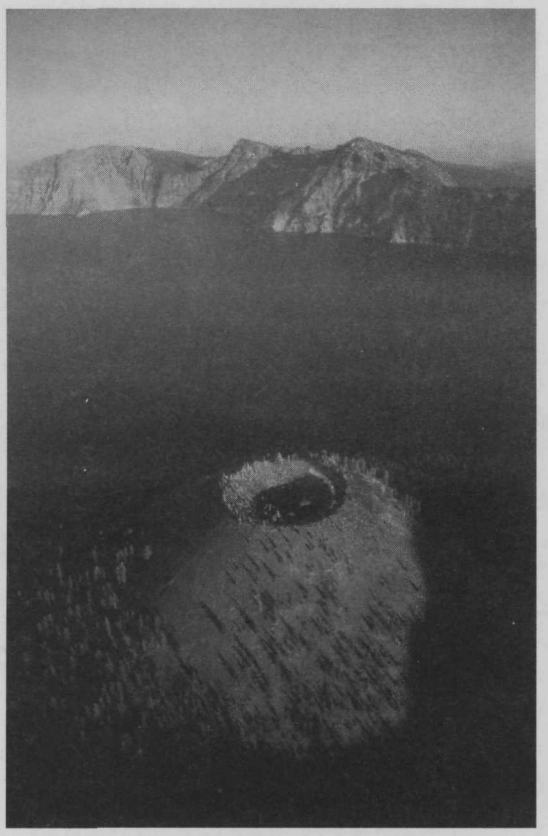
ADMINISTRATIVE HISTORY
Chapter 18: Research



CRATER LAKE NATIONAL PARK

U.S. Department of the Interior National Park Service Pacific West Region

ADMINISTRATIVE HISTORY

Chapter 18: Research

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ADDENDA

CHAPTER EIGHTEEN—RESEARCH

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Introduction

This is the second chapter added to the administrative history of Crater Lake National Park that originally appeared in 1988. It utilizes both a chronological and thematic approach to how research has shaped park administration, a topic that has remained completely absent from almost all historical narrative on Crater Lake and other park areas. Readers will note particular emphasis on the relatively recent past, in part because of the comparatively high output of studies, but this is also due to how research activities have lately had a more intimate relation to administration of the park.

This narrative is not intended as an overview of past research, nor is it aimed at necessarily evaluating the relevance of that work to the present. It merely provides some background with which to organize a highly eclectic mix of studies employing methods ranging from experimental to empirical, but that generally employ some degree of comparative analysis. As to how the term is used in this chapter, research culminates in documents that address specific scientific or historical questions. The writing undergoes formal review, as part of publication or the printing required to complete contract obligations. Other kinds of information on park resources, such as unpublished field observations and data collection, or narrative reports by

NPS staff, are not included in this chapter because this material was addressed (at least to some extent) in a previous chapter on resource management by Unrau.[1] Like other kinds of administrative history, this narrative is organized chronologically, with emphasis placed on where research has affected park management.

As for key issues, the two most outstanding reflect their respective periods of park administration. The first was fundamentally tied to a focus on interpreting the forces that produced Crater Lake, as well as connecting it and Mount Mazama to a larger regional context. Much of that work revolved around the classic study by Howel Williams during the 1930s, yet Charles R. Bacon and others in the U.S. Geological Survey (USGS) continue to revise and expand previous geological interpretation so that more is known about Crater Lake than any other caldera lake. The second arose during the early 1980s, as the NPS began to sponsor its own research efforts as a way of supporting newly initiated resource management programs. Whether the lake itself was changing became a concern, so that the need for special studies and a long-term monitoring program eventually made these endeavors a part of park operations.

Research activities, 1886-1926

Although research may not have dominated park operations through time, it did influence establishment of Crater Lake National Park. One of the earliest bills aimed at establishing the park contains a line specifying that

"said reservation shall be open to...those making scientific researches." This provision is usually attributed to the interest USGS geologist Joseph S. Diller and others had, beginning in 1883, of studying the volcanic phenomena associated with the climactic eruption of Mount Mazama. The provision for access by scientists (something Diller himself inserted) persisted in most of the bills aimed at establishing a national park at Crater Lake, including the one that proved ultimately successful in 1902. Diller also produced a special quadrangle map of the Crater Lake area published by the Government Printing Office in 1896 that allowed the successful bill to shift park boundaries from the ten townships withdrawn by President Grover Cleveland in 1886 to ones corresponding with the map. The first government-sponsored interpretation of Crater Lake appeared on the map's reverse side.[2]

Research conducted in support of establishing the park largely consisted of papers published by the Mazamas (a mountaineering group centered in Portland) for the first guidebook to Crater Lake. They appeared in 1897, and included papers by Diller (geology), C. Hart Merriam of the U.S. Biological Survey (mammals), Frederick Coville of the Bureau of Plant Industry (vegetation), and Barton Evermann of the U.S. Fish Commission (potential for sport fishing). Starting in 1898, their corresponding testimonials then became the report from the Department of the Interior on bills aimed at establishing Crater Lake National Park.[3]

Diller's professional paper on Crater Lake, one that he co-authored with Horace B. Patton in 1902, represented the first monograph to describe

the park's geological story and the lake's limnological properties.[4] He later condensed the information presented in his monograph for a pamphlet first printed by the government in 1912. Intended as a companion to the 1908 update of the special quadrangle for Crater Lake, Diller aimed the pamphlet as an aid to visitor interpretation.[5]

With no formal interpretive programs in the park until 1926, these materials virtually stood alone as sources of geological information on Crater Lake. Diller's monopoly on geological work during this period did not extend to vegetation, where John F. Pernot of the U.S. Forest Service (USFS) published a pamphlet on the park's forests with descriptions of each tree species in 1916.[6] Like Diller's pamphlet printed four years earlier, Pernot's publication aimed at assisting visitors even though on-site distribution of either piece was virtually non-existent. Contributed work on park-related topics during the first half of the 1920s for the most part consisted of an article on wildflowers and some geological interpretation compiled for another guidebook to Crater Lake, a project undertaken by the Mazamas as something of a reprise to the one of 1897.[7]

Naturalists and research, 1927-1952

The hiring of a few seasonal naturalists beginning in 1926 allowed for the possibility of trained personnel conducting research in conjunction with giving talks and contacting visitors. As with external investigations, these studies represented contributed work since the NPS carried no tradition of

actually paying for research. Park managers could not muster funds to pay even one permanent full-time naturalist until 1931, so it is not surprising to find only one paper originating from a seasonal naturalist hired for the summer during the first five years of the summer interpretive program.[8]

Recruitment of university professors and graduate students to serve as ranger naturalists (later known as seasonal interpreters) became more common as a permanent chief naturalist position became an established part of the NPS organizational chart at the park. Publication of results from research studies conducted by the ranger naturalists was encouraged, even though a duty schedule aimed at visitor contact rarely permitted paid time for fieldwork. Most naturalists conducted their studies as part of a degree program or to help bolster chances for academic promotion, with some publications resulting from scholarly pride of scientists who happened to be NPS employees for about 90 days each summer. These naturalist investigators came from fields such as botany (Elmer Applegate, F.L. Wynd), aquatic biology (Arthur Hasler, O.L. Wallis, J. Stanley Brode), geology (John Eliot Allen, Warren D. Smith, Carl Schwartzlow), and zoology (Donald Farner, James Kezer, Ralph Huestis).[9] Farner could even claim the distinction of being the lone NPS employee at Crater Lake to have published his findings in book-length form through a university press. This came through an external subsidy so that *The Birds of Crater Lake National Park* appeared in 1952.[10]

While much of the published research remained largely inaccessible to visitors, the naturalists regularly produced *Nature Notes from Crater Lake* for

distribution in the park. This publication did not go through the same editorial review process as the academic journals, but the short articles in it were aimed at the general public rather than a small number of scholars. The mimeographed version appeared several times each summer from 1928 to 1938, then started up again as an annual volume beginning in 1946. The series even contained one full monograph, on golden mantled ground squirrels by Huestis, which appeared in 1951.[11] With a few notable exceptions, the page count of annual volumes exceeded that of the mimeographed bulletins, partly because formation of the Crater Lake Natural History Association in 1942 eventually led to donations that underwrote conventional printing of *Nature Notes*. A precedent was set by the late 1940s to encourage submissions through the permanent naturalist allowing ranger naturalists one day per week as project time for the pursuit of research topics in exchange for written contributions.[12]

Hiring of the first permanent naturalist in 1931 came in direct response to recommendations by a group called the "Committee on Educational Problems in National Parks" sanctioned by the Secretary of the Interior. Chaired by the president of a foundation devoted to scientific research called the Carnegie Institution of Washington (CIW), the group's expenses were funded by a grant from the Laura Spelman Rockefeller Memorial. Each of its members visited a number of parks to assess where educational facilities might be located to best advantage, how many staff members were needed, and where research problems might touch on the

visitor experience.[13] The chairman, John C. Merriam, took special interest in Crater Lake because of the potential to relate the scientific story of the lake to aesthetic values so as to foster what he called "nature appreciation" in visitors. Merriam believed that understanding how people reacted to natural beauty was a prerequisite before success could be achieved in getting them to truly comprehend the geological story of Mount Mazama.

His ideas about Crater Lake are perhaps best expressed through an essay published in 1933, followed by a section on the park in his book on nature appreciation that appeared a decade later.[14] The only other related publications resulted from the efforts of his protégé Doris Payne in 1943-44, though there are also exist a considerable number of unpublished reports and memoranda on interpreting the contrast of spectacular power that produced Crater Lake with the peaceful beauty of its present setting.[15] Interest in nature appreciation and aesthetics on the part of Merriam's associates at the University of Oregon also gave rise to a short-lived summer session course cosponsored by the university and the NPS. Poor attendance and logistical problems limited the Crater Lake Field School of Nature Appreciation to the season of 1947.[16]

Although better interpretation through linking aesthetics with science remained elusive, Merriam succeeded in bringing about a classic study of the park's geological story. It originated when two geologists who worked as ranger naturalists at the park advanced an "explosion" theory to explain the origin of Crater Lake, this being in direct opposition to the "collapse" of the

caldera interpreted by Diller. Merriam then placed funds from the CIW for restudying this question in the hands of volcanologist Howel Williams from the University of California.[17] Williams, whose earlier work included monographs on Mount Shasta, Lassen Peak, and Mount Theilson, conducted his fieldwork at the park from 1936 to 1940. He essentially supported Diller's interpretation of Crater Lake as a feature of the caldera's collapse, but also expanded upon the earlier USGS work.[18]

Merriam encouraged Williams to take the unusual step of publishing a popular guide to the geology of Crater Lake through a university press, one that appeared before the technical volume. More than any other single factor, the appearance of *Crater Lake: The Story of its Origin* in 1941 provided impetus to form the Crater Lake Natural History Association. Superintendent Ernest P. Leavitt and Chief Park Naturalist George Ruhle formally organized the cooperating association in June 1942, though it undertook no business activity until the summer of 1946 due to staff reductions during World War II.[19]

Williams periodically drew on the naturalists for help in the field starting in 1936. Two years later chief naturalist John Doerr began assisting Williams by taking charge of re-sounding Crater Lake for three summers.[20] Although the project faced obstacles (the pressure of public contact work by the naturalists and having to rent boats from the concessionaire), Doerr was able to obtain sounding equipment from the USGS.[21] These measurements refined those obtained by Diller in 1886, and even helped to lure the first

university-sponsored research efforts to Crater Lake. A team of oceanographers from the University of Washington came in the wake of a fledgling limnological program, one outlined by ranger-naturalist Arthur Hasler in 1937 and continued upon his departure by Donald S. Farner. Hasler, later renowned for his work in aquatic ecology and fisheries at the University of Wisconsin, also supplied the basis for later conclusions about a downward trend in the clarity of Crater Lake with his Secchi disk readings that summer.[22] The studies initiated by Hasler and Farner centered on fish, but in July 1940 the UW investigators expanded the breadth of study by measuring vertical penetration of bands in the visible light spectrum and took water samples to examine the quantity and kinds of phytoplankton present in the lake.[23]

Merriam previously solicited a report on Crater Lake's optical properties, one to serve as the basis for interpreting to visitors how the lake appears as blue. He recruited an astronomer who worked for the CIW at the Mount Wilson Observatory for the work. Edison Pettit's report was thus subsequently distilled into a CIW news bulletin for mass distribution. It prefaced explanation of "Why is Crater Lake So Blue?" with citations from Merriam's essay of 1933 in order to tie the physics of scattered light to why the lake held such great appeal for visitors.[24]

The centerpiece of what Merriam orchestrated at Crater Lake, however, lay in Williams' geological study, one funded to allow for collaboration with related investigations. Most prominent among the cross-

disciplinary work involving Crater Lake were the archeological investigations of Luther S. Cressman, who excavated caves east and north of the park beginning in 1935. Cressman related the formation of Crater Lake as a time marker to prehistory in the northern Great Basin and, like Williams, published both technical monographs and a popular account.[25] Merriam orchestrated funding for much of Cressman's work in the late 1930s, partly in hopes that it could assist with tying Crater Lake to a larger regional study of change in recent geological time. The CIW also funded studies by Henry P. Hansen on forest succession within the past 10,000 years through pollen analysis at various localities in south central Oregon.[26]

As a catalyst for the interpretive program at Crater Lake, Merriam viewed research not merely as a means to protect national parks. He saw the main purpose of the NPS as educating visitors, with research as the way to deepen the understanding and enhance the credibility of the naturalists. By 1944 he found himself in disagreement with the director (his long-time associate in the Save-the-Redwoods League, Newton B. Drury) over the idea that scientific research had a place in the NPS. Drury's objections stemmed not so much from hostility to science, but from the reality of running a bureau whose tiny infrastructure for support of research had been gutted prior to his appointment in 1940. The soft money supporting staff positions in biology, forestry, and geology during the work relief programs like the Civilian Conservation Corps almost vanished after 1938, with all but three NPS biologists transferred to the U.S. Biological Survey in 1939.[27]

While the NPS slowly recovered from the deep cuts in staffing taken during war years, the agency continued to encourage (rather than fund) research. Naturalists, as they had prior to World War II, conducted studies on a part-time basis for small rewards at places like Crater Lake. Many of them, as Merriam observed in 1944, lacked training to conduct the critical studies to serve as the basis for an interpretive program.[28] For more than a decade after 1945, the naturalists nevertheless continued to supply the bulk of what little research output the NPS could claim to have fostered.

Science on a shoestring, 1953-1973

Increased federal funding for scientific research beginning in the mid-1950s profoundly influenced the number and scale of studies throughout the United States. Crater Lake and other national parks began to receive increased attention from university-affiliated scientists who could tap grants from the National Science Foundation or other newly created funding sources. Naturalists served as the primary points of contact with outside researchers, though the NPS could do little in the way of providing direct financial support or equipment for these studies.

Just as they had before the war, some of the naturalists continued to work on Crater Lake. A couple of short reports and several articles in the annual volumes of *Nature Notes* summarized these activities. Assistant (later Chief) Park Naturalist C. Warren Fairbanks and ranger naturalist John Rowley also contributed to the published literature on diatoms in Crater

Lake.[29] Despite Fairbanks' resignation in 1958 and the departure of Rowley after the 1955 season, investigations on Crater Lake subsequently became more ambitious. The budget for scientific research for the entire national park system totaled only $28,000 that year, but NPS acquisition of a launch and a skiff at Crater Lake allowed for the U.S. Coast and Geodetic Survey to produce a bathymetric map. By employing echo-sounding technology, the Coast and Geodetic Survey obtained 4,000 individual depth measurements on the lake over a period of six weeks in 1959.[30] A new bathymetric chart (one that showed the lake floor contours in much greater detail than previously) was eventually interpreted by three short papers generated by scientists outside of the NPS, including one by Howel Williams who memorialized Merriam in naming a newly discovered underwater cinder cone.[31]

The bathymetric work allowed a new ranger naturalist, C.H. "Hans" Nelson, to begin the first study on sediments in Crater Lake. It was something intended to be the cornerstone of his master's thesis, and eventually resulted in Nelson's first scientific publication.[32] Chief Park Naturalist Bruce Black recognized the potential significance of the project, and so made the somewhat unusual allowance for Nelson to have two duty days per week away from public contact work in order do his fieldwork.[33] The occupational makeup of the naturalists had, by this time, shifted away from a seasonal staff dominated by college professors to one composed of

graduate students, one or two faculty members, and several high school teachers.[34]

A research orientation (thought by Black to be fairly unusual in most national parks of the period) persisted among the naturalists at Crater Lake into the 1960s. While Black cooperated with researchers where he could, his one-time assistant Dick Brown became the leading promoter of scientific study at the park. Brown arrived as a seasonal in 1952, and then became the permanent Assistant Park Naturalist just a year later. After leaving Crater Lake in 1960, he returned as the Chief Park Naturalist once Black departed in 1963. A vascular plant taxonomist by training, Brown provided specialized assistance to the seasonal staff members such as Elizabeth Mueller, who undertook a thesis on the ecology of the Pumice Desert.[35] He also made a point of hiring one or two professors each summer. This provided the NPS with some employees who had experience in front of groups and the possibility of obtaining studies at bargain prices.[36] Dwayne Curtis of Chico State College, for example, produced two short pieces on discoveries made about the park's nonvascular plants, while Marion Jackson of Indiana State University co-authored a classic ecological study of Wizard Island.[37]

Brown's acceptance of a new position in 1967, that of research biologist, formalized his role as broker for studies at the park. His goals supposedly differed than those of being chief naturalist since the focus of the previous job was visitor contact rather than supplying the basis for which

to manage resources. In practice, however, funding for the NPS science program of the time rarely allowed him much more than continuing the studies begun when he was chief naturalist, or as he put it, "conning people to do things for the park for next to nothing."[38] Brown could devote more time to coordinating research efforts fortuitously funded by other government agencies or universities through grant programs. His ability to actively assist researchers, however, decreased the further away a project moved from his interests in botany, zoology, or forestry. He actively supported geological and limnological studies, but could provide little more than some limited logistical support for them.[39]

Many of the problems plaguing Brown's effectiveness as a research biologist were similar to those experienced by others holding similar positions in the NPS at that time.[40] In addition to possessing limited ability to influence funding decisions, Brown and other research biologists had an administrative supervisor (the park superintendent) and a research supervisor (regional biologist), an arrangement that led to "all kinds of conflicts."[41] Brown transferred to Point Reyes National Seashore in 1970, in part due to the difficulties imposed by two supervisors, and was succeeded by James Blaisdell, a biologist from the Western Regional Office in San Francisco.

Blaisdell worked from the Klamath Falls Group Office, established by Superintendent Donald Spalding and approved by NPS Director George Hartzog in 1969 to serve Crater Lake, Lava Beds, and Oregon Caves. The new location allowed Blaisdell to participate in an ambitious big horn sheep

restoration project at Lava Beds National Monument, something which got underway in 1971 and resulted in one publication aimed at interpreting a resource management (rather than research) effort.[42] NPS-sponsored research, especially in biology, rarely went to press; it instead aimed at a final report, and left implementation to park operations. Scientists based in regional offices or in Washington provided review of the findings, and the research process generally concluded with the report's release.[43] For Crater Lake in the early 1970s, NPS-sponsored research resulted in just two reports. One came about as the park finally moved to close the last open garbage dump in 1972, mostly to reduce the dependence of bears on this source of food.[44] The other centered on elk in order to determine relative numbers and their distribution, its purpose being to provide the Oregon Department of Fish and Wildlife with data so that better projections of an elk "harvest" could be made outside the park.[45]

Substituting a research biologist (whether stationed at Crater Lake or Klamath Falls) for the chief park naturalist as coordinator for scientific studies had little effect on limnological or hydrological investigations conducted in the park. Any research effort in either field was almost entirely dependent on outside funding and expertise. The NPS, through a long-range aquatic resources management plan approved in 1969, articulated some fairly general research needs: 1) describe fully the stream and lake ecosystems; 2) determine the extent of human influence on the aquatic resources, especially in regard to Crater Lake and fishing on Sun Creek; 3)

determine the feasibility of eradicating all fish from Crater Lake and exotic fishes from park streams.[46]

These needs, of course, were secondary concerns to those conducting research from outside the NPS. Most of the USGS work, for example, related to water supply needs of the region.[47] The Atomic Energy Commission (AEC) underwrote several studies starting in 1967 that centered on whether nuclear fallout deposited uniformly on land or sea. Scientists considered Crater Lake as the perfect study site to obtain measurements of radioisotopes associated with nuclear weapons testing since the complexities of circulation and currents in ocean waters led to conflicting interpretations of the data.[48] Concurrent with the AEC work were studies funded by grants from the National Science Foundation and other sources on optical properties of the lake, culminating with one that compared Crater Lake with Lake Tahoe.[49] The NPS could be credited with some logistical support in all of these research efforts, but its contribution did not include funding. The agency simply encouraged, and in some cases promoted, scientific study in line with its policy.[50]

NPS policy in the late 1960s also voiced the need for a mix of basic and applied science, something it dubbed "mission-oriented research." This work, presumably to be funded by the agency, was aimed at assisting the process of internal decision making. Irrespective of needs expressed in the park's long-range aquatic resources management plan, the NPS limited its staff and funds to a precious few studies related to terrestrial biology. This

course reflected the existing expertise in the agency to some extent, though the policy allowed for enlisting universities and other independent scientific entities in the same way Merriam orchestrated studies at Crater Lake during the 1930s.[51] Chronic shortages of even minimal funding, however, became the main obstacle to sustaining the NPS science program of the 1960s and 70s. It was thus an almost foregone conclusion that a limnology program for Crater Lake initiated by Oregon State University (OSU) professor John R. "Jack" Donaldson would quickly grind to a halt.

Donaldson launched the limnology program in the summer of 1967, but had to borrow a boat and motor from a colleague at OSU.[52] The program, as such, was entirely dependent on a grant from a short-lived bureau in the Department of the Interior, the Office of Water Resources, whose focus in funding research at that time included studies of eutrophic (nutrient-rich) lakes. Donaldson's grant was funneled to the Water Resources Institute at OSU, which then made funds available to study Crater Lake as a baseline (it being classed as oligotrophic, or nutrient-poor) for studying the process and impacts of nutrient enrichment.[53] Although meager, the grant allowed Donaldson to work on the lake with three graduate students: Owen Hoffman, Douglas Larson, and James Malick. Their work resulted in two master's theses, one doctoral dissertation, and several journal articles before Donaldson's funding disappeared in 1970.[54] The borrowed boat remained at the park long enough to assist three OSU oceanographers interested in the lake's thermal properties. Funded by a

grant from the Office of Naval Research, their work began in 1969 and eventually included the first research ever conducted on the lake during winter.[55] The latter took place in February 1971 after four previous attempts.[56]

Naturalists, now called interpreters, were no longer involved with research by the early 1970s due to several factors. Probably the most critical stemmed from NPS reorganization of the time that led to a merger with the ranger division while also reducing the number of permanent employees at Crater Lake with an interpretive function to one technician.[57] The educational program was now lodged in the park's organization chart under "Interpretation and Resource Management," a misnomer that resulted from trying to disguise the contraction in NPS staffing during the Vietnam War era.[58] Visitor programs persisted throughout the summer season due to seasonal staffing, but interpretation's traditional link with research (especially that conducted on the lake) was almost severed from 1971 to 1978. When limnological studies at Crater Lake finally resumed after this hiatus lasting seven years, they came about due to the interest of an outside researcher, not because interpretation's status as a separate division in the park had been restored.

