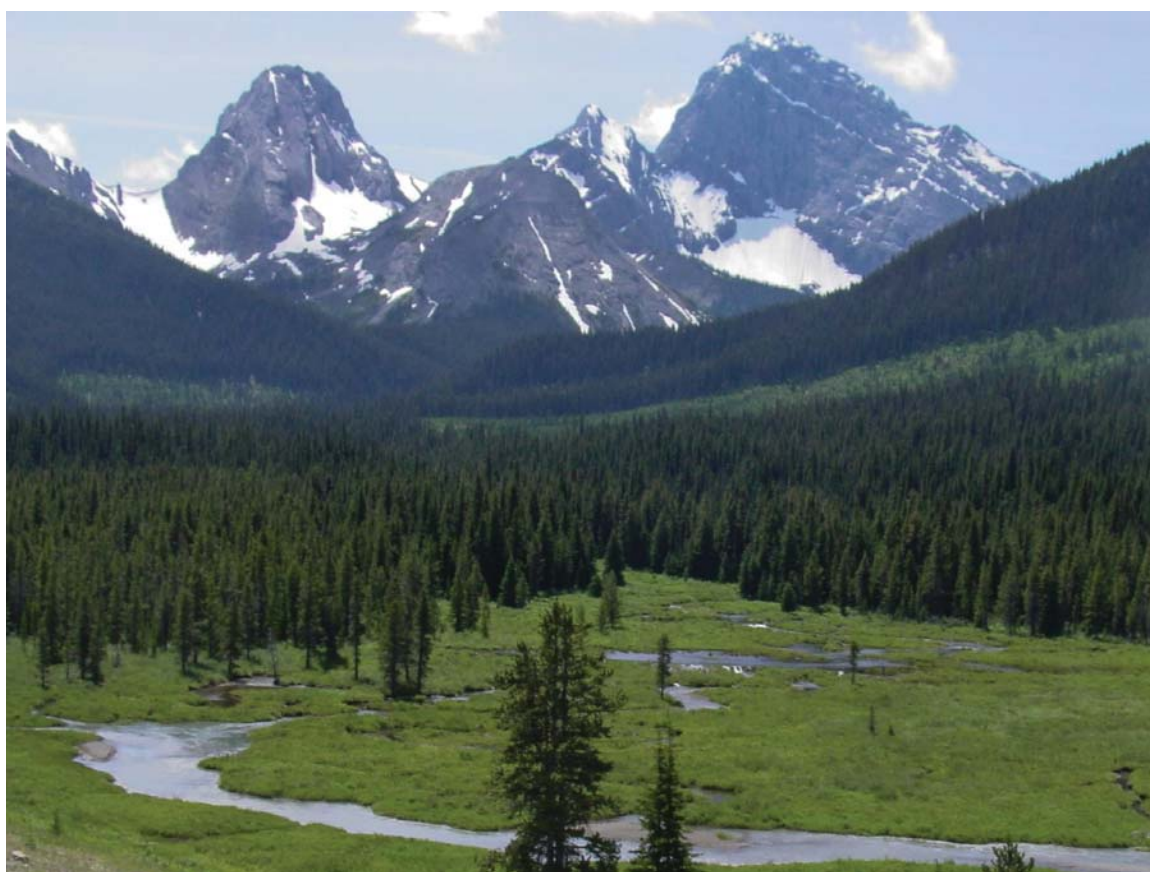


Mountain Views

Chronicles of the Consortium for Integrated
Climate Research in Western Mountains

CIRMOUNT



Informing the Mountain Research Community

Volume 12, Number 1 • May 2018

ALPINE OBLIGATES OF CALIFORNIA

These are the nine hardy plant species that can only be found in California at elevations above 3,500 m (11,500 ft).



Alpine Obligates of California, Illustration, Allie Fitzmorris

Front Cover: Peter Loughheed Provincial Park between Banff, Alberta and Elkford, British Columbia, Canada. Photo, Tim Duane

Editor: Connie Millar, USDA Forest Service, Pacific Southwest Research Station, Albany, California

Layout and Graphic Design: Diane Delany, USDA Forest Service, Pacific Southwest Research Station, Albany, California

Back Cover: Wetlands of Upper Burt Canyon, Sierra Nevada. Photo, Jeff Wyneken

Read about the contributing artists on page 45

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Volume 12, No.1, May 2018

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<i>Question:</i> Actionable science is scholarship designed to inform and support resource decision-making, improve evaluation of risks and impacts, and assist in development and implementation of public policies. In the context of mountain ecosystems, climate change, and western North American resource-management		

and policy, what aspects of your (and/or your students and collaborators) research touch on actionable science? Or if you are a user of science information, what topics do you feel are most urgent for actionable science in our mountain context?

Replies from:

John Abatzoglou, Craig Allen, Henry Diaz, Beth Hahn, Jessica Halofsky, Geoff McQuilkin, Bret Meldrum, Anne Nolin, Nina Oakley, Imtiaz Rangwala, and Connie Woodhouse

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EDITOR'S WELCOME

Welcome to the Spring 2018 issue of *Mountain Views Chronicle*, the biannual periodical of CIRMOUNT. In western North American mountains, water rules. Each year we ask, survey, assess, interpret, and worry about water: how much, when, what form, what effects it will have. Spring is an especially important time of year for taking stock of the past winter in anticipation of its influence on the upcoming warm, dry season. Where I work, in California's Sierra Nevada, winter was eerily – if increasingly common – warm and dry. “Mitigation March” brought late but welcome precipitation, which continued through the weeks to become “Miracle March.” April and May also were cool and wet.

The *Brevia* in this issue summarize recent papers that tackle aspects of the mountain water-cycle puzzle. As severe droughts become more common, understanding their characteristics relative to prehistoric events helps to inform understanding of process as well as to provide context that informs resource management. A question often asked by many people in drought-stricken areas, once cooler-wetter conditions return, is, “Is the drought over”? High temperatures, of course, contribute to drought severity, affecting hydrologic outcomes. Measuring temperatures at high spatial and temporal resolution with low cost methods is greatly needed. Studies on these and related topics enable better vulnerability assessments that help to curb undesired impacts to ecosystems and human communities.

A commitment that has been strong in the CIRMOUNT community from its inception is that our research efforts be useful and contribute to effective resource management and conservation. Through the years of my career, the nature of this “technology transfer,” “extension work,” and “boundary spanning” has – I hope I am correct – become increasingly effective on the ground and not just a moniker of the day. In the *Voices* section of this issue, I asked colleagues how “actionable science” relates to their work. The rich detail of their responses provides useful insight on the diversity of opportunities and the value of environmental professionals from all sides of the lab bench working together.

MtnClim 2018, CIRMOUNT's biennial conference is coming up in September this year (9/17—9/21), and Andy Bunn (WWU) and Scotty Strachan (UNR) have been hard at work with planning. For years we have wanted to bring MtnClim to the Rocky Mountain Biological Lab in Gothic, CO, and that will be fulfilled this year. Register, submit an abstract, and reserve lodging by July 2, 2018 – and see more details on page 17.

I hope you enjoy the articles in this issue that describe adventures and misadventures encountered by our colleagues in the course of their field work, as well as the conservation stories that the photographs, poetry, and illustrations in this issue portray.

--Connie Millar



CIRMOUNT, www.fs.fed.us/psw/cirmount/
USDA Forest Service, Pacific Southwest Research Station
Albany, California, USA

Multi-Century Evaluation of Recovery from Strong Precipitation Deficits in California

Eugene Wahl¹, Henry Diaz², Russell Vose¹, Wendy Gross¹

¹NOAA's National Centers for Environmental Information, Center for Weather and Climate, Climatic Science Division, Boulder, Colorado and Asheville, North Carolina

²Department of Geography, University of Hawai'i, Manoa, Hawai'i

Wahl, E., Diaz, H., Vose, R., and Gross, W. 2017. Multicentury evaluation of recovery from strong precipitation deficits in California. *Journal of Climate* 30:6053-6063, doi: 10.1175/JCLI-D-16-0423.1.

Abstract

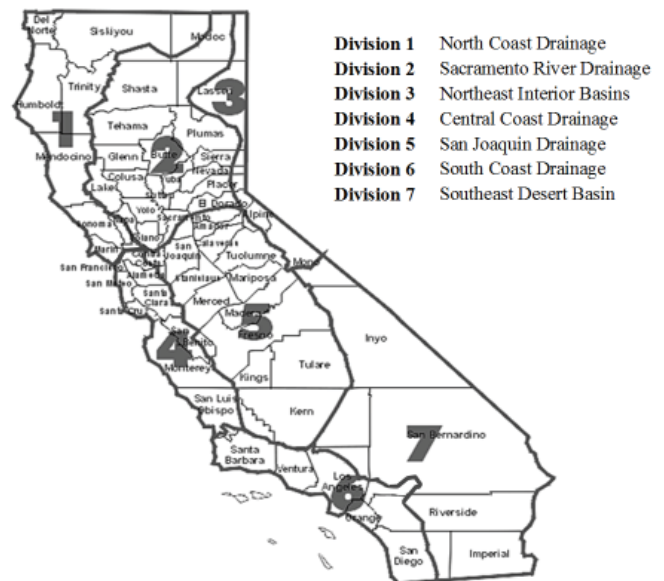
The 2012-2015 dry period in California was unprecedented in the instrumental record. This article employs spatially-explicit precipitation reconstructions for California in combination with instrumental data to provide perspective on this event since 1571. 2012—2015 stands out as particularly extreme in the southern Central Valley and South Coast regions, which likely experienced unprecedented precipitation deficits over this time. Some areas lost more than two years' average moisture delivery during these four years, and full recovery to long-term average moisture delivery could typically take up to several decades in the hardest-hit areas. These results highlight the value of the additional centuries of information provided by the paleo-record, which indicates the shorter instrumental record underestimates the statewide recovery time by over thirty percent.

Overview

The 2012-2015 water-year (Oct₋₁ through Sept₁) dryness in California was unprecedented in the instrumental record, going back at gridded scale for the state to 1896. We developed spatially-explicit precipitation reconstructions for California (0.5° grid cells), and used them in combination with instrumental data to provide perspective on this event going back to 1571, a nearly 450 year span. Four points stand out in summary.

- 2012-2015 was particularly extreme in the southern Central Valley and South Coast regions (NOAA Climate Divisions 5 and 6, respectively, Fig. 1), which likely experienced unprecedented precipitation deficits over this time going back to at least 1571 (Fig. 2).

- The unprecedented precipitation deficits in Divisions 5 and 6 occurred entirely in terms of moisture delivery, *apart* from considerations of increasing temperatures or drought metrics that combine both temperature and moisture information.
- Some areas in the state lost more than two years' average moisture delivery during these four years (Fig. 3a), and full recovery to long-term average moisture delivery could typically take up to several decades in the hardest-hit areas (Fig. 3c, e).
- The wet and very wet water years of 2016 and 2017, respectively, reduced the likely recovery time for the state as a whole by nearly two-thirds, representing a twentieth percentile outcome compared to the median value expected from random selection of the first two recovery years.



Map source: NOAA's Climate Prediction Center

Figure 1. California's standard climate divisions and associated names, overlaid on the state's counties for reference.

Implications

A key outcome of this work is its demonstration that the highly-resolved paleo-record (annual time scale and relatively fine spatial scale) provides important understanding of the dryness and potential for recovery from the 2012–2015 drought that cannot be estimated from the instrumental record alone. That the moisture delivery loss in the southern Central Valley and South Coast regions was likely unprecedented over nearly 450 years, apart from additional impacts due to temperature increases, underscores the extreme hydroclimate variability that the climate system can produce in the region, *before* any additional variability that is identifiable in potential climate change scenarios. Going further, the paleo-record indicates that the shorter instrumental record underestimates the most likely statewide recovery time by over thirty percent (Fig. 3, compare panels c and e).

Considering the additional drying impacts of increasing temperatures under climate warming scenarios, the potential for combinations of severe precipitation deficits with high

temperature-driven evaporation and evapotranspiration indicates the possibility of “megadroughts” in the American Southwest, including California, that will exceed the worst such episodes reconstructed during medieval times by the second half of the 21st century. Related Sierra Nevada snowpack reconstructions and instrumental-period reanalyses suggest such a signal may already be present in the unprecedented low snowpack that occurred in the Sierra Nevada in early 2015. The intensity of the snowpack loss was greatest at lower montane elevations (< 2,130 m) where the impact of higher winter temperatures on moisture retention is first expected to be detectable.

Finally, we note that the estimated recovery times are long compared to some related analyses. This distinction is primarily due to different ways in which the threshold for deficit and recovery is defined. In our analysis, length of recovery is defined as the number of years it takes for the cumulative precipitation in a grid cell to equal or exceed the cumulative climatological average over the same number of years, when the grid cell is initialized at the start of the recovery period by the 2012–2015 loss (Fig. 3a; recovery periods up to 50 years in length were

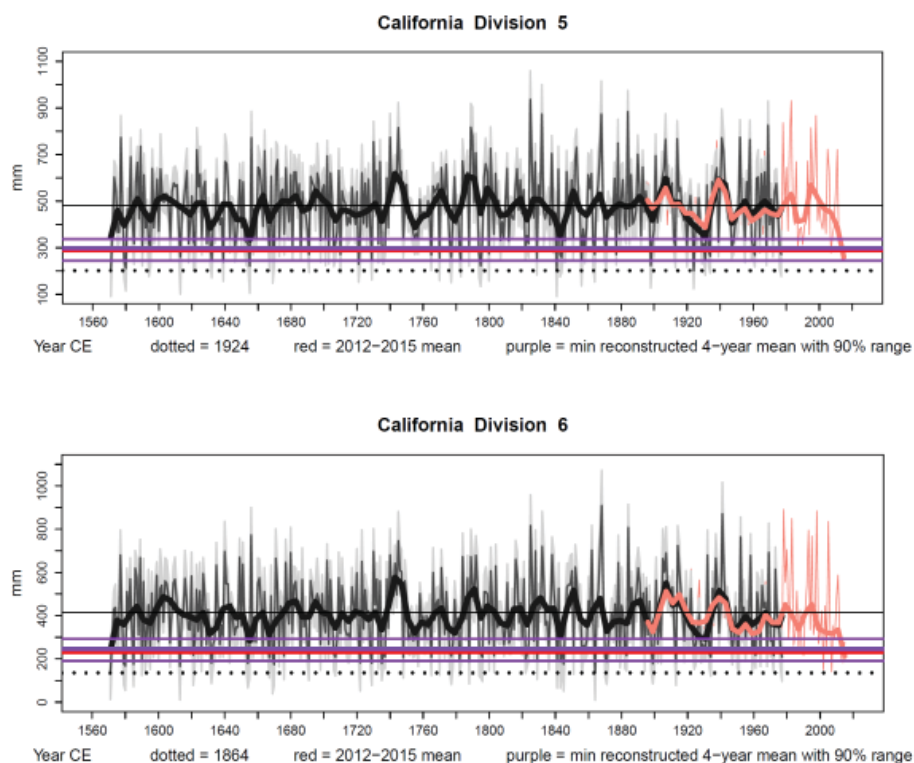


Figure 2. Water year precipitation for northern California climate Divisions 5 and 6 (see Figure 1 for map and names of the divisions). Dark grey lines show annual expected value (EV) reconstructions; light grey shading shows associated 90% probability ranges from reconstruction ensemble; salmon lines show corresponding instrumental data; heavy black and salmon lines show ~decadal LOWESS smooths; horizontal black lines show 1896-2015 instrumental averages; red lines show 2012-2015 means; purple lines show lowest EV 4-year running means (darker purple) and corresponding 90% probability ranges (lighter purple); dotted black lines show lowest single-year EV reconstruction (years are indicated on each plot).

evaluated, so the longest recovery time noted in Fig. 3 is 50 or more years). In some studies, thresholds significantly below the climatological average have been employed to define recovery. In one related case analyzing snowpack loss in the Sierra Nevada mountains, nearly 80% of the years evaluated were above the

threshold and would thus contribute (on average) to recovery. In our analysis only 50% of years would do so (on average), leading to much longer estimated recovery times by construction, which we believe best represents the actual situation of moisture delivery in the highly variable California hydroclimate.

