Crater Lake National Park

Natural Resource Preservation and Research

Annual Accomplishments Report
December 2000

The Year 2000
An Extraordinary Year For Natural Resource Preservation At Crater Lake National Park

I am particularly pleased to present our Annual Accomplishments Report for fiscal year 2000. Our staff knew we had dished up a full plate when we set our goals for last year. We did not know that by the end of the year we would have returned for a second helping. We not only overcame some significant obstacles to meet our goals last year but we also capitalized on some very important, but unanticipated opportunities for resource preservation.

The aquatics program at the park continues to be one of the best in the National Park Service. An independent panel of aquatic ecologists that reviewed the program last March stated that the Crater Lake limnological program "has become an outstanding investigation" and confirmed that it is well organized, managed and on course. We also made history last summer by mapping the floor of Crater Lake; the first time since 1956. The information from these new data will launch the park's research program into a new plateau of scientific investigations about the lake and its volcanic origins.

> "I want to commend each and every one of you for your hard work in such a challenging season. We are very proud of and grateful for your accomplishments."
>
> Charles V. Lundy
> Superintendent

A late summer season and high stream flows prevented us from finishing our bull trout restoration project in 1999. We rebounded in 2000 and found funding to continue with the preservation of bull trout last summer. We simultaneously prevented its extirpation in the park and developed an international model for bull trout restoration.

Our terrestrial staff made great strides this year in developing successful interagency partnerships for resource stewardship. By using creativity, leveraging base funds and partnering with sister agencies, we have expanded terrestrial inventories in the park beyond our original suite of sensitive species to include small carnivores such as wolverine and lynx. We have new information on the health of whitebark pine in the park. We are working with the USGS and NRCS to complete a geology map and a soils survey for the park We have secured funding through the Klamath Network to plan for additional inventories for vertebrates and vascular plants in the upcoming years. And we were awarded $210,000 in regional research funds to investigate the critical linkages between small mammals, fungi and forest ecosystem health.

The terrestrial team has also been an invaluable partner to our fire managers. We have taken up the challenge to develop a scientifically derived set of resource objectives for our future Fire Management Plan. These objectives will help focus fire management as a tool for future ecological restoration.

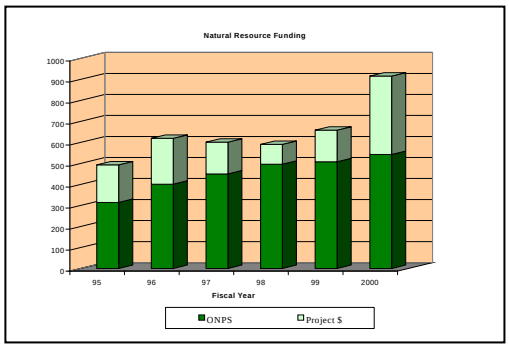
We are increasingly dependent on sound information to make decisions in the park. The information management system that the GIS Branch is developing is key to our ability to manage the park. Over the last year almost all of the park divisions took advantage of the geographic information system we have developed. Our staff has become increasingly aware of the power of spatial data in their planning, program management and operations.

It has been a banner year for the preservation of natural resources at Crater Lake and the stage is set for continued progress into the new century.

William M. Brock
Chief, Resource Preservation and Research
Crater Lake National Park

Our ability to know, understand and protect the natural heritage of Crater Lake National Park is grounded in a foundation of management investment. The pillars of funding, staffing and infrastructure support our mission to preserve resources unimpaired. A sound foundation is critical to a solid preservation program.

Natural resource funding, staffing and infrastructure remained strong in FY 2000. We owe much of our success last year to our ability to attract sufficient funding, sustain a highly talented and motivated staff and provide the right tools for their job.



Financial support for natural resource preservation increased for the seventh year in a row. Base financial support for natural resources preservation increased to $543,000 or 7% over our 1999 allocation. This resulted from an increase for personal services due to the Director's Resource Careers Initiative and Congressional approval for a 3.6% cost of living adjustment.

Project support soared in 2000. Through a variety of NPS and other public and private grant sources, we secured over $373,000 to support natural resource preservation needs. This accounted for almost 41% of our total funding in 2000. We expect project support to continue to be strong in 2001. Our staff submitted four funding proposals that, along with carry over funding, have already secured $421,000 in future project support.

Through a concerted effort that began years ago, we have developed a talented and highly motivated staff of science professionals to meet the modern challenges of resource preservation. Although we are operating at about 50% of our ideal workforce based on a regional assessment of our workload, we have nevertheless established the nucleus of a professional cadre. We remain hopeful that future base increases will decrease our staff deficit and help us round out our program with increased science oversight, fisheries and wildlife management expertise as well as data management capabilities.

"Our workforce must have the appropriate professional, technical, and leadership skills to be able to identify resource issues; obtain, interpret, and apply scientific information; and solve highly technical and complex policy problems on the ground."

Director Robert Stanton

It is not enough to attract talent to our staff. In today's job market it is equally important to retain that talent. We are increasingly competing with others for professional expertise. Servicewide initiatives like Resource Careers spawned by the Director's Natural Resource Challenge has helped us professionalize our staffing and identify career ladders to enhance their career growth. We are working hard to ensure a safe and mutually respectful workplace by driving down employee accidents to zero and maintaining a zero tolerance for

employee discrimination or harassment. We are also striving to provide a stimulating work environment for our employees; to foment a place where we recognize, value and promote diversity in our employees and their ideas.

In FY 2000 we had 35% minority representation in our workforce. Our seasonal workforce was made up of 33% minority candidates while we maintained the minority compliment of our permanent workforce at 29%. We had zero complaints of discrimination or harassment either formal or informal.

Finally, we have become aware that the sublime beauty of our work environment cannot compensate for 21st century demands in our employee's family and social lives.

We foresee an important emerging management challenge: helping our employees find a balance between work and family life.

Isolation, dual career opportunities, adequate schools, social interaction and day care facilities are but some of the obstacles to attracting and retaining the high quality professional employees that we must have to meet our goals. We foresee an important emerging management challenge; helping our employees find a balance between work and family life. Last year, with the support of the Superintendent, we began experimenting with flexible workplace arrangements and schedules to overcome some of these obstacles.

Through equipment replacement funds last year, we replaced an inflatable research vessel and engine. With that, we have completely replaced and upgraded our research fleet with stable, safe and more environmentally friendly vessels. We now have the capability to work safely on the lake at any time of the year. We have completely switched from two cycle outboard engines to more environmentally friendly inboard, 4-stroke and EFI outboard engines. Our primary research vessel, the Neuston, has proven to be a very stable, reliable and efficient platform for our operations and to support independent research efforts. We were also able to replace an under powered generator at our boathouse facilities at Wizard Island. The new generator assures that we can safely haul all of our boats into the boathouse for winter storage.

Safety is, and continues to be a primary focus of our line supervisors. Continued diligence in building safety awareness and promoting safe work behaviors helped us maintain our record of zero OSHA reportable and zero OWCP lost time accidents.

