STATE OF THE PARKS®

November 2009

LASSEN VOLCANIC NATIONAL PARK

A Resource Assessment

National Parks Conservation Association®
Protecting Our National Parks for Future Generations®

STATE OF THE PARKS®

Center for State of the Parks®

More than a century ago, Congress established Yellowstone as the world's first national park. That single act was the beginning of a remarkable and ongoing effort to protect this nation's natural, historical, and cultural heritage.

Today, Americans are learning that national park designation alone cannot provide full resource protection. Many parks are compromised by development of adjacent lands, air and water pollution, invasive plants and animals, and rapid increases in motorized recreation. Park officials often lack adequate information on the status of and trends in conditions of critical resources.

The National Parks Conservation Association initiated the State of the Parks program in 2000 to assess the condition of natural and cultural resources in the parks, and determine how well equipped the National Park Service is to protect the parks—its stewardship capacity. The goal is to provide information that will help policymakers, the public, and the National Park Service improve conditions in national parks, celebrate successes as models for other parks, and ensure a lasting legacy for future generations.

For more information about the methodology and research used in preparing this report and to learn more about the Center for State of the Parks, visit www.npca.org/stateoftheparks or contact: NPCA, Center for State of the Parks, P.O. Box 737, Fort Collins, CO 80522; phone: 970.493.2545; email: stateoftheparks@npca.org.

Since 1919, the National Parks Conservation Association has been the leading voice of the American people in protecting and enhancing our National Park System. NPCA, its members, and partners work together to protect the park system and preserve our nation's natural, historical, and cultural heritage for generations to come.

* More than 325,000 members
* Twenty-four regional and field offices
* More than 120,000 activists

A special note of appreciation goes to those whose generous grants and donations made this report possible: MSST Foundation, Ben and Ruth Hammett, Alec Rhodes, Lee and Marty Talbot, and anonymous donors.

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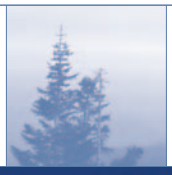
Cover photo: Changing leaves frame Manzanita Lake in autumn. Photo courtesy of Russell Virgilio.



REPORT SUMMARY

In 1915, the spectacular eruption of northern California's Lassen Peak—long a tourist landmark for early western travelers—attracted the attention of the nation. Metropolitan newspapers carried the arresting images and firsthand written accounts of amateur photographer Benjamin Franklin (B. F.) Loomis, a local resident who was one of the first to photographically document the volcano's eruption. Due to increased interest in the volcano, Lassen Peak National Monument and nearby Cinder Cone National Monument—which had been created in 1907 and were administered by the U.S. Forest Service—were incorporated into the new Lassen Volcanic National Park in 1916. Lassen Volcanic was established after Washington's Mount Rainier National Park (1899) and Oregon's Crater Lake National Park (1904), two other parks in the Cascade Range that include volcanoes.

When covered with snow in winter, it can be difficult to imagine the impressive eruption of Lassen Peak that took place less than a century ago. For a historic photograph of the 1915 eruption, see page 14.

LASSEN VOLCANIC NATIONAL PARK AT A GLANCE

- **Volcanic and geothermic forces:** The Lassen region was formed almost entirely by volcanic forces. Lassen Volcanic National Park contains the most extensive, intact network of hydrothermal resources west of Yellowstone National Park.
- **High biodiversity:** Because of its geographic location and multitude of habitats, Lassen Volcanic National Park exhibits a rich diversity of plant and animal life. The park encompasses a 5,257-foot elevational gradient from its lowest point near Warner Valley to its highest point atop Lassen Peak. This elevational shift, as well as differences in moisture, temperature, soil type, and natural and human-caused disturbance, results in varied environmental conditions throughout the park.
- **Historic trails:** With more than 150 miles of hiking trails, Lassen Volcanic National Park is especially popular with hikers and backpackers. Portions of two congressionally designated trails pass through the park: The National Park Service administers the Nobles Emigrant Trail, part of the California National Historic Trail, while the U.S. Forest Service administers the Pacific Crest National Scenic Trail. The Nobles Emigrant Trail, which crosses the park's full width in its northern section, was established in 1852 and played a vital role in the migration of settlers to the West. A 17-mile portion of the Pacific Crest National Scenic Trail, established in 1968, is located in the park east of Hat Mountain. (The entire trail spans 2,650 miles from Mexico to Canada.)
- **Scenic highway:** The 30-mile Lassen Volcanic National Park Highway, which is part of the Volcanic Legacy Scenic Byway/All-American Road that also passes through Lassen National Forest, runs between the park's southwest and northwest corners. Climbing to 8,512 feet in elevation at Lassen Peak, the park highway is the highest auto road in the Cascades and is open only in the summer. The annual opening of the highway—and the accompanying snow removal process—is one of the most challenging tasks of the year for managers at Lassen Volcanic. The road can open as early as May 10 or as late as mid-July, depending on the year's winter snowfall; as much as 40 feet of snow can accumulate on parts of the highway.

Volcanism continues to draw tourists to Lassen Volcanic National Park today. The park is home to all four types of volcanoes found in the world: shield (e.g., Prospect Peak), composite (e.g., Brokeoff Mountain), cinder cone (e.g., Cinder Cone), and plug dome (e.g., Lassen Peak). In addition, visitors can experience ongoing hydrothermal activity in the form of hissing fumaroles, bubbling mudpots, and boiling springs. These boiling, acidic environments harbor some of the most recently discovered and least known life-forms—archaebacteria. In an effort to understand more about organisms that can withstand such harsh conditions, scientists are eagerly researching these extreme environments in Lassen Volcanic National Park. For example, researchers for several universities are in the middle of a five-year project to study thermophilic archaebacteria in Boiling Springs Lake, the largest hot spring in North America.

Located in northeastern California at the crossroads of three biogeographic regions—the southern Cascade Mountain range, the northern Sierra Nevada Mountains, and the Basin and Range Province—Lassen Volcanic National Park is home to a multitude of animal and plant species. Varied environmental conditions, due in part to a 5,257-foot elevational difference between its lowest and highest points, also add to its biodiversity. More than 700 flowering plants provide food, cover, breeding sites, and shelter to an excess of 250 mammal, bird, fish, amphibian, and reptile species in the park. Many invertebrates, such as butterflies and other insects, also live there.

Lassen Volcanic National Park has a long human history, with an archaeological record dating back 7,500 years. The Achumawi, Atsugewi, Mountain Maidu, and Yahi/Yana tribes all lived in the area before European colonization and westward migration. For the descendants of these traditionally associated peoples, the entire park is considered sacred. The stories of these indigenous people—as well

as Euro-American pioneers, prospectors, and early western tourists—are interpreted at the newly opened, all-season Kohm Yah-mah-nee Visitor Center, the historic Loomis Museum, and at wayside exhibits along the scenic Lassen Volcanic National Park Highway.

Past land use practices and policies in the Lassen region have degraded the diverse habitats in the national park. Former grazing practices and alterations to the park's hydrology—from road construction and water diversion—have negatively affected the park's Drakesbad Meadow, home to a rare and sensitive wetland ecosystem known as a mountain fen. Although park managers have begun to rehabilitate the meadow by restoring water flow, they recognize that the historic integrity of Drakesbad Guest Ranch—a working resort since the late 1800s and a cultural landscape featuring historic structures—must be preserved.

For the last 100 years, a policy of fire suppression at Lassen Volcanic has resulted in park forests that exhibit increased, unhealthy tree densities. To restore forest and shrub habitat, the park's fire management team uses prescribed and wildland fire and fuel reduction methods to replicate natural fire regimes.

Funding shortages at Lassen Volcanic have left two critical management positions—cultural resource manager and geographical information systems (GIS) program manager—unfilled. The park requires additional support to address voids in other areas. For example, the backlog of archaeological surveys that must be conducted has made it difficult for staff to conduct needed compliance work; solutions might include engaging university students or acquiring funding to hire contracted archaeologists. Recent accomplishments include completion of 65 archaeological site assessments in 2006 and 2007.

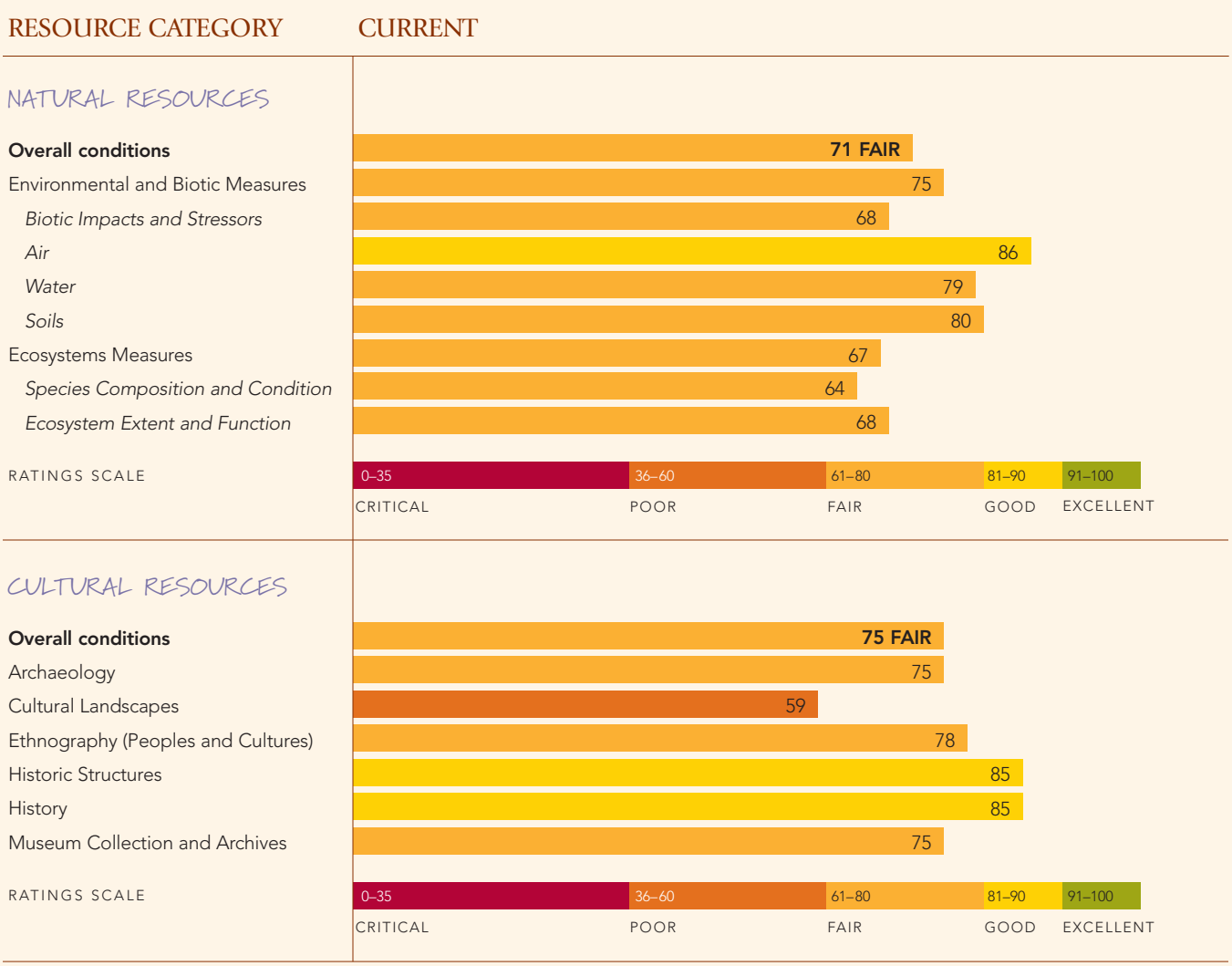
The park recently hired three permanent employees to staff its new year-round visitor center; seasonal staff are now needed to supplement visitor services during the busy summer and shoulder seasons.

To take advantage of interest in Lassen Volcanic by external scientists, the park needs to develop a research plan that will allow it to strategically pursue researchers to accomplish

NATIONAL PARK SERVICE

The park's active hydrothermal features include bubbling mudpots.

Note: When interpreting the scores for resource conditions, recognize that critical information upon which the ratings are based is not always available. This limits data interpretation to some extent. For Lassen Volcanic National Park, 65 percent of the natural resources information was available, and 97 percent of the cultural resources information was available.



The findings in this report do not necessarily reflect past or current park management. Many factors that affect resource conditions are a result of both human and natural influences over long periods of time, in many cases before a park was established. In addition, some park resources (e.g., air quality and water quality) can be affected by factors that are outside the park and beyond the Park Service's control. The intent of the Center for State of the Parks is not to evaluate Park Service staff performance, but to document the present status of park resources and determine which actions can be taken to protect them into the future.

work that will contribute to a greater understanding of park resources and that can be used to guide resource management.

RATINGS

Current overall conditions of the known **natural resources** at Lassen Volcanic National Park rated a "fair" score of 71 out of a possible 100. Ratings were assigned through an evaluation of park research and monitoring data using NPCA's Center for State of the Parks comprehensive assessment methodology (see "Appendix" on page 56). Challenges facing the Park Service include human-caused alterations to the landscape at Lassen Volcanic National Park that have negatively affected its ecosystems. Fire suppression policies, construction of roads, and the drainage of wetlands have degraded important habitat in the park. Adjacent land uses are also cause for concern, as both livestock and motorized vehicles trespass in the park.

The Park Service has made great strides addressing a number of these concerns through fire management that includes prescribed burns. Park staff have also engaged in wetland habitat restoration. To learn more about these and other resource management highlights, see pages 8 and 9.

Overall conditions of the park's known **cultural resources** rated 75 out of a possible 100, also indicating "fair" conditions. The scores for cultural resources are based on the results of indicator questions that reflect the National Park Service's own *Cultural Resource Management Guideline* and other policies related to cultural and historical resources. Factors influencing the overall score include a lack of important baseline inventories and reports, which was a major consideration in the "poor" score of 59 out of 100 for cultural landscapes. Conversely, the park has been able to complete needed reports to bolster the history program through the use of outside contractors, which helped this program achieve a "good" score of 85 out of 100.

NATIONAL PARK SERVICE

Wildflowers and green, rolling hills lead to Brokeoff Mountain in the background of this photograph. The mountain is part of what remains of the eroded caldera of Mount Tehama, a large composite volcano that gradually built up through many eruptions about 600,000 years ago.

