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Informing the Mountain Research Community

Cover Art: Ice on the Bitterroot, 2018 oil on board. *I'm attracted to the stark colors of Montana winters, especially the dark leafless cottonwood and deep red dogwood combined with the endless tones of ice and snow in the slow stillness of the river.* Suzanne Shope.

Stella at Woodside, 2019 oil on canvas. *This painting utilizes the unique slivers of fading sunlight and dark mountain silhouette of an autumn evening to honor the passing of my canine friend Stella*. Suzanne Shope.

About the Artist

Suzanne Shope is a Montana scholar, practicing artist and producer living in Missoula, Montana. She holds degrees from The New York State College of Ceramics at Alfred, NY and The University of Montana. She has an interdisciplinary doctorate in history, Native American studies, and art education from the University of Montana, 2009. Shope has held teaching positions at Minot State University and The University of Montana – Western and currently teaches at Salish Kootenai College.

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From the Editors

Nov. 05, 2021

Dear Friends and Colleagues,

This past year (and more) has been a time characterized by disruption and upheaval in numerous ways. Across the Mountain West the omnipresent impacts of climate change have manifested in heat waves, drought, fires, and floods. On a societal level, we continue to cope with a constantly shifting state of pandemic, the politics and economics of addressing environmental change, and our own individual personal challenges. Wanting to acknowledge this experience, we chose to make the theme of our 2021 issue of the Mountain Views Chronicle **disturbance and transition**.

In this issue we share stories about changes and shifts of all kinds, exploring how they are observed, research approaches to tracking change, and the societal relevance of this research. Our *Feature Article*, from Dr. John Harte, considers how anthropogenic influences may be inferred from observed transitions in the alpine. An *Article Summary* by Dr. Bethany Coulthard discusses using tree rings as records of the past to better comprehend snow droughts of the present. This issue's *Brevia* share examples of transitions that inspire hope, with one reflecting on mining impacts and recovery, while another considers the role of the growing presence of citizen science in tracking change.

In addition to sharing research, we also sought to make space to consider the emotions associated with transitions and disturbance. In addition to evocative contributions of poetry and art, this issue's *Field Notes* respectively consider the roles of awe and curiosity in our observations of the natural world.

Thank you to each of the contributors for their willingness to share their discoveries and experiences with us. For you, the reader, we hope that the following pages will offer you inspiration and reflection.

Sincerely,

Elise Osenga
Aspen Global Change Institute

Ian Billick
Rocky Mountain Biological Laboratory

Martha Apple
Montana Technological University

Ben Hatchett
Desert Research Institute

Inferring Anthropogenic Disturbances from Observed Transitions

John Harte
Energy & Resources Group, UC Berkeley; Rocky Mountain Biological Laboratory

June 26, 2021

Montane ecosystems are increasingly subject to numerous disturbances, including higher temperatures, reduced snowpack, more frequent drought, more variable rainfall, deforestation, nitrogen deposition, more dust on snow and earlier snowmelt, and increasing human presence as manifest in roads, housing and recreation. At the same time, an increasing number of ecological transitions in species diversity, composition, and productivity are being observed in subalpine and alpine habitats. An important attribution problem thus arises: how can we infer which actual anthropogenic disturbance or combination of disturbances, are causing observed transitions in specific instances?

A recent published analysis (Franzman et al., Ecosphere 2021) from the Rocky Mountain Biological Laboratory suggests a pathway toward an answer. Repeated vegetation censuses carried out by Benjamin Blonder and his students over six years on 50 alpine plots on a southeast-facing 20° slope of Mt. Baldy, in the Gunnison National Forest of western Colorado (photo, top right), revealed declines in species richness and total abundance from 2014 to 2019. The site contains a sparsely populated alpine plant community with a total of eighteen species in its most species-rich year. In the year with greatest abundance there was an average of nine individuals per square meter. For a full site description, see Blonder et al. (2018).

A section of the plots at the Mt. Baldy Site, with author in the background, June 15, 2021, following a low snowpack, early-melt winter.

Looking beyond these relatively coarse indicators of stress, Franzman et al. (2021) turned to the field of macroecology, the study of detailed patterns in the abundance and distribution of species, for finer-grained and more informative fingerprints of disturbance.

Macroecological theory has historically focused on understanding macroecological patterns in relatively static, undisturbed ecosystems (Newman 2019), whereby static we mean that coarse indicators like species richness and total abundance were not trending in time. For such systems, it has been shown that macroecological patterns, such as the distribution of abundances over species, the distribution of metabolic rates over individuals, and the species-area relationship, can be accurately predicted using a statistical tool derived from information theory: the Maximum Information Entropy (MaxEnt) method of inference. A detailed explanation of the

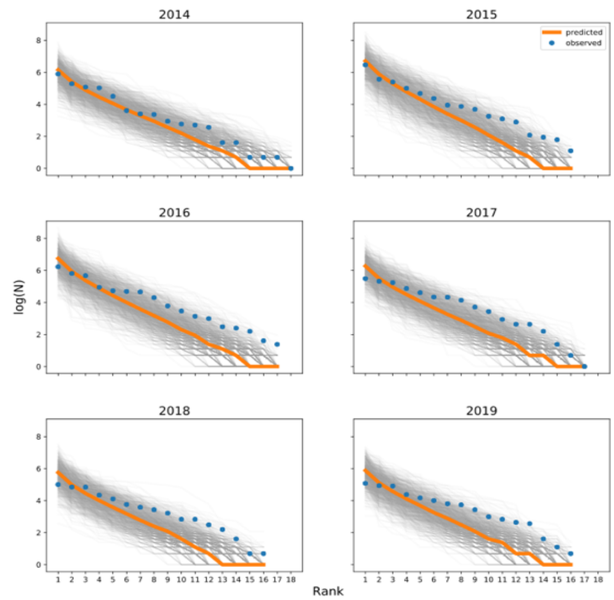

Fig. 1. Comparison of observed and MaxEnt-predicted abundance distribution through rank- ordered graphs in each of the six years. The cloud of thin lines represents 1,000 rank-ordered random draws from the distribution predicted by theory.

Maximum Entropy Theory of Ecology (METE), can be found in Harte (2011) and Harte and Newman (2014) which review its logical foundation in information theory and summarize its predictions and their validity for relatively undisturbed ecosystems.

Two of the theory's predictions are particularly relevant to the Mt. Baldy data set. First is the distribution of abundances over the species of plants in a community. MaxEnt theory predicts a Fisher log-series distribution for the probability that a randomly chosen species will have abundance n: $p(n) \sim e^{-an}/n$. Over the span of abundances, from rarity to commonness, this distribution predicts a preponderance of relatively rare species. Extensive tests of this predicted abundance distribution for a variety of habitats, taxa and spatial scales by White et al. (2012) confirm its general validity.

