that result when decision-making entities and their policies are included as part of evolving landscapes.

Here, I describe a new application of Envision in which we are focusing on potential water scarcity in the Willamette River Basin, Oregon. Water scarcity is determined by the abundance of water, demands on the resource, as well as the timing of supply and demand. Within a watershed, we also are concerned with location of water scarcity since as described earlier, geologic differences between subwatersheds strongly influence water availability in during the low flow season. Water scarcity in this watershed is affected by climate change, geology, land cover disturbance (e.g. fire, timber harvest), land use change (e.g. transition from forest-to-agriculture or agriculture-to-municipal), and water use patterns (e.g. consumption per unit of municipal or agricultural land use), dam operations, and population growth. Multiple socio-economic

factors affect land use and water use at the watershed scale including the skills and traditions of landowners in the watershed, government regulations (e.g. the Endangered Species Act), land values and water prices, water management infrastructure (e.g. dams, irrigation, aquifer storage and recovery), and these need to be considered when attempting to assess the effects of climate change and land/water management on water resources.

In summary, a robust and representative monitoring scheme is needed to characterize the complex interactions that can lead to water scarcity within a mountain watershed, with consideration not only for the present-day conditions but for projected future climate as well. But documenting and explaining interactions of climate change, water, geology, vegetation and humans in the mountain system is only the first step. Modeling can provide a means to explore strategies for increased resilience and adaptive capacity. The Envision model is the first of its kind that incorporates hydrologic, ecosystem, and socio-economic processes within an agent-based framework. Such a modeling approach allows decision makers the means to visualize how policies and potential scenarios interact with various stressors to create alternative future landscapes thus giving them key insights for planning that can enable this region to prevent, mitigate, or adapt to water scarcities.

Acknowledgements

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BREVIA

Modeling Snow Water Equivalent: What is the Ideal Approach?

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Raleigh, M. S. and J.D. Lundquist. 2012. Comparing and combining SWE estimates from the SNOW-17 model using PRISM and SWE reconstruction. *Water Resources Research*, 48(1): 1-16.

Variability in the spatial distribution of snow is important in mountainous areas because it controls vegetation distributions (Barbour et al., 1991), tree growth (Littell et al., 2008), wildlife habitat (Millar and Westfall, 2010), and the frequency of wildland fires (Lutz et al., 2009). However, existing observational networks are too sparse to represent fine scale variation in snow water equivalent (SWE) and snow disappearance timing. Spatial patterns of these variables may be better understood by using some combination of remote sensing and distributed snow modeling, the latter of which may be implemented in a variety of configurations (Fig. 1). These include a forward configuration based on spatial extrapolation of measured precipitation, such as with the Parameter Regressions on Independent Slopes Model (PRISM, Daly et al., 1994), and a reconstruction configuration based on snow disappearance timing and back-calculated snowmelt (Martinec and Rango, 1981). However, little guidance exists as to which configuration is more accurate. Additionally, the two approaches have opposite sensitivities to model forcing, such as air temperature. We (Raleigh and Lundquist, 2012) hypothesized that combining (i.e., averaging) the SWE estimates from these two parent configurations may yield the greatest accuracy.

The forward configuration (Fig. 1a) is intuitive because it operates in the same direction as time, and is practical because it can simulate past, current, or future conditions. However, this accumulation-based approach requires accurate distributed precipitation data, which often has high uncertainty due to spatial variability in mountainous areas at different scales (e.g., orographic effects and local wind-induced redistribution). As an alternative approach, the reconstruction configuration (Fig. 1b) can estimate peak SWE without precipitation data. Starting at the date of snow disappearance and moving backward in time, snowmelt is summed in order to determine how much snow must have existed prior to melt (Fig. 1b). Snow disappearance timing can be observed at point locations with buried temperature

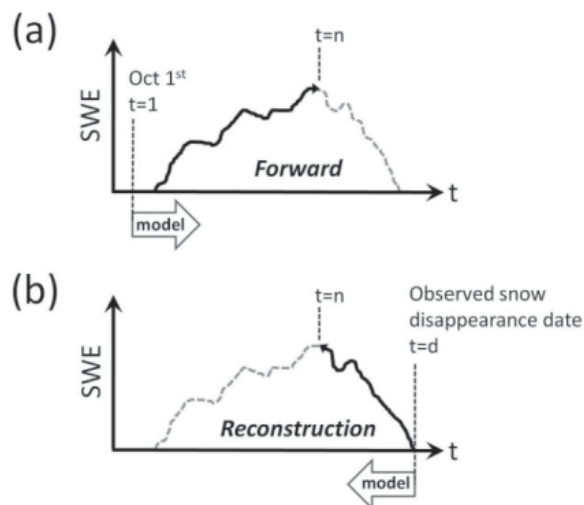


Figure 1. Conceptual schematic of SWE simulations from (a) forward and (b) reconstruction configurations of the same deterministic snow model. SWE in (a) is simulated forwards in time from October 1st, while SWE in (b) is simulated backwards in time from the observed snow disappearance date. In this example, peak SWE occurs at $t=n$.

sensors (Lundquist and Lott, 2008) or across basins using optical remote sensing (e.g., NASA Moderate Resolution Imaging Spectroradiometer). Because reconstruction first requires the snow to disappear, it is inherently retrospective and can only simulate past SWE.

Using 154 snow pillow sites located in maritime mountain ranges of the western United States (Fig. 2), we compared forward, reconstruction, and combined configurations of a simplified version of the SNOW-17 temperature-index model (Anderson, 1976). For this experiment, we assumed that only air temperature and snow disappearance timing were known at each site, and assumed no knowledge of melt rates or locally observed precipitation and SWE, which were used for validation. The forward configuration was driven by precipitation data from the nearest neighboring snow pillow, and PRISM was used to distribute these data to account for spatial variations in precipitation. The SNOW-17 model parameters were calibrated at a subset of snow pillows (squares in Fig. 2), and

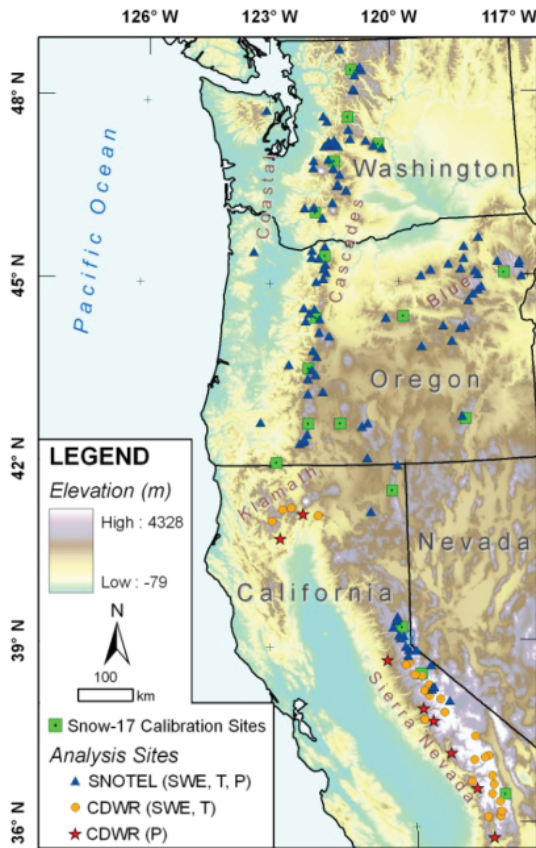


Figure 2. Snow pillow analysis sites and model calibration sites in Washington, Oregon, and California shown on top of a 1km digital elevation model. Analysis sites are from the NRCS SNOTEL and California Department of Water Resources (CDWR) networks.

transferred to the nearest snow pillows. We evaluated model errors in (1) annual precipitation and (2) peak SWE, and (3) mean errors in SWE during the accumulation and ablation seasons. We also conducted a separate analysis to assess the sensitivity of peak SWE to biased forcing data and parameters.

When estimating annual precipitation, the forward model (i.e., PRISM) had the greatest accuracy (Fig. 3a). Estimates of annual precipitation backed out of reconstructed SWE were the least accurate, due to errors in the model parameters. When estimating peak SWE (Fig. 3b), the combined model had the greatest accuracy in SWE. While inferior to the combined SWE, the forward and reconstruction configurations had comparable accuracy with each other, suggesting that neither of those two parent approaches was more advantageous in estimating peak SWE distributions (Fig. 3b). When assessing the accuracy of the models throughout the year, we found that the forward model could not reliably estimate snow disappearance timing

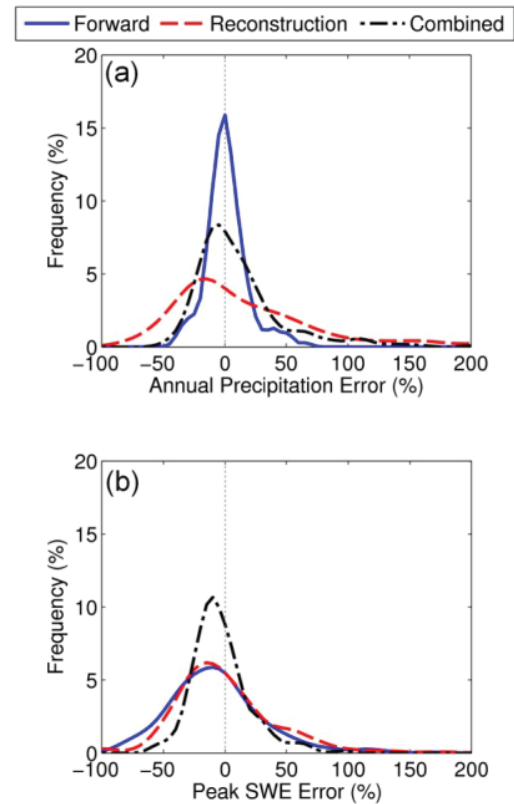


Figure 3. Smoothed error histograms for (a) annual precipitation ($n=294$) and (b) peak SWE ($n=334$) from the three model configurations. Histograms were smoothed across bins of 5% error using kernel density estimation.

(no figures shown here). This suggested that the reconstruction and combined configurations were more appropriate for ablation season applications, such as the construction of snow depletion curves.

The combined model was more accurate for SWE estimation than the two parent configurations because (unquantifiable) errors in air temperature and model calibration parameters resulted in a number of cases where one parent configuration overestimated SWE and the other underestimated SWE. This situation was present in 58% of the SWE tests ($n=334$). When the combined model averaged the SWE estimates from the forward and reconstruction configurations, SWE estimation was improved in the majority of these cases. This feature was explored in a sensitivity analysis (Fig. 4), which showed that the forward and reconstruction models demonstrated opposite sensitivities to errors in air temperature (Fig. 4a) and model parameters (no figures shown here). For example, a positive bias in air

temperature resulted in overestimation of snowmelt, leading to overestimated SWE by the reconstruction configuration. The same positive bias generally yielded underestimation of snowfall, leading to underestimation of SWE by the forward configuration. These SWE errors tended to cancel in the combined model (Fig. 4a).

