NWRRI - Nevada Water Resources Research Institute

Nevada Water News

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Photo by Scottthezombie

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Climatic and Hydrologic Aridification in Mid- and High-elevation Ecosystems of Southern Nevada

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Climate change is contributing to more water-limited conditions, known as aridification, in forests and woodlands throughout the Southwest. These conditions can lead to vegetation dieback and ecosystem declines that directly affect human communities. The focus of the project "Climatic and Hydrologic Aridification in Mid- and High-elevation Ecosystems of Southern Nevada" was to use field instruments, detailed ecosystem characterizations, and land surface modeling to determine how recent climate change has affected water balance processes in local forest and woodland ecosystems. The project also identified how the landscape and vegetation of the study sites amplified or dampened aridification, which helped to identify the potential locations and characteristics of future ecological decline in southern Nevada.

The climate of southern Nevada is warmer and drier than other locations in the Southwest, especially from April through September when precipitation is often low. Although southern Nevada has been fortunate to avoid some of the severe ecosystem declines that have occurred in other parts of the Southwest over the past two decades, it is important to prepare for their potential occurrence. "Ecosystem declines can contribute to intensified fire regimes, increased air pollution, reduced water retention/infiltration and greater flood risk, higher regional temperatures, and even the loss of

This Issue

If you have questions about submitting a NWRRI proposal, email Suzanne Hudson (Suzanne.Hudson@dri.edu).

Visit the NWRRI website (www.dri.edu/nwrri) for current RFP information.

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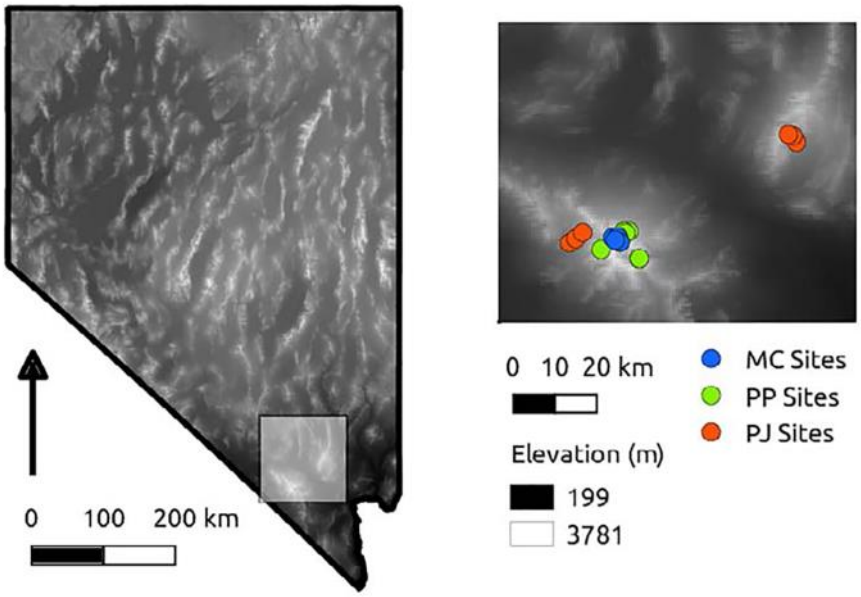
(Project Spotlight continued)

recreation areas," explains Dr. Matthew D. Petrie (UNLV), the principal investigator (PI) of the project that also included co-PIs Dr. John Bradford (USGS) and Dr. Daniel Schlaepfer (USGS).

Climate change is projected to promote moisture deficits and high temperatures not previously experienced in the Southwest, potentially leading to severe declines in forest and woodland ecosystems. Both moderate and severe vegetation declines negatively affect water resources by reshaping the water balance, often over very large areas. In many cases, losses of vegetation cover are associated with reduced soil water retention, which leads to greater discharge of water and soil into surface waters, reduced deep water recharge, and higher temperatures because of reduced evapotranspiration. It is also extremely challenging to combat or reverse ecosystem declines and the loss of services provided by ecosystems. "Our study sought to illustrate the potential trajectories and organization of climate-driven changes to water balance across ecosystems in southern Nevada to help land managers identify where declines are most likely to occur," Petrie says. "This allows them to allocate resources more efficiently and design management interventions that can limit the occurrence of these declines."