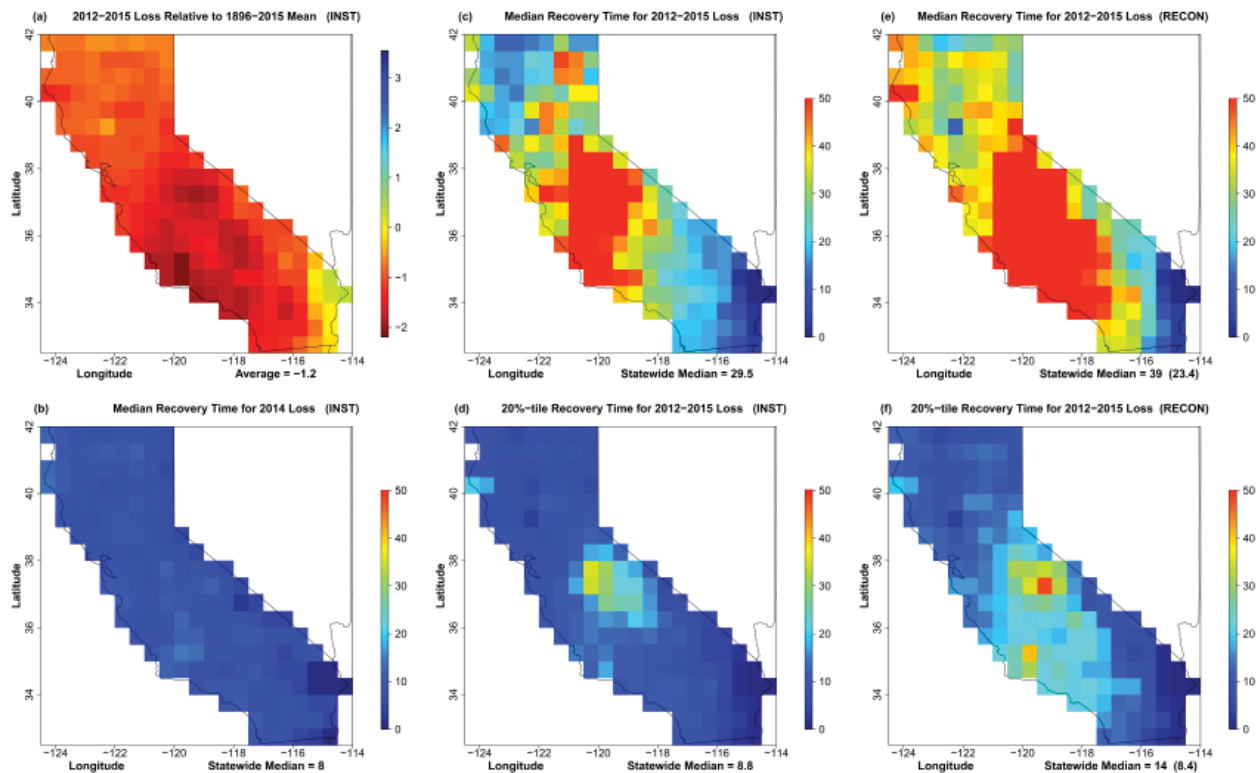


Figure 3. Precipitation losses for 2012-2015 water years and estimated recovery times (in years), across California 0.5 deg. grid cells: (a) cumulative precipitation loss (-) or gain (+), relative to one year's average, for water years 2012-2015 as indicated by instrumental data ("INST"); (b) median recovery time for single-year 2014 loss, as indicated by INST; (c) median recovery time for cumulative 2012-2015 loss, as indicated by INST; (d) 20th percentile recovery time for cumulative 2012-2015 loss, as indicated by INST; (e) median recovery time for cumulative 2012-2015 loss, as indicated by reconstruction data ("RECON"); (f) 20th percentile recovery time for cumulative 2012-2015 loss, as indicated by RECON. Numbers in parentheses for panels (e) and (f) represent $p = 0.05$ probabilities from the reconstruction ensemble that the statewide median recovery time noted will be this value or less.

Origins of Northern Sierra Nevada Snow Drought

Benjamin Hatchett and Daniel McEvoy

Western Regional Climate Center and Division of Atmospheric Sciences
Desert Research Institute, Reno, Nevada

Hatchett, B.J. and McEvoy, D.J. 2018. Exploring the origins of snow drought in the northern Sierra Nevada, California. *Earth Interactions* 22: 1–13, <https://doi.org/10.1175/EI-D-17-0027.1>

Summary

Snow droughts can be simply defined as periods when snow water equivalent (SWE) is below normal for a given time of year, typically 1 April, or the time near peak SWE accumulation. A more comprehensive definition includes two types of snow droughts; dry, where both SWE and precipitation (PPT) are below normal; and warm, where SWE is below normal but PPT is near or above normal. Our goal was to identify snow droughts using the most basic definition and examine how these conditions evolved throughout the water year using point-based observational data at monthly, daily, and hourly time

scales. We identified eight snow droughts between 1951–2017 (Fig. 1a). The two dry snow droughts, 1977 and 2015, were (unsurprisingly) characterized by typical drought conditions resulting from well-below normal precipitation. Warm snow droughts, on the other hand, can occur from multiple pathways, such as singular extreme precipitation events with high snow levels or anomalous warm and dry conditions inducing late winter SWE and snow cover loss at lower elevations (Fig. 2). Warm snow droughts tended to demonstrate notable elevation dependence, with lower elevations exhibiting larger negative SWE anomalies (Figs. 1b–c). Last, water year 2017 was used as an example of a year that would not show up in a 1 April definition of below average SWE (black dots in Fig. 1a), but this year had notable snow drought conditions early in the winter season (Fig. 3) with likely implications for snow-dependent recreation.

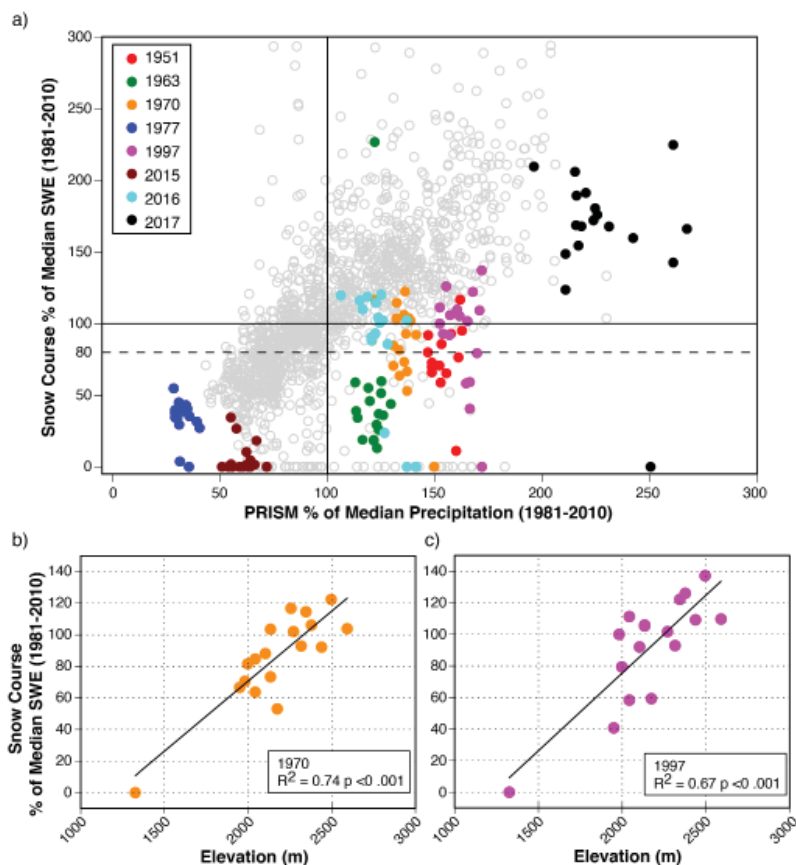


Figure 1. Snow droughts identified in the northern Sierra Nevada. (a) Scatterplot of PRISM October–March accumulated precipitation (PPT) and snow course SWE for 1 April as a percentage of 1981–2010 median values. Each dot represents a different snow course and year. All years are shown in grey with identified snow droughts colored. WY2017 (black dots) is also shown since although it failed to be classified as a snow drought on 1 April, snow drought conditions were present during November–December. (b) Percentage of 1 April 1981–2010 median snow course SWE versus elevation for WY1970. (c) As in (b) except for WY1997.

The characteristics of snow droughts and how they originate, persist, and terminate likely have varying implications for mountain socioeconomics and ecohydrology. Continued super-disciplinary (inclusive of trans-, multi-, and interdisciplinary approaches) collaboration is needed to precisely define and constrain the varied implications of snow droughts in mountain environments in order to provide managers with adaptive management strategies as snow droughts will likely increase in both magnitude and frequency with continued regional and global warming.

Remarks

Snow droughts are not a new phenomenon; they have always and will always occur. A concerning aspect, however, is that snow droughts of some type and some impact have been observed in

each year since 2015. Lower elevation mountains with a maritime influence, such as the northern Sierra Nevada, are highly sensitive to changes in climatic regimes that favor increased snow drought frequency, magnitude, and duration. Increasing winter snow levels, or the elevation where snow turns to rain, have been observed over the past decade in this region and appear to be related to Pacific sea surface temperatures and atmospheric river landfall (Hatchett et al. 2017). Continued warming of the ocean and increased atmospheric river activity are both expected as the climate continues to warm. This implies that snow levels will continue to rise and the frequency of warm snow drought will increase. Extremely dry winters are also projected to become more frequent as the climate warms and Arctic sea ice declines (Cvijanovic et al. 2017). The occasional extremely cold storm or snowy month (e.g., March 2018) may provide the saving grace for the winter recreation industry and ecosystems that depend on

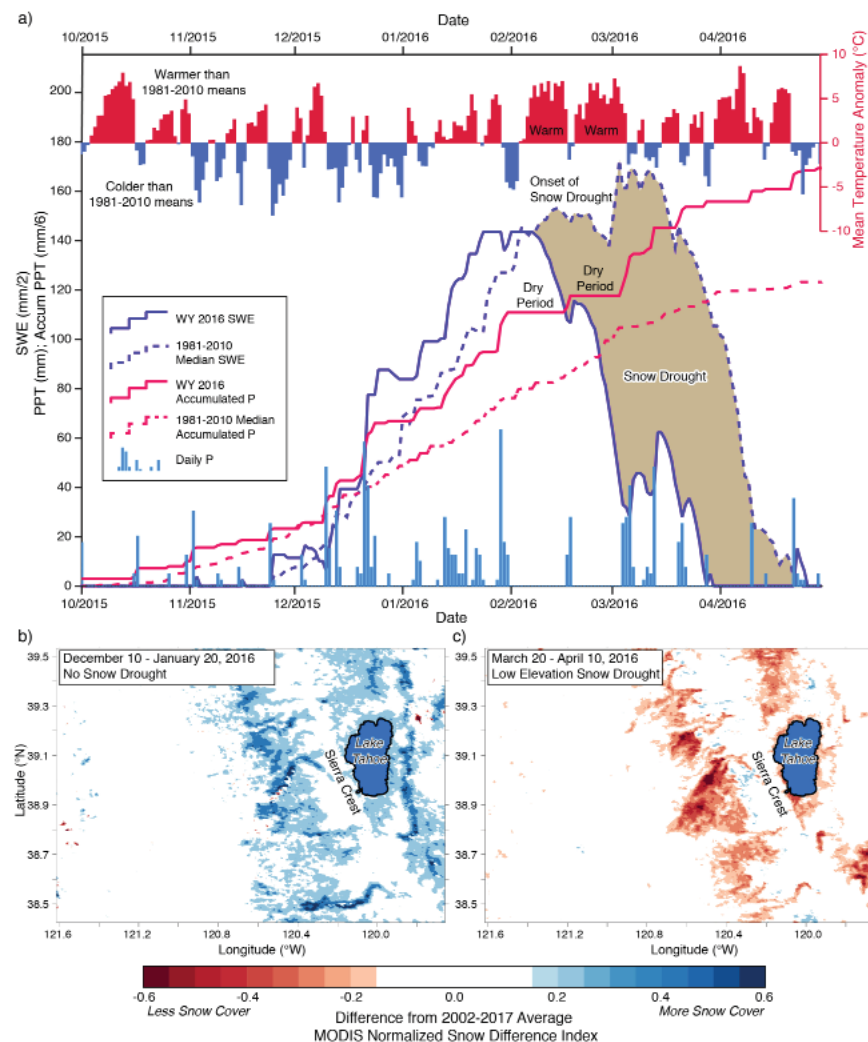


Figure 2. Late season onset of warm snow drought and its manifestation using remote sensing. (a) Time series of 1981-2010 median and WY2016 observed SWE, PPT, and temperature anomalies for the Tahoe City Cross SNOTEL spanning 1 October 2015 to 30 April 2016. MODIS-derived normalized difference snow index (NDSI) values (differenced from 2002-2017 averages) for the 30-day periods during no snow drought (b) and after the onset of low elevation snow drought (c). NDSI data was processed using Climate Engine (Huntington et al. 2017).

snow, yet if these events become less frequent or shifted later in the year, the negative impacts may not be overcome by a miracle month.

The specific impacts of snow drought on mountain and rangeland fire regimes, ecophysiology (e.g., canopy water storage, root mortality, senescence, vegetation compaction), migration and reproductive success of fauna, hydrology, and recreation at this point are poorly quantified. We are currently exploring methods to better monitor snow drought conditions using station and

remote sensing-based applications to aid in the quantification and identification of snow drought impacts. Consideration of ways to monitor snow drought through existing and upcoming monitoring networks is strongly encouraged (Strachan et al. 2016). In order to maintain a socially and ecologically productive mountain environment, these impacts will need to be better understood and monitored in order to develop successful adaptation strategies to deal with the ‘new normal’ of highly variable precipitation amidst a warming background climate with less snow.