Secondly the theory predicts the shape of the species-area relationship, which informs us about how diversity increases as we sample larger areas. Ecologists have long worked with the assumption that species richness increases as a fractional power of area, or $S \sim A^z$, with z a constant for any given ecosystem. A growing body of empirical data, however, fails to support this. MaxEnt theory, in contrast, predicts that z is not a constant, but instead decreases with area in a prescribed way for all ecosystems, and for all taxonomic groups. Numerous empirical tests of the predicted scale-dependence of z in undisturbed ecosystems support the theory (Harte and Newman, 2014).

Evidence is accumulating that in disturbed, dynamic, rather than undisturbed, ecosystems, MaxEnt predictions of macroecological patterns fail (see Harte et al, 2021, for a review). A recent example is the study by Newman et al. (2020) using spatially explicit vegetation censuses in Bishop Pine Forest at Pt. Reyes National Seashore to compare macroecological patterns in forest that has not burned in recent history with nearby forest undergoing succession as it recovers from a major forest fire in 1995. At the unburned site, macroecological patterns agree with the static MaxEnt predictions, whereas in the transitioning site large deviations from theory were observed.

That Newman et al. study compared contrasting sites in space, leaving open the possibility that pre-existing site-specific differences (for example, proneness to fire) might have played a role. Franzman et al. (2021) instead look at a single system that is changing over time in response to drought stress. They document that the species abundance distribution and the species area relationship agree closely with the purely statistical theory in 2014 but that in the subsequent five years, most of which had well-below average precipitation and early snowmelt, distinct departures from the theoretical predictions for the abundance distribution and the species-area relationship appear in the data (Figures 1 and 2).

Returning to the question of attribution of the cause of disturbance, it is noteworthy that the Newman et al. and the Franzman et al. studies reveal quite different signatures of static theory failure under disturbance. Indeed, an examination of deviations between MaxEnt predictions and observations in many other types of habitats, with different taxonomic groups, and subject to different kinds of disturbance show that the patterns of failure differ from case to case. This suggests the possibility that the deviation of macroecological patterns from static MaxEnt theory has the potential to be a kind of fingerprint that can allow attribution of the mechanism of disturbance.

But to pursue that agenda on a more solid foundation, macroecological theory that can be applied to dynamic, disturbed, as well as static ecosystems is needed. Such theory, if successful, would actually predict how macroecological patterns change under specific types of disturbance. Toward that end, we have hybridized pure MaxEnt theory, which avoids making mechanistic assumptions, with explicit mechanisms of disturbance (Harte et al., 2021) to create a dynamic extension of METE, which we call DynaMETE. The predictions of this theory are derived using an iteration-in-time procedure that is computationally intensive, and so its full range of predictions remains to be explored.

It is promising that preliminary investigation does indeed show that DynaMETE predicts macroecological patterns that deviate from the static METE predictions in characteristic ways that depend explicitly upon the mechanism assumed to be causing disturbance (Figure 3).

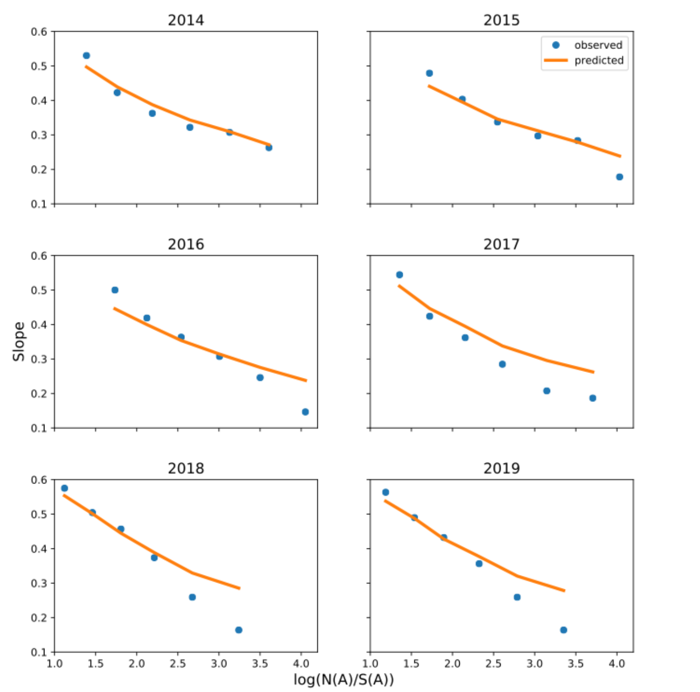

Fig. 2. Comparison of the observed and the MaxEnt-predicted slopes, z, of the species-area relationship in each of the six years. The scaling variable plotted on the x axis is the quantity predicted by MaxEnt to make all species-area curves collapse onto the universal curve shown in the graphs.

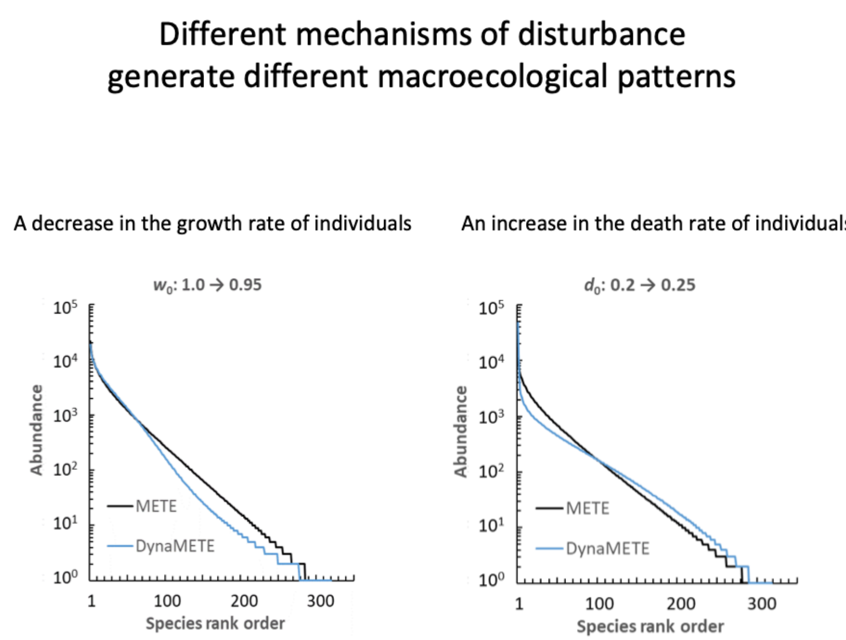

Fig 3. Examples of macroecological patterns predicted by DynaMETE in disturbed ecosystems.