The location of the project study sites in relation to the state (left) and the other location sites in the project area (right) (figure courtesy of Matthew Petrie).

At the start of the project, the team characterized 23 sites in southern Nevada that included higher-elevation mixed conifer (MC) forest, mid-elevation ponderosa pine (PP) forest, and lower-elevation piñon pine-juniper (PJ) woodland that had different vegetation densities and were in different locations. They compared meteorological variation between the sites and used water balance modeling and information theory to estimate similarities in soil temperature (Ts), soil water potential (SWP), and transpiration partitioning into total evapotranspiration (T/ET) within and across ecosystems during

The results of this project were presented at the 2023 American Geophysical Union Fall Meeting:

- Petrie, M.D., J.B. Bradford, and D.R. Schlaepfer, 2023. Elucidating aridification pathways across the ecosystems of a semiarid elevational gradient. American Geophysical Union Fall Meeting, San Francisco, CA. December 11-15, 2023.

A manuscript discussing the findings from the project is also currently undergoing peer review.

(Project Spotlight continued)

wetter and drier seasons and cooler and warmer decades. The goals of this project were to:

1) Determine changes in meteorological measures of water deficit (when atmospheric water demand exceeds water supply by precipitation) in these ecosystems over the long term (1941 to 1980) and in the more near term (1981 to 2020).

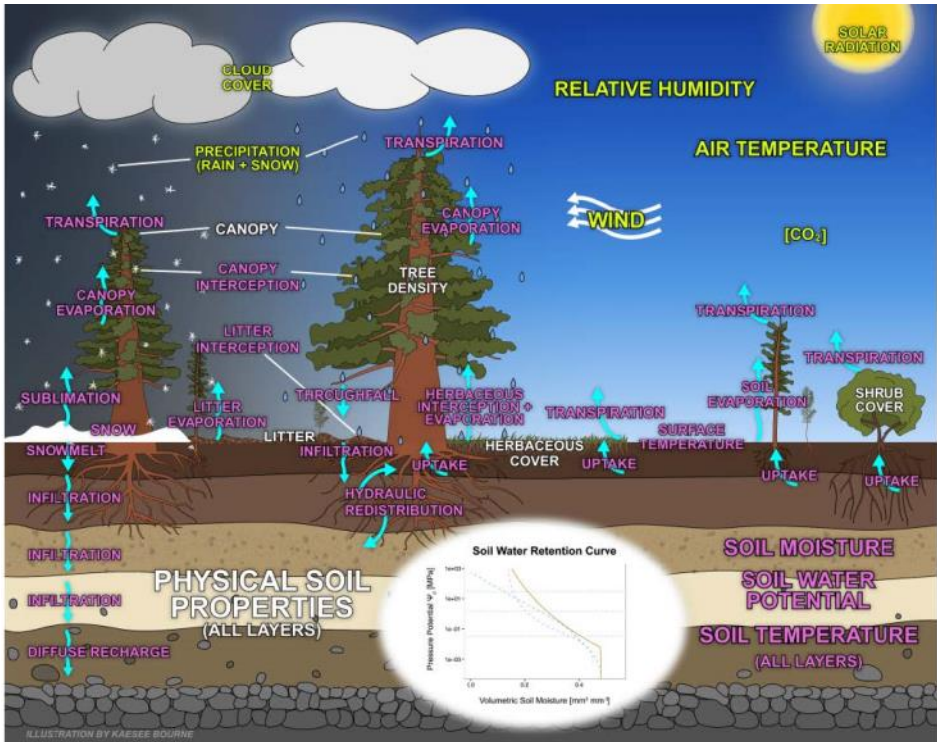
2) Contrast the characteristics of meteorological water deficit between MC, PP, and PJ ecosystems during the cool season (October to March) and warm season (April to September) from 1981 to 2020.

3) Quantify similarities in SWP, Ts, and vegetation T/ET between MC, PP, and PJ ecosystems in dry, average, and wet seasons.