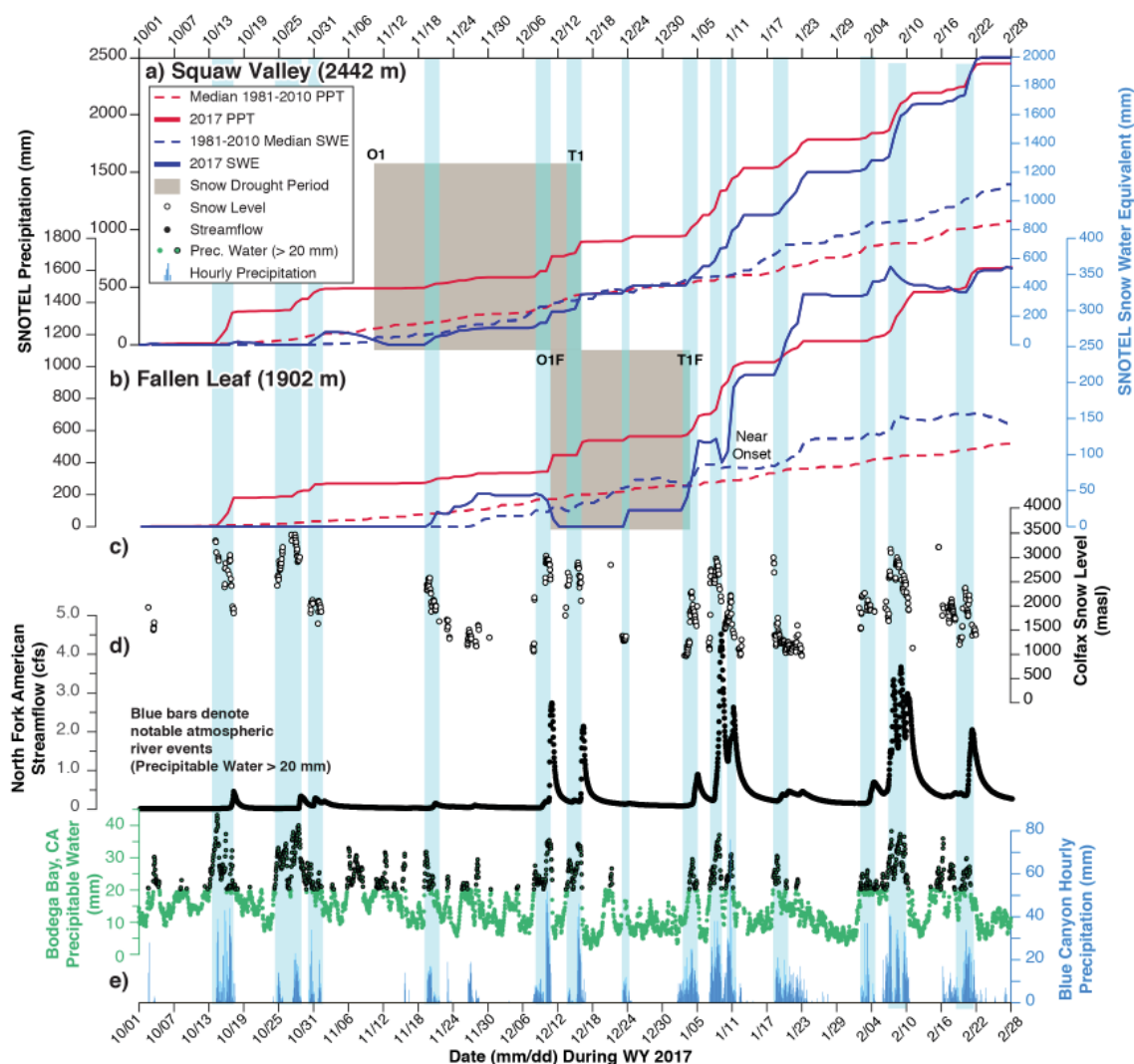


Figure 3. A paleoclimate-inspired time-series perspective of the hydrometeorological conditions during the record wet water year of 2017 in the northern Sierra with early season snow drought conditions noted as grey boxes. (a) Median 1981-2010 precipitation (PPT; salmon) and snow water equivalent (SWE; light blue) and WY2017 observed PPT (red) and SWE (dark blue) at Squaw Valley Gold Coast SNOTEL for 1 October – 28 February 2017. (b) As in (a) but for Fallen Leaf SNOTEL. (c) Brightband-derived snow levels derived from the Colfax, CA snow level radar. (d) Streamflow at gauge on the North Fork of the American River. (e) GPS-derived total precipitable water at Bodega Bay (left) and precipitation at Blue Canyon (right).

Got Impacts? Report Them Here!

The National Integrated Drought Information System (NIDIS) recently developed a snow drought web page to provide updates on snow drought conditions and a dashboard of snow related web tools. Conditions updates will be released bi-weekly during the snow season. An impact reporting page is also available to help gather on-the-ground impacts related to water resources, recreation, and ecosystems.

NIDIS Snow Drought Web Page: <https://www.drought.gov/drought/data-maps-tools/snow-drought>

NIDIS Snow Drought Impact Reporter (can also be accessed from the Snow Drought Web Page): <https://survey123.arcgis.com/share/d19575fdb234442087f1ee838bc8b2dc>

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Could Satellite Thermal Remote Sensing Make i-Buttons* Obsolete?

*small in situ temperature sensors

Jessica Lundquist

Department of Civil and Environmental Engineering

“I’m constantly going into i-Button debt,” Bob Westfall told me several years ago at a MtnClim meeting. “I put out these little temperature sensors one summer, and then my entire next summer is devoted to fetching them again. It’s like an addiction.” (And I was responsible for getting Bob hooked.)

When I became a mother with small children, the severity of the problem became personally apparent. I could no longer spend all of my summers hiking to launch temperature sensors into trees, but I still needed to know what the temperatures were. So I started taking infrared photos of scenes with lots of i-buttons (Fig. 1).

Initial experiments taught me that emissivity matters. All objects emit thermal radiation as a function of their temperature, but this emission is a function of the material properties, the wavelength, and the viewing angle. Puppy Dome (Fig. 1) looks much more colorful in infrared than its true surface temperature would expect because different minerals have very different emissivities (e.g., quartz = 0.93; granite = 0.45; and gravel = 0.28). Thus, to an instrument sensing thermal radiation, quartz would appear about twice as bright as granite at the same physical temperature, and

using thermal remote sensing to identify rock types is a well-established field (Siegal and Gillespie 1980).

Fortunately for me, I generally don’t want to know rock temperatures but rather want air temperatures and snow temperatures. On 5-8 February 2016, we flew infrared cameras on a Cessna aircraft over Dana Meadows, Yosemite California (Figs. 2a and 2b) and showed that in the winter, the greatest temperature differences are between the snow surface temperature and the forest surface temperature, and the forest surface temperature is typically a good match for the air temperature (Fig. 3). Both snow and forests have very high emissivities, which makes remotely-sensed temperatures very close to true physical temperatures.

Of course, flying an airplane repeatedly over a study site is even less cost-effective than putting out i-buttons, so we would like to be able to measure the temperatures we need from space, using a satellite that’s already paid for. Currently land surface temperatures (LST) are available from the MODIS instrument on the Terra and Aqua satellites at 1 km resolution. However, at 1 km (see yellow boxes in Fig. 2a), the LST represents multiple objects: here, a mix of lodgepole pines and snow. In our recent

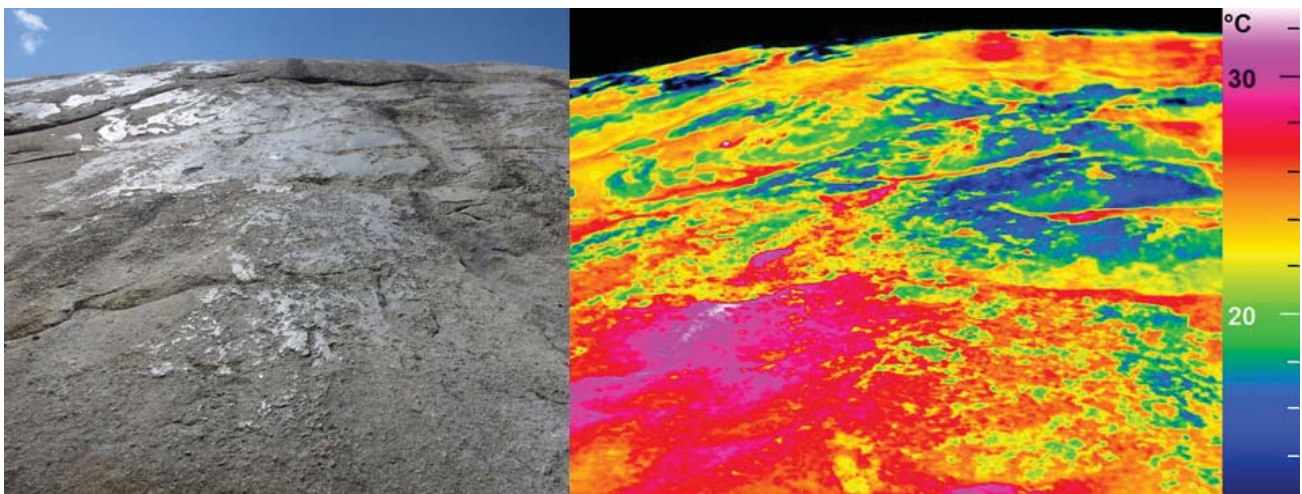
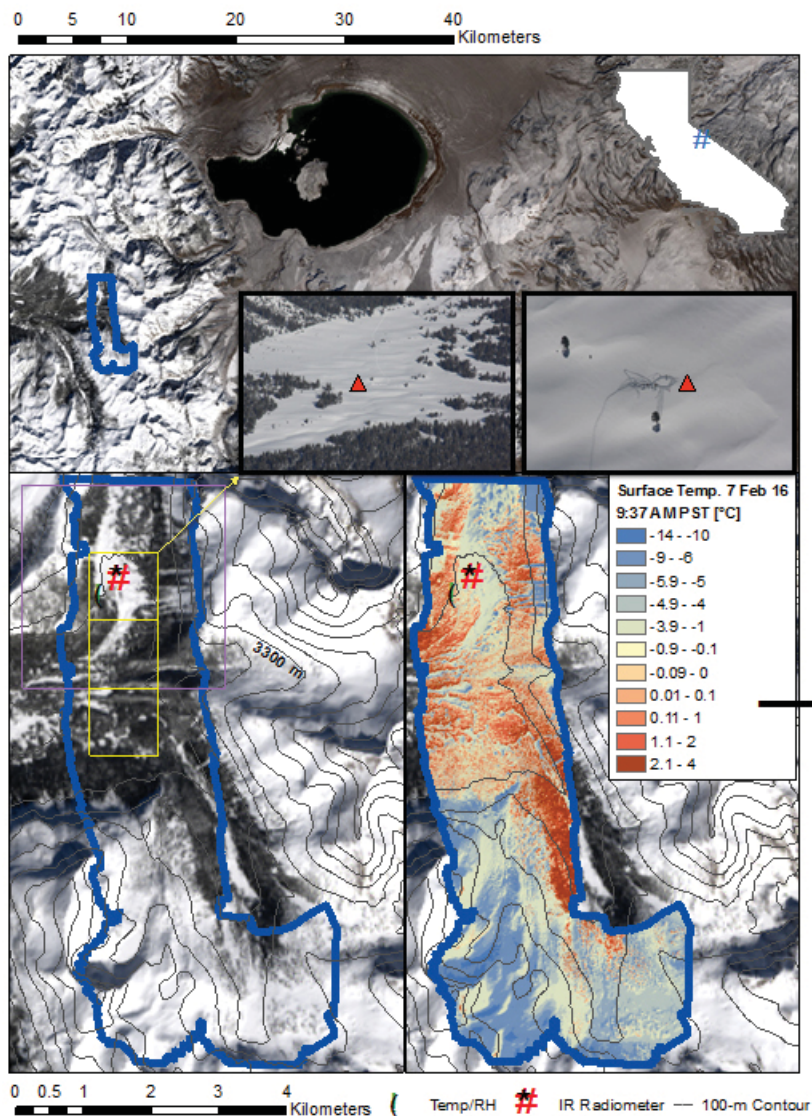


Figure 1. Visible image (left) and infrared image (right) of Puppy Dome, in Tuolumne Meadows, Yosemite National Park, CA. The temperatures of 12 small temperature sensors scattered across the domain all read 29–33°C. Temperatures recorded by the camera (colorbar, right) ranged from 16–33°C.



Field Experiment

5-8 Feb 2016

Dana Meadows,
Yosemite, CA



Figure 2a. Map of the study area in both visible and infrared (left) and pictures of the field team, Ryan Currier, Eric Keenan, Brian Henn, and Teddy Thorson. Yellow squares (left) represent the size of a MODIS pixel (adapted from Lundquist et al. 2018).

paper (Lundquist et al. 2018), we demonstrated how to use thermal radiation sensed by multiple wavelengths on MODIS to derive separate temperatures for the forest and snow components (Fig. 3). Now, instead of a mixed LST (black squares in Fig. 3), we can look at snow and forest temperatures individually. During the day, the forest temperatures track air temperature (which can also be measured by a sensor hanging in a tree) closely, and together, Terra and Aqua provide remotely sensed temperature observations four times a day (Fig. 3).

So, does this make i-buttons obsolete? For the immediate future, of course not! (My children are finally getting old enough to hike with me and help deploy these things as distributed validation measurements.) The technique cannot provide temperatures beneath clouds, and while the three days of comparison in Figure 3 look promising, they also hint there is room for improvement.

As we continue to evaluate and improve our remote-sensing algorithms, there is hope that at least for areas with snow, trees, and no clouds, we should be able to map both air and snow surface temperatures across the landscape. MODIS and VIIRS will allow us to do this at 1-km resolution up to 6 times a day, and the new GOES-16 and GOES-17 satellites will allow us to do this at 2-km resolution every 15 minutes across the entire western hemisphere. For people obsessed with spatial patterns of mountain temperature for any application, this is exciting! And while Bob will still need to hike to locations where he has to hide i-Buttons under rocks, he should soon be able to monitor lapse rates (temperature changes with elevation) and cold air pools anywhere he likes using satellites and cloud computing.

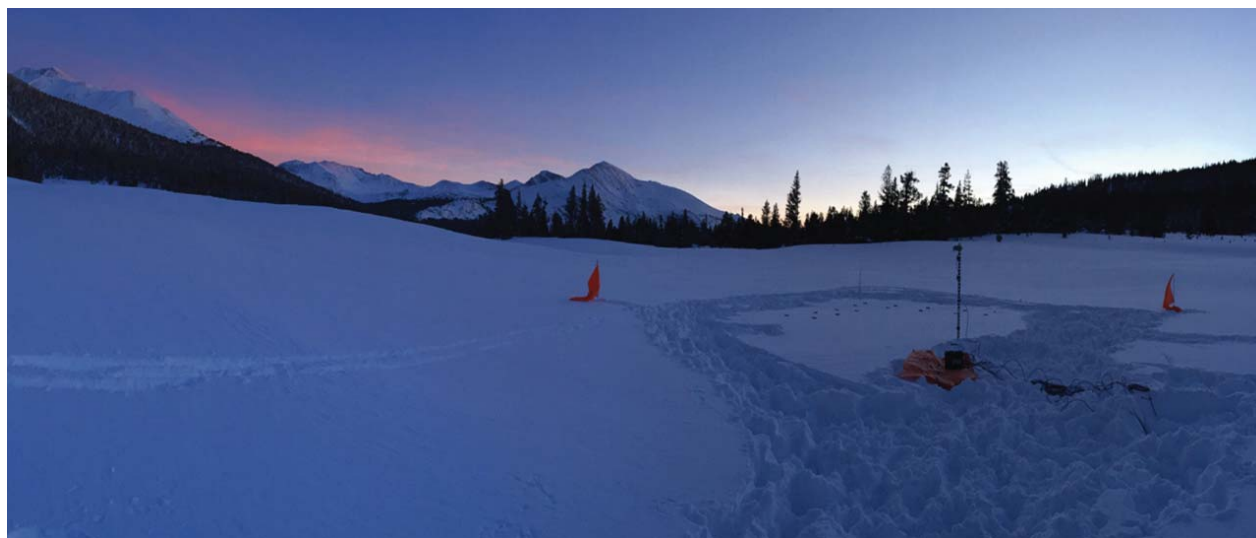


Figure 2b. Ground site for the study area.

