Sierra Nevada Network
Inventory & Monitoring Program

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The Greening of Mountain Lakes

Lonely Lake, Sequoia National Park, one of the many Sierra Nevada lakes that are destinations for wilderness hikers. NPS photo by SIEN lake crew.

Example of algal bloom in Sky Pond, Rocky Mountain National Park.

The clear, blue waters of mountain lakes contribute to the scenic beauty of the Sierra Nevada and Rocky Mountain national parks. These lakes support a variety of plants and animals adapted to live in the cold, dilute, nutrient-poor waters that characterize high-elevation lakes. Now imagine hiking to a favorite lake 10 years from now and seeing green algae flourishing in the water, and the clarity you remember replaced with murkiness.

In recent years, scientists have observed filamentous green algae for the first time in lakes in Sequoia and Rocky Mountain national parks. During the 2012-2016 hot drought in California, low snowpack and warm air temperatures interacted to produce lake water temperatures 2 to 4°C above average, and algal blooms were observed along the shoreline in Sequoia National Park's Emerald Lake; similar algal growth was documented in the Loch Vale watershed of Rocky Mountain National Park in 2011. These types of algae are not typical of cold, nutrient-poor lakes.

To investigate the extent of algal growth in lakes and potential factors associated with these changes, the Sierra Nevada Network (SIEN) is collaborating with the U.S. Geological Survey (Fort Collins Science Center, Colorado), Colorado State University, University of California, and Sequoia and Kings Canyon and Yosemite national parks to implement a research project funded through the NPS-USGS Water Quality Partnership. The research project is called: *Are mountain lakes on a rapid trajectory toward harmful algal blooms?*

The project will study the interactive effects of temperature and nutrients in regulating lake algal growth, and assess the extent of lake greening across both time and space in mountain lakes of the Rockies and the Sierra Nevada.

National Park Service scientists on this project include former Sequoia & Kings Canyon Science Coordinator Koren Nydick (now Chief of Resource Stewardship at Rocky Mountain NP) and SIEN Physical Scientist Andi Heard.

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What's Inside?

Learn about: New Forest Monitoring Video, Recent Publications and Reports, 2018 Field Projects, and an opportunity to review the Inventories 2.0 Draft Plan

The Greening of Mountain Lakes

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To provide information on the spatial extent and variability of algal blooms and productivity across SIEN parks, Andi and her lake crew will incorporate algal sampling at the 24 lakes they sample as part of SIEN's existing monitoring project in 2018 and 2019.

A community science app called WATR2016 enables park staff and visitors to collect images of algae in mountain lakes on iPhones, and then upload them to a central database for analysis. Sequoia National Park Sub-district Interpreter Daniel Blankenship is coordinating outreach for this app. To learn more, visit: http://tiny.cc/WATR2016.

In addition to studying the spatial extent of algal blooms, this project will also address:

- The history of algal assemblages and productivity in Sierra Nevada and Rocky Mountain lakes: How have productivity and algal blooms changed over time, and does the temporal pattern of algal growth correlate with other drivers of change such as temperature, drought, or deposition of nutrients?
- The causes of algal blooms: To what extent do temperatures and nutrients interact to drive algal growth?

In addition to reducing water clarity, filamentous algal growth can also have ecological and health effects. This type of algae is difficult for most invertebrates to harvest, decreasing feeding, reducing invertebrate population sizes, and thus reducing predators at higher levels of the food chain.

The knowledge gained from this project can help managers decide whether to adopt guidelines for mountain lakes that can be used to warn visitors if bacteria or toxins from algae are present. California has developed guidelines for response to harmful algal blooms, which include criteria and actions for monitoring the blooms and actions such as posting advisories to the public. There has not yet been evidence of algal-related toxicity in Sequoia, Kings Canyon, or Yosemite lakes.

In Colorado, information on increased nitrogen in mountain lakes has been used to develop regional air quality initiatives with state and federal regulatory agencies to reduce nitrogen emissions.

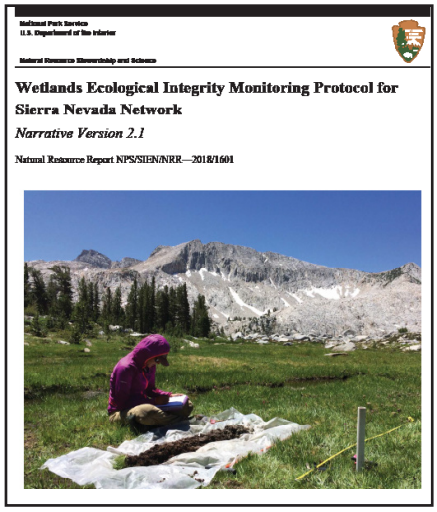
We will share additional information as this project progresses!