Space needs loom ahead as a potential constraint to our operations. Office space last year was tight but "doable." Remodeled garage bays in the Machine Shop modernized and increased the efficient use of our storage but not the amount. We rely on several other areas in the park to store equipment and supplies. We will be evaluating space needs in the park next year and hopefully we can identify some creative solutions to provide adequate office and storage facilities for current and future needs.

The Crater Lake National Park

Science and Learning Center

In cooperation with
Oregon Caves and Lava Beds National Monuments

A proposal for the Natural Resource Challenge

Crater Lake National Park faces three challenges which until recently appeared mutually exclusive. They include the restoration of two important historic buildings, promoting and supporting independent research in the park, and enhancing our educational outreach to neighboring schools. Last year we developed a plan to coalesce these issues and solve them concurrently through the development of an interdisciplinary Science and Learning Center at Crater Lake National Park. The concept of such a center was first identified in the park's Visitor Services Plan approved in 1998. We proposed that funding for the Center come from multiple sources including fee demonstration funding, ONPS base funding, private philanthropy and hopefully, the newly announced Natural Resource Challenge. The Center expands upon long term partnerships the park has established with regional universities, conservation organizations, state and federal agencies and area schools.

The Natural Resource Challenge

Applying good science to resource management is our best hope to restore and retain the rich heritage found in our National Park System.

In 1998 the United States Congress passed the National Parks Omnibus Management Act, calling for "a broad program of the highest quality science and information" to enhance management of the National Park System.

In August 1999, National Park Service Director Robert Stanton announced a major new NPS program, the Natural Resource Challenge. The Challenge is already underway. The Service is stepping up to a new level of resource management with a $14 million increase for natural resource activities in fiscal year 2000.

In the early 1900's the National Park Service initiated its servicewide Inventory and Monitoring (I&M) Program in response to criticism that parks lacked basic knowledge of the ecosystems they managed. The goal of the program is to provide park managers with comprehensive, scientifically based information about the nature and status of selected biological resources occurring within park boundaries in a form that increases its accessibility and utility for making management decisions, for scientific research, and for educating the public.

"The goal of the program is to provide park managers with comprehensive, scientifically based information about the nature and status of selected biological resources occurring within park boundaries…"

NPS I&M Program

Last year this program got a financial boost by Congress through funding of the Director's Natural Resource Challenge. The current funding is aimed at Level I inventories for vascular plants and vertebrates. The goal of Level I inventories is to establish the presence of as many species as possible but at least 90% of our potential species. The distribution and relative abundance of species of special concern will be determined in this inventory and expanded upon in future monitoring.

Through the I&M program, parks are organized geographically into networks to share resources and facilitate cost effective inventories. Crater Lake is part of the Klamath I&M Network that includes: Lava Beds, Redwood, Lassen, Oregon Caves and Whiskeytown. We have organized our network team and developed a preliminary study plan to qualify for inventory funding. The total anticipated budget for the targeted network inventories is $731, 392.00 over the next five years. Last year the network received $165,500.00 to complete our plan. Approximately $100,000 will carry over to initiate inventories in FY 01.

Prior to this new emphasis on inventories spawned by the Natural Resource Challenge, we had been successful in furthering our Level I inventories. Last year we continued our work to build a spatial database in our geographic information system (GIS) and inventory the park's flora and fauna, soils, geology and bathymetry.

Geographic Information Systems

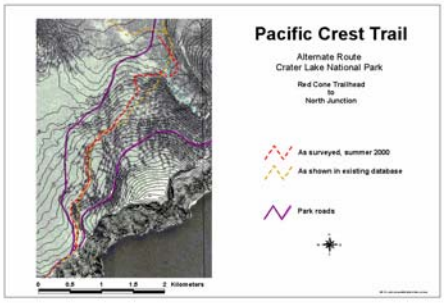
We added significant new data elements to our spatial database during the past year. Several of the digital orthoquads (DOQs) originally provided to the park contained incorrect information. While some of the quads were corrected in our GIS facility as the need arose, we ultimately obtained replacement data sets through our contacts at Winema National Forest. They also provided us with a seven-band thirty-meter Landsat Thematic Mapper satellite image of the park and its surrounds.

Thanks to Dr. Charles Bacon and his colleagues at the USGS in Menlo Park, we acquired quad-based ten-meter DEM data sets covering the park. We subsequently merged these into a seamless ten-meter DEM covering the park.

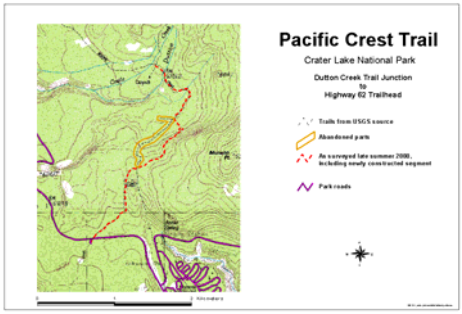
As a result of last summer's bathymetry project, the GIS lab now has archived a preliminary version of the survey results in the form of two datasets including: the bathymetry data for the lake bottom area and the acoustic back-scatter data set.

The GIS program at the Oregon Institute of Technology provided us with a thirty-meter raster vegetation data set for western Oregon (including about half of the park). The data were classified by the BLM from Landsat TM data.

Our GIS Specialist entered newly-surveyed or resurveyed trail sections for: the Pacific Crest Trail alternate routes; the newly-constructed trailhead area and trail realignment at the north end of the



Crater Peak trail; the newly-constructed PCT segment; the Wizard Island trail; the Cleetwood trail; the Castle Crest Wildflower Garden trail; the new



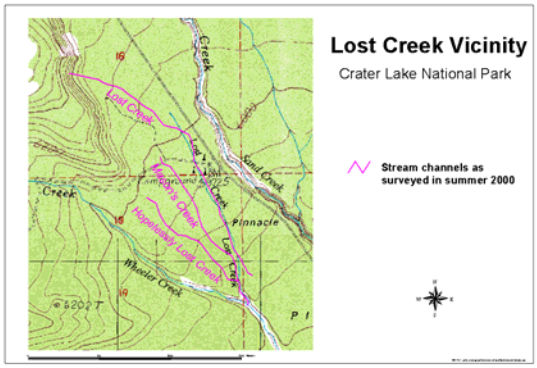
The GIS Lab has provided data sets, consultation, and/or cartographic products to the following groups during the year:

- Oregon Institute of Technology (Environmental Sciences/GIS)
- Klamath County (Planning)
- Lava Beds National Monument (Resources)
- US Fish and Wildlife Service (Klamath Basin)
- Winema National Forest (GIS)
- J. Cissel (private party)
- CRLA Ranger Division (Fire, Trails, Wilderness, Law Enforcement)
- CRLA Interpretation & Cultural Resources Division
- CRLA Maintenance Division (R&S, B&U)
- CRLA Administration/Management Divisions
- CRLA Resources Protection & Research Division
- US Department of Energy (Savannah River group)
- US Geological Survey (Menlo Park)
- USDA NRCS (Portland, OR)
- J. Halperin (student)
- Klamath Inventory & Monitoring Network

Munson Valley Historic District interpretive trail; the Watchman trail; the Dutton Creek trail; and two segments of the historic bridle trail along Munson Ridge.