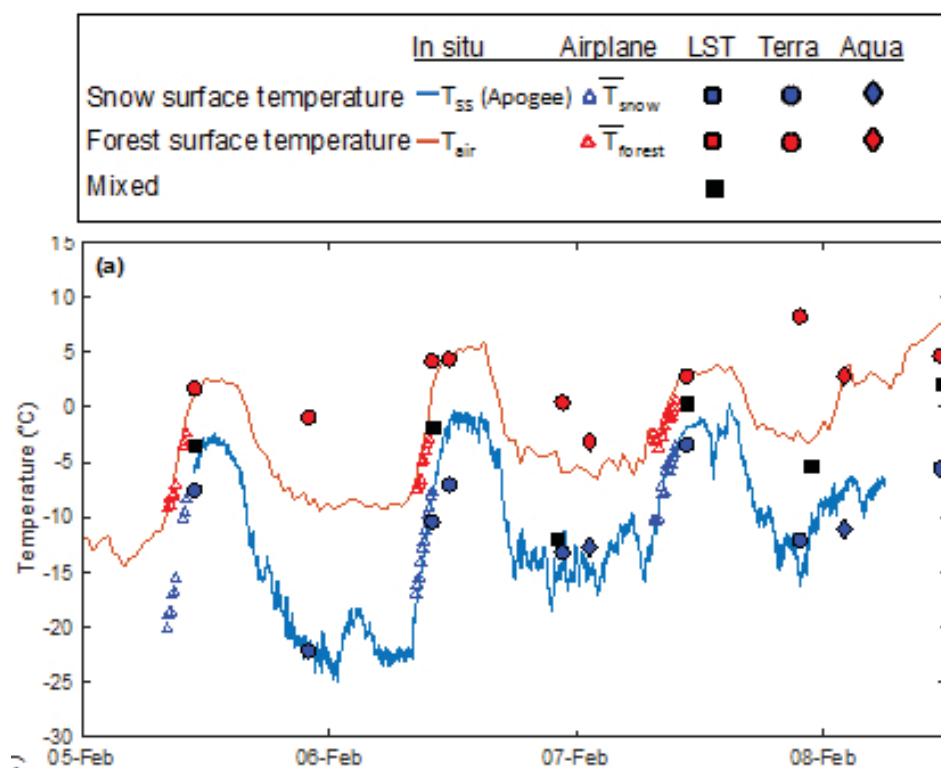


Figure 3. (adapted from Lundquist et al. 2018). Remotely sensed forest surface temperature closely tracks air temperature (as measured by a small temperature sensor hanging in a tree).

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In addition to typical *Brevia* articles that summarize recently published articles, I am adding *Brevia* that summarize planned dissertation research by graduate students. Justin Gay will be leading a workshop at *MtnClim 2018*, and also contributing a presentation. This *Brevia* describes his intended graduate research. —Editor

Landscape Biogeochemical Patterns Through the Lens of Stable Isotopes

Justin Gay

Montana State University

Department of Land Resources and Environmental Sciences

Montana State University, Bozeman, Montana

My dissertation work is focused on biogeochemical cycles across terrestrial ecosystems, and I am working under the tutelage of Dr. Jack Brookshire at Montana State University. Our lab combines techniques in theory, field, and laboratory analysis to answer questions about how global change is altering patterns of ecological organization, function, and interactions across a wide array of landscapes and plant-soil systems. Specifically, I am interested in how natural disturbance affects nutrient loss pathways, and the subsequent changes to the bioavailability of nutrients. Currently, I am investigating how vegetation and soils respond to prescribed fire in the Musselshell/Missouri River breaks (Fig. 1). The role of fire is known to increase inorganic nitrogen (N) availability, and has been characterized in ponderosa pine (*Pinus ponderosa*) forests (Deluca et al. 2006), but its role in the woody expansion into savanna of the Northern Great Plains remains unresolved. My role is investigating how nitrogen (N) availability changes in response to fire using bulk soil isotopic ratios of ^{15}N : ^{14}N to track the legacy of N availability, and its possible impact on the recruitment on seedlings. The stable isotope distributions of ^{15}N : ^{14}N will be used as they have been shown to be a proxy for bioavailable N across a number of systems (McLaughlin et al. 2010, McLaughlin et al. 2017). In addition, I will be using dendrochronology techniques to couple the soil and plant system to explore more historical feedbacks (Fig. 2).

I intend to extend my investigation of the role of disturbance on soil N availability to montane ecosystems. Currently, there exists considerable uncertainty about the relative strengths of biologically-mediated (e.g., denitrification) versus climate-mediated, and disturbance-mediated (e.g., fire and landslides) controls on soil ^{15}N : ^{14}N in steep mountainous terrain. I have begun analysis on a series of elevational transect data sets from across the neo-tropics in an effort to better understand the controls on N availability in elevated complex terrain. The isotopic ratio of ^{15}N : ^{14}N have been well constrained in their response to mean annual temperature and mean annual precipitation, MAT and MAP, across the tropics (Amundson et



Figure 1. Field work (with my dog Kia) in the Musselshell/Missouri River Breaks of Montana. We hiked through the rugged and rolling landscape to collect soil chemistry samples to process for bulk ^{15}N .

al. 2003, Craine et al. 2015). However, I plan to offer a better characterization of ^{15}N : ^{14}N patterns of montane systems at higher latitude ranges, in more N limited systems (Fig 3). I propose to run a series of elevational transects across a variety of mountain ranges in undisturbed systems across the North American Pacific Northwest. Ranges being targeted include the Olympic Mts, WA, Bridger Mts, MT (Fig 4), Selkirk Mts, ID, and White Mountain Mts, CA. Planned data collection includes soil cores for a depth profile of ^{15}N : ^{14}N , tree cores, and foliar samples. This work will better illuminate if the same climatic indicators (MAT, MAP) heavily influence patterns of N availability in more northern

latitude mountain systems. This work has direct ramifications as mountains of the North American West continue to show a trend in warmer temperature with increased variability in precipitation (Oyler et al. 2015). It will be increasingly important to better constrain our understanding on the controls over ^{15}N : ^{14}N distributions and if northern latitudes exhibit the same patterns of climatic control in the tropics, as opposed to a more biologically or disturbance driven system.

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Figure 2. Cross sections of *Juniperus scopulorum* used to age trees within our plots in the Missouri Breaks. Tree cores were also taken from trees within the plots to access patterns of ^{15}N through time.



Figure 3. I maintain our lab's atmospheric deposition sensor in Bozeman, Montana. We are following National Atmospheric Deposition Program protocols to better understand patterns of nitrogen and phosphorus deposition in the relatively unpolluted and unstudied Gallatin Valley. We are interested in looking at potential nitrogen signatures of wildfire late in the fire season.

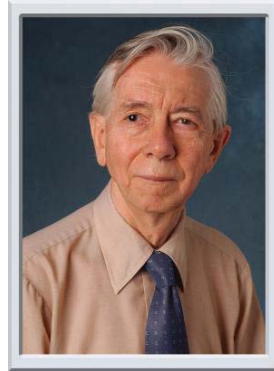


Figure 4. Hardscrabble Peak from Sacagawea Peak in the Northern Bridger Range outside of Bozeman. A potential site for the future transect study.

NEWS and EVENTS

Roger Graham Barry

November 13, 1935 – March 19, 2018



Roger Barry, Distinguished Professor of Geography Emeritus in the Geography and Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, was a mentor, friend, and colleague to many CIRMOUNT scientists. Those who attended the MtnClim 2008 climate conference in Silverton, Colorado recall that Roger gave a wonderful keynote talk, titled, "Recent advances in mountain meteorology and climatology." Roger passed in March this year. Please see more information in his Memorium, from which I extracted the following. —Editor

Roger Barry, longtime faculty member, colleague, and friend to many, passed away March 19, 2018 at the age of 82. Roger had lifelong research interests ranging widely from polar climates to mountain climates to climate change. He was the author of hundreds of research papers and review articles and an avid author and co-author of textbooks, including *Atmosphere Weather and Climate*, *Synoptic and Dynamic Climatology*, *Mountain*

Weather and Climate, and *Microclimate and Local Climates*. His final book, focusing on polar environments, will be published posthumously. Roger was recognized around the world for both his scientific accomplishments and his service to the community.

Please read more at: <https://www.colorado.edu/geography/2018/03/21/memoriam-professor-emeritus-roger-barry>

Adapted from USGS Release, dated April 11, 2018

Dan Fagre Receives USGS Award for Lifetime Achievement in Science Communications

Research Ecologist Dan Fagre is the recipient of the 2017 Eugene M. Shoemaker Award for Lifetime Achievement in Communications.



Photo, USGS

In 2017, USGS Research Ecologist Dan Fagre received his 30-year pin and Length of Service certificate from the U.S. Department of the Interior. Particular recognition was given for his “communication skills and scientific and technical contributions to understanding interactions between climate, ecosystem function and snow-glacier dynamics in Glacier National Park and across Western North America.”

This recognition has followed Fagre into 2018 with his recent selection as the 2017 U.S. Geological Survey’s Shoemaker Lifetime Achievement award recipient. The Eugene M. Shoemaker Award for Lifetime Achievement in Communications is presented annually to a USGS scientist who creates excitement and enthusiasm for science among non-scientists using effective communication skills.

“Dan’s unfaltering ability to eloquently communicate the complexities of his research to a myriad of audiences illustrates his dedication not only to his research, but also to ensuring that the public understands mountain ecosystem change and the implications of those changes for communities worldwide,” said Claudia Regan, the center director for the USGS Northern Rocky Mountain Science Center (NOROCK) where Fagre works.

Fagre began his Interior Department career in 1988 with the National Park Service, joining the National Biological Survey in the early 90’s and eventually the USGS in the Biological Resources Division in the late 90’s. Fagre is stationed at the USGS NOROCK Glacier Field Station in Glacier National Park, Montana.

“An award given to an individual is nearly always a reflection of a team effort,” said Fagre. “I’ve been honored to work with a stellar group of talented colleagues that share my passion for communicating the adventure and social relevance of science and the daily delight I take in being a scientist.”

Since 1997, Dan has participated in over 700 outreach events including congressional tours and media events such as

documentaries, radio broadcasts, magazines, contemporary non-fiction, television, and news print. He is recognized by his colleagues for his extraordinary skills and success in communicating complex scientific concepts in an understandable and compelling way, making science accessible to everyone.

A colleague who provided a letter of support for Fagre’s nomination wrote, “Whether he is delivering a technical talk at a scientific meeting, addressing a group of resource-managers, or leading public field trips in his beloved Glacier National Park, Dan has a magician’s capacity for inspired teaching.”

Fagre is the director of the Climate Change in Mountain Ecosystems Project, and lead investigator in the USGS Benchmark Glacier Program. He has collaborated with other scientists around the world on diverse research projects that address glaciers, avalanches, amphibians, alpine plants, paleoclimates, snow chemistry and ecosystem dynamics of bioregions, among others. He is currently active in the Western Mountain Initiative, a program to coordinate mountain research across different areas; GLORIA, a global program to monitor alpine vegetation on mountain summits on six continents; and CIRMOUNT, a consortium of mountain scientists. He has presented his work in countries all over the world including Argentina, Australia, Italy, Kyrgyzstan, the United Kingdom, Switzerland, Columbia, Austria and France.



Dan Fagre at Grinnell Overlook.
Photo, USGS

Fagre received his Ph.D. from the University of California, Davis, has been a faculty affiliate at six different universities and mentored or sponsored many graduate students, published three books and 170-plus scientific publications, and co-founded several national and international science networks.

Conference Announcement
MtnClim 2018
September 17-21, 2018, Gothic, Colorado



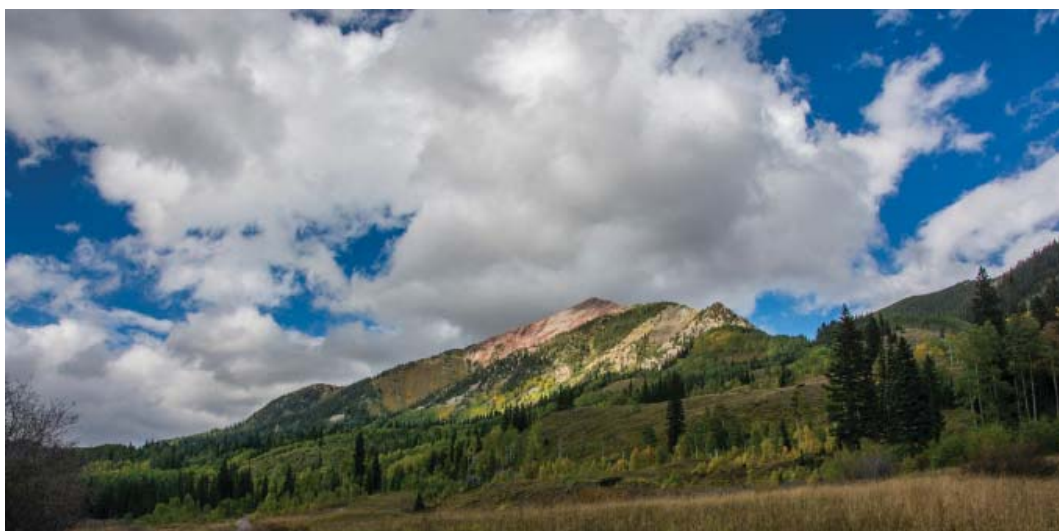
The MtnClim conferences are the flagship events of CIRMOUNT, the first of which was held in 2003 in the Lake Tahoe Basin, California. Now biennial, *MtnClim 2018* is scheduled for September 17-21, 2018 at the Rocky Mountain Biological Lab in Gothic, Colorado. The overarching theme for this year's meeting is, "Anticipating climate change impacts in mountains: Embracing variability", with subthemes of 1) Trees, snow, and water, and 2) Causes and consequences of temperature and hydroclimate variability during the Common Era.

The week will begin with a pre-conference field trip on Monday (9/17), followed by afternoon registration, dinner, and the opening Redmond keynote talk given by Chris Daly (OSU). Invited speakers and contributed presentations (posters and talks) continue through Thursday (9/20) noon, and a range of workshops on diverse themes will begin Thursday afternoon and continue Friday morning. *MtnClim 2018* concludes at noon on Friday (9/21). Other keynote talks will be given by John Harte (UC Berkeley) and David Inouye (U Maryland). For more information on the venue and program see the *MtnClim 2018* website, below.