Attempts at linking resource management with research, 1974-1983

The NPS found a new way to obtain scientific studies with the advent of cooperative park studies units (CPSUs). Although a CPSU had been

established at the University of Washington (UW) as early as 1970, studies at Crater Lake through this conduit were not initiated until a CPSU came into existence at Oregon State University in 1974. Over the following decade this CPSU acted as something of a broker, one that sometimes induced graduate students to do their theses work at the park. Paid staff at the CPSU in Corvallis during the first fiscal year of operation consisted of NPS research biologist Edward E. Starkey (who served as coordinator at first, then became project leader in later years), one secretary, and a technician. The "research assistants" often pursued their thesis work with a small stipend in exchange for progress reports.[59] Where a proposed thesis study generated sufficient interest from park management, a contract to produce a separate report might then be offered to a student through the CPSU.[60]

Situated within the School of Forestry at OSU, the CPSU remained elastic enough to provide some funding for fieldwork at Crater Lake and other parks while occasionally utilizing the expertise of USFS scientists like Jerry Franklin or faculty members outside forestry such as geographer James Lahey.[61] It accommodated Starkey's research interests (which lay mostly in Olympic and Mount Rainier national parks) while expanding staff to include sociologist Donald R. Field and writer-editor Jean Matthews by the end of 1983.[62] As the CPSU in Corvallis seemed to widen the scope of its activities, support for thesis projects began to dissipate in favor of funding for studies led by collaborators holding academic appointments at OSU.[63] This shift in the early 1980s was repeated at other CPSUs, but the resource

management priorities at Crater Lake dictated that the NPS continue with seeking research conducted by graduate students.

Prescribed fire dominated NPS resource management efforts at Crater Lake in the late 1970s, but the program had its roots earlier in the decade when Robert "Bob" Martin and Dave Frewing from the USFS silviculture laboratory in Bend identified a need for fire history information.[64] They piqued the interest of Donald B. Zobel from the Department of Botany, who then served as major advisor to a pair of graduate conducting studies of forest types in the park with funding provided by the NPS through CPSU contracts. One of the graduate students pointed to how the reintroduction of fire might perpetuate ponderosa pine and sugar pine in the "panhandle" portion of the park, thus leading directly to management-ignited burns which began in 1976.[65]

Superintendent Frank Betts banned such burns in the park the following year due to severe drought conditions while park staff completed a fire management plan. With a plan in place for 1978, NPS crews conducted a management-ignited burn of more than 3,000 acres in the northeast corner of the park that fall. They also allowed six lightning-caused fires to burn over 540 acres in the summer, marking the debut of prescribed natural fire among units of the National Park System located in the Pacific Northwest.[66] Although formerly something of a backwater for the practice of forestry in the national parks, Crater Lake possessed the combination of aggressive leadership in fire management and a few ongoing studies whose scope went

well beyond the mixed conifer stands dominating the panhandle.[67] Lodgepole pine forests in the park were the subject of another thesis completed at OSU in 1978, while another investigator affiliated with the University of Idaho conducted studies on how the burns of 1976 and 1978 affected the dynamics of vegetation change.[68] Control of fire effects research at Crater Lake eventually passed to James K. Agee, a research biologist stationed at UW. He initiated three studies through the CPSU in Seattle in 1980, resulting in several subsequent reports completed through contracts.[69]

Fire management was also destined to be virtually the only area where research played a role in the planning process at Crater Lake during the 1970s. Even then, it simply featured as citations at the back of documentation prepared for compliance purposes in 1976 and 1977.[70] The park's first general management plan (GMP), meanwhile, proceeded toward approval by Regional Director Russell Dickenson in December 1977 by borrowing heavily from previous master plan drafts which emphasized the need for improved facilities at Rim Village and other developed areas in the park. With the planning process well underway by the time two contracted CPSU studies on visitor use were begun in the summer of 1977, it is perhaps understandable why the GMP glossed over their findings. One of the studies focused on social impacts of design changes at Rim Village and on Rim Drive, while the other contained the modifications needed in park facilities to allow for handicapped accessibility.[71]

If research seemed largely disconnected from park planning of the time, its linkage with operations other than fire management remained weak ever since Dick Brown left Crater Lake in 1970. Funding for a "resource management specialist" at the park somewhat improved the situation, and came about when Blaisdell accepted a transfer from the group office in Klamath Falls. Mark Forbes filled the new position, one aimed at better coordination of resource management projects in the park and improved logistical support for scientific investigation. Resource management specialists promoted studies like the biologists had, but did not delve into research design nor provide peer review of methods and findings. They instead provided more focus on legislative compliance with the National Environmental Policy Act of 1969 and served to centralize the resource management function, rather than it being divided among park rangers as a collateral duty to law enforcement."[72]

Forbes arrived at Crater Lake in 1978 and then served as the first point of contact with outside researchers. He took a lead role, for example, in coordinating the logistical aspects of two USGS studies on Crater Lake that began in 1979. Both projects eventually provided dramatic reinterpretations of previous work, with one building on a previous temperature study by oceanographers at OSU in order to emphasize the importance of hydrothermal processes in Crater Lake.[73] The other started by mapping the caldera walls, an endeavor that resulted in discovery of the only known pair of nesting peregrine falcons in Oregon at that time. Park

personnel subsequently cooperated with the state game department and other partners in a recovery program.[74]

The mapping and other components of a study by Charles R. Bacon gave the NPS far more than merely triggering an effort to insure the continued presence of an endangered bird. His first publication focusing on the park appeared in 1983 and represented the first significant revision of the study by Howel Williams that had stood virtually unmodified for four decades.[75] Bacon's paper directly influenced many of the interpretive programs given by park staff (given its direct connection to the primary interpretive theme at Crater Lake), something nicely coincident with USGS funding aimed at analyzing Mount Mazama's geothermal system and assessing associated volcanic hazards. Although Bacon had a technical emphasis, he gave occasional training talks for park staff and assisted a seasonal interpreter who revised his guide to the park's geological story accordingly.[76]

Resumption of limnological studies on Crater Lake more or less coincided with the return of USGS scientists, but remained a volunteer effort for several years. The First Conference on Scientific Research in the National Parks preceded it, where Owen Hoffman (formerly one of Donaldson's students, but now an environmental scientist) trumpeted how the lake made an ideal benchmark for future research in limnology. He made a compelling point at the conference held in 1976 about how little emphasis the NPS had placed on studying lakes anywhere in the National Park System,

yet also identified a number of "mission oriented" questions that could be addressed through a monitoring program on Crater Lake.[77] Hoffman was not positioned to spur action by the NPS, so the matter of a monitoring program dropped until Douglas W. Larson (another of Donaldson's former students) returned to Crater Lake in 1978 after an absence of eight years. Larson collected data for four summers with some assistance from seasonal interpreters who also volunteered their time in an effort to establish a baseline for future comparisons.[78]

Papers from Larson's initial efforts focused on the differences from previous surveys of phytoplankton and an apparent decline in optical properties, but he refrained from speculating publicly as to the causes for these changes.[79] Larson discussed his suspicions about an anthropogenic cause of elevated nitrate levels at one inner caldera spring with Forbes and Superintendent James S. Rouse as early as September 1978, but Rouse dismissed the possibility. The superintendent finally came around to endorsing the need for a monitoring program, but this came only after Larson's recommendation in 1980 for such a program "to head off possible irreversible lake degradation."[80] Rouse had Forbes draft a funding request aimed at establishing a monitoring program in the spring of 1981, something estimated to cost $13,500 as start up and $4,500 on an annual basis.[81] Revising the cost estimates for monitoring upward to more realistic figures that fall brought the request no closer to funding until Larson's annual report to the NPS for 1981 somehow reached congressional staff in Washington.[82]

A portion of the report discussed a continued decline in clarity from what it had been prior to 1970 and linked the drop to nutrient enrichment, a situation that demanded study as to whether this was linked to human activity (such as sewage) or other causes.[83]

Legislation mandating a monitoring program initially came through Denny Smith, a congressman from Oregon who entered the House of Representatives in January 1981. Smith sat on the House Committee for Interior and Insular Affairs, and was thus situated to offer an amendment to legislation aimed at correcting the inadvertent inclusion of a timber sale on national forest land when Congress voted to expand the park in 1980.[84] The congressman acted on the basis of one conversation between his legislative director and Rouse just a few days earlier. This amendment to the bill aimed at deleting the timber sale directed the Secretary of the Interior to instigate studies "as to the status and trends of change in the water quality of Crater Lake."[85] These investigations were to last for a period of ten years and allow for the application of findings in much the same fashion that other federal agencies at that time received prescribed direction to link basic and applied research in order to address certain land management problems.[86] Smith introduced the amendment on December 10, 1981, stating in his explanation that the NPS "has developed an initial research program to address this concern [of diminished clarity] and should be prepared to move ahead promptly."[87]

Conference on the amended bill was not scheduled until midway through 1982, but the likelihood of passage made the NPS regional office in Seattle take notice. After briefing Regional Director Daniel Tobin on January 8, Regional Chief Scientist James W. Larson set up a research planning meeting in Corvallis for later that month.[88] Formulation of some objectives prior to the meeting helped interested scientists and NPS staff members generate a list of alternative hypotheses to address recorded changes in the lake's clarity before providing specific recommendations. The latter included urging the NPS to conduct and coordinate a long-term monitoring program, followed by one that highlighted the need for a limnologist to run it.[89]

As much as the prospect of such a program represented a great leap forward, Smith's bill said nothing about putting any new money toward monitoring Crater Lake, so one of the stated objectives at the meeting in Corvallis involved identifying low cost tasks to address specific needs. The regional office in Seattle, largely through the efforts of James Larson and his assistant Shirley Clark, pieced together $30,000 to start the program in 1982. This amount allowed the NPS to reimburse the Army Corps of Engineers for ten percent of Douglas Larson's time and allowed Larson, a limnologist with the Corps, to set up a laboratory, buy equipment, go to meetings, and train NPS personnel.[90]

The legislation mandating study of Crater Lake became law on September 15, 1982, roughly one week after the final sampling day for the year.[91] Monitoring could be described as a shoestring operation, but served

the purpose of demonstrating to Congress that the NPS had begun a program in advance of prescribed direction.[92] The program consisted of a seasonal biotech, Mike Gillmore, and Douglas Larson, whose responsibility as investigator included writing an annual report. This document became the basis for comment by members of a peer review committee, a body initially convened in February 1983 at OSU.[93] Although respondents represented a number of academic institutions, Larson received the most substantial comments from a group of scientists at the University of California, Davis. They represented the research group that studied the limnology of Lake Tahoe for two decades and pointed to the need for an investigation of nutrient enrichment among their eleven recommendations, urging that the NPS fund such work during the coming summer.[94]

As Larson pointed out in the report's recommendation section, monitoring *per se* is not research, but instead a mechanical process of data collection for future interpretation and possible determination of causal relationships. He urged the launch of an initial research project "to determine the cause or source of reported deterioration of Crater Lake's optical transparency."[95] The project, as envisioned through a work plan prepared by Larson in July 1983, consisted of several studies to be conducted in conjunction with the established protocols for monitoring.[96] Larson identified a potential source for the deterioration, in that some springs within the caldera below Rim Village contained high nutrient concentrations suggestive of a possible link with sewage influx. He and Clifford Dahm at

OSU cautioned, however, that further investigation was needed to conclusively evaluate hypothesized linkages between enriched spring water going into the lake and the dynamics of algae affecting clarity.[97]

Jack Dymond and Robert Collier, two oceanographers at OSU, widened the range of possible explanations for the apparent decline in the lake's clarity by using sediment traps to measure the flux and composition of particles falling through the water column of Crater Lake. Initiated independently of the park program coordinated by Larson, the work by Dymond and Collier introduced the possibility that trace metals such as zinc and iron could be limiting the lake's biological productivity. They also suggested that hydrothermal springs located on the bottom of Crater Lake might contribute to the particle flux (this reflects outside inputs of nutrients and inorganic particles) and perhaps cause turbidity in deep water.[98]

Even if other funding sources absorbed much of the costs associated with the two examinations conducted on Crater Lake by Dymond and Collier in 1983, the NPS needed to increase its budget for its monitoring infrastructure. Roughly $160,000 became available (compared with only $30,000 the previous year) to purchase equipment (this included a boat for winter sampling, a floating boathouse, and a water quality laboratory located at Park Headquarters) and pay for contracted work. The funds also provided two new biotechnician positions, one as a seasonal and the other as permanent, in line with recommendations made in the annual report on the program for 1982.[99]

This quadrupling of the lake monitoring budget largely came through the Natural Resources Preservation Program (NRPP), a competitive funding source established by the NPS in the early 1980s to address high-profile issues in the parks. NRPP came as part of the agency's response to criticism initially leveled by the National Parks and Conservation Association that existing natural resource management capability of the NPS could not deal with a rising number of external threats. A new training program that began in September 1982 represented another part of this response, one where employees aiming for careers in natural resource management divided their time between off-site coursework and regular duties in parks for a period of two years. Jonathon B. "Jon" Jarvis came to Crater Lake to participate in the program and joined Forbes as a resource management specialist, just as the park received the NRPP funding to monitor the lake. As far as officials in the regional office were concerned, such a boost in budget and staffing could be justified by Crater Lake serving as an example of how the NPS was working to meet a legislative mandate. It also helped to show what the agency could do in light of criticism that very few parks possessed baseline information needed to identify incremental change possibly affecting the integrity of natural resources.[100]

From an operational standpoint, this buildup in the park's infrastructure came not only in response to an expanded summer monitoring program, but also in anticipation of the first winter sampling trip sponsored by the NPS. Set for January or February 1984, the operation would involve

lowering personnel and equipment down a snow chute near the Crater Lake Lodge to an all-weather dock and boathouse, where researchers could launch a boat and "set course for a quick trip to the sampling location."[101] This prospect vanished in a windstorm that raged from November 7 to 11, 1983, an event which damaged the winter boat, destroyed the boathouse, and sank the vessel used for summer sampling.[102]

Expanded limnological and geological studies, 1984-2002

The ravages of that November windstorm were not a major setback to plans for winter sampling, but they did delay the trip until March 1986. Several changes took place in the mean time that profoundly affected the limnological program's focus and appearance. Monitoring continued during the summer of 1984 with approximately the same funding level as the previous year, once another peer review session conducted in November 1983 found existing protocols defensible and well-structured. When it came time to hire a full-time principal investigator, however, NPS officials passed over Douglas Larson in favor of Gary Larson, an aquatic ecologist already working for the agency as regional chief scientist at the Midwest office in Omaha.[103]

Gary Larson's appointment at the CPSU in Corvallis became official in September 1984. It came less than six months after a new superintendent, Robert E. Benton, arrived at the park.[104] Benton magnified his predecessor's uneasiness with the suggestion by Douglas Larson that sewage or elevated

nitrate levels from one inner caldera spring might have a role in Crater Lake's perceived decline in clarity.[105] He noted in the superintendent's annual report for 1984 that hiring Gary Larson constituted "perhaps the greatest improvement during the year in the lake research program," while the discovery of some new historical data might dispute "the early conclusions that the lake clarity has diminished."[106]

At an organizational meeting held near the end of October, Gary Larson said that the lake program should concentrate on "loss of clarity" rather than more tangential "interesting projects."[107] He recommended the monitoring program continue in a form similar to previous practice, but with certain additions. These included studying atmospheric chemistry, zooplankton, fish, and the lake's paleolimnology. The latter project was enticing since it held the potential to provide evidence of how biological conditions had changed through time, but did not receive the necessary additional funding.[108]

Larson did, however, hire the first two graduate students funded specifically by the NPS to conduct research on the lake. Elena Karnaugh completed her masters thesis in 1988 on the structure, abundance, and distribution of pelagic zooplankton populations, and Mark Buktenica completed his masters thesis in 1989 on the ecology of kokanee salmon and rainbow trout in the lake, with reference to their long-term impact to the ecosystem. Buktenica later became an aquatic ecologist in charge of coordinating the monitoring program on Crater Lake. Although he did not

hold a research appointment, Buktenica was the first park employee with a position description that included conducting independent scientific research. Work by Buktenica eventually included sole or joint authorship of papers on fish ecology, benthic biological communities, zooplankton, lake morphology, bull trout restoration, water clarity, and submersible studies.

A peer panel convened in April 1985 supported the recommendations of the new principal investigator, though one committee member remarked

"objectives of the (limnological) program are broader than just monitoring optical properties...it is apparent that the Park Service is also able to support a variety of limnological studies within the program, as long as such studies are potentially related to management goals."[109]

Another respondent, Jack Dymond, advanced his mass balance modeling approach to studying the lake as a way of defining specific goals from what he called "very general objectives" of the mandated ten year study.[110] For his part, Gary Larson saw the monitoring program as essentially "in place." With clarity readings of early July 1985 for Crater Lake being a cause for optimism (one of 37.1 meters was exceptional and seemed to contradict fears of steady downward spiral), the monitoring program's direction could shift toward the "interrelationships among environmental, terrestrial, cultural, and aquatic aspects of the (lake) ecosystem." Larson also developed a conceptual model from which specific research objectives were established and areas needed additional study identified.[111]

With sampling periods extended to March and May in 1986, adding to the data collected during the summer season, Gary Larson ventured a

tentative explanation of Crater Lake's clarity in his annual report. The apparent decline in readings during August, he surmised, could probably be explained by "small increases in the densities of light scattering particles in the water column."[112] Larson went on to state that particle density is affected by natural environmental factors, loading of anthropogenic material from atmospheric and on-site sources, and perhaps internal lake processes such as hydrothermal vents and biological activity. If nothing else, one of two special studies conducted that summer (one aimed at replicating Pettit's work, but with new technology) found that the color of Crater Lake had changed little over the past half century, though month to month variation could be substantial.[113]

Results from the other special study of 1986 helped push clarity away from central position as the focus of the limnological program, at least in the short term. Work by Dymond and Collier over three summers found that approximately 95 percent of total productivity in the lake's euphotic zone (that part of Crater Lake where light penetrates) was derived from recycled nutrients rather than input of new nutrients from the atmosphere or point sources. They also studied deep lake waters and found evidence of hydrothermal venting, leading them to propose a four-year program, one aimed at evaluating the influence of hydrothermal systems on Crater Lake's composition and ecology. It involved instruments towed from boats, a remotely operated vehicle sent to the bottom and even manned submersibles to precisely locate and sample the vents.[114]

The fact that Dymond and Collier believed such work to be feasible could be attributed, at least in part, to what the NPS had achieved in the enhancement of its support for the limnological program. Not only had the agency sought to bring additional staff and funding to Crater Lake, but it also handled complex logistics needed for conditions that resembled what scientists often encountered on the ocean. It supplied a laboratory at Park Headquarters to process water samples and made replacement of the boat house on Wizard Island a top priority so that a new one could be completed during the summer of 1985.[115]

An impetus for more funding to support the study of the lake's hydrothermal processes came in the form of legislation passed late in 1986 which instructed the Secretary of the Interior to publish a proposed list of significant thermal features within selected units of the National Park System. The NPS included hydrothermal vents on the floor of Crater Lake in its list published on February 13, 1987. Crater Lake was nevertheless dropped from the final list transmitted by the Department on June 30 due to "insufficient information," with any determination of significance deferred, pending additional research and review.[116] Passage of amendments to the Geothermal Steam Act in September 1988 superceded the earlier legislation and directed the Secretary to report on the presence or absence of significant thermal features at Crater Lake (among other national parks) within six months of becoming law.[117]

As wording in the House Report on the amendments explained, the legislation passed in 1986 sought to address "a long standing concern with potential geothermal development activities near certain units of the National Park System."[118] In the case of Crater Lake, the concern arose when geothermal leases were awarded on the adjacent Winema National Forest in 1984.[119] California Energy Company of Santa Rosa subsequently gained approval through the Bureau of Land Management's environmental assessment process to drill four test wells within five miles of the park boundary.[120] Drilling began in September 1986 near Mount Scott and the "panhandle" as part of the company's search for hot water that could be further developed as an energy source.[121] For the moment NPS officials did not publicly express their anxiety about future geothermal development and its impact, though Benton certainly had his suspicions about the company's request to amend the environmental assessment.[122]

Cal Energy called for a meeting hosted by the Geothermal Resource Council once it learned that the NPS intended to recommend Crater Lake be added to the list of significant thermal features mandated by P.L. 99-591. Two days of discussions in late February 1987 failed to produce anything other than some lively debate about whether Crater Lake merited a place on the list.[123] The NPS and BLM remained on opposite sides two months later as the question went to the Secretary of the Interior's office for resolution.[124]

Crater Lake remained off the list of significant thermal features, at least for the time being, pending some resolution of the hydrothermal

question. BLM meanwhile approved a revised environmental assessment allowing continued geothermal exploration under relaxed procedures for drilling, though two conservation groups quickly filed appeals.[125] Dymond entered the fray over drilling as he and Collier began their work on Crater Lake in August 1987. He cautioned that "any drilling or activity around [park] boundaries may upset the ecology of the lake."[126] After 20 days on the lake with instruments such as a remotely operated vehicle (ROV) which took the first video images of the lake floor, Dymond and Collier felt they had demonstrated the presence of thermal waters in the south basin. The draft report, however, qualified this position with a statement about how the exact location and characteristics of the [hydrothermal] inputs were still unknown, though they "significantly narrowed down the target for the proposed submersible work."[127]

USGS personnel provided initial review of the draft report and supported the need for a submersible since only the collection of additional data could provide unequivocal proof of whether hydrothermal vents existed. This meant obtaining fluid samples and temperatures form several of the vents observed by the ROV. Officials in the Department of the Interior therefore recommended that the Secretary not revise the list of parks containing significant thermal features until a manned submersible could gather affirmative evidence from the vents. They also wanted the existing moratorium on new leasing in the area around Crater Lake left in place for another year.[128] A member of the Oregon congressional delegation, Senator

Mark Hatfield, then attempted to preempt any deferment by introducing a bill in January 1988 aimed at placing Crater Lake on the list. He did so in the aftermath of Dymond and Collier having presented findings in their draft report at a national scientific meeting.[129]

With Hatfield's provisions for Crater Lake incorporated as part of Senate amendments to the Geothermal Steam Act, this piece of legislation went to the House Committee for Interior and Insular Affairs. The Crater Lake language faced opposition from one committee member who attempted to insert a provision allowing the Secretary to remove parks from the list if conclusive evidence showed that no thermal feature could be harmed by leasing. Legislators instead crafted a compromise that kept Crater Lake on the list, but required the Secretary to report to Congress within six months of passage as to whether or not thermal features actually existed on the lake floor.[130] The clock began for such a report when S. 1889 became law as P.L. 100-443 on September 13, 1988.[131]