Our GIS Specialist also surveyed Lost Creek and its associated drainages (Mason's Creek and Hopelessly Lost Creek) to determine the nature of any historical connectivity between these channels and Wheeler Creek and/or Sand Creek. Field evidence, in the form of cleanly incised drainage channels, clearly suggests that Mason's Creek and Hopelessly Lost Creek both have had, and continue to have, direct discharges

to Wheeler Creek during years of high spring flow. Lost Creek itself, however, has no erosion channel that connects directly to either Wheeler Creek or Sand Creek as suggested on USGS topographic maps. The historic erosion channel that does persist below the present visible active end of flowing water in Lost Creek can be followed gently trending toward Wheeler Creek, but that channel vanishes as an identifiable surface geomorphologic artifact long before any connection to Wheeler Creek is clear. A visible historic connection between Lost Creek and Mason's Creek is absent also, even though Lost Creek and the Mason's Creek channel converge to within about 40 meters at one point. Next year we will traverse upstream from the Pinnacles Road along the Wheeler Creek gulch to determine if there is any evidence for a connection with Lost Creek.



In the GIS Lab itself we have kept current our GIS software, with particular attention to our ESRI suite of ArcInfo, ArcView, and ArcExplorer products and our Clark Labs IDRISI32 and CartaLinx products. We added the 3D Analyst extension to ArcView to give us greater flexibility in analysis and display of three-dimensional data sets. We significantly enhanced the capability of our GIS-2 workstation by adding both RAM and hard disk capacity to the limits that the machine can accommodate. In the data access area, we have begun to move selected elements of our archive to a read-only location on the park's local server, from where any within-park user with ArcView or ArcExplorer software may view or copy the files as needed. Available data sets include basic topographic information, transportation, hydrography, and imagery comprised of digital orthographic quads and DRGs (images of the familiar USGS 7.5-minute topographic quadrangle maps). Additional data layers, and revisions of existing ones, will be added as time passes.

Floral Inventories

Spectacular views of the lake are often observed against a backdrop of twisted, gnarly whitebark pine trees found perched on the windswept crater rim and mountain peaks above 7000 feet. Whitebark pine *(Pinus Albicaulis)* is a long-lived and hardy tree able to thrive on sites that experience harsh environmental conditions. The pine's large and nutritious seeds are prized by park wildlife including Clark's nutcrackers, black bears, and red squirrels. Elk and grouse use tree clusters for shelter. Their canopies support arboreal lichens and understory flora such as woodrush and currants. Whitebark pines also stabilize soil and regulate snowmelt.

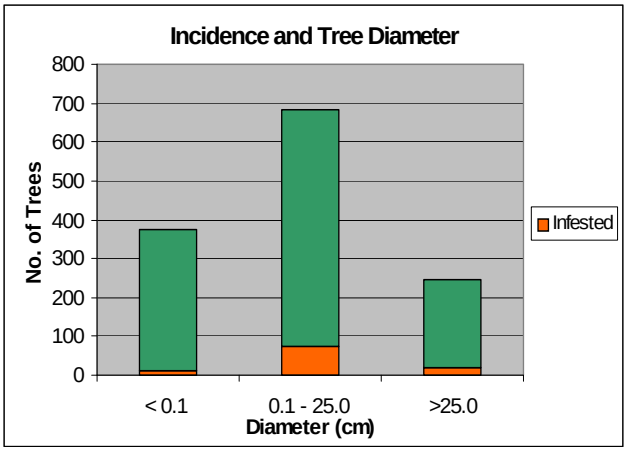
An introduced fungus (*Cronartium ribicola*) infects whitebark pine and causes the white pine blister rust, a typically fatal disease.

Whitebark Pine along the crater rim.

Although blister rust occurs on all five-needled pines, such as western white (*P. monticola*) and sugar (*P. lambertiana*), whitebark pine is by far, the most susceptible. White pine blister rust has proven very lethal in some parts of North America where up to 90% mortality has been estimated. Because of the threat this disease poses to the health of whitebark pine throughout its range, inventory efforts to assess the health of the park's whitebark pine population were initiated in 1999, and intensified in 2000.

We measured twenty-four transects, consisting of 1200 trees during the summer of 2000. We detected blister rust on all transects except three. The disease infects up to 20 percent of trees at some sites. We found disease on all size classes of pine. About eight percent of trees greater than 25 cm in diameter at breast height (dbh) were infected. Trees between 0.1 and 24 cm dbh exhibited infections at 12 percent. Nearly three percent of saplings (trees less than breast height) were infected. Infections are more difficult to detect on both saplings and very large trees, so incidence may be slightly higher.

Blister rust incidence.



Blister rust poses a significant long-term threat to the park's whitebark pine population. Trees along the west caldera rim are dying the quickest. Annual loss is difficult to estimate without regular fixed-plot monitoring. Based on tallies of mature trees (≥ 7cm dbh) killed during the past year, we estimate the current rate on the western rim at 0.7% per year. Using an optimistic estimate of recruited mature trees every year (0.3%), based on our size class observations, we predict an overall decline of 0.4% for mature trees annually. Assuming that the disease has been in the Park since detected in the area during 1935, then at 0.4% annual mortality, current conditions may represent an overall shortfall of trees by 26%. That is, we would expect 26% more live whitebark pine trees today.

SURVEY CONCLUSIONS

- Blister rust currently infects up to 20% of the Park's whitebark pine, especially on the western rim.
- We predict a 46% decline in mature whitebark pine by 2050.
- Present and future mortality on Wizard Island appears to be mostly mistletoe–related.
- A map and monitoring program is needed to provide better understanding of infection and mortality rates.
- A rust-resistance seed orchard program using nutcracker dispersal will counter impending pine population bottlenecks.
- Knowledge of natural fire regimes for the Park's whitebark pine is lacking and should be investigated before management uses it as a conservation tool.

In the short-term, the Park's whitebark pine populations appear to be only gradually declining and do not correspond to steeper downtrends elsewhere in the Cascade region. However, populations in the Park are under a significant long-term threat due to several factors. First, as illustrated, whitebark pine may have already decreased by 26% with an additional loss of 20% by the year 2050. Second, global warming is expected to favor conditions for survival and spread of the blister rust fungus and increase the competitiveness of mountain hemlock, lodgepole pine and Shasta fir – further stressing whitebark pine. Third, whitebark pine does not mature and produce seeds until the age of 20-50 years. Therefore, any management scenarios must consider a time lag resulting in population bottlenecks before pine numbers can rebound.

National Parks are managed to preserve natural conditions. If whitebark pine is to remain an important component of the park, managers must decide how much loss is unacceptable, and establish an action plan to monitor and mitigate the impacts of blister rust caused decline.

Fungi

In the Pacific Northwest, forest ecosystems are under a constant threat of habitat alteration from many sources. Logging, urbanization, recreation, and commercial harvest are a few of the activities that have come under the scrutiny of the Northwest Forest Plan. The focus of the plan is to maintain and restore biological diversity – to protect the long-term viability of more than 1,100 species that depend on late successional and old growth forests. Of the 1,100 species targeted, 527 are identified as fungal species. Loss of fungal diversity is a primary concern to area scientists.