4) Explore the influence of differences in vegetation density (at the MC and PP sites) and location (at the PJ sites) on SWP, Ts, and T/ET.

5) Determine how recent higher temperatures influenced SWP, Ts, and T/ET across ecosystems in dry and wet seasons.

An important objective of the project was to identify the ecosystems that were most vulnerable to aridification. The detailed site characterization data collected by the team allowed them to implement parameterizations of each of the 23 sites using the SOILWAT2 ecosystem water balance model developed by USGS. "The model has been used successfully to simulate water balance and temperature dynamics in woodlands and forests of the southwestern United States," Petrie says. "We used the model to simulate the water balance and temperature dynamics of each of our study sites during the 1981-2020 water years. We then quantified the density distributions of SWP, Ts, and T/ET between the groups of study sites in climatically different periods [wet, average, and dry seasons; warm versus cool decades] to determine the similarities and differences of a variable between site groups."



The SOILWAT2 model can utilize a suite of observed and estimated abiotic and biotic conditions to generate daily ecosystem water balance processes (figure designed by Kaesee Bourne and courtesy of Matthew Petrie).

The meteorological results of the study showed that although there were significant temperature increases

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– Matthew Petrie

(Project Spotlight continued)

Study sites of pinion pine-juniper woodland in the Sheep Mountains (left) and Spring Mountains (right) (photos by Matthew Petrie).

in the Spring and Sheep Mountains in recent decades, the Spring Mountains actually experienced significant declines in meteorological water deficit during both the cool and warm seasons because of higher precipitation, whereas the Sheep Mountains experienced significant increases in water deficit during the warm season. "Higher precipitation over recent decades in higher-elevation ecosystems is a good thing for southern Nevada," Petrie says. "Land managers may be sitting in a window of opportunity for climate adaptation measures that can insulate regional ecosystems from future climate change, which has not been possible in much of the Southwest."

Despite higher precipitation during recent decades, the results of the project showed that temperature increases have already altered the water balance of local forest and woodland ecosystems at both lower and higher elevations. Over the past two decades, temperature distributions across lower- and higher-elevation ecosystems have become more similar. However, temperature change appears to have reduced the similarity of water balance distributions between ecosystems that were more similar in the past. In other words, groups of similar ecosystems (e.g., MC forests and high-density PP forests) are experiencing less similar water balance dynamics. This suggests that the dynamics of these ecosystems may diverge further under a warming climate and shows how a change in "behavior" may indicate the potential for ecosystem decline. "Our results suggest that land managers in southern Nevada may want to consider expanding their management interventions within MC and PP ecosystems because the impacts of recent climate warming have not been limited to only lower-elevation ecosystems where temperatures are higher," Petrie says.

A key component of the NWRRI program is to support the next generation of water researchers. Kaesee Bourne, a recent UNLV School of Life Sciences graduate, was hired as the science communication technician for this project. She had the opportunity to gain an in-depth understanding of the project and other research at UNLV, as well as develop research diagrams, outreach materials, and brochures to improve scientific research communication. "Kaesee did an excellent job on her part of the project," Petrie says. "We were also very happy that she was subsequently hired for a full-time position as a wildlife educator with the Nevada Department of Wildlife through AmeriCorps." ■

NWRRI Undergraduate Internship Interview: Amy Kalandos

Amy Kalandos participated in the NWRRI Undergraduate Internship Immersion Program in the fall of 2023. She worked on the project "Wildfire Impacts on Yosemite's Snowpack" and was mentored by Dr. Gabrielle Boisrame of DRI. The focus of the project is to understand how wildfires affect snowpack in Yosemite National Park. This involved converting time-lapse imagery into numerical data that could be used to describe snow cover in different locations. We asked Amy about her experience during the internship, current research, and plans for the future. Here's what she had to say:


Photo by Amy Kalandos

1) What are you currently studying and how did you find out about the internship?

I am currently studying environmental management at the College of Southern Nevada (CSN) and I will be graduating in the spring with my bachelor's degree. I found out about this internship through the science resource page on Canvas that the dean of the program, Dr. Douglas Sims, had posted.