It quickly became evident, however, that even peer review of the research conducted during the 1988 season could not be conducted during the six months prescribed by legislation.[132] Charles Goldman of the Tahoe Research Group at the University of California, Davis, chaired the peer panel on May 2, 1989. He and other members of the panel were charged with evaluating extant data and examine the hydrothermal program as part of focusing the latter on providing "more evidence for both scientists and decision makers on the geothermal heating question."[133] The panel demurred

on the question of whether hydrothermal vents in the floor of Crater Lake were significant by accepting Dymond and Collier's plan for another field season, one aimed at completing a final report by June 30, 1990. The deadline was then extended to late summer 1991 once the NPS submitted an interim report to Congress.[134]

No immediate answer concerning the vents could be made because none of the eleven dives made with the manned submersible in the south basin study area during August 1988 could find hydrothermal features other than several "bacterial mats" with water temperatures too low to qualify as thermal features.[135] The major goal of the hydrothermal program, however, was "to evaluate the environmental significance of hydrothermal activity in the lake as part of an overall ecological model of the lake." This meant that the grand total of twenty-one manned submersible dives during August 1988 served a variety of purposes, among them the collection of rock samples during the four dives underwritten by the USGS.[136] Despite the breadth of goals for the submersible work, finding the vents became even more of a focus for the NPS in light of the Interior Board of Land Appeals rejection in early 1989 of a motion to stop the drilling filed by several conservation groups.[137] Drilling by Cal Energy resumed on July 3, 1989, one month prior to the submersible's return to Crater Lake.[138]

The NPS readied itself to capitalize on the publicity expected when the dives started on August 5 by formulating a media plan and several advance press releases.[139] Five days later, during the fourth dive, Dymond found a

"blue pool" near the bacteria mats. He dubbed the kidney shaped pool, one whose aqua blue color reminded scientists of a miniature Crater Lake, "Llao's Bathtub." This discovery, which press accounts immediately linked to hydrothermal vents, was followed by announcement of a new species of mite found on some rock samples taken from the bottom of Crater Lake.[140] Vents or springs hot enough to qualify as significant thermal features remained elusive over the following week, though scientists hoisted samples of pitch black, granular mud from a blue pool.[141] Collier then piloted the submersible to a bacterial mat on August 19 and obtained a temperature several degrees warmer than the difference of ten degrees Celsius (between the thermal feature and surrounding water) needed to show significance. An even hotter temperature of 18.9 degrees Celsius was measured at another mat three days later, to the delight of park staff.[142]

Collier cautioned that temperatures represented only one factor in substantiating the existence of hydrothermal input to Crater Lake, and pointed to a number of data sets produced from the dives that still had to be analyzed and evaluated over the coming year. Cal Energy, on the other hand, responded to the temperatures found in the bacterial mats with a press release of its own. The company attempted to cast doubt on whether the evidence was conclusive, since no one had observed any flow of water in association with the bacterial mats.[143] It seemed a half-hearted effort at best, because drilling east of Mount Scott found temperatures of only 265 degrees Fahrenheit when Cal Energy officials had hoped for ones around 450

degrees.[144] Test drilling outside the park continued in 1990, but continued to produce lower than expected temperatures.[145]

Any further drilling near the park became virtually moot in February 1991, when BLM suspended the leases held by Cal Energy for two years.[146] The company responded by announcing layoffs in its Portland office, though a spokesman for Cal Energy maintained for several weeks that they "had no intention" of backing away from projects in the Pacific Northwest.[147] Although Cal Energy eventually announced plans for a geothermal power plant on the flanks of Newberry Crater near La Pine in September, they simultaneously agreed to plug their test wells east of Crater Lake.[148] With their terms set to expire, Cal Energy formally relinquished leases near the park in February 1994, roughly a year after another spokesman admitted that the company had made a mistake in pursuing exploration there.[149]

The announcement by Cal Energy in February 1993 came only a month after Secretary of the Interior, Manuel Lujan, Jr., confirmed the presence of significant thermal features in Crater Lake.[150] His cover letter to Congress, meant to accompany the report mandated by passage of P.L. 100-443, represented an end point to a process that saw the NPS pitted against both Cal Energy and BLM. Opposition to listing by the latter resulted in the NPS citing a technicality to omit BLM's comments, as expressed in the report to Congress, even though it (very much like the USGS) had the status of consulting party.[151] The lone USGS consultant hedged on the question of presence or absence of thermal features, though participants at a peer

review meeting in January 1991 generally supported the affirmative position.[152]

Although the pronouncement by Lujan derived its basis from scientific findings, it also signified that the NPS had won the battle of public relations. Cal Energy operated almost exclusively on the defensive about its drilling near Crater Lake, with spokesmen being forced to either dispute evidence gathered by the dives or blame the alleged sewage influx from Rim Village for fluctuations in lake clarity.[153] Both tactics crumbled in a wash of publicity favoring the NPS that surrounded the submersible in 1988 and 1989. Superintendent Benton publicly put further exploration of the lake at the top of his Christmas wish list, though he scarcely needed it after Soviet scientists from the Lake Baikal region visited the park in September 1990.[154] The visit came two months after a Soviet-American research team found evidence of a hot vent field in the world's deepest lake. It provided Benton an opportunity to link the two lakes as "sisters," but he also subsequently allowed Buktenica to join Dymond on a follow up visit to Lake Baikal that resulted in joint studies on Crater Lake.[155]

The cooperative work with scientists on Lake Baikal capitalized on momentum provided by studies conducted on Crater Lake in 1988 and 1989, when the submersible obtained samples to substantiate an evaluation of the early volcanic evolution and post caldera volcanic history of Mount Mazama. In addition to allowing for analysis of rocks and sediments, as well as identification of subaqueous post caldera volcanology, the submersible

provided the means to document life residing in the deepest part of the lake. These life forms included flatworms, nematodes, earthworms, copepods, ostracods, and midge fly larvae. Plant communities and their associated invertebrates were also found at great depths (85 to 460 feet beneath the surface) in a band that encircled the lake.[156]

Although the hydrothermal question occupied central position for a short time in park operations and public perception of Crater Lake, it was never divorced from the limnological program despite the series of separate reports. Collier and Dymond went back to their water column investigations upon submitting a final assessment of hydrothermal processes in May 1991. They again joined other researchers who conducted special studies of varying length connected with the limnological program. The CPSU at OSU served as the funding conduit for these studies, with most investigators being either graduate students or faculty members holding research appointments.[157] Progress reports or summaries on the studies appeared in the limnological program's annual reports, with a final report with full presentation of results projected for 1993.

The limnological program held both a review of results obtained thus far and a symposium at roughly the halfway point in its ten-year study of Crater Lake. The symposium convened in Corvallis on June 21, 1988, as an annual meeting of the Pacific Division of the American Association for the Advancement of Science (AAAS) and led to publication of an anthology on the topic of Crater Lake as an ecosystem. It also allowed for presentation of

divergent views, something discussed at length by the senior editor in her introduction to the volume.[158] She made specific reference to controversies over possible hydrothermal activity and whether the clarity of Crater Lake might be affected by long-term sewage influx. A paper by Douglas Larson and two other investigators hypothesized a link between sewage and declining clarity, supplying some contrast to Gary Larson's more open-ended model of the lake, where multiple variables interacted to produce a dynamic lake ecosystem.[159]

Charles Goldman played the role of respondent at the symposium, in effect utilizing components of Gary Larson's conceptual model to compare Crater Lake with Lake Tahoe. This served to validate the approach Larson developed in 1985, but Goldman did not discount the possibility of sewage leading to elevated nitrate levels when he made specific recommendations for further study. His concluding statement even recalled Merriam's emphasis on cooperative research, though the modern aim was protection rather than visitor appreciation.[160]

Douglas Larson did not dispute the merits of a broad approach to the study and monitoring of Crater Lake, yet grew increasingly vocal about the limnological program failing to directly confront the possibility of sewage contamination. The NPS could point to removal (in 1991) of the septic leach field identified by himself and others as the potential source of trouble, given its geographic proximity to the relatively high nitrate levels associated with Spring 42 below Rim Village.[161] Park staff routinely monitored this and other

inner caldera springs, but did not study the hydrology and groundwater of the Rim Village area using the florescent dyes or salt tracers recommended by Stan Gregory and other OSU investigators who reported on the ecology of selected park streams in 1987.[162] During peer review of this report, however, scientists on the panel recommended against conducting a tracer study because samples could not be taken from the spring at regular intervals during the year. Even if the leach field was connected to spring 42, they knew the dye could be missed if it surfaced during the winter months. The panel concurred with the Gregory report's recommendation for removing the leach field and sent this finding to Benton, who then worked with officials in the regional office to have a new system of waste treatment become part of the NPS line-item construction program.[163]

Another symposium held to observe the ninetieth anniversary of the park's establishment in 1992 triggered an exchange between Douglas Larson and Park Superintendent David Morris over whether the NPS had allowed sewage to reach the lake.[164] The controversy quickly faded from public view, but Douglas Larson renewed his allegations the following year about how the NPS had not investigated the septic leach field as a possible source of contamination. In a letter to the chairman of the House committee on natural resources, he contended that the abundance of limnological data assembled in the report mandated by P.L. 97-250 did not meet direction previously given by Congress through the legislation.[165]

Panelists conducting a peer review of the ten-year study in February 1993 nevertheless concluded that the limnological program met the goals and objectives for monitoring and study on Crater Lake, but had gone well beyond what was envisioned by researchers in 1982. One member of the panel, Raymond Hermann, stated that the clarity question had been settled by the report, though he added a caveat about the processes controlling clarity were still imperfectly understood. The panel's chairman, Stanford Loeb, observed that Crater Lake stood alone among units in the National Park System in possessing a well-developed data chain. He made reference to the fact that only six or seven other parks had so much as a data set that might serve as a starting point for meaningful monitoring efforts. Loeb cautioned, however, that any future monitoring efforts should be driven by a hypothesis and statistically based experimental design. In a fairly direct way, Loeb tried to interest the NPS in a marketing program for long-term monitoring, one where collection of baseline data was integrated with compelling research questions. He threw out two possible focal points that reached beyond the confines of Crater Lake: global change (aimed at better understanding the processes affecting lake clarity) and the sensitivity of the lake's food web in relation to introduced fish.[166]

This program review, it should be noted, came at a time when Gary Larson and park staff lacked funding to proceed with long-term monitoring in conjunction with additional special studies.[167] The process of authorizing another study of the lake's water quality began in 1992 when Oregon

congressman Bob Smith drafted legislation aimed at providing $160,000 annually for monitoring over a period of ten years. Introduced in January 1993, his bill insured that funding for the limnological program held the top regional priority in an initiative intended to further professionalize natural resource management enacted as part of the NPS budget for 1994.[168] Smith withdrew the bill once the initiative incorporated the amount requested for Crater Lake so that it became part of the park's annual (or "base") budget in October 1993.[169]

With the additional funding in hand, the NPS initially chose to replace an antiquated pontoon-style research boat designed for recreational use on calm water with an all-weather vessel. Hiring a second aquatic biologist, Scott Girdner, followed in order to assist the monitoring program with operations, data management, and reporting. The new boat and additional staff represented significant additions to existing infrastructure (such as previous installation of a laboratory at Park Headquarters and the boathouse on Wizard Island) so that a full-fledged monitoring and research program was now essentially in place.

Although monitoring the lake could be assured of a permanent place in park operations, special studies still depended upon project funds obtained largely with the assistance of staff working at the regional office in Seattle. The number of special studies subsequently declined in comparison to those conducted during the original ten-year study, though contributions to

refereed journals on the limnology of Crater Lake appeared almost annually during the 1990s.[170]

Published research and attendant publicity surrounding the limnological program nevertheless led to creating a separate natural resources management division at the park in 1993, if only indirectly. The move stemmed from recommendations by personnel specialists at the regional office in Seattle who stressed that such a move would "reflect the importance of resource management programs and [create] a professional image" for the NPS in dealing with other agencies.[171] This division initially consisted of two permanent employees and some seasonals hired with project money, then grew as funding opportunities permitted, but without publications having a direct effect on grade levels.[172] Meanwhile, the only NPS employee working under a research appointment in relation to Crater Lake was stationed at the CPSU in Corvallis. This arrangement lasted until October 1993, when Gary Larson and his colleagues throughout the agency were involuntarily transferred to a "National Biological Service" by order of Bruce Babbitt, the Secretary of the Interior.[173] When the NBS failed to gain congressional authorization, however, Larson and other scientists initially hired by the NPS landed in the Biological Resources Division of the USGS. He continued in his role as principal investigator for the limnological program at Crater Lake and remained in Corvallis, while park staff and personnel based at OSU assisted with the operational aspects of long-term monitoring.[174]

The limnological program dwarfed other resource management activities at Crater Lake, however, its infrastructure of personnel and equipment allowed Buktenica, assisted by Gary Larson, to start a fishery restoration effort on Sun Creek in 1989. It targeted bull trout, the only native fish species in the park, which had been under threat through competition from introduced eastern brook trout. By 2000, three publications came of what was essentially a resource management effort, with the first (a habitat survey) printed as a report in 1993, followed by papers comparing methods of eradicating brook trout.[175]

As compelling as restoring bull trout or any resource management project in the park's backcountry might be, the bulk of scientific interest remained squarely fixed on Crater Lake and its geologic setting. Led by Bacon, journal articles by USGS authors referencing the park through 1995 greatly exceeded the number produced by limnologists and other specialists in aquatic biology. Pursuit of broader questions in volcanology and the use of funding sources other than the NPS may have been the reasons for this disparity in output, though USGS research also seemed to carry less political sensitivity than the limnological work. USGS publications (which also included open-file reports, field guides, and maps) had some effect on interpretation among park operations, with a few papers containing revisions to the geological story being presented to visitors.[176] What was perhaps the most significant contribution appeared in May 1994 and presented the sequence of Mount Mazama's climactic eruption and subsequent formation

of the lake as part of a cycle in the evolution of small calderas.[177] It not only synthesized information about the lake floor (much of which was derived from the submersible dives in 1988 and 1989) for interpreters, but also gave them a new way of using Crater Lake as a model when making comparisons with other caldera lakes.[178]

Subsequent USGS work to discern volcanic and earthquake hazards that could affect the park or nearby communities had little effect on park planning or operations, even when the NPS contracted for seismic evaluations of several buildings as part of initiating construction projects at Crater Lake in 1999.[179] Park managers and staff, however, eagerly embraced an opportunity to have the USGS oversee mapping the lake floor using new sonar technology in July and August 2000. The NPS provided ground support and most of the funding so that a research vessel could take more than 16 million echo soundings and produce a map where objects as small as one meter across could be identified.[180] Multicolor bathymetry and selected views of Crater Lake were made available to the public as one result from the work. Bacon and others meanwhile capitalized on survey data to better assess morphology, volcanism, and mass wasting in the lake.[181]

Other research, 1984-2002

In contrast to the profusion of limnological studies on Crater Lake where the CPSU served as a conduit for funding, only three pertaining to the park's terrestrial biology appeared from that source after 1984. In addition

to reports on elk and prescribed fire effects in the "panhandle," one of Agee's students at the University of Washington received CPSU support to complete his thesis on Shasta red fir forests near Crater Lake as late as 1991.[182] A grant program sponsored by the Crater Lake Natural History Association subsequently underwrote terrestrial studies like the survey of Whitehorse Ponds in 1993, though none of them culminated with a publication.[183] Another program allowing the NPS and the Nature Conservancy to share costs associated with a contract where UW botanist Peter Zika added 54 new species to the park's checklist of plants.[184] This cost-sharing program also allowed the NPS to study threats (such as blister rust infection) to a keystone tree species, the whitebark pine. Unlike the project aimed at revising the park's checklist of plants, however, the study of whitebark pine signaled the start of what could be long-term efforts by the NPS aimed at conserving the species.[185]

Except for one oral history interview done on a trial basis, none of what the NPS commissioned in the realm of cultural resource management went through the CPSUs.[186] Recognition of any need to do historical research in conjunction with natural or cultural resources came slowly, but by 1981, the deteriorating condition of Crater Lake Lodge drove preparation of a historic structure report on the building through the Denver Service Center (DSC).[187] The author of its historical data section, Linda Greene, subsequently produced a historic resource study (HRS), a document aimed at identifying and evaluating properties eligible for the National Register of

Historic Places.[188] This project came amid planning for rehabilitation of stone structures at Park Headquarters that were built between 1926 and 1941, but which also constituted excellent examples of rustic architecture, some of the finest in the National Park System.[189] The third project completed by DSC staff consisted of an administrative history for the park, one where two volumes had been completed by the end of 1987.[190]

The HRS and the administrative history that followed it were the first two projects aimed at giving subsequent survey, documentation, and management of cultural resources a reference point or "baseline." Neither of them addressed protecting and interpreting archeological resources at the park, so the regional office in Seattle contracted for an overview and assessment of them in 1989. The resulting document finally appeared five years later, though it included an ethnographic section that obviated the need for a separate overview.[191] What park staff wanted, however, was a study that could provide a knowledge base that could help establish government-to-government relations with federally recognized Indian tribes traditionally associated with Crater Lake, such as the Klamath and the Cow Creek Band of the Umpqua. Project funding allowed the NPS to advertise a contracted traditional use study in 1997, one that involved obtaining information about the park from knowledgeable tribal members.[192] Inventory and recommendations for preserving cultural landscapes has, by contrast, handled almost exclusively by NPS staff stationed in Seattle due to the dearth of qualified contractors. The most expansive work in this program

area at the park took place in Rim Village, where a major rehabilitation effort was anticipated after approval of a development concept plan for the site in 1988. A cultural landscape report printed two years later provided impetus to eventually nominate much of Rim Village to the National Register of Historic Places and then begin restoration of significant features there, mainly through line-item construction projects facilitated by the Denver Service Center.[193]

Unlike the "baseline" projects, most of the published historical work pertaining to Crater Lake did not stem from needs articulated through the park's resource management plan. Like the bulk of published scientific papers, it may have had some benefit for interpretation among park operations, even if there was a substantial difference in quantity between these two kinds of research. Virtually all of the historical pieces have appeared since 1980, with the greatest number clustered around the Crater Lake centennial observance in 2002. At that point Rick Harmon's *Crater Lake National Park: A History* appeared as the first comprehensive historical work published through a university press, though all funding came from non-NPS sources.[194]

Conclusion

It remains to be seen whether the "mission oriented" research commissioned by the NPS will have greater long-term value for management than contributed studies. Both types of work can be useful in gaining an

insight to specific questions or as background for a related topic. In this regard, one of the last CPSU projects presented a "resource database," one aimed at obtaining a handle on the information necessary to develop adequate inventory and monitoring programs as well as define needs for further research at the park. The compilers made the following observation in the course of describing its contents:

> "As opposed to most parks where the great majority of work can be classed as surveys or general overviews, Crater Lake has supported and/or spawned a substantial amount of basic research...In part this is because of the focus on one element of the park's resources, the lake. The quality of the research conducted at Crater Lake is reflected in the relatively high proportion of studies on the park that were published either in peer-reviewed scientific journals or as theses."[195]

Although the volume and high standard of work in comparison with other parks provides some advantages for managers at Crater Lake, as well as being a source of pride, it does not necessarily mean that research has exerted a profound effect on NPS administration of the area. Bureaucracies are inherently reactive, but develop a set of organizational values that furnish justification for the tasks and outputs of the agency. Even if survival of a bureau such as the NPS depends on responding in some measure to a changing political climate, organizational values are set during the formative stages of an agency's existence. They subsequently shape a collective orientation among its members, serving to institutionalize a set of beliefs that also filter the bureau's perception of public demands.[196]

Advocates for the new NPS in 1916 needed to cast the national parks as public resorts to a broad-based, though dispersed, group of clients. The parks appealed to a burgeoning tourist industry, one whose early growth came in relation to the increased availability of private automobiles.[197] Irrespective of the legislative mandate to manage the parks unimpaired for future generations, administration of these areas needed to reinforce how recreational tourism provided greater economic value than alternative uses like logging, mining, and grazing. Park concessionaires thus became vitally important to NPS managers because of their indirect economic contribution in serving a clientele (visitors) who supposedly chose to direct their discretionary spending at domestic markets rather than ones overseas. The NPS had to take visitor access and services seriously since virtually all of the 17 national parks the agency controlled during its first year of existence lay in remote areas and away from the few main roads that traversed the western United States. When staff assigned to education and capable of doing research appeared in park operations (at Crater Lake this took place in the summer of 1926), they served a perceived need and helped to make the NPS more relevant to visitors. The naturalists never really had the chance, however, to push the promotion of recreation away from central position in the social system of the agency.

Merriam and others situated outside of government wanted to enhance the role of research in operations of parks like Crater Lake, but obtained limited success because the NPS came into existence without this

function specifically assigned to it. Park managers thus had to depend on other federal bureaus such as the USGS to supply scientific expertise. In the years before 1980, funding for studies languished in chronically short supply and was further hampered by a "component" in the NPS (some of whom held key positions that controlled budget priorities) that did not see the value of such capability as a requisite for management.[198]

The advent of "mission-oriented" research helped direct NPS policy makers toward seeing nature and what the agency managed as "resources" potentially under threat. The case was made to Congress by the early 1980s that research could alleviate threats (whether from external sources or internal ones stemming from ignorance), so some funding could be obtained and the beginnings of a supporting infrastructure for resource management assembled. What could be considered the apogee of research activity in its relation to park administration at Crater Lake required a highly publicized threat (drilling for geothermal energy on land adjacent to the park) so that funding for special studies involving submersible dives in 1988 and 1989 could materialize. Development of both in-house scientific expertise and the logistical support provided by staff trained in the operational aspects of natural resources management were also critical to obtaining the needed data and completing the studies.[199]

Alignment of these three factors (threat, funding, and infrastructure) is where research continues to have the most obvious impact on park administration, particularly when it can play a role in bolstering resource

management programs. The character of NPS supported research and whether its findings can be applied by means of subsequent resource management efforts remains heavily influenced by the availability of subject matter expertise on the park staff. These specialists, most notably in the lake program, succeeded when they garnered support from the superintendents at Crater Lake and officials in NPS central offices.