We have successfully secured $210,000 for a multi-year research project to study the interrelationships between fungi, vascular plants and small mammals, looking at disturbed and undisturbed sites within the mountain hemlock and Shasta red fir forests of the park. Beginning in 2001, CRLA is poised to be an active partner in providing increased understanding to the public and scientific community regarding the importance of fungi.

Fungi are an incredibly diverse group of non-photosynthetic organisms that absorb their food. They inhabit every possible environment. Fungi are as distinct from plants as they are from animals or insects, although they do share similarities with each. Unlike plants, fungi lack chlorophyll and therefore are unable to manufacture their own food from sunlight. Like animals and insects, they must feed themselves by absorbing carbon compounds from the immediate environment. Fungi have evolved enzymes for digesting recalcitrant substrates such as chitin (insect exoskeletons), keratin (hair, skin, horn, feathers), cellulose (most plant material), and even lignin (wood). Like plants, most fungi are nonmotile although some possess motile spores. Fungi reproduce by spores, which are simpler in structure than seeds or eggs.

Although traditionally grouped with plants, they have no direct evolutionary connection. More than 35 years ago, fungi were deemed distinct from plants and placed in their own kingdom. The Kingdom Fungi is second only to insects in numbers of species. Over 200,000 fungal species have been described, but estimates of total fungi in the world range from 1 to 1.5 million.

Fungi contribute to the function of healthy forest ecosystems by forming mutually beneficial associations with plants, decomposing organic matter, contributing to nutrient cycling, providing food for animals, and creating habitat diversity for many forest organisms. Some species of fungi depend on mycophagous (fungus-eating) animals for spore dispersal. As these fungi mature, they produce odors that attract forest animals, especially small mammals like squirrels, chipmunks, voles, and mice. These mammals excavate and consume sporocarps; spores pass through the digestive tract unharmed and are excreted in the animals' feces. Spores from the fecal pellets are washed into the soil where they contact roots of mycorrhizal hosts.

Morels are one species of edible mushroom.

Many species of fungi are mycorrhizal. Mycorrhiza, which literally translates as "fungus-root", refers to a common and mutually beneficial association between plants and specific fungi. Indeed, nearly all terrestrial woody plants depend upon mycorrhizal fungi for their survival and growth. Mycorrhizal hyphae greatly extend the nutrient absorbing surface area of the roots and are more effective in nutrient and water absorption than roots themselves. Soil nutrients essential to plant growth, such as phosphorus and nitrogen, are absorbed by the mycorrhizal fungus and transported to the root for use by the plant. In return, the plant provides sugars produced in photosynthesis to fuel activities of the mycorrhizal fungus. The ability of plants to form mycorrhizae with numerous fungus species benefits the host by increasing access to nutrients and water and by protecting against fine-root pathogens.

Fungi are important wildlife food and are consumed by numerous animals including deer, elk, bears, small mammals, slugs, insects, and birds. The sporocarps provide animals with minerals, amino acids, proteins, carbohydrates, and vitamins. Some rodents, such as the California red-backed vole and northern flying squirrel, rely on fungi for more than 90% of their food supply. In turn these small mammals are primary food for predators such as the northern spotted owl.

In addition to mycorrhizal fungi, fungi can be divided into two other categories based on their relation to the environment. Pathogenic fungi inhabit the living tissue of plants, animals and even other fungi, typically causing damage and disease. They contribute to habitat diversity in forests by killing trees that later become snags and logs inhabited by wildlife and a variety of other organisms. Openings develop in the canopy when diseased trees die and fall, allowing shade-intolerant plants to flourish in the increased light. Saprobic fungi perform essential ecosystem functions by decomposing dead organic matter (wood, humus, plant material, dung, bones, insects, etc.) and cycling nutrients. Wood-decay fungi soften the interiors of snags and logs, allowing birds, reptiles, amphibians, insects, small and even some large mammals to burrow into them and create homes.

We cannot discount the importance of poorly understood organisms to ecosystem function. The importance of the diverse fungal community of the Pacific Northwest forests to tree growth and interactions with forest organisms, and to people for medicines and esculents, is still being discovered.

Potential Natural Vegetation

For the second year in a row, we have worked with sister agencies (USFS and BLM) to classify and map the potential natural vegetation of southwestern Oregon, as part of an information sharing initiative under the Northwest Forest Plan. Field crews have collected data on overstory and understory vascular plant species to provide input for a computer model to predict plant

Classifying potential natural vegetation involves assessing the structure and composition of a forest stand.

associations groups and site productivity for federally owned lands within the range of the northern spotted owl. With no additional project funding, we were able to contribute 60 data points this year (with funding, 265 data points were collected in 1999). The information is to be compiled this winter and the model used to predict plant associations for the western half of the park. A draft map is expected by June of 2001. The map will be useful to park mangers for assessing impacts of disturbance relative to site productivity, including fire use and wilderness recreation activities. Future plans include classifying the east side of the park as part of the Klamath province.

Faunal Inventories

Breeding Bird Survey

The park's terrestrial resource staff provided logistical support to a regional breeding bird survey conducted by the Klamath Bird Observatory during June and July. The objective of the survey is to establish new routes within the park as part of a network of 8000 long-term monitoring stations in the Klamath-Siskiyou region of Oregon and California. The goal is to establish one monitoring route per 7.5-minute topographic mapping unit. This summer two new routes were established for the Crater Lake East and Crater Lake West quads in the area of Lightening Springs and Mt. Scott respectively. Along each route point count stations are used to identify avian species, breeding status, and abundance. These data are then correlated to more general bird habitat relationships and landscape level distribution for the region.

MacGillivray's Warblers breed in nests on the ground. They are Neotropical migrants who winter in Mexico.

Forest Carnivores

The high-elevation coniferous forests of Crater Lake provide forage, denning, and travel habitat for two species of carnivores listed as threatened: the Canada lynx *(Lynx canadensis)* and the California wolverine *(Gulo gulo)*. We

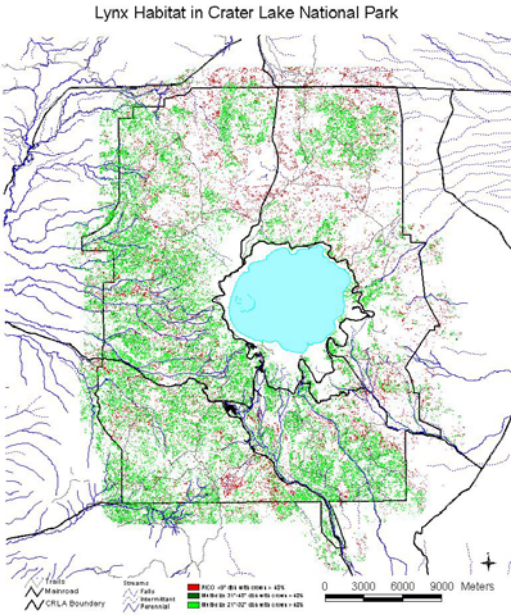
Mustelid tracks recorded near Union Peak.

have conducted surveys over the past few years to determine if lynx and

Biologists rig bait at a wolverine survey station in Crater Lake National Park.