Lassen Volcanic National Park	
Park location	Northeastern California, approximately 165 miles from the Sacramento airport
Park size (acres)	106,372 acres
Park establishment	1916, incorporating Lassen Peak and Cinder Cone National Monuments into a newly designated national park
Annual recreational visits (2008)	377,361

KEY FINDINGS

- **Activities on adjacent land affect park.** Nearly 75 percent of Lassen Volcanic is designated wilderness. Even though the park prohibits uses that are contrary to this wilderness designation, the park is almost entirely surrounded by Lassen National Forest, which permits grazing, logging, and off-road vehicle recreation. This has led to increased invasive plant species along park borders and damaging effects—such as noise and landscape disturbance—associated with trespass motorcyclists, snowmobilers, and cattle.
- **Fire suppression effects being addressed.** A history of fire suppression has altered vegetation at Lassen Volcanic National Park, leading to unhealthy forest conditions, such as increased tree density (and the resultant decrease in tree height and diameter); a reduction in the extent of brush fields; encroachment of trees (primarily lodgepole pine) into meadow areas; a shift in species composition; and a decrease in the variety of forest gaps necessary for healthy ecosystems to function. The park is using various management strategies to address these conditions.
- **Historic water flows restored to rare wetland.** Lassen Volcanic's sensitive wetlands have been damaged by human modifications to the landscape. Most severe is the situation at Drakesbad Meadow, which features important fen (peaty marshland) habitat. An access road was built through a major spring complex in this area during the Park Service's Mission 66 (program from 1956 to 1966 that was intended to expand visitor services), and drainage and irrigation ditches were installed for livestock, all of which resulted in the depletion of the fen's vital water supply. Degradation of soils, loss of important peat-forming wetland plants, and an invasion of upland plants have followed. In an effort to partially remedy the situation, in 2003 culverts were installed under the access road to allow for natural water flow, and some drainage ditches were experimentally dammed with sheet metal to allow replenishment of water to the fen habitat.
- **Cultural landscape work undone.** Cultural landscape inventories—providing essential baseline information to guide treatment and interpretation of cultural landscapes—are required for several landscapes at Lassen Volcanic. In addition, cultural landscape reports, which identify threats and prescribe protective measures, have been completed for only one of the nine identified landscapes in the park (Drakesbad Guest Ranch). Also, while historic features in the Juniper Lake area (e.g., Horseshoe Lake Ranger Station) are listed in the National Register of Historic Places, Juniper Lake is not designated as a cultural landscape; this area should be considered for designation in the future.
- **Park improving relationships with traditionally associated peoples.** Relationships between Lassen Volcanic National Park and its traditionally associated peoples have not always been consistent or positive. With insights provided in a 2004 traditional use study, Lassen Volcanic staff are currently working to strengthen existing relationships, build new ones, and improve interpretation of indigenous history. For example, park managers would like to reintroduce Atsugewi basketry demonstrations, which used to take place in previous decades but no longer occur.

MEGAN LOWERY

Grazing, road construction, and water diversion have harmed Drakesbad Meadow, home to a rare and sensitive wetland ecosystem known as a mountain fen. Park managers have begun to rehabilitate the meadow by restoring water flow.

- **Historic photos need better protection.** Although a great deal of the park's museum and archival collections is held at a shared facility in Orick, California, key items such as the photographic slide collections of the eruption of Lassen Peak remain at the park for interpretive purposes. These irreplaceable items are housed in an administrative building closet that lacks climate control and earthquake protection and is too small. Digitizing the photos for internal use and storing the originals at the Orick facility would safeguard the historic collection.

- **Critical staff positions remain unfilled.** Filling the vacant cultural resource manager position would greatly benefit the park. Because the park lacks this first-line supervisor, holistic oversight of the park's archaeology, ethnography, cultural landscapes, historic structures, and museum collections is missing. Managers at Lassen Volcanic are considering the possibility of sharing a cultural resources manager with another park as a way to address this need, given funding limitations. In addition, the geographical information systems (GIS) program suffers from the lack of a dedicated staff person to meet the park's GIS data management, information analysis, and mapping needs.

RESOURCE MANAGEMENT HIGHLIGHTS

- **New visitor center opened.** In October 2008, the Kohm Yah-mah-nee Visitor Center—the park's first all-season visitor center—opened at its southwestern entrance. The center's name means "snow mountain" in the Mountain Maidu language, and refers to Lassen Peak. Due in part to its use of recycled and locally obtained materials, the new visitor center meets the high environmental standards for Leadership in Energy and Environmental Design (LEED) certification from the U.S. Green Building Council. The Lassen Chalet—a former ski lodge closed in the 1980s—was torn down for the construction of the new center, yielding 1,500 tons of reusable concrete, asphalt, and gravel. In addition to providing construction material, this process eliminated disposal and transport costs of such items from the park, which would have filled an estimated 60 dump trucks, each making a 60-mile round-trip from the town of Chester. More than 50 tons of steel were also recycled at a local scrap yard. The new visitor center is built with local lumber from sustainable forests, incorporates decorative stone from local sources near Red Bluff, and features countertops made of recycled glass.

- **Fire management begins to restore ecosystems.** Park managers have turned to prescribed burns, wildland fire (wildfires), and mechanical or manual treatments to rectify the effects of past fire suppression policies (for more on these treatments, see "Landscapes Altered by Human Activity" on page 30). From 2004 to 2005, the Lassen Volcanic National Park fire management team treated approximately 10,000 park acres using wildfire and prescribed fires. In 2007 and 2008, the team treated more than 1,500 acres and 620 acres, respectively, through a combination of prescribed burning, pile burning, manual fuel treatment, and mechanical fuel reduction. The Lassen Volcanic fire crew also assisted with prescribed burns at Crater Lake National Park in Oregon and with hazardous fuel removal at Lava Beds National Monument in California.

- **Land improvements ongoing.** A 1999 Disturbed Lands Inventory and Recommendations report identified 24 sites at Lassen Volcanic National Park that have been affected by past human uses and where resources would benefit from restoration efforts. Since the report's release, the park has completed 16 projects to improve these sites. Of the 195 acres of disturbed land, 109 were restored by autumn 2008, with an additional 60 acres scheduled for restoration in the next five years. Completed projects include removal of several roads; habitat restoration at the former downhill ski area (operational from 1935 to 1985); habitat restoration at five rock/pumice quarries that were operated to obtain road construction and building materials in the 1920s and 1930s; landscaping and construction of the southwest entrance station and visitor center; removal of parking lots at Manzanita Lake; and extensive revegetation of the Lassen Volcanic National Park Highway. This restoration program is funded by monies brought in through park fees and by the Natural Resources Preservation Program (NRPP), created in 1981 to fund natural resources research and management programs in the National Park Service.

Lassen Volcanic's fire crew uses prescribed burns and other management tools in its efforts to restore ecosystems.

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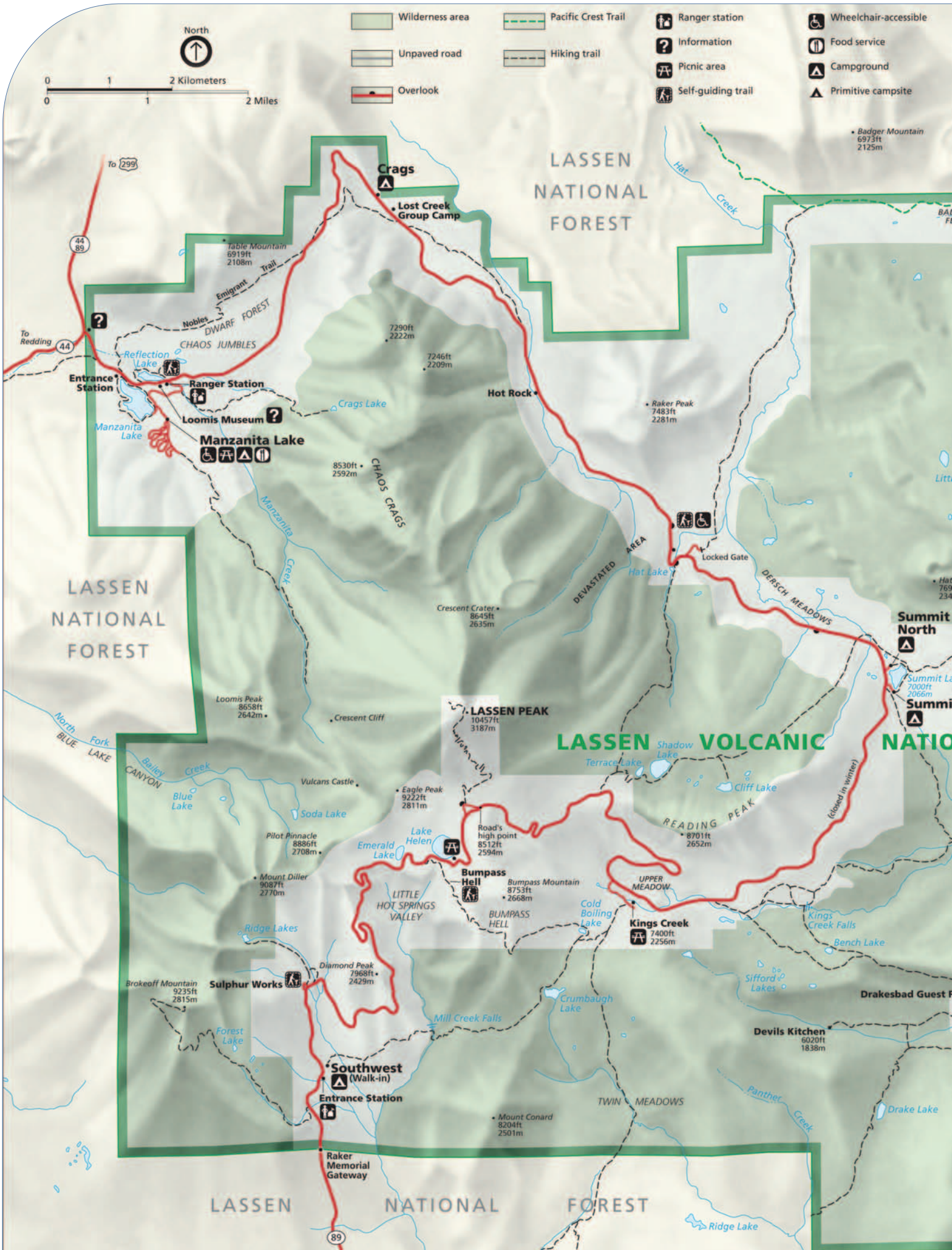
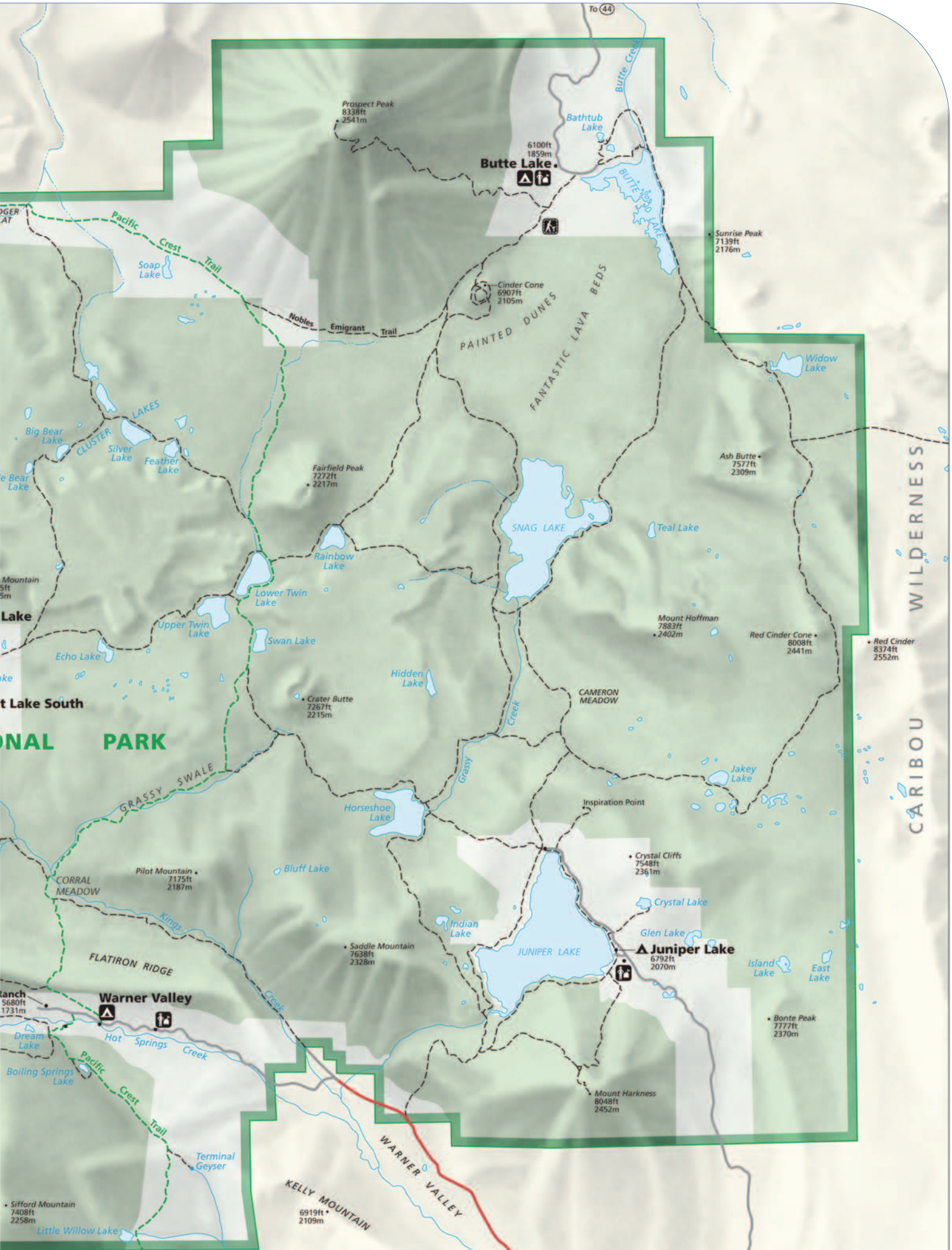
- **Resource monitoring under way.** As part of the Park Service's Klamath Inventory and Monitoring Network (KLMN)—one of 32 such networks developed by the Park Service to collect, organize, and make available natural resource data—Lassen Volcanic resource managers have worked with resource professionals from other agencies as well as university researchers to identify vital components of the park's ecosystems to monitor. Implementation of monitoring protocols has begun in several areas, including those for water quality and songbirds. Through the KLMN, a number of data gaps have been identified and researchers have been hired to collect information in these areas (work has included the 2007–2008 ecological assessment of aspen communities within the park).
- **Management conflicts being addressed.** Drakesbad Guest Ranch, occupying a picturesque setting within the Warner Valley of Lassen Volcanic National Park, is considered one of the park's premier cultural landscapes. The first lodge at the site was built in the late 1800s, and development continued after the ranch changed ownership at the turn of the 20th century. A new lodge built at the ranch in 1938 has operated continuously since then. The Dream Lake dam at Drakesbad, constructed in 1932 to create a fishing and boating lake for guests, has altered water flows and negatively affected sensitive ecosystems there. While park managers are cognizant of the dam's historic value, they are equally aware of damage it has caused to sensitive wetlands. In order to address this natural and cultural resource management conflict, and to preserve the integrity of the entire Drakesbad Guest Ranch Historic District, the park is completing a comprehensive site plan for the Warner Valley area, scheduled for completion in 2009. The plan will help guide cultural and natural resource staff to ensure preservation of this important cultural site and the protection of its natural resources—including sensitive wetlands and hydrothermal features—while also providing for visitor access, facilities, and programming.
- **Archaeology program making progress.** Recognizing the need for baseline information, the park has made archaeological site assessments a high priority; 30 assessments were completed in 2006, while 35 were completed in 2007. In addition, a seasonal archaeological technician is working to organize and overhaul park data recorded in the Archeological Sites Management Information System, a service-wide database containing information on prehistoric and historic archaeological resources.
- **Historic collections organized.** In 2004, through cooperation with the University of Washington, the park organized and preserved 35 separate historic photograph collections. Searchable finding aids, which can be accessed online via the park's website (www.nps.gov/lavo), make it easy to locate information about items in the collections. Next steps include digitizing images, placing the remainder of the finding aids on the park's website, and developing protocols for responding to researchers' requests to use the collections.


