The impact of people on mountain wilderness lakes

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Students collect benthic plants from the Kearsarge Lakes in Kings Canyon National Park to evaluate the effects of human use.

Small alpine lakes are natural magnets to tired backpackers in high mountain areas in California, and at times they have looked like busy campgrounds. For example, even with strict limits on visitor use, an estimated 40 campers per night occupied the small Kearsarge Lakes basin of Kings Canyon National Park during midsummer, 1976. Less than a decade ago, with fewer restrictions, daily visitors probably numbered well over 100.

The National Park Service has been concerned about the possible deterioration of these lakes as well as the practical problem of contaminated drinking water. Under a contract between the Park Service and Whitaker's Forest Cooperative Natural Resources Research Station, my students and I began, in 1976, to study the biological, chemical, and physical characteristics of ten lakes in Kings Canyon National Park. In the first summer of study we compared two Rae Lakes (Upper and Lower) that have heavy visitor use with two of the Sixty Lakes that lie in the next drainage basin west and have considerably less use. Snow and ice cover at these lakes' elevations of 10,400 to 11,100 feet limit sampling to about four months. In the following two summers the four Kearsarge lakes and Bullfrog and Charlotte lakes were studied.

With special permission of the Park Service we were allowed to camp near the lakes, after 16 horses and burros had packed in our equipment. For the first two years we mapped and sampled the lakes from a small inflatable raft. The final year the lakes were sampled by skin divers.

Estimating the number of visitors to a lake was difficult while maintaining a full study of the lakes. Also, our initial results suggested that the impact of people on lake properties may be the result of long term use rather than of current more restricted use. The Park Service developed a method of estimating historic use by ranking the number of trails, campsites, and areas of disturbance around each lake. Subsequently we used this human impact index to compare conditions among the lakes.

We found that the lakes, even those most heavily used, still have most of the chemical and biological properties typical of unproductive alpine lakes. No gross signs of pollution were detected. Bacterial quality was variable but not clearly traceable to human contamination. More than likely, the indicator bacteria we detected came from other vertebrates around the lakes, a finding that other investigators have noted in lakes in the Sierra Nevada and in the Rockies.

A close examination of the amount of dissolved nitrate in the lakes and of the rooted plants on the lakes' bottoms revealed a significant pattern: Lakes with the *highest* human impact (Lower Rae Lake, Charlotte Lake, Bullfrog Lake) had less nitrate and more aquatic plants on the bottom than did the other lakes. Nitrate in the heavy-use lakes is apparently taken up by the plants, whereas in lakes with less impact and fewer plants, nitrate is in less demand and remains dissolved in greater amounts. Our work also suggests that people may be causing an increase in such trace elements as iron, and it is these elements that accumulate at the bottom, stimulate plant growth, and result in nitrogen uptake. After adjusting the data from the impact index and the frequency of bottom plants for correct statistical properties, we found a direct correlation among these variables Insects, aquatic worms, and small clams that live on the bottom followed the same trend as the plants; they were more abundant in lakes with historically more visitor use.

Bullfrog Lake is particularly interesting because overnight camping and stock grazing have been prohibited from the shores since 1961; yet, the lake still reflects heavy use. Possibly drainage from the Kearsarge basin upstream has continued to affect the lake or else recovery at these extreme elevations is slow.

Thus, from several directions our studies reveal differences in the high elevation lakes that indicate use levels are causing changes in lake characteristics. To a hiker walking along the trails that parallel these lakes, their beauty is the clarity of their water. Usually, a clean sand or rocky bottom is visible with occasional patches of aquatic plants in quiet shallows. But because of years of over-use, some lakes now have distinctly "mossy" bottoms. Careful management and regulation of use in these basins is essential to recover their pristine quality and to protect them for future generations.

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