Ahead lies the task of systematically exploring how different causes of disturbance give rise to different macroecological patterns. DynaMETE provides a means of determining the effects of disturbance mechanisms on not just coarse measures like diversity and productivity but also on more fine-grained fingerprints such as abundance distributions, body size distributions, and species area relationships. Hence, from observed transitions in these macroecological patterns, we may be able, in the future, to attribute specific combinations of mechanistic causes of disturbance in our rapidly changing ecosystems in the Anthropocene.

ACKNOWLEDGMENTS

The author thanks Micah Brush, Kaito Umemura, Benjamin Blonder, Courtenay Ray, Erica Newman, and especially Juliette Franzman for helpful conversations. Instrumental to the formulation of the views expressed here have been support from the US National Science Foundation (DEB 1751380), the UC Berkeley Undergraduate Research Apprenticeship Program, and the Rocky Mountain Biological Laboratory.

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Snowpack Signals and Tree Rings

Bethany Coulthard
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The text below is a summary of a recent research publication: [Coulthard, B. L., Anchukaitis, K. J., Pederson, G. T., Cook, E., Littell, J., & Smith, D. J. (2021). Snowpack signals in North American tree rings. Environmental Research Letters, 16(3), 034037]().

Climate change is causing snowpack declines and related water supply challenges across western North America, profoundly impacting ecosystems and human welfare. This trend is only expected to intensify over the 21st century, especially in the western USA – a global snow drought hotspot.

A major problem with recent snowpack declines is that while low snowpack years, or 'snow droughts,' over the past century tended to be dry (caused by an overall lack of winter precipitation), many recent snow droughts have been warm (caused by higher winter air temperatures and more precipitation falling as rain rather than snow). These warm snow droughts present a particular water management challenge by changing the timing and quantity of runoff; rather than being stored in the snowpack and slowly released during summer when water use demands are highest, more rainfall-driven runoff and flooding instead happens during winter. Because water storage infrastructure, operations, and management plans were not designed for warm snow droughts, these events are now causing water reservoir and supply challenges, as well as higher winter flood and summer drought risk, across the West.

Bethany Coulthard takes a manual snow survey sample on the Mogollon Rim, Arizona in 2016. Image Credit: Joel Biederman.

Clearly, forecasting future snow drought causes (warm or dry?), severities, and probabilities has become essential. Luckily, while our current understanding of mountain snowpack variability is limited by short and strongly temperature forced observational records, tree rings are a tried and true archive for yielding the long hydroclimate records needed to accomplish this.

The catch is that compared with the wealth of high-quality, well-replicated drought, streamflow, and cool-season precipitation reconstructions that have been widely used for decades to understand western North American hydroclimate, dendroclimatologists are still figuring out how to reconstruct past snowpack dynamics. One reason less attention has been paid to snow than rain may be that the former's important – and substantially different – influences on surface hydrology, water supply, storage, and runoff timing have only recently become clear. But regardless of the reason, high-resolution paleoclimatologists are now trying to determine whether, and how, tree ring physiology may record snow droughts in order to reconstruct and examine the past variability of global snowpack systems.

In this study, we used climate correlation tests and cluster analyses to identify and examine snow-growth relationships in a network of 326 North American tree-ring records ('chronologies') which, taken together, make up the new Western Paleosnow Network. We found three distinct snow proxy types, each of which is based on distinct physiological tree-growth mechanisms and has advantages and disadvantages as a paleosnow archive.

The **first type** are chronologies from mid- to high-elevation forests concentrated in the American Southwest that directly benefit from local snow meltwater inputs in spring and are negatively impacted by high summer temperatures (Figure 1(B), positively correlated with snow). The **second type** are low-elevation chronologies synoptically influenced by the same weather systems that deliver local precipitation as rain and at higher elevations as snow (Figure 1(A), positively correlated with snow). These trees rely on cool-season rainfall to recharge soil moisture for growth and are generally distributed around the central valley of California and windward foothills of the Sierra Nevada. The **third type** are chronologies whose growth is limited by deep and late-lying snowpacks that shorten the growing season, resulting in a smaller annual growth increment in years with high snowpacks (Figure 1(C), negatively correlated with snow). These are found mainly at mid- to high- elevations in the Cascade Range, British Columbia Coast Mountains, and northern Rocky Mountains where deep, wet snowpacks persist.

Importantly, the three proxy types record snow droughts very differently! For example, the first type may misdiagnose cool season rainfall as snow, since both forms of precipitation result in a wide growth ring. Whereas the third type may faithfully record both warm and dry snow droughts, since both kinds of snow drought can ultimately control growing season length. The ability to use these proxies separately or in tandem to independently reconstruct and analyze past warm and dry snow drought variability across a wide range of environments is a big step forward for understanding snowpack declines. But a precise understanding of the local tree-ring phenology and physiology, as well as meteorological processes at each sample site, will be essential for developing future snowpack reconstructions wisely!

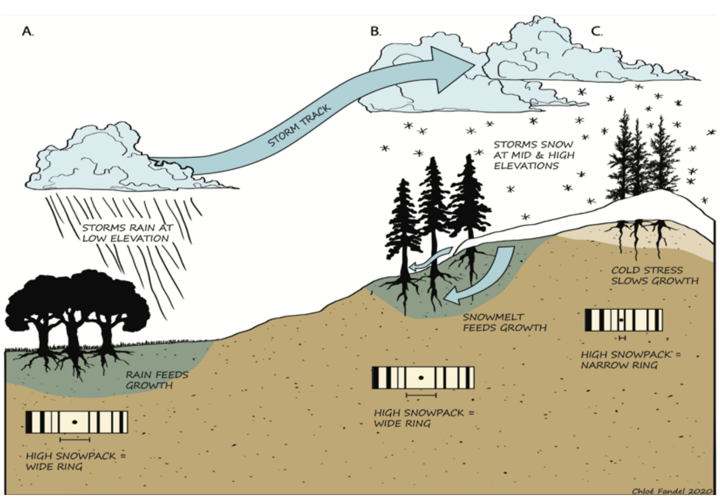


Fig. 1
Schematics of the three snow proxy sample site types during a high snowpack year.