North
0 1 2 Kilometers
0 1 2 Miles
Wilderness area
Unpaved road
Overlook
Pacific Crest Trail
Hiking trail
Ranger station
Information
Picnic area
Self-guiding trail
Wheelchair-accessible
Food service
Campground
Primitive campsite
LASSEN NATIONAL FOREST
LASSEN VOLCANIC NATIONAL PARK
To 299
To Redding
44
89
Crags
Lost Creek Group Camp
Table Mountain 6919ft 2108m
Emigrant Trail
Nobles
DWARF FOREST
CHAOS JUMBLES
Reflection Lake
Entrance Station
Ranger Station
Loomis Museum
Manzanita Lake
Manzanita Creek
Crags Lake
7290ft 2222m
7246ft 2209m
Hot Rock
Raker Peak 7483ft 2281m
8530ft 2592m
CHAOS CRAGS
Hat Creek
Badger Mountain 6973ft 2125m
DEVASTATED AREA
Locked Gate
Hat Lake
DERSCH MEADOWS
Crescent Crater 8645ft 2635m
Summit North
Loomis Peak 8658ft 2642m
Crescent Cliff
LASSEN PEAK 10457ft 3187m
North Fork BLUE LAKE
Bailey Creek CANYON
Blue Lake
Vulcans Castle
Eagle Peak 9222ft 2811m
Soda Lake
Pilot Pinnacle 8886ft 2708m
Lake Helen
Emerald Lake
Road's high point 8512ft 2594m
Shadow Lake
Terrace Lake
Cliff Lake
READING PEAK 8701ft 2652m
(closed in winter)
Mount Diller 9087ft 2770m
Bumpass Hell
Bumpass Mountain 8753ft 2668m
LITTLE HOT SPRINGS VALLEY
BUMPASS HELL
UPPER MEADOW
Cold Boiling Lake
Kings Creek 7400ft 2256m
Kings Creek Falls
Bench Lake
Ridge Lakes
Diamond Peak 7968ft 2429m
Brokeoff Mountain 9235ft 2815m
Sulphur Works
Sifford Lakes
Drakesbad Guest
Crumbaugh Lake
Mill Creek Falls
Forest Lake
Devils Kitchen 6020ft 1838m
Southwest (Walk-in)
Entrance Station
TWIN MEADOWS
Panther Creek
Drake Lake
Mount Conard 8204ft 2501m
Raker Memorial Gateway
Ridge Lake


To 44
Butte Creek
Prospect Peak
8338ft
2541m
Bathtub Lake
6100ft
1859m
Butte Lake
BUTTE LAKE
Sunrise Peak
7139ft
2176m
Pacific Crest Trail
Soap Lake
Cinder Cone
6907ft
2105m
Nobles Emigrant Trail
PAINTED DUNES
FANTASTIC LAVA BEDS
Widow Lake
CLUSTER LAKES
Big Bear Lake
Silver Lake
Feather Lake
Fairfield Peak
7272ft
2217m
Ash Butte
7577ft
2309m
SNAG LAKE
Teal Lake
Rainbow Lake
Lower Twin Lake
Upper Twin Lake
Swan Lake
Echo Lake
Mount Hoffman
7883ft
2402m
Red Cinder Cone
8008ft
2441m
Red Cinder
8374ft
2552m
WILDERNESS
Hidden Lake
Crater Butte
7267ft
2215m
CAMERON MEADOW
Grassy Creek
PARK
GRASSY SWALE
Jakey Lake
Inspiration Point
Horseshoe Lake
Crystal Cliffs
7548ft
2361m
Pilot Mountain
7175ft
2187m
Bluff Lake
CORRAL MEADOW
Crystal Lake
Kings
Indian Lake
Glen Lake
Saddle Mountain
7638ft
2328m
JUNIPER LAKE
Juniper Lake
6792ft
2070m
Island Lake
East Lake
FLATIRON RIDGE
Warner Valley
Hot Springs Creek
Bonte Peak
7777ft
2370m
Dream Lake
Boiling Springs Lake
Pacific Crest Trail
Mount Harkness
8048ft
2452m
Terminal Geyser
WARNER VALLEY
KELLY MOUNTAIN
6919ft
2109m
Sifford Mountain
7408ft
2258m
Little Willow Lake

NATIONAL PARK SERVICE

Bumpass Hell is the park's largest hydrothermal area, with 75 major fumaroles, acid sulfate hot springs, and numerous mudpots.

GEOLOGY OF LASSEN—THE FORCES OF FIRE, STEAM, AND ICE

The Lassen region was formed almost entirely by volcanic forces and includes three distinct volcanic centers—areas of concentrated volcanic activity. The Dittmar Volcanic Center was active approximately 2 million years ago, and Warner Valley comprises its eroded remains. The Maidu Volcanic Center, active 2 million to 800,000 years ago, encompasses the present-day towns of Mineral and Battle Creek Meadows south of Lassen Volcanic National Park. Lastly, the Lassen Volcanic Center accounts for the current volcanic activity in the park. Lassen Volcanic National Park is just one of many active, dormant, or extinct volcanic areas extending around the Pacific Ocean in what is known as the "Pacific Ring of Fire." The Pacific Ring of Fire is a zone marking the edges of the plates that form the crust of the Earth; volcanic eruptions and earthquakes are the result of the great plates passing over and grinding against each other.

Because the park's origins are volcanic, sedimentary rock—the most common type on earth—is virtually absent. Instead, igneous rock—formed as molten rock cools—is prevalent. Lassen Volcanic National Park's landscape is diverse, with rugged volcanic mountain peaks in the west, a lava plateau in the east, and eroded lava peaks and ridges in the north. The Warner Valley in the southern portion of the park is a result of glaciations that occurred 10,000 years ago. Today, no true glaciers exist in Lassen Volcanic, but permanent snowfields are present. Glacial features within the park include moraines, tarns, cirques, and U-shaped valleys. Melting glaciers left jewel-like footprints in the form of 51 lakes.

The world's volcanoes are classified into four different types, and visitors to Lassen Volcanic National Park can view examples of all of them. **Plug dome volcanoes** contain dacite lava that tends to rise directly over the volcano's vent, forming a dome. Dacite lava is relatively rich in silica, causing it to flow sluggishly, if at all. This

results in lava plugging the vent, leading to an eruption. These volcanoes are steep-sided and may erupt only once before becoming extinct. Lassen Peak, which rises 2,000 feet to an elevation of 10,457 feet, is considered the largest plug dome volcano in the world and is still considered to be active. (See "The Eruption of Lassen Peak" on page 14.) Other plug dome volcanoes in the park include Chaos Crags, Loomis Peak, Crescent Crater, and Eagle Peak.

Shield volcanoes release basaltic lava, which is fluid and flows outward from the vent, forming a gently sloping shield shape. Mount Harkness, Raker Peak, Prospect Peak, and Sifford Mountain are all shield volcanoes found in the park.

Mount Tehama, a large **composite volcano**, gradually built up through countless eruptions about 600,000 years ago. Mount Tehama stood in what is now the park's southwest corner, 1,000 feet higher than Lassen Peak and measuring more than 11 miles across at its base. After hundreds of thousands of years of weathering and erosion, what is left of Mount Tehama today—composite remnants—are jagged peaks: Mount Diller, Pilot Pinnacle, Brokeoff Mountain, and Mount Conard once made up the flanks of Mount Tehama's caldera. The Sulphur Works thermal area in the park was formerly the main vent of the ancient volcano.

Cinder cones usually exhibit just one episode of activity, erupting lava that shatters in midair, falling as fragmented pieces. The park's second-most famous volcano, aptly named Cinder Cone, is located in its northeast corner. Speculation on the eruption of Cinder Cone had been debated for years. While some scientists believed the volcano erupted as little as 150 years ago, others were convinced that the eruption had occurred hundreds of years ago. A study conducted by the U.S. Geological Survey and published in 2000 demonstrated the actual eruption date to be between 1630 and 1670. This estimate was obtained by carbon dating—measuring carbon 14 levels in the remains of trees killed by the eruption. Within Lassen Volcanic National Park, remnants from the Cinder Cone eruption include the Fantastic Lava Beds and the Painted Dunes. Snag Lake was formed when the Painted Dunes lava flows blocked Grassy Creek. In addition to Cinder Cone, Hat Mountain, Crater Butte, and Fairfield Peak are other cinder cone volcanoes found in the park.

Sites of future eruptions and hazard areas in the park may include Lassen Peak, Chaos Crags, Sunflower Flat, Tumble Buttes, Bogard Buttes, Hat Mountain, and Prospect Peak.

Lassen Volcanic's extensive, intact network of hydrothermal resources features boiling springs, hissing fumaroles (steam vents), and bubbling mudpots (hot springs containing boiling mud). Steam generated by the boiling of underground reservoirs of hot water drives hydrothermal activity. Bumpass Hell is the largest hydrothermal area in the park, with 75 major fumaroles, acid sulfate hot springs, and numerous

MEGAN LOWERY

Carbon dating conducted by the U.S. Geological Survey indicates that Cinder Cone, in the northeast corner of the park, last erupted between 1630 and 1670.

THE ERUPTION OF LASSEN PEAK

Lassen Peak formed nearly 30,000 years ago, beginning as a volcanic vent on Mount Tehama's northern flank. Lassen Peak first erupted 27,000 years ago. A plug dome volcano, it was once steep sided. Glaciers eroded the volcano from 25,000 to 18,000 years ago, during the last ice age.

When Lassen Peak erupted on May 19, 1915, it had been mildly active for a year; more than 180 steam explosions had occurred since 1914. The eruption—captured on film by amateur photographer B. F. Loomis—was spectacular. Hot rocks and lava combined with deep mountain snow to create a mudflow known as lahar. This devastating flow, a half-mile wide, surged down the peak's northeast side and into the drainages of Hat and Lost Creeks. Hat Creek was partially dammed with mud and debris, creating Hat Lake.

Lassen Peak's climactic eruption occurred three days later on May 22. The volcano—which rained ash as far away as 200 miles—hurled an avalanche of fast-moving, hot lava fragments. This pyroclastic flow followed the same path as the earlier lahar, leveling any remaining vegetation in its path. An estimated 5 million board feet of trees perished in this area, referred to today as the Devastated Area. The pyroclastic flow swept Jessen Meadows out of existence and formed a 67-foot gully through the Lost Creek drainage. It is estimated that more than 390 smaller-scale eruptions occurred at Lassen Peak from 1915 to 1921. Almost a century later, Lassen Peak is still considered an active volcano.

Large eruptions in the Lassen area have an average recurrence interval of 10,000 years. However, the most recent eruption on this scale produced Chaos Crags just 1,100 years ago. Chaos Crags comprises six plug dome volcanoes that are considered the steepest volcanic domes on Earth. One of these dacite domes collapsed about 300 years ago, forming Chaos Jumbles, which spans three square miles and measures up to 130 feet thick.

The park uses a variety of instruments to monitor earthquakes and volcanic activity. Tiltmeters on Lassen Peak measure the change in angle of a surface; a significant change may indicate renewed volcanic activity. Seismometers throughout the park measure and pinpoint the location of subsurface movement. And at Chaos Crags, inclinometers measure the movement of surface formations. Minor slippage of rock is a warning, since it usually occurs before a major avalanche. Warning signs can appear a few weeks or a few months before an eruption. There has been no significant activity measured during the last decade.

B. F. Loomis captured this image of Lassen Peak steaming just hours before its major eruption on May 22, 1915.

B. F. LOOMIS, COURTESY OF THE NATIONAL PARK SERVICE

ERIN MCPHERSON

Lassen Volcanic's hydrothermal areas are constantly evolving, which can make it a challenge to maintain the park highway and other infrastructure. This chain-link fence is a temporary solution to protect visitors from dangerous hydrothermal activity.

mudpots. Big Boiler, the largest fumarole in Lassen Volcanic, is found there. Its steam temperatures can reach 322° F, the hottest in the world.

Volcanic activity continues to be a dynamic feature of Lassen Volcanic National Park. For example, in the winter of 2008–2009, the largest mudpot at Sulphur Works, which is bisected by the Lassen Volcanic National Park Highway, expanded to three times its previous size and began discharging mud onto the highway. In this evolving hydrothermal area, concern for visitor safety is an ongoing issue. A chain-link fence and warning signs at Sulphur Works separate visitors from dangerous areas. Further monitoring of this area will be needed in spring 2010.

Lassen Volcanic's geothermal resources comprise highly sensitive areas that require boardwalks and designated trails for their protection. Because these resources are dynamic, park staff reroute trails (e.g., the boardwalk at Bumpass Hell) as needed. In addition, the constant heat and moisture damage boardwalks and they must be repaired or replaced annually. Although signs instruct visitors to stay on trails and there is a chain-link fence at the Sulphur Works area, visitors damage hydrothermal resources by leaving designated trails (leaving behind footprints) and discarding trash at the sites.

LAND USE HISTORY, PARK ESTABLISHMENT, AND ADJACENT LAND USE

For at least 7,500 years, people have inhabited the Lassen region. Indigenous societies that used regional resources included the Achumawi and Atsugewi people in what is now the northern portion of the park, the Mountain Maidu in the park's southeast region, and the Yana/Yahi in the southwest. Although these aboriginal peoples were not year-round residents, they camped in the region on a seasonal basis,

RUSSELL VIRGILIO

In addition to compelling hydrothermal features, Lassen Volcanic National Park is home to spectacular waterfalls such as Kings Creek Falls.

harvesting plants and animals in the warmer months.

By the 19th century, Euro-Americans had begun to explore and settle what is now the state of California. While Spanish missions extended along the Pacific coast as far north as San Francisco, the Lassen region was not visited by missionaries. Euro-American fur traders traveled near the present-day park beginning in 1826, but by the 1840s, fur trading in California had waned. Lassen Peak is named for one of the early Euro-American settlers to the region, Danish immigrant Peter Lassen, who obtained a land grant from the Mexican government in 1844. In 1848, California was ceded to the United States at the end of the Mexican-American War.

In 1849, the discovery of gold at Sutter's Mill, near Sacramento in the Coloma Valley, brought a flood of fortune seekers into California, guaranteeing the westward expansion of the United States. By the mid-1800s, prospectors, homesteaders, and cattle and sheep ranchers had begun to settle the Lassen region. Movement of emigrants into the area was facilitated by the Nobles Emigrant Trail, a California Trail shortcut blazed through a mountain pass between the Humboldt River and the Sacramento Valley.

The Gold Rush of the 1850s forced American Indians in California to migrate to areas unclaimed by settlers. With this influx of population, American Indian societies were decimated by unfamiliar diseases, environmental degradation, dislocation from traditional areas, and warfare. Those American Indians who survived the influx of pioneers were forced onto reservations, and by the 1870s, the Yana/Yahi, Mountain Maidu, Atsugewi, and Achumawi had been almost obliterated.

Emigration to California increased dramatically in the years following the Gold Rush, with settlers to the Lassen region favoring the more hospitable southern portion of what is now the park. Prospectors searched the Lassen region for precious metals and minerals, but actual mining activity in what is the present-day park occurred only at Sulphur Works. There, in 1866, Mathias B. Supan mined and hauled ore, transporting it to Paynes Creek in order to extract and refine the sulfur. (The business was unprofitable and short-lived.) Cattle and sheep ranching proved more lucrative than mining, and certain areas in Lassen Volcanic National Park are named for early ranchers. Kings Creek and Kings Meadows are named for J. M. King, a horseman who grazed his mules and horses in the meadows below Lassen Peak in the 1860s. Dersch Meadows near Summit Lake is named for Fred Dersch, who kept sheep at Hat and Bear

Creeks in the late 1800s. By the end of the century, the area had also become a tourist destination. Western travelers made special trips to the Lassen region to experience its hydrothermal features and volcanoes.