In general, we recommend PRISM for precipitation estimation and the combined model for SWE estimation at ungauged locations in maritime mountain ranges, but these conclusions depend on data availability and the geophysical characteristics of the area of interest. In areas where PRISM is not available or precipitation uncertainty is high (Fig. 4b), reconstruction may be a more viable tool, but this depends on the quality of snow disappearance timing data (e.g. remote sensing) and the accuracy of modeled snowmelt. Areas with persistent cloud cover and heavily forested areas are likely to have large uncertainties in snow disappearance timing (Fig. 4c), which limits the accuracy of reconstruction. Additionally, the results may differ in areas outside the maritime zone, especially in cold, continental areas where the configurations may exhibit less sensitivity to errors in air temperature. Future work is needed in order to quantify errors in model data and parameters, and to improve estimation of snowfall and snowmelt.

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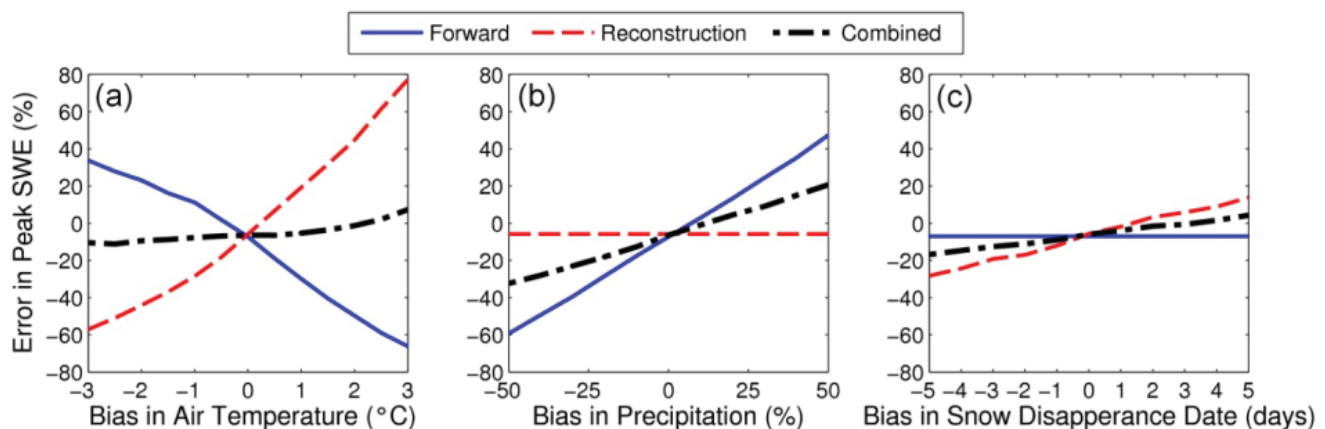


Figure 4. Sensitivity of median peak SWE errors ($n=334$) to artificial biases in model inputs (a-c) with the three model configurations. Distributions about the medians were not presented for clarity.

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Temperature and Snowpack Controls on the Growth of Alpine Shrubs

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Franklin, R.S. In press. Growth response of the alpine shrub, *Linanthus pungens*, to snowpack and temperature at a rock glacier site in the eastern Sierra Nevada range of California, USA. *Quaternary International*.

Although much attention has been directed to the importance of documenting recent climatic changes in arctic and alpine ecosystems and tracking the composition, range expansion and contraction and other climate-related changes of above-tree line plant communities (Elliot and Jules 2005; Pauli et al., 2007; Scherrer and Körner, 2011) there exist few annually resolved records of alpine plant growth spanning the past century. Several high-latitude chronologies of arctic shrubs document the growth-response of these plants to recent warming (Hallinger et al., 2010; Bär et al., 2008; Rayback, and Henry, 2006), but few analogous records exist in lower-latitude mountainous regions.

I present here the first multi-decadal and annually resolved shrub chronology for the Sierra Nevada (California, USA) and the first *Linanthus pungens* ([Torr.] J.M. Porter & L.A. Johnson) chronology. The study sought to determine which, if any, climate variables are controlling growth of above-tree line shrub communities and to create the first in a network of above-tree line shrub chronologies along the Sierra Nevada escarpment. Knowledge of the ways in which high elevation shrub communities have responded to the climate of the previous century can inform conservationists and land managers of possible alpine ecosystem responses to projected future climatic changes. Using dendroclimatic techniques to evaluate potential climate responses of above tree line areas can complement international monitoring efforts (e.g., Global Observation Research Initiative in Alpine Environments [GLORIA] program; Grabherr et al., 2000) and National Park and National Forest inventory and monitoring programs.

Creating an Alpine Shrub Chronology

Herb- and shrub-chronology are techniques adapted from dendrochronology, and utilize annual growth increments in the

rootstock or other perennial structures of the plant as a way of gathering ecological or climatic information recorded by the growth of individuals or groups of plants. Clearly demarcated and annual growth rings are widespread in dicotyledonous perennial plants (Fig.1), especially in temperate zones and at high latitudes and elevations (Dietz and Ullman, 1997; Schweingruber and Dietz, 2001; von Arx and Dietz, 2006).

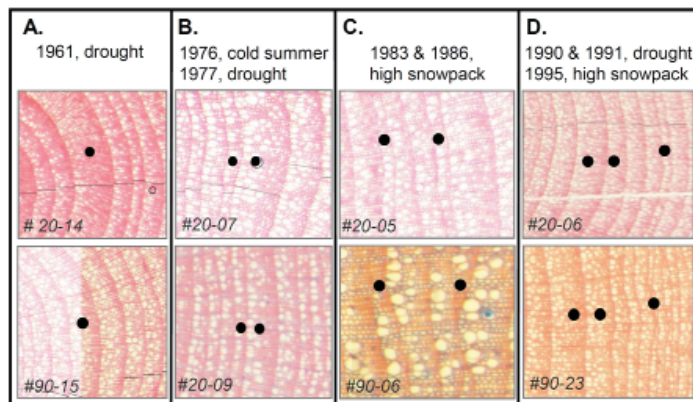


Figure 1. *Linanthus pungens* crossdating examples. Black dots denote years of exceptionally wide or narrow rings in the majority of individuals sampled at the BL site. Column headings describe the specific years indicated by the black dots and also describe the corresponding climatic conditions occurring in those specific years.

The periglacial Barney Lake rock glacier (BL) and adjacent cirque wall slope chosen for this study represent important landforms in the alpine landscape. Rock glaciers (occupying a mean elevation 3300 m. in the Sierra Nevada) in the region of this study site have a greater density of alpine sub-shrubs than adjacent slopes of comparable elevation, aspect and slope (Franklin, unpublished data). Rock glaciers are a feature on the landscape with the potential to store water (in the form of ice) into the summer months until it is released as meltwater. Often this water source beneath talus or rock fields, which may buffer projected warming and snowpack decline for high elevation flora and fauna, is not recognized (Millar and Westfall, 2008).

The sub-shrub *Linanthus pungens* (Torr.) J.M. Porter & L.A. Johnson (Polemoniaceae), one of the more widespread plants at BL (Fig. 2), was chosen for chronology-building because of its cosmopolitan distribution, relative longevity, and clearly demarcated ring boundaries. *L. pungens* is a one to three-decimeter tall, suffrutescent plant with a dense multi-branching crown, and it grows on rocky, well-drained soil at elevations of 1000 to 3500 m throughout the western United States and British Columbia.

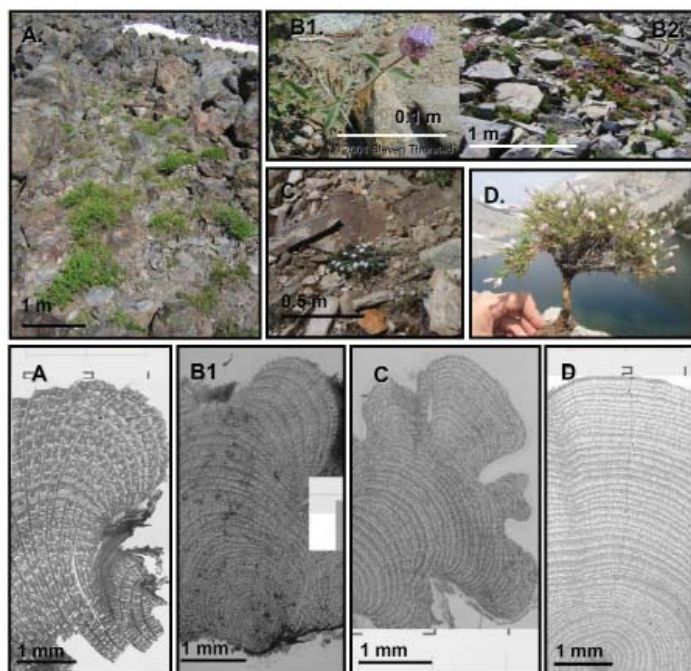


Figure 2. BL Rock Glacier plant types and corresponding wood anatomical structure. Twenty-nine vascular plant species were found in a vegetation survey of the BL rock glacier. Some typical plant species found on the BL rock glacier and their corresponding wood anatomical structure are: A) larger shrubs, *Ericameria* spp.; B) forbs, *Monardella odoratissima* and *Primula suffrutescens*; C) sub-shrubs, *Phlox difussa*, D) the study shrub, *Linanthus pungens*.

Histological cross sections of *L. pungens* main root were crossdated (precise year of formation assigned to every ring in the chronology) using diagnostically wide and narrow marker years common to all samples of individuals collected at the BL site (Fig. 1). Standardization of the chronology was performed with ARSTAN (Cook & Peters, 1981; Cook, 1985) using a two-thirds spline, which removed individual growth trends and accounted for auto-correlation of a ring with the previous years' growth. The ARSTAN-produced chronology was the residual chronology

with the common signal estimated using the bi-weight robust mean. The Barney Lake *L. pungens* chronology is 112 years in length with sufficient sample replication (expressed population signal, EPS, > 0.75) to capture a robust common signal from 1946 through 2007.

Correlation and response function analyses used to evaluate the climate-growth response of the *L. pungens* chronology were conducted with DendroClim2002 (Biondi and Waikul, 2004) using Parameter-elevation Regressions on Independent Slopes Model (PRISM) (Daly, 2002) generated monthly precipitation (PPT) and temperature (T) for BL. The BL chronology was also compared against regional 1 April snow water equivalent (SWE). To represent a regional snowpack pattern, data from four snowcourse stations near BL (Tioga Pass, Virginia Lakes, Mammoth Lakes and Agnew Pass) were standardized and averaged. 1 April SWE was used as a metric for snowpack, because records for this month are longer than those of any other months of the year; and the April 1 SWE represents a standard measure of snow pack variability (Mote, 2003). Snowpack data were accessed from the California Department of Water Resources Data Exchange Center.

Linanthus pungens: Annual Ring Growth and Climate

Marker years in the BL chronology correspond to drought (wide rings) and persistent snowpack (narrow rings). Response function analysis indicates significant associations with July T maxima and previous year's November PPT. Radial taproot growth has varied little over the past century and is correlated with T (positively; $R = 0.6$, $p < 0.01$) during the early portion of the chronology period and with SWE and PPT (negatively; $R = -0.43$ and -0.41) during the latter half of the chronology period. For the entire chronology period, response function values are significant at the 95% confidence level for prior November PPT (-0.23) and current July maximum T (0.22) (Fig. 3).

