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Source: Mountain Research and Development, 41(4)

Published By: International Mountain Society

URL: https://doi.org/10.1659/mrd.mm268.1

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Mountain Research and Development (MRD)
An international, peer-reviewed open access journal
published by the International Mountain Society (IMS)
www.mrd-journal.org

Lakes and Watersheds in the Sierra Nevada of California: Responses to Environmental Change. By John M. Melack, Steven Sadro, James O. Sickman, and Jeff Dozier

Oakland, CA, USA: University of California Press, 2021. 203 pp. Hardcover: US$ 85.00, ISBN 978-0-520-27879-0. E-book: US$ 39.95, ISBN 978-0-520-96734-2.

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Lakes and Watersheds in the Sierra Nevada of California: Responses to Environmental Change is a science textbook available as a hard copy and an e-book. The book synthesizes investigations of high-elevation lakes over more than 30 years throughout the Sierra Nevada of California. It contains 7 chapters, references, and an index, including an introduction to the Sierra Nevada and its water resources, snow cover, hydrology and biogeochemistry of watersheds, and limnology. At the end, it sums up the understanding for trends and future scenarios. The book is enjoyable and easy to read, and the clarity of presentation is unusually good. The authors have followed the philosopher Wittgenstein's advice: "what you can say, you can say clearly."

The first chapter introduces the Sierra Nevada from physical, biological, and cultural aspects, starting with the geological history. The mountains extend 700 km north–south, with a width of around 100 km and the highest peak reaching 4421 m (Mount Whitney). The life and culture of the Native Americans in the Sierra Nevada is not well known, so anthropogenic impact and water resources are described from the arrival of the Europeans in the 1800s. Mining, use of water resources, and nature protection have progressed in parallel since then. The second chapter continues the introduction, with a focus on water resources. There are thousands of small lakes and ponds in the region, but only a few of them have lateral scales in kilometers. Hydrological and limnological monitoring data concern about 10 lakes, with the most extensive information for Emerald Lake, which has a size of 2.7 ha, a maximum depth of 10 m, and an outlet at 2.8 km elevation.

The main source of water in the Sierra Nevada is snow, which is treated in chapter 3. Mapping is challenging, since snow accumulation is heavy, with a snow water equivalent of more than 1000 mm, and measurement sites are not easily accessible. Therefore, snow remote sensing is an excellent tool. Although not yet well solved for snow water equivalent, remote sensing strongly supports snow monitoring through snow surveys and modeling. The chapter makes a very nice presentation about snow distribution in the mountains, snow cover energy balance, and snow melting. The radiation balance was treated properly, but I would have preferred more information about the turbulent fluxes, especially since the radiation balance is sensitive to topographic effects here. Also, runoff during the snow melting period could have received more attention.

Watershed hydrology and biogeochemistry are treated in chapters 4 and 5. The water balance is simplified due to very small groundwater discharge, and the question was covered by measurements of precipitation, snow accumulation, and stream flow. The water balance is governed by snow input and stream discharge output (peaking at snowmelt), but in some years rain or evaporation could be comparable to the main terms. The biogeochemistry study is based on long-term monitoring and modeling, as well as specific research, especially in the Emerald Lake watershed. In the Sierra Nevada mountains, atmospheric deposition is an important source of particles and gases, also reflecting anthropogenic activities. The chapter considers nutrient balances and major solute dynamics in particular.

Chapter 6 presents limnological and ecological data and analyses. Emerald Lake is the focus, complemented by surveys from a few other lakes throughout the Sierra Nevada. Water temperature, thermal stratification, and ice period are taken as the annual cycle in physics. The ice cover is quite exotic due to the heavy snow accumulation that could have been discussed more in the book. The ice cover consists of layers of snow, slush, and snow-ice, depending on the winter's weather history. Persistent liquid layers also serve as habitats for biota. The lake physics provides the background for the biogeochemical and ecological processes in the lakes, including rates of primary production and ecosystem respiration. Acidification is examined based on experimental data and observations. Sediment cores are analyzed that go back to the 1800s. The chapter gives a good picture of the annual cycle of the lakes in the region.

The last chapter discusses the variability and future scenarios of the Sierra Nevada's lakes and watersheds. The time series are several decades long and reveal past trends and variabilities. The relationship between thermal characteristics of the lakes and air temperatures is not straightforward, since the snow accumulation and snow melting have a major impact on the state of the lakes in summer. The variations in snow conditions are in turn driven by large-scale atmospheric circulation patterns. The climate change scenarios are largely uncertain. Even though air temperature scenarios are available, the snow problem leaves the Sierra Nevada watershed scenarios largely open. This question and climate impact conclusion is very well written, with expectations and uncertainties in balance.

Lakes and Watersheds in the Sierra Nevada of California is an excellent scientific book on mountain hydrology and limnology in one mountain area where the water balance is

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governed by snowfall. As a monograph book, the chapters are of the same style and level, and the package is a comprehensive presentation. I was, however, missing 2 items. First, there is no presentation of how the elevation influences the physical and biogeochemical processes, with the air temperature and air pressure decreasing with altitude and the consequences to hydrology and limnology. Second, more quantification would have benefited the book, for example, using scaling analysis for the various processes in the mountain watersheds. These items would have given a good frame for a reader not familiar with the geoscience of mountain regions.

I can warmly recommend the book for the science, engineering, and nature protection community not only in California, but also for those working in mountain environments overall. There is a wide literature in hydrology and limnology, but the unique property of this book is in providing a full understanding of how mountain hydrology and limnology work in a fixed region based on long-term data. The book serves hydrologists well with illustrations of the influence of elevation and heavy snow accumulation on hydrological systems. I greatly appreciate the clarity of the text, reflecting the authors' high level of expertise.

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