MS student Inga Homfeld extracts a tree core sample from a subalpine larch (*Larix lyallii*) tree at Sunrise Lake, WA. Image Credit: Bethany Coulthard

About the Author: Bethany Coulthard is an applied hydroclimate and paleoenvironmental scientist specializing in dendroclimatology and water resource management, and the director of the Hydrology, Tree Rings, and Climate (HYTRAC) Lab at UNLV.

Interviews

Entering the Career Ecotone: Reflections from Scientists Connie Millar and Nate Stephenson on Transitioning to Retirement

Elise Osenga
Aspen Global Change Institute

Among the many up-endings of the past year, two quiet but momentous shifts took place within the mountain climate research community: Dr. Connie Millar and Dr. Nate Stephenson transitioned into retirement. They were generous enough to each participate in an interview and share some of the reflections and anticipations surrounding this new chapter of life. Rest reassured that while they may be retired in name, both Connie and Nate still plan to continue their scientific and personal explorations of the mountains they love!

Interview with Connie Millar

As a founding figure of CIRMOUNT and the MVC, Dr. Connie Millar is a familiar face to many in our community, with her expertise spanning multiple topics. Over the course of her career, Connie's research directions have included: conifer forest genetics, dendrochronology and climate change, alpine geomorphology, and pika survival. She has received numerous awards and recognitions, including most recently, in 2020, the Robert F. Lewis Pioneer in Science Award and being honored as a AAAS Fellow.

In 2020, Connie was interviewed by Aino Kulonen for the Mountain Research Initiative (MRI) Newsletter. With permission, we re-share excerpts from this interview, followed by a few questions of our own. To read the full, original MRI interview, please visit: https://www.mountainresearchinitiative.org/news-content/global/ambassador-of-interdisciplinary-mountain-research-interview-with-connie-millar.

Ambassador of Interdisciplinary Mountain Research – 2019 Interview with Connie Millar

Aino Kulonen
Mountain Research Initiative

You've had a long and outstanding career as an ecologist. How did you first get into studying mountains?

Thank you. From the day I could walk, so my parents would tell me, I wanted to be in the mountains. That passion has never died, and my true home will always be amidst lofty pine forests and rocky heights.

Hiking the uplands as a teen in the Cascade Range of Oregon (my family home) cemented that ease and familiarity, while also opening my eyes to mysteries that I

Connie Millar in the East Humboldt Range. Image Credit: Jeff Wyneken

encountered. ("What is Douglas-fir doing on the east side of the Cascades?" was the title of a high-school science project.) I was forever curious about trees, how they grew, and why they were where they are. My family had a log cabin in an old-growth ponderosa pine (*Pinus ponderosa*) forest on the east slope of the Cascades, at the edge of the high desert. I imprinted on that landscape. When I moved to California for graduate school in 1977, I sought out the familiar pine forests, rugged mountains, and alpine landscapes of the Great Basin, reminiscent of my childhood in the eastern Cascades. I haven't strayed from this region since. My early years wandering and wondering outdoors conditioned me to become first and foremost a field scientist.

What drives your passion for mountain sciences?

I am most excited when I can leverage the natural ability of mammals (including humans) to recognize pattern in nature and use it as a springboard for learning. A longtime colleague once asked, "You seem to make your research around stories of unique conditions and events." And she was right: my strategy, an easy one given my love and curiosity for mountain environments, has been to immerse myself in a place and learn about it from every angle and season, under extreme and ordinary conditions. In so doing, if one keeps eyes and ears open, pattern imprints almost unconsciously in our minds, such that anything encountered outside the pattern leaps out. Those novel situations then become a valuable focus of research, where one can ask, "Why doesn't this follow expectations from scientific theory?" and, "How does this 'errant condition' inform me about possible limitations in existing scientific theory"?

For example, my observations of treeline ecotones in mountains of the Great Basin suggested that pines weren't (only, or at all) moving upslope in response to contemporary warming, as theory suggests. That led to studies to investigate why they weren't moving up, and what else was going on. This approach is similar to mutation analysis in genetics, which was my academic training: Mutations can be very useful for dissecting natural processes that are otherwise difficult to approach.

In this community many know you from the activities of [Consortium for Integrated Climate Research in Western Mountains (CIRMOUNT)](). What is the story behind the success of this interdisciplinary network?

In the late 20th century a movement emerged in environmental science across North America to conduct major regional ecosystem assessments. These required interdisciplinary work, throwing scientists from fields as diverse as environmental law, sociology, hydrology, atmospheric science, forest ecology, and wildlife biology into single teams. I was fortunate to be involved with one of these efforts, the Sierra Nevada Ecosystem Project (SNEP). I recall initially feeling adrift and almost a bit ill from the cultural clashes among scientists of different disciplines: I could barely understand the language of my social science or physics team members. It was revealing to see how easy it is for humans to be clannish. Eventually I got used to the "otherness."

During those years the idea of integrative research was in the air. I met Greg Greenwood (former MRI executive director), and other western mountain scientists who would later comfortably and naturally look to each other and say, "We should be working together across disciplines in western North American mountains to integrate research and better understand the effects of climate change!" That was the seed of the effort to rally together and tackle climate-related problems concertedly at cross-disciplinary and bioregional scales.

With key players Henry Diaz (NOAA); Mike Dettinger (USGS); Kelly Redmond (DRI-WRCC); Malcolm Hughes, Lisa Graumlich, and Tom Swetnam (University of Arizona); Dave Peterson (USFS); Greg Greenwood (MRI); Dan Cayan (UCSD); Dan Fagre and Nate Stephenson (USGS), and myself, we advanced by baby steps to test the water. In 2004 we hosted the first full conference on the topic, as the "Mountain Climate Science Symposium" at Lake Tahoe, CA. From there the regular *MtnClim Climate Conferences*, now held biennially, were launched. I attribute any success of them to the fact that they offer serious science, across disciplines, in beautiful and informal settings (the mountains!).

Seeking further ways to communicate, in 2007 Henry Diaz and I launched the CIRMOUNT newsletter, *Mountain Views*, later *Mountain Views Chronicle*. I like to think that the same theme of serious science integrated with informal essays and art makes that forum useful to keep the community together. I further hope to think everyone with science or resource interest in mountains feels welcome and valued in the loose-knit CIRMOUNT community.

CIRMOUNT has advantage and disadvantage in that it never became a formal, official institution. The grass-roots nature kept options easy and open (no Board of Directors to ask for things). On the other hand, we lack the benefits that a Board of Directors with staff and operating budget would offer.

[The following questions were added this year, in 2021, when Elise Osenga followed up with Connie.]

How has observing ecological transitions and change throughout your career shaped the way you view transitions in your own life?