Wolverines are present in the park as they were historically. A combination of techniques is used – snow track surveys during the winter for both species; camera/bait stations in the winter for wolverine; and hair snag stations in the

summer for lynx. This year's wolverine surveys detected only pine martens, although a reliable siting of a wolverine was made in late summer by a state biologist visiting the park. We collected seven hair samples during last summer's lynx surveys. Using DNA analysis, one sample was positively identified as non-domestic feline, but the sample was not sufficient to determine from which species – bobcat, lynx, or mountain lion. Additional surveys next year may yield more positive results.



Lynx habitat at CRLA.

Soils Inventory

Echoes of Mt. Mazama's eruptions resonate today in the more than 17 different soil taxonomic families found within the park's boundaries. This summer, soil scientists completed the second season of mapping efforts to provide the park with a comprehensive soil survey. The project is being completed under a cooperative agreement with the Natural Resource Conservation Service (NRCS) with funding provided by the WASO Inventory and Monitoring Division.

Soil pits provide a means for describing soil characteristics

To date, 120,000 acres of the park have been surveyed and mapped (FY99 – 35,000, FY00 – 85,000), with 46,000 acres remaining to be completed during the summer of 2001. The soil survey is a multi-purpose, science-based inventory of the distribution and properties of soils and factors affecting the soil environment. Soil surveys include predictions of soil behavior related to park management activities such as the siting of facilities, roads, and trails.

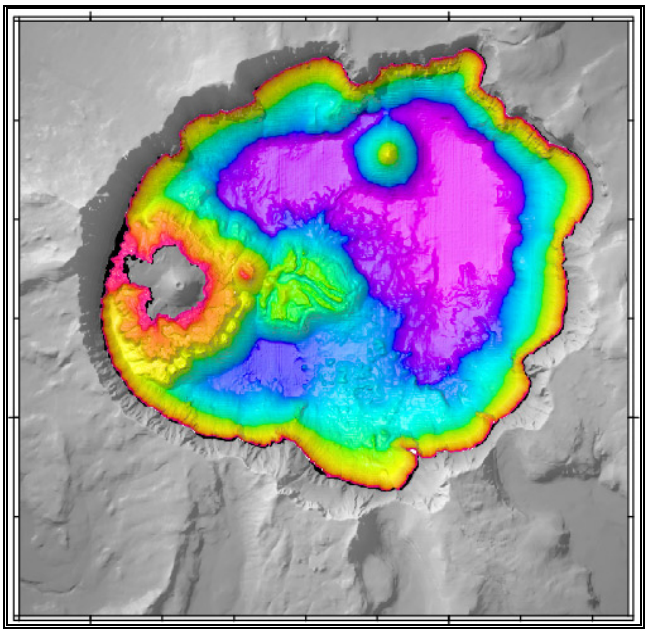
This soil survey will provide park managers the information necessary to make sound management decisions, ensuring the protection of sensitive soil resources. Additionally, scientists will be able to use this information to better understand the relationships between soil, plants, animals, and other ecosystem components.

Bathymetry

Last year, our staff along with the USGS completed a survey of the floor of Crater Lake using new high resolution, multibeam sonar technology. The 11,200 lb. research vessel used in the mapping was trucked from Louisiana to the park. The U.S. Army Reserves from Ft. Lewis, Washington helped transport the vessel 1000 feet from the caldera rim to the lake surface. Once on the surface, the USGS surveyed the near shore first and finally the deep-water areas.

> We deliberately shared our "discoveries" of the sonar research through a media campaign that focused on the technology and the scientific contributions of the survey. Throughout the period of the survey we made 74 media contacts. We conservatively estimate that our message was delivered repeatedly to over a million individuals based on the reported viewing audiences and subscribers to those local stations and newspapers who ran spots and articles on the events of the survey. This is analogous to reaching twice our annual visiting public with a very focused message of "parks as laboratories."

The multibeam sonar equipment used in the survey was the most advanced available. Only six equivalent units are in service worldwide. The scientists took over 16 million measurements and recorded, among other things, a maximum lake depth of 1958 feet, 26 feet deeper than previously measured. The survey took five days.



The amazing new images reveal incredible details of ancient lava flows, huge landslide debris fields and other fascinating geologic features. We anticipate that the information from these new data will launch us into a new plateau of scientific investigations about the lake and its volcanic origins.

"This is showing immensely more detail – it's revolutionary. This is going to greatly improve the understanding of the lake's history."

Dr. Charlie Bacon
U.S. Geological Survey

Although the survey phase of this project is now complete, we will continue to reap the benefits of this research for years, if not decades to come. In the near future these data will be made available to interested scientists. Our NHA is interested in developing a map/brochure from the data as a future sales item and we have plans for an interactive interpretive display for our visitor center.

Independent Peer Panel Reviews Crater Lake Monitoring Program.

On March 21, 2000, a panel of aquatic ecologists met at Oregon State University to review our Long-Term Limnological Monitoring Program (LTLMP). The panel included Chairperson Dr. Stanford Loeb (University of Kansas), Dr. Douglas Markle (Oregon State University), Dr. John Reuter (University of California, Davis), Dr. Raymond Herrmann (USGS-BRD, Fort Collins), and Dr. Dixon Landers (Environmental Protection Agency, Corvallis). The panel believes that the review was an excellent technique for obtaining constructive comments and guidance for the research team. The panel felt the limnological program is well organized, managed, and on course. They commented that the program has developed into one of the outstanding long-term aquatic monitoring efforts anywhere in the world. "While some other programs certainly may have longer data sets, the comprehensive, interdisciplinary and unique nature of the Crater Lake data set it apart."

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Results of the ongoing lake monitoring program and special research projects indicate that Crater Lake is a complex and dynamic system. However, no unidirectional change in any of the parameters monitored (lake and spring water chemistry, nutrients, chlorophyll, primary productivity, phytoplankton, zooplankton, fish, water clarity, light penetration, and temperature) has been detected.

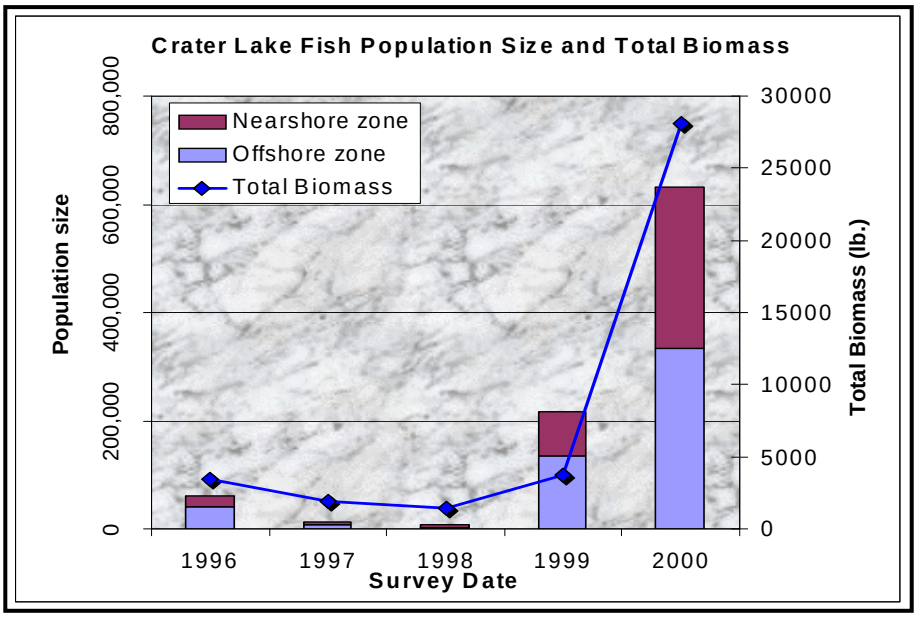
We conducted the annual monitoring trips for 2000 in June, July, August, and September, with the assistance of personnel from OSU and Rogue Community College.