A plot of T, PPT and SWE time-series shows an apparent change in synchrony and an increase in SWE variance for the second half of the chronology period. For the second half of the chronology (after 1968), T and PPT are more highly and significantly anti-correlated and SWE switches from being not significantly correlated with either June-July T or previous November PPT to being highly and significantly correlated with PPT ($r = 0.81$, $p < 0.001$) and highly and significantly negatively correlated with June-July temperature ($r = -0.62$, $p < 0.01$) (Fig. 3).

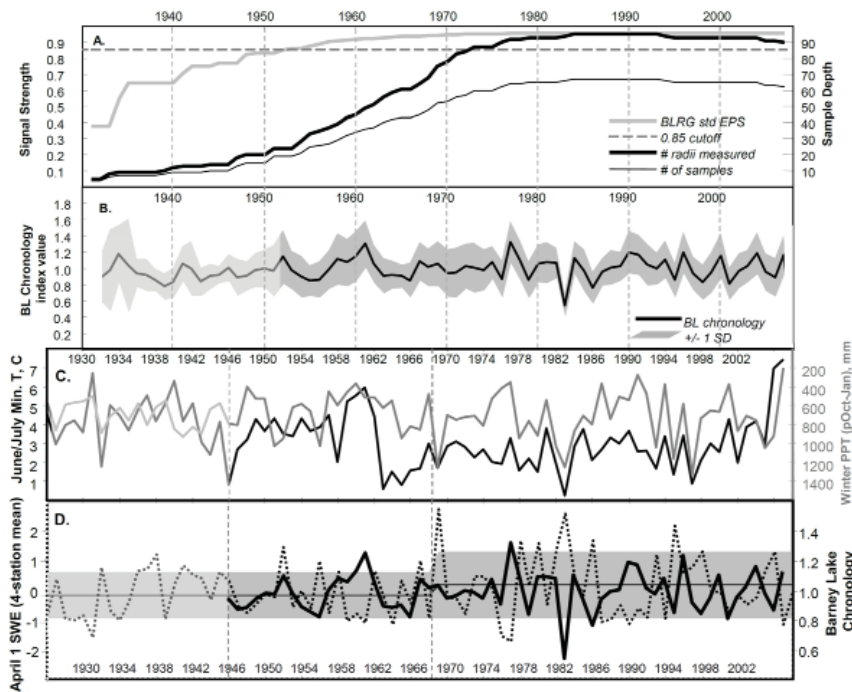


Figure 3. BL Rock Glacier Chronology and Climate Time Series. A) Sample depth through time, thick black line; number of radii measured, thin black line, EPS value, grey line, 0.85 cut-off level (for evaluating EPS value), dashed grey line. B) Barney Lake chronology (residual time series) is in black and grey shading indicates plu or minus one standard deviation. Years before 1952 are shaded, indicating an EPS value below 0.85. C) Time series for June-July average temperature (black line) and winter (previous October – current January) precipitation (grey line) for the PRISM 800-meter gridcell at the BL site (note that the axis for precipitation is reversed for ease of comparison). D) Time series of a four-station average of April 1 SWE values (dashed line) and the BL chronology (solid line). Grey shading indicates the variance (± 1 SD) in SWE for the two periods, 1926 – 1968 and 1969 – 2007.

A Closer Look at the Influence of Snowpack

As several of the rings with the highest negative [positive] standard deviations in the BL chronology (i.e. 1983, 1986, 1995, [1961, 1977]) occur during years of record snowpack [drought] in the Sierra Nevada and response function values are highest for winter PPT (negative associations), the BL chronology was regressed against the regional April 1 SWE composite. For ease of visualizing the relationship between snowpack and ring width growth, April 1 SWE values were ranked from highest to lowest and divided into deciles. The years in each decile were linearly regressed against the same years of the BL chronology. The results are plotted in Fig. 3 as relative April SWE value in deciles against correlation with the BL chronology. This was done to capture the non-parametric relation between April 1 SWE and the BL chronology in years of extreme high and low snowpack, as years of average snowpack were less highly correlated with the chronology.

A contingency table was constructed to quantify the relationship between snowpack and *L. pungens* growth (Fig. 4). Both snowpack and BL chronology values were partitioned into quintiles from lowest to highest values. The likelihood of coincidence of highest and lowest quintile from each dataset falling in the same year was then calculated and compared to the actual coincidence of high-high, low-high, high-low and low-low

years. There was a significantly higher than expected incidence of both high snowpack-low ringwidth years and low snowpack-high ringwidth years with a confidence value of $p < 0.02$ (for an adjusted G statistic to account for the special case of low expected values).

As noticed for the trends in PPT and T relationship with ring width over the chronology period, the correlation coefficients between *L. pungens* ring width and April 1 SWE shift between 1968 and 1969. A plot of the four-station mean of April 1 SWE values is also divided into two time periods: 1926 – 1968 and 1969 – 2007 (Fig. 3). Prior to 1969 there is relatively low variability in the snowpack record; and from 1969 – 2007 there is a significant increase in April 1 SWE variability ($p < 0.05$). Coincident with fewer years of extremely high or low SWE values, the Pearson's Correlation Coefficient (PCC) for the BL chronology and April 1 SWE from 1946 – 1968 is approximately 0, but switches to a strong anti-correlation ($r = -0.43$, $p < 0.01$) for the period 1969 – 2007. The increase in anti-correlation coincides with the increased incidence of high snow pack levels post-1968. During years of high peak snowpack, extremely narrow or “micro-rings” are produced in *L. pungens* at this site (Fig 1).

The Future of Alpine Shrubs

Figure 3 displays the increase in synchrony of drier (wetter) winters and warmer (cooler) growing seasons since 1969; these patterns appear to amplify the response of *L. pungens* growth to winter PPT and snowpack. If this synchrony persists into the future, the expected decrease in the level of snowpack in the Sierra Nevada for the coming century (Dettinger and Cayan, 1995; Kapnick and Hall, 2010) could possibly indicate increased growth for alpine shrub species with a similar climate response as *L. pungens*. However, with projected increases in temperatures for California and the Sierra Nevada (Cayan et al., 2008), the decreasing positive correlations with growing season temperature and *L. pungens* may at some time place a limit on future growth.

Even with these two climate variables predicting seemingly different growth trajectories for this shrub, the heterogeneity

of the mountain landscape may provide thermal relief for high elevation species as surface temperature variations between alpine microhabitats are found to be up to 10 °C in some mountain regions. Temperature mosaics in the alpine landscape may provide a buffer for rising isotherms at high elevations, indicating that there may be local refugia for plants in these habitats (Scherrer and Körner, 2011). However, a modeling study found topography to impede the ability of alpine plants to migrate upslope in some cases (Van de Ven et al., 2007).

Although decreases in snowpack are expected in the coming century for the Sierra Nevada range (Dettinger and Cayan, 1995; Hayhoe et al., 2004; Kapnick and Hall, 2010), increased shrub growth (both in upslope establishment and increased crown dimensions) may provide enough raised relief on the alpine landscape for a small increase in local snow accumulation (e.g. as in some Arctic sites; Sturm et al., 2001). Even if this is true for the alpine Sierra Nevada, changing PPT and snowpack levels will still exert an increasing influence on alpine shrub growth and distribution in xeric mountain areas. Changes in albedo and winter and summer temperatures due to up- or around-slope shrub encroachment will likely modify alpine conditions further still.

A. Correlations Between Climate Variables and BL Chronology

Correlation Variables			Time Period	
			1946 - 1968	1969 - 2007
1 April SWE	-	BL	0.00	-0.43**
June + July T	-	1 April SWE	0.27	-0.62***
pNov PPT	-	1 April SWE	0.4	-0.80***
June/July avg T	-	pNov PPT	-0.43	-0.50***

B. Changing Snowpack Variability

	1926 - 1968	1969 - 2007
Mean 1 April SWE	29.03 ‡	33.86 ‡
SD	10.25 ‡‡	14.81 ‡‡
N	43	40

Pearson's r Correlation significant at ***p < 0.001, **p < 0.01, *p < 0.05

‡ indicates means are not significantly different

‡‡ indicates variances are significantly different at p < 0.05

C. DendroClim2002 Correlation and Response Function

Minimum Temperature		Maximum Temperature		Precipitation	
Correlation					
April	0.25	p-November	0.34	p-October	-0.31
June	0.28	April	0.26	p-November	-0.34
July	0.31	June	0.21		
		July	0.40		
Response Function					
		July	0.22	p-November	-0.23

Figure 4. Chronology-Climate Correlations. A) Pearson correlation coefficients for the BL chronology and climate variables for the BL site for the time periods 1946 – 1968 and 1969 – 2007. B) Mean SWE values, standard deviation and number of years for each of the two periods. C) DendroClim2002-derived correlations and response functions.

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BREVIA

A Tree-Ring Record of Monsoon Climate in the US Southwest

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Griffin D., D.M. Meko, R. Touchan, S.W. Leavitt, and C.A. Woodhouse. 2011. Latewood chronology development for summer moisture reconstruction in the US Southwest. *Tree-Ring Research*, 67: 87-101.

Southwestern North America is characterized by seasonally distinct and dynamically independent precipitation regimes (e.g., Sheppard et al. 2002). Cool-season precipitation comes from frontal storms associated with the westerly-driven winter storm track. In contrast, warm-season precipitation is delivered by convective thunderstorms associated with the summer monsoon (Fig. 1; Douglas et al. 1993; Adams and Comrie 1997), which emanates northward from western Mexico from July through September. Although regional water supplies derive primarily from winter precipitation, the summer monsoon contributes substantially to annual precipitation totals across the region (Fig. 2). Monsoon precipitation is particularly dramatic over the southwestern U.S. (e.g., Higgins and Shi 2000), and this variability impacts the social and environmental systems of the southwest (Ray et al. 2007). For example, monsoon precipitation modulates wildfires, ecosystem structure and health, dryland and rangeland agricultural productivity, and demand for imported surface water supplies. As southwestern resource managers begin adapting to 21st century climate changes, understanding the nature of long-term monsoon variability is more important than ever. This was our motivation for turning, once again, to tree-ring records as proxies for paleoclimatology.

In the Southwest, cool-season precipitation dominates the annual water balance and is primary driver of annual tree growth (St. George et al. 2010). Accordingly, most of the regional tree-ring studies of hydroclimate have targeted annualized or cool-season variability. However, it has long been hypothesized (e.g., Douglass 1919; Schulman 1951) that “latewood,” the dark-colored summer growth component of annual conifer tree rings (Fig. 3), contained monsoon-specific precipitation signal. Over the past decade, the potential for latewood reconstruction of monsoon hydroclimate has been clearly demonstrated (Meko and Baisan 2001; Therrell et al. 2002; Wright and Leavitt 2006; Sheppard and Wiedenhoef 2007; Stahle et al. 2009). Drawing on these findings, we recently developed the first systematic network of monsoon-sensitive latewood chronologies for the southwestern U.S. (Fig. 2; Griffin et al. 2011). We made new collections at over 50 historic sampling sites, and for the first time, analyzed earlywood-and latewood-width on archived and newly collected tree-ring specimens. Our recently minted database of earlywood and latewood chronologies offers a novel means for evaluating the Southwest’s dual-season hydroclimatic history.