An intimate relationship with hierarchic time scales in earth and evolutionary history has deeply influenced my life. I feel as comfortable living in the Eocene and studying biogeographic movements of pines across millions of years as tracking daily dynamics of pikas in the present. I don't "live in the past" any more than I focus on the here and now—rather these time scales blend together in one holistic sense of the world and my life. I integrate past, current, and future times as if viewing a periscope that looks simultaneously backwards and forward. As I venture into the third trimester of my life, with its one inevitable outcome, I am deeply aware at once of my youth, my career, pines emerging on an early version of the northern hemisphere, Pleistocene glaciers moving over where my house now sits in the Mono Basin, the twinkle and love in my husband and daughter's eyes of this moment, even the future extinction of *Homo sapiens*.

What are you most looking forward to about retirement?

Now that I am more than half a year into this glorious phase of life, I still pinch myself every morning that I am not dreaming. I love living in the Mono Basin year around,being active daily (no more cubicles!), and that this activity takes me in pursuit of endless questions about the natural world that unfold in front of me (thank you, USFS/PSW for supporting me as emerita). I love working with old and new colleagues on new and ongoing research projects – mountain ecosystems, pines, pikas and other small mammals, rock glaciers and patterned ground. I love having time to explore the seemingly endless Great Basin mountains from every angle. I am deeply grateful for my health, daily interactions with my loving daughter and husband, and with friends who support me (and have come to understand that retirement means I'm usually out of reach). I look forward to this active physical, emotional, and intellectual life as long as I am able.

Poetry

Love Song

Cobalt seconds of blue flash
Condensed galaxy at her knees
An ocean
Collapsed

Holds air in wing, hand
Married to the current
Her eyes, his life
In a bluebird's embrace of the wind

Suzanne Shope

Interview with Nate Stephenson

Nate's professional career has encompassed multiple facets of how to understand forests so that we may better protect and manage them, with recent emphases including: mechanistic understanding of forest carbon, detection and attribution of forest changes, and adaptation in response to rapid global change. He has been honored for his work multiple times, including receiving the Director's Natural Resource Award from the National Park Service in 2012.

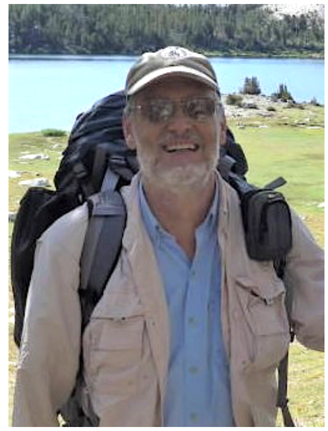
How did you first become interested in being a scientist?

Certainly the foundations were set by the 1960s' post-Sputnik emphasis on science in public schools, and by having a geophysicist for a father. But I was always intrinsically drawn to the outdoors and to living things (the slimier the better – my pets included Dave the frog, Charlie the toad, and Isaac the newt). My love of the natural world was especially encouraged by my mother and ultimately led me into ecology.

Much of your career centers on researching forests. What about this ecosystem captured your attention and your passion?

I have a thing about wanting to be able to directly see, smell, and touch what I study, without needing microscopes or chemical analyses. And perhaps there's a lazy part of me that likes the fact that trees don't run away. But at a gut level, I'm simply in awe of big, old trees; they always help me put my own life in perspective. It's a gift to work among them.

" I'm simply in awe of big, old trees; they always help me put my own life in perspective. "



Nate Stephenson enjoys a hike.

Because of its relationship to global change, your work is somewhat interdisciplinary in nature. What do you find valuable about approaching ecology from a multi-faceted lens?

In an era of rapid global changes, interdisciplinary science isn't a luxury, it's a necessity; otherwise we risk becoming the proverbial blind men and women separately struggling to describe and understand an elephant. For example, during California's unprecedented 2012-2016 hotter drought, unexpectedly, the giant sequoias that died were on wet sites, not dry sites. Of necessity, our research to understand why includes population biology, physiology, entomology, molecular biology, stable isotope analysis, soil science, and fire ecology.

In your participation with the broader research community, you have served as a coordinator for CIRMOUNT. How did that experience shape your perspective of collaboration?

It sounds like a cliché, but in good collaborations, the whole is greater than the parts. This truth was driven home by how freely the CIRMOUNT "elders" shared their vast, diverse knowledge, inevitably leaving me buzzing with new ideas that helped improve my own research, and sometimes leading to direct research collaborations. It has been a joy!

Is there a particular finding or moment from your work with USGS that was especially impactful to you that you would like to share?

I can think of three. First, back in the mid-1990s, the evidence finally broke through my denial, and I got it at a gut level – not just intellectually – that future climatic changes would almost certainly upend many of the key goals for natural areas stewardship. This got me looking hard for stewardship options that would be realistic in an era of rapid global changes.

Second, I have been struck by how abruptly ecosystem "tipping points" can be passed, catching managers and scientists completely off-guard; it happened on my home landscape of the Sierra Nevada around 2015. Since meaningful responses to these tipping points can't wait for the next funding cycle, we will do well to build our quick-response capacities.

Finally, the climate-linked changes to my home landscape have smacked me in the face with just how limited our ability to predict change is. Some of the available state-of-the-art model predictions were little better than flipping a coin, and others were off by 180 degrees – they would have guided managers to treat the least vulnerable, not the most vulnerable parts of the landscape. It's only in hindsight that we start to pin down why the model predictions were so far off, with those post-hoc explanations often depending on intensive natural history observations made during the ecosystem change.

I'm reminded of Box's dictum: "All models are wrong, but some are useful." Our models of ecosystem change can help us think about a range of possible futures, but cannot necessarily be relied on to meaningfully predict the future at the scales useful to managers. This argues for using extreme events as previews of the future, helping us develop empirical maps and understanding of ecosystem vulnerabilities.

One of your avowed career goals is to improve understanding the impact of global changes on forests. How has this perspective shaped how you view transitions in your own life?

Happily, my own life transitions haven't yet been as dramatic as some of those occurring on the landscapes around me! But I must say that some of the strongest lessons have been about acceptance and letting go in the face of change.

What are some of the things you are looking forward to most in this next phase of your life?

More backpacking. More time with family and friends. More travel. More backpacking. More snorkeling. Did I mention more backpacking?

And because I can't help myself, I'll also keep doing science.

A collage image of the approach to Williamson Bowl in the southern Sierra, photos from a Fuji film box. Mount Williamson on the left, corner of Mt. Tyndall on the right. Elevation ~ 12,200'. Image Credit: Larry Ruth.