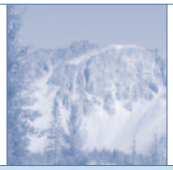
The Lassen Peak Forest Reserve, designated in 1905, was the first protected area to include the Lassen region of northern California. Shortly thereafter, the U.S. Forest Service (which administered the forest reserve) pressed Congress to designate Cinder Cone, Lassen Peak, Bumpass Hell, and Butte Lake as national monuments. In response, Lassen Peak and Cinder Cone National Monuments were created in 1907, encompassing 1,280 and 5,120 acres, respectively.

By 1912, Rep. John E. Raker of California had begun advocating an upgrade in status for the new monuments, proposing the establishment of a larger protected area—"Peter Lassen National Park"—and when Lassen Peak began to erupt in May 1914, the Lassen region was catapulted into the national spotlight. To preserve the site of the then most recent volcanic eruption in the United States, Lassen Peak and Cinder Cone National Monuments were integrated into Lassen Volcanic National Park on August 9, 1916. The National Park Service was created a mere 16 days after Lassen Volcanic National Park was established, but the park remained under the administration of the Forest Service until 1925 for logistical reasons.

Much of Lassen Volcanic's early infrastructure—roads, trails, and buildings—are the result of the New Deal Era of the 1930s and were constructed by the federally funded Civilian Conservation Corps (CCC). It was in the '30s, too, that winter enthusiasts discovered Lassen Volcanic National Park—a place where one could ski well into the summer—and in 1935 the park's main concessionaire constructed a small ski tow. Though the ski area closed during World War II, it reopened in 1946 to such popularity that additional facilities were needed. A new entrance station kiosk, large parking area, and the Lassen Chalet lodge were all built in 1966. The Park Service allowed moderate expansion of downhill ski facilities at Lassen Volcanic until the operation became unprofitable in 1985, due to a lengthy drought and the opening of a ski area nearby on Mount Shasta. The ski resort and its associated structures were dismantled in 1993.

Lassen Volcanic National Park has grown since its establishment. In 1929, Congress expanded the park's boundaries to protect additional resources, including Manzanita and Reflection Lakes, the summit of Brokeoff Mountain, Chaos Jumbles, Raker Peak, areas of Lost and Hat Creeks, and additional sections of the Nobles Emigrant Trail. In 1947, the park acquired 160 acres of Forest Service land adjacent to the Manzanita Lake Campground. Congress designated a majority of Lassen Volcanic National Park a wilderness area in 1972. In 1987, the park acquired additional property at the Terminal Geyser area, southwest of Drakesbad. The park's total size today is 106,372 acres.

Lassen Volcanic National Park is almost completely surrounded by Lassen National Forest, although several small sections of private property adjoin the park boundary. There are three wilderness areas within the national forest—Caribou Wilderness on the park's eastern boundary, Thousand Lakes Wilderness northwest of the park, and Ishi Wilderness southeast of the park. Although Lassen Volcanic National Park is within a day's drive of Sacramento and the San Francisco Bay area, the counties in which it resides (Lassen, Plumas, Tehama, and Shasta) are relatively slow growing. Primary land use activities adjacent to the park are logging, wood products manufacturing, cattle ranching, agriculture, and tourism. Lassen Volcanic contains two inholdings (privately held lands) totaling 4.22 acres at Hat Creek and Juniper Lake.



THE LASSEN VOLCANIC NATIONAL PARK ASSESSMENT

RUSSELL VIRGILIO

Lassen Volcanic National Park's diverse ecosystems are not well understood, partly because some key baseline information has not been collected. Projects conducted through the Klamath Inventory and Monitoring Network will contribute to the knowledge base.

NATURAL RESOURCES—HABITAT DEGRADATION THREATENS ECOSYSTEMS

NPCA's assessment rated the overall condition of natural resources at Lassen Volcanic National Park a 71 out of 100, which ranks park resources in "fair" condition. The park's ecosystems are only partly understood, largely due to a lack of baseline data. Work being done through the Klamath Inventory and Monitoring Network will add to the knowledge base.

Habitats in the park have suffered from past human modifications to the landscape, such as a policy of fire suppression, historic grazing practices, and alterations to the park's hydrological systems through road construction and water diversion and damming. Livestock and motorized vehicles that trespass from adjacent lands are also of concern.

PLANT COMMUNITIES REPLETE WITH WILDFLOWERS

Because of its volcanic origins and glaciation, Lassen Volcanic National Park's topography is diverse, exhibiting a 5,257-foot elevational gain from its lowest point near Warner Valley (5,200 feet) to its highest point atop Lassen Peak (10,457 feet). Along with elevational shifts, the park's location at the convergence of three biogeographic regions—the southern Cascade Mountain range, the northern Sierra Nevada Mountains, and the Basin and Range Province—contributes to its species diversity.

According to the California Native Plant Society, 20 known special status plant species are found at Lassen Volcanic National Park. Plant species are included on the special status list if they are rare, localized, or declining throughout their range; no plants that are federally listed as threatened or endangered are found in the park. Lassen Peak is home to three extremely rare alpine wildflowers—talus collomia (*Collomia larsenii*), Mt. Lassen draba (*Draba aureola*), and alpine false candytuft (*Smelowskia ovalis* var. *congesta*). Due to their rarity, hiking trails near populations of these plants were closed in 1996 to minimize the impacts of trampling. The park's variety of alpine false candytuft, the rarest plant of the three, is endemic to the slopes of Lassen Peak—it is found nowhere else on Earth and is also referred to as Mt. Lassen smelowskia. Although these rare wildflowers are not accessible via hiking trails, the park harbors many other wildflower species that are easily reached on foot. Hiking to view wildflowers is popular with park visitors, and the Lassen Volcanic website includes an extensive gallery of wildflower photographs.

Alpine communities at Lassen Volcanic National Park occur from 8,500 feet to 10,000 feet. They are above treeline but below the permanent snow level, and they cover about 10 percent of the park. Soils here are poorly developed, and due to high elevation and lack of shade, solar radiation is intense. In winter, plants are exposed to windborne ice particles, while summer brings blowing sand and gravel. Plants in this severe environment have evolved to survive these extreme conditions; some adaptations include low, spreading growth, succulence, reflective hairs, and extensive root systems. The growing season in the alpine communities is short, which results in low numbers of individual plants and low rates of reproduction. Species found in these communities include Davidson's penstemon (*Penstemon davidsonii* var. *davidsonii*), Pringle's bluegrass (*Poa pringlei*), Mt. Lassen draba, Shasta buckwheat (*Eriogonum pyrolifolium*), and alpine mountainsorrel (*Oxyria digyna*).

Because alpine plants and animals are especially vulnerable to changes in temperature and precipitation, alpine areas are considered sensitive indicators of climate change. In the Sierra Nevada range of the western United States, research suggests that some negative impacts on plant and animal species are the result of a warming climate. For example, a resurvey of small mammals within Yosemite National Park (first surveys done by Joseph Grinnell in 1918; follow-up surveys conducted by University of California–Berkeley biologists beginning in 2006 and scheduled to be completed in 2009) has demonstrated a significant shift of mammal species to higher elevations, presumably to avoid

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Volunteers conduct rare plant surveys on Lassen Peak.

the warmer temperatures in the lower elevations. Another study in the Sierra Nevada range (and other areas in the West) documented increasing annual mortality of pine and fir trees over the decades-long study period; researchers concluded that this increasing mortality was likely caused by increased temperatures without increased precipitation.

Resource managers are concerned about the impacts of climate change on the park's flora and fauna. To learn more about possible climate change in the park, in 2008 Lassen Volcanic began a long-term study of American pika (*Ochotona princeps*). These small mammals, which are related to the rabbit, cannot survive extended exposure to temperatures above 77 ºF. Many scientists believe that significant warming will cause this species to shift its geographic range to higher elevations, if it can. Mammal resurveys at Yosemite, mentioned above, have already shown that the pika has shifted the lower limit of its range up by 1,500 feet in elevation at that park.

The park's **subalpine forest** community is found on nutrient-poor sites above 8,000 feet to treeline and covers only 6 percent of Lassen Volcanic National Park. Whitebark pine (*Pinus albicaulis*) and mountain hemlock (*Tsuga mertensiana*) are hardy tree species that have adapted to the harsh conditions at these elevations. As evidence of the extreme growing conditions present in subalpine forest, it takes an average of 29 years for mountain hemlock seedlings to reach one foot in height in this environment. In the summer months, wildflowers such as purple mountainheath (*Phyllodoce breweri*), lupine (*Lupinus* spp.), Indian paintbrush (*Castilleja* spp.), and penstemon (*Penstemon* spp.) are prominent there.

Red fir forests occur at elevations ranging from 6,500 to 8,000 feet. This forest type is the most extensive, covering almost half of the park. Tree species found here include California red fir (*Abies magnifica*), western white pine (*Pinus monticola*), mountain hemlock, and lodgepole pine (*P. contorta*). Old-growth stands of red fir trees—which can live more than 300 years—are scattered throughout the park.

Mixed coniferous forest covers about a fourth of Lassen Volcanic National Park. This community occurs below 6,500 feet in elevation, and tree species include ponderosa pine (*Pinus ponderosa*), Jeffrey pine (*P. jeffreyi*), sugar pine (*P. lambertiana*), incense cedar (*Calocedrus decurrens*), and white fir (*Abies concolor*). Wildflowers found in this forest type include spotted coralroot (*Corallorrhiza maculata*), violets (*Viola* spp.), and lupine. Mixed coniferous forests in the park face various threats. Incense cedar have declined, largely because of drought. Also of concern are high ozone concentrations due to air pollution that have caused visible injury (white or yellow mottling) to some Jeffrey pine and ponderosa pine near Manzanita Lake.

Dry and wet meadows and **riparian areas** are scattered throughout Lassen Volcanic National Park. Wetland meadow habitat supports the greatest diversity of plant life in the park, and many wildflower species—including monkey flower (*Mimulus* spp.), buttercup (*Ranunculus* spp.), alpine shootingstar (*Dodecatheon alpinum*), and marsh marigold (*Caltha leptosepala* var. *biflora*)—occur there. The 35-acre Drakesbad Meadow is the park's largest wetland. Riparian areas include

NATIONAL PARK SERVICE

Mt. Lassen draba is one of three extremely rare alpine wildflower species found on Lassen Peak.

NATIONAL PARK SERVICE

Boiling Springs Lake is the third-largest body of hot water found anywhere in the world.

willows (*Salix* spp.) and thinleaf alder (*Alnus incana*), and they provide habitat and migration corridors for many wildlife species. These areas also contain wildflowers such as crimson columbine (*Aquilegia formosa*), monkshood (*Aconitum columbianum*), and leopard lily (*Lilium pardalinum*).

Rare and important communities of **whitebark pine** and **quaking aspen** (*Populus tremuloides*) are more abundant within park boundaries than on adjacent lands. (See "Keystone Species at Lassen Volcanic" on page 24.)

Finally, fires in the park have resulted in two successional habitat types. **Mountain chaparral** communities in Lassen Volcanic National Park are found near Manzanita Lake and in areas destroyed by crown fires (e.g., Badger and Table Mountains). These communities are composed primarily of dense greenleaf manzanita (*Arctostaphylos patula*), pinemat manzanita (*A. nevadensis*), huckleberry oak (*Quercus vacciniifolia*), bush chinquapin (*Chrysolepis sempervirens*), and whitethorn ceanothus (*Ceanothus cordulatus*). **Lodgepole pine forests,** which cover about 13 percent (14,000 acres) of the park, are the result of lodgepole trees that invaded burned and bare areas after intense fires.

PARK PRESERVES LAKES, RIVERS, AND RARE FENS

Lassen Volcanic National Park preserves more than 200 lakes, most of which were formed or altered by volcanism. Glaciers created the 573-acre Juniper Lake—the park's largest and deepest—as well as 50 others. Some lakes in the park are stunningly colorful. Lake Helen's intense blue is a result of minerals in the water; both minerals and algae combine to make Emerald Lake a deep green. Other lakes are extremely hot—Boiling Springs Lake is the third-largest body of hot water (i.e., body of geothermally heated groundwater that has emerged from the Earth's crust) found anywhere in the world. In addition to lakes, the park is home to more than a dozen perennial streams.

Wetlands are also an important part of Lassen Volcanic's hydrology. They provide many ecolog-


NATIONAL PARK SERVICE

Wetlands such as Dersch Marsh, shown here, provide many ecological services. These services include natural water storage, filtration, interception of sediments, nutrient processing, carbon sequestering, and surface water temperature stabilization.

ical services: natural water storage, filtration, interception of sediments, nutrient processing, carbon sequestering, and surface water temperature stabilization. Wetlands in the park, which also harbor a multitude of plant and animal species, occur in a wide variety of settings—riparian areas, pond edges, near springs, montane meadows, and snowmelt depressions.

At an elevation of 5,708 feet, Drakesbad Meadow is the largest wetland at Lassen Volcanic and the highest wetland in the Warner Valley. Drakesbad Meadow is supported by perennial groundwater discharge. Over thousands of years, this discharge has led to the development of a rare mountain fen. Fens are low-lying wetlands characterized by the presence of peat—dead and partially decayed plant matter that accumulates in wet environments. Some peat soils in the Drakesbad Meadow fen exceed 15 inches in depth, and deposits in the southeastern part of the meadow date back 4,200 years. Peat acts as a carbon sink, lowering the amount of greenhouse gases in the atmosphere by storing organic materials.

Acid geothermal fens—a globally rare habitat—also occur at Lassen Volcanic National Park. These fens, characterized by a low pH (3–4.5), are found in the park at the Forest Lake area, just east of Ridge Lakes, and immediately adjacent to Bumpass Hell. In these geothermal fens, sulfuric acid forms in areas where water and gas from steam vents combine near the soil surface. A researcher from Colorado State University is collecting data on the pH, chemical content of the water, and the kinds of flora, particularly mosses, that inhabit the acid geothermal fens.

WILDLIFE SPECIES NUMEROUS

Because of the park's wide variety of habitats, Lassen Volcanic's ecosystems exhibit great species diversity. The park boasts 779 plant, 57 mammal, 215 bird, and 14 amphibian and reptile species. In addition, 83 species of butterfly and 147 species of moth have been recorded. No federally listed threatened or endangered animal species are found at Lassen Volcanic National Park.

Joseph Grinnell—the renowned biologist who introduced the concept of the "ecological niche"—originally surveyed the Lassen area for mammals, birds, amphibians, and reptiles from 1924 to 1929. In 2006, researchers from the University of California–Berkeley's Museum of Vertebrate Zoology began a resurvey of Grinnell's "Lassen Transect," which comprises a 3,000-square-mile swath of northern California from the Sacramento River to the Nevada border. Results of this survey, due to end in 2009, will yield information regarding possible changes in species ranges in the region and the park.

Mammals. Large and small herbivores roam Lassen Volcanic and are a food source for the park's predators. The East Tehama deer herd of Columbian black-tailed deer (*Odocoileus hemionus columbianus*) occupies parts of the park during the summer. This herd—the largest in California—has a migration route of nearly 100 miles, moving from lower elevations in the winter to higher ones in the summer. During the late 1950s and early 1960s, the deer population reached an all-time high of 100,000 individuals. Today's population is at an all-time low of 25,000 to 30,000 individuals, and a rebound is not expected. While drought conditions in the 1970s caused the deer population to plummet, its slow recovery is blamed primarily on fire suppression throughout the animals' range , which has changed vegetation structure and reduced the deer's food supply.