Targeting the Arizona-Sonora sub-region of the North American monsoon (Fig.2; NAME 2012), we used principal components multiple linear regression to develop high-quality reconstructions of standardized precipitation (Guttman 1999) for the cool season (Oct-Apr) and summer monsoon (Jun-Aug). These reconstructions explain over half of the variance



Figure 1. A monsoon thunderstorm (right) moves across the Tucson Valley, July 17, 2009. Summer rains eventually extinguished the naturally ignited “Guthrie” wildfire (left). Photo: D. Griffin.

in the instrumental precipitation records (Fig. 4), pass standard validation tests, and extend from CE 1539-2008 (Fig. 5). Analysis of the monsoon reconstruction points to a period of dry summers in the late 19th century more persistent than any during the instrumental era. Comparison with the companion reconstruction (Fig. 4) indicates that persistent monsoon drought often coincided with cool-season drought periods, including the 16th century Megadrought (e.g., Stahle et al. 2000), the 17th century Puebloan drought (e.g., Parks et al. 2006), and the ongoing 21st century drought (Cook et al. 2010; Woodhouse et al. 2010).

We are currently developing monsoon precipitation reconstructions for other regions in the southwest (i.e. New Mexico; Four Corners) and are in the process of evaluating the relationship between these records and large-scale modes of ocean-atmosphere variability. This research offers a novel paleoclimatic perspective on the current drought and underscores the importance of precipitation seasonality in the Southwest. The new latewood dataset establishes an accurate, precisely-dated geochronology for comparison with other paleorecords of monsoon climate (e.g., speleothem, terrestrial and marine sediment proxies), and provides a target for comparison with regional climate model output.

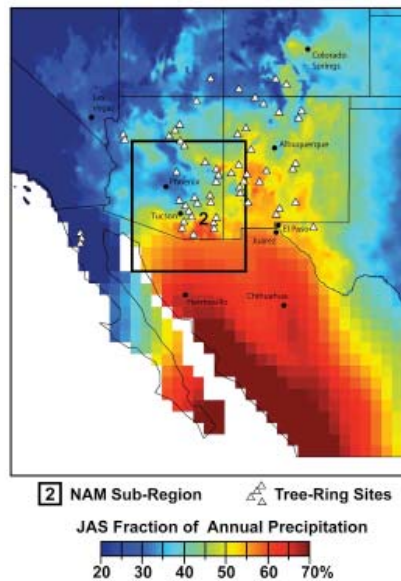


Figure 2. Map showing the July-September fraction of annual precipitation (color ramp), sub-region 2 of the North American monsoon (NAME 2012; black box), and location of new monsoon-sensitive latewood chronologies (triangles).

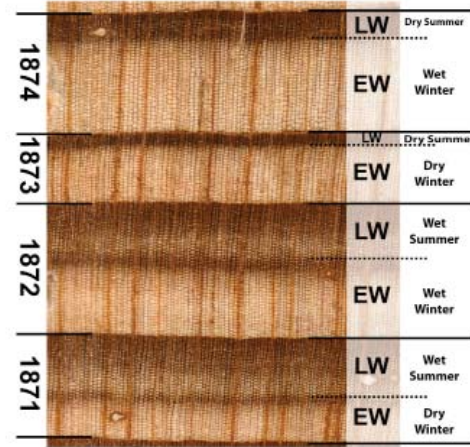


Figure 3. A photomicrograph illustrates four annual Douglas-fir (*Pseudotsuga menzeisii*) growth rings (1871-1874) from the Gila Wilderness of southwest New Mexico. Note the independent width variability of the light-colored earlywood (EW) and the dark colored latewood (LW), which correspond to season-specific moisture variations.

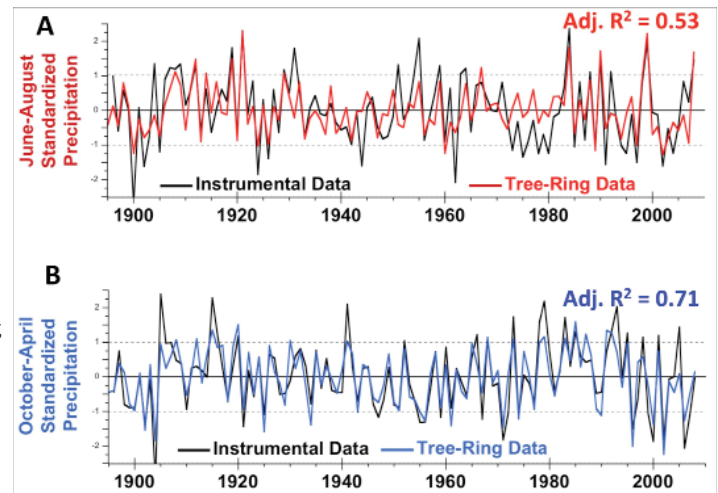


Figure 4. Time series of observed (black) and reconstructed (colored) standardized precipitation indices for the summer monsoon (a; red) and the cool season (b; blue). R^2 has been adjusted downward for the degrees of freedom lost in regression.

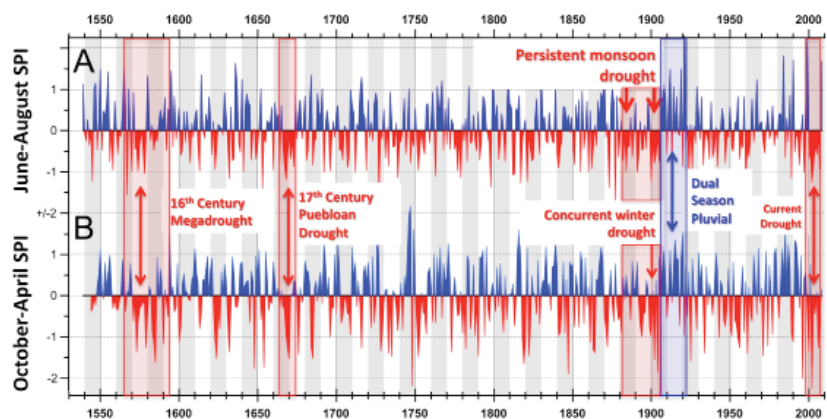


Figure 5. Reconstructed standardized precipitation indices for the summer monsoon (a) and cool-season (b), CE 1539-2008.

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DATA BASIN

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Data Basin (www.databasin.org), built by Conservation Biology Institute (CBI; www.consbio.org), has been publically available for 17 months and has become a robust mechanism for organizing, publishing, and disseminating spatial datasets and associated information. To date, Data Basin has nearly 3,500 registered users (Fig. 1), the majority of whom are professionals and self-identify as conservation scientists, practitioners, policy-makers, advocates, consultants, educators, students, or interested citizens. Data Basin users are associated with academic/research institutions (25%), non-profits (18%), corporations (11%), federal government (10%), local or regional government (6%), foundations (>1%), and other (29%). CBI expects the role of Data Basin to grow and is looking for new collaborations to develop innovative tools that make spatial information even more easily available to the public and useful to land managers.

There are over 5,600 publically available spatially explicit biological, physical, or socio-economic datasets in Data Basin. They may show where a bird species has been observed, where a particular type of forest management changes with land ownership, where the highest number of renewable energy project permit applications occurs in a particular region, or where climate models disagree about projections of climate change. Most recently, Data Basin was updated to allow the import and visualization of time-enabled datasets in NetCDF format, the original file format used for most climate change information released by the various research teams around the world. The change in file format is absolutely transparent to Data Basin users who will visualize the dataset in exactly the same way as any other map. But in addition to viewing animations of the data on their screen, users will also be able to save the animations as movies to share with colleagues. Over 200 datasets from the North American Regional Climate Change Assessment Program are being uploaded this month (Feb 2012) and these regional climate projections will be made available to users as monthly averages for current and future conditions (<http://bit.ly/ybX7lK>).

Data Basin users have downloaded over 7,000 datasets thus far. Academics/researchers, corporations, and non-profits account for the majority of dataset downloads. For user-defined and customized maps, recent improvements in exporting make it easier than ever. In the past, exporting a map was restricted to a PDF document or a ZIP file containing PNG images of the pages of the PDF document. The new ZIP file now contains individual images of the map components (the map image, individual legend images, and an image of the locator map) that can be used in any third-party application. In addition, any dataset can be exported in PPT format, which greatly simplifies the creation of PowerPoint presentations using spatial datasets accessed on the web site.

Data Basin users have established more than 160 working groups (user-defined subset of Data Basin users) for a variety of purposes and topics, such as (a) taxonomic focus (e.g., Longfin smelt, California Mammal Species of Special Concern, etc.), (b) specific topics and regions (e.g., Bear River Watershed Planning, Agua Fria Collaborative Adaptive Management, Great Basin Connectivity), (c) organizational data sharing (e.g., Wild Connections, Freshwater Trust), (d) conferences, workshops, or other events (e.g., Society for Conservation Biology 2011, Wild Links), and (e) online courses (e.g., Biodiversity Informatics 2011). Data Basin now includes a Spanish version with many South American datasets documented in Spanish.

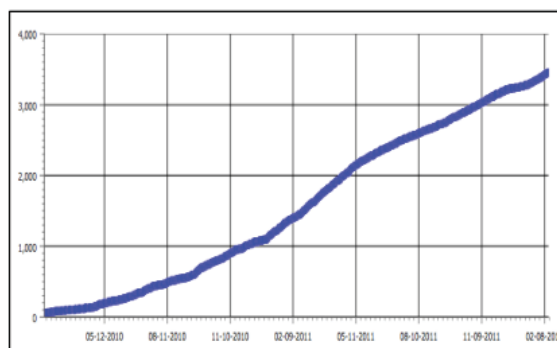


Figure 1. Number of users of Data Basin.

For a fee, organizations can also now customize a portion of Data Basin to focus on their specific region or topic. These ‘gateways’ provide a view of a subset of Data Basin content, but allow for easy access/integration with other resources in Data Basin (e.g. global climate projections). For example, the IABIN gateway (www.databasin.org/iabin) hosts Latin America datasets and tools relating to (a) ecosystems, (b) invasive species, (c) pollinators, (d) protected areas, and (e) species & specimens. Other gateway examples include: (1) the Forest Stewardship Council (FSC-US) Controlled Wood Gateway (www.databasin.org/fscus): a platform for FSC certificate holders and other stakeholders to better understand regional environmental and social risks (e.g. legality, traditional & civil rights, high conservation values, forest conversion, GMO) and (2) the Yale Mapping Framework: Integrating Climate Adaptation and Landscape Conservation Planning (www.databasin.org/yale).

We encourage you to use Data Basin to share your data or encourage your colleagues to share their data through this truly innovative website, because the richness of the site depends greatly on your contributions. We also encourage you to collaborate with us on proposals that could provide financial support to upload datasets or develop new web tools to analyze or display your data of interest.

For further details contact Tosha Comendant (tosha@consbio.org) or Dominique Bachelet (dominique@consbio.org).