Poetry

Leaving Manzanar

4.22.21

Jan. 4, 2020 AP — "*A skeleton found by hikers last fall near California's second-highest peak was identified as a Japanese American artist who had left the Manzanar internment camp to paint in the mountains in the waning days of World War II.*"

I

Twenty miles by trail, then south and east,
leaving Symmes Creek, he hiked here,
talus and tarn, climbed scree and snow
seven thousand feet to a deep bowl,
three lakes over a high saddle, taking colors
of sky, cobalt, ultramarine, cerulean,
he'd hiked with younger men, all of them
from the camp, Manzanar, free to leave, no
place to return now, nowhere called home,
so they ascended, first Shepherd Pass, then
a boulder bridge to a ledge above, the basin
too high for fish, yet there were fish,
Colorado River Cutthroat trout, exotics,
transplanted from the Rocky Mountains.

II

Transplanted from the Rocky Mountains,
the fish arrived in Nineteen Thirty One,
concern over Colorado trout led to a plan,
mules to pack them in, high up and away
to lakes in Williamson Bowl, waterfalls
and rock on the creek below, once there,
the fish were safe, and trapped, no escape,
kept Colorado Cutthroats out of trouble,
forty-odd years later, worried over survival
of Cutthroats in Colorado, fisheries folk
learned of their Sierra refuge, wondered
if some of those fish, returned as natives
could multiply, stave off danger, save
habitats, and help the Cutthroats survive.

III
Habitats and help, the Cutthroats survive,
the younger men carried fishing rods,
the older man, watercolors, pad, pencils,
looked for a place to paint, dark of granite
slide,
solitude above streams fed by snowmelt
and ice from the mountain, a niche to wait,
caricature a single fish, body twisting,
as it rose out of blue water   breaking
the surface, rubies on its throat and fins
showing against long dihedral faces
of Mount Versteeg, or the shadows
thrown by Trojan Peak, two long clouds
peer over the ridge, weather turning
in the high country at the end of July.

IV
In the high country at the end of July,
separated from the fishermen, the artist
on his own in the bowl, no warning,
watched the storm, lightning, thunder,
wind funneling rain, made it hard to see
the deluge in the canyon, the artist lost
the trail, no way back to his companions,
the fishermen too lost their way, sheltered
under overhangs in the mountain, rock
and roof enough, perhaps the older man,
they hoped, had scurried down the creek
to safety, yet he was not seen alive again.
In Twenty Nineteen, near summer's end
two hikers found part of a man's skeleton.

V
Two hikers found part of a man's skeleton,
the body of the artist was buried long ago,
after the storm, a makeshift grave by a lake,
stones of gray granite marked his tomb.
A photograph of the burial site was taken
by the men who had gone up the mountain,
all that remained to give to the family,
the memory of the storm left in the basin.
Over time, the grave in that high bowl
was lost, until the mountain, its shift
and slide, exposed the bones, no one
knew at first, no one could remember
who the man might be, or exactly how
a man's body came to rest in this place.

VI
A man's body came to rest in this place,
forty years on, the Cutthroats journey
home, arrangements made to fit the fish,
logistics to reduce risk, shorten the hours
fish'd be out of water, transported, in tanks,
helicopter, until they made it to the Rockies
two hundred forty-six river trout, high
up Ptarmigan Creek, high up and home
again.
Where the Cutthroats thrive, maybe a child
maybe Colorado, pastel, or chalk, her hand
traces the flash of fin, swerve of body, tail,
she pauses, rubies rise out the water.
What was found, what was rescued,
what was lost, what is saved.

VII
What was lost, what is saved,
a half-century ago, a son of the artist
climbed over twelve thousand feet,
then clambered down dark rock to the lake.
Searching, one always thinks rescue,
hopes for the best, though one cannot
always save what is loved once it is lost.
What was found there somehow stayed lost.
What was lost, what they searched for,
what was found is memory,
not memory of losing the artist,
it is memory of a man, his family.
and those who walked mountains to find
him,
twenty miles by trail, then south and east.

LARRY RUTH

About the Poet Larry Ruth is a consultant in environmental policy. He lives in Berkeley and conducts research in forest and natural resources, wildland fire policy and mitigation, and ecological sustainability. He enjoys the vestiges of the wild, far and near.

Citizen Science Inspiring Stewardship of Wild Places

Philip Halliwell, PhD
Colorado Mountain College

Assessment of a program operated by the Rocky Mountain Sustainability and Science Network (RMSSN) shows that citizen science promotes a stronger attachment to and deeper concerns for the natural world. Moreover, the experience has been shown to foster stronger stewardship motivations for publicly protected landscapes.

RMSSN, founded in 2009 with a National Science Foundation grant, annually selects a diverse group of 20-25 undergraduate and graduate students who have an interest in science and sustainability to conduct citizen science in Grand Teton and Yellowstone National Parks (Halliwell et al., 2020). The program has had a two-year hiatus due to the Covid pandemic but is slated to continue in 2022. Program participants spend an immersive two-weeks doing research on one of three subjects: pollinators surveys, mammal distribution and behavior, or social and cultural factors related to park use and visitation. With the support of faculty members, students navigate each step of the research process. Working together, each team formulates a new research question which serves to guide their efforts. Teams design study protocols and analyze data, with the program culminating in a comprehensive report presented to RMSSN faculty and National Park Service staff.

Participants of RMSSN complete pre and post surveys to better understand how the experience shapes their attachment to the parks, nature, and stewardship beliefs.

Above: RMSSN participants discussing citizen science protocols for a marmot and pika interaction study near Tower Junction in Yellowstone National Park. Image Credit: Philip Halliwell.

Below: Two RMSSN students hiking to a pollinator study field location in Yellowstone National Park. Image Credit: Philip Halliwell.

Additionally, focus groups are formed and narrative responses solicited to dive deeper into understanding the impact of this citizen science experience. Furthermore, this research also explores how participants perceive, interact with, and relate to the natural world.

Survey responses of 22 students from the 2019 cohort showed that most participants entered the experience with strong biocentric beliefs holding that nature deserves to exist for its own sake outside its usefulness to humans. Generally, the citizen science experience did not significantly shift these beliefs toward a more utilitarian ethic and participants maintained biocentric views. Additional research also revealed that this experience cultivated a stronger sense of attachment to place. Participants expressed deeper connections with the places that they were engaging, exploring, and attempting to understand. Furthermore, participants noted stronger stewardship motivations following their experience engaging with nature in this manner. Specifically, there was a statistically significant shift toward being more likely to make a future visit, encourage others to visit, donate, volunteer, write in advocacy for the parks, or join a 'friends of' organization.