Growth in budget and staffing of the park's natural resources division is one (and perhaps a somewhat indirect) manifestation of how research has affected NPS management and organization at Crater Lake, yet this activity has also influenced planning and compliance. The latter is especially evident where studies of cultural resources were used to shift the scope and impact of proposed construction at Rim Village from building a second hotel and underground parking toward rehabilitating extant structures.[200] More recent investigation of linear features such as Rim Drive helped to frame discussion of alternatives in an update of the park's general management plan, largely because of a finding that several roads and trails were eligible for the National Register of Historic Places. These determinations can also trigger compliance requirements for construction or maintenance activities, such as ones associated with Section 106 of the National Historic Preservation Act or the National Environmental Policy Act.[201]

It is far more difficult to assess how research has affected educational programs such as interpretation, much less what visitors have derived from a body of work still dominated by contributed studies. To which degree the

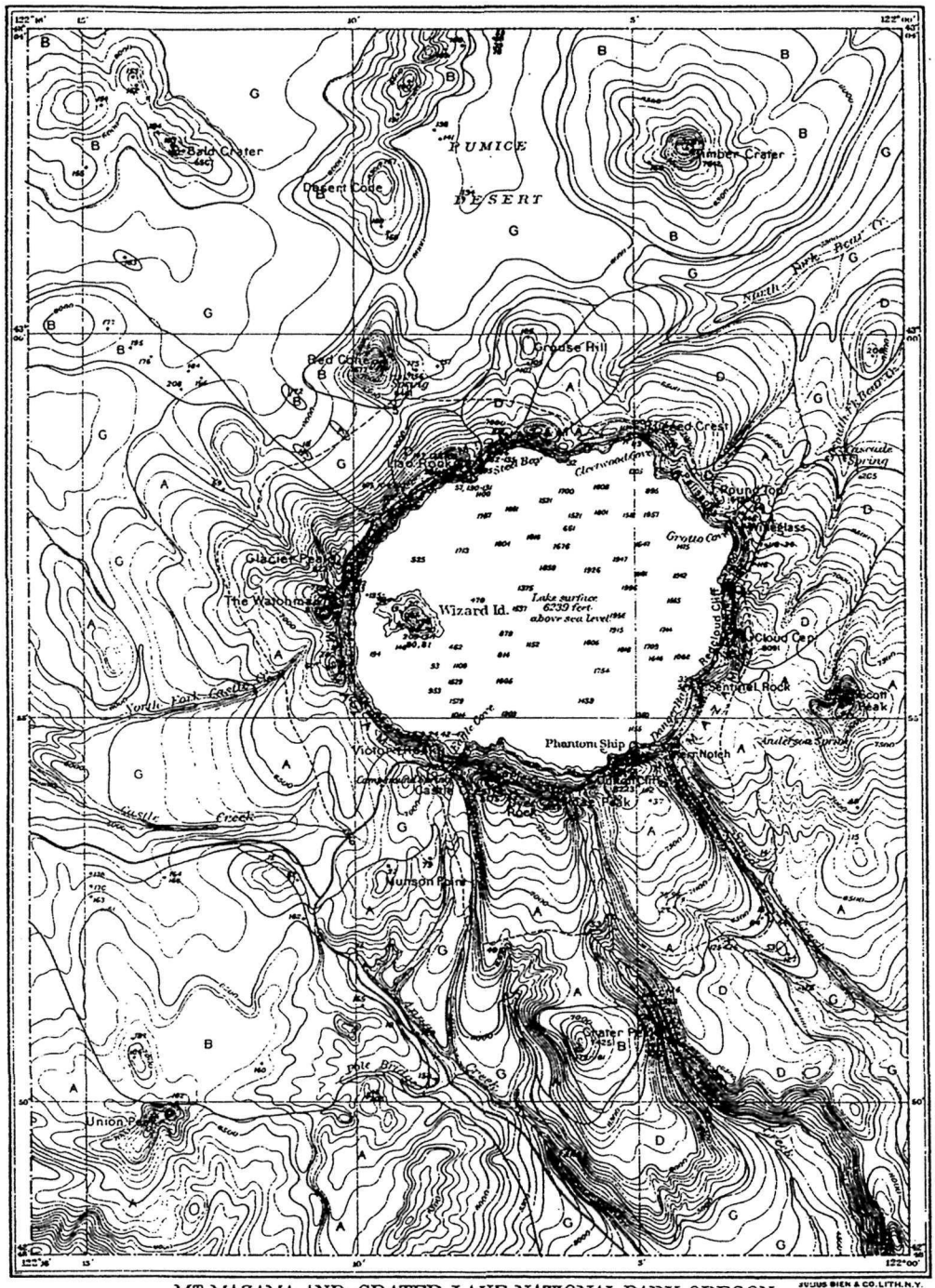
less voluminous "mission-oriented" investigations have made the NPS a better steward of park resources also remains unknown. This is due to a variety of factors, none of which are easy to measure. Research has nevertheless been the main impetus in changing both the number and types of resources at Crater Lake National Park, as well as approaches to their management.

Acknowledgments

Mark Buktenica approached me in early 2000 and asked for a narrative to supply historical context on past limnological research activities. It quickly became evident that these studies had to be seen in reference to all of the scientific investigations that have taken place in the park over the past century or so. Finding an adequate approach proved to be the most challenging part of this project, an undertaking that finally commenced in January 2001. For technical assistance I frequently turned to Tom McDonough, a long-time seasonal employee at Crater Lake and physics instructor at Chemeketa Community College in Salem, Oregon, and am very grateful for his help. Mary Benterou assisted me with reproducing a number of the illustrations, both from park collections and other sources. I also wish to thank reviewers who took the time to send comments on the draft version of this chapter: William "Mac" Brock, Mark Buktenica, Owen Hoffman, Jon Jarvis, Glen Kaye, Gary Larson, Gretchen Luxenberg, Ron Mastrogiuseppe, and Jim Milestone. My draft also benefited from presenting a condensed

version of the chapter with John Salinas at a symposium held on the campus of Southern Oregon University to celebrate the park centennial in October 2002.

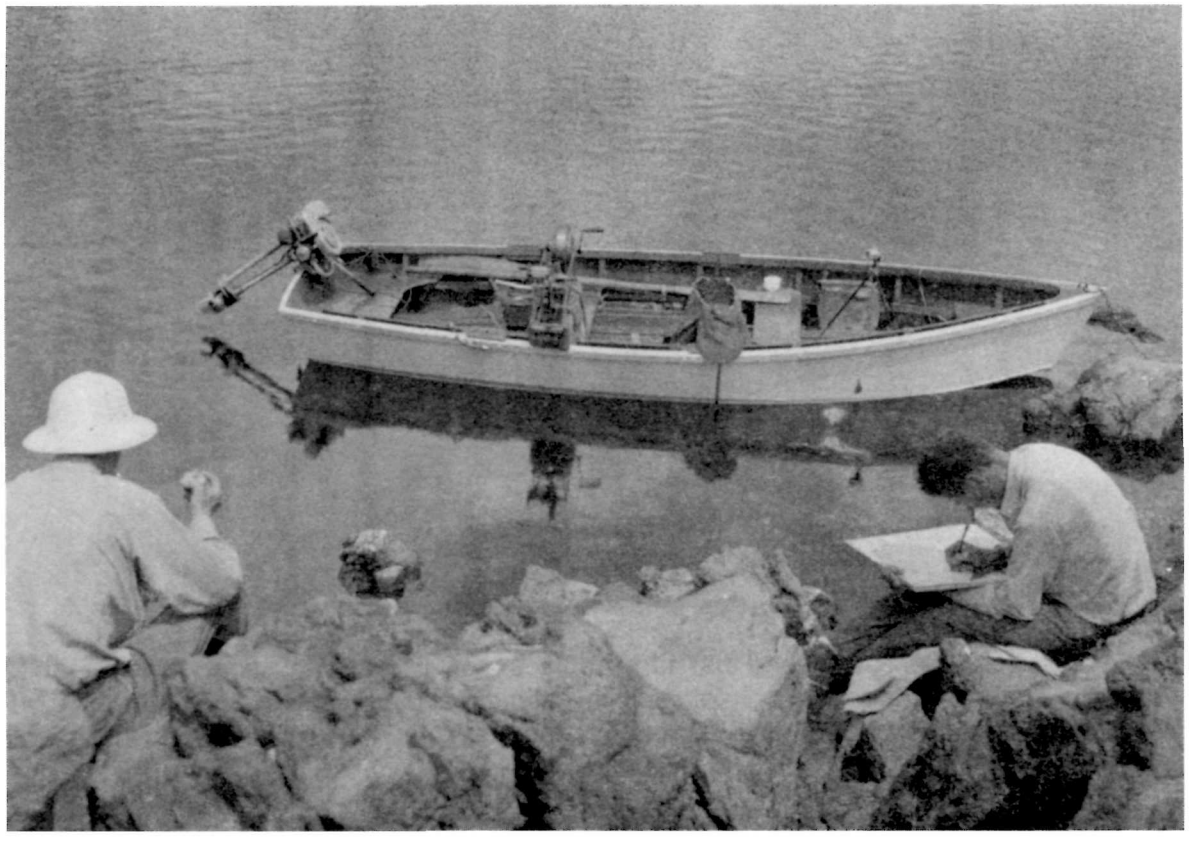
Stephen R. Mark
July 2003



J.S. Diller conducted the first geological studies at Crater Lake, yet he also used them to set park boundaries in the organic legislation of 1902. (USGS)

U.S. Biological Survey expedition to Crater Lake, 1896. Pictured are biologists Vernon Bailey (with rifle, center) and C. Hart Merriam (right). *Park collections*

Raft and pan used by Diller to measure surface evaporation, 1901. (USGS)

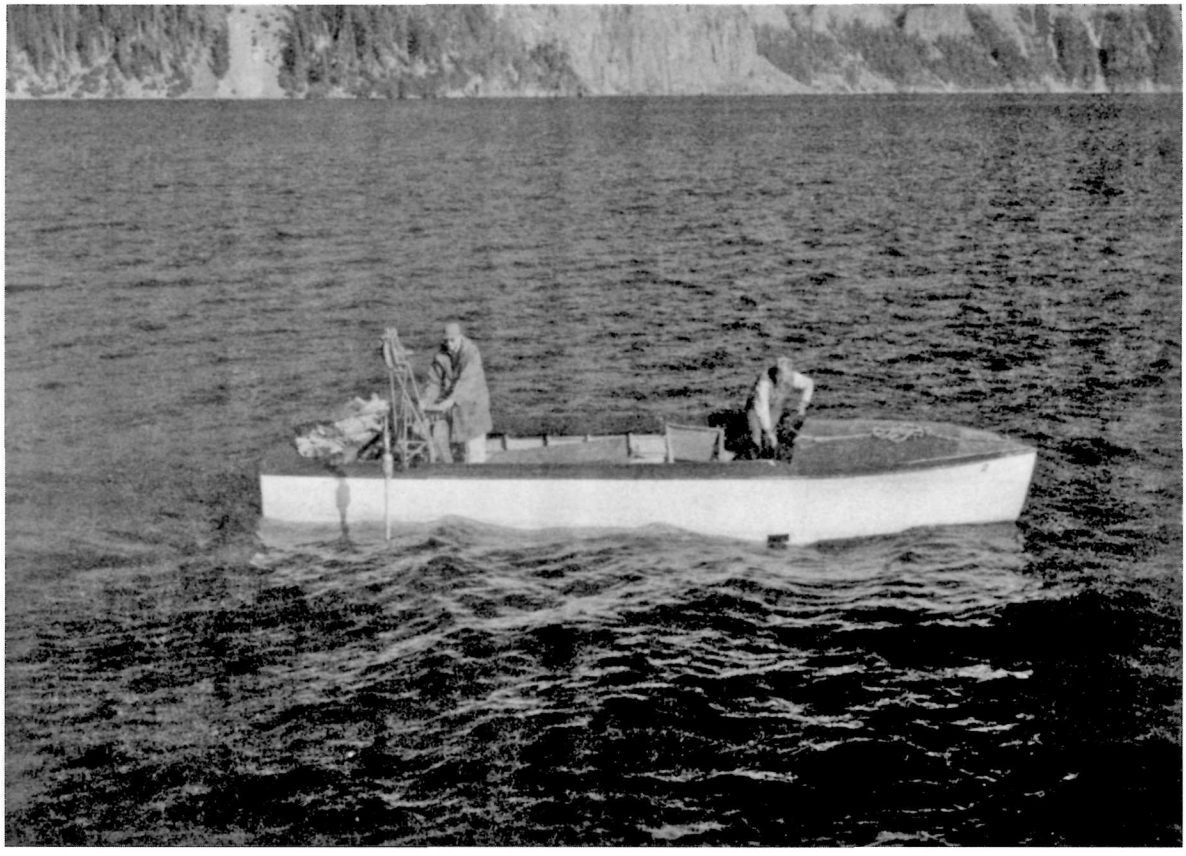


Loren Miller and John Doerr on Wizard Island working on the project to re-sound Crater Lake, 1939. *Park collections*

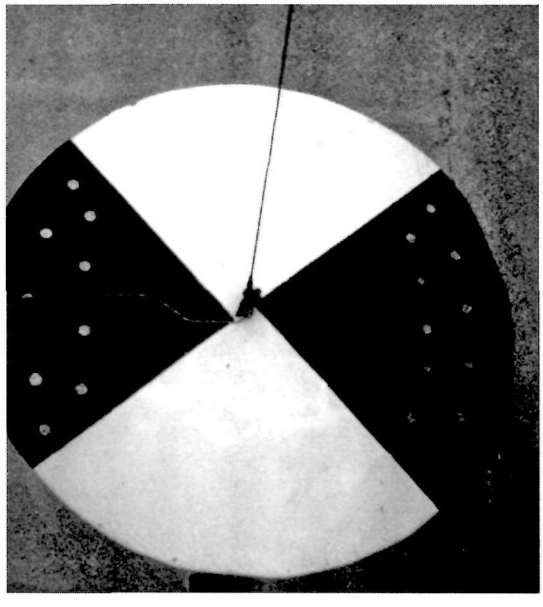
Howel Williams at the Watchman Overlook, 1962. *Park collections*

Luther Cressman established that early peoples most likely witnessed the event that created Crater Lake through archeological investigations conducted in caves located east of the park. This view shows Winter Rim from Paisley 5 Mile Point Cave in 1938. *Park collections*

Researchers from the University of Washington (Thomas Thompson, Jr., Lyman Pfiffer, Rex Robinson, and C.L. Utterback) at the dock below Rim Village. Ranger naturalist Donald Farner is at right, 1940. *Park collections*

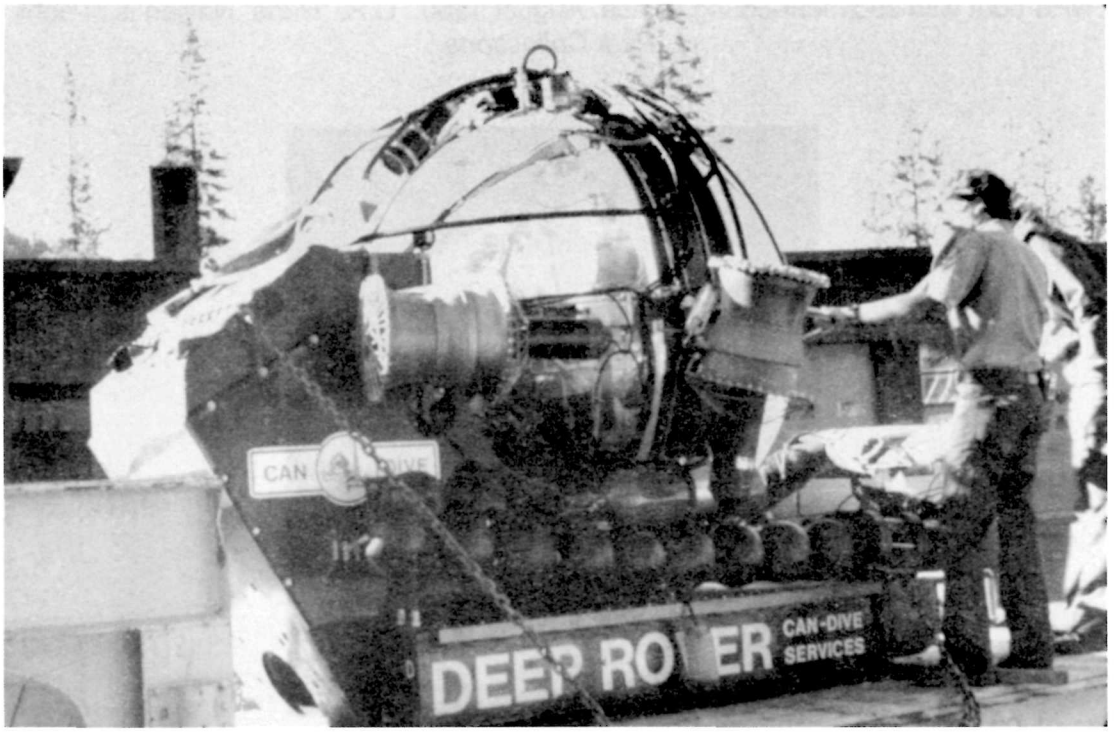


NPS boat with sediment-coring device, August 1960. C.H. "Hans" Nelson is at right.
Park Collections



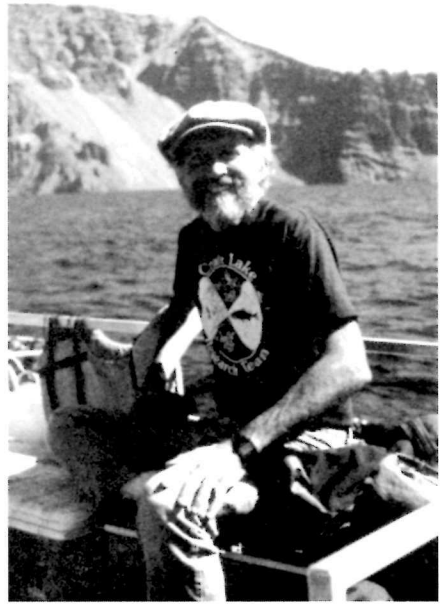
A secchi disk used by researchers to measure the clarity of Crater Lake.
Depth is recorded where the disk disappears from view.

Jack Donaldson (left), James Malick (center), and Owen Hoffman (right) at the top of the Cleetwood Cove Trail, August 1968. *Photo courtesy of Douglas W. Larson.*



Deep Rover submersible prior to its launch in Crater Lake, August 1988. Mark Buktenica is at right. *Park Collections*

Douglas W. Larson in 1983.
Photo by John Salinas.



Jack Dymond in 1987.
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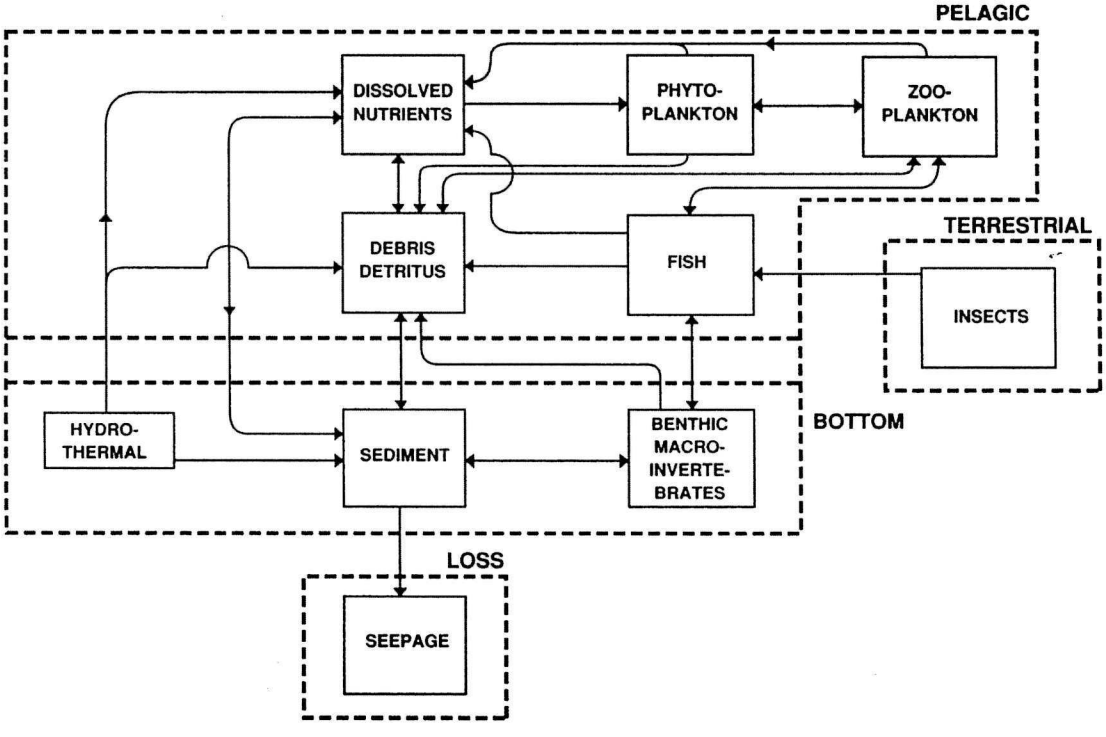
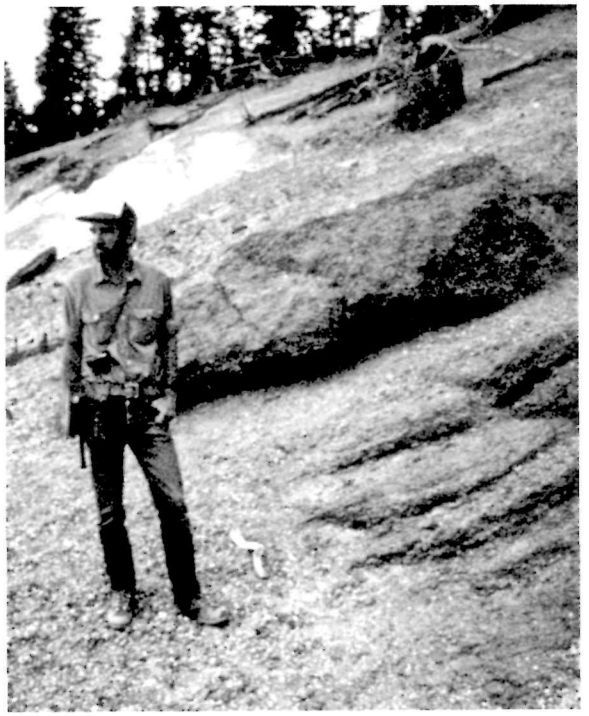


Conceptual model of Crater Lake's ecosystem developed by Gary Larson.