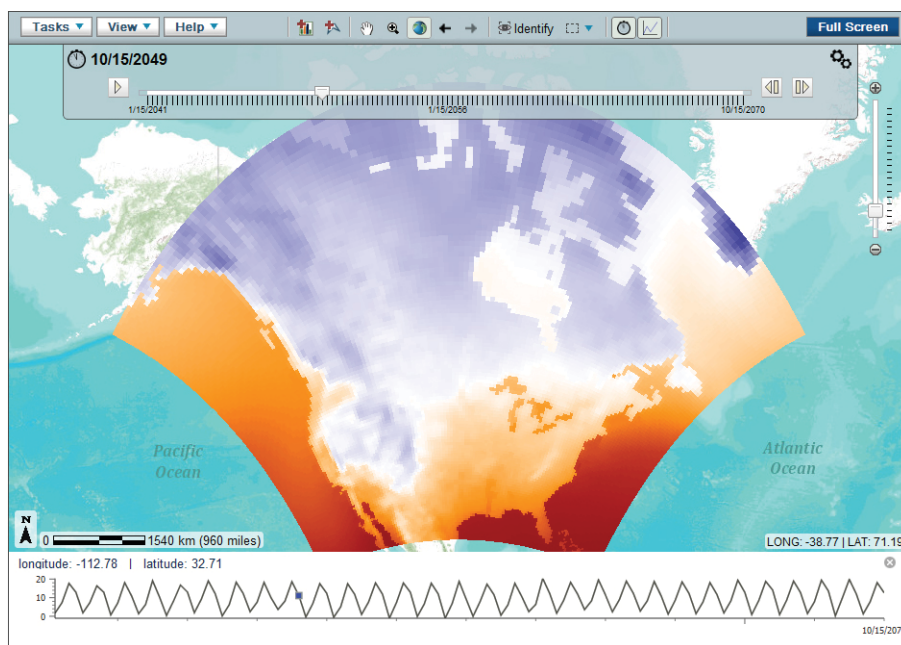


Figure 2. Screen capture from Data Basin showing the time slider allowing animations of the monthly changes in future temperature simulated by one of NARCCAP (North American Regional Climate Change Assessment Program) regional climate models.

The WestWide Climate Initiative; Preparing for Climate Change on Federal Lands

Dave Peterson

*USDA Forest Service, Pacific Northwest Research Station
Seattle, Washington*

Just five years ago, adaptation to climate change was only a concept for land management agencies in the United States (U.S.). Now federal agencies have a wide range of information and tools for assessing the vulnerability of natural resources to climate change and developing management strategies that will help mountain ecosystems adjust to a changing environment. The primary objective of the WestWide Climate Initiative (WWCI) has been to provide the scientific foundation for adaptation across the western U.S.

A coalition of scientists in the Pacific Northwest, Pacific Southwest, and Rocky Mountain Research Stations of the U.S. Forest Service, the WWCI has focused on three projects: (1) developing a web-based portal of information on climate change for federal resource managers (Fig. 1), (2) writing an adaptation guidebook applicable at the national level, and (3) implementing case studies of adaptation on national forests and other lands in the West (Fig. 2). These projects are now mostly complete, accompanied by several publications that document WWCI accomplishments.

The Climate Change Resource Center (<http://www.fs.fed.us/ccrc>) is regarded as the premier website for climate change information for federal land managers. It contains an annotated bibliography with thousands of citations, summaries of climate science for a broad range of issues, online scientific presentations, links to scientific sources relevant for managers, and short courses on adaptation, carbon, water resources, and fisheries. It receives thousands of hits each year and is used far beyond its home base of the Forest Service.

A recently published guidebook for climate change adaptation in national forests provides a state-of-science summary of principles of adaptation, methods for vulnerability assessment, and tools and processes to facilitate the development of adaptation strategies and tactics. Distributed to all 176 national forest units, the guidebook is being used throughout the Forest Service and by

other agencies to integrate climate change in sustainable resource management.

Finally, case studies of vulnerability assessment and adaptation in national forests in California, Washington, and Wyoming have been pioneering efforts across large landscapes. Conducted in collaboration with National Park Service units, the case studies have tested different tools and processes, creating a cadre of scientists and managers who are “early adapters” available to network with others who want to begin the adaptation process.

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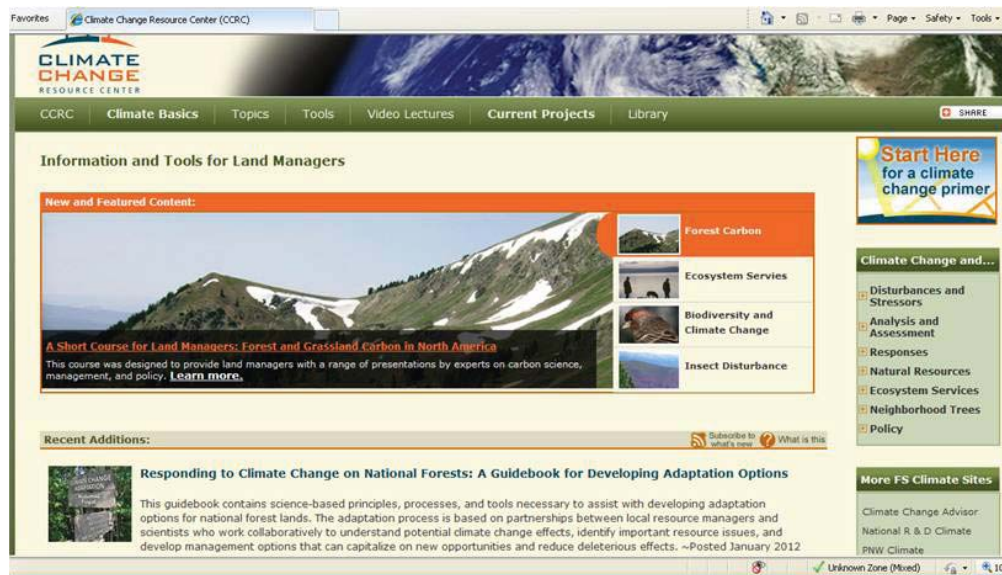


Figure 1. The Climate Change Resource Center (<http://www.fs.fed.us/ccrc/>) is the go-to web portal for information on climate change adaptation and mitigation for natural resource managers, developed by the WestWide Climate Initiative.

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Figure 2. Case studies were a critical component of the WestWide Climate Initiative. Break-out groups here on the Inyo National Forest, Bishop, CA, discuss potential climate adaptation options. Photo: T.L. Morelli

Did You See (Hear, Feel, Touch, Smell,) It?

Oddities of Mountain Weather and Climate

For this new section of Mountain Views Newsletter, we invite submissions of interesting or unusual mountain weather or climate-related phenomena you have witnessed. We introduce the section with several observations of rare ice events, apparently related to unusual circumstances of freeze-thaw conditions during late 2011 and early 2012. We welcome your comments on processes and observations described. --Editors

#1 The Sierran Frood (Rhymes with 'Flood) of Winter 2011/2012

Connie Millar¹ and Wally Woolfenden²

¹USDA Forest Service, Albany and Lee Vining, California

²USDA Forest Service (retired), Swall Meadows, California

By late December, 2011, residents of the eastern Sierra Nevada, CA were sharing among themselves stories and pictures of what we could only describe as frozen-floods along river banks and across meadows of the eastern escarpment (Figs. 1, 2). The early snows of October had long melted in all but the high country or on cold and shady north slopes; since those storms, the region experienced virtually no precipitation, and days were sunny and clear. For the first time in collective memories, all three “closed-in-winter” highway passes (Tioga Pass, Sonora Pass, and Monitor Pass) remained open into the new year, providing access to high-country that is usually slumbering by November.

Dubbed the Sierran Frood by Jeff Wyneken of Mono City, our observations were characterized by clear or frosty expanses of solid ice flows that mounded above running water or local depressions and flowed overland, sweeping in halt-action form across slopes and through meadows. In some cases running water appeared to be the source of the ice, even then the ice flowed far from stream channels. In other cases no running water was apparent and only lingering snow seemed a source of water. These ice flow formations occurred from relatively low areas of the region, for instance along the Walker Canyon of West Walker River (1530 m) to elevations above 3500 m, in Rock Creek Canyon (Fig. 3) and below Tenaya Pk (Fig. 4).

Having never seen this phenomenon before, we conjectured that the Sierran Frood events resulted from the unusual combination this fall and winter of freezing nights, very warm (but short, given the season) daytime temperatures, and lack of snowcover. Clear skies and little wind favored especially cold nights with

inversions common. What sources of water existed (creeks or rivers; lingering snow) froze hard at night, as did exposed soils, but melted rapidly in the unusual warmth of daytime. During midday, we saw surfaces of existing ice flows melting, with water flowing over underlying ice and soils, which by virtue of being frozen and saturated, did not allow water to infiltrate. Instead, the meltwater drained around and over existing mounds, flowing overland and even up slight slopes to be frozen in action once again by cold night temperatures. Repetition of these freeze-thaw conditions seemed to be the process that enabled build-up of the beautiful frozen floods we were seeing.



Figure 1. Meadow along Clearwater Creek, Bodie Hills (2200 m), Mono Co., California. Photo: C. Millar.



Figure 2. Another view along Clearwater Creek, enroute to Bodie State Historic Park. Photo: C. Millar.



Figure 3. Little Lakes Valley, Rock Creek Cyn (3230 m), Inyo Co., California. Photo: W. Woolfenden.



Figure 4. Tenaya Creek, near Tenaya Peak, Yosemite National Park (2480 m), Merced Co., California. Photo: Gary Milano.

Did You See (Hear, Feel, Touch, Smell,) It?

Oddities of Mountain Weather and Climate

#2 Feather Frost in Oregon

George Taylor

Applied Climate Services, Corvallis, Oregon

Reprinted with permission from George Taylor's blog: <http://appliedclimate.wordpress.com/>

My friend Dennis Creel sent some amazing pictures of a rare phenomenon, “feather frost” (Figs. 1, 2). According to Dennis, “David Hampton was out in the brush laying out a harvest unit and took these pictures with his cell phone. They were near Grand Ronde on Hampton Resources Timberland.”

According to *SnowCrystals.com*, “Some of the stranger ice formations you’re likely to find in the woods are called “frost flowers” or “feather frost”. A typical example looks like a small puff-ball of cotton candy, a few inches across, made up of clusters of thin, curved ice filaments. Frost flowers usually grow on a piece of water-logged wood. It’s something of a rare find, meaning that conditions have to be just so before it will form. Not much has been written on this unusual phenomenon, and to my knowledge it has never been reproduced in a controlled laboratory environment. It appears that the ice filaments are essentially

pushed out from pores in the wood as they freeze. It’s something of a misnomer to call this frost, by the way, since it freezes from liquid water, not water vapor.”

For further information and more pictures, see: Carter, J.R. 2012. Ice formations with daily (diurnal) freeze/thaw cycles.

<http://my.ilstu.edu/~jrcarter/ice/diurnal/>



Figure 1. Frost feathers at Agency Creek, Oregon.
Photo: Dennis Creel.



Figure 2. More frost feathers at Agency Creek.
Photo: Dennis Creel.