Rodents account for almost half of all mammal species at Lassen Volcanic. Species seen in highly trafficked visitor areas include golden-mantled ground squirrels (*Spermophilus lateralis chrysodeirus*) and Douglas' squirrel (*Tamiasciurus douglasii albolimbatus*). Lagomorphs, a taxonomic order that includes rabbits, hares, and pikas, are often mistakenly called rodents. Pika and snowshoe hare (*Lepus americanus*) are two lagomorphs known to occur in the park. Population levels of snowshoe hare have never been high in the Lassen region, but those hares that do reside in the park are threatened by habitat loss due to fire suppression. These animals prefer forests with a diverse understory at higher elevations, or burned areas with dense brush and plenty of dead vegetation for cover. Fire suppression has caused a decline in these types of habitat. Pikas den and nest beneath rock masses at the base of cliffs (talus), where they remain active year-round using stored "haypiles"—heaps of gathered vegetation—as a food source during the winter months. Therefore, pikas that inhabit Lassen Peak have only three months to gather the food they will rely on all year.

Omnivores and carnivores are not often seen at Lassen Volcanic, yet they play vital roles in controlling prey populations. Historically, both black bears (*Ursus americanus*) and grizzly bears (*Ursus arctos*) inhabited the park, but only black bears remain today. It is unknown when the last grizzly was taken from the area, but a journal record from 1855 describes sightings of grizzly bears at the base of Lassen Peak. Human-bear interactions, which usually occur because bears become dependent on human food, are not currently a problem in the park. Previous conflicts in the Butte Lake area were alleviated with the installation of bear-proof garbage containers in the campgrounds in 2003. Although bear sightings nearly doubled from 2006 to 2007, it is unknown if the rise was due to an increase in sighting reports or an actual population increase.

continued on page 26

MEGAN LOWERY

The East Tehama deer herd of Columbian black-tailed deer—the largest herd in California—occupies parts of the park during the summer. This herd migrates nearly 100 miles, moving from lower elevations in the winter to higher ones in the summer.

KEYSTONE SPECIES AT LASSEN VOLCANIC

"Keystone species" is the term used to describe a species that has a major influence on the structure of the ecosystem it lives in; its presence or absence has far-reaching impacts on other community members. For this reason, natural resource managers often target keystone species for research, as a way to monitor larger ecosystems. The following keystone species have been identified for Lassen Volcanic National Park:

Quaking aspen

Quaking aspen stands, which possess a high diversity of understory plant and animal life, are more commonly found in Lassen Volcanic National Park than in the surrounding region. Most aspen stands within Lassen Volcanic occur in the Devastated Area and extend along Hat Creek, and also in Warner Valley and the Butte and Snag Lakes region.

Aspens reproduce clonally, via suckers that sprout from existing root systems. As a result of this reproductive strategy, aspens tend to grow in pure stands, meaning that a stand of trees can be one large organism. The park, in cooperation with the U. S. Forest Service and other land management agencies, began mapping and assessing individual aspen stands in 2004, and to date, 32 stands have been mapped. Using a standard assessment protocol, 86 percent of these stands were determined not to be successfully regenerating, due to a combination of shading and competition with conifers (due to fire suppression) and excessive browsing by deer. Some smaller stands could disappear. The park received funds from the Lassen Park Foundation, a nonprofit organization, to conduct a low-elevation flight over the park in fall 2009, when the aspen are changing color, to map additional stands. This should result in good information on the total distribution and extent of the park's aspen.

In addition to stand mapping and assessment by Lassen Volcanic staff, researchers from the University of California–Davis, are quantifying changes in the extent of aspen stands over the past 50 years by comparing aerial photographs taken in 1952 with those from 2004, and they are measuring the difference in diversity of understory plant life between aspen stands and conifer stands. This project was funded by the Park Service's Klamath Inventory and Monitoring Network; a draft report was submitted by the researchers in spring 2009. Preliminary results indicate that in aspen stands where conifers increased and aspens decreased over the past 50 years, there was also a decrease in the number of understory plant species.

Whitebark pine

Whitebark pines provide multiple services to ecosystems at Lassen Volcanic by regulating snowmelt, preventing soil erosion, and supplying seeds that are an important food source for many birds and mammals. Whitebark pines in the park are threatened by white pine blister rust, a disease native to Asia caused by the fungus *Cronartium ribicola*. The disease can result in significant tree mortality (up to 99 percent). While the pathogen is most lethal in seedlings, it will cause top-killing in older trees, resulting in deformities. Within a year or two of infection, cankers form on branches. When a stem or branch is girdled by the canker (i.e., the entire circumference of the stem or branch is killed), then the tree is killed from that point up (stem) or out (branch).

White pine blister rust was introduced to the United States around 1900, via infected

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Aspen is considered a keystone species at Lassen Volcanic National Park. Some stands of aspen trees are unable to successfully regenerate, due to shading and competition with conifers (shown here) and excessive browsing by deer.

European seedlings, and has since spread throughout the range of white pine. Treatment options include removing cankers by pruning when a branch is infected; however, stem infections within the tree trunk are usually lethal. Another option is to screen for general resistance among individual trees and then propagate seedlings from them. This disease is currently present within the park (on the east slope of Lassen Peak) and is locally abundant in white pine and sugar pine stands, but the extent and degree of infection within the entire park is poorly documented.

Bats

The eight bat species found at Lassen Volcanic National Park contribute to ecosystem health by controlling insect populations, their primary food source. Yuma myotis (*Myotis yumanensis*) is the most widespread bat species in the park.

Bats are slow-growing mammals with low reproductive rates. Because individuals of many species do not reach sexual maturity until two or more years of age, and the average female rears just one juvenile per year, bat recovery is sluggish following population declines.

Bat populations in California—including those found within the park—have been in decline in recent decades, due in large part to the widespread use of organochlorine pesticides, which can persist in the environment and remain toxic for years. These types of pesticides drift into Lassen Volcanic National Park from adjacent agricultural areas. With their high metabolisms, bats readily accumulate pesticide toxins in their body fat reserves, which are metabolized in times of stress (e.g., migration). When fat reserves are metabolized, pesticide concentrations in a bat's body—especially in the brain—can reach lethal levels. In addition to harming bats exposed to the pesticides, toxins that have accumulated in female bats are passed on to their nursing young in high amounts.

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Bufflehead ducks, the rarest of California's boreal duck species, breed in Lassen Volcanic National Park and the adjacent national forest.

Scientists believe the Lassen region contains the densest population of Sierra Nevada red fox (*Vulpes vulpes necator*) in California. This fox is a California threatened species, and it is also the state's only native red fox. While fur trapping was once a major source of fox mortality, poisons used for predator and rodent control outside of the park are a major threat today. Limited food supply is also negatively affecting the red fox. A 2005 scientific study of red fox in the park found an abundance of shrews in their diet, indicating low availability of more palatable prey (rabbits and squirrels, for example). In addition, foods typically eaten during periods of starvation (insects) were also present. Red fox are often seen begging at campsites and parking lots in the park, indicating hunger. Other evidence—below-average body size, massive home ranges, low population density, negligible observed reproduction, and seasonal elevational migration—all suggest that limited resources are restricting red fox populations.

Birds. Lassen Volcanic is home to roughly 215 bird species, and half of these are known to breed in the park. Bird-watchers favor trips to the park's meadows and wetland areas, where greater sandhill cranes (*Grus canadensis tabida*), a California threatened species, are occasionally seen. Both Drakesbad Meadow and Warner Valley provide important breeding habitat for many songbirds, including sparrows, warblers, and chickadees. With Park Service personnel and base park funding, the park operates a mist-netting station at Drakesbad Meadow and conducts regular surveys as part of its efforts to monitor songbird populations. Continued monitoring is a high priority for the park.

Lassen Volcanic's wetlands and lakes provide habitat for a variety of waterfowl, including bufflehead ducks (*Bucephala albeola*), California's rarest boreal duck species. The majority of bufflehead ducks in northeastern California breed in the park and adjacent Lassen National Forest and are isolated from other, more northerly breeding populations of this species. For this reason, and because this population is relatively small and affected by land uses—including fish stocking, loss of dead trees (used for nest cavities), and high human recre-

ational use of their habitat—the park began monitoring this species in cooperation with the U.S. Forest Service and California Waterfowl Association in 1997.

Birds of prey are popular with wildlife enthusiasts, and several species—including golden eagle (*Aquila chrysaetos*), osprey (*Pandion haliaetus*), sharp-shinned hawk (*Accipiter striatus*), northern goshawk (*A. gentilis*), California spotted owl (*Strix occidentalis occidentalis*), bald eagle (*Haliaeetus leucocephalus*), and peregrine falcon (*Falco peregrinus*)—occur in the park.

Fish. Because the region's ponds, streams, and lakes have been stocked with fish since the 1800s, it is unclear which water bodies were naturally barren, which ones contained native fish, and, to some degree, what species are actually native.

Prior to park establishment, people transported fish in buckets to present-day park waters. In 1968, the practice of fish stocking in the park began to be phased out, ending completely by 1992. Due to winterkill—a fish die-off resulting from oxygen depletion that can occur during severe winter weather—and lack of suitable spawning habitat, some park water bodies have reverted back to a fishless condition, while others have been able to support self-sustaining fisheries. It is probable that most lakes within Lassen Volcanic were historically empty of fish due to natural barriers, although Manzanita Lake, Butte Lake, and Blue Lake Canyon may have supported native fish due to their connectivity with trout streams. Today, all the park's major streams contain introduced trout species. Fishing is permitted in certain areas of the park, per California State regulations. Manzanita Lake—a world-class fly-fishing lake—is managed as a natural fishery where catch and release fishing is permitted.

It is generally accepted that rainbow trout (*Oncorhynchus mykiss*) are the only fish native to the region, although their populations in the park—and those of brook trout (*Salvelinus fontinalis*) and brown trout (*Salmo trutta*)—are attributed to fish stocking. Other species found in Lassen Volcanic waters are bait fishes introduced over the years by anglers, such as Tui chub (*Gila bicolor*), Lahontan redside (*Richardsonius egregius*), and speckled dace (*Rhinichthys osculus*). Golden shiner (*Notemigonus crysoleucas*) were likely introduced as a food source for the introduced brown trout and rainbow trout at Manzanita Lake.

Amphibians and reptiles. Six amphibian and eight reptile species inhabit Lassen Volcanic National Park. Amphibians include southern long-toed salamander (*Ambystoma macrodactylum sigillatum*), Sierra Nevada ensatina (*Ensatina eschscholtzii platensis*), rough-skinned newt (*Taricha granulosa*), western toad (*Bufo boreas*), and Cascades (*Rana cascadae*) and Pacific tree (*Pseudacris regilla*) frogs. Like most of the world, the park has seen severe amphibian population declines. These population "crashes" at Lassen Volcanic have been attributed to predation by fish, disease and parasites, and pesticide drift. The thinning of the ozone layer is also a threat, as increased ultraviolet light levels due to loss of ozone cause damage to amphibians' sensitive, gas-permeable skins.

The Cascades frog was abundant throughout the park until the mid-1970s. It is estimated that the Cascades frog has been extirpated from about 99 percent of its southernmost range (Lassen Peak and surroundings) and 50 percent of its total historical distribution in California. Pollution and disease may be important factors in the decline. With only one small, non-reproducing population remaining, this frog species is in danger of being extirpated from the park. In a 2005 study by the Pacific Southwest Research Station of the U.S. Forest Service, biologists urged human intervention and recommended a captive-breeding program using other individuals from the region. Managers are considering a reintroduction of the Cascades frog using populations from the Trinity Alps,

about 100 miles west of the park. The Park Service, U.S. Forest Service, U.S. Fish and Wildlife Service, and U.S. Geological Survey are investigating reintroduction options. Because the reasons behind the extirpation of this species are not fully understood, it is not known if a reintroduction would be successful.

Limb deformities, prevalent in Lassen Volcanic frogs, are the result of infection from a parasite (*Ribeiroia ondatrae*). In 1974, Pacific tree frogs with extra hind legs were first discovered in Dersch Meadows. The park was resurveyed between 1999 and 2002 for the parasite; results confirmed that the park supports a Pacific tree frog population with a high frequency of hind limb deformities. The parasite is a significant source of mortality, since affected frogs rarely survive to sexual maturity. The historical data on malformations in the frogs is insufficient to determine whether the frequency of malformations is increasing or decreasing within the park.

Lassen Volcanic reptiles include five snake, one turtle, and two lizard species. The park's lone turtle species, the western pond turtle (*Clemmys marmorata*), is at risk. Poor reproduction—caused by disease, non-native predators and competitors, and loss of nesting habitat—has led to population declines throughout its range. While the turtle has occurred historically in the Manzanita Lake and Reflection Lake areas, no recent sightings have been reported.

NON-NATIVE PLANTS, PESTS, AND DISEASES POSE RISKS

Less than 5 percent of Lassen Volcanic National Park has been surveyed for non-native species, with a focus on disturbed areas and transportation corridors. While a relatively low number (59) of non-native plants have been documented, these "weeds" still pose threats to natural resources. Six of the 59 species identified have a high potential for invasiveness—the displacement of native species—and two others pose a significant threat. Bull thistle (*Cirsium vulgare*) and woolly mullein (*Verbascum thapsus*) are the two most invasive and widespread non-native plant species in the park.

Each year, park managers treat 150 acres of non-native plant species at Lassen Volcanic. The park receives funds from the California Exotic Plant Management Team (EPMT), which is part of the California Invasive Plant Council, to treat non-native plants. In 2008, two weed removal crews assisted the park. Both crews received funds from the California EPMT. A Sierra Club group focused on non-native plants at Manzanita and Butte Lakes. A Bureau of Land Management Special Weeds Action Team treated bull thistle near Butte Lake. Support from the California EPMT in 2008 also allowed the park to hire a Student Conservation Association intern devoted to non-native plant management. In addition, the park hires a three-person crew of seasonal biological technicians each year that spends about 60 percent of its time mapping and controlling invasive non-native plants. Even with this assistance, Lassen Volcanic needs additional support for non-native plant control during critical periods in the summer. The Klamath Inventory and Monitoring Network has requested Park Service funds to address this need.

Of greater concern than the non-native plants that currently exist in the park is the threat posed by invasive species encroaching on public and private lands surrounding Lassen Volcanic National Park. Yellow starthistle (*Centaurea solstitialis*) St. John's wort (*Hypericum perforatum*), and oxeye daisy (*Leucanthemum vulgare*)—all highly invasive species that have the ability to greatly alter ecosystems—are common on lands near the park's boundary. The entities that manage adjacent lands do not have the resources to control them. Interagency cooperation and coordination to control invasive species on lands adjacent to the park is critical.

In addition to non-native species, insect pests threaten plant communities at Lassen Volcanic National Park. At Crags and Lost

NATIONAL PARK SERVICE

Members of the park's fire crew assist with non-native plant control efforts. On the left, bull thistle is removed with a small tool, and on the right woolly mullein is pulled by hand. Mature flower heads are bagged and removed to prevent the spread of seeds.