Charles R. Bacon standing at the Cleetwood Flow in 1985.
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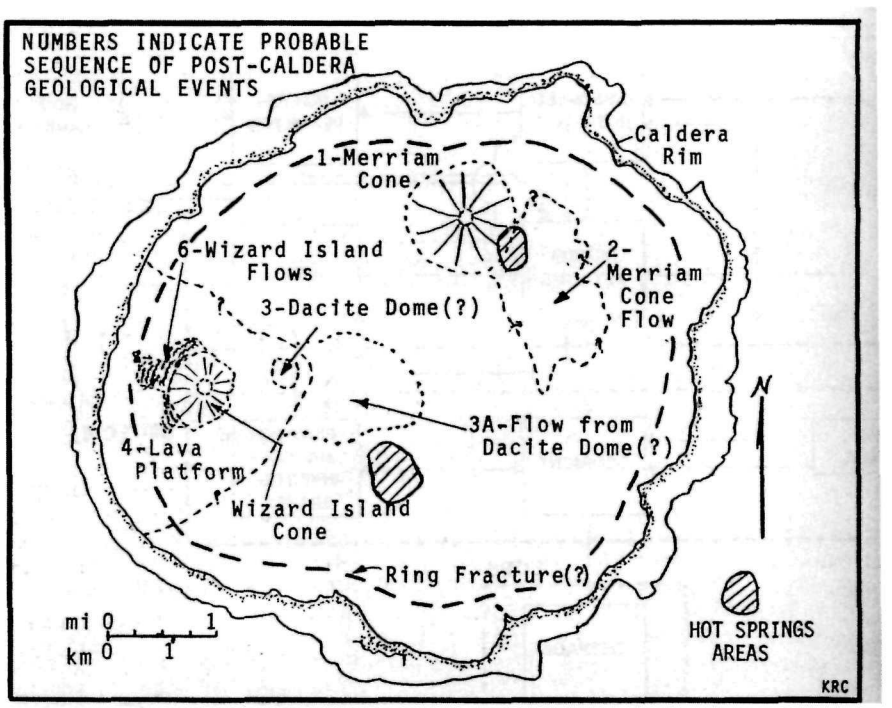


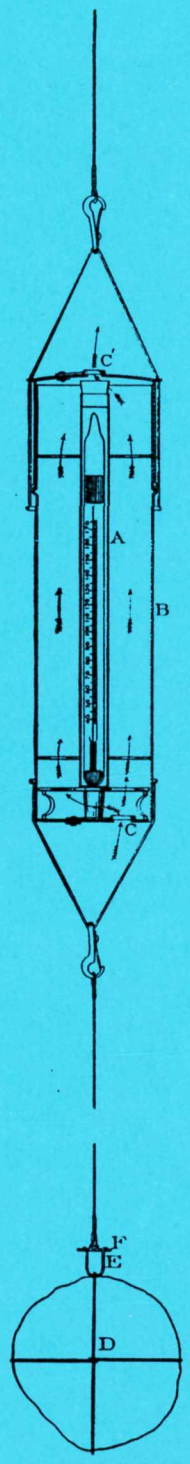
Better understanding of the climactic eruption of Mount Mazama and subsequent volcanic events have allowed scientists to use Crater Lake as a model of how small calderas evolve over several thousand years. *Diagram by K.R. Cranson, 1980.*

Efforts to document traditional uses of the park by native peoples began in the 1990s. This photograph of a camp at Huckleberry Mountain shows berries gathered in the vicinity as well as game. *Courtesy of the Hescock family.*

The "Ball Field," a largely treeless area on the northwestern edge of the caldera, is part of a cultural landscape associated with the Klamath Tribes. Documented in a traditional use study, it was the site of a contest between supernatural beings, Llao and Skell, as well as their assembled minions of mythic creatures. *Park Collections*

NPS landscape architects used naturalistic design in a revegetation program at Rim Village during the 1930s. Native sedges, shrubs, and trees planted along the promenade represented one of the key features documented in a cultural landscape report printed in 1990. *Park Collections*

Andesite boulders quarried at the base of the Watchman during the 1930s became a conspicuous part of designed cultural landscapes at Rim Village, *Park Headquarters, and along Rim Drive. Park Collections*



An early thermometer used in Crater Lake (Diller 1902) *USGS.*

Notes to Chapter 18

Endnotes for Chapter 18

[1] Harlan D. Unrau, *Administrative History, Crater Lake National Park, Oregon* (Denver: USDI-NPS, 1988), pp. 411-453.

[2] Diller, "Illustrations and Description of Crater Lake," Crater Lake Special Map, edition of 1896, Crater Lake National Park Museum and Archives Collections.

[3] Articles by the four scientists appeared in *Mazama* 1:2 (1897). The reports are part of the legislative package on bills H 613 (1898), H 533 (1899), H 872 (1901) and S 1318 (1902). For the particulars surrounding park establishment, including Diller's role in it, see Stephen R. Mark, "A National Park for Oregon: the Crater Lake Reservation," *Journal of the Shaw Historical Library* 15 (2001), pp. 35-55.

[4] Diller and Patton, *The Geology and Petrography of Crater Lake National Park,* USGS Professional Paper No. 3 (Washington, DC: Government Printing Office, 1902).

[5] Diller, *Geological History of Crater Lake* (Washington, DC: GPO, 1912), with reference to the topographic map appearing on page 5. His other work related to Crater Lake includes "Crater Lake, Oregon," *American Journal of Science* 3 (March 1897), pp. 165-172, and "The Wreck of Mount Mazama," *Science* 15:371 (n.s.), 2/7/02, pp. 203-211. An earlier article "Fulgurite from Mount Thielson," *American Journal of Science* 166 (October 1884), pp. 252-288, may have provided justification for including that peak within the original boundaries for a national park, as withdrawn by the President in February 1886.

[6] Pernot, *Forests of Crater Lake National Park* (Washington, DC: GPO, 1916).

[7] See Albert R. Sweetser, "Common Wild Flowers of Crater Lake National Park," and Ira A. Williams, "Some Notes on the Geology of Crater Lake," in Harriet E. Monroe, et al (eds.), *Oregon Out of Doors—Crater Lake* (Portland: The Mazamas, 1922), pp. 29-94.

[8] Frederick Lyle Wynd, "The Ferns of Crater Lake National Park," *American Fern Journal* 19:2 (April-June 1929). His work as a naturalist at Crater Lake led to the first masters thesis on the park, Life Zones with Special Reference to the Botanical Features of those in Crater Lake National Park, University of Oregon, 1930. Several of Wynd's collections are mentioned in L.F. Henderson, "Some New Species and Varieties from Oregon," *Rhodora* 32 (February 1930), pp. 20-28.

[9] Citations, in order of reference to author, are: Applegate, "Plants of Crater Lake National Park," *American Midland Naturalist* 22:2 (September 1939), pp. 225-314; Wynd, "The introduced flora of Crater Lake National Park," *Torreya* 36 (February 1936), pp. 5-6, "Plants Described Originally from Crater Lake National Park," *Madrono* 3 (1936), pp. 346-359, "The flora of Crater Lake National Park," *American Midland Naturalist* 17 (1936), pp. 881-949, "The floral wealth of Crater Lake," *Natural History* 20 (1937), pp. 419-427, "The botanical factors of the life zones of Crater Lake National Park," *American Midland Naturalist* 25 (1941), pp. 324-347; Hasler, "Fish Biology and Limnology of Crater Lake, Oregon," *Journal of Wildlife Management* 2:3 (July 1938), pp. 94-103, "Fisheries Investigations in Crater Lake, Oregon," *Journal of Wildlife Management* 6:4 (October 1942), pp. 319-327; Wallis and Carl E. Bond, "Establishment of Kokanee in Crater Lake, Oregon," *Journal of Wildlife Management* 14:2 (April 1950), pp. 190-193; Brode, "The Denizens of Crater Lake," *Northwest Science* 12:3 (1938), pp. 50-57; Allen, "Structures in the Dacite Flows at Crater Lake, Oregon," *Journal of Geology*19:6 (August-September 1936), pp. 737-744; Smith and Schwartzlow, "Mount Mazama: Explosion versus Collapse," *Bulletin of the Geological Society of America* 47 (12/21/36), pp. 1809-1830; Farner, "Notes on the Food Habits of Salamanders of Crater Lake, Oregon," *Copeia* 4 (1947), pp. 259-261; Farner and Kezer, "Notes on the Amphibians and Reptiles of Crater Lake National Park," *American Midland Naturalist* 50:2 (October 1953), pp. 448-462; Kezer and Farner, "Life History Patterns of the Salamander *Ambystoma macrodactylum* in the High Cascade Mountains of Southern Oregon," *Copeia* 12 (1955), pp. 128-131; Huestis, "Crater Lake *Peromyscus*" *Journal of Mammology* 20:3 (August 1939), pp. 341-395.

[10] Farner, *The Birds of Crater Lake National Park* (Lawrence: University Press of Kansas, 1952). The subsidy came through the Crater Lake Natural History Association.

[11] Huestis, "The Golden Mantled Ground Squirrel," *Nature Notes from Crater Lake*, Special Number, (1951), pp. 5-15.

[12] Interview with James L. Kezer, Crater Lake National Park Oral History Series (hereafter CLNPOHS), 11/26/97, p. 2. This practice continued through the 1960s; F. Owen Hoffman to Steve Mark, electronic mail in park historian's possession, 12/14/02.

[13] Merriam, "Suggestions Relating to Purpose and Educational Program of Crater Lake National Park, 1929," in Reports of John C. Merriam on Studies of Educational Problems in National Parks, pp. 1-3. A shortened version appeared as "Reports with recommendations from the Committee on Study of Educational Problems in National Parks," *National Parks Bulletin* 9:56 (April 1930), p. 4.

[14] Merriam, "Crater Lake: A Study in Appreciation of Nature," *American Magazine of Art* 26:8 (August 1933), pp. 357-361. It reappeared in slightly revised form in Merriam's *The Garment of God* (New York: Scribners, 1943), pp. 83-92.

[15] Payne, "Human Values in Nature as Represented at Crater Lake," *The Living Wilderness* (October 1943), pp. 15-20, and the somewhat more anthropomorphic "My Friends, the Hemlocks of Crater Lake," *American Forests* 50:8 (August 1944), pp. 377-379, 415. Merriam wrote numerous memoranda about aesthetic values of Crater Lake, many of which landed in NPS files and were intended to support future planning efforts. He prompted UO faculty members to compile a copyrighted collection, "Notes and Materials on the Study of Appreciation of Nature at Crater Lake, Oregon," (1941; copy in park library locked cabinet).

[16] Ralph Leighton, "Crater Lake Field School of Nature Appreciation," University of Oregon circular, 1947. A file in the writer's office contains copies of memoranda written between 1944 and 1947 about the origin, development, and evaluation of the school. One of the instructors, Ruth Hopson, so impressed NPS officials that she was hired as a ranger-naturalist, the first woman to serve in that capacity.

[17] The question of Crater Lake's origin was presented by Lincoln Constance, "Crater Lake National Park as a Field for Scientific Research," *Oregon Education Journal* (January 1932), p. 5. The explosion theory appeared in an article by two ranger naturalists at Crater Lake, Warren D. Smith and Carl R. Schwartzlow, "Mount Mazama: Explosion versus Collapse," *Bulletin of the Geological Society of America* 47 (12/31/36), pp. 1809-1830. An earlier paper by Smith, "Reconsideration of Geological Dogma," *Pan-American Geologist* (September 1930), pp. 95-98, was apparently written to refute what Diller presented in "Did Crater Lake, Oregon, originate by a volcanic subsidence or an explosive eruption?" *Journal of Geology* 31 (April/May 1923), pp. 226-227.

[18] Williams, *The Geology of Crater Lake National Park, Oregon, With a Reconnaissance of the Cascade Range Southward to Mount Shasta*. Publication 540 (Washington, DC: CIW, 1942). He also incorporated contemporary studies of pumice and ash, see Bernard N. Moore, "Deposits of possible *nuee ardente* origin in the Crater Lake region, Oregon," *Journal of Geology* 42 (1934), pp. 358-375, and "Nonmetallic mineral resources of eastern Oregon," *USGS Bulletin 875* (Washington, DC: GPO, 1937), pp. 150-175.

[19] See Unrau, *Administrative History*, pp. 652-654. Merriam undoubtedly encouraged its formation as all three men, along with Williams, were members of an advisory committee on education in Oregon parks, initiated by Merriam in 1941.

[20] Williams, *The Geology of Crater Lake National Park*, p. 6; results of the re-sounding project appear on p. 110. The link with Williams' work is mentioned in "Information Bulletin," 2/1/39, p. 2; also Arno B. Cammerer, Director, NPS, to W.C. Mendenhall, Director, USGS, 8/17/37, LRMF.

[21] Doerr, "Sounding Crater Lake," script for Medford's Rogue Wonderland Program, 1/12/40, pp. 2-3, in lake research manuscript file (hereafter LRMF), Historian's office. Some description of the machine used for sounding is in correspondence from Earl A. Trager, Acting Assistant Director (NPS), to Leavitt, 6/3/38, LRMF.

[22] Gary Larson to Steve Mark, electronic mail in park historian's possession, 2/26/03.

[23] C.L. Utterback, et al., "Some Planktonic and Optical Characteristics of Crater Lake," *Ecology* 23:1 (1942), p. 102, summary provided by Douglas W. Larson, "Probing the Depths of Crater Lake: A Century of Scientific Research," *Oregon Historical Quarterly* 100:3 (Fall 1999), pp. 300-301. See also Rex J. Robinson, "Some Chemical Observations on Crater Lake, Oregon," in *Proceedings of a Symposium on Hydrobiology* (Madison: University of Wisconsin Press, 1941).

[24] Pettit, "On the Color of Crater Lake Water," *Proceedings of the National Academy of Science* 22:2 (1936), pp. 139-146, and "Why is Crater Lake So Blue?" *Carnegie Institution of Washington News Service Bulletin* 4:4 (1936), pp. 39-44.

[25] Cressman, Williams, and Alex D. Krieger, *Early Man in Oregon: Archeological Studies in the Northern Great Basin* (Eugene: University of Oregon Press, 1940); Cressman, *Archaeological Researches in the Northern Great Basin.* Publication 538 (Washington, DC: CIW, 1942); Cressman, *The Sandal and the Cave* (Portland: Beaver Books, 1977).

[26] Hansen, in Cressman's *Archaeological Researches in the Northern Great Basin*, pp. 103-114; also Hansen, "Post-Mount Mazama forest succession on the east slope of the Central Cascades of Oregon, *American Midland Naturalist* 27 (1942), pp. 523-535. Hansen's studies culminated in *Postglacial Forest Succession, Climate and Chronology in the Pacific Northwest* (Philadelphia: American Philosophical Society, 1947).

[27] The Biological Survey subsequently became known as the U.S. Fish & Wildlife Service. The lone remaining biologist serving Crater Lake, Joseph Dixon, conducted wildlife surveys during the war years as a "field naturalist" and was not transferred because of being near retirement.

[28] Merriam to Lawrence C. Merriam, 3/16/44, Merriam Manuscript files, Crater Lake National Park. For a summary of the elder Merriam's role in both science and interpretation at the park, see Stephen R. Mark, "A Study in Appreciation of Nature: John C. Merriam and the Educational Purpose of Crater Lake National Park," *Oregon Historical Quarterly* 103:2 (Spring 2002), pp. 98-123.

[29] Fairbanks had, incidentally, been one of Farner's graduate students. For the work on diatoms, see H.E. Sovereign, "The Diatoms of Crater Lake, Oregon," *Transactions of the American Microscopy Society* 77:1 (1958), pp. 96-124, and "New and Rare Diatoms from Oregon and Washington," *Proceedings of the California Academy of Sciences* 31:14 (1963), pp. 349-358. Other activities on the lake have been summarized by Larson, "Probing the Depths of Crater Lake," p. 302.

[30] R.E. Williams, Hydrographic Description Report, CL-1159, copy in Crater Lake National Park Museum and Archives Collections (hereafter CLNPMAC). The number of soundings contrasted markedly with those obtained by Doerr (200), which was just a few more than obtained by the *Cleetwood* in 1886. The budget figure for NPS scientific research was obtained from Richard West Sellars, *Preserving Nature in the National Parks: A History* (New Haven: Yale University Press, 1997), p. 169.

[31] Howel Williams, "The Floor of Crater Lake, *American Journal of Science* 259 (February 1961), pp. 81-83; John Bryne, "Bathymetry of Crater Lake, Oregon," *The Ore Bin* 24:10 (October 1962), pp. 161-164, and "Morphometry of Crater Lake, Oregon," *Limnology and Oceanography* 10:3 (July 1965), pp. 462-465. Production of the contour map by the USGS was delayed until 1962, accounting for the lag in publication.

[32] Nelson, "Sediments of Crater Lake, Oregon," *Geological Society of America Bulletin* 78 (1967), pp. 833-848; his thesis was titled Geological Limnology of Crater Lake, Oregon (University of Minnesota, 1961).

[33] Black interview, 9/27/88, Crater Lake National Park Oral History Series, p. 14. The subject is mentioned in an interview with Ted Arthur, 9/1/92, CLNPOHS, pp. 12-13.

[34] James Kezer, who worked as a ranger-naturalist (seasonal interpreter) in 1951-52, attributed the decline in the numbers of college faculty in NPS seasonal ranks to funding increases for research. This came in response to the Russian launch of Sputnik in 1957, an event that set off a "space race" with the United States; Kezer, CLNPOHS, 11/26/97, p. 2.

[35] Mueller, Introduction to the Ecology of the Pumice Desert, MS thesis, Purdue University, 1966, p. iii. See also Elizabeth Mueller Horn, "Ecology of the Pumice Desert," *Northwest Science* 42:4 (1968), pp. 141-149, and "Pumice Desert Revisited," *Nature Notes from Crater Lake* 32-33 (2001/2002), pp. 37-40.

[36] Brown, CLNPOHS, 9/15/88, p. 52.

[37] Curtis, "*Barbeyella Minutissima*, A New Record for the Western Hemisphere," *Mycologia* 40:3 (May-June 1968), pp. 708-710; "New Records of *Myxomycetes* from Oregon. I." *Madrono* 20:2 (April 1969), pp. 75-77. Jackson, "A Floristic Survey of Wizard Island, Crater Lake National Park," *Wasmann Journal of Biology* 31:2 (Fall 1973), pp. 313-321; Jackson and Adolph Faller, "Structural Analysis and Dynamics of the Plant Communities of Wizard Island, Crater Lake National Park," *Ecological Monographs* 43:4 (Autumn 1973), pp. 441-461.

[38] Brown interview, p. 52. For a list of park projects, see Office of Natural Science Studies, "List of Natural Science Research Projects in the National Park System, Calendar Year 1967, pp. 13-14, copy in park library.

[39] Brown freely admitted this limitation; Douglas Larson interview, CLNPOHS, 2/14/00, pp. 16-24. See also Brown to John E. Tyler, 9/15/65, RG 79, 73A-805, Box 14, File D6215, copy in park historian's files.

[40] Lowell Sumner, "A History of the Office of Natural Science Studies," pp. 1-6 in Proceedings of the Meeting of Research Scientists and Management Biologists of the National Park Service, April 6-8, 1968, copy in the park library. For more background about the structural defects of the science program at the Washington level, see Richard Sellars, *Preserving Nature in the National Parks* (New Haven: Yale University Press, 1997), pp. 221-233.

[41] Brown interview, p. 4. Some hint about these conflicts is in an interview with former superintendent Donald Spalding, CLNPOHS, 4/2/91, p. 24.

[42] Blaisdell, *Return of the Bighorn to Lava Beds National Monument* (Washington, DC: Government Printing Office, 1976), p. 19.

[43] USDI-NPS, Natural Sciences Research Handbook, Release No. 1, July 1965, Chapter 3, pp. 1-4.

[44] Hauling garbage out of the park came about more in response to to the widely publicized bear studies by the Craighead brothers at Yellowstone than to reports and recommendations made about the bear problem at Crater Lake. One aim of a study begun by Michael T. McCollum in 1972 involved determining the effects of closing the dumps on bears who fed their habitually; Superintendent's Annual Report (hereafter SAR) 1972, p. 10. See also McCollum, Research and Management of Black Bears at Crater Lake National Park, NPS Progress Report, 1/20/74, copy in park library. It should be read in conjunction with previous work by Joseph S. Dixon, such as Report on the bear problem at Crater Lake National Park, 12/14/44, and New Garbage Disposal Site and Bear Situation at Crater Lake National Park, 8/1/45. See also Stephen Herrero, Observations on Black Bears (Ursus Americanus) at the Munson Dump, CLNP, cover letter of 11/12/69, copies of all reports in the bear file, Historian's office.

[45] Blaisdell stated the purpose of studying elk in his abstract for the Science/Resource Management Workshop, Pacific Northwest Region, April 18-20, 1978, p. 52. Essentially a monitoring project begun by McCollum in 1972, Tana Hill continued the project in 1975-76, though she did not acknowledge the earlier work. Her report dated October 1976 is appendix D in the notebook containing the park's resource management plan signed by Superintendent James Rouse on 11/30/81, copy in park library.

[46] Larry L. Hakel, Supervisory Park Ranger, and Glen Kaye, [Assistant] Park Naturalist, Long Range Aquatic Resources Management Plan, 1969-1978, p. 5. The two men prepared the plan in accordance with a requirement in the NPS Wildlife Handbook, Part II, Aquatic Resources, Natural and Historic Areas, October 1966, Chapter 1, Page 5. The third research need identified by Hakel and Kaye recalled Merriam's fear that stocking Crater Lake with fish might ultimately affect the lake's color; Merriam to Newton B. Drury [NPS director], 2/26/43, p. 3, MSS 71/100c, Carton 2, Bancroft Library, University of California.

[47] The lone exception is an article by H. Richard Blank, Aeromagnetic and Gravity Survey of the Crater Lake Region, Oregon," pp. 42-54 in Hollis M. Dole, *Andesite Conference Handbook* Bulletin 62 (Salem: Department of Geology and Mineral Industries, 1968) as part of broader geophysical study in southwest Oregon. There were two water resources papers: Kenneth N. Phillips and A.S. Van Denburgh, *Hydrology of Crater, East and Davis Lakes, Oregon*, Geological Survey Water Supply Paper 1859-E (Washington, DC: GPO, 1968); F.J. Frank and A.B. Harris, *Water Resources Appraisal of Crater Lake National Park, Oregon* (Portland: USGS Open File Report, 1969). The latter project came about after the NPS failed to locate water from test wells drilled near the Cleetwood Cove parking area and the vicinity of the North Entrance. The NPS and USGS Water Resources Branch entered into a formal cooperative relationship following installation of a lake level gauge at Cleetwood Cove in 1959. Maintenance of the gauge by USGS came in exchange for the use of the warehouse situated on park property in Medford.

[48] H.L. Volchok, et al., "Ocean Fallout – the Crater Lake Experiment," *Journal of Geophysical Research* 75:6 (2/20/70), pp. 1084-1091. See also H. James Simpson, "Tritium in Crater Lake, Oregon," *Journal of Geophysical Research* 75:27 (9/20/70), pp. 5195-5207, and J.S. Leventhal and W.F. Libby, "Brief Report: Tritium Fallout in the Pacific United States," *Journal of Geophysical Research* 75:36 (12/20/70), pp. 7628-7633 for related work.

[49] Raymond C. Smith and John E. Tyler, "Optical Properties of Clear Natural Water," *Journal of the Optical Society of America* 57:5 (May 1967), pp. 589-595. The investigators, along with C.R. Goldman, went on to quantify differences in color with "Optical Properties and Color of Lake Tahoe and Crater Lake," *Limnology and Oceanography* 18:2 (March 1973), pp. 189-199. NSF grants also underwrote, at least in part, contributions to the study of geology at Crater Lake. These include Virginia C. Steen and Roald Fryxell, "Mazama and Glacier Peak Pumice Glass: Uniformity and Refractive Index after Weathering," *Science* 150:3698 (11/12/65), pp. 878-880. See also Lawrence R. Kittleman, "Minerology, Correlation and Grain Size Distribution of Mazama Tephra and Other Post-glacial Pyroclastic Layers, Pacific Northwest," *Geological Society of America Bulletin* 84 (September 1973), pp. 2957-2980.

[50] USDI-NPS, Natural Sciences Research Handbook, issue of July 1965, Chapter 2, p. 1.

[51] Natural Sciences Research Handbook, Chapter 2, p. 3.

[52] The boat used by NPS personnel for lake studies since the 1950s was in such bad shape that it could not be used; J. Leonard Volz, Superintendent, to John E. Tyler, 7/7/66, RG 79, 73-805, Box 14, Filecode A42, copy in Park Historian's files. This boat was sunk the following year (ironically enough by one of the aquatic plan's co-authors, Larry Hakel), and replaced by a borrowed Boston whaler until the summer of 1971; Owen Hoffman interview, CLNPOHS, 8/25/98, p. 6. Studies aimed at the lake's fish population, as well as calculating heat budgets at various depths, surface currents, and primary productivity were undertaken by doctoral candidate Harold V. Kibby over the summer of 1966, but his advisor at OSU was Carl Bond. Kibby and others eventually published "Temperature and Current Observations in Crater Lake, Oregon," *Limnology and Oceanography* 13:2 (April 1968), pp. 363-366.