Peer Panel Observations and Recommendations

- The development of a data management system was deemed critical to the future success of the program.
- The program should be reviewed again in two years.
- Maintaining the interdisciplinary approach was highlighted as a very strong and important feature of the program.
- A paleolimnological investigation of the lake sediments should be conducted to assess historical climate change and recent potential human-induced changes (climate, land use, introduction of fish, etc.).
- Sampling the lake outside of the existing summer schedule was recognized as critical to the understanding of the lake.
- Other recommendations include: increasing the spatial understanding of the lake; continuing investigations of the nitrogen budget; expanding the bacterioplankton studies; studying the margins of the lake and moss beds; investigating the reasons for variation in lake clarity; investigating the sources of variation in fish catch data and fish mortality; investigating the role of UV light on the lake system and; collaborating with outside investigators especially Lake Tahoe.

Fluctuation in the populations of kokanee salmon and rainbow trout in Crater Lake has been dramatic. Since 1998, the fish population has skyrocketed both in terms of total number (7500% increase) and biomass (1800% increase). It appears the widely fluctuating kokanee salmon numbers are driving the zooplankton community structure and abundance through the periodic elimination of the dominant crustacean

zooplankton *Daphnia pulex*. Using the population and biomass data from the annual acoustic fish surveys in conjunction with additional data from the monitoring program, we are presently examining quantitative effects of the introduced fish population on various aspects of lake ecology, especially the effects on zooplankton.

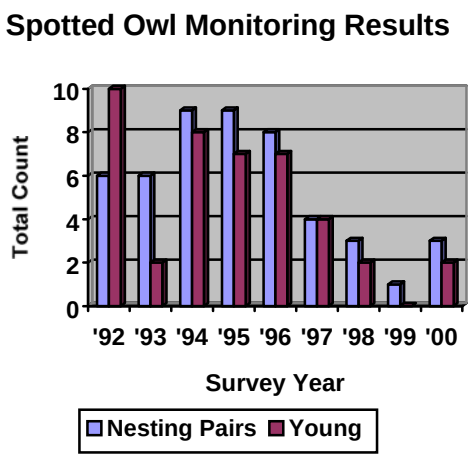


In 2000 we started our long-awaited data management program for the Long-Term Lake Monitoring Program. With the financial assistance of Columbia Cascades System Support Office, we hired a term Data Manager to design and develop a centralized data management program. Tremendous progress has been made in eight months. We started the data management program by reorganizing and centralizing files into one location and software program (Microsoft Access), checking and ensuring the accuracy of the data, and developing a data management plan. The Long-Term Monitoring Program presently has of 25 distinct data sets comprising approximately 5.9 gigabytes of information about the physical, chemical, and biological characteristics of Crater Lake. That is enough information to fill a stack of computer floppy disks six stories high! Twelve of the data sets have been incorporated into a centralized data management system based in Access. Computer programs were created and written in Access to incorporate user-friendly and menu-driven interfaces to view, enter, verify, edit, calculate, and extract data. This data management program will incorporate past, present, and future data, insure the integrity and security of data, provide accessibility to data for offsite program cooperators, and facilitate timely data analysis for sound resource management decision-making. We secured additional funds from the Water Resources Division to continue the development phase of the project in 2001 and 2002. We hope to solidify the data management program through a future increase to base funds.

We maintain an annual monitoring program for the federally listed northern spotted owl *(Strix occidentalis)*. The objective of the monitoring program is to assess the nesting and reproductive status of owl pairs living in the park. Since 1992, we have tracked 17 owl pairs. Our survey results vary year to year and tend to mimic the results found at Olympic National Park where 250 spotted owls are being studied to assess the effectiveness of the Northwest Forest

plan. Fluctuations in numbers are expected for many reasons, including changing weather patterns, foraging habits, prey availability, and habitat suitability.

In the park, three pair nested last year, which is a rebound from 0 in 1999. Only two offspring were observed in 2000 up from 0 in 1999. The 1999 breeding season was dismal, with no reproduction and the lowest recorded response rate on record for spotted owls throughout their range. To put the responses from the last two years in perspective, the following graph illustrates the nesting and reproductive success for spotted owls monitored in the park between 1992 and 2000.



The 2000 breeding season suggests a rebound in nesting efforts but still represents back-to-back seasons with little or no reproduction. The park's most successful pair is located in the vicinity of Boundary Springs. This pair has nested every year of the monitoring program and produced nine young during six different breeding seasons.

Through the use of historical records, aerial photos, and employee interviews, we have identified 58 sites as having significant human disturbance. Thirty-four of these were field surveyed for site condition and impacts between 1998 and 2000. The areas impacted are scattered throughout the park on more than 29 acres. Sixteen of the sites are located within park developed areas, the remaining 18 are located within the wilderness management zone.

All 34 of the surveyed sites have been ranked according to severity of impact to vegetation and soils and the presence of hazardous materials. The seven listed in the table below are the highest priority for restoration.

Site Name	Major Impacts
Anderson Bluffs Post Site	Hazardous Materials
Fisch Construction Site	Construction Debris
Garfield Trail	Soil Erosion
Lodge Dump Rd	Soil Erosion
Munson Valley Stump Dump	Debris
North Junction Overlook	Trampled Vegetation Soil Compaction
Pumice Desert Barrow Pit	Soil Loss
Vidae Falls Picnic Area	Trampled Vegetation Soil Compaction

Hazardous materials at Anderson Bluffs Post site.

Soil erosion on the old Lodge Dump Road.