2) The project you worked on was "Wildfire Impacts on Yosemite's Snowpack." What did this project entail and in what ways did you participate?

This project entailed using different methods to see which gave a more accurate measure of the days that had snow versus the days that didn't have snow. When processing the camera data, we would identify the days according to what we could see and use the information that was provided to us when we first started the project. After processing a few cameras, the group broke out into individual work, and I began working on temperature and light intensity tasks. When working with the temperature data, a study was already published (Dickerson-Lange et al., 2015), so we used their criteria to define if there were days of snow or no snow. We learned that the criteria began to miss a few days, which indicated it was too strict for this project, so we adjusted our temperature cutoff. We used the same method for the light intensity tasks as we did for the temperature tasks, but we made our own cutoffs based on box-and-whisker plots we created because there wasn't a published study on this. Based on our data, we can say that the light intensity data pick up a few more days of snow than the temperature data, but the numbers are close enough to each other. The camera data show fewer days of snow because they are subjective, which means that they can be interpreted differently as a full snow day or a partial snow day depending on who is observing the data.

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"At the beginning of the internship, I didn't know what I wanted to do, but now I feel like I would love to participate in more research projects or conduct a few of my own."
– Amy Kalandos

(Student Interview continued)

3) What did you learn about how wildfires affect snowpack? How does this research improve our understanding of water resources/water availability in mountainous terrain?

Reintroductions of fires to an area can actually be beneficial to the environment. The Illilouette Creek Basin allows for fires that occur from lightning strikes to burn as long as they don't threaten the surrounding areas. This study found that the transpiration rates were reduced, which allowed the water to remain in the system. There was also an increase in snowpack, which is vital for many areas that receive water supply from snow melt. The nature of the basin showed the potential to change and adapt depending on what conditions were present and how severe or moderate a fire was. The basin exhibits changes from an arid climate that was densely forested to a mesic basin, which has a variability in vegetation that is widely spread.

Understanding the impact of wildfires on snowpack is crucial for water resources management. Wildfires can alter vegetation, reducing the snowpack's ability to capture and retain water. This, in turn, affects the timing and amount of water runoff, influencing downstream water availability for both ecosystems and human consumption. By studying this interaction, water managers can develop more effective strategies to mitigate the consequences of wildfires on water resources and plan for sustainable water management.

4) What did you learn from your experience on the project? Was there anything you found particularly interesting or surprising?

I learned that science can be unpredictable and sometimes won't fit your expectations. The biggest thing I learned is that you can't make the data say what you want them to say. Instead, you need to take them as is and explain what you have. What I found interesting in this project is that 2023 was a great season for snow. Most areas in our target sites had snow for over a hundred days and it sometimes covered the cameras, which are mounted about six feet high. In contrast, 2021 and 2022 usually never reached more than a hundred days of snow and it was never too deep.

Camera data from the project showing snowfall in the Illilouette Creek Basin (screenshot courtesy of Amy Kalandos).

5) Did participating in this internship give you any ideas for your future studies that you may not have thought about otherwise?

Throughout my studies in college and through this internship, I was always curious about fires and how the environment changes over time when a fire does occur. My mentor, Dr. Gabrielle Boisrame, has gotten me interested in pursuing a career in the hydrologic sciences in the future.

6) What are your goals for the next steps in your studies and what career direction are you pursuing?

At the beginning of the internship, I didn't know what I wanted to do, but now I feel like I would love to participate in more research projects or conduct a few of my own. I would love to have a job that is half hands-on in the field and half data processing. My goal after graduation is to finally specify which category of science I want to focus on. There are many options out there and all of them have sparked my interest in one way or another.