[53] Larson interview, pp. 6-7. Treating Crater Lake as a baseline for the study of eutrophication was highlighted in "Oregon's Dying Lakes," Medford *Mail Tribune* 10/8/67. The grant was initially aimed at the National Science Foundation, with Carl Bond (a full professor and head of the Department of Fisheries and Wildlife at OSU) as principal investigator since Donaldson's appointment in Corvallis did not become effective until October 1966. See proposal attached to letter from Richard M. Brown to Harold V. Kibby, 2/1/66 in Kibby file, N22, microfiche sheet 475, CLNPMAC.

[54] The publications are: Douglas W. Larson, "Temperature, Transparency, and Phytoplankton Productivity in Crater Lake, Oregon," *Limnology and Oceanography* 17:3 (May 1972), pp. 410-417; Larson, "Comparative Limnology and Phytoplankton Ecology of Four "Oligotrophic" Lakes in Oregon, USA, with emphasis on lake typology," *Northwest Science* 46:2 (May 1972), pp. 149-163. The thesis work was by Owen Hoffman (1969) and Jim Malick (1971), while Larson completed his dissertation in 1970. See Larson's article in the *Oregon Historical Quarterly* 100:3 (Fall 1999), pp. 305-309 for a summary of the program.

[55] Victor T. Neal, et al., "Temperature Microstructure in Crater Lake, Oregon," *Limnology and Oceanography* 16:4 (July 1971), pp. 695-700; idem, "Vertical Temperature Structure in Crater Lake, Oregon," *Limnology and Oceanography* 17:3 (May 1972), pp. 451-454.

[56] The logistical challenge required assistance from a park ranger who insisted that the scientists familiarize themselves with snowmobile operation, snowshoes, and winter survival; Paul Crawford, Supervisory Park Ranger, to Chief I&RM [Glen Henderson], 3/6/71, filecode copy N3043 in Lake Research file, Historian's office.

[57] *Interpretive Prospectus, Crater Lake National Park, Oregon* (Denver: USDI-NPS, 1973 [1971], p. 17. Naturalists lost their separate job series as part of NPS reorganization prompted by the implementation of recommendations by the Field Operations Study Team in 1968. See "Field Operations Study Report Approved," *NPS Newsletter* 1:7 (11/17/66), p. 1 and "FOST Burns Charter...New Management Era Launched for NPS," *NPS Newsletter* 3:14 (7/11/68), pp. 1-2. Reorganization was fueled by budget restrictions on federal bureaus brought by the Vietnam War; see "Udall Orders Cutbacks in National Park Service Operations," *NPS Newsletter* 3:21 (10/17/68), pp. 1-2.

[58] The effects of reorganization on the dismal state of the NPS interpretive program are documented by William C. Everhart, A Report on NPS Interpretation, March 1973, copy in the park library.

[59] Starkey, Oregon Cooperating Park Study Unit, School of Forestry, Oregon State University, 4/1/75-12/31/77, pp. 1-5. The first thesis completed was Terri Jo Thompson, Dispersed Winter Recreational Use Patterns and Visitor Attitudes at Crater Lake – Diamond Lake, Oregon (December 1976). It was followed by a dissertation from Stephen J. Walsh, An Investigation into the Comparative Utility of Color Infrared Aerial Photography and LANDSAT Data for Detailed Surface Cover Type Mapping within Crater Lake National Park, Oregon (August 1977). Thompson later co-authored (with Kent Downing) "Dispersed Winter Recreation in the Crater Lake – Diamond Lake Area," *Proceedings of the First Conference on Scientific Research in the National Parks*, Vol. 2 (Washington, DC: Government Printing Office, 1979), pp. 965-970. Walsh eventually published a summary of his work at Crater Lake, "Coniferous tree species mapping using LANDSAT data," *Remote Sensing Environment* 9 (1980), pp. 11-26.

[60] Robert S. Ziegler entitled his thesis The Vegetation Dynamics of *Pinus Contorta* Forest, Crater Lake National Park, Oregon (June 1978). It served as the basis for a contracted report co-authored with his major professor at OSU, Donald B. Zobel, and bore the title Lodgepole Pine at Crater Lake: History and Management of Forest Structure (1978).

[61] Susan Seyer and Jerry F. Franklin, Sphagnum Bog: An Ecological Inventory and Recommendations for Management and Use, report dated June 1980. It was based on Seyer's masters thesis, Vegetative Ecology of a Montane Mire, Crater Lake National Park, Oregon (December 1979). Geographers William L.

Hamilton and James F. Lahey meanwhile pursued a study called An Investigation into Modeling Snow Cover Elements at Crater Lake National Park and Surrounding Environs as an Improved Ground Truth Method for Satellite Snow Observations, abstract in Oregon CPSU 1978-79, p. 3. It was published as "A Mountain Snow Cover Model for Crater Lake National Park and Vicinity," *Physical Geography* 3 (1982), pp. 83-95.

[62] Starkey, et al., 1983 [OSU CPSU] Annual Report, pp. 1-7. Field moved from being the Regional Chief Scientist at the Pacific Northwest Regional Office in Seattle in 1982 to holding joint appointments at the CPSUs located at OSU and UW. Matthews spent much of her time editing and contributing to the quarterly *Park Science.*

[63] This is not to say that the CPSU ignored contributed work that could be transformed into one of its reports. The potential threat of disease outbreak prompted S. Kent Schwarzkopf, a masters candidate in geography at OSU, to submit a paper called Feeding of Golden Mantled Ground Squirrels by Park Visitors at Crater Lake National Park. He built upon the monograph by Ralph Huestis (published as a special number of *Nature Notes from Crater Lake* in 1951) in doing his fieldwork during the summer of 1983. It became CPSU Report 84-9 in May 1984.

[64] Martin and Frewing were first contacted by the NPS to ascertain whether western juniper stands were advancing at Lava Beds National Monument. Martin subsequently examined the stands of ponderosa pine in the "panhandle" portion of Crater Lake National Park whose reproduction seemed to be imperiled by its white fir associate which had crowded out both ponderosa and sugar pine. He called for fire history information to determine whether more active management of mixed conifer stands through fire might be warranted. Interview with Ron Mastrogiuseppe 5/19/03.

[65] Robert C. McNeil, titled his thesis Vegetation and Fire History of a Ponderosa Pine – White Fir Forest in Crater Lake National Park (July 1975). The NPS underwrote McNeil's work with a contract whose issuance preceded establishment of a CPSU in Corvallis; see Final Report, Research Study to Determine Vegetation Dynamics in Ponderosa Pine Forest, Crater Lake National Park (June 1975). McNeal and his major professor Donald Zobel subsequently co-authored "Vegetation and Fire History of a Ponderosa Pine –White Fir Forest in Crater Lake National Park," *Northwest Science* 54 (1980), pp. 30-46.

[66] The largest "p.n.f." was called the Goodbye Fire (much of it burned a portion of Crater Peak) since the fire represented both a "goodbye" to the old suppression policy at Crater Lake and farewell to Superintendent Betts. He transferred to Denali National Park in August 1978; Interview with Ron Mastrogiuseppe 5/19/03, and the Superintendent's Annual Report (hereafter SAR) for 1978, p. 6.

[67] This "aggressive leadership" in fire management corresponded to the tenures of Frank Betts (1976-78) and Jim Rouse (1978-84) as superintendent, both former chief rangers who had their first experience as park manager while at Crater Lake. Support for the program also came from Dan Sholly (1976-81) and Roger Rudolph (1981-83), who served as the chief rangers during that period.

[68] Ziegler, op. cit.; SAR 1978, p. 6; SAR 1979, p. 4. Ron Mastrogiuseppe, Vegetation Dynamics and Prescribed Fire Effects, CRLA-N-23, in Donald R. Field, Annual Report of the Associate Regional Director for Science and Technology, Pacific Northwest Region, NPS, CY 1980, pp. 2-3. Mastrogiuseppe eventually submitted several reports to the park superintendent on his work at several localities within the park; see Field, Annual Report for 1982, p. 5, and a similar document for 1985, edited by Jean Matthews, pp. 15-18.

[69] Agee's studies were summarized in the annual science reports issued by the Pacific Northwest Regional Office for the years 1980 through 1983. They include CPSU reports issued through UW: Agee, Initial effects of prescribed fire in a climax *Pinus contorta* forest: Crater Lake National Park (Winter 1981); Agee, Biomass of Coniferous Understory Trees in Crater Lake National Park, Oregon (Fall 1981); Agee and Terri L. Thomas, Forest Restoration at Sun Creek, Crater Lake National Park (Spring 1982). A thesis by Thomas bears the same title as the CPSU report. She and Agee co-authored "Prescribed fire effects on mixed

conifer forest structure at Crater Lake, Oregon," *Canadian Journal of Forest Research* 16 (1986), pp. 1082-1087. He continued to monitor this forest type; see Agee, "Monitoring Postfire Tree Mortality in Mixed-Conifer Forests of Crater Lake, Oregon, USA," *Natural Areas Journal* 23:2 (April 2003), pp. 114-120. An earlier CPSU report provided some basis for subsequent monitoring; Michael Swezy and Agee, Prescribed Fire Effectsin the Panhandle Area, Crater Lake National Park, CPSU/UW 89-1, Autumn 1988. Swezy and Agee co-authored "Prescribed fire effects on fine-root and tree mortality in old-growth ponderosa pine," *Canadian Journal of Forest Research* 21 (1991), pp. 626-634.

[70] USDI-NPS, Environmental Assessment for Prescribed Fire in the Panhandle Section, Crater Lake National Park, [1976]; USDI-NPS, Environmental Review, Proposed Fire Management Plan, Crater Lake National Park, Oregon, signed by Park Superintendent Frank Betts, 4/29/77.

[71] The study by Bo Shelby and Donald W. Wolf followed from a statement in one of the GMP components, the General Development Plan, which directed that a comprehensive design would be prepared prior to implementing any major changes proposed for Rim Village (III-C-5). Shelby and Wolf had preliminary results available after their first summer of work in 1977, though the final report from the CPSU in Corvallis did not appear until 1981; see Social Impacts of Design Alternatives, Crater Lake National Park, report 81-2. The general development plan also called for providing "all necessary access for the handicapped to facilities and features throughout the park" (III-C-2), yet did not acknowledge the submission of an interim report in August 1977 by Jacqueline M. Beechel that provided detail on how to modify those facilities. Beechel, who worked through the CPSU at UW, chose Crater Lake for the study because it contained elements in common with both large and smaller NPS units in the Pacific Northwest, while the superintendent (Frank Betts) offered enthusiastic verbal support for the project; Interim Report, p. iii. The final version of her report appeared in May 1979 as CPSU/UW report S-79-2. Despite the support from Betts, who transferred to Denali National Park in 1978, park staff implemented very few of the recommendations.

[72] SAR 1978, p. 7. See Sellars, *Preserving Nature in the National Parks* for more detail about how resource management specialists evolved from "wildlife rangers" (pp. 234-235) and their place in the struggle between rangers and scientists in the NPS (pp. 221-224).

[73] David L. Williams and Richard P. von Herzen, "On the Terrestrial Heat Flow and Physical Limnology of Crater Lake, Oregon," *Journal of Geophysical Research* 88 (February 1983), pp. 1094-1104.

[74] SAR 1979, p. 3; Resource Management Plan, 1981, project statement CRLA-N-5. See also Mark Forbes, "Peregrine Rescue Efforts Continue at Crater Lake," *Park Science* 2:4 (Summer 1982), pp. 9-10. Active participation in hacking efforts lasted until 1990; peregrine falcons were subsequently dropped from the endangered species list.

[75] Bacon, "Eruptive History of Mount Mazama and Crater Lake Caldera, Cascade Range, U.S.A.," *Journal of Volcanology and Geothermal Research* 18 (1983), pp. 57-115. By no means did the paper constitute an attack on Williams, who Bacon memorialized by having the name of Forgotten Crater changed to honor the man that encouraged to pursue the study in its early stages. Bacon also noted the most important topical contributions made by others in the intervening years, including one that appeared in a volume which contained an article by Williams. The latter aimed at correcting an earlier miscalculation; see Alexander McBirney, "Compositional Variations in the Climactic Eruption of Mount Mazama," as well as Williams and Gordon Cole, "Volume of Mazama Ashfall and the Origin of the Crater Lake Caldera," in Hollis M. Dole (ed.) *Andesite Conference Handbook* (Salem: Department of Geology and Mineral Industries, 1968), pp. 37-56.

[76] K.R. Cranson, *Crater Lake: Gem of the Cascades* (Lansing, MI: KRC Press, 1980, rev. 1982). The Crater Lake Natural History Association sold the book from its debut in 1980 until 1990.

[77] F.O. Hoffman and J.R. Donaldson, "The Significance of Crater Lake as a Scientific Benchmark for Limnological Research," in Robert M. Linn (ed.), *First Conference on Scientific Research in the National Parks* (Washington, DC: Government Printing Office, 1979), pp. 591-594.

[78] These included water temperature, pH and alkalinity, clarity, algae growth and distribution, as well as chemical composition; Resource Management Plan draft [spring 1981], Caldera Ecosystem Management project statement, p. 15. The seasonal interpreters who assisted Larson included Seth Phalen, Rick Kirchner, and Mike Gillmore. Permanent interpreters Hank Tanski and Pat Smith also helped, while Forbes secured a raft and negotiated time so that Larson could use the Zodiac boat brought by the USGS. The NPS finally acquired a pontoon boat in 1982.

[79] Larson and N.S. Geiger, "Species Composition and Vertical Distribution of Pelagic Zone Phytoplankton in Crater Lake, Oregon: 1940-1979," [at the Second Conference on Scientific Research in the National Parks, November 1979] in E.E. Starkey, et al (coord.) *Ecological Research in National Parks of the Pacific Northwest* (Corvallis: OSU Forest Resources Laboratory, 1982), pp. 138-142; Larson and Forbes, "Optical Properties of Crater Lake, Oregon: Variations in Secchi Disk Transparency," same publication, pp. 135-137; Larson and Geiger, "Crater Lake: Its Planktonic Algae," *Mazama* 69 (1981), pp. 54-59.

[80] Larson, Limnology of Crater Lake, with emphasis on the distribution and abundance of phytoplankton, CRLA-N-32, in Donald R. Field (comp.), Annual [Science] Report, [NPS] Pacific Northwest Region, C.Y. 1980, p. 7.

[81] Resource Management Plan draft, spring 1981, pp. 15-16. The rationale for such low figures was that Forbes believed park personnel could perform the monitoring once equipment had been purchased, though some contracted laboratory work was figured as part of the annual budget.

[82] Larson maintained that he had nothing to do with how the report reached Washington; Larson interview, 2/14/00, CLNPOHS, p. 35. The intermediary may have been Rouse, who contacted his long-time friend Clay Peters, ex-NPS and an advisor to the chairman of the House subcommittee on national parks. Peters played a critical role in getting legislation passed in 1980 that expanded park boundaries by some 22,000 acres; Rouse interview, CLNPOHS, 9/18/97, p. 20.

[83] Larson, Limnology of Crater Lake, with emphasis on the distribution and abundance of phytoplankton, CRLA-N-32, in Donald R. Field, Annual Report of the Associate Regional Director for Science and Technology, Pacific Northwest Region, CY 1981, p. 5.

[84] The lands "scheduled for timber harvesting," resulted in a deletion from the park of 480 acres in 1982.

[85] Smith to Rouse, 12/10/81, W3815, 1982 Boundary Legislation file, Historian's office. The timber inadvertently offered for sale by the Rogue River National Forest was included within the expansion of 22,890 acres in 1980 (P.L. 96-553). Apparently no one challenged Smith's contention about the necessity for such studies on the lake. Smith's rationale for the amendment may provide an explanation for the lack of scrutiny: "I believe the language of this amendment is consistent with the [Reagan] Administration's policy of making a top priority the deteriorated National Park System facilities. The Administration has also expressed deep concern about public health and safety hazards and proposed activities to correct and prevent such defects by providing appropriate care for the parks."

[86] A somewhat analogous research program in the vicinity of Crater Lake was BLM's "Forestry Intensified Research," a ten year program on the Medford District in cooperation with the OSU College of Forestry. It came about when the Federal Land Policy Management Act of 1976 directed BLM to classify lands managed by the agency. When approximately one third of the district's land base was found to be "marginal" (not potentially suited) for timber production in 1979, a legislatively mandated program of basic and applied research ensued for ten years, with periodic reporting requirements.

[87] Copy of amendment to S. 1119, attached to a letter from Smith to Rouse in Boundary Legislation file. e. The "program" Smith identified consisted entirely of what Larson and a few others had done as volunteers in collecting baseline information for monitoring the lake, an effort that one draft of the resource management plan (Spring 1981) stated as coming to an end in August that year.

[88] [James W. Larson] Executive Briefing, Research Activities on Crater Lake, 1/8/82; Larson, Crater Lake Research Planning Meeting, 1/27-28/82, Corvallis. He explained (p. 1) that such a meeting had been conceived in August 1981, presumably because Douglas Larson's work on baseline characteristics of Crater Lake was due to conclude that summer. James Larson's position as regional chief scientist came about when Field (who had been associate regional director for science and technology) left the regional office for a position with the CPSUs. For the origin of regional chief scientists in the NPS, see Sellars, *Preseving Nature in the National Parks*, pp. 228-229.

[89] Hypotheses can be found on pp. 10-11 of the research planning meeting document. Other recommendations related to protocol, the availability of a research boat, year-round observation and data gathering in order to obtain information on seasonal variation, and annual meetings (presumably among scientific peers) on research activities.

[90] Larson interview, pp. 35-37. Most of the training went to Mike Gillmore, who was hired as a biological technician to collect data, process samples in the lab, and maintain equipment; Larson, Annual Report on the Limnology and Water Quality Program at Crater Lake National Park, 1982 (1/10/83), p. 5, Park Library.

[91] P.L. 97-250; see Cathleen Frank (comp.), Legislative History for Crater Lake National Park, April 1986, vol. II, p. 283, NPS Pacific Northwest Regional Library for a summary of the history.

[92] John Salinas interview, CLNPOHS, 4/7/98, p. 13.

[93] Larson et al., Crater Lake Limnological Studies 1982, [February 1983], p. 19, Park Library.

[94] Richard Axler, Stanford Loeb, and John Reuter to Douglas Larson, 2/28/83, in Appendix V of Crater Lake Limnological Studies 1982. Loeb and Reuter's comparative work included Crater Lake; see "The epilithic periophyton community in a five-lake comparative study of community productivity, nitrogen metabolism and depth distribution of standing crop," *Verh. Internat. Verin Limnol.* 21 (July 1981), pp. 346-352.

[95] Larson, Crater Lake Limnological Studies 1982, p. 12.

[96] The baseline work included estimating primary production, sampling the chemistry of certain nutrients, examination of horizontal patchiness in chlorophyll concentrations, as well as gauging the phytoplankton and temperature effects on a species of diatom in the surface waters of Crater Lake; SAR 1983, p. 10.

[97] Dahm, Crater Lake Limnological Study in Jean Mathews (ed.) 1983 Annual Science Report, NPS, Pacific Northwest Region, pp. 4-5; see also Larson and Dahm, Crater Lake Limnological Study, in the 1983 annual report for the CPSU at OSU, p. 11. Summaries of findings from the various studies conducted that summer appeared in Larson, Crater Lake Limnological Studies 1983 [March 1984], pp. 18-21. One spring located below Rim Village emitted roughly ten times more nitrogen than other caldera springs tested by scientists; Larson, "Probing the Depths of Crater Lake," p. 313. Discovery of what came to be known as Spring 42 convinced Larson more than ever that what was dubbed as the "sewage hypothesis" ought to be tested; Larson, "Probing the Depths of Crater Lake," *American Scientist* 90:1 (January-February 2002), pp. 70-71. He had in mind Waldo Lake, where increased productivity in this ultraoligotrophic body of water raised similar questions. See Larson and Donaldson, Waldo Lake, Oregon: A Special Study, Water Resources Research Institute, May 1970, and John R. Tilstra, et al., A Study on Disposal of Campground Wastes adjacent to Waldo Lake, Oregon, Working Paper #7, National Eutrophic Research, February 1973.

Both are cited in Larson, "Waldo Lake, Oregon: Eutrophication of a rare, ultraoligotrophic, high mountain lake," *Lake and Reservoir Management* 16:1-2 (2000), pp. 2-16.

[98] Dymond, Particle fluxes in Crater Lake and their relationship to water clarity, in Matthews (ed.), Annual Science Report, pp. 7-8. Dymond did, however, acknowledge that the discovery of high nutrient levels and coliform bacteria in three springs entering Crater Lake as the most important finding from studies conducted in 1983; Dymond to Forbes, 12/14/83, pp. A5-A6 in Larson, Crater Lake Limnological Studies 1982.

[99] Larson, Crater Lake Limnological Studies 1982, p. 13; see also the report for 1983, p. 1. The second seasonal biotech was John Salinas, at the time an OSU graduate student, while Gerry McCrea filled the permanent position. The NPS also furnished Larson with an additional $10,000 for his administrative and clerical expenses.

[100] For additional background on how the limnological program at Crater Lake reflected many of the changes that occurred in NPS resource management and research from 1980 to 1993, see Sellars, *Preserving Nature in the National Parks,* pp. 262-271. The writer is grateful for the details supplied by Jarvis and his successor Jim Milestone about the shift in support of natural resource management and research took place at Crater Lake; Jarvis to Mark, 2/5/03, and Milestone to Mark, 1/28/03, electronic mail in park historian's possession.

[101] Larson, Crater Lake Limnological Studies 1983, p. 9.

[102] SAR 1983, p. 10.

[103] Gary Larson to Steve Mark, electronic mail in park historian's possession, 2/26/03. Larson's previous work on Oregon lakes included "Sand content of the sediments in three sand dune lakes in Oregon, USA," *Archiv fur Hydrobiologie* 75 (1975), pp. 240-252. He also authored (with Gerald E. Davis) Sediment Characteristics and the Trophic Status of Four Oregon Lakes, project completion report, Water Resources Research Institute, OSU, 9/1/76.

[104] Benton realigned duties in resource management a few months after his arrival. Jarvis thus coordinated all park research and resource management, while Forbes moved to being a "chief of operations" in charge of "visitor protection and the implementation aspects of resource management;" Jarvis, Organizational Meeting on the Status of Crater Lake Limnological Studies, 10/24/84 (draft of December 1984), p. 1. According to the park's organizational chart, both Jarvis and Forbes were supposedly supervised by the chief ranger, but in reality Jarvis reported directly to the superintendent.

[105] Larson first raised the sewage question publicly in 1981 and found himself at odds with Rouse's quotes in several newspaper articles; "Crater Lake's Boss Disputes Sewage Theory," Medford *Mail Tribune* 12/15/81; "Crater Lake Losing its Clarity," Grants Pass *Courier*, 12/21/81. Rouse mentioned this exchange when prefacing his assessment of why Gary Larson was hired as principal investigator, stating "Doug had done some very good research, but it wasn't the same direction we were going in the ten year [monitoring] program. He probably felt he was left out. I remember a meeting with Jim Larson. We felt that the way Doug was oriented was not the course we believed was needed for Crater Lake." See Rouse interview, CLNPOHS, 9/18/97, p. 26.