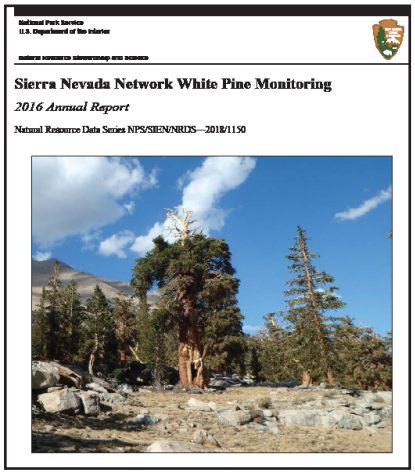
New Video: High Elevation Forest Monitoring

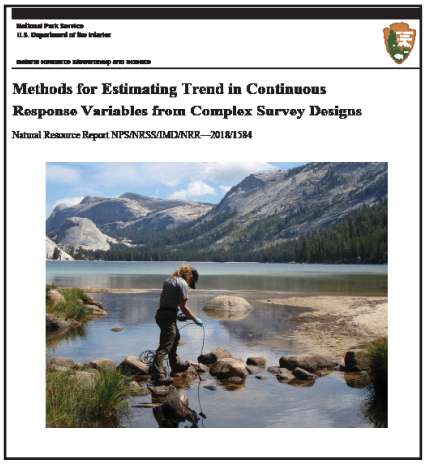
Forest Crew Lead Sean Auclair measuring foxtail pine diameter. Photo: © Michael Durham.

Visit https://youtu.be/q3DA9oxsusQ to watch a new video featuring our high elevation forest monitoring project. Thank you to the park staff who graciously participated - Woody Smeck and Christy Brigham, Superintendent and Chief of Resources Management & Science, respectively, at Sequoia & Kings Canyon, and Garrett Dickman, Botanist at Yosemite. We thank our regional I&M Program Manager Lisa Garrett who coordinated the contract, our forest crew (Sean Auclair, Tressa Gibbs, Hanna Mohr, and Sam Zuckerman) for skillfully demonstrating what they do, and videographer Michael Durham who cheerfully endured heat, snowstorms, and steep slopes to film this video.

Recent Publications, Protocols, and Reports







The publication of our wetlands monitoring protocol brings our protocol development and review phase to completion. This project includes monitoring three vital signs – plant communities, macroinvertebrates, and groundwater hydrology, and so involved many authors, including network and park staff as well as university cooperators. Bolded names are current or former SIEN staff members.

Gage, E. A., **J. C. B. Nesmith**, **L. Chow**, **A. Chung-MacCoubrey**, D. J. Cooper, **A. M. Eddy**, **S. A. Haultain**, J. G. Holmquist, J. R. Jones, L. R. Jones, **S. T. McKinney**, P. E. Moore, **L. S. Mutch**, L. A. H. Starcevich, and H. Werner. 2018. Wetlands ecological integrity monitoring protocol for Sierra Nevada Network: Narrative version 2.1. Natural Resource Report NPS/SIEN/NRR—2018/1601. National Park Service, Fort Collins, Colorado.

The following annual reports capture the highlights from our white pine monitoring project for 2015 and 2016. In this project, we monitor populations of whitebark pine in Sequoia & Kings Canyon and Yosemite national parks, and foxtail pine in Sequoia & Kings Canyon.

Nesmith, J. C. B. 2017. Sierra Nevada Network white pine monitoring: 2015 annual report. Natural Resource Data Series NPS/SIEN/NRDS—2017/1141. National Park Service, Fort Collins, Colorado.

Nesmith, J. C. B. 2018. Sierra Nevada Network white pine monitoring: 2016 annual report. Natural Resource Data Series NPS/SIEN/NRDS—2018/1150. National Park Service, Fort Collins, Colorado.

For those wanting the gritty statistical details of trend estimation for complex survey designs in monitoring projects, the following report and publication may be of interest. The authors feature water chemistry data from SIEN's lake monitoring project in these analyses.

Starcevich, L. A. H., T. McDonald, **A. Chung-MacCoubrey, A. Heard**, **J. Nesmith**, and **T. Philippi**. 2018. Methods for estimating trend in continuous response variables from complex survey designs. Natural Resource Report NPS/NRSS/IMD/NRR—2018/1584. National Park Service, Fort Collins, Colorado.