Interview: Jill Baron Elected as President-Elect of the Ecological Society of America

U.S. Geological Survey research ecologist Dr. Jill Baron was recently named President-Elect of the Ecological Society of America. As a USGS research ecologist (Natural Resources Ecology Lab, Colorado State University, Ft. Collins, CO), Dr. Baron has led national efforts to understand the consequences of nitrogen deposition and climate change on mountain ecosystems and identify ways for public lands managers to prepare for and adapt to these changes. She was a member of the Science Strategy Team that now shapes the intellectual direction of the USGS, and is founder and Co-Director of the John Wesley Powell Center for Earth System Science Analysis and Synthesis. She has been involved in other roles with the ESA since 1991.

Dr. Baron has edited two books: *Rocky Mountain Futures: An Ecological Perspective* (Island Press 2002), which addresses the past, present, and possible future human influences on ecosystems of the Rocky Mountains, and *Biogeochemistry of a Subalpine Ecosystem* (Springer-Verlag 1992), which summarized the first 10 years of long-term research in the Loch Vale Watershed in Rocky Mountain National Park. Dr. Baron received her Ph.D. from Colorado State University in 1991, and has undergraduate and master's degrees from Cornell University and the University of Wisconsin. She has authored more than 140 publications.

Dr. Baron is the recipient of numerous achievement awards for her work from the National Park Service, USGS, and USDA Forest Service, including the Department of the Interior Meritorious Service Award in 2002. She has been a member of the Governing Board of the Ecological Society of America, serves on several Science Advisory Boards, has given testimony to Congress on acid rain, and is an Editor-in-Chief of *Issues in Ecology*, an ESA publication for communicating accurate and unbiased summaries of the current status of scientific knowledge on environmental issues to non-scientists. Results from her long-term mountain research have been used to set air quality policy in the State of Colorado.

-- Modified from the USGS Press Release. December 15, 2011.

Jill graciously gave me time to answer questions I had about her new appointment.
 – Connie Millar

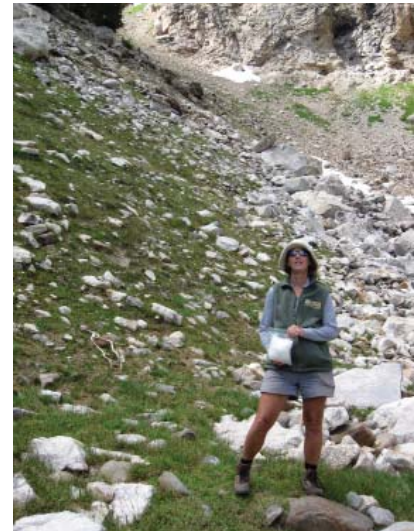


Figure 1.
Jill collecting snow
in Grand Teton NP.

Connie: Hearty congratulations, Jill, on your election as President-Elect of the Ecological Society of America (ESA)! Can you explain a little of what this position will entail? How long does your appointment last? During this time will you maintain your ongoing research program and other collaborative projects or set them aside?

Jill: At a minimum, the President chairs Governing Board meetings, but that is not the answer you are looking for. Among ESA's purposes are promotion of the science of ecology, raising public awareness of the importance of ecological science, attracting a continual supply of new ecologists, increasing the resources available for the conduct of ecological science, and ensuring the appropriate use of ecological science in environmental decision-making. Since ESA governs by committee, and has an extremely effective, efficient professional staff, my role will be mostly to keep the organization successfully moving forward.

I will officially start as President-Elect in August 2012, serve a year as President (2013), and then one more year as Past-President (2014), but I've begun to take on chores already because there is so much to do!

But not so much to do that I can't maintain our wonderful mountain ecosystem research efforts and direct the Powell Center for Earth System Science Analysis and Synthesis (<http://powellcenter.usgs.gov/index.php>). A past president described the time involved as adding one more research project to the portfolio. I hope he's right.

Connie: Do you have specific goals or projects you hope to engage as President of ESA?

Jill: Why yes, yes I do! I've been involved with ESA long enough to be strongly influenced by several pivotal ESA initiatives that have not only shaped the Ecological Society, but the direction of Earth and Environmental Science in this country. The Sustainable Biosphere Initiative (led by Jane Lubchenco set forth an ecological research agenda to understand human impacts on the environment and enhance environmental capacity to provide for and sustain the world's population. The Visions Report developed the blueprint for implementation. And now we are trying to accomplish the implementation under the Earth Stewardship initiative in an attempt to actively shape trajectories of social-ecological change to enhance ecosystem resilience and human well-being. During my presidency I would like to increase the effectiveness of our (i.e., ecological scientists) communication about environmental challenges facing all of Society, and begin to move the dialog toward solutions. If this sounds familiar, it should. These are the same goals identified over and over among the world's mountain science community.

Connie: Are there ways that CIRMOUNT and mountain colleagues broadly might contribute to these efforts?

Jill: Many ways. We can all become more effective communicators about environmental challenges and solutions, drawing from scientific evidence but framing it in language that appeals to the many sectors of society that are influential agents of change. My goal would be to have every mountain scientist and every ESA member (all 11,000 of them) become fluent global change ambassadors that help convince people to reduce the causes and impacts of climate change, correct the disruption of other major global biogeochemical cycles, implement more sustainable water use practices, and so on. The goal is sustainability, and our mountain environments are especially dramatic examples of how far from sustainable we are. The rapid, and sometimes irreversible, changes we observe in mountains can be used to highlight the urgency for better stewardship, but also the successes we can achieve if we put our knowledge to good use. Should we consider holding a workshop at *MtnClim* on effective communication skills?

Connie: Leadership capacity and science excellence are key traits sought for incumbents of this position. In reflecting on your career, what elements of leadership do you most enjoy? Do you have any guiding philosophy in how you approach your research?

Jill: Well, no woman is an island, and as an ecosystem ecologist I know the complex issues facing society can only be addressed through collaboration. The synthesis of ideas from many disciplines and experiences allows us to learn from each other, to develop a kind of collective intelligence that I think leads to faster breakthroughs in understanding. I have the most fun pulling together great teams so we can do that. And fun is the operant word. Yes, this is geeky, but what could be more fun than bringing great creative people together in a beautiful (mountain) place to ask interesting questions? Good local food and beer/wine help, too! The Powell Center, which I founded, is now attempting to facilitate that same level of energy and creativity for others by supporting groups of scientists who come together to address interdisciplinary questions of their choice.

Connie: Jane Lubchenco, currently Under-Secretary of Commerce for Oceans and Atmosphere and Administrator of NOAA, served as President of ESA (as well as AAAS) in years prior to her appointment by President Obama. Would you have aspirations for such leadership roles in Department positions, and if so, how would their serve your career goals?

Jill: Not a chance! No way would I ever be as effective as Jane Lubchenco (or Marcia McNutt, for that matter), and it would take me away from research and the mountains. Scientists can and must be extremely effective agents of change at all scales, not just national.

Connie: What aspect of the position as President-Elect are you most eagerly anticipating?

Jill: Working with whole new communities of bright people!



Figure 2. Jill (center right) with Lindsey Christensen, David Swift, and Melannie Hartman in Rocky Mountain NP.

News and Events

MTNCLIM 2012, CIRMOUNT's Biennial Mountain Climate Conference

October 1 – 4, 2012, Estes Park, Colorado

www.fs.fed.us/psw/mtnclim/

Deadlines for Registration and Abstracts: July 20, 2012 – see website

The MTNCLIM research conferences are sponsored by CIRMOUNT and dedicated to promote communication on mountain climate sciences and effects of climate variability on ecosystems, natural resources, and management of western North American mountains. MTNCLIM conferences feature invited and contributed talks, poster sessions, and field trips. Post-conference workshops are organized for natural-resource managers to address implications of climate variability and climate change in conservation and resource management. MTNCLIM convenes every two years, and alternates inter-annually with the PACLIM (Pacific Climate) Workshop.

MTNCLIM 2012 will be held October 1-4, 2012 in Estes Park, Colorado at the YMCA of the Rockies (website above).

On Sunday (September 30), Bill Bowman (Dept of Ecology and Evolutionary Biology, University of Colorado, Boulder, CO) will lead a pre-conference field trip to the Niwot Ridge Long Term Experimental Research Site (<http://culter.colorado.edu/NWT/>), where a long history of interdisciplinary research has focused on the conceptual model of the Landscape Continuum. A short field trip on Monday will visit research sites along the Trail Ridge Highway in Rocky Mountain National Park.

The main MTNCLIM 2012 conference convenes Monday afternoon, Oct 1, with check-in at 4pm, dinner at 6pm, and Kelly Redmond (Desert Research Institute, Reno, NV) giving his now-famous, *Climate Round-Up* talk for 2011-2012 as the opening evening session. Invited-session themes Tuesday through Thursday noon include *Mountain Lakes*, *Humans and Mountains of the West* (the Dennis Machida Memorial Session), an *Early Career Scientists Session*, and panels on the *Future of Mountain Climate Research* and *Emerging Mountain Climate Institutions*. Invited presentations will address the *Role of Human Intervention in Climate Adaptation and Extreme Events*. Harald Bugmann (Institute of Terrestrial Ecosystems, Zurich, Switzerland) will give a keynote talk addressing comparisons among mountain climate ecosystems and climate adaptation strategies, and Ellen Wohl (Colorado State University) will give another keynote talk on the changing role of rivers in shaping mountain ecosystems.

A post-conference Manager's Workshop takes place Thursday afternoon (Oct 4), after MTNCLIM 2012 adjourns. This workshop is entitled *Bridging Boundaries; Climate Change Adaptation Planning*, and organized by Linda Joyce, USFS, Rocky Mountain Research Station, Ft. Collins, CO; Jill Baron, USGS, Natural Resources Ecology Lab, Colorado State University, Ft. Collins, CO; Gregg Garfin, School of Natural Resources and the Environment, University of Arizona, Tucson, AZ; and Sarah Hines, USFS Rocky Mountain Research Station, Ft. Collins, CO. Contact Linda Joyce for information, ljoyce@fs.fed.us.

Conference Participation

The MTNCLIM conferences are intended for scientists, students, managers, policy makers, and other professionals interested in mountain climate sciences, their effects on ecosystems, and interactions with resource management, conservation, policy, and society in western North America. Meetings rotate around western mountain regions. They are designed to communicate serious science in informal settings, with registration capped around 120 participants to foster interaction. We encourage presentation of work-in-progress, innovative directions, controversial topics, and especially encourage young scientists to offer abstracts.