"…establishing a sense of attachment to the area made me more likely to want to steward these parks."

Focus groups and narrative responses offered additional insights. One student explained the place attachment-stewardship connection, expressing that "establishing a sense of attachment to the area made me more likely to want to steward these parks." Interestingly, the ability to do science, learn alongside fellow participants that shared similar interests, and learn from passionate faculty were common themes that facilitated connections. Citizen science presents an opportunity to learn, study, and explore in a social setting while in nature. This research strategy engages participants in nature and represents an additional avenue for inspiring connections to, and ultimately stewardship of, wild places.

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Halliwell, P., Whipple, S., Hassel, K. N., Bowser, G., Husic, D. W., & Brown, M. A. (2020). Twenty-First-Century Climate Education: Developing Diverse, Confident, and Competent Leaders in Environmental Sustainability. The Bulletin of the Ecological Society of America, 101(2), e01664.

The Mexican Cut Nature Preserve of south-central Colorado reveals the restorative power of nature and time. Image Credit: Howard Whiteman.

Nature Heals All Wounds

Howard Whiteman
Professor, Department of Biological Sciences; Director, Watershed Studies Institute, *Murray State University*

One of my favorite places on the planet is a former precious metal mine. The Mexican Cut Nature Preserve in western Colorado started in the late 1800s as a silver and gold operation, with tunnels, metal carts on rails, cabins, and all the impacts associated with early mining. The Town of Elko, with 1,000 people at its heyday, emerged at the base of Galena Mountain to house, feed, and entertain the miners. The miners never found abundant precious metals, but they squeaked out a meager existence mining galena, a form of lead, giving name to the mountain on which Mexican Cut is perched.

It has been a long journey for Mexican Cut to recover from the scars left by mining. No restoration efforts were made, but left alone, nature began healing the wounds. The recovery process took a significant step forward in 1958 when Dr. Ruth (Scottie) Willey and her husband, Dr. Bob Willey,

arrived at the nearby Rocky Mountain Biological Laboratory (RMBL).
When they found Mexican Cut, they were hooked. They reveled in the numerous rare and unique plants and animals that called the site home, including a species of fern, Steller's cliff brake, found in only two places in Colorado. They were drawn to wilderness re-emerging.

Through patience, determination, and skillful negotiation, the Willeys convinced The Nature Conservancy (TNC) to purchase the Mexican Cut, creating a 960 acre preserve and designating RMBL as the caretaking institution. In turn, RMBL found donors to repay the purchase cost to The Nature Conservancy. Mexican Cut was the first nature preserve purchased by The Nature Conservancy in Colorado and to this day remains the crown jewel of TNC's Colorado preserve system. The Willeys also secured the water rights to Mexican Cut, an important protection in Colorado, where water use becomes more contentious each year.

Despite its protected status and its buffering by the expansive White River National Forest, the preserve requires vigilance. Shortly after its preservation, Scottie Willey famously used a dip net to stop a bulldozer operator on his way to wreak mechanized havoc. In the last 30 years, other collaborators, including my research team, have been an almost daily presence ensuring that the occasional trespasser or lost hiker avoids disrupting the unique chemistry of the ponds.

Mexican Cut reveals the **power of place**.

" Mexican Cut reveals the power of place. "

Wildflowers in full bloom at Mexican Cut. Does this look like a mining site to you? Image Credit: Howard Whiteman.

Preserves are special places that we humans have set aside for other species, communities, and ecosystems.

We may be unable to set aside all the habitat we would like, but the jewels we do save, such as Mexican Cut, nourish human souls while generating valuable conservation outcomes. Maintaining intact ecosystems is a powerful tool for maintaining biodiversity in a changing world.

The story of Mexican Cut doesn't end with its preservation; its protection was a prelude to an unfolding scientific story. One of the reasons that Mexican Cut was set aside was its unique salamander population, one of the largest and highest-elevation populations of tiger salamander in Colorado, which uniquely has two distinct adult forms. Metamorphic adults are those that metamorphose from aquatic larvae into a terrestrial form that can live on land and breath air, and thus disperse across the landscape, exactly like frogs. Paedomorphic adults (paedo means juvenile) are salamanders that never metamorphose, instead retaining their larval characters such as gills, permeable skin, and a fleshy tail fin. Paedomorphic adults never go on land, but rather live their lives within the ponds, and will mate with other paedomorphic as well as metamorphic adults.

I've been studying the Mexican Cut salamander population for the past 30 years to understand the secrets of how and why these two forms exist.
Most recently, my collaborators, Dr. Kelsey Reider (James Madison University) and Dr. Scott Thomas (Murray State University), and I have been studying these populations to explore how climate change affects other salamander populations.

Dr. Reider has implanted temperature data loggers in both forms to document the thermal tolerances of these salamanders, using them as sentinels of climate change. As ectotherms, their temperature tracks the environment. By following the temperature of these salamanders over time, we will document the impacts of climate change on their thermal biology. Additionally, because the two life-history morphs of these salamanders may be impacted differently by climate change, we will be able to predict whether one morph or the other is likely to be more successful on a warming planet. This will allow more accurate conservation plans for these and other amphibian species.

Dr. Thomas is interested in how energy gradients affect salamander populations, and whether climate change might influence these relationships. Mexican Cut is very nutrient poor; it can be difficult for the salamanders to find food. Because of this, they sometimes cannibalize. Work by the late Dr. Scott Wissinger and myself demonstrated that cannibalism leads to population cycles. Dr. Thomas has hypothesized that in lower-elevation, energy-rich environments, cannibalism will be reduced, dampening population cycles. Climate change, including increased temperatures at high elevation, may change this dynamic, increasing the energy available

Researchers at one of the ponds of Mexican Cut.
Image Credit: Howard Whiteman.

to high-elevation sites such as Mexican Cut, and thus reducing the cycles.

Understanding these relationships can help us better understand how to manage and conserve other species whose population dynamics may be driven by energy gradients.

The scientific story continues to unfold, but Mexican Cut shows that nature can heal wounds and produce a vibrant, diverse ecosystem. We hope that our research in that pristine but restored nature preserve will allow us to better mitigate the impacts of an even bigger disturbance, one which is ongoing and will have global, rather than local, impacts, both on mountain ecosystems and many others.

A Riddle of the Alpine

Rachael Jones
Student, Colorado Mountain College
CW3E-AGCI Summer Intern

I love watching the rising snowpack graph each winter and cheering on that moving dial that seems so full of promise. In recent years, though, that dial has peaked early and well below average, inevitably inducing visions of drought, wildfire, and drying vegetation in our local ecosystems. I'm not an ecologist, however, and while some of these assumptions surrounding drought conditions are accurate, one experience this summer reminded me that ecology is profoundly nuanced.