Creek Campgrounds, a fir engraver beetle (*Scolytus ventralis*) infestation is responsible for some limited tree mortality, which increased during the dry years of 2007 and 2008. A bark beetle epidemic in the mid-1990s caused heavy mortality in Jeffrey and ponderosa pines in the park. Populations of Jeffrey pine beetles (*Dendroctonus jeffreyi*) increased in 2007, and mortality of Jeffrey pines in developed areas near Manzanita Lake increased in 2008. Mountain pine beetle (*Dendroctonus ponderosae*) activity has increased in lodgepole pines at the southern boundary of Lassen Volcanic. The park is using prescribed fire to help control fuel loading, forest composition, and disease, thereby reducing susceptibility to bark beetle infestations. Research in the Rocky Mountains and at national parks such as Yellowstone indicates that warming temperatures resulting from climate change can facilitate and worsen beetle infestations. For more information on how climate change affects national parks, see NPCA's recent report *Climate Change and National Park Wildlife: A Survival Guide for a Warming World* (www.npca.org/climatechange/wildlife_survival).

Several diseases threaten fir trees in the park. Cytospora canker of true fir (*Cytospora abietis*), a fungal disease that usually occurs in combination with true fir dwarf mistletoe (*Arceuthobium abietinum magnificae*) infection, is blamed for the deaths of red fir in the southwest section of Lassen Volcanic. True fir needle cast (*Virgella robusta*) infections have been observed in white fir, but have not had a significant impact. Armillaria root disease and annosus root disease, in addition to fir engraver beetles, have caused reduced fir populations in the Lost Creek and Crags Campgrounds. And Indian paint fungus (*Echinodontium tinctorium*), a stem decay organism, has been observed in mature fir trees. Prescribed fires should help the park's forests contend with these diseases and pests by directly destroying some pathogens and by decreasing tree density (which can result in increased vigor of the remaining trees).

LANDSCAPES ALTERED BY HUMAN ACTIVITY

Through their policies and practices, human beings have altered Lassen Volcanic National Park's natural systems. Fire suppression, livestock grazing, water diversion, road construction, and adjacent land use have all affected the park.

Fire suppression. Fire has long been a natural disturbance at Lassen Volcanic, and naturally occurring fires are important to preserve the health of forests. In 1905, before the park was established, the U.S. Forest Service implemented a complete fire suppression policy that remained in place until the mid-1980s. This policy is the primary cause of increased (and unhealthy) tree density in the park's forests today. Fire suppression has increased fuel loads, disease, mortality, and risk of high-intensity fires. It has decreased the variety of light gaps in the forests, reduced herbaceous vegetation, and resulted in shifts in species composition. Because fire helps them establish in new areas, quaking aspen stands—important park habitats—have been reduced by lack of fire.

It is estimated that fire suppression has substantially altered 35 percent of Lassen Volcanic's vegetation. On Prospect Peak, the current stem density for Jeffrey pine/white fir forests is 10.6 times greater than in forests without fire suppression. The proportion of firs to pines is also higher today than would normally occur. The composition of Jeffrey pine/white fir forests has shifted, allowing shade-tolerant, fire-sensitive white fir to dominate the understory. Without fire, white fir eventually replaces Jeffrey pine and ponderosa pine.

The number and size of gaps in Lassen Volcanic's forests has dramatically decreased. Gaps of light that are created by fires provide for a mosaic of vegetation and varying age classes, enhancing biodiversity. Lack of fire in the park has also led to an increased layer of duff—decaying leaves and branches that cover the forest floor. Increased duff at the base of trees will smolder longer following a fire, causing large-diameter trees to die.

At Lassen Volcanic National Park, natural fires are most likely to occur from July to October. During this fire season, the park experiences the highest incidence of lightning, highest daytime temperatures, and lowest relative humidity. Fuel moisture and persistent snowpack during the rest of the year make fires unlikely. Since the mid-1980s, managers at Lassen Volcanic have attempted to mimic a natural fire regime through prescribed fire and wildland fire use (i.e., allowing wildfires to burn with oversight). These management fires are small, however, when compared to pre-settlement fires; their scale is insufficient to restore the park's larger ecosystems. In addition, repeated burns are needed to reduce stand density and ground fuels to historic levels. Various factors influence the park's ability to use prescribed fire and wildland fire as management tools. For example, prescribed burns may not be allowed on days when air quality is predicted to be poor due to other factors, such as dust or smoke from other natural or human-caused fires in the region. The park's fire activities are subject to state air-quality regulations. In 2009, the park transitioned to the U.S. Forest Service's new Wildland Fire Decision Support System, which will improve its ability to manage all fires to achieve multiple resource objectives, regardless of whether the fire was ignited naturally or by humans.

Mechanical and manual fuel reduction—

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Since the mid-1980s, managers at Lassen Volcanic have used prescribed burns as part of an effort to mimic the area's natural fire regime.

using machinery or handheld equipment to break fuels like brush and small trees into small pieces—is a routine part of fire management in the park. Once fuels are reduced to pieces or chips, they are left to decompose, removed from the site, or burned in a controlled fire. Mechanical and manual treatments reduce the potential for destructive fires by reducing vegetation between tree stands (fuel loads) and removing the lower branches of trees (ladder fuels).

The fire crew at Lassen Volcanic National Park is comprised of a ten-member fuels crew and a four-member engine crew. Fire crews from Whiskeytown National Recreation Area and Lava Beds National Monument occasionally assist Lassen Volcanic with burns. The park also receives assistance from other entities, such as the Bureau of Land Management, U.S. Forest Service, and other parks. From 2004 to 2005, the Lassen Volcanic fire crew treated approximately 10,000 park acres—more than 10 percent of the burnable vegetation—using wildfires and prescribed burns. Within this interval, the park was successful in managing two wildland fires that totaled 4,939 acres.

In 2007, Lassen Volcanic treated 1,500 acres with prescribed burns; 250 acres with pile burning; 15 acres at Manzanita Lake Campground, 40 acres at Loomis Blocks A and B, and 30 acres at Historic Flume using manual fuel treatment; and 66 acres at Manzanita Lake Campground with mechanical fuel reduction. The crew also assisted with prescribed burns at Crater Lake National Park and with the removal of hazardous fuel (dead vegetation that can easily ignite) at Lava Beds National Monument. In 2008, the park treated 620 acres using the above methods.

Grazing. Grazing activities have had profound impacts on the natural communi-

ERIN MCPHERSON

Livestock grazed meadows in several areas of the present-day park until the practice was eliminated in 1933. Horses continued to graze pastures at Drakesbad Meadow until 1982. Today the horses at the Drakesbad Guest Ranch are corralled and do not graze Drakesbad Meadow.

ties of Lassen Volcanic National Park. Livestock disturb the soil surface, suppress native plants by grazing them, spread the seeds of non-native plant species, increase lake and stream bank erosion, and disturb archaeological sites. Livestock grazing can be traced back to 1850 with the establishment of the Nobles Emigrant Trail. In the mid-1860s, resident cattle, horses, and sheep grazed several meadows in what is now the park, including land near Summit Lake and Kings Creek. By the turn of the century, grazing was a major enterprise in the region. In 1912, 15 ranchers were grazing 2,200 sheep and 1,000 cattle and horses in areas of the present-day park. When the park was established in 1916, 200 to 500 sheep were still permitted to graze at Lassen Volcanic. Horse and cattle grazing also continued after 1916, confined to lush subalpine and montane meadows on the lower flanks of Lassen Peak, and meadows and lodgepole flats at lower elevations in the Warner Valley. While livestock grazing was ultimately eliminated in the park in 1933, the Drakesbad Guest Ranch concessionaire horses continued to graze pastures in Drakesbad Meadow until 1982. Today, horses at the dude ranch are corralled and do not graze.

Fire suppression and grazing often lead to what is known as "tree invasion"—invasion of trees into naturally unforested areas. Suppressing fires allows trees to establish in open areas. Heavy grazing suppresses tree growth, but when grazing is discontinued, trees may invade those formerly grazed areas. Lodgepole pine is the most common tree invader in Lassen Volcanic National Park.

Water diversion and road construction. The Lassen Volcanic National Park Highway—constructed from 1916 to 1942—interrupts the natural flow of streams and springs, and the resulting drier conditions have accelerated tree invasions. At Lassen Volcanic's Summit Lake and Badger Flat meadows, tree invasions peaked between 1941 and 1955 and have continued since then. According to a 1997 study, if tree invasion continues at the meadows—where invasion is already extensive—the meadows will be completely unrecognizable in less than a century. The Park Service addresses the problem of tree invasions by working to restore the natural hydrology. For example, existing culverts at Dersch Meadows were replaced with larger ones, and five new culverts were added, to increase water flow through the road prism.

Tree invasion is but one consequence of changes to natural water systems in the park. The rare and sensitive fen in Drakesbad Meadow is supported almost entirely by groundwater discharge and

cannot survive droughtlike conditions. Between the late 1800s and the early 1900s, drainage and irrigation ditches were constructed in—and willows were removed from—the meadow in order to facilitate grazing. This network of ditches intercepted the natural flow of water to the fen, effectively draining portions of Drakesbad Meadow. In addition to ditches, in the early 1960s, the park installed a 40,000-gallon water tank, which required the construction of an access road through the meadow's main spring complex. A similar access road was built for the Drakesbad Guest Ranch bathhouse and pool. These habitat alterations resulted in the degradation of organic soils, a loss of wetland plant species, and an invasion of upland plant species. In addition, waste products from the horse corral at Drakesbad Guest Ranch entered the water supply, polluting the fen.

To help remedy the situation at Drakesbad Meadow, in July 2003 the park and partners from Colorado State University installed culverts under the water tank access road and dammed some drainage ditches, creating a sheet flow of water across the fen. As a result of this restoration, within a month, surface flows from the spring complex to the wetland were reestablished; restoration of the surface flow across the water tank access road increased the number of flowpaths from five to 21 points of spring discharge, allowing the water table to rise within eight inches of the soil surface. Additional work is needed to restore the meadow's hydrology, including permanently filling ditches and replacing dirt trails with boardwalks in many areas. Also needed is a biofiltration system at the corrals to contain effluent.

Adjacent land use. In addition to addressing the lingering effects of past land use practices within the park, Lassen Volcanic also faces challenges that stem from land uses outside its boundary. Almost all of the land adjacent to the park is part of Lassen National Forest, where recreational snowmobile and motorcycle use are popular activities. Although these activities are not permitted within the national park, each year 30 to 50 motorized vehicles trespass into the park's wilderness. Motorcycle tracks from trespassers have left deep scars on the Cinder Cone and Fantastic Lava Beds landscapes. Snowmobiles can inhibit snowmelt through compaction, causing a delay in runoff, changes in soil moisture, and postponed spring plant growth. Trespassing snowmobiles and motorcycles also disrupt the park's wilderness solitude, lead to conflicts with skiers and snowshoers, and disturb wildlife with noise and motion.

In addition to effects from recreational use, the park also faces challenges related to grazing that occurs on adjacent national forest lands. More than one-third of the park boundary has been fenced to exclude livestock, but most of this fencing has fallen into disrepair, allowing cattle to trespass in the park. (The responsibility for fence upkeep lies with permittees—those allowed to use the forest land to graze stock—not the park.) The Park Service has the ability to levy fines against the U.S. Forest Service and the operators of grazing allotments when livestock trespass.

Timber sales in the adjacent Lassen National Forest have resulted in loss of trees from the national park when trees are cut by mistake due to misidentification of the location of the park's boundary. In addition, the U.S. Forest Service does not control non-native plant species in the national forest adjacent to the park, providing an inlet for plant invasions. This is especially evident on Lassen Volcanic National Park's western boundary, where non-native plant invasion is extensive, due to seed dispersal from prevailing winds.

SCENIC VISTAS REDUCED BY POLLUTION

The federal Clean Air Act, as amended in 1977, requires the highest level of protection for "Class I" airsheds (Class II and III airsheds are less protected and more polluted). Lassen Volcanic National Park is a Class I area. Although NPCA's assessment indicates that air quality at Lassen Volcanic is currently "good," it may deteriorate as development increases in the nearby northern Sacramento Valley. Already, scenic vistas within the park are reduced most days of the year due to pollution from this region. The park's dark night skies are also at risk as development continues and light pollution increases.

In addition to visibility, other air-quality parameters are well monitored at Lassen Volcanic National Park. Ozone concentration, wind speed and direction, temperature, relative humidity, solar radiation, and precipitation are all monitored at an air-quality station at Manzanita Lake. In 1995, dry acid deposition monitoring began through the Environmental Protection Agency's Clean Air Status and Trends Network (CASTNet). Finally, wet deposition monitoring began in 2000, through the park's participation in the National Atmospheric Deposition Program (NADP).

Ground-level ozone, formed when nitrogen oxides and volatile organic compounds react in the presence of sunlight, is harmful to people, wildlife, and plants. Ozone concentrations at Lassen Volcanic National Park occasionally exceed California State standards. High ozone concentrations are blamed for visible injury (discoloration and spotting) in Jeffrey pine and ponderosa pine near Manzanita Lake. Interestingly, despite exceeding California State standards on several occasions, neither ozone nor particulate matter concentrations have exceeded National Ambient Air Quality Standards.

Dry deposition of sulfur dioxide and nitrate at Lassen Volcanic are both well below the national annual average. Nitrogen concentrations in lichen are within the background range in the park, indicating that nitrogen deposition is not elevated. (Lichens function as nitrogen pollution indicators in forests. Because of their sensitivity to nitrogen deposition, lichen declines foretell of detrimental effects to other terrestrial and aquatic systems.) There is not yet any trend information for wet deposition of pollutants.

While air quality in the park is good, the long-distance transport of airborne contaminants from the Central Valley of California or even Asia is a threat to resources at Lassen Volcanic. Researchers have identified agricultural pesticides and herbicides as sources for toxins found in both vegetation and the air of the park. Lichens and conifers within the park were tested and found to be contaminated with pesticides used outside of park boundaries. Relatively high levels of polycyclic aromatic hydrocarbons or PAHs (combustion by-products) were also detected. All of these pollutants are of concern because they can remain in the environment for long periods of time and accumulate as they make their way up the food chain—for example, from plants to invertebrates to fish to higher predators such as humans. The U.S. Geological Survey is examining amphibians (primarily tree frogs) in the park to check for the presence of pesticides (at the same time, they will check for chytridriomycosis, an infectious and deadly disease caused by a fungus), and the park is partnering with researchers from Oregon State University to analyze fish from backcountry lakes to determine if pollutants are affecting their endocrine functions.

WATER-QUALITY DATA INCOMPLETE; BACKCOUNTRY MONITORING INITIATED

Water resources at Lassen Volcanic are numerous. The park protects 277 permanent and ephemeral lakes and many streams and rivers. Because the headwaters for all streams lie inside the park, they are safeguarded from sources of upstream pollution. According to NPCA's assessment, Lassen Volcanic National Park's water quality rated "fair," although data were lacking for a number of parameters such as alkalinity, flow, drawdown, recharge, and temperature. Nutrients, organic wastes, sedimentation, and high sulfate (common in geologically active areas) affect certain water bodies. Some sources of degraded water quality are natural and attributed to geothermal activities, while others are human-caused (e.g., storm water runoff, recreational use, use of retardant chemicals in fire suppression, and atmospheric deposition). Water-quality monitoring began in 2008 at select backcountry lakes and streams. Monitoring of these waters will continue every three to six years.

In addition to park staff and visitors, area communities use water from Lassen Volcanic National Park. Water treatment plants at Forest Creek and Manzanita Creek within the park—which process water from these two creeks—provide 30,000 gallons and 62,000 gallons of drinking water per day, respectively.

In addition to water use by surrounding communities, one family has rights to water in the Kings Creek, Cold Springs, and Sunflower Flat areas of Warner Valley. The family uses the water for irrigation and personal needs. The Park Service is negotiating with the family to ensure this water diversion is properly managed and degradation of the area (e.g., damage from access road improvements and construction of water storage tanks and piping) is minimized.