[106] SAR 1984, p. 1; this was Benton's first attempt at discrediting Douglas Larson in the wake of the latter's publication of "The Crater Lake Study: Detection of possible optical deterioration of a rare, unusually deep caldera lake in Oregon, U.S.A.," *Verh. Internat. Verein. Limnol.* 22 (July 1984), pp. 513-517. Benton would go so far as to question several years later whether Larson represented the Army Corps of Engineers (his employer) in a letter to Larson's supervisor, something that became public; Robert Sterling, "Letter to Corps angers scientist," Medford *Mail Tribune* 12/1187. Larson, in continuing to co-author papers about Crater Lake on his own time may have unknowingly precipitated Benton's query to the Corps; see, for example, "Vertical partitioning of the phytoplankton assemblage in ultraoligotrophic Crater Lake, Oregon,

USA," *Freshwater Biology* 18 (1987), pp. 429-442. What may have served as the spark was an editorial that Benton suspected Larson to have written; "Save Crater Lake's Clarity," Eugene *Register Guard* 9/9/87.

[107] Jarvis, op. cit., p. 4.

[108] Gary Larson, Crater Lake Limnological Studies 1984 [July 1985], p. 51. Rationale for the study is in Larson, "Limnological Studies in Crater Lake National Park," in Marshall Flung (ed.), *Toward the Year 2000: Conference on Science in National Parks*, Proceedings v. 3, p. 79. A tentative start toward some understanding of paleolimnological conditions was made by C. Hans Nelson through dredging samples from the lake floor in 1984; Nelson, Geologic History of the Floor of Crater Lake, in Jean Matthews (ed.), 1984 Annual Science Report, Pacific Northwest Region, pp. 5-6.

[109] C. David McIntire to Gary Larson, 5/28/85, p. 1, in Appendix 1 of Larson, Crater Lake Limnological Studies 1984. Other panelists included Clifford Dahm (University of New Mexico), Ray Herrmann (NPS Water Resources Division), Stanford Loeb (University of California, Davis), and Richard Petersen (no affiliation given).

[110] Dymond to Gary Larson, 7/2/85, p. 2, in Appendix 1 of Larson, Crater Lake Limnological Studies 1984.

[111] Larson, Crater Lake Limnological Studies 1985 [July 1986], p. 2. The conceptual model is treated in more detail on pp. 31-39. If the limnological program gained an expanded scope in 1985, its immediate effect at the park was limited. Douglas Larson continued to visit Crater Lake that summer to share data with Gary Larson and help conduct an independent investigation of the lake's optical properties. Other investigators launched special studies of benthic (deep water) macroinvertebrates, the abundance and distribution of fish, and the ecology of two surface streams located away from the caldera that bore evidence of sewage contamination. All three studies went no further than writing a report (see the first two appendices in Limnological Studies 1985 and Stan Gregory, et al., Ecology of Streams in Crater Lake National Park, a CPSU report that first appeared in January 1987). Perhaps more long lasting was the building of a boathouse on Wizard Island that summer, one intended to house research vessels and equipment. The only staffing change on the lake came in the spring, when Larson hired a graduate student at OSU, Mark Buktenica, to replace the departed Gillmore as the seasonal biotech.

[112] Larson, Crater Lake Limnological Studies 1986 [August 1987], p. 2.

[113] Peter Fontana, Lake Color, in Larson, Crater Lake Limnological Studies 1986, p. 71.

[114] Dymond and Collier, Particle Flux and Hydrothermal, in Larson, Crater Lake Limnological Studies 1986, pp. 71-79.

[115] Jarvis to Mark, electronic mail in park historian's possession, 2/5/03; mention of the boathouse as a priority is in SAR 1985, p. 2. Sampling required a separate planning effort; see Position Statement and Operational Plan written by Jarvis and attached to a transmittal from Benton to the acting regional director, 11/13/85, N3043 in park historian's lake research files.

[116] USDI-NPS, Interim Report to Congress on Presence or Absence of Significant Thermal Features in Crater Lake National Park, September 1989, pp. 1-2. The legislation consisted of a rider (Section 115) to the Interior Appropriations Bill (P.L. 99-591). Lists were published in the Federal Register of February 13 and August 3, 1987.

[117] Section 7 of P.L. 100-443, enacted September 22, 1988.

[118] House Report 100-664, p. 6.

[119] Jenni Hill, "'Mining' Crater Lake for energy debated," Portland *Oregonian* 10/6/84, and "Drilling for Energy Approved, Portland *Oregonian*, 12/5/84.

[120] The NPS expressed its concern by requesting that drilling be delayed until it was demonstrated by geological analysis that Crater Lake would not be affected by geothermal exploration; Regional Director Daniel Tobin quoted in Marc Prevost, "Hotspot: Crater Lake National Park," *Oregon Conifer* (December 1985), pp. 11-12. Conservation groups did more to publicize the controversy; see, for example, "Geothermal Testing Set for Crater Lake Area," *National Parks* 59 (March/April 1985), p. 39.

[121] Jim Kadera, "Geologist eager to get into hot water," Portland *Oregonian* 10/23/86, p. D12. The other two locations were near the Newberry Caldera in Deschutes County.

[122] SAR 1986, p. 2. The immediate fears about drilling impacts related to possible effects on Crater Lake, but future development had the potential to create visual and noise impacts if experienced from Rim Drive or high points in the park.

[123] The meeting gave two investigators a forum to present their findings based on some hydrological analysis that regional groundwater flow was away from Crater Lake. Drilling outside the park, in their opinion, would have no effect on the lake nor the caldera; Edward A. Sammuel and Sally Benson, "An analysis of the hydrologic effects of proposed test drilling in the Winema National Forest near Crater Lake, Oregon," *Geothermal Resource Council Transactions* 11 (1987), pp. 293-303. This was cited by Joseph LaFleur [Cal Energy geologist], for his own purposes; see "Crater Lake Hot Springs: A Product of Model Mania," [1987], pp. 7-9, and Crater Lake Fact Sheet, [1988], p. 1, both in Park Historian's file. The meeting was summarized by Peter James Spielmann, "Scientists debate Crater Lake drilling," Medford *Mail Tribune*, 3/15/87, p. 16C.

[124] "Crater Lake 'springs' debates heat up," Portland *Oregonian* 2/27/87.

[125] "Geothermal permit revised to allow work on Winema," Klamath Falls *Herald and News* 7/9/87; SAR 1987, pp. 3-4. Details about the appeal are in "Sierra Club blasts geothermal drilling," Klamath Falls *Herald and News* 9/22/87, p. 3.

[126] "Phantom sub hunts Crater Lake secrets," Portland *Oregonian* 8/12/87. It is unclear whether Dymond referred to production or test wells. Collier said only if more were known about the importance and role of input by hot springs in Crater Lake, then perhaps a prediction of effects caused by drilling could be made; "Scientists start lake research," Medford *Mail Tribune* 8/11/87. David L. Williams, the scientist who co-authored the first paper with Von Herzen in 1983 on possible vents in Crater Lake, believed that the drilling of test wells could have no effect on the lake; "Mining Crater Lake for energy debated," Portland *Oregonian* 10/6/84. Some environmentalists, on the other hand, made a point of publicizing damage to geysers and other thermal features stemming from drilling; Elizabeth M. Dodd, "The Geothermal Steam Act: Unlocking its Protective Provisions," in David Simon (ed.) *Our Common Lands: Defending the National Parks* (Washington, DC: Island Press, 1988), pp. 426-427.

[127] Collier and Dymond, Studies of Hydrothermal Processes in Crater Lake: A Preliminary Report of Field Studies conducted in 1987 for Crater Lake National Park, und. [9/18/87], p. 6. Collier likened the evidence to a fingerprint rather than a photograph; "Lake Watchdog unveiled," Klamath Falls *Herald and News* 8/11/87. Caution on the part of Dymond and Collier, however, prevented the immediate release of video footage; Jeff Bernard, "Hot Springs? Crater Lake Scientists still not sure," Medford *Mail Tribune* 8/13/87. One vent had indeed been recorded on the footage, though its location could not be pinpointed with much accuracy.

[128] Assistant Secretary, Land and Minerals Management, and Assistant Secretary, Fish and Wildlife and Parks to Secretary (Donald Hodel), fax containing USGS findings, 11/24/87. The USGS played a critical role in evaluating hydrothermal studies according to procedures in an interagency agreement initially drafted by BLM in order to implement the Department of the Interior and Related Agencies Appropriations Act in Regard to Geothermal Leasing.

[129] Jeff Barnard, "Crater Lake energy project could be cooked," Portland *Oregonian* 1/21/88; Mary Wessling, "Plan would protect Crater from drilling," Medford *Mail Tribune* 1/28/88. LaFleur, in his "Crater Lake fact sheet," made the claim that the NPS sent the draft report to Barnard. The document, however, became freely available after the joint meeting of the American Geophysical Union and the American Society of Oceanography and Limnology in New Orleans; see John Enders, "Scientists end thermal vent search on Crater Lake," Medford *Mail Tribune* 8/16/87, p. 4A.

[130] Mary Wessling, "Crater Lake bill gets OK," Medford *Mail Tribune* 5/25/88. The wording is in the *Congressional Record* for June 13, 1988, on H. 4163; see p. 622 of M.E. Bartholomew (comp.) Legislative History for Crater Lake National Park, vol. IV, NPS Pacific Northwest Regional Library, Seattle, 1990.

[131] The final bill dropped the House language that identified the USGS as the agency to provide an analysis regarding the presence or absence of vents. See the Senate report on the House amendment, p. S11255 of the *Congressional Record* for August 9, 1988 (p. 646 in Bartholomew) and section 7 of P.L. 100-443 (p. 660 in Bartholomew). The definition of "significant" is in the House Report 100-664, p. 10 (p. 609 in Bartholomew).

[132] "Crater Park authorities miss geothermal report deadline," Medford *Mail Tribune* 3/24/89, p. 3A.

[133] Goldman, et al., Peer Review of Research Program and Recommendations for Additional Investigation of Possible Hydrothermal Activity, July 1989, p. 1.

[134] USDI-NPS, Interim Report to Congress on Presence or Absence of Significant Thermal Features in Crater Lake, September 1989, pp. 1-6.

[135] Collier and Dymond, Studies of Hydrothermal Processes in Crater Lake: A Report on Field Studies Conducted in 1988 for the NPS, OSU College of Oceanography Ref. #89-2, 3/22/89, p. 4. See also Robert Sterling, "Sub dive finds no lake vent," Medford *Mail Tribune* 8/24/88, p. 18A; Lee Juillerat, "LaFleur not swayed by lake investigation," Klamath Falls *Herald and News* 8/29/88. Dymond and Collier maintained that the mats, lithified crust, and pebbles (which are relatively common in the south basin study area) do not occur in other parts of the lake. This observation is in Appendix 2 of the Responses to the List of Recommendations from the Peer Review Panel on the Proposed Research, pp. 4-5 [attached to the Interim Report].

[136] Collier and Dymond, Studies of Hydrothermal Processes in Crater Lake: A proposal for a third year of research conducted for the National Park Service through the Cooperating Park Studies Unit, Oregon State University [attached to Interim Report to Congress], p. 5.

[137] "Panel upholds steam drilling," Medford *Mail Tribune* 2/26/89, p. 6A. The main issue concerned whether Cal Energy needed to recapture drilling fluids while deepening two test holes, one being near Mount Scott whose temperature encouraged further exploration; Lee Juillerat, "Drilling to Resume Outside of Crater Lake National Park," Klamath Falls *Herald and News*, 2/23/89, pp. 1-2. Conservation groups feared that the drilling fluids might harm the waters of Crater Lake; "Drilling questions raised by Sierra Club," Klamath Falls *Herald and News* 4/6/89.

[138] "Geothermal drilling resumes," Medford *Mail Tribune* [und., July 1989], p. 3A. The announcement from Cal Energy came on May 16, two weeks after the peer review in Corvallis; "Exploratory drilling to resume near Crater Lake," Medford *Mail Tribune* 5/17/89, p. 3A. At least one reporter linked the two events; Robert Sterling, " Sub to resume research in Crater Lake," Medford *Mail Tribune* 7/24/89.

[139] Park staff saw the submersible dives as an opportunity for a major public relations promotion for the agency as a whole, provided dealings with the press were orchestrated properly. See Briefing Paper, Hydrothermal Research Program, Press Plan, p. 1, attached to press releases of July 27, and August 1, 1989, in submarine file, Historian's office. These assisted reporters in writing stories like one on the UPI wire, "Park Service dives into Crater Lake to stop development," Eureka *Times Standard* 8/1/89, p. 5.

Placing a submersible into Crater Lake also involved a complex logistical effort on the part of park staff that greatly exceeded what limnological monitoring required. It included a large helicopter in 1988 and an Erikson sky crane the following summer in addition to frequent shuttling of supplies and samples to and from Wizard Island; Jim Milestone to Steve Mark, electronic mail in park historian's possession, 1/28/03.

[140] "Mystery fluid found on bottom of Crater Lake," Medford *Mail Tribune* 8/11/89, p. 3A; Lisa Strycker, "'Bizarre' pool found in lake," Eugene *Register Guard* 8/12/89, pp. 1B-2B. There was evidence for such a link, given how the "Bathtub" contained dissolved mineral salts having very high levels of radon gas.

[141] "Pitch-black mud hoisted from Crater Lake floor," Portland *Oregonian* 8/17/89.

[142] Jim Milestone, "Latest Discoveries in Crater Lake," NPS press release of 8/23/89; Robert Sterling, "Deep Rover submarine ends up in hot water," Medford *Mail Tribune* 8/24/89, p. 3A; Richard Hill, "Crater Lake lower area measures 'hot' at 64 F," Portland *Oregonian* 8/25/89, p. D1. See also SAR 1989, p. 2.

[143] Press release, California Energy Company, Incorporated, and American Pacific Power Corporation, 9/3/89; David Perlman, "Furor Erupting Over Exotic Finds Deep in Crater Lake," San Francisco *Chronicle* 9/4/89.

[144] Robert Shotwell, "Initial geothermal drillling out of steam," Portland *Oregonian* 3/14/90.

[145] Lee Juillerat, "Testing of geothermal wells to continue near Crater Lake," Klamath Falls *Herald and News* 3/13/90, pp. 1-2, and Juillerat, "Geo test wells by Crater Lake still in firm's plans," Klamath Falls *Herald and News* 12/13/90. See also "Geothermal Tests Eyed," Medford *Mail Tribune* 12/15/90.

[146] Mark Freeman, "Crater Lake Decision wins praise," Medford *Mail Tribune* 2/17/91, p. 1A.

[147] One of the layoffs targeted LaFleur, though this came just two weeks after an equity deal led to the replacement of CEO Charles Condry. See Gavin Power, "California Energy Replaces Its CEO," San Francisco *Chronicle* 2/21/91, p. C3; "California Energy cuts 2 of 3 Portland posts," Bend *Bulletin* 3/7/91; "Geothermal company drops two workers, eyes markets elsewhere," Medford *Mail Tribune*, 3/9/91.

[148] The boundaries of Newberry National Volcanic Monument were drawn so as to accommodate possible geothermal development. Dedication of the monument in 1991 culminated a process to formally establish it that began in 1986; "Boundary agreement Ok'd for Newberry national monument," Klamath Falls *Herald and News* 2/24/89, p. 7; "Not Crater Lake, it's Newberry....the West's newest national monument," *Sunset* (July 1991), pp. 24-25; "Newberry geo plan proposed," Klamath Falls *Herald and News* 9/4/91; Robert E. Shotwell, "Geothermal exploration suspended," Portland *Oregonian* 9/6/91.

[149] Jackie Clark, Acting Chief, Lands and Minerals Adjudication Section, Oregon State Office, BLM, to CLNP, received 3/21/94, attached to Clark's correspondence accepting relinquishment from Cal Energy, 3/15/94, Geothermal drilling file; Bill Manny, "Crater geoplant canceled," Medford *Mail Tribune* 2/10/93, p. 1A. The leases had been issued non-competitively in 1984 by BLM, in accordance with provisions in the Geothermal Steam Act of 1970. Under this legislation, geothermal leases had a primary term of ten years, after which they expired unless commercial quantities of steam were produced or the lessee diligently pursued drilling operations; Dodd, "The Geothermal Steam Act, Unlocking its protective provisions," in Simon (ed.) *Our Common Lands*, p. 429.

[150] Lujan to Hon. J. Danforth Quayle, President of the Senate, 2/11/93, and Lujan to Hon. Thomas S. Foley, Speaker of the House, same date, geothermal drilling file, Historian's office.

[151] BLM inadvertently handed the NPS an avenue to marginalize 13 pages of comments on the draft report of hydrothermal studies conducted in 1989. It recommended that a public comment period for the final report to Congress when it suspended the Cal Energy leases in February 1991; "BLM stops drilling by Crater Park," Medford *Mail Tribune* 2/16/91. The NPS brushed the recommendation aside due to the

alleged urgency of sending a final report to Congress but at the same time categorized BLM's comments as "public participation in the decision making process," yet nowhere did it reference the comments when the final report went to Lujan. Correspondence at the regional and national levels indicated an increasingly rancorous relationship between the two bureaus over the issue; [NPS] Regional Director, PNR, to State Director, BLM, State of Oregon, 7/1/91, N3039 Draft Report on Presence or Absence of Significant Thermal Features in Crater Lake National Park. It was attached to a memo from James Ridenour (NPS) to Cy Jamieson (BLM), 5/23/91, L54 Report to Congress on Crater Lake thermal features, and D. Dean Bibles (BLM) to Charles Odegaard (NPS), 6/26/91, 3200 Draft Report on Presence or Absence of Significant Thermal Features. Acrimony between NPS and BLM over drilling extended back several years; Jeff Barnard, "BLM says lake study faulty," Medford *Mail Tribune* 5/6/88.

[152] The USGS researcher concluded, "the research program at Crater Lake has demonstrated an influx of thermal water that is important to lake dynamics. The characteristics of this thermal water and its impact on lake dynamics remain imperfectly understood;" Manuel Nathenson, Review of studies concerning the presence of thermal water in flows into Crater Lake, in USDI-NPS, Report to the Secretary, September 1992, p. 17. Reviewers at the meeting in Corvallis cautioned that the evidence was thermal and geochemical. Although the slightly warmer and more saline water found near the bacterial mats contained an isotope signifying a magmatic source leaking into Crater Lake, the geological context of those fluids remained unknown. See Charles Goldman, et al., Peer Review of Research Program and Draft Report on Studies of Hydrothermal Processes in Crater Lake, Oregon, March 1991, pp. 35-37 in USDI-NPS, Report to the Secretary. Goldman and his colleagues reviewed the draft report on 1989 field studies by Collier, Dymond, and James McManus dated 10/26/90. The trio went on to produce a final report dated 5/31/91 whose executive summary stated Crater Lake has hydothermal inputs and that the input dominates the flux of dissolved chemicals in the lake, thereby making the hydrothermal process highly significant. This argument was presented in an abbreviated form; see Jack Dymond, et al., "Bacterial mats from Crater Lake, Oregon and their relationship to possible deep lake hydrothermal venting," *Nature* 342:6250 (12/17/89), pp. 673-675.

[153] Even when the company attempted to take the offensive, most notably by conducting a simulation for reporters on what an operating geothermal plant would sound like, the prospect was dubbed a "ghetto in the woods." See, for example, Richard L. Hill, "Simulation of geothermal plant seeks to gain public support," Portland *Oregonian* 8/4/88, p. 3B, and Lee Juillerat, "Listen to a 'ghetto in the woods'" Klamath Falls *Herald and News* 8/4/88, p. 2. This took place simultaneously with the final submersible dives, characterized as "oceanography in a tea cup," Richard L. Hill, "Crater Lake: Tea cup Oceanography," Portland *Oregonian* 8/7/88, p. E6.

[154] Lee Juillerat, "Sub on Crater Lake wish list," Klamath Falls *Herald and News* 9/6/89, p. 2.

[155] Richard L. Hill, "Deep lakes' secrets unlocked," Portland *Oregonian* 10/4/90, pp. 1-2B; Robert Sterling, "Soviets vow to protect lakes," Medford *Mail Tribune* 9/29/90, p. 1A; Lee Juillerat, "From 'Kreyter ^eyk' with love," Klamath Falls *Herald and News* 9/30/90, pp. 1-2. Benton hoped that some "mutual agreement" might develop between scientists at Crater Lake and Lake Baikal, but this did not come to fruition due to the "concerns" of the Washington Office; SAR 1990, p. 3. An informal "exchange" continued for several years afterward, with NPS aquatic biologist Mark Buktenica participating in a visit to Lake Baikal in 1991. Two Russian scientists returned to Crater Lake in 1993 to study zooplankton and attempting to replicate Jackson and Faller's ecological study on Wizard Island; Lee Juillerat, "Russians hurry studies," Klamath Falls *Herald and News* 8/20/93, pp. 1-2, and SAR 1993, p. 3.

[156] For a concise and entertaining summary of the submersible studies, see Mark Buktenica, "Journey to the Bottom of the Lake: Results & Personal Observations from Studies Conducted by Submarine in Crater Lake, 1988-89," *Journal of the Shaw Historical Library* 15 (2001), pp. 103-109. Life in the lake's deep water is discussed by C. David McIntire, et al., "Vertical Distribution of a Deep-Water Moss and Associated Epiphytes in Crater Lake, Oregon," *Northwest Science* 68:1 (1994), pp. 11-21.

[157] In contrast to the 1970s and early 1980s, however, only a couple of reports were printed under the auspices of the CPSU. See, for example, Elena N. Karnaugh, Structure, Abundance and Distribution of Pelagic Zooplankton in Crater Lake, Oregon, [1988], CPSU/OSU 88-3, and Robert Collier, et al., Geochemistry and Phytoplankton Studies of Crater Lake, CPSU/OSU 88-5. At least two master's theses and doctoral dissertation resulted from the ten year limnological program. These included John Salinas, A Critical Comparison of Methods for the Determination of Phytoplankton Chlorophyll [1988], Mark W. Buktenica, Ecology of Kokanee salmon and rainbow trout in Crater Lake, a deep ultraoligotrophic caldera lake [1988], and James McManus, On the chemical and physical limnology of Crater Lake, Oregon [1993].

[158] Ellen T. Drake, "Introduction," in Drake, et al. (eds.), *Crater Lake: An Ecosystem Study* (San Francisco: Pacific Division, AAAS, 1990), p. 5. This volume contained 18 articles and focused on the lake and geological processes affecting it, in line with the traditional application of the ecosystem concept. For a subsequent extension of the concept across the park and adjacent lands, see James F. Milestone, "Geographic Description of the Greater Mount Mazama Ecosystem," in William E. Brown and Stephen D. Veirs, Jr. (eds.) *Partners in Stewardship: Proceedings of the Fourth Conference on Research and Resource Management in National Parks and Protected Areas* (Houghton, MI: George Wright Society, 1993). Milestone applied ideas advanced by "conservation biologists" of the time who advocated an integrated system of large nature reserves were necessary to protect biological diversity, especially in terrestrial environments.