Contact: Connie Millar, USFS, cmillar@fs.fed.us



YMCA of the Rockies, Estes Park, CO

Rocky Mountain Futures: Preserving, Utilizing, and Sustaining Rocky Mountain Ecosystems

Symposium Session at the Ecological Society of America, 2012 Annual Meeting, August 5-10, Portland, Oregon

Session is Tuesday afternoon, August 7, 2012

www.esa.org/portland/

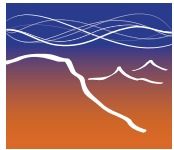
Convener: Jill Baron, USGS, Ft. Collins, CO, Jill.Baron@colostate.edu

In 2002 the Rocky Mountain region boasted the fastest growing human population in the country. Prior to that, more than a century of natural resource exploitation for water, minerals, energy, forest and animal products left a patchwork legacy of altered ecosystems that now serves as the palimpsest for current attempts to manage public and private lands and resources while adapting to climate change. In 2002 we forecast a future of continued erosion of natural processes and habitats in the Rocky Mountains if decisions continue to be made piecemeal and isolated from each other. We suggested instead that land, water, biota and society are parts of an interconnected whole and must be managed accordingly. Rocky Mountain ecosystems of today and tomorrow are a mosaic of human habitation and uses embedded within a less utilized natural setting. Ten years after publication of *Rocky Mountain Futures, an Ecological Perspective*, we revisit this profoundly human landscape. In evaluating the current ecosystem state of Rocky Mountain coupled human - natural ecosystems we ask what we, as scientists, as resource managers, as policy makers, and as citizens, have learned about ecosystem stewardship. Each speaker will rise to the challenge of evaluating management practices in light of short-term services and long-term sustainability. Our symposium is all about preserving ecosystems and their functions, extracting natural resources while minimizing the loss of services, and above all attempting to implement a balanced approach that may lead toward sustainable existence of humans in the Rocky Mountain region.

The Session features eight invited speakers:

1. The indirect human influence on western mountain environments: vulnerabilities and resiliencies. Dan Fagre, USGS
2. Grassland transformations in the Rocky Mountain West. Timothy Seastedt, UC-Boulder
3. The emerging significance of bark beetle outbreaks in the Rocky Mountains. Jeffrey Hicke, U Idaho
4. Forest health challenges in the Rocky Mountain West. Diana Tomback UC-Denver
5. The influence of climate change and climate-influenced disturbances on streamflow and carbon cycling in western mountains. Elizabeth Garcia, UCSB
6. Trends and issues associated with energy development in the West. Zachary Bowen, USGS
7. How land use modifies potential climate change adaptation strategies in mountain ecosystems. David Theobald, Colorado State University
8. Only fools and newcomers predict the future: the hubris of forecasting. Jill Baron, USGS

Canyonlands Research Center Opens Campus in May 2012



CANYONLANDS RESEARCH CENTER

Barry Baker, *The Nature Conservancy, Moab, Utah*

Canyonlands Research Center announces the opening of its field station in May 2012. Dedicated to long-term ecological research on the interactions between climate change and land use in arid and semi-arid lands, the Center presents a host of unique research opportunities. Located in southeastern Utah on The Nature Conservancy's Dugout Ranch, adjacent to the Needles District of Canyonlands National Park, the Research Center offers access to over 800,000 acres of private and public lands ranging in elevation from 1,100 m to 3,600 m. A wide spectrum of ecosystems and land-use histories, as well as proximity to relatively undisturbed areas, rivers and perennial streams, archeological sites, and a collaborative relationship with local ranchers make this an ideal base for scientists in a range of disciplines. Bringing together a suite of private, agency and academic partners, the Center is a new nexus for education and action to help sustain the lands and waters of the Colorado Plateau.

Facilities in this initial phase of the Center's development include a field-prep lab with a variety of basic lab equipment, freezer and cold storage, drying racks and oven, Internet access and GIS capability, as well as an on-site meteorological station.



Figure 2. Barry Baker is Director of the new Canyonlands Research Center.

Living accommodations consist of eight double-occupancy tent cabins with cots, mattresses, desks and chairs; an outdoor kitchen pavilion with gas cook stove and potable water; and toilet facilities, including three solar hot water showers. An adjacent campground is also available for larger groups and field classes.

For further information and to reserve space at the Canyonlands Research Center, please see www.canyonlandsresearchcenter.org and contact the Center's director, Barry Baker, Ph.D. at 435-259-4183 or 970-217-3068; bbaker@tnc.org.



Figure 1. Scenes of the new Canyonlands Research Center environment and facilities as rendered by the designer for the completed center, and under construction. Photos: B. Baker, Drawing, CRSA Architecture.

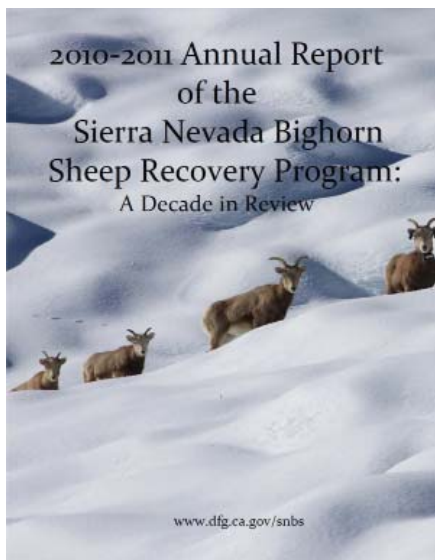
2010-2011 Annual Report of the Sierra Nevada Bighorn Sheep Recovery Program: A Decade in Review

Thomas R. Stephenson¹, John D. Wehausen², Alexandra P. Few¹, David W. Germa¹, Dennis F. Jensen¹, Derek Spitz¹, Kathleen Knox¹, Becky M. Pierce¹, Jeffrey L. Davis³, Jeff Ostergard³, and Jonathan Fusaro¹

¹California Department of Fish and Game, Sierra Nevada Bighorn Sheep Recovery Program

²University of California, White Mountain Research Station

³United States Department of Agriculture, Animal and Plant Health Inspection Services, Wildlife Services



An electronic version of this report is available at <http://www.dfg.ca.gov/snbs/Literature.html>

This report presents a review of the Sierra Nevada Bighorn Sheep Recovery Program from 1999, when Sierra Nevada bighorn sheep were placed on the federal endangered species list, to June 30, 2011. Since 1999, Sierra bighorn numbers have increased from just over 100 animals to about 400. The current reproductive base of almost 200 females over 1 year old is about two-thirds of the numerical recovery goal of 305 females (Fig. 1). Of the 12 herd units required for recovery (USFWS 2007), only 4 remain.

Herds that grew substantially since listing (Wheeler Ridge, Mount Langley, Sawmill Canyon, and Mount Baxter) tended to have the highest growth rates early in the decade (Fig. 2). During periods of high growth, survival rates of adult females generally exceeded 90%. Periods of slowed population growth were accompanied by more variable and poorer adult female survival and declining recruitment of yearling females. Mountain lion predation was the highest known cause of mortality and was con-

centrated in herds in proximity to dense mule deer winter ranges (Fig. 3; Johnson 2010a).

The Recovery Program is directed by the Recovery Plan for Sierra Nevada bighorn sheep drafted in 2001 (USFWS 2007) which presents the conservation strategies that California's Department of Fish and Game (DFG) has employed over the last decade. The Recovery Plan has a 20-year implementation schedule beginning when the plan was released in 2007. The stated goal for downlisting is 2017. Considerable progress has been made in implementing the Recovery Plan conservation strategies. These strategies focus on 1) increasing the number and distribution of bighorn sheep through augmentations and habitat enhancement projects and 2) reducing threats that limit their survival by managing predators and reducing the proximity of domestic sheep grazing allotments. Based on the first strategy, we implemented three translocations to augment small herds. Additionally, we planned prescribed burns and initiated two to enhance the quality of habitat for bighorn sheep. Following the

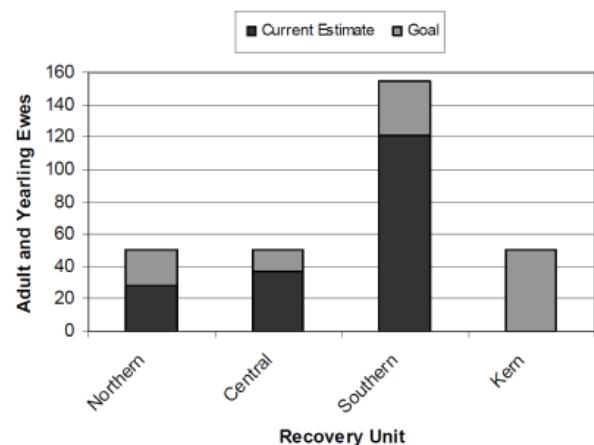


Figure 1. Proximity to downlisting criteria for each Sierra Nevada bighorn sheep recovery unit based on number of adult ewes over 1 year old.

second strategy, we removed mountain lions when they posed an imminent threat to bighorn sheep, and land management agencies worked to shift grazing away from areas near bighorn recovery units.

After reviewing 11 years of progress, we are optimistic that we could meet the goals for downlisting to threatened status within the next decade, barring any catastrophes. If we are to meet this ambitious timeline, key recovery strategies need to continue. Implementing translocations for reintroductions to vacant herd units is essential to achieve the distribution required to meet recovery goals. This necessitates adaptive management and a predator management program to protect herds used as a source of translocation stock so that reintroductions and augmentations can occur.

For more information on Sierra Nevada bighorn sheep, please visit our new website at www.dfg.ca.gov/snbs.

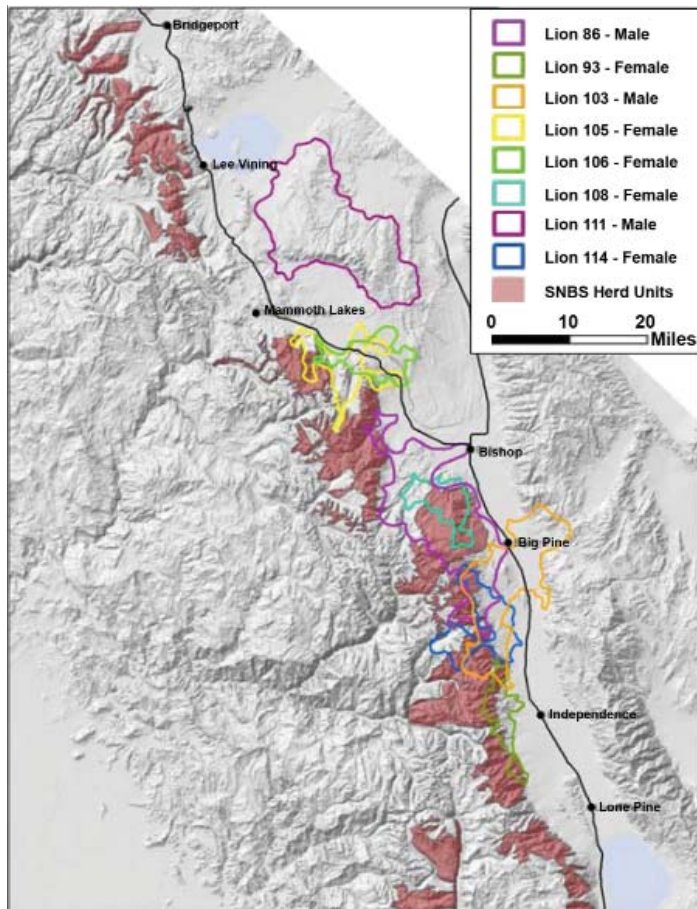


Figure 3. Mountain lion activity adjacent to Sierra Nevada bighorn sheep low elevation winter range identified by GPS collar data during July 2008 to June 2009. From the report, pg. 21