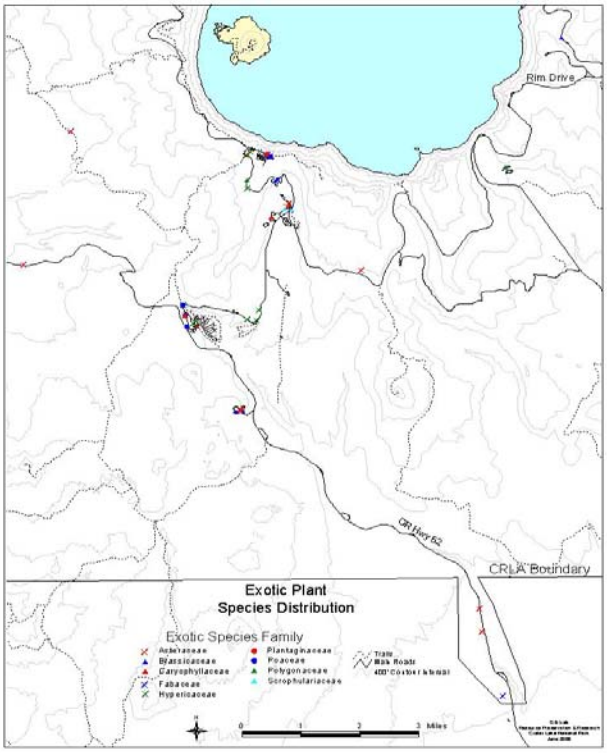
There remain at least 24 known sites that need to be surveyed in the near future. Some of these sites will be part of a recently funded 3-year study to assess the relationship between vascular plants, mycorrhizal fungi, and small mammals. Funds to finish this park-wide assessment of human disturbance will be sought from the Fee Demonstration and Disturbed Lands Restoration programs. Establishing a restoration strategy and time schedule is a high priority.

Nonnative Plants

Through the direct efforts of the park's YCC crew, We have won another battle in the war on weeds. Over a two-week period, crew members manually removed populations of Klamathweed *(Hypericum perforatum)* and spotted knapweed *(Centaurea biebersteinii)* along a 6-mile corridor of Highway 62. These two invasive plants pose the biggest threat to the park's native plant communities and wildlife.

Invasive plants are plants that have been introduced into an environment in which they did not evolve and thus usually have no natural enemies to limit their reproduction and spread. Their fast growth characteristics and high reproductive rates allow them to "invade" new habitats, and out-compete native plants for light, water, and nutrients. Some species are poisonous to wildlife.

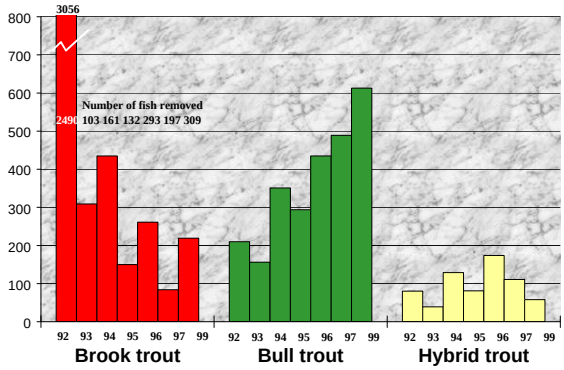
We have a limited but on-going program to identify and map populations of invasive species, to rank the immediate and potential threats to native species, and to prioritize treatments. From field surveys conducted in 1997 and 1998, we have identified 49 invasive plant species on more than 120 acres. Compared to other parks in our region, this impact is relatively minor. With continued monitoring and early corrective action, the threat from invasive, non-native plants should remain low.



A map showing the distribution of known invasive plant populations.

Bull Trout

Twelve years of bull trout restoration efforts reached a pivital milestone this year with the elimination of non-native brook trout from Sun Creek. Previous years' electroshocking efforts were aimed at reducing brook trout abundance



to allow bull trout numbers to increase. However, we recognized this technique had little potential to actually eliminate the non-native brook trout.

Beginning in July of this year, we began removing as many bull trout as we could from Sun Creek with electroshockers and a scaled down trapnet we designed to reduce electroshocking impacts to bull trout. Bull trout were held in a stream-side raceway or were taken to a Oregon State Fish Hatchery if they were too small to reliably identify to species.

With the assistance of Bruce Roselund from the USFWS in Colorado, Sun Creek was treated below Sun Meadow with the fish toxin antimycin in August of this year to remove all remaining fish in the creek. Antimycin is an antibiotic that is extremely toxic to fish at dosages as low as 4 parts per billion but it is not toxic to mammals and birds. We neutralized the antimycin with potassium permanganate just downstream of the park boundary. One week after the antimycin treatment, bull trout were iced down, oxygenated and transported back to the creek in 2 1/2 gallon coolers on backpack frames. We removed 618 bull trout from Sun Creek with trap-net electroshocking. Of the 618 bull trout captured, 480 were returned to the stream in September and 130 went to the hatchery due to their small size. The small fish will be returned to the stream when they are large enough to positively identify.

Bull trout, the only known native fish species to Crater Lake National Park, is on the road to recovery. Sun Creek once again supports its native fish assemblage and the restoration efforts at Crater Lake National Park are leading the way for preservation of this federally threatened fish species throughout the Klamath Basin. The NPS Fee Demonstration Program, Columbia Cascades Cluster Funding, and USFWS Hatfield Restoration funds provided financial assistance for FY 2000.

It is always better to prevent damage to natural resources than to fix damage once it has occurred. Reaction to a problem is usually more expensive, time consuming and less effective than prevention. The investments we make in resource protection can stop many natural resource impacts before they occur, eventually saving time and money. We focus on three areas of prevention: environmental impact analyses, conservation planning and law enforcement.

Our environmental compliance process takes advantage of a number of laws designed to evaluate impacts to resources prior to making a decision that could have adverse consequences. Last year we reviewed 39 internal project proposals and approved 35 of those submitted. Most often projects require a minimum of review. The compliance process is not only legally required but is also valuable for increasing awareness and communications about the park's sensitive resources and our role as resource stewards. New servicewide guidance (DO 12) on conservation planning and environmental impact analyses will be finalized in 2001. It is likely that this new guidance will focus more attention on resource preservation and the use of science in decision making.

"…it is essential that NPS management decisions (1) be scientifically informed and (2) insist on resource preservation as the highest of many worthy priorities."

Director's Order 12

We focused most of our efforts in conservation planning last year on specific action plans. Our staff completed several specific draft plans for our division as well as for other divisions and in collaboration with other parks. These included the Boat Operations Plan, Hazard Tree Plan and an inter-park Inventory and Monitoring Plan. We also provided significant consultation on resource concerns for the Concessions Prospectus and the Fire Management Plan. Our planning responsibilities will likely increase next year as we embark on a new General Management Plan for the park.