[159] Douglas Larson, et al., "Limnological Response of Crater Lake to Possible Long-term Sewage Influx," in Drake, et al., pp. 197-212. Gary Larson's model is included in his article, "Status of the Ten-Year Limnological Study of Crater Lake National Park," pp. 7-18, same volume. The model was first presented in the annual report for the limnological program in 1985.

[160] Goldman expressed the hope that "careful study by the diversity of scientists represented at this symposium" would lead to an effective management strategy that might protect the lake in perpetuity. See "Summary of Crater Lake studies and comparison with the early stages of eutrophication of Lake Tahoe," in Drake, et al., same volume, p. 220.

[161] Doug Larson pointed to this hypothesized relationship on numerous occasions; a diagram showing the location of the leach field in relationship to Spring 42 is in Larson, et al., "Limnological response..." in Drake et al., same volume, p. 206.

[162] Stan Gregory, et al., Ecology of Streams in Crater Lake National Park, final report 10/30/87, p. 80.

[163] Gary Larson to Steve Mark, electronic mail in park historian's possession, 2/26/03. The recommendation was almost immediately adopted by NPS planners; USDI-NPS, Crater Lake National Park Mazama Campground/Rim Village Corridor, Supplement to the 1984 Environmental Assessment/Development Concept Plan, October 1987, p. 57.

[164] An editorial started the exchange; see Douglas Larson, "Decades of stalling muddied Crater Lake," Portland *Oregonian* 5/24/92, p. 1B. This was followed by "Scientist renews his claim that sewage taints Crater Lake," Medford *Mail Tribune* 5/25/92, p. 3A; Lee Juillerat, "Crater Lake claims denied," Klamath Falls *Herald and News* 5/28/93, pp. 1-2; "Park chief denies sewage entering Crater Lake," Portland *Oregonian* 5/29/92. A previous article by Alston Chase contained the same thesis later voiced by Larson directly; "Politics add to murky Crater Lake issue," Portland *Oregonian* 10/17/89.

[165] Douglas Larson to George Miller, 6/25/93, p. 2, copy in research file. The letter was apparently in response to the NPS release of a draft summary for the mandated ten-year report. Larson disagreed with the NPS contention (as quoted in press accounts and trumpeted by Morris) that "Except for consequences of fish introductions, no long-term change caused by human activities could be identified or separated from those caused by natural phenomena...No changes are evident in water chemistry or quality." See Betty Brickson, "A clear bill of health..." Portland *Oregonian* 5/5/93, p. 1B, and Lee Juillerat, "Crater Lake still

clear," Klamath Falls *Herald and News* 5/6/93, pp. 1-2. For more detail about the exchange from Larson's perspective, see his interview in the CLNPOHS, pp. 46-47 and 55-56.

[166] Notes from program review, 2/27/93. Hermann and Loeb quoted in concluding portion of the writer's transcript, lake research file.

[167] Loeb's recommendations for promoting a long-term monitoring program subsequently appeared in Gary Larson, et al., "Long-term Monitoring Program," in Larson, et al. (eds.), Crater Lake Limnological Studies Final Report, Technical Report NPS/PNROSU/NRTR-93/03, July 1993, p. 722.

[168] SAR 1992, p. 6; Pati O'Connor, "Crater Lake bill introduced," Klamath Falls *Herald and News* 1/27/93. For more detailed justification for an extended monitoring program, see Gary Larson, "10 Year Study of Crater Lake underscores need for long term monitoring program," *Park Science* 14: 1 (Winter 1994), p. 1, 28.

[169] Bill Manny, "Crater fish study continues," Medford *Mail Tribune* 7/28/93, p. 4A; Dennis Fenn to Gary Larson, 10/20/93 (e-mail message); SAR 1993, p. 4. The $160,000 addition to the park's "base" budget was aimed at an additional position (an aquatic biologist) and costs associated with support from OSU. Hiring the biologist was deferred until 1995 in order to pay for a new research vessel called the *Neuston*.

[170] The decline can be attributed to the absence of a hydrothermal question that had driven so much research during the late 1980s, as well as reorganization within the NPS. The latter event spelled an end to the regional office in Seattle and its ability to direct large chunks of funding to specific projects at Crater Lake. A contracted study of petroleum hydrocarbon contamination by OSU scientists began in 1995, however, and cost $80,000 over a two year period; Benjamin F. Ladd, Superintendent, to Regional Director, PNR, 1/13/95. It aimed at quantifying the introduction of residues associated with boat operations and appeared in 1998 as: Daniel R. Oros, et al., Investigation of the Extent and Significance of Petroleum Hydrocarbon Contamination in Crater Lake, Crater Lake National Park, Oregon, USA.

Published research from the limnological program in the park during the 1990s totaled 17articles, though six of them appeared in a special issue of the *Journal of Lake and Reservoir Management* (12:2) in July 1996 which were selected contributions derived from the ten-year report. These included: G.L. Larson, "Development of a 10-year Limnological Study of Crater Lake," Larson, et al., "Temperature, Water Chemistry, and Optical Properties of Crater Lake," P.O. Nelson, et al., "Chemical Solute Mass Balance of Crater Lake, Oregon," C.D. McIntire, et al., "Taxonomic Structure and Productivity of Phytoplankton Assemblages in Crater Lake, Oregon," Larson, et al., "Zooplankton Assemblages in Crater Lake, Oregon, USA," and M.W. Buktenica and Larson, "Ecology of Kokanee Salmon and Rainbow Trout in Crater Lake, Oregon." The remaining articles were spread among five different journals. These citations include: M.K. DeBacon and C.D. McIntire, "Taxonomic structure of phytoplankton assemblages in Crater Lake, Oregon, USA," *Freshwater Biology* 25 (1991), pp. 95-104; James McManus, et al., "Physical Properties of Crater Lake, Oregon: A Method for determination of a conductivity- and temperature-dependent expression for salinity," *Limnology and Oceanography* 37:1 (January 1992), pp. 41-53; McManus, et al., "Mixing Processes in Crater Lake, Oregon," *Journal of Geophysical Research* 98:C10 (10/15/93), pp. 18295-18307; McIntire, et al., "Vertical Distribution of a Deep-water Moss and Associated Epiphytes in Crater Lake, Oregon," *Northwest Science* 68:1 (1994), pp. 11-21; Gary L. Larson, "Overview of the Limnological Program of Crater Lake," *Northwest Science* 70:2 (1996), pp. 39-47; McManus, et al., "Spatial and temporal distribution of dissolved oxygen in Crater Lake, Oregon," *Limnology and Oceanography* 41 (1996), pp. 722-731; Jack Dymond, et al., "Unbalanced particle flux budgets in Crater Lake, Oregon: Implications for edge effects and sediment focusing in lakes," *Limnology and Oceanography* 41 (1996), pp. 732-743; G.B. Crawford and R.W. Collier, "Observations of a deep-mixing event in Crater Lake, Oregon," *Limnology and Oceanography* 42:2 (1997), pp. 299-306; Larson and Mark W. Buktenica, "Variability of Secchi disk readings in an exceptionally clear and deep caldera lake," *Arch. Hydrobiol.* 141:4 (1998), pp. 377-388; C. Geoffrey Wheat, et al., "Hydrothermal fluid circulation through the sediment of Crater Lake, Oregon: Pore water and heat flow constraints," *Journal of Geophysical Research* 103:B5 (5/10/98), pp.

9931-9944; and David L. Peterson, et al., "Detecting Long-Term Hydrobiological Patterns at Crater Lake, Oregon," *Northwest Science* 73:2 (1999), pp. 121-130.

[171] Charlene Gurr, et al., Personnel Management Evaluation, Crater Lake National Park, August 24-28, 1992, p. 4. Brief mention of a split in the former Resource Management and Visitor Protection division is in SAR 1992, p. 5, with no comment as to whether a separate division came in response to increased research responsibility or as part of a larger trend in the NPS. It took place without incorporating staff assigned to cultural resource management, despite the recommendation to that effect.

[172] Grade levels (the hierarchy associated with pay) were instead based on the perceived complexity of duties associated with resource management. By the end of the decade, permanent staffing in the natural resources management division (which once consisted of the resource management specialist and the aquatic biologist) had grown to six. The other four positions were the aquatic biologist funded by the professionalization initiative, a "terrestrial" biologist, a geographic information systems specialist, and a part-time program assistant.

[173] Ed Starkey and Gary Larson to PNR Superintendents, electronic mail in park historian's lake research file, 10/27/93.

[174] Leading the monitoring effort was Mark Buktenica, whose tenure at Crater Lake began in 1985 as a biotechnician. Eventually promoted to aquatic biologist and then aquatic ecologist, Buktenica proved himself capable of coordinating the operational aspects of the monitoring program as well as an investigator. Scott Girdner began assisting Buktenica as aquatic biologist in 1985. Suzan Poole worked on a term appointment as data manager for two years, starting in 2000. Funds for monitoring also paid a research assistant (Bob Hoffman) and a post-doctoral fellow (Scott Rumsey), both from OSU. Special studies continued, with OSU microbiologist Steve Giovannoni working on a project funded by the National Science Foundation to investigate the microbial "loop" and productivity in the lake, while William Warncke completed a master's thesis on the littoral (near-shore) zooplankton assemblage in 1998; [Buktenica, et al.,] Introductory Section, Crater Lake Long-term Limnological Monitoring Program Review, March 2000, (draft report).

[175] Jeffrey M. Dambacher, et al., Fishes and Stream Habitat in Tributaries of the Klamath River in Crater Lake National Park, with special reference to the Sun Creek Bull Trout, Technical Report, NPS/PNROSU/NRTR-93/17, December 1993. The two papers comparing eradication methods have the following citations: Mark Buktenica, "Bull Trout Restoration and Brook Trout Eradication at Crater Lake National Park, Oregon," in W.C. Mackay, et al. (eds.), *Friends of Bull Trout Conference Proceedings* (Calgary: Bull Trout Task Force, Alberta, 1997), pp. 127-135; and Buktenica, et al., "Response of a Residential Bull Trout Population to Nine Years of Brook Trout Removal, Crater Lake National Park, Oregon," in Dan Schill, et al. (eds.), *Wild Trout VII*, Proceedings of a conference held at Yellowstone National Park, October 2000, pp. 127-132. Some observations in a master's thesis at Oregon State College provided the initial spark for the bull trout project; see Orthello L. Wallis, Trout Studies and a Stream Survey of Crater Lake National Park, Oregon, 1948, copy in park library. Wallis also provided an update to work by C.H. Merriam in 1897; see A Study of the Mammals of Crater Lake National Park, Oregon, 1947, copy in park library.

[176] Most of the papers were technical in nature and thus of limited use for programs. For a list of papers by USGS authors from 1983 to 1992, see the attachment to the transmittal from Bacon to Steve Mark, 2/2/93, Historian's geological file. Bacon's article on the eruptive history of Mount Mazama served as a basis for the Crater Lake section in a popular guide by Stephen L. Harris, *Fire Mountains of the West: the Cascade and Mono Lake Volcanoes* (Missoula: Mountain Press, 1988). The book represented a main source of geological information for many seasonal interpreters, even though Bacon also produced a field guide for the park, "Mount Mazama and Crater Lake caldera, Oregon," for the Geological Society of America centennial in 1987 (pp. 301-306 of the proceedings in the Cordilleran section). He also revised the explanatory section by Howel Williams on a new edition of the USGS topographic map of the park and vicinity (1988).

[177] C. Hans Nelson, et al., "The volcanic, sedimentologic, and paleolimnologic history of the Crater Lake caldera floor, Oregon: Evidence for small caldera evolution," *Geological Society of America Bulletin* 106 (May 1994), pp. 684-704.

[178] Such comparisons have been made numerous times in the literature since Diller published his professional paper in 1902, but received only limited attention through interpretation at the park. For a recent comparison written in a popular style, see Tom McDonough, "Other Crater Lakes," *Nature Notes from Crater Lake* 31 (2000), pp. 29-34.

[179] Bacon, et al., *Volcano and Earthquake Hazards in the Crater Lake Region, Oregon,* Open-File Report 97-487 (Vancouver, Washington: USGS, 1997); Bacon, et al., "Late Quaternary slip rates and seismic hazards of the West Klamath Lake fault zone near Crater Lake, Oregon Cascades," *Geology* 27:1 (January 1999), pp. 43-46. J.F. Sato and Associates of Littleton, Colorado, prepared the seismic evaluations for the Warehouse and Superintendent's Residence at Park Headquarters, as well as the Watchman Lookout, but made no direct mention of the USGS work.

[180] Much of the funding was provided by a settlement agreement that resulted from a helicopter crash into Crater Lake on September 23, 1995; David Preszler, "Lake's mapping stars on Web site," Medford *Mail Tribune* 8/2/00, pp. 1A, 12A. See also Tom McDonough, Preliminary Results of a recent Sonar sounding of Crater Lake, NPS staff background information draft, April 2001, p. 1.

[181] James V. Gardner, et al., *Bathymetry and Selected Perspective Views of Crater Lake, Oregon*, USGS Water-Resources Investigations Report 01-4046, 2001. Charles R. Bacon, et al., "Morphology, Volcanism, and Mass Wasting in Crater Lake, Oregon," *Geological Society of America Bulletin* 114:6 (June 2002), pp. 675-692. The paper published in the GSA Bulletin included a section on the time it took to fill the lake, a topic initially addressed by F. Owen Hoffman, "The Filling of Crater Lake," *Nature Notes from Crater Lake* 30 (1999), pp. 10-13.

[182] The two reports were: Kurt Jenkins, et al., Ecology of Elk Inhabiting Crater Lake National Park and Vicinity, CPSU/OSU 88-2, February 1988; and Michael Swezy and James K. Agee, Prescribed Fire Effects in the Panhandle Area, Crater Lake National Park, CPSU/UW 89-1, Autumn 1988. The thesis by Christopher B. Chappell was titled: Fire Ecology and Seedling Establishment in Shasta Red Fir Forests of rater Lake National Park, Oregon, University of Washington, December 1991, and later served as the basis for Chappell to write an article with Agee, "Fire severity and seedling establishment in *Abies magnifica* forests, Crater Lake, Oregon," *Ecological Applications* 6 (1996), pp. 876-889.

[183] John Salinas, et al., Crater Lake National Park, Whitehorse Ponds Limnological and Vascular Plant Study, Report RCC-9404, July 1994. The only other project where a final report was produced was Thomas E. Robertson, An Ecological Assessment of Five Springs in Crater Lake National Park, Part I: Water Chemistry and Vegetation of Saturated Soils [1999]. Most other studies were simply progress reports that contained limited data.

[184] Approximately 700 plant taxa are found within the boundaries of the park; Peter Zika, Compiling an annotated checklist of vascular plants in Crater Lake National Park, a report to the National Park Service, revised 12/18/95. Sandra Klepadlo and Wendy Campbell prepared an edited version of the checklist through the auspices of the Crater Lake Natural History Association in 1998. The association then published a more complete version five years later; Zika, *A Crater Lake National Park Vascular Plant Checklist* (Crater Lake: CLNHA, 2003). He previously authored a note about the rare sedge *Carex whitneyi* in the park through the journal Madrono 41 (1994), p. 232.

The Nature Conservancy also underwrote nomination of four research natural areas at the park, a project initiated in 1986, but not completed with NPS concurrence until almost a decade later. They became part of a natural heritage plan for Oregon and were administratively designated to promote scientific research in them; see Steve Mark, "Research Natural Areas," *Nature Notes from Crater Lake* 31 (2000), pp. 13-16.

[185] Michael P. Murray and Mary C. Rasmussen, "Non-native Blister Rust Disease on Whitebark Pine at Crater Lake National Park," *Northwest Science* 77:1 (2003), pp. 87-91.

[186] The exception was an interview with Mabel Hedgpeth by Royal Jackson (Monograph No. 1, Crater Lake National Park, Oral History Program), CPSU/OSU 87-4, Fall 1987.

[187] As an example of this slow recognition, Superintendent Einar Johnson refused funding for the maintenance of historic buildings in the park. According to him, Crater Lake had no such structures as of March 1971, yet the lodge was determined eligible for the National Register of Historic Places by 1975. Its listing in May 1981 led to the HSR; David Arbogast, et al., *Historic Structure Report, Crater Lake Lodge, Crater Lake National Park, Crater Lake, Oregon* (Denver: USDI-NPS, Branch of Cultural Resources, March 1982).

[188] Greene, *Historic Resource Study, Crater Lake National Park, Oregon* (Denver: USDI-NPS, Branch of Cultural Resources, April 1984). The nomination of contributing structures, however, was done independently by staff in the cultural resources division of the regional office in Seattle. They drafted a multiple property nomination in 1984 and revised it several years later so that listing occurred in December 1988.

[189] The significance of structures at Crater Lake attracted attention in the earliest NPS effort to document rustic architecture in the National Park System; William C. Tweed, et al., National Park Service Rustic Architecture: 1916-1942, typescript completed February 1977 in the Western Regional Office, Division of Cultural Resource Management, pp. 66-68. Subsequent rehabilitation of three buildings at Park Headquarters (Administration Building, Ranger Dormitory, and Messhall) came in response to the need for office space brought about by closure of the Klamath Falls Group Office as well as staff increases that took place under Superintendent Benton. The Portland Chapter of the American Institute of Architects commended the NPS and its contractors for project excellence in 1988.

[190] Harlan D. Unrau, *Administrative History, Crater Lake National Park, Oregon* (Denver: USDI-NPS, 1988), two volumes. One additional chapter was added subsequently; see Stephen R. Mark, "Planning and Development at Rim Village" (Seattle: USDI-NPS, 1991).

[191] John Mairs, et al., Archeological and Ethnological Studies of Southwest Oregon and Crater Lake National Park: An Overview and Assessment, Winthrop Associates Cultural Research, Ashland, May 1, 1994. A short article derived from the report appeared as Robert H. Winthrop, "Crater Lake in Indian Tradition: Sacred Landscapes and Cultural Survival," *Nature Notes from Crater Lake* 28 (1997), pp. 6-12.

[192] An award to contractor Douglas Deur was made in 1998. The final report has not yet been submitted, but Deur has written "A Most Sacred Place: The Significance of Crater Lake among the Indians of Southern Oregon," *Oregon Historical Quarterly* 103:1 (Spring 2002), pp. 18-49. He and Steve Mark discussed the rationale and approach of the study in "Traditonal Use as Starting Point: Opening Cross-Cultural Dialogue at Crater Lake and Lava Beds," *CRM* 23:3 (2000), pp. 16-17.

[193] Cathy A. Gilbert and Gretchen A. Luxenberg, *The Rustic Landscape of Rim Village, 1927-1941* (Seattle: USDI-NPS, 1990). It served as the basis for a nomination that resulted in Rim Village being listed on the National Register in September 1997. This took place during work on the park's visitor services plan, an effort that revised development concept plans approved in 1988 and 1995, and led to a construction project that rehabilitated four historic buildings and the promenade wall at Rim Village in 2001-2002. Approval of the park's visitor services plan constituted an intermediate step; USDI-NPS, Visitor Services Plan, Crater Lake National Park, Oregon, November 1999. Documentation of cultural landscapes in the park has also included Gilbert and Marsha Tolon, *Cultural Landscape Recommendations: Park Headquarters at Munson Valley, Crater Lake National Park* (Seattle: USDI-NPS, Cultural Resources Division, Summer 1991).

[194] Rick Harmon, *Crater Lake National Park: A History* (Corvallis: Oregon State University Press, 2002). Special issues of two journals, the *Oregon Historical Quarterly* (Spring 2002) and the annual *Journal of the Shaw Historical Library* (2001) also appeared at roughly the same time. Park history has been the subject of some previous work, beginning with Howard and Marian Place, *The Story of Crater Lake National Park* (Caldwell, Idaho: Caxton, 1974).

[195] Gay Edelbrock and R. Gerald Wright, Crater Lake National Park Resource Database: Its Structure and Contents, NPS/PNRUI/NRTR-92/02, March 1992, pp. 8-10.

[196] Ben Twight, *Organizational Values and Political Power: The Forest Service versus Olympic National Park* (University Park: The Pennsylvania State University Press, 1983), pp. 137-138.

[197] Ronald Foresta, *America's National Parks and Their Keepers* (Washington, DC: Resources for the Future, 1984), pp. 26-27.

[198] J. Robert Stottlemeyer, "Evolution of Management Policy and Research in the National Parks," *Journal of Forestry* 79:1 (January 1981), p. 20.

[199] John Salinas interview, CLNPOHS, 4/7/98, pp. 19-20.

[200] Planning documents released 12 years apart show marked differences; USDI-NPS, Crater Lake National Park, Mazama Village/Rim Village Corridor, Supplement to the 1984 Environmental Assessment/Development Concept Plan/Amendment to the General Management Plan, October 1987, with USDI-NPS, Visitor Services Plan, Crater Lake National Park, November 1999.

[201] Concurrence from the State Historic Preservation Office with the NPS finding that Rim Drive and some early wagon roads in the park were eligible for the National Register was largely based on an assessment of the park road system. See Stephen R. Mark, Historic American Engineering Record, Addendum to Crater Lake National Park Roads, HAER no. OR-107 [historical narrative transmitted to the Library of Congress], 2003. Much of the HAER work drew from an earlier draft of a site history for a forthcoming cultural landscape report on Rim Drive.

A restored Mount Mazama as seen from the southwest (Williams1942).
Carnegie Institution of Washington.

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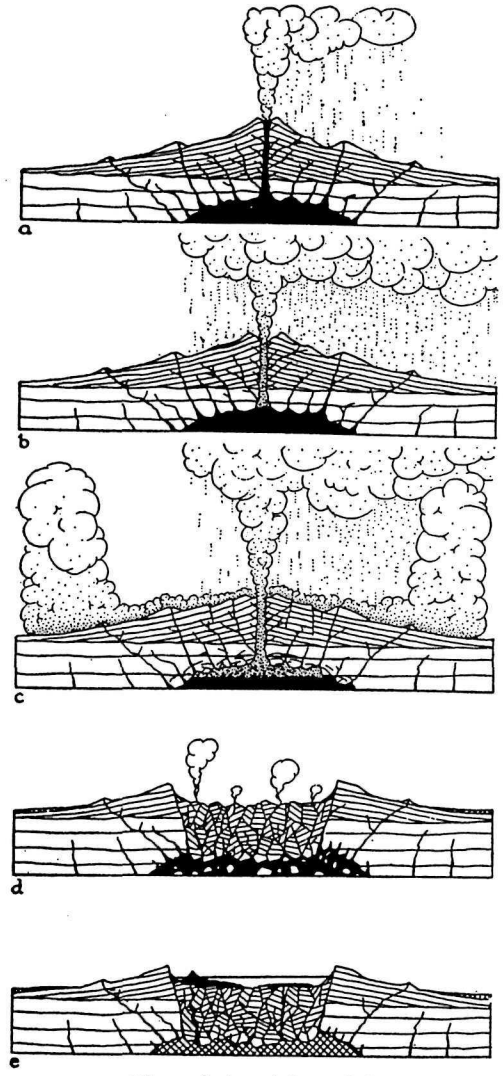

The evolution of Crater Lake.

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