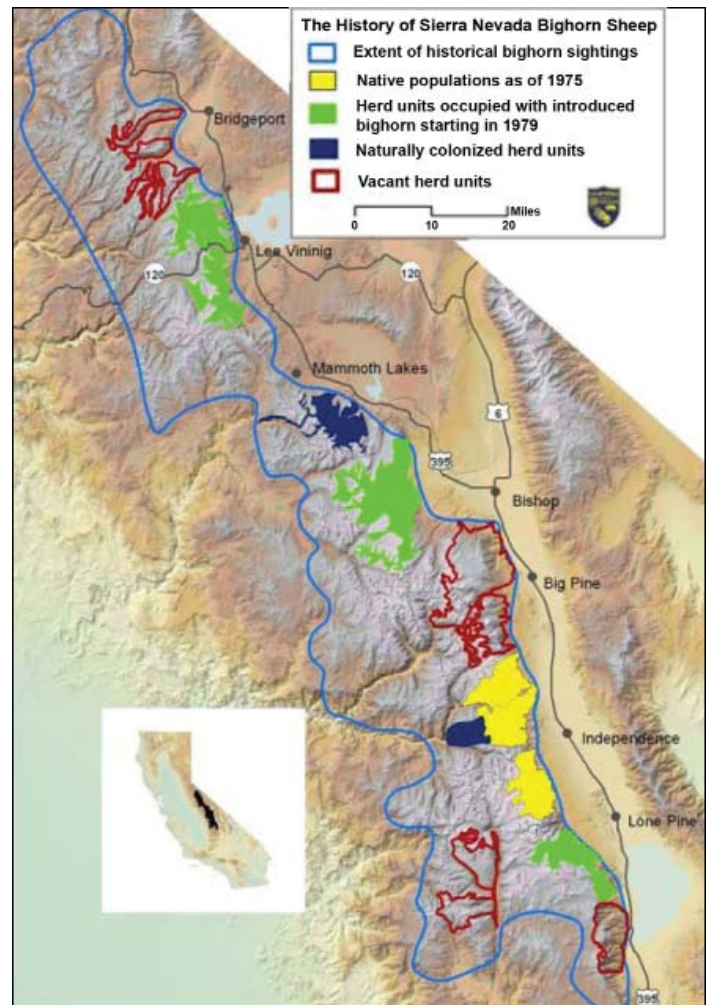


Figure 2. Temporal changes in the distribution of Sierra Nevada bighorn sheep during 1975-2011. From the report, pg 15.

How will Forest Diseases Respond to Climate Changes?

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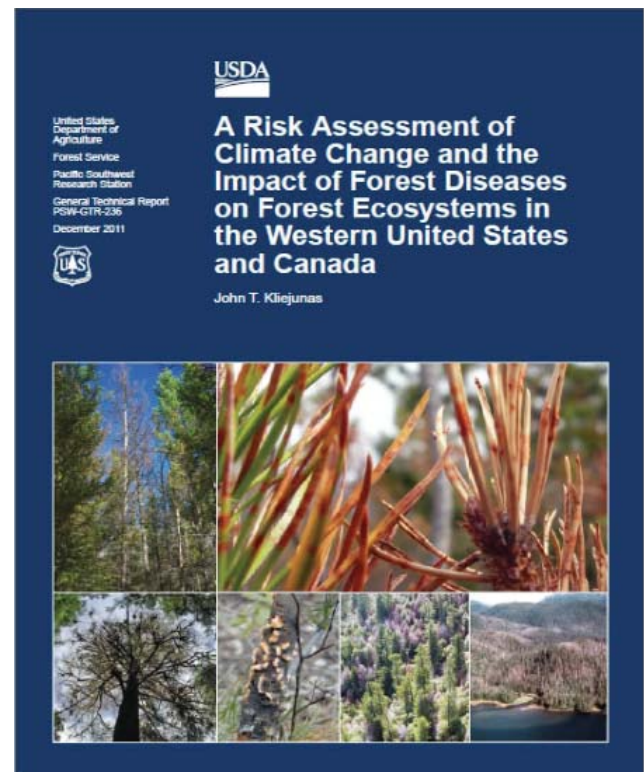
Citation: Kliejunas, John T. 2011. **A risk assessment of climate change and the impact of forest diseases on forest ecosystems in the Western United States and Canada.** Gen. Tech. Rep. PSW-GTR-236. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 70 p. http://www.fs.fed.us/psw/publications/documents/psw_gtr236/

To assess risks to North American forests from tree pathogens under a changing climate, we examined what is known about how several types of tree diseases behave under various environmental conditions. This risk assessment projects the effects of eight forest diseases under two climate-change scenarios (warmer and drier, warmer and wetter). Forest diseases discussed in this report include foliar diseases, *Phytophthora* diseases, stem rusts, canker diseases, dwarf mistletoes, root diseases, and yellow-cedar decline. The likelihood and consequences of increased damage to forests from each disease as a result of climate change are analyzed and assigned a risk value of high, moderate, or low. The risk value is based on available biological information and subjective judgment.

Under drought conditions the pathogen projected to pose the greatest risk is *Armillaria* root disease. *Armillaria* is common on conifers and some hardwoods; it lives on tree roots and grows exponentially when a tree becomes stressed. A drier climate would, in general, stress hosts more than a wetter climate, and thus increase host susceptibility to root diseases. Yellow-cedar decline, *Cytospora* canker on Aspen and dwarf mistletoes also pose high risk.

If climate changes are wetter and warmer, sudden oak death and other *Phytophthora* tree diseases are likely to be most damaging.

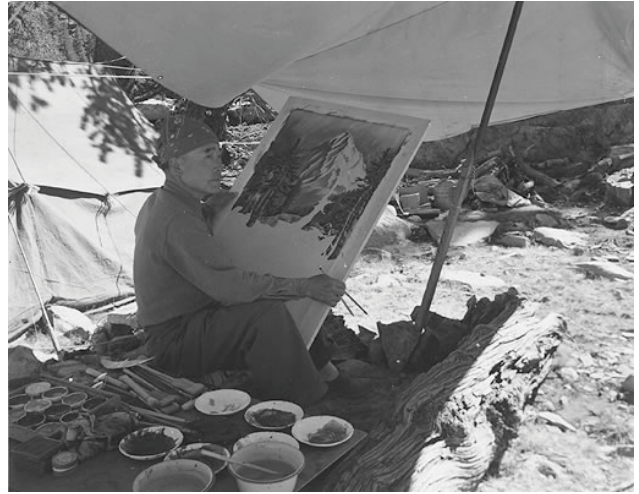
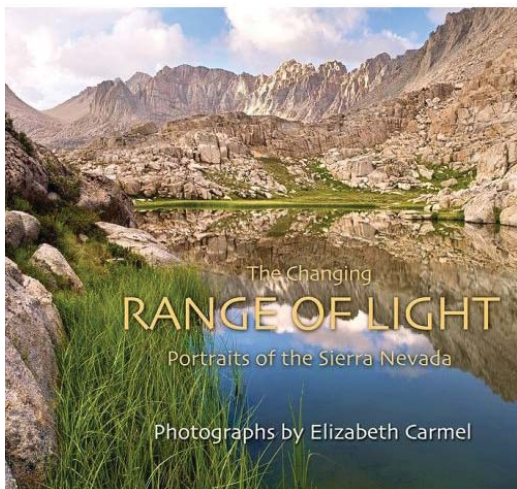
Although the results of this risk assessment suggest that climate change will affect forest health, the uncertainties associated with the risk potentials need to be kept in mind. In this assessment, uncertainty arises regarding the degree of climate change that will occur, pathogen biology under changing climate; the effects of changing climate directly on the host, and the interactions between the pathogen, host, and climate.



The risk assessment was developed by the “Climate Change and Western Forest Diseases” project sponsored by the USDA Forest Service, Western Wildland Environmental Threat Assessment Center (WWETAC) and the Pacific Southwest Research Station (PSW).

About the Artists

In this issue of *Mountain Views Newsletter*, we are honored to include three selections of mountain photography by renowned photographer **Elizabeth Carmel**. Elizabeth focuses her work on the Sierra Nevada, California landscape, and owns and runs the *Carmel Gallery* in Truckee, California. Her prints have been displayed at the California Museum of Photography and the Nevada Museum of Art. In 2006 Elizabeth published a book of her photography titled *Brilliant Waters, Portraits of Lake Tahoe, Yosemite and the High Sierra*. In her second book, *The Changing Range of Light, Portraits of the Sierra Nevada* (Hawk Peak Publishers, 2009), Elizabeth teamed up with 30-year veteran mountain hydrologist **Bob Coats**, of Hydroikos Ltd (Berkeley, CA), who wrote the accompanying text that summarizes key changes anticipated as a result of global climate change. Bob's vignettes capture the work of mountain-climate scientists and through this he explains how the Sierran landscapes shown in Elizabeth's photos will be affected by changing climate. The photographs reproduced in this issue of *MVN* are selections from *The Changing Range of Light*. We include as well a poem that Bob wrote, "When the Drought Broke", which was also included in the book. We have featured Bob's poetry in the past, and this particular selection captures the imagery by which Bob experiences mountain landscape through his perspective as a climate scientist. Thank you, Elizabeth and Bob, for sharing your work with our mountain colleagues. See more information at: www.elizabethcarmel.com/Range-of-Light-Book-p/bks102.htm



Chiura Obata painting in Yosemite National Park, 1927.
Credit: © Yosemite Conservancy

Jessica Lundquist is well known to the CIRMOUNT community. An associate professor of mountain hydrology in the Department of Civil and Environmental Engineering, University of Washington, Seattle, Jessica teamed up with her oceanographer husband, **Andrey Shcherbina**, to design and create the stained glass window that graces their new home in the Green Lake District of Seattle. Jessica spent summers of her youth in the Tuolumne Meadows region of Yosemite National Park, hiking the high country that surrounds the meadows. These ranges were also the focus for the wood-cut landscape paintings rendered by Chiura Obata (University of California, Berkeley) during the early 20th century. Both the high Sierra and Obata's work have long been imprinted in Jessica's heart, and these days she continues to conduct her research as well as hike and revel in the Yosemite highlands.

Wally Woolfenden, retired US Forest Service paleo-ecologist and archeologist, has contributed art to *MVN* before. Wally's research focuses on Quaternary landscapes and unraveling secrets of the past through pollen analysis. He lives at Swall Meadows, California above the Owens Valley, where his house overlooks the sweep of the great southern escarpment of the Sierra Nevada. Wally has been drawing since he was a child, and equally long he has been a naturalist. Wally's interwoven science and art persona complement each other in the beautiful rendering of whitebark pine in winter that we reproduce here.

Mountain Visions



Clearing Storm, Euer Valley © ElizabethCarmel.com

When the Drought Broke

Deep in the cloud-shrouded night
the storm woke me:
gnashing at the window,
stalking across the roof on
padded paws, slashing

at the last leaves of autumn.

In the pale dawn I rose
to see the peach moon
shawled by ragged nimbus
setting behind bare maples,
and smelled the oak-bay leaf mold
breath of newly soaked earth.

Now high in the Range of Light
the wind hones little knives of ozone
on cornice, on sheer granite cliff,
A coyote wakes, sniffs the new air,
sets out into a crystalline world of solitude.

-- Robert Coats, 2009



how it grows low on the granite in the wild winds roots deep not minding the winter

-- Wally Woolfenden, 2012



Night Journey, Lake Tahoe © ElizabethCarmel.com