Starcevich, L. A. H., K. M. Irvine, and **A. M. Heard**. 2018. Impacts of temporal revisit designs on the power to detect trend with a linear mixed model: An application to long-term monitoring at Sierra Nevada lakes. Ecological Indicators 93(2018): 847-855. https://doi.org/10.1016/j.ecolind.2018.05.087

SIEN Data Manager Alex Eddy published a paper on her M.A. thesis from Ohio State University, based on research done in Peru. The journal that published the paper is in Spanish.

Eddy, A. M., B. G. Mark, M. Baraër, J. McKenzie, A. Fernández, S. Welch, and S. Fortner. 2017. Exploring patterns and controls on the hydrochemistry of proglacial streams in the Upper Santa River, Peru. Revista de Glaciares y Ecosistemas de Montaña 3(2017): 41:57.

Field Project Updates

Birds

The Institute for Bird Populations (IBP) has returned for the seventh season of monitoring birds in these parks. Crew Lead Graham Montgomery has returned for his fifth year working with IBP and his second tour with the Sierra Nevada Network (SIEN). He and Eric Stary of Portland, OR are stationed in Sequoia & Kings Canyon, while Ela (Rae) Engert (who worked as an IBP bird-bander in 2017) and Max Brier (both from Marin County, CA) are working out of Yosemite and Devils Postpile. The crews started their training in recognizing bird calls in early May, and began visiting transects at the end of the month.

What is it like monitoring birds in the SIEN parks? Lots of hiking, and lots of birding! Each two-person crew starts their tour by hiking to and camping near their first transect origin, so that they can be up and birding at first light. When they are done collecting data, it's time to hike to the next transect—which could be ten miles away—and start all over again.

Bird crew members Rae Engert, Max Brier, Eric Stary, and Graham Montgomery, and staff biologist Bob Wilkerson, The Institute for Bird Populations. NPS photo by: Linda Mutch.

A typical tour lasts seven days, and depending on travel distances, can include anywhere from 3 to 6 transects. Why are the bird crews in such a rush? Bird-monitoring is tied to the breeding season, and so all sample points have to be visited before July 24th.

High Elevation Forests

Whitebark pine (*Pinus albicaulis*) exhibiting a windswept growth form, near Townsley Lake, Yosemite National Park. NPS photo by: Sarah Hoff- Phillips.

The iconic whitebark pine (*Pinus albicaulis*) is recognized as a 'keystone' species throughout its range on the high, windswept ridges of the Rocky Mountains, Cascades, and Sierra Nevada. In response to severe population declines in the Rocky Mountains, the US Fish and Wildlife Service (FWS) is evaluating whitebark pine for listing as an endangered species. Although our program is taking a 'rest' year from high elevation forest monitoring, the field crew – Sean Auclair, Rosa Cox, and Sam Zuckerman –is

Whitebark pine cones with protein-rich seeds that provide an important food source for birds and mammals, Yosemite National Park. NPS photo by: Jonny Nesmith.

spending the summer visiting a subset of I&M plots as well national forest sites for a FWS-funded investigation into drought tolerance and vulnerability in whitebark pine stands.

SIEN Ecologist Jonny Nesmith is part of an interagency team of scientists overseeing the collection of tree cores and vegetation samples from Sierra Nevada sites where whitebark pine is predicted to either persist or decline over the next 50 years (including Sequoia, Kings Canyon, and Yosemite). This study is part of a suite of projects designed to characterize whitebark pine persistence in the Sierra Nevada, which will help inform the listing process as well as future conservation efforts.

Field Project Updates

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Lakes

For the eleventh season of lakes monitoring, crews will visit 25 lakes across Sequoia, Kings Canyon, and Yosemite. In Yosemite, crew members are Hannah Besso (crew lead) and Dustin Garrison, and in Sequoia & Kings Canyon, Talia Chorover (lead, returning for her 3rd season with I&M) and Glauco Puig-Santana. Geoscientist-in-the-Parks interns Isabel Christy and Marisa Monroe will join the crews to help with regular lake monitoring as well as a special research project targeting algae in lakes.

Annually, crews collect data on a suite of measures to monitor water chemistry and amphibians. They take on-site measurements of water quality and collect samples that are processed in a lab, as well as conducting amphibian surveys. This year the crews will also work on a new research project to better understand algal blooms in mountain lakes. This research involves surveying for algae along lake shorelines, conducting productivity experiments, and collecting algae samples. See the article on page 1-2 to learn more about the algae project and the potential impacts of algae on these lakes.