Register, submit an abstract, and sign up for lodging by **July 2, 2018** at:

<http://www.rmbl.org/mtn-clim-2018/>

Contact Andy Bunn or Scotty Strachan for more information



Photos by Scotty Strachan

Conference Announcement
PACLIM 2019 February 17-20th, 2019
Asilomar Conference Grounds, Pacific Grove, California

Paclim is the sister event to the *MtnClim* conferences, and the two events alternate years for meeting. *Paclim* is a multidisciplinary workshop that broadly addresses the climatic phenomena occurring in the eastern Pacific Ocean and western North America. The purpose of the workshop is to understand climate effects in this region by bringing together specialists from diverse fields including physical, social, and biological sciences. Time scales from weather to the Quaternary are addressed in oral and poster presentations.

The theme for *Paclim 2019* will focus on the **Weather and Climate of Extreme Events**. The past year has been marked by extreme heat, wildfires, landslide and flooding events. These events are related to immediate weather conditions as well as recent historic drought conditions. The workshop encourages participation from climate scientists who are examining the climate dynamics behind extreme events and paleoclimatologists reconstructing past extreme events and connections. We also encourage the participation of archaeologists and historians who examine the impact of such events on society as well as current policy and emergency preparedness managers.

Information regarding the conference can be found at the *Paclim* website below. The website will be updated with information as it becomes available (e.g. registration deadlines, housing, funding support for early career and graduate students etc.).

Please mark your calendars and also please spread the word to interested colleagues and students.

Paclim website: <https://sites.google.com/site/paclimconference/>

Contact: Michelle Goman (Sonoma State University) or Scott Mensing (University of Nevada, Reno)



Asilomar Conference Grounds

Adapted from the First Announcement

United Nations International Workshop: Global Mountain Safeguard

Emerging Risks and Future Challenges for
Mountain Regions Worldwide

Bozen/Bolzano, Italy, 17 – 19 October 2018



Eurac Research and the United Nations University Institute for Environment and Human Security, through their new joint program, Global Mountain Safeguard Research (GLOMOS), are organizing the above United Nations International Workshop in order to enhance disaster risk reduction, climate change adaptation, and emergency response preparedness in mountain regions worldwide; to increase the resilience of mountain communities towards natural and man-made hazards and disaster risks; to protect the wealth of biological and cultural diversity; and to support the sustainable development of the highly sensitive social-ecological systems.

FORMAT: The congress will act as a platform for communication and exchange inviting interested researchers from numerous disciplines, practitioners, government representatives and NGO's, UN agencies, public and private institutions, the private sector, as well as international networks and organizations related to mountain specific topics.

GOALS: Major aims of this conference are to discuss present and future challenges in mountain areas worldwide, to bridge between the international academic community and the United Nations system, and to facilitate a global community of practice dealing with contemporary mountain specific subjects. In more detail, main objectives of the conference will include:

- the identification of adequate approaches to turn scientific knowledge into action, specifically to support the implementation of the most recent global conventions and frameworks, such as the Sendai Framework for Disaster Risk Reduction, the Paris Climate Agreement, the New Urban Agenda, and the Sustainable Development Goals,
- facilitating the science-policy dialogue and promote scientifically sound guidelines and recommendations for decision makers and planners to foster evidence-based advocacy for mountain specific topics,
- strengthening the resilience of mountain communities within the context of major drivers such as climate change, urbanization or economic development and the development of inclusive and people-centred DRR concepts including gender-mainstreaming.

TOPICS with mountain specific reference addressed at the workshop will be:

- innovative approaches in the fields of disaster risk reduction (DRR) and climate change adaptation (CCA),
- mountain ecosystems and biodiversity,
- migration and livelihoods of mountain communities; minorities and socio-cultural context,
- renewable energy and mountain engineering,
- urbanization and industrialization in mountainous areas (including waste management);
- mountain emergency medicine; multi-hazard early warning systems (EWS) and emergency response preparedness,
- recreation, mountaineering and tourism, as well as
- education, capacity development and training.

Conference events include selected keynote addresses by renowned experts from across the disciplines and focussed group discussions. The conference will provide ample opportunities to meet established authors, researchers, experts and professionals along with those who are new to the field. Special events and short field trips will be scheduled for entertainment and to learn about the history of mountaineering, mountain research, most recent advances in alpine technologies, and the unique mountain environment of the Dolomites in South Tyrol, declared as UNESCO World Heritage Site since August 2009.

For further details with regard to local arrangements and conference logistics please contact Mrs. Alexa De Marchi, Local Workshop Management, Eurac Research, e-mail: alexa.demarchi@eurac.edu, Tel: +39 0471 055 057

For information regarding the scientific coordination of the workshop please contact:

Dr. Jörg Szarzynski, United Nations University Institute for Environment and Human Security, UN campus, Bonn, Germany

E-mail: szarzynski@ehs.unu.edu

Telephone: +49 228 815 0327

Dr. Stefan Schneiderbauer, Eurac Research, Institute for Earth Observation, Bozen/Bolzano, Italy

E-mail: stefan.schneiderbauer@eurac.edu

Telephone: +39 0471 055 373



End of Snow A Film by Day's Edge Productions

In *End of Snow*, climate scientist Jane Zelikova traces her love of snow to her birthplace in Ukraine, interviews a University of Wyoming researcher (Bryan Shuman) who dredges the bottom of alpine lakes to trace historic climate variations, a Colorado man (Billy Barr, of Rocky Mountain Biological Lab legacy) who has been meticulously recording snowpack for 40 years, and a Wyoming rancher (Freddie Botur) trying to cope with the uncertainty of a fluctuating water supply.

Special treat for *MtnClim 2018* attendees: Billy Barr will host a walk in the Rocky Mountain Biological Lab during the *MtnClim 2018* conference week (Wednesday, September 19) to discuss his long climate and phenology record.

End of Snow

Morgan Heim and Jane Zelikova

21 minutes

Read about the film and watch it, streaming, at www.endofsnow.com/



VOICES IN THE WIND

In this section, I query members of the CIRMOUNT community for their perspective on a topic of current interest. — Editor

Question: *Actionable science* is scholarship designed to inform and support resource decision-making, improve evaluation of risks and impacts, and assist in development and implementation of public policies. In the context of mountain ecosystems, climate change, and western North American resource-management and policy, what aspects of your (and/or your students and collaborators) research touch on actionable science? Or if you are a user of science information, what topics do you feel are most urgent for actionable science in our mountain context?

Jessica Halofsky, School of Environmental and Forest Sciences, University of Washington, Seattle, WA

As a part of the Adaptation Partners team (<http://adaptationpartners.org>), and in collaboration with the Forest Service Office of Sustainability and Climate, my work focuses on climate change adaptation in the western United States. Projects, ranging from individual national forests and national parks to entire regions, are led by science-management partnerships and a consistent framework to assess climate change effects and identify on-the-ground adaptation options for addressing those effects. This approach has been applied to 40 national forests, 32 National Park Service units, and other lands (27 million hectares). Adaptation Partners workshops have been attended by over 1000 participants from over 100 organizations.



Adaptation efforts are intended to inform sustainable management of natural resources, reduce the negative effects of climate change, transition ecosystems to a warmer climate, and help integrate climate change in natural resource management and operations. Science-based vulnerability assessments are led by scientific teams from Forest Service research stations, other agencies, and universities in collaboration with agency resource specialists. Assessments synthesize the best available science, evaluate the quality and relevance of the science for each application, and identify geographic locations where sensitivity is high. Adaptation plans are then developed to respond directly to the scenarios and conditions documented in vulnerability assessments, addressing both general management strategies and specific management tactics. Resource managers have the lead on developing adaptation options, and scientists ensure that scientific documentation supports those options.

Assessments and adaptation options developed by Adaptation Partners are resulting in revised management approaches on the ground. For example, Olympic and Okanogan-Wenatchee National Forests have modified their stand density management guidelines in light of a warmer climate. Several national forests in the Pacific Northwest have modified engineering guidelines for roads and culverts in anticipation of higher peak flows (flooding) in the winter. National forests and national parks throughout the West are modifying conservation strategies for cold-water fish, especially bull trout, which will experience stress from low summer streamflows and high temperatures. National forests and Bureau of Land Management units in southwest Oregon have modified restoration and vegetation management projects in anticipation of increased thermal stress and wildfire occurrence. National forests in Oregon and Utah are considering how to increase the flexibility of recreation management to accommodate increased summer recreation and decreased winter recreation in a future with less snowpack. Assessments and adaptation information are also being integrated in national forest plan revisions, in compliance with requirements of the Forest Service 2012 Planning Rule.

Imtiaz Rangwala, NOAA Earth Science Research Lab, CIRES/ Western Water Assessment, University of Colorado, Boulder, CO

In my engagements through “climate service” bodies of Federal agencies, including the Western Water Assessment (a NOAA RISA) and DOI’s North Central Climate Science Adaptation Center --- working on the issues on the changing nature of droughts, climate extremes, and snow under climate change on mountain ecosystems in the Inter-mountain West, I have developed certain appreciation for doing science differently in order to better engage, inform and



learn from the community of actors at large. Some essential elements, in my view, include:

- i. Long-term commitment that fosters iterative and continuous engagement with a team of stakeholders (biggest challenge usually)
- ii. Ensure deep understanding of relevant sciences and issues all around the team of diverse expertise (getting better at the art of listening)
- iii. Use a multi-faceted verbiage to promote effective understanding, and do not shy away from bringing in relevant nuances and uncertainties
- iv. Develop acceptance for “reasonable” accuracy. Better informed decisions need work out all the time (being realistic)
- v. Emphasize process more than product because actionability manifests over long term.

Connie Woodhouse, School of Geography and Development, University of Arizona, Tucson, AZ

I use tree-ring data to reconstruct climate over past centuries. Over the past 15 years or so, many of the reconstructions I've produced, in collaboration with other researchers, have been of annual streamflow for rivers in the western US. Much of this work has been motivated by communication and/or collaborations with water resource managers. Thus, I consider the work to be use-inspired, and certainly, since much of it is in response to needs and interests voiced by water resource managers, I hope that it is useful in some way. It is potentially “actionable science” but it is mostly rather difficult to determine if and how this information is being used in support of decision making. This difficulty arises from the fact that the reconstructions are not always something that can be incorporated into the traditional tools or practices for decision making in a given agency. In some cases, water managers have incorporated a reconstruction into a water resource system or planning model to test the response of the system to conditions outside the range represented in the observed hydrology. That's a pretty tangible application, but how the information resulting from these runs is used is not obvious. Another difficulty in determining how the streamflow reconstructions are being used comes from the time lag between when reconstructions are produced and shared, and



when they might be considered for use. The lag can be related to a host of issues including agency capacity, funding, personnel, politics, or other pressing priorities. Over the years, I've come to realize that the extended records of streamflow from tree rings are valued, first and foremost, for the long-term perspective they provide. This perspective is most often integrated into decision making in very subtle ways. One of my favorite quotes from a water manager on the usefulness of streamflow reconstructions is that the data “inform my intuition.” Does this sound like actionable science? Perhaps not, but I'm glad to be doing work that has any impact at all!

John Abatzoglou, Department of Geography, University of Idaho, Moscow, ID

My research group at the University of Idaho tackles both basic science questions and actionable science centered on western US climate and climate impacts. We are interested in climate variability and change pertaining to hydroclimate in mountains at a variety of scales - and how this has and will continue to impact water resources and ecosystems. We are also interested in understanding how climate directly and indirectly affects landscape disturbance such as wildfire and the role that people have had in modulating climate-fire relationships. Gaining a scientific understanding of how resilient (or not) our mountain landscapes are to change can help inform policies on measures that might help us adapt. Finally, we develop a number of datasets and tools (e.g., <http://climatetoolbox.org>) that the broader scientific community and managers are using to better understand yesterday and plan for tomorrow. Future changes in montane landscapes will continue to be shaped by climate change. Conducting research that directly informs decisions we make today helps keep my batteries charged.



As academics we are trained to value basic science. However, our changing landscape and the value placed on actionable science to inform decision-making has created value in applied science. I credit my personal interest in applied and actionable science to mentors in the community such as the late Kelly Remond. To me, part of actionable science is engaging in a two-way dialogue with others across fields (and different organizations) and communicating results back to the broader public.

Anne Nolin, College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, OR

Broadly speaking, my research focuses on snow and ice in the climate system, how they melt and become water for communities and ecosystems. Lately, students in my research group have been examining snow-forest interactions, especially with regard to forest disturbance such as wildfire and timber harvest. The USDA Forest Service has allowed us to maintain a network of



sites along an elevational gradient in the Oregon Cascades. Our message to forest managers is that “snow matters to forests.” While it is well known that snow matters to forests in terms of wildfire frequency, intensity, and size, we have also learned that snow matters after a fire. Regrowing vegetation in the post-wildfire landscape depends not only on summer precipitation but also on the previous winter’s snowpack – and that this continues for several years. We also know that forests matter to snow – in terms of snowpack accumulation and retention. Recently published work by PhD student Travis Roth has shown that lower elevation forests are warmer, accumulate less snow and cause snow to melt earlier than in adjacent open areas. The converse is true for colder higher elevation forests where there is abundant snow accumulation in the forest and it lasts longer there than in adjacent open areas. In terms of actionable science, this means that forest managers have additional information available as they consider forest thinning, gap size, fire management, and post-fire vegetation regrowth.

While the previously described research is based on field observations, I have also been active in collaborative modeling work using an innovative coupled human-natural systems model. Funded by NSF, our 6-year modeling project asked the question: “Where, when, and under what conditions might water scarcity emerge in Oregon’s Willamette River Basin (WRB) from present day through the end of the century”. To answer this complex question, we used the Envision modeling framework with spatially explicit sub-models to simulate upland snow processes, hydrologic routing through the basin, forest water use, reservoir management, land cover/land use change, irrigation, water rights, municipal water use, and more. We had about 150 stakeholders from across the WRB and a dedicated Technical Advisory Group that represented about 30 different water interests. Together with our partners, we examined over 20 scenarios of future policy, climate, population growth and water use. Our findings indicate

the importance of understanding the roles of reservoirs and environmental flows (for fish) – and that although municipal and irrigation water uses are much smaller than other water uses, they have outsized economic importance. We have also learned that water scarcity manifests differently in the mountains compared with the valley. Climate change and declining snowpacks drive water scarcity in the uplands, and the impacts are mainly on forests. Thus, forest management is key. Water scarcity in the valley is mainly driven by changes in water use so reservoir management, land use, and cost are most important there. To learn more about this project, visit the Willamette Water 2100 website at <http://inr.oregonstate.edu/ww2100>. We are continuing this modeling effort with a new phase looking at tradeoffs between water, energy and food. In the mountains, the tradeoff is between managing for forest fires vs. the energy and water expended to suppress or fight wildfires. No results yet with this newest project but please stay tuned.

Geoffrey McQuilkin, Executive Director, Mono Lake Committee, Lee Vining, CA

The Mono Lake Committee has the opportunity to lead tours and stroll the shore of this 45,000-acre salt lake avian oasis with many thousands of visitors. Some of the questions people ask are timeless (how is a tufa tower formed?) but in recent years an increasingly common question has been about climate change, precipitation, and the protection of Mono Lake.