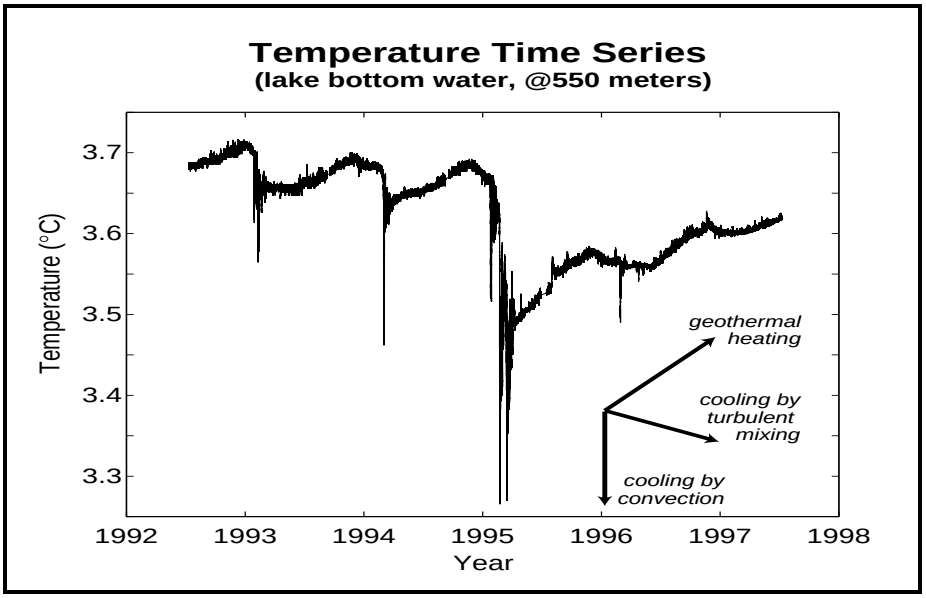
The threats to natural and cultural resources preservation from human activities is increasing. However, resource protection has not always been seen as a core responsibility by either the ranger or resource management staffs. Last year our General Biologist served on an interdisciplinary panel to complete a white paper at the request of the Regional Director. The paper entitled "Resource Stewardship – Rebuilding a House Divided," focused on the evolution of resource protection dilemma and offered a road map to integrate resource protection interdivisionally in the parks. We also assisted with the Servicewide Interdisciplinary Resources Protection Training Course held in San Louis Obispo, California.

Effective resource protection will require a team approach to identify resource protection issues and strategies. Effective resource stewardship should integrate science, management and protection. The Ranger Division seems eager to discuss this growing concern and develop a comprehensive strategy.

We have a history of scientific collaboration at Crater Lake National Park. We strive for highly integrated research through close working relationships with universities, other public and private research institutions, non-profit conservation organizations and federal and state agencies.

Last year we entered into a cooperative agreement with Southern Oregon University (SOU), to pursue programs of mutual interest in research, education, and natural, cultural, and social studies related to park resources and management. Our Park Aquatic Ecologist was invited to join the SOU faculty as an Honorary Adjunct Professor of Biology. He has established a part-time office in the School of Sciences Building on the SOU campus in Ashland. This was a natural alliance, ripe for picking. Graduate committee membership, centennial symposium collaboration, education outreach (curriculum development) internships, and the presentation of campus science seminars are a few of the cooperative projects already developing.

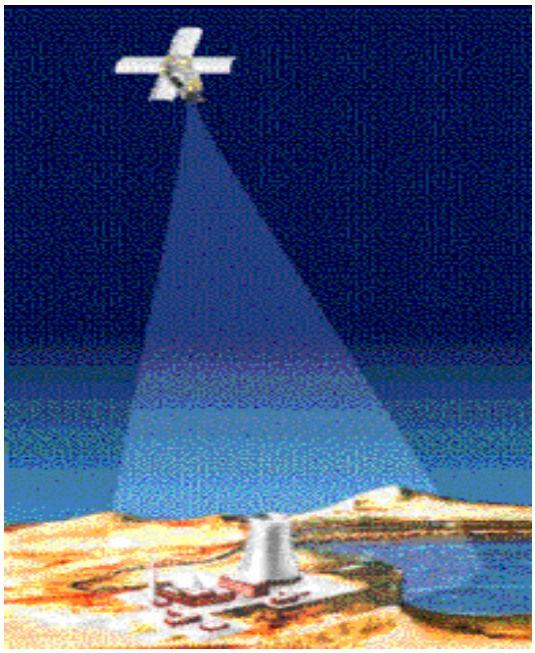
Dr. Robert Collier (Oregon State University) recently received continuation of USGS Global Climate Change funding for an additional five-year research project to study the impact of climate on the physics, hydrology, and biogeochemistry of Crater Lake. This project promises to greatly expand the understanding of mixing dynamics and nutrient regeneration on lake ecology. Crater Lake offers a pristine and relatively simple system to detect aquatic system changes through long-term study and provides a powerful natural laboratory to study the processes that link climate physics to the operation of nutrient cycles in aquatic ecosystems. Results to date show how dramatic vertical mixing 'events' in the lake ventilate the bottom of the deepest basins and force nutrients up in the water column where they can be used by phytoplankton. The temperature record from the deepest of 19 moored thermistors show how the annual cycle of early winter cooling followed by relatively steady geothermal heating is punctuated by spikes of colder water associated with these mixing 'events.'



The climatic conditions associated with such events and the potential for global climate change to effect lake ecology are being studied.

A satellite was recently launched by the Department of Energy to demonstrate advanced multispectral and thermal imaging, image processing, and

associated technologies that could be used in future systems for detecting and characterizing facilities producing weapons of mass destruction. Civilian applications of Multispectral Thermal



Imager (MTI) include support of Global Change Research Programs, hazardous waste site characterization and surveying, resource exploration, and crop health and yield assessment. Crater Lake National Park and Oregon State University aquatic scientists assisted Los Alamos and Sandia National Laboratories and the Savannah River Technology Center with calibration of the MTI satellite. Crater Lake makes a perfect high-elevation cold-water calibration site because we are already collecting the necessary precision water temperature calibration data within the Long-Term Limnological Monitoring Program and Global Climate Change Program. It is hoped that the images produced by the satellite will reveal information on the spatial temperature regime and mixing dynamics of Crater Lake and fill in the shallow water bathymetry around the lake that was not possible to collect using boat based systems.

Park scientists also assisted engineers from the NASA Jet Propulsion Lab (JPL) in testing an ice-core probe on Crater Lake. The JPL scientists needed to test a newly developed probe and camera system to deep depths prior to sending the system to the Antarctic. The park research vessel *R/V Neuston* transported the probe, camera, and winch system to different areas of the lake where it could be tested to various depths. These ice-melting probes are being developed to support subsurface exploration in continental-scale ice masses on Earth, Mars, and Jupiter's forth-largest moon, Europa.

Dr. Bruce Hargreaves from Lehigh University in Pennsylvania visited the lake for a second time this summer to further study the penetration of ultra-violet (UV) light into the lake. Crater Lake is extraordinary in that UV-light penetrates to extremely deep depths (50–100 meters) compared to almost all other lakes and oceans. The limited algal and bacterial activity observed in the top 40 meters of Crater Lake may be the result of high UV intensity near the surface. Deep UV-light penetration in Crater Lake is closely tied to the very low concentrations of dissolved organic carbon (DOC) in the water. Because global climate change and adjacent land-use practices hold the potential to affect Crater Lake through small changes in UV-light and DOC, further study is warranted.

Stay Tuned…

Producers from the popular Oregon Public Broadcasting weekly television show, *Oregon Field Guide*, came to the park last summer to film television programs on three projects. Shows will air sometime in early 2001 on the bull trout restoration project, lake bathymetry mapping, and the NASA Jet Propulsion Lab ice-core probe project. Themes for Oregon Field Guide shows concern natural sciences and outdoor recreation activities in and around Oregon. A segment on the Long-Term Limnological Monitoring Program was produced in 1998 and is shown in the park visitor center on a routine basis.