MEGAN LOWERY

Lassen Volcanic's numerous streams and rivers all originate within the park, and so they are protected from upstream pollution.

ERIN MCPHERSON

The 440-acre Drakesbad Guest Ranch is one of the oldest developed areas in Lassen Volcanic National Park and includes this lodge built in 1938. It is still a functioning dude ranch operated by concessionaires.

CULTURAL RESOURCES—MANAGER NEEDED TO OVERSEE ALL PROGRAMS

Lassen Volcanic National Park scored an overall 75 out of 100 for the condition of its cultural resources, which include archaeology, cultural landscapes, history, historic structures, ethnography, and museum collection and archives. This score indicates that the resources are in "fair" condition.

Like many other national parks, Lassen Volcanic was created to protect its scenic and scientific resources, with less attention given to its cultural resources and human history at the time it was established. Volcanoes, geothermal features, forests, and dramatic vistas are the main focus of park management; the park did not hire its first cultural resource manager until 2001. Prior to her tenure, cultural resource management was the collateral duty of various staff members.

Although she faced daunting challenges, the new cultural resource manager was able to significantly improve conditions in all programs. Sites, structures, and landscapes were nominated to the National Register of Historic Places. An archaeological inventory and an overview and assessment were completed. During the cultural resource manager's tenure, rehabilitation and adaptive re-use of historic

structures occurred as well. The park's museum and archival collections were transferred to a secure, shared off-site facility. Finally, the park increased efforts to determine traditional resource uses and resource management practices preferred by the park's traditionally associated peoples.

Lassen Volcanic's cultural resource manager left the park in 2008, and her position has yet to be filled. The park is reevaluating the need for a full-time cultural resource manager and could pursue other options. Today, the lack of a manager is one of the greatest threats to the park's cultural resource programs. Currently, three staff members—the park's chief of education and interpretation, the chief of resource management, and the environmental protection specialist—fulfill the duties of the cultural resource manager. Due to their other job responsibilities, there is a limited amount of time that they can spend on cultural resources, and it is difficult for these three employees to provide the level of care that is needed for all programs. In addition, cultural resources management is a specialized field that requires oversight from a professional trained in that discipline.

In addition to resource management challenges associated with the lack of a cultural resource manager, the park faces difficulties interpreting cultural resources for visitors. To date, interpretation at Lassen Volcanic National Park has focused on geologic and natural features, with less consideration given to cultural landscapes, historic structures, archaeological sites, and ethnography. To remedy this situation, park managers intend to develop a comprehensive interpretive plan, which will guide planning, implementation, and assessment of interpretive program development at Lassen Volcanic. The plan will also identify park themes, describe desired visitor experience goals, and recommend a variety of services, such as media, ranger-led programs, and outreach activities. This plan might receive funding at the end of 2009.

ERIN MCPHERSON

Much of the interpretation at Lassen Volcanic currently focuses on the park's geology and natural features, as demonstrated in this exhibit. As part of an effort to include more interpretation of cultural resources, park managers intend to develop a comprehensive interpretive plan.

ETHNOGRAPHY (PEOPLES AND CULTURES)—RELATIONSHIPS WITH TRIBAL MEMBERS NEED FOSTERING

Over time, different groups of people have lived in or visited the Lassen region and made use of its many resources. The Park Service is charged with identifying these traditionally associated people and protecting park resources that are important to them. As early as 7,500 years ago, four societies—the Atsugewi, Achumawi (of which the Atsugewi were a distinct population), Mountain Maidu, and Yana/Yahi—seasonally inhabited different areas of the present-day park. In the summer months, members of the four communities ascended into the higher elevations to collect food (roots, nuts, berries, trout, and deer); at the onset of winter they camped in low-elevation villages. While the tribes were distinct, they all shared a common reverence for Lassen Peak, which was considered a place of deep spiritual significance. Today, all of Lassen Volcanic National Park is considered sacred by descendants of these indigenous groups.

Lassen Volcanic's traditionally associated peoples live throughout the area and are integrated into ten modern federally recognized tribes. A small community of Atsugewi lives north of the park in the Hat Creek area. Some 2,000 descendents of the Mountain Maidu can be found throughout California's Indian reservations. The descendants of the Achumawi, also known as the Pit River Indians, reside in northeastern California. The Yana/Yahi people were virtually eliminated in open warfare at the start of the Gold Rush, with fewer than 100 surviving by 1870; it was believed that no member of the tribe had survived to see the 20th century. A man known as Ishi proved the single exception. Out of hunger and profound loneliness, Ishi

NATIONAL PARK SERVICE

Tribal members Allen Lowry and Marvena Harris present a cultural program to guests at the Drakesbad Guest Ranch.

emerged from hiding in the wilderness in 1911. He spent the rest of his life at the University of California–Berkeley, living at the National Museum of Natural History, where he relayed oral history of his culture to noted anthropologist Alfred Kroeber. Ishi died in 1916, though his remains were not returned to his closest relatives—the Pit River Tribe—until 1999; his reburial ceremony was conducted just outside Lassen Volcanic in 2000.

Lassen Volcanic National Park has a history of reaching out to traditionally associated people. For example, the park repatriated funerary objects from its museum collection in the 1980s, and the "Ancestral Spiritual Run" has been an annual event at Lassen Volcanic since 1993. Runners representing the park's indigenous tribes make the trek from Mt. Shasta to Lassen Peak as a way of remembering and honoring their ancestors and the seasonal return to their homeland. In addition, the park has instituted an American Indian fee waiver that allows tribal members to access the park at no charge, and tribal elders conducted a blessing ceremony at the Kohm Yah-mah-nee Visitor Center at its opening in 2008. Atsugewi basketry demonstrations used to take place in previous decades but no longer occur; park staff would like to reintroduce these demonstrations.

To facilitate communication between American Indian tribes and the Park Service, a traditional use study was conducted in 2004. Through the course of the study, tribal consultants proposed actions that would improve relations between the Park Service and tribes, emphasizing both the contemporary and historical importance of Lassen Peak as a religious site. Areas in the park that were traditionally used to obtain resources were also identified, and many plants are harvested today by associated tribes. Sensitive information gathered during the study, regarding religious practices and the locations of specific sites, is not made available to the public.

Despite the above examples of collaboration, relationships between the Park Service and traditionally associated peoples have not always been positive or consistently nurtured. However, Lassen Volcanic's ethnography program has made encouraging progress, and the park superintendent, who has taken on the role of tribal liaison, is striving to build new relationships and strengthen existing ones. One way to further improve communications and foster teamwork would be to host regularly scheduled meetings between the park and tribal representatives. Currently meetings occur only when specific projects arise.

Park staff recognize the need to accomplish more with the ethnography program and have initiated some important projects. As previously mentioned, the park uses information gathered through its 2004 traditional use study to assist with compliance with the Native American Graves Protection and Repatriation Act, interpretation of ethnographic resources, and management of sacred sites. A proposal for an ethnographic management plan for a tribally significant, undisclosed site in the park was submitted for Park Service funding in 2009, and a study of the park's museum collection, which will determine what objects may have significance to the park's affiliated American Indian tribes, has also been proposed.

NATIONAL PARK SERVICE

Allen Lowry and Marvena Harris conducted a tribal blessing ceremony at the Kohm Yah-mah-nee Visitor Center at its opening in 2008.

ARCHAEOLOGY—SUPPORT NEEDED FOR SURVEYS AND RESEARCH

Lassen Volcanic National Park includes 106 documented archaeological sites. Ten sites—all located in the Sulphur Creek Archeological District—are listed in the National Register of Historic Places. Other sites may be eligible.

The majority of Lassen Volcanic National Park's archaeological sites are prehistoric and include base camps, which feature a high density of archaeological material and house pits; activity and workshop areas, characterized by the presence of lithic scatter (stone tools and material chipped from carving stone tools); and hunting areas that contain projectile point scatter (rock fragments from the chiseling of arrowheads and spear points). Historic archaeological sites in the park are associated with ski areas and early park development, and they include campsite and lookout features, as well as relics such as metal cans, porcelain, and glass. Several sites include both prehistoric and historic components.

Under a cooperative agreement among Lassen Volcanic National Park, the National Park Service, Redwood National and State Parks, and the California State University Archaeological Research Program, an archaeological overview and assessment of Lassen Volcanic was completed in 2005. (An archaeological overview and assessment addresses gaps in the current program, provides direction for future projects, and allows park personnel to better identify, preserve, and protect valuable sites by developing funding proposals and completing projects.) Survey coverage associated with the overview and assessment was limited to about 9,750 acres, focusing on trails, a buffer zone along trails, Drakesbad, and areas to the north and south of that historic district. Additional surveys are still needed in other areas of the park. An archaeological excavation was conducted as part of the 2005 overview and assessment. During the excavation, archaeologists officially documented 37 sites—17 newly discovered and 20 revisited. At one site, Drakesbad Guest Ranch, 33 historic features were identified and recorded; the remaining 36 sites pre-date contact with Euro-Americans and provide important information regarding indigenous use of the area.

The 2005 archaeological overview and assessment made recommendations for further research at Lassen Volcanic, such as interdisciplinary studies to explore the cultural diversity of tribes inhabiting the region. Given that the archaeological record may be incomplete due to volcanism that could have destroyed sites, the assessment also recommended studies that could more accurately reveal human habitation. One suggested approach is the analysis of obsidian objects. Obsidian flakes and tools exhibit geochemical properties that can reveal their age; in the context of where it was found, an obsidian relic can tell scientists when a site was occupied by people. Fire is a concern because it can alter or destroy the geochemical properties in obsidian. To protect known sites, the park must manually reduce vegetation to decrease the fuel load; this has been done at several locations. In 1998, for example, a large volume of dead and down material was removed from a lithic scatter near Terminal Geyser. The park also conducts archaeological surveys prior to prescribed burns. Because much of the park is unsurveyed, additional sites that may contain obsidian flakes have yet to be documented and protected.

Visitor impacts pose the greatest potential threats to archaeological resources at Lassen Volcanic National Park. Lithic scatter sites, which are comprised of stone debris scattered over the ground surface, present a particular management difficulty because they can be unintentionally damaged by visitors not aware of their presence.

The park lacks a staff archaeologist but receives assistance from the Park Service's Pacific Regional Office and archaeological staff from neighboring parks; however, additional support

is needed to identify, document, and protect archaeological resources at Lassen Volcanic National Park. For example, the park needs support to document dendroglyphs in the Warner Valley. This support could come from contracted archaeologists, university students, and seasonal staff. The park has already made use of such avenues to address some of its resource needs. During the summers of 2006 and 2007, for example, a seasonal technician conducted 65 archaeological site assessments and reorganized the park's archaeological database, significantly improving data management.

To convey the park's archaeological story to visitors, additional interpretation is needed. This could include exhibits and ranger-led programs. At present, the park has some exhibits that reflect the influence of the environment on human history, but the park's archaeological story is not interpreted. Signs posted along trails ask visitors not to disturb natural and cultural features, but no interpretive programs are in place to educate visitors about archaeological site protection or the archaeology program in general.

CULTURAL LANDSCAPES AND HISTORIC STRUCTURES—DOCUMENTATION NEEDED FOR PARK LANDSCAPES

Cultural landscapes are geographical areas associated with specific cultures or historical events, and they help illustrate how humans have adapted to and altered their surroundings through time. The Park Service's Pacific Regional Office, which manages Lassen Volcanic's cultural landscape program, has identified nine individual cultural landscapes in the park; a tenth area may be considered a cultural landscape in the future. Historic structures are integral parts of cultural landscapes, and at Lassen Volcanic National Park they include ranger stations, roads, ditches, and fire towers. The park's identified cultural landscapes and their component historic structures are described in the following paragraphs.

Most visitors experience the park by traveling the **Lassen Volcanic National Park Highway**. Constructed from 1916 to 1942, the road is considered both a cultural landscape and a historic structure. The 29-mile highway runs between the park's southwest and northwest

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The Lassen Volcanic National Park Highway is considered both a cultural landscape and a historic structure, and it is listed in the National Register of Historic Places. In winter, as much as 40 feet of snow can accumulate on parts of the highway.

corners, winding through geothermal areas, subalpine forests, meadows, and lava fields. At Lassen Peak, the road climbs to 8,511 feet in elevation, the highest paved road in the Cascades. The highway and its associated historic structures—culverts, bridges, signs, and pullout areas—have been listed in the National Register of Historic Places as the Lassen Volcanic Park Highway Historic District. The Park Highway landscape encompasses most of the park's interpretive features and stops, including new wayside exhibits that were installed along the road in 2004, to replace those that were worn and outdated. The final phase of park road rehabilitation has been funded through the American Recovery and Reinvestment Act of 2009 and will be completed in 2010. It will include maintenance on historic structures, such as culverts, that had previously been deferred.

Although some maintenance work conducted on the road in the past included inappropriate removal of original features, the park now strives to ensure all maintenance work preserves the road's historic integrity. For example, recent work has preserved the original alignment and width of the road. The Lassen Volcanic National Park Highway is currently listed in "fair" condition in the park's cultural landscapes inventory, but once recently completed maintenance work and work that will be completed in 2010 are considered, the highway's condition rating could improve.

The Manzanita Lake visitor area, the largest developed area in the park, is a first stop for travelers entering the park from the northwest. This area encompasses two of the park's cultural landscapes: **Loomis Museum and Seismographic Station** and **Manzanita Lake/Reflection Lake**. Features of both landscapes are listed in the National Register as the Manzanita Lake Naturalists Services Historic District. Separate National Register listings include the Loop C Comfort Station and the Manzanita Lake Comfort Station at Camp Store (restrooms).

As previously mentioned, Benjamin Franklin Loomis is famous for photographing the Lassen Peak eruption of 1915; he was also active in creating and promoting the national park. The Louisa Mae Loomis Memorial Museum—constructed in 1926 by Benjamin and Estella Loomis in honor of their daughter—housed photographs and other artifacts relating to the dramatic eruption. The museum was donated to

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Benjamin and Estella Loomis built the Louisa Mae Loomis Memorial Museum in 1926 in memory of their daughter, who died at the age of 20. A photographic collection used for interpretation, examples of Atsugewi basketry, and Loomis's photographic equipment are exhibited there.

the National Park Service in 1929. Prior to the opening of the all-season visitor center in 2008, the Loomis Museum was the only visitor center at Lassen Volcanic. The Seismographic Station is a 470-square-foot concrete building that houses seismic monitoring equipment.

Historic structures at Manzanita Lake include the Loomis Home and garage, which served as the Loomis residence, photo lab, and office until the 1950s. The Loomis Home was rehabilitated in 1997 for use as a ranger station. Additional historic structures within the landscape are a campground, picnic area, and general store; the popular Manzanita and Reflection Lake Trails; park signs and a kiosk; and a ranger residence called the Park Naturalists Residence. This residence, built in 1934 by the Civilian Conservation Corps, is representative of the Park Service "rustic style." The logs and stone used in its construction help it blend into its natural setting. In 2002, the park rehabilitated the residence to serve as a "Discovery Center" for children, featuring a science lab, hands-on exhibits, and learning stations that focus on natural history themes.

The Manzanita Lake area also includes the **Nobles Emigrant Trail**, a shortcut on the California Trail blazed and promoted by William Nobles in 1851. The Nobles Trail stretched for 300 miles, from the western Nevada desert to Shasta, California, and served as a primary route for emigrants until the completion of the Central Pacific Railroad in 1869. The 24-mile portion of the trail that exists in the park today is considered a cultural landscape.