Does climate change, people wonder, mean that Mono Lake will never recover from decades of water diversions and rise to its mandated, ecologically sound management level? It’s a question we have been asking ourselves as well, and it is one we have started to hear from policy makers too. And it is a disturbing one, because Mono Lake is an iconic example of a place where present day resource management requirements have been built on broad based scientific understanding of the resources themselves. And we don’t want that to change.

The answer requires actionable science. Specifically, we need projections of climate change impacts on snowpack, precipitation, temperature, and runoff timing at a geographic scale that is meaningful within the Mono Lake watershed. We are already good at using past hydrology to project lake level over years and decades—now we need to do that in ways that incorporate expectations of a climate-altered future.

We need that actionable science rather urgently, because as advocates of Mono Lake's protection we know that information gaps can quickly be filled with off the cuff speculation. And, we don't want to see hard-won protections for Mono Lake and its tributary streams undermined by guesses about the changing future and speculation about whether today's protections will continue to work (for the record, based on the science so far we expect they will).

Just this spring Dr. Alex Hall and his team at the UCLA Center for Climate Science published a report, *Climate Change in the Sierra Nevada*, that downscales climate models and produces the kind of information we are seeking. Although much work remains to be done to integrate such downscaling with the water balance model of the lake, it has been immediately helpful. Their April publication is informing the Mono Lake Committee's May policy and management discussions, which leads to better answers in June and July when engaged visitors inevitably ask about the local effects of climate change. That's the great thing about actionable science from the viewpoint of an advocacy and education organization: we can put it into action right away.

Nina Oakley, Western Regional Climate Center, Desert Research Institute, Reno, NV

Post-fire debris flows pose a significant threat to life and property in mountainous areas of the West. As the fire season lengthens, extreme precipitation becomes more prevalent, and populations situated on alluvial fans likely grow, the potential for impacts increases. These events are driven by short duration, high intensity precipitation; sub-hourly precipitation rates are often the most important.

My colleagues and I have been studying the meteorological origins of cool season post-fire debris flow events in California. Our goal is to present our findings such that they can be used by floodplain and emergency managers, engineers, weather forecasters, fire agencies, and the public to improve situational awareness, planning, and mitigation strategies related to these events. We are working towards this goal by presenting our findings not just at academic conferences, but also at the meeting and workshops that our target audience members attend. We are also developing informative handouts that our partners can

use to communicate with their stakeholders as well as publish papers that are accessible to an audience broader than just the meteorology community.

As an example, we observed that post-fire debris flows are often associated with narrow bands of intense precipitation, typically along a cold front. Such bands may occur within a weak to moderate storm event with unimpressive storm total precipitation (as well as more significant storms). This information is valuable to forecasters as they can look for the ingredients favorable for development of these rain bands. Emergency managers can use this information to improve their awareness of potential hazards and better explain their decisions to the public. We are also working towards developing or refining precipitation intensity-duration thresholds for areas where they do not exist or are not well defined. This information will allow improved constraint in the issuance of warnings or evacuations to avoid fatigue and complacency among those impacted. We are also working to determine how the frequency of precipitation intensities exceeding known post-fire debris flow triggering thresholds is likely to change in the future. This can inform the design of communities and mitigation strategies such as debris basins.

Henry Diaz, Department of Geography, University of Hawai'i, Manoa, HI

It stands to reason that natural resources management decision-making should be based on the best available science and on best management practices. Of course, as management is implicitly a human activity, societal values cannot in general be excluded from the equation. In the past half-century, recognition that human activities were modifying the climate of Planet Earth, stimulated increasing collaborations between physical and social science experts with the goal of enabling increasing knowledge about environmental changes to be incorporated into natural resources management decisions.

On a personal level, research into drought manifestations and mechanisms led to an interest in water resources management issues, such as inter-basin and transboundary water transfer protocols, and on how climate change might affect drought frequency and intensity, and thus lead to potential societal conflict. The American West is nothing, if not a heavily plumbed system whose purpose is to deliver water from sparsely populated



areas where it is relatively plentiful, to urban and agricultural uses in places with natural water scarcity.

Which brings me naturally to the mountainous West. In the words of the poet Thomas Hornsby Ferrill, the West is “A Land Where Life is Written in Water”. Mountains have been described as the “Water Towers” of the planet, and their significance in supporting western society cannot be overstated. Much of the West is warming faster than areas in the East, while drought has been a frequent occurrence over the past two decades. Some of our political leaders recognize the urgency for developing actions to mitigate and enhance adaptation to the physical environmental changes coming as a result of our warming planet. They also recognize that the best available science is crucial to developing the right kinds of interventions to help society cope with the coming changes.

Bret Meldrum, Social Science Program, National Park Service, Ft. Collins, CO

Conducting social science inquiry in our parks and protected areas is, and should continue to be, administered with the assumption it is actionable. It is, however, likely not the type of science most readers primarily think about regarding actionable science in mountain ecosystems.

Social science-based research and monitoring is largely visitor-focused in park and protected area contexts. This comes as a result of the efficacy that organizations perceive regarding what they can influence. Visitors and their recreation experiences are something we can and should actively manage, though a significant variation of that actually occurs. Oftentimes, the degree of social science inquiry to inform active visitor management is commensurate with the resource and social impacts that visitation is anecdotally thought to create. As visitation rises, interest in actionable information on visitors and their impacts is piqued. It should not come as a surprise then that social science inquiry tends to be something viewed worthy when visitation increases.

Scientific studies via research and monitoring seek to understand visitor volume, density, and travel patterns. This allows for a more accurate picture of how people systematically interact with the environment across recreation settings. This foundational information allows for science to inform management’s understanding of what is occurring on the ground. Largely



dependent on understanding conditions empirically, managers derive proposed actions to further protect resources and/or provide for visitor enjoyment. A second type of study explores visitor attitudes towards these proposed management actions. Typically, these studies are derived once a thorough understanding of existing conditions has occurred. A wide variety of attitudinal questions and discrete choice tradeoffs via inquiry are used for these methods. Both of these types of studies enable science-informed action but are considered within a suite of other empirical and managerial considerations.

In moving beyond borders to transboundary contexts, social science inquiry is increasingly challenging for the field of conservation. While the objective should remain the fostering of actionable science, policy applications and other forms of action are not always as clear as in land management contexts. Organizational efficacy can be challenged in thinking about actionable science within respective jurisdictions. Oftentimes, when park and protected area management receives an opportunity to conduct studies outside of a visitor scope, the focus is on broader societal relevancy and engagement of the U.S. population by their organization. In my opinion, this transboundary challenge is the crux in tackling wicked problems that do not neatly conform to management boundaries for common pool resource decisions. I would generally argue that actionable social science inquiry bridging transboundary contexts in land and resource management remains truly an aspiration.

Beth Hahn, Aldo Leopold Wilderness Research Institute, Missoula, MT

In recent years, I have worked to support decision making related to ecological interventions in wilderness. Annually, the four agencies that manage wilderness—the USFS, BLM, USFWS, and NPS—receive dozens of proposals to implement ecological restoration actions within the NWPS, a network of 765 units across 110 million acres of public land.

Ecological restoration treatments that are currently implemented within the NWPS include actions that manage vegetation (e.g., chemical and mechanical removal of invasive plants, planting trees); actions that manage fish, wildlife, insects and disease (e.g., introducing biological control agents, fish stocking, animal removal); actions that manage soil and water (e.g., mine site reclamation, spreading lime to buffer acid deposition); and, actions that manage fire (e.g., suppressing human-caused fire,



mechanical fuels reduction treatment, prescribed fire).

The combination of climate change with other landscape stressors is driving ecological restoration to be one of the single most important, challenging, and potentially litigious wilderness stewardship issues. In addition, different stakeholders have divergent views about what the “right” decision should be, and decisions need to go beyond routine technical analysis to incorporate scientific, legal, and ethical considerations. Current law and policies, however, do not provide explicit support for restoration decision-making, which requires managers to evaluate the effects of proposed restoration actions while also responding to a legislative mandate to preserve wilderness character. As defined by the Wilderness Act, wilderness lands were intended to be protected in their “natural condition” (i.e. species, patterns, and processes that evolved in the area) and “untrammeled by man” (i.e. freedom from intentional modern human control and manipulation). Balancing the natural and untrammeled qualities of wilderness character is a persistent wilderness stewardship challenge. For instance, taking actions to restore whitebark pine *Pinus albicaulis* by planting rust-resistant seedlings or using prescribed fire may compromise the untrammeled value of wilderness, while not taking restoration actions may compromise the natural value of wilderness if this keystone species becomes extinct, since more than half of all whitebark pine occurs in wilderness.

Evaluating the risks, benefits, and uncertainties of ecological intervention in wilderness entails prioritizing and manipulating specific resources to achieve desired outcomes, a challenging triage with implications for the economic and social values of wilderness affected by the interventions. For example, reintroducing extirpated predators such as gray wolves *Canis lupus* may have cascading effects on ecological communities, and over time may influence how the public uses these lands (e.g., recreation, hunting) and how they view wilderness stewardship decisions. Ultimately, the scientific context is necessary but not sufficient in making these wilderness stewardship decisions: ecological intervention in wilderness raises questions that also demand weighing legal authorities, as well as values and ethics. In close collaboration with my colleague, Peter Landres, and with support from an interagency-university team, we developed a comprehensive, structured tool that includes questions to guide the evaluation of proposals for ecological intervention in wilderness. This framework of questions is a voluntary tool designed to increase communication and transparency regarding the tradeoffs and uncertainties of ecological intervention, and promote public deliberation when managing the public resource of wilderness. We strived to create a framework that is not biased for or against proposed ecological interventions in wilderness, nor does its use guarantee consistent project-

level decisions across the NWPS. Instead, the purpose of this framework is to ensure that the appropriate information about a proposal is available to the decision maker, ultimately facilitating a transparent and informed decision. The issue of ecological interventions in wilderness requires expansive, holistic actionable science.

Craig D. Allen, New Mexico Landscapes Field Station, U.S. Geological Survey, Los Alamos, NM (as written by Connie following a phone conversation with Craig)

Craig’s career has exemplified a model of actionable science. This emerged organically from his long tenure in one region, the Jemez Mountains of northern New Mexico, where he conducted both MS and PhD research during the 1980s on ecological changes in this landscape. From early in his student days, Craig interacted closely with local land management agencies, especially Bandelier National Monument and the Santa Fe National Forest. Applied ecological researchers were scarce in New Mexico at that time, and Craig quickly assumed an informal role of science advisor to local land managers. When he finished his dissertation research he was offered a term ecologist position at Bandelier; this ultimately provided opportunities for a place-based career devoted to long-term studies of forest and disturbance dynamics of these wonderful mountain landscapes, in support of diverse land management issues. As part of national re-organization of US Dept. of Interior ecological research capacities in 1993, Craig was administratively transferred to the short-lived National Biological Survey (which in 1996 was consolidated within USGS), but he has physically remained place-based and co-located with land managers in northern New Mexico throughout, overseeing the Jemez Mountains Field Station (recently renamed the New Mexico Landscapes Field Station to reflect an expanded scope), as an outpost of the USGS Fort Collins Science Center. From this position, he has conducted globally influential work on disturbance ecology (notably drought- and heat-induced forest die-offs, and fire) that derives from long-term local- to landscape-scale studies in the Jemez Mountains. The basic science information from now-decades of study continues to be of direct interest to forest and wildland managers in the American Southwest, as well as to other policy and decision-makers for their broad implications. The equation that has made Craig’s work truly actionable science includes highest quality and relevant research, plus the essential piece of long-term place-based science. This model, unfortunately, is supported only rarely in US national research agendas at present.



INTERVIEWS

Carolina Adler

Carolina Adler is the current Executive Director of the Mountain Research Initiative (MRI) hosted by the Swiss Academies of Arts and Sciences in Bern, Switzerland, and Research Fellow at the Transdisciplinary Lab at ETH in Zurich, Switzerland. As part of her MRI responsibilities, Carolina is tasked with coordinating scientific research agendas and supporting regional and thematic networks on global change research in mountains. Currently she is Lead Author for the “High Mountains” chapter of the Intergovernmental Panel on Climate Change special report on oceans and cryosphere, as well as Lead Author for Working Group II on Impacts Vulnerability and Adaptation for the Sixth Assessment Report. Carolina is an environmental scientist and geographer with a career spanning research and practice in the public and private sectors. Her research focuses on participatory approaches, particularly in the assessment and evaluation of such approaches on questions related to sustainable development in mountains. Carolina obtained her PhD at Monash University (Australia) in 2010, focusing on climate change adaptation and relevant policy processes for sustainable development in mountain regions. Following a passion for mountaineering, she also shares her environmental expertise as delegate to the International Mountaineering and Climbing Federation (Union International des Associations d'Alpinisme - UIAA) Mountain Protection Commission, assuming the role of President in 2016. Given the close ties of CIRMOUNT and MRI, I am pleased to share an interview I had with Carolina. — Editor

Carolina Adler



Connie: What attracted you to the MRI and to accept the challenges of being the MRI Executive Director?

Carolina: I must confess that at the very beginning, when I first saw the job advertised, it had not immediately crossed my mind as an opportunity for me to pursue, simply because I had just secured funding for an exciting research project on transdisciplinary research at ETH Zurich and was not sure how I would find a way to balance these two ‘dream jobs’, should the MRI position indeed materialize for me (as it eventually did). In the end I managed to find a way, convinced that much of the research work I would be undertaking has direct relevance and application in the coordination job as MRI Executive Director. Having been a member of the MRI for some years, since my PhD, and after some time thinking about new research directions for mountain science, I began to see a unique opportunity to steer a new direction for mountain research via MRI. In the meantime,

I was also approached by many colleagues who encouraged me to consider the position at MRI, so knowing about this endorsement from several well-known and esteemed colleagues in mountain research provided me with a certain degree of validation that encouraged me to consider it seriously. Besides, working on mountain research – and mountains in general – has always been a passion of mine, so I realized that all the stars were aligning in a very special way at a given point in time. I just simply had to go for it! The MRI position would, and so far, has, allowed me to remain focused and dedicated to mountains and their people, while at the same time reflect on and design new prospects for mountain research....and I’m very glad I did.

Connie: What is your vision for MRI's role and contribution at regional to global scales in the coming years?

Carolina: When I first came to MRI, I realized there was a great deal to review, assess, and evaluate before even coming up with a new vision and strategy for the coming years. The MRI has a legacy that spans over more than 15 years, and so it was important to be diligent and acknowledge this past, harvest the key findings and experiences, put the key pieces together while incorporating new ideas, and from that develop a new vision for the future. First, it was important to recruit and assemble a great team of people at the coordination office to support the joint task ahead, and after a year at MRI we have now managed to form a great team to start this important work. Over the past few months we have come up with a work plan strategy that would allow us to structure our work and complete the current funding cycle now under the Swiss Academies of Sciences (SCNAT), while at the same time, in parallel, develop a new science plan and strategy for the new funding cycle starting in 2019.