Reference

Dickerson-Lange, S.E., J.A. Lutz, K.A. Martin, M.S. Raleigh, R. Gersonde, and J.D. Lundquist, 2015. Evaluating observational methods to quantify snow duration under diverse forest canopies. *Water Resources Research,* 51(2), 1203–1224. https://doi.org/10.1002/2014wr015744 ■

NWRRI Undergraduate Internship Interview: Jacques Scott

Jacques Scott participated in the NWRRI Undergraduate Internship Immersion Program in the fall of 2023. They worked on the project "Wildfire Impacts on Yosemite's Snowpack" and were mentored by Dr. Gabrielle Boisrame of DRI. The focus of the project is to understand how wildfires affect snowpack in Yosemite National Park. This involved converting time-lapse imagery into numerical data that could be used to describe snow cover in different locations. We asked Jacques about their experience during the internship, current research, and plans for the future. Here's what they had to say:

1) What are you currently studying and how did you find out about the internship?

I am studying wildlife ecology at Truckee Meadows Community College and learned about the internship in my natural resource ecology class during the Spring 2023 semester.

2) The project you worked on was "Wildfire Impacts on Yosemite's Snowpack." What did this project entail and in what ways did you participate?

Photo by Jacques Scott

The project was centered around the interpretation of data collected from various sensors and cameras placed in Yosemite from October 2022 to June 2023. Initially, I and the other interns in my team processed images from several cameras and recorded precipitation levels using Excel. Then, we were given our own projects to focus on and I worked on processing and analyzing data related to soil temperature and moisture to develop a soil climate summary spreadsheet, documenting precipitation levels from 2015 to 2023.

3) What did you learn about how wildfires affect snowpack? How does this research improve our understanding of water resources/ water availability in mountainous terrain?

Natural wildfire cycles are ideal for absorption of the snowpack. When there are too many mature trees, the snow that has fallen on their branches evaporates rather than being absorbed into the soil, leading to drier and hotter soil conditions because of water's high specific heat capacity. This process supports growing evidence that natural wildfire cycles improve ecological conditions and that preventing these cycles will result in a less efficient introduction of the snowpack into the watershed.

4) What did you learn from your experience on the project? Was there

"[Participating in this internship] helped me realize I enjoy working with data and research projects. A lot of jobs in the wildlife ecology area involve fieldwork, so knowing that data analysis is something I prefer will help me apply for jobs I would enjoy more."
– Jacques Scott

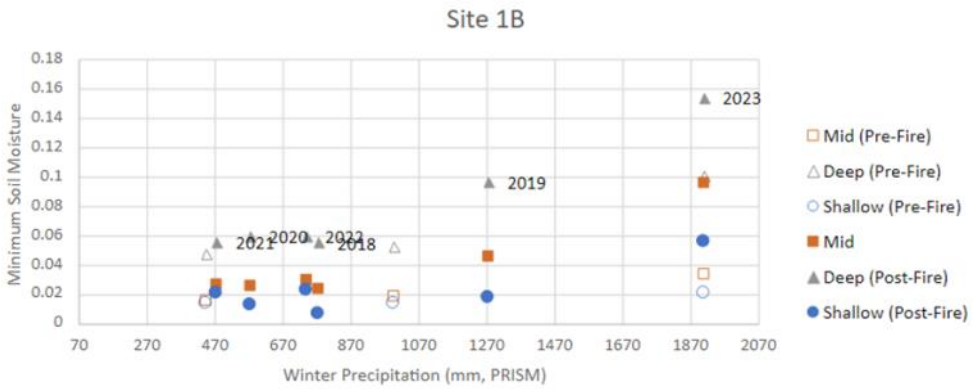
(Student Interview continued)

anything you found particularly interesting or surprising?

I was surprised soil moisture levels were higher during a certain period after wildfires when most trees were not fully mature. This was because snow that fell onto the trees would melt and evaporate into the air instead of being absorbed by the soil. Therefore, regular wildfires thin out forests, which leads to better absorption of precipitation.

5) Did participating in this internship give you any ideas for your future studies that you may not have thought about otherwise?

It helped me realize I enjoy working with data and research projects. A lot of jobs in the wildlife ecology area involve fieldwork, so knowing that data analysis is something I prefer will help me apply for jobs I would enjoy more.



Project results showing that soil moisture was higher after wildfire for a given amount of winter precipitation. Regular wildfires help thin out vegetation, increasing the amount of precipitation that can reach the soil surface and reducing the soil water removed by roots (figure courtesy of Jacques Scott).