While my winter was spent worrying about the snowpack, my summer was spent researching (and worrying about) climate change as an intern with Aspen Global Change Institute. One day in early July, my mentor and I (along with a handful of other ecologists and interns) conducted a vegetation survey on Independence Pass. This allows us to identify the species present this year and compare the data with that of prior years. On the day of the survey, due to wildfire smoke, we could barely see the Geissler twin summits and Twining Peak across the valley from our chosen site near the Independence Pass iRON station. I noticed only a couple small cornices remained near their 13,000+ foot summits. No one needed a sweater, and I regretted my heavy boots and wool socks. The still, sticky, ambient air and the stifling feeling induced by the smoke layer made it difficult to believe that we were in the alpine above the treeline. I'd come to the mountains to escape the heat hundreds of times over the years, but that was not the case today.

Rachael Jones (center, back) works with other interns and Independence Pass Foundation staff to identify species in a vegetation survey plot, July 12, 2021. Image Credit: AGCI.

Much to our collective delight, however, the tundra at 12,000 feet was teeming with plant life. We set up transect tape for our Modified-Whittaker plot, then crouched down near the first 2m x 5m rectangle. Western paintbrush, alpine sagebrush, bistort, diamond leaf saxifrage...this was my first vegetation survey, and the names of the species quickly caught in my mind as I paired them with the flowers in front of me. We found dozens of species, from the tiniest moss campion, minuartia and Draba aurea, to taller, robust king's crown and marsh marigolds. The arctic gentians were present but not yet in bloom. James' snowlover, a rare Colorado wildflower, was abundant. I filled my notebook with this Latin litany.

Nothing changed in the sky that day; the smoke and warm temperatures stagnated.

But as we squatted inches above this green, diminutive landscape, everything shifted for me. I was startled to see the alpine plant life so abundant despite the megadrought upon us in the West and the global temperatures rising to astonishing heights. I wonder what systems are in place to bring about such a cacophony of wildflowers in this dry year. I wonder what other ecological surprises I will encounter in the upcoming decades.

Awe—A Catalyst to Inspire Climate Advocacy

Scott Ramsey, PhD

Core Faculty, Prescott College
Director of the Alaska Outdoor Science School

Seeking more fieldwork to complement my Masters in Environmental Sociology, I landed a summer job as a naturalist/guide in Alaska. I treasured this learning opportunity, but at the end of the season, the plan was to pursue a doctorate. However, a comment from a client from Chicago dramatically changed my trajectory. Overwhelmed by the grandeur of the glaciers, she declared, "I have never been hiking before, and I can see now why we're trying to save these places." Inspired to make a difference, I have dedicated the past 25 years of my life to being a conduit to these types of awe experiences.

The implications of a changing climate may be considered the "gravest challenge that humanity has ever faced" (Stanley et al., 2000, p. 3). Despite local, regional, and global climate transitions, like the ones happening in glacial country, many still have trouble conceptualizing the interconnected nature of climate change. A more subtle awareness of how carbon emissions influence melting glaciers can be challenging to take in. Finding ways to educate, inspire climate awareness, and promote advocacy seem more vital than ever.

Awe in nature is one potential means to transformation. The suite of emotions that constitute awe can catalyze a sense of humility through feelings of being part of something bigger than ourselves, something outside ourselves, and something that has been here before us and may last beyond us. Such transcendent experiences can serve as vaccines against climate apathy and even inspire climate advocacy.

AOSS student Austin Edmonds holds glacial ice from the Medenhall. Image Credit: Wes Overvold.

Needed more than ever are experiences of natural phenomena so vast and complex that we are caused to shift our understanding of the world. Research has indicated that experiences of awe can promote a sense of purpose and pro-social goals such as generosity and helping people in need (Piff et al., 2015; Prade & Saroglou, 2016). A transition from self-interest to things larger than the self seems to shift our attention from 'me' toward 'we'. This may be the exact re-orientation needed for us to see the far-reaching implications of our actions.

Such a change that comes from witnessing an ablating glacier can give us a new sense of scale, an external scale. What better way to fathom the enormity of a changing climate than to float on water that was once trapped as glacial ice? Through decades of field observations, I have seen this interplay where participants have consistently been impacted by encounters with melting glaciers which clearly display the effects of a changing climate. One participant on a multi-day trip captured the sense of the life-changing impact of awe, journaling: "Seeing the glaciers recede to such great extent really reinforced my feelings about climate change. I'm inspired" (Ramsey, 2018).

Being the conduit to these opportunities, witnessing people reaffirm, motivate, and enhance their orientations toward sustainability is why I guide and educate.

As we continue to navigate the transitions associated with a global pandemic, a purposeful focus on efforts to mitigate climate change is still needed. More than ever, we need experiences of awe in nature. "It seems to become paramount to prioritize experiences of awe, to attune to them, attend to them, seek them out, and protect those things that bring them out" (Piff, 2018). Awe. How can we fully live without it?

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" Being the conduit to these opportunities, witnessing people reaffirm, motivate, and enhance their orientations toward sustainability is why I guide and educate. "

News and Events

MtnClim 2022

CIRMOUNT is expecting to host MtnClim at beautiful Rocky Mountain Biological Laboratory in Gothic, Colorado next year, in **September of 2022**. As with the last two years, plans are contingent on regulatory and safety considerations regarding the COVID virus and may change as the situation evolves.

JOIN THE TEAM

Does seeing the MVC in your inbox fill you with joy? Are you fascinated by the latest stories from the field? Consider joining our Mountain Views Chronicle editorial team. Inquiries should be sent to: MtclimMVC@gmail.com

Call for Submissions:

The next issue of the Mountain Views Chronicle will run Fall 2022. Our theme will be Extreme Events. This includes reporting research on drought, fires, floods other natural events, but we also welcome stories of working in intense conditions—field work in remote locations, intense weather conditions, or breathtakingly high elevations. The Mountain Views Chronicle accepts submissions of articles, field notes, artwork, and poetry. Please send all inquiries to MtClimMVC@gmail.com

Back Cover Art: Ice, Snow, and Water at Blacktail Creek. Ice, creek water, bubbles, snow and frost are all represented in this photograph. These different forms represent the transitions and complexity of water so they are an illustration of the Transitions theme of the 2021 MVC Issue. This photograph was taken on a cold day in mid-winter along Blacktail Creek in Butte, Montana. Image Credit: Martha Apple