For many years, MRI has been about advancing global change research in mountains. The new work plan during these 'transition years' to 2019 builds on this legacy by connecting people and knowledge in mountains in relevant and meaningful ways. The MRI plays an important role in addressing knowledge needs on global change phenomena within and across mountain regions at a time of very rapid change globally. Our direct involvement in global processes such as the assessment work we do via the Intergovernmental Panel on Climate Change (IPCC), is one such example. In its current sixth assessment cycle, the IPCC has placed a focus on mountains, for instance through a chapter on 'High Mountains' in its Special Report on Oceans and Cryosphere in a Changing Climate (SROCC) and via a cross-chapter paper on 'Mountains' planned for the sixth assessment report, AR6. As a Lead Author in both reports, and as Lead for the cross-chapter paper on mountains in AR6, I am well-placed to ensure MRI and its community connects to yield the necessary synthesis and assessment work that represent the state of mountains on a global scale.

There are several key publications that we are preparing at MRI to present this synthesis work, as well as this new vision, structure, and participatory approach to scientific research through transdisciplinarity, and we hope to share them during the coming years.

Connie: Are there particular research foci you hope MRI will address?

Carolina: Addressing global change in mountains is a broad and complex subject, requiring interdisciplinary and transdisciplinary approaches to knowledge production that consider and interrelate three key types of knowledge: systems, target, and transformation. It is important to observe and understand global change phenomena as they manifest in the mountain space, within and across socio-ecological systems. As a mountain research community, the MRI has endeavored to do so for many years. However, we also need to take note of how these global change phenomena affect our context-specific notions and aspirations for sustainable mountain development, our target, and how to bridge this gap between the experienced problem in context (e.g. combined impacts of climate change and other socio-economic factors on water resources) and the ideal situation, i.e. how to transform. Acknowledging and incorporating these three knowledge types as part of our research in mountains is effectively about structuring an agenda for mountain research, and one that also compels a need to bring in the social sciences and humanities alongside the physical sciences, and society in general, in this process of knowledge co-production.



At the IPCC outreach panel event on mountains, Quito, Ecuador



With the lead authors of the IPCC SROCC chapter on Mountains - Antisana Glacier, Ecuador

Ensuring scientifically-sound synthesis and assessment of global change phenomena in mountains also means questioning and refining our methods for synthesis and assessment in the first place, ensuring they are also compatible in capturing and depicting the context-specificities that each mountain region has. Generalizing knowledge across mountain regions is not so simple or meaningful if taking a nuanced socio-ecological systems approach, and this is where the research work I have been undertaking on transferability and evaluation of transdisciplinary research comes in very handy to create and steer these new research agendas and collaborations for mountain research. This is also relevant for the synthesis work mentioned as part of the work we do with the IPCC. In the end it is all connected and serves a common purpose.

Connie: What relationship would you hope MRI to have with users of science information (policy makers, community leaders, resource managers)?

Carolina: I hope for a very productive and engaging exchange between the MRI community and users of scientific knowledge. Being scientifically sound is important to ensure the credibility of that scientific information, but we must also work on and acknowledge the role that legitimacy and relevance have for what we do in this complex science-policy and broader societal interaction. We are already taking steps in this direction; however, I see this as a process that needs continued development, innovation, and dedication over time. Our active participation in bodies such as the Steering Committee of the Mountain Partnership, and others, such as the IPCC, can help us keep a finger on the pulse, so to speak, and identify key policy interactions and knowledge needs.

Connie: Do you see opportunities to increase coordination between MRI and CIRMOUNT and with mountain scientists in western North America broadly?

Carolina: Sure! In fact, there are many networks and groups of mountain scientists all over the world with whom the MRI has had very good collaborations in the past, and with whom we hope to continue to connect and grow. Likewise, many new groups are emerging, and we are making connections to ensure we build these collaborations and to grow this community. CIRMOUNT has been very integral to work of the MRI in the past, and now that we have the human resources and capacities in place to work more effectively in the regions and with local networks, now is an opportune time to explore these collaborations in more detail.

Connie: I understand you have worked (or still do) in leadership roles for the International Climbing and Mountaineering Federation (UIAA). Do you see connections and/or complementary opportunities between this group and MRI?

Carolina: Yes, that is right. It all started for me as a member of the New Zealand Alpine Club (NZAC) while a student in Australia and training in technical mountaineering in New Zealand many years ago. Over the years, and in addition to developing my mountaineering skills and experiences in mountain climbing, I became very active in the environmental and social cause for mountains more generally. The NZAC was supportive in endorsing me as a member of the Mountain Protection Commission of the UIAA and allowing me to apply my scientific and environmental expertise to work for this cause and fulfil this passion. After some years as a member delegate to this Commission, I was eventually elected to President in 2016 and have since been very involved not only with this Commission's work but also in the work of Commissions such as Access and Training Panel and working with the UIAA Board and Office. The newly formed 'strategy working group' of the UIAA, in which I am also a member, has identified many strategic partnerships and collaborations to ensure the mountaineering community also participates in the 'solutions space' and realize sustainable mountain development. As part of this work, key research and information needs have been identified for which the MRI and its community are well-placed to respond to and participate.



Carolina on the summit of Copa (6,188 m), Cordillera Blanca, Peru



Dave Peterson

In January 2018, Dave Peterson retired from the U.S. Forest Service (USFS) after 37 years as a research scientist. Dave was a founding father and has been a key coordinator of CIRMOUNT and organizer of the MtnClim conferences since the first meeting in 2003. Dave's career spans many areas of forest and ecological research and application. Most recently he has been the pioneering leader in the USFS for developing and implementing vulnerability assessments and climate adaptation strategies in public land management. The climate action group he founded, Adaptation Partners, exemplifies a model of collaboration that is now widely adopted, with projects based on scientist-manager partnership and strong foundations in current scientific knowledge. The climate adaptation projects promoted by Dave and his team, and the books and publications describing them, represent the cutting edge for the field. Dave's research team focuses on fire ecology and environmental stress in forest ecosystems, especially how climate change affects them, and how fire disturbance can be integrated into forest management. His research group has employed a combination of empirical studies and modeling to investigate the responses of mountain ecosystems to climatic variability and change. In retirement, Dave continues to work as a Senior Research Biologist Emeritus with the USFS Pacific Northwest Research Station and also Professor, School of Environmental and Forest Sciences, at the University of Washington, Seattle. Dave has been an important mentor, trusted colleague, and dear friend of mine for many years, and I join in wishing him all the best in retirement from his CIRMOUNT colleagues. —Editor

Dave Peterson on his tree farm in Washington



Connie: As a pioneer in climate adaptation studies and implementation (don't try to deny this), what were some of the most exciting, tractable challenges in the early days of your work in this field?

Dave: When we first started working on climate change assessments, there was lukewarm interest in the topic by federal agencies, because they were not convinced that climate change was relevant, especially in the near term, compared to more pressing issues. After many discussions and workshops, that started to change when it became apparent that including climate change in management and planning would be necessary to ensure long-term sustainability. Then it became a matter of

keeping up with the demand for assessments. Bringing scientists and resource managers together to produce assessments, then observing the managers develop a wide range of creative adaptation options, was very rewarding. We're making progress

Connie: Given your experience, do you recognize any keys to success in helping resource managers to successfully incorporate climate adaptation in project planning and implementation (people/places/money)?

Dave: Face time and relationship building are critical for transferring scientific knowledge into applications. Resource managers rarely have the time to wade through the scientific literature and search databases, so it is important to find opportunities to connect at workshops and other professional meetings. It also helps when scientists take the time to understand key management enterprises, such as land management planning, NEPA, project development, and monitoring—all of which require climate change science to inform decisions. If scientists can quantify climate change effects (risk assessment), then managers can generally develop adaptation options (risk management). On-the-ground implementation of climate adaptation is still in early stages in most places. As implementation occurs over time, sharing information between organizations will facilitate successful adaptation.

Connie: At the broadest level (from the ground to agency programming), what do you think are the most important actions on which to focus in the coming years regarding climate adaptation in mountain ecosystems of the West?

Dave: The effects of climate change on water resources are already apparent, as a result of declining snowpacks, receding glaciers, and altered stream hydrographs. Water has a high value for human populations in the West and for a broad range of aquatic and terrestrial systems, so it is urgent that adaptation plans move forward. Climate-informed planning is critical in watersheds that supply water to downstream communities. The effects of altered hydrologic regimes on cold-water fisheries (higher winter flows, lower summer flows, higher stream temperatures) will be an increasingly important issue in future decades. In addition, the effect of extreme winter flows on roads and other infrastructure is a topic of great interest to land managers, because replacing damaged infrastructure is so costly. The aggregate effects of wildfire and insects on terrestrial systems are also a concern, although adaptation efforts appear less tractable at large spatial scales.

Connie: Reflecting on CIRMOUNT, can you identify key opportunities for its community of scientists and practitioners to make tangible, effective contributions in the context of climate adaptation?

Dave: The scientific community could have a significant impact by becoming more engaged with resource managers and decision makers of various kinds. Extra effort is required to connect with resource managers, but there is a big need for science communication and applications, not more research. This can be addressed, at least partially, through coproduction of knowledge (a jargon term, I know), based on a true partnership between researchers and practitioners. Including resource managers at the start of a project helps ensure that climate science is relevant for a particular application. Scientists need to take resource managers out for lunch more often!



Dave with Linda Joyce, another USFS climate adaptation pioneer.



Dave speaking at the *MtnClim2014* conference at Homestead Resort in Midway, Utah

Haikus for Dave on the Occasion of his Retirement

19 January 2018

Decisions to be made
 Uncertainty is not ignorance
 First, save all the parts
 —Jill Baron

Dave P the Elder
 He's wild at Washington
 The leader of FAME
 —Andy Bunn

Retirement is here
 Without attainment report
 The woods are still grand
 —Diane Delany

Water trickles down unseen
 As winter's grip relents and hesitates
 Soon the marigolds will bloom
 —Henry Diaz

The climate warms here
 More fires, less snow, trees suffer
 A giant fights back
 —Jeff Hicke

Peterson says, "No
 data is worth dying for."
 Behold, a brown bear!
 —Jeremy Littell

Smoke in Seattle
 Mountain forests rage in fire
 Peterson knows why
 —Jessica Lundquist

Dave's Tree Farm

Pitch quickens in tall firs
 Fertile soil heaves and glistens
 Sharpened edge on hoe and saw
 —Connie Millar

Tribute to David Peterson "recovery"

Oppressive heat, creek dry
 Spark aflame, valley full of smoke
 Sapling sprouting leaf
 —Dennis Ojima

Flame embraces slope
 Quickly, loudly, back again
 A western vignette
 —Meagan Oldfather

FIRST PERSON

The Unicorn

Andrew Smith

School of Life Sciences

Arizona State University, Tempe, AZ

It was not a pretty sight; the Unicorn was in a world of hurt. I named my VW campervan “the Unicorn” because its radio antenna ascended gracefully between the split windshields. But I digress.

A young upstart, I was conducting my second summer of dissertation research in 1970, working on the ecology of American pikas on the Bodie plateau (eastern Sierra Nevada, California). My goal for the day was to inspect isolated lava outcrops looking for any sign that they had ever been occupied by pikas. The Unicorn and I left my camp at the old mining town of Masonic that morning and ventured up a promising narrow dirt road cut from the side of a ridge. The road became narrower and narrower, however, and soon I could proceed no farther nor turn around. I was forced to back down the road.

Unfortunately my left rear tire dislodged a big rock leaving the Unicorn’s left rear wheel dangling over the edge of the road. Needing to do something, I cranked the steering wheel, anchored it in place with a rope, and pushed the car back up on the road; but now the front left wheel was left hanging in space. It was disconcerting to be standing downslope, my face even with the front bumper, as I attempted to push the Unicorn back up on the road. The task would take momentum, thus a well-timed series of big heave-hoes... With bad luck, the Unicorn went on the ho, careened back over me, and I had to dive out of the way. I helplessly watched it bounce down the sagebrush slope, hit a rock, and come to rest straddling a small rivulet at the bottom of the draw (Fig. 1).



Figure 1. The Unicorn in the hurt locker, Masonic, CA; July 1970



Figure 2. The Pembar Garage today, Bridgeport, CA; March 2018. Photo, C. Millar

It was a long discouraging walk out to Highway 182 so that I could hitch a ride into Bridgeport, CA, the quaint seat of Mono County. I apprehensively approached the Pembar Garage, met “Mr. Pembar” inside, and haltingly asked him if he would like to see some pretty country and make a lot of money that day. He replied that he was always ready to see pretty country, but wasn’t so sure about the money part. I was instructed to wait while he got things in order, which meant rounding up his grandson, his dog, and his cup of coffee. Then off we went.

When we turned off SR 182 onto the dirt road leading to Masonic I offered to hold the coffee cup, which was brim full. Mr. P replied “If I spill a drop, then I ain’t driving right.”

As we climbed up through the pinyon-juniper belt in his wrecker, Mr. P told me a story about the last time he was en-route to Masonic to extricate another fool like me—when he let his dog drive the wrecker, and the dog drove it off the edge of the road. His fare was incredulous and asked what he could do to help. “Just pray that I get myself out of this fix before any of my friends in town come by” he replied. Whereupon Mr. P anchored the wrecker to a very sturdy pinyon pine and winched it back up on the road, just before his best friend drove by. He related telling his client “Thanks for prayin’.”

Mr. P successfully winched the Unicorn back up onto the dirt road, and miraculously—aside from a few dents—the only significant damage was a broken steering strut. I was able to drive out, following the wrecker back to the Pembar Garage (Fig. 2). There I proudly presented my American Automobile Club card, which provided me with full coverage for any tow with a maximum charge of \$25—one hell of a deal given the many miles driven and over half a day’s effort to extricate me. Then my countenance fell as Mr. P said that the AAA garage was down

the street; the Pembar Garage was affiliated with the National Automobile Club, so he could charge me anything he wanted.

Mr. P then handed me his bill, as I braced myself for the shock. The bill was for \$25 (Fig. 3). When I later learned of the high prices that the Pembar Garage had charged some of my colleagues (summer hires for California Fish and Game) who had to be towed out of the same area, I became especially grateful for Mr. P’s generosity.

A post-script from this story is another lesson I learned. Never jokingly tell your automobile insurance agent, when submitting a claim, that you pushed your car over a cliff.

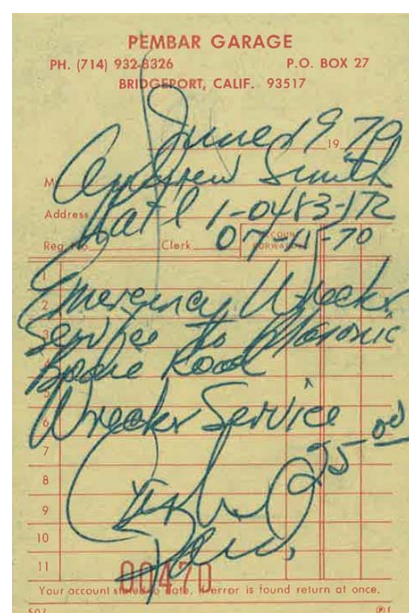


Figure 3. Receipt for emergency towing services, Pembar Garage, Bridgeport, CA; July 1970

FIELD NOTES

The Case for Fieldwork

Benjamin Hatchett

Western Regional Climate Center and Division of Atmospheric Sciences

Desert Research Institute, Reno, Nevada

Many scientists choose to study their respective discipline after spending time in the field. How they got there, to come upon such a realization in the first place, has numerous potential origins—a long-standing desire to do field work, extracurricular activities, athletic endeavors, a class field trip, perhaps an internship.