6) What are your goals for the next steps in your studies and what career direction are you pursuing?

If possible, I would like to participate in more collaborative long-term research projects while in school. I will probably end up preferring jobs in my field related to analyzing and interpreting field data. ■

Events List

Please keep an eye on the event websites for changes in conference schedules.

AGU Ocean Sciences Meeting
February 18-23, 2024
New Orleans, LA
www.agu.org/ocean-sciences-meeting

AEG Southern Nevada Chapter
"A Novel Approach for the Remediation, Reclamation, and Development of the Three Kids Mine Site for Residential Reuse"
March 5, 2024
Henderson, NV
www.aegsnv.org/meetings

NGWA's Hydrogeology of States Webinar Series: District of Columbia
March 7, 2024
Virtual
www.ngwa.org/detail/event/2024/03/07/default-calendar/24mar07web

2024 Pacific Northwest Ground Water Exposition
March 15-16, 2024
Vancouver, WA
pnwgwa.org/

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Events List Continued

Please keep an eye on the event websites for changes in conference schedules.

AWRA 2024 Geospatial Water Technology Conference
March 25-27, 2024
Orlando, FL
www.awra.org/Members/Events_and_Education/Events/2024-GWTC-Conference/2024_GWTC_Conference.aspx

AWRA 2024 Spring Conference
April 8-10, 2024
Tuscaloosa, AL
ww.awra.org/Members/Events_and_Education/Events/2024-Spring-Conference/2024_Spring_Conference.aspx

AEG Southern Nevada Chapter
"The Las Vegas 50-Year Water Plan"
April 9, 2024
Las Vegas, NV
www.aegsnv.org/meeting

Groundwater in the PFAS Era: Stressors, Protection, and Compliance
April 16-17, 2024
Tucson, AZ
www.ngwa.org/detail/event/2024/04/16/default-calendar/24apr5010

20th Annual Truckee River Field Study Course
May 2-3, 2024
Reno, NV
www.nvwra.org/2024-truckee-river-tour

AEG Southern Nevada Chapter
"Can We Mine Our Way to a Less-warm Planet"
May 14, 2024
Las Vegas, NV
www.aegsnv.org/meetings


Photo by BLM Nevada

GSA 2024 Joint Cordilleran and Rocky Mountain Section Meeting
May 15-17, 2024
Spokane, WA
www.geosociety.org/GSA/Events/Section_Meetings/GSA/Sections/cd/2024mtg/home.aspx?hkey=88411fd7-3278-41be-aa78-f451032e17f3

SSSA Conference: Common Ground – Soils Beyond Borders
June 10-12, 2024
San Juan, Puerto Rico
www.sacmeetings.org/

AGU WaterSciCon
June 24-27, 2024
St. Paul, MN
www.agu.org/waterscicon

NWRRI - Nevada Water Resources Research Institute

Success and the dedication to quality research have established the Division of Hydrologic Sciences (DHS) as the Nevada Water Resources Research Institute (NWRRI) under the Water Resources Research Act of 1984 (as amended). As the NWRRI, the continuing goals of DHS are to develop the water sciences knowledge and expertise that support Nevada's water needs, encourage our nation to manage water more responsibly, and train students to become productive professionals. The work conducted through the NWRRI program is supported by the U.S. Geological Survey under Grant/Cooperative Agreement No. G21AP10578. The Desert Research Institute (DRI) administratively houses and logistically supports the operations of the NWRRI.

About DRI

The Desert Research Institute (DRI) is a recognized world leader in basic and applied environmental research. Committed to scientific excellence and integrity, DRI faculty, students who work alongside them, and staff have developed scientific knowledge and innovative technologies in research projects around the globe. Since 1959, DRI's research has advanced scientific knowledge on topics ranging from humans' impact on the environment to the environment's impact on humans. DRI's impactful science and inspiring solutions support Nevada's diverse economy, provide science-based educational opportunities, and inform policymakers, business leaders, and community members. With campuses in Las Vegas and Reno, DRI serves as the nonprofit research arm of the Nevada System of Higher Education. For more information, please visit www.dri.edu.

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