Our lake monitoring provides managers with a snapshot of current lake resource condition, and we are building a long-term dataset to examine trends. We have learned that up to 37% of the lakes in the parks are affected by high nutrient concentrations. Nutrients from agricultural, mobile (vehicles), and industrial sources throughout California drift into the parks via air currents and are deposited in high elevation areas where they can contribute to increased algal growth in remote mountain lakes.

Roxanne Kessler (left) is wetlands crew lead again this year, and Talia Chorover is returning to be the lakes crew lead after 2 years at Cornell University earning her M.S. Photo from video by: Eliza Goode.

Wetlands

This summer is our fifth season of wetlands monitoring. The field crew will travel to Devils Postpile, Sequoia & Kings Canyon, and Yosemite to assess wetland ecological integrity by monitoring plant communities, invertebrates, groundwater levels, and soil characteristics. Roxanne Kessler (crew lead, and returning for her 5th season on SIEN crews), Wesley Meyers (assistant crew lead, returning for his 3rd season), and two new members, Geoscientist-in-the-Parks interns Scott Gilb and Zoe Klein, form the 2018 wetlands team.

Plants known as bryophytes (such as mosses and liverworts) contribute to plant diversity and productivity in wetlands. Photo of moss *Pohlia cruda* by Paul Wilson.

This spring, Paul Wilson, Professor at California State University at Northridge, generously offered his time to share his expertise in moss sample collection and identification. The mosses that cannot be identified in the field are collected in small amounts, labeled, and sent away to Paul for identification.

Why is this wetlands crew member wearing a hood and jacket on a sunny summer day? In addition to being able to identify wetland plants and assess wetland soils, wetland monitors must be able to endure mosquitos and flies that flourish in these soggy areas. If you look closely you may see a mosquito head net too. NPS photo by SIEN wetlands crew 2017.

Field Project Updates *(continued from page 5)*

River Hydrology

Field technicians performing a discharge measurement at the outlet of Tuolumne Meadows, Yosemite. NPS photo.

The Sierra Nevada Network (SIEN), Yosemite, and Devils Postpile work collaboratively to measure streamflow at three river gaging stations on the Tuolumne River and the Middle Fork of the San Joaquin. Yosemite Resources Management and Science field technicians, Hannah Besso, Patrick Longley, and Rachel Hallnan are measuring streamflow this summer at the Tuolumne River at Tioga Road Bridge station and upstream at the Lyell Fork of Tuolumne below Maclure. Student Conservation Association interns Danny Parks, Austin Riley, and Alissa Chrisekos are measuring streamflow along the San Joaquin in Devils Postpile. Data from two of the sites can be observed in near real time on the California Data Exchange Center and USGS National Information System websites:

Tuolumne River at Tioga Road Bridge: http://cdec.water.ca.gov/dynamicapp/staMeta?station_id=TUM

Middle Fork of the San Joaquin River near Mammoth Lakes CA: https://nwis.waterdata.usgs.gov/nwis/inventory/?site_no=11224000&agency_cd=USGS

The Sierra Nevada Network River Hydrology Monitoring Protocol reports on streamflow data from 14 gages in and near SIEN parks. The additional eleven gages are operated by cooperators and data will be shared with SIEN annually. This is one of the network's newer protocols and the first hydrologic summary report will be completed next year.

Review of Draft Inventories 2.0 Plan

The NPS Inventory & Monitoring Division (IMD) has completed the draft plan for Inventories 2.0 and is requesting review from NPS staff by July 20. The plan can be reviewed using the Planning, Environment, and Public Comment (PEPC) website at: https://pepc.nps.gov/inventories.

Inventories 2.0 is the next generation of NPS inventories, and this draft plan is the result of scoping workshops and surveys that began in 2016, with input from over 800 NPS staff at the regional, network, and park levels.

Joe DeVivo, Deputy Chief of Science for IMD, thanks those who participated in the Inventories 2.0 scoping process over the course of the last year and a half.

Participation in the review is voluntary, and your feedback is greatly appreciated. Your contribution helps the Inventory & Monitoring Division ensure the inventory data collected can be integrated into park management and planning.

Sierra Nevada Network

The Sierra Nevada Network is one of 32 National Park Service inventory and monitoring networks that monitor vital signs to assess the condition of park ecosystems and contribute to a body of scientific knowledge that informs park management decisions.

Parks in the network are:
*César E. Chávez National Monument (CECH)
Devils Postpile National Monument (DEPO)
Sequoia & Kings Canyon National Parks (SEKI)
Yosemite National Park (YOSE)

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*Established in 2012, César E. Chávez NM is not included in the vital signs monitoring program.

Devils Postpile interns, Natural Resource Program Manager, and contractor at viewpoint with Rainbow Falls in distance. NPS photo: T. Caprio