Fieldwork is a critical component of doing physical and social science. It is where we observe some aspect of the landscape, develop questions, collect data, test hypotheses, or seek to enact positive change. However, many also become scientists but have no interest in ever going outside. While this is fine—some may ultimately become masters of their discipline by never leaving the desk or laboratory—others may benefit from incorporating field components into their work. Such components, which may be as simple as recreating in your favorite field area (Fig. 1) may bring inspiration, additional understanding, new friendships or collaborations, or may simply refresh the mind and help break through a problem that exists only on paper, scrawled on a whiteboard, as code, or in a beaker. For me, fieldwork was always an excuse to get outside and broaden my appreciation of the landscape. Here I will describe some experiences from the past 15 years that I have been fortunate to be able to do as fieldwork in California.

Fieldwork-oriented scientists generally prefer working outside, even if they acknowledge it has occasional, or perhaps more

frequent, challenges. While helping Mark Engle to quantify mercury emissions from natural sources in Lassen National Park (Engle et al. 2006), I learned that days of inhaling a plethora of gases while standing atop soils baking away at $>100\text{ }^{\circ}\text{C}$ can give you quite a bit of a headache. Trouble visits those who relax their vigilance, and when boiling water sits beneath hollow and highly altered soils, the prudent scientist will take extra care to watch their step. One might also want to watch where you choose to sample. My field assistant Henry Meyer and I were collecting surface exposure samples from granite erratics resting atop Tioga-age moraines and nunataks in the Mono Basin (example shown in Fig. 2). Much to our chagrin, we soon realized that the terminal moraine ridge we were sampling sits above a shooting range. We weren't the only ones detonating explosives that day! Luckily, we never had to explain why we were drilling holes in boulders and then using a nail to discharge a .27 caliber construction load. "But officer, we're trying to solve a grand mystery of Earth Science!" Yeah, that will go over well. Even getting to the field location can be challenging. Your once-modest 4-wheel driving skills undergo abrupt and unintended improvements, usually at night, and hopefully in the comfort of a university fleet vehicle that you've never driven before. Always be wary of older scientists who haven't been up a road in multiple decades (names withheld to protect the not-so-innocent) but declare it was "totally fine before" as you search for the low range.

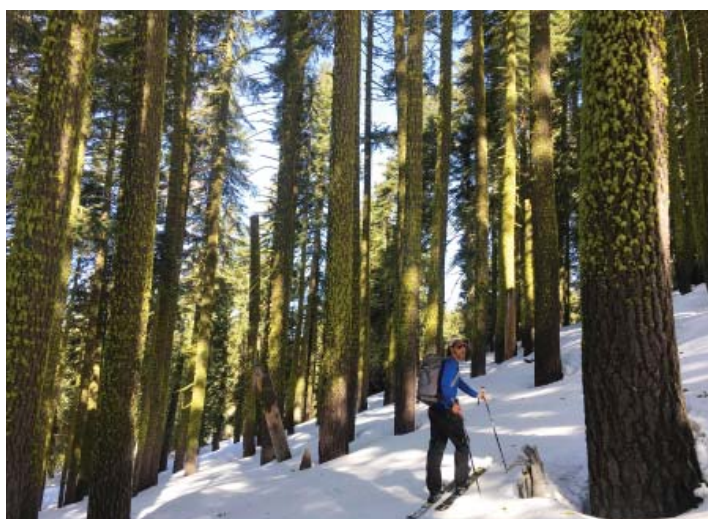


Figure 1. Skiing with Matt Church through a below average spring snowpack on Donner Summit, California.



Figure 2. Granite erratics deposited on a basalt bedrock nunatak near June Lake, California.

Class field trips can be wildly different: A friend described how a world-renowned theoretician needed quite a bit of guidance traveling through the mountains, so take care in your planned exploits. On the other hand, the professor might be so fast and efficient that you are constantly behind them, sprinting over boulders as you scramble to take notes on all the observations and interpretations flowing out of their mouth before they charge off to the next outcrop. If you are fortunate enough to take a course from a field-oriented person, do not hesitate to inquire further about learning more. It might just put you in the aircraft seat next to them and provide a whole new way to view the geomorphologic signatures of past climates (Fig. 3).

Because of my enjoyment of the field and of both human and environment interactions, I was naturally drawn to geography, where fieldwork is a long-standing tradition. "What is geography," you ask? Professor Jessie Clark of the University of Nevada provides my favorite description, "Geography is the why of where," which is just wonderfully precise and all-encompassing at the same time. Any formal study concerned with space and its attributes and associations could fit under the veil of geography. As a perpetually keen and engaged observer, I always liked how wandering around a forest, neighborhood, or desert could tell so much about a place and its human, plant, and animal inhabitants (or lack thereof). Always take photos (Fig. 4) or draw sketches (Fig. 5) when you are in the field, as having entertaining images to share at presentations or while teaching can do wonders for engaging an audience and may answer questions that arise long after your return home.

Once upon a time, as students, we occasionally poked fun at the Martian geologists, "So, how's your fieldwork coming

along?" Over a decade later I realized our folly when a friend published his work that had found analogs for aeolian (wind-driven) erosion on Mars in the Atacama desert (Perkins et al. 2015). Last year at the Nevada Space Grant Consortium meeting, I met a student who proudly produced a thin section of Mars rock (knocked off by an asteroid impact) from her purse that was part of her Master's thesis. The multifaceted ways that we can study planetary bodies from the comfort of our office made me appreciate the value of analogs and the creativity that allows us to escape the confines of our own home planet to understand the universe around us.

When working on science questions associated with natural landscapes, I find it valuable to at the very least visit the place, even if no actual data is collected. Just being there provides context for how it operates. If your data ultimately comes up as non-useable, such as when we travelled to various subalpine lakes



Figure 4. Fire danger in Montecito, California during a Sundowner wind event (Hatchett et al. 2018).



Figure 5. Sketch of alpine granite walls and talus above Patricia Lake near Rock Creek, California.



Figure 3. Walker River meanders and Pelican Point, a cusate bar formed during episodes when Walker Lake was higher.

in Northern California (Fig. 6) in hopes of extending the list of direct geomorphic indicators signifying medieval megadroughts (currently or previously submerged terrestrial plants; Hatchett in press) and came home with modern radiocarbon ages, do not let this deter you from subsequent trips. Any number of reasons could have prevented you from missing the one location where the key piece of evidence may be found that ties the story together.

Fieldwork grounds our science, provides a real laboratory for natural experiments to take place, and offers perspective on the actual complexity of the problems. The science that results from it informs our management, enjoyment, and appreciation of unique places and how sensitive these places are to past, present, and future change that occurs at local, regional, and global scales. The final image (Fig. 7) highlights the beauty of doing fieldwork: At 11,000 feet, a team of scientists and friends work along moraine crests and floating atop tarn lakes in an effort to constrain the timing of one of the final gasps of the last glacial period. Many techniques and hours of laboratory time will be consumed before the paper can even begin to be written, but the goal remains, to use our natural laboratory to understand what happened in the past so to plan for the future. We can also use field-based data from many sources to address the statement “I believe you, now show me!” By showing and telling with strong evidence and solid reasoning, policy that promotes positive change can be enacted and brought to the forefront of public awareness and reality, leading to preservation, appreciation, and understanding of our world.

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Figure 6. Curious submerged stumps in the Trinity Alps, California.



Figure 7. Adam Hudson and Aaron Putnam collect surface exposure samples from a Recess Peak-age moraine crest. The “islands” in Baboon Lake are actually the lake coring platform and raft.

DID YOU SEE IT?

Oh! The Signs You Will See!

Connie Millar

*USDA Forest Service, Pacific Southwest Research Station
Albany, California*

Mountain signs: Yes, we need them for navigation but they offer so much more. In travels through mountain back roads and trails we have no doubt all seen signs that made us laugh, marvel, puzzled, shake our heads, or lock the doors. I gathered a few of my colleagues' favorite sign photos and also pulled several from my files to share with you here, letting them tell their own stories.



Gasterntal, Switzerland. Photo, C. Millar

Warning!



Figure 1. Jackson Hole, Wyoming. Photo, Jim Blanchard



Figure 2. Courmayeur, Italy. Photo, Jim Blanchard

Things We Don't Expect on the Road



Figure 3. Petaluma, California.
Photo, David Charlet



Figure 4. Great Basin National Park, Snake
Range, Nevada. Photo, C. Millar



Figure 5. Near Caldwell, Idaho.
Photo, Jeff Wyneken

Only in Nevada (or nearby)



Figure 6. Near Malheur National Wildlife Refuge, Oregon. Photo, Jim Blanchard



Figure 7. Spring Mountains, Nevada. Photo, David Charlet



Figure 8. Anchorite Hills, Nevada. Photo, C. Millar



Figure 9. Sheep Range, Nevada. Photo, David Charlet

Swiss Expressions



Figure 10. Meteorology, Chur. Photo, Jim Blanchard



Figures 11 and 12. Swiss cooking, Kandersteg. Photo, C. Millar

Swiss Persistence



Figure 13. Swiss persistence in the face of disaster, Ueschinental. Inscription on chalet: “Totally destroyed by an avalanche in the severe winter of 1999. In the same year, newly rebuilt by master carpenter, Daniel Lauener. Owner Hans Schneider.”



Figure 14 Inscription on chalet: “An avalanche came and took our hut [chalet] from us. Rebuilt by Albert and Heli Keuffer in the year 2000.



Figure 15. View behind the chalets, maybe this was not the best place to rebuild chalets.

Come Visit Me!

Japanese Time Warp



Figure 16. Kenso, Japan. Photo, Jim Blanchard



Figure 17 State Route 167: clean! Mono Basin, California. Photo, C. Millar

A Ladies' Club Reminder



Figure 18. Tuscarora, Nevada. Photo, C. Millar

CONTRIBUTING ARTISTS

Bob Coats is a frequent contributor of poetry to *Mountain Views Chronicle*. He is a research hydrologist affiliated with the UC Davis Tahoe Environmental Research Center, and Principal of Hydroikos Ltd. in Berkeley, CA. He has been studying climatic, hydrologic, and ecological processes in the Lake Tahoe Basin—and writing poetry—for more than 40 years. His poems have appeared in *Orion*, *Zone 3*, *Windfall*, *The Acorn*, the Pudding House anthology, *Fresh Water: Poems from the Rivers, Lakes and Streams*, and his book *The Harsh Green World*. Bob wrote "My 18th Birthday" in 2018, recollecting a day he spent peak bagging on his birthday in 1961 in the Independence Mountains of northern Nevada.

Tim Duane is U.C. Professor of Environmental Studies at the University of California, Santa Cruz and visiting U.C. Professor of Law at the University of San Diego School of Law, where he teaches energy and environmental law and policy. Tim was a lead author and team member for the Sierra Nevada Ecosystem Study in the 1990s, served on the California Spotted Owl Federal Advisory Committee, and is author of the book *Shaping the Sierra: Nature, Culture, and Conflict in the Changing West* (University of California Press, 1999). Tim is also a professional musician and photographer. Visit his photography website at: <https://www.timduanephotography.com/>

Alli Fitzmorris. I learned of Alli's work through Phil Rundel (UCLA), whom she had asked about alpine plants of the Sierra Nevada. Alli's response to my inquiry about how she ended up in scientific illustration was so rich that I copy it here, with her permission:

"I got my BA at Fordham University in Philosophy while rowing competitively on their varsity women's crew team. After college I was very restless and decided to tackle the Pacific Crest

Trail. I had only been backpacking once before but I knew how incredible it was, and so I was confident about spending six months in the wilderness. I loved every second! It was hard, and I was often lonely, but I experienced the most intense joy I've ever felt while on that trail. Afterward I worked as a freight broker in South Carolina but felt that my life was missing a critical element. I loved science so I decided to go back to school. I started bird banding in the Santa Monica Mountains, volunteering at the Natural History Museum in Los Angeles, volunteering at an ecology lab at UCLA, taking community college classes in field botany and zoology, taking a field methods course in Costa Rica, trying to soak up as much knowledge as possible. I landed a field job on the Sierra Nevada Red Fox study and found my place in the world. While working in the backcountry, I kept drawing and eventually someone told me about science illustration. I decided to take a shot at it. Now I'm in a graduate certificate program for scientific illustration at CSU Monterey Bay, and I'm looking forward to building my career around art and science. Ultimately, I still want to pursue an advanced degree, but I'm going to spend the next few years figuring out my place in the order of things and developing my profession as an artist."

Jeff Wyneken has been exploring and photographing mountains of the West since childhood. After two decades working as a production editor for a San Francisco publisher, he enjoys greater flexibility currently as a freelance editor. In this capacity, he spends his work time transforming manuscripts like those that many of us draft into clearer and more understandable prose. He is frequently found hiking in the mountains with his wife, Connie, who plies him regularly for advice about future issues of *Mountain Views Chronicles*.

MOUNTAIN VISIONS

ON MY 18TH BIRTHDAY

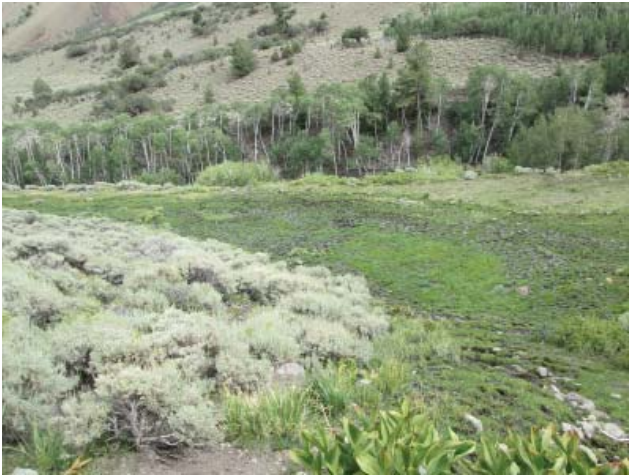
I climbed McAfee Peak,
stood on the summit over ten thousand feet
under an azurite dome,
gazed out over the wide open.
To the south, the Ruby Range,
east, the Jarbidge.

Then descended talus and scree
of red quartzite to the saddle,
drove down the North Fork,
set out with fly rod
through sagebrush, mule ears
toward the beaver pond where I knew
fat cutthroats lurked.

But at the pond's verge the aspen foliage
was trimmed as high as sheep could reach.
Corn-lilies and timothy, so verdant
in June, now grazed down to dirt
or trampled into the dust.

Floating in the turbid pond
the carcass of a ewe,
stinking, fly-blown.

— Robert Coats, February 2018



North Fork Pine Creek



South Fork Pine Creek



Mt Jefferson Plateau (Elev 11,520')

Feral horses, Moores Canyon



Trespass cattle, Pasco Canyon



Impacted Wetlands, Mt Jefferson Research Natural Area, Alta Toquima Wilderness Area, Toquima Range, Nevada. "Encompassing the highest points of this range is the Mount Jefferson Research Natural Area (forest lands that are permanently protected as baseline areas). The Mount Jefferson Research Natural Area is one of the country's most unique environments." (Humboldt-Toiyabe National Forest website, 2018) Photos, Connie Millar



Wetlands of Upper Burt Canyon, Sierra Nevada.
Photo, Jeff Wyneken