The **Summit Lake** cultural landscape contains one of the oldest structures in the park. The ranger station, erected in 1925, represents early national park administration, as well as the architectural design principles seen in National Park Service Rustic and later Civilian Conservation Corps construction. In 1980, the ranger station was completely rehabilitated and is now used to house seasonal personnel. The Summit Lake cultural landscape also includes a ranger cabin at Lower Twin Lake—one of a series of backcountry patrol cabins built in the park by the Civilian Conservation Corps—as well as two large campgrounds, a horse corral, and a trailhead to Twin Lakes.

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The Loomis Home was rehabilitated in 1997 and currently serves as a ranger station.

Two cultural landscapes—**Warner Valley Major Developed Area Historic District** and **Drakesbad Guest Ranch Historic District**—are located within Warner Valley. Both historic districts are listed in the National Register of Historic Places. Like the Summit Lake Ranger Station, the Warner Valley Ranger Station is one of the earliest Park Service buildings (1926) at Lassen Volcanic. The ranger station is also significant for its unique construction style—the building's walls exhibit the extended butt joints of a log cabin, yet logs were not used; the walls are composed of 2 x 6-inch wood planks laid flat atop each other. (The extended butt joint method used is characteristic of the early 20th-century Arts and Crafts movement in the United States.) In addition to the ranger station, the historic district includes a small campground, trailheads to volcanic areas and wilderness destinations, and the Warner Valley Road. Fire towers in the vicinity represent early U.S. Forest

Service protection, prior to establishment of the national park.

The 440-acre Drakesbad Guest Ranch is one of the oldest developed areas in Lassen Volcanic National Park. Pioneer Edward Drake settled the area in the 1880s; in 1900 he sold his ranch to the Alexander Sifford family. The Siffords were responsible for turning the ranch into a popular summer resort. Sold to the Park Service in 1953, the resort is a functioning dude ranch operated by authorized concessionaires. Twenty buildings and other structures are located within the Drakesbad cultural landscape, including the lodge (constructed in 1938), dining hall, food locker, bunkhouse, and six cabins. The historic district also includes Dream Lake, a man-made fishing and boating lake for guests at Drakesbad Guest Ranch, that was constructed in 1932 by damming a swampy pothole filled by a tributary of Hot Springs Creek. The Dream Lake dam has been a source of discussion between cultural and natural resource managers at Lassen Volcanic. While the dam is altering the natural flow of water to the surrounding fen environment, and natural resource managers would like to remove it, it is also a historic structure in a cultural landscape listed in the National Register. This management challenge will be addressed through a special document, the Warner Valley Comprehensive Site Plan, scheduled for completion in June 2010. (See "Planning" on page 49.) Currently, the Drakesbad Guest Ranch landscape is considered to be in "fair" condition.

The **Mineral Headquarters Historic District**, considered to be in "good" condition, is a cultural landscape located in the town of Mineral, just outside Lassen Volcanic's southwest boundary. The headquarters area includes the park's main administrative offices, maintenance facilities, and employee housing. Like the park's other historic structures, many of the buildings here exhibit rustic-style, CCC-era construction. While the headquarters buildings are considered historic structures adaptively reused as offices, they are not interpreted as such at this site. Interpretation at headquarters could include the Kohler Electric Pad, the remains of the earliest power source in the Mineral Headquarters Historic District. A pioneer cemetery, about which little is known, is also located there. In addition to basic interpretation, the headquarters area lacks vegetation management and integrated pest management plans, although a draft of the latter is in progress.

The **Butte Lake** cultural landscape, located in the far northeastern corner of the park, includes a campground, horse corral, ranger station, and a popular trail to the summit of Cinder Cone.

Finally, the **Juniper Lake Area**, though not identified as a cultural landscape, contains historic structures. Located in the extreme southeast corner of the park, the Juniper Lake Area includes a campground, ranger station, and horse corral. Trailheads lead to wilderness destinations such as Horseshoe Lake, site of a ranger station listed in the National Register of Historic Places, and Mt. Harkness, location of a historic fire lookout that is still used. Like the Summit Lake and Warner Valley Ranger Stations, the Horseshoe Lake Ranger Station represents early national park administration and CCC-era design principles. Additional study is needed to determine whether the Juniper Lake area qualifies for listing as a cultural landscape.

The cultural landscape program at Lassen Volcanic scored poorly in this assessment for several reasons, but a lack of baseline information is the biggest threat to the program. Six of the nine identified landscapes (Loomis Museum and Seismographic Station, Manzanita Lake/Reflection Lake, Nobles Emigrant Trail, Summit Lake, Warner Valley Major Developed Area Historic District, and Butte Lake) have incomplete inventories, meaning that their conditions and significance are unknown, and that treatment options have not been identified for their preservation. The three landscapes with complete individual inventories have been assigned condition ratings as stated previously—Mineral Headquarters Historic District:

"good"; Drakesbad Guest Ranch Historic District and Lassen Volcanic National Park Highway: "fair."

Cultural landscape reports, which expand the historical record, identify treatment opportunities, and provide direction for management, are required for all nine sites at Lassen Volcanic National Park. To date, only one landscape—Drakesbad Guest Ranch—has a completed report. The park's top priority is a cultural landscape report for Mineral Headquarters Historic District. Funds were requested, but the project has not yet received funding. Funds have not yet been requested for a cultural landscape report for the Park Highway. According to the park's strategic plan, Manzanita Lake and Summit Lake are next in line for cultural landscape inventories and cultural landscape reports, and these will be addressed when funding is available.

Although Lassen Volcanic National Park's cultural landscapes program is managed at the regional level, its historic structures program is managed at the park level. Lassen Volcanic National Park protects 109 historic structures; currently, 87 structures are in "good" condition, 18 are in "fair" condition, and three are in "poor" condition; one structure's condition is "unknown" (ranger cabin at Lower Twin Lake). Lassen Volcanic's maintenance team has improved the condition of historic structures through seismic stabilization, pest proofing, rehabilitation, and by prioritizing needs using facility management software. A historic architect at the regional level is available as needed.

Historic structures in the park face a variety of threats. Buildings that date to the 1920s and '30s face deterioration due to weather and aging. Earthquake activity is also a concern, so about half of the historic structures have been retrofitted. Many historic structures are vacant in the winter, leaving them unattended for half a year. During the six months they are not monitored, routine maintenance is not conducted, so these buildings must be repaired each summer. Finally, park managers would like to remove some seasonal housing, which they consider decrepit and unsafe. Because the buildings are historic, their removal must be approved by the State Historic Preservation Officer.

Important documentation, such as historic structure reports, is needed to ensure the irreplaceable structures at Lassen Volcanic are fully protected. For example, historic structure reports are necessary to help guide treatment. Some resources, vulnerable to the effects of weather and aging, may be in danger of being lost forever.

HISTORY—ADDITIONAL STAFF NEEDED TO PROVIDE PROGRAMS

Human history at Lassen Volcanic is as varied as its geothermal features. A multitude of historical themes have been identified and researched at the park: indigenous and American Indian history; the fur trade and early American settlement; westward expansion and the establishment of emigrant trails; response to Euro-American settlement; permanent settlement and industries (logging, mining, ranching, and hydroelectric power); early federal management under the U.S. Forest Service; volcanic eruptions and geologic studies; recreational use; and National Park Service administration and development. Currently, interpretation in the park is focused on volcanic resources. Staff intend to complete a comprehensive interpretive plan in 2010 to address voids in the program and make specific recommendations to advance interpretation of cultural themes at Lassen Volcanic National Park.

The park's historic resource study—completed in 2003—identified subjects for future historical research. The history of recreation at the Drakesbad Ranch is an example, and funds for this project—which would rely on oral history and interviews with descendants of the original resort owners—have been requested through the Park Service's Project Management Information System. The study

also identified three 19th-century pioneer graves near park headquarters as a future topic of historical research. These include the grave of Mary Westrope (1829–1877), whose family lived in the Mineral area and ran a dairy farm, and the grave of Sarah Cunningham, who died of tuberculosis on July 25, 1866.

Lassen Volcanic National Park does not employ a full-time historian, but it has access to one at the regional level. Some projects, such as the historic resource study, are completed under contract by outside researchers. The park's administrative history, which is nearing completion by a researcher at Montana State University, is another example. Even with this outside assistance, the park could use more on-site staff to interpret history.

Museum Collection and Archives—Historic Photograph Collection Requires Protection

Museum and archival collections at Lassen Volcanic—totaling 231,233 items—include archaeological relics such as stone blades, manos, and woven objects as well as historic photographs and geological specimens. The majority of the park's collection is housed with the collections of Redwood National Park and Whiskeytown National Recreation Area in a shared facility in Orick, California (about 240 miles from Lassen Volcanic). A museum management plan for all three collections was produced in 2008 by Redwood National Park, after collaboration with park representatives and regional staff. A small portion of Lassen Volcanic's collection remains at the park. A photographic collection used for interpretation, examples of Atsugewi basketry, and B. F. Loomis's photographic equipment are all exhibited at the Loomis Museum. A herbarium of plant specimens is also located in the park, managed by Lassen Volcanic's plant ecologist.

While most of the park's collection has been well protected at the climate-controlled, secure facility in Orick since 2006, many irreplaceable items, such as the photographic slides of the eruption of Lassen Peak, remain at Lassen Volcanic for interpretive purposes. Storage facilities at the park meet only 38 percent of the standards on the Park Service's *Checklist for the Preservation and Protection of Museum Collections*; storage space comprises two walk-in closets located in the park's natural resources administrative building at headquarters. This building, due to its historic nature, suffers from poor ventilation, and there are no systems in place to regulate humidity, temperature, or light levels. In addition, the location of the closets—adjacent to a bathroom—increases the risk of water damage should a pipe leak or burst. The building also needs a seismic retrofit to increase its ability to withstand an earthquake.

Because it is especially vulnerable to so many threats, the photographic collection at Lassen Volcanic National Park should be digitized at the earliest opportunity. Once photographs are scanned and organized, the actual collection can be physically moved to the Orick facility for safekeeping. In the meantime, a secure cabinet system is necessary for the photographic collection.

Exhibits in the Loomis Museum, which include Loomis's camera, photo enlargements, and Atsugewi basketry, are well protected overall, but special film—to filter damaging ultraviolet light—must be installed on the museum skylights.

In addition to inadequate storage, park collections are at risk from lack of documentation and planning. A condition survey of all items at the park and a housekeeping plan for their preservation are both needed. (This does not apply to items on display in the Loomis Museum, where humidity and temperature are adequately monitored and a collection condition survey is complete.) Also needed is an assessment of the park's rare book collection, which houses original editions of early 20th-century works pertaining to regional topics, and an integrated pest management plan to

address the threat of damage due to rodents or insects. Two important projects—a collection conservation assessment and cataloging of natural resource specimens—have been submitted for funding. The regional curator has also recommended developing a scope of collections statement. Finally, a project to create and implement the multipark storage plan for all three collections at the Orick facility will move forward, now that the museum management plan is complete.

In 2004, searchable finding aids for the park's historic photograph collections were created through an agreement with University of Washington photo archivists. This nationally recognized project was labor-intensive. Photo archivists were required to locate the many pieces of the park's collections held at various sites around the country (e.g., National Archives locations in San Bruno, California, and Reston, Virginia). Donor and photographer information for each image was often unclear due to inconsistent record keeping. The project resulted in the organization of 35 separate collections totaling 7,000 images—a major accomplishment for the park. Next steps for the project include digitizing images to preserve them in perpetuity and adding the remainder of the finding aids to the park website.

A large backlog of uncataloged items prevents park staff and researchers from fully using the Lassen Volcanic National Park collections. One-third of the total collection is backlogged, and most of these items are archival. While the curator and two technicians at the Orick facility are responsible for cataloging items, they are still shorthanded. Additional support would greatly help in cataloging the more than 70,000 archival items backlogged. Finally, although many items are cataloged and finding aids do exist for the photographic collection, Lassen Volcanic National Park is unable to manage research requests for collection items, due to funding and staffing shortfalls. Another complicating factor is that the collections are located 240 miles from the park. A cost recovery program that would allow for research requests to be fulfilled has been proposed, but no formal funding request for this proposal has been submitted. The proposed program would be administered by the Lassen Association, the park's official nonprofit cooperating association, which would charge small fees to the requestors of collection items.

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The park's archive includes thousands of historic photographs. In 2004, photo archivists from the University of Washington created searchable finding aids for the historic photograph collections.

Volunteers assist park staff with a variety of projects. In this photo, a park staff member and a volunteer from the Student Conservation Association are spreading mulch at the park's new visitor center.

STEWARDSHIP CAPACITY

FUNDING AND STAFFING—IMPORTANT POSITIONS REMAIN UNFILLED

In fiscal year 2008, Lassen Volcanic National Park had an operational budget of $4.3 million, which was insufficient to fund all projects. As a result of funding and staffing shortfalls, many natural and cultural resource projects could not be conducted. Natural resource projects awaiting funding include an assessment of impacts at park boundaries (i.e., cattle and motor vehicle trespass effects) and control of non-native plants. Due to a lack of baseline information, Lassen Volcanic's ecosystems are only partly understood. The Park Service is addressing this data gap through both in-house inventory and monitoring programs (e.g., black bear monitoring, pika monitoring, climate change studies) and projects in conjunction with the Klamath Inventory and Monitoring Network (see "Resource Management Highlights" on pages 8 and 9). The park needs funds for equipment and staff to support both in-house projects and work done through the network.

Cultural resource projects that require funding include a conservation survey of museum objects, the collection of oral histories from people who worked or stayed at Drakesbad Guest Ranch during its period of

significance (e.g., descendants of the Sifford family, which owned the ranch from 1900 to 1953), and archaeological investigations at two impacted sites at Drakesbad. In addition to resource management projects, money is needed for infrastructure, such as the installation of protective ultraviolet filtering film to the museum's skylights.

In early 2009, through the National Park Service Recovery and Reinvestment Act, $15.7 million was earmarked for Lassen Volcanic. (In total, the National Park Service will invest $750 million in nearly 800 national park projects to stimulate the nation's economy.) Money directed to Lassen Volcanic National Park will be used to construct trail footbridges at Mill Creek Falls, inspect and clean park sewage lines, and rehabilitate the Lassen Peak hiking trail and ten miles of park road to improve visitor safety. Erosion and failing retaining walls along the trail will also be addressed.

Critical positions remain vacant at Lassen Volcanic National Park, including a geographical information systems program manager and a cultural resource manager. And while regional and contracted expertise may be sufficient to support Lassen Volcanic's historic research program, the park needs additional staff on-site to interpret history.

PLANNING—WARNER VALLEY SITE PLAN WILL ADDRESS MANAGEMENT CONFLICTS

To guide management of diverse resources, parks need a variety of plans. Lassen Volcanic National Park's 2003 general management plan is used frequently to direct management decisions. The general management plan stresses the need for increased cooperation with the U.S. Forest Service and other land managers to achieve successful ecosystem-wide management.

The park's resource management plan is outdated. Written in 1999, it does not reflect changes in the last decade with regard to major issues, new staff positions, and the need for ongoing monitoring. The Park Service has begun to replace resource management plans with resource stewardship strategies. Lassen Volcanic will initiate a resource stewardship strategy within the next five years, based on the results of pilot parks within the system.

Other plans at Lassen Volcanic National Park are more recent. A weed management plan and environmental assessment was completed in 2008, and resource managers are developing an integrated pest management plan, due for completion in 2010. Lassen Volcanic's administrative history was finished in 2008.

The park's fire management plan—soon to undergo a five-year review process—was completed in 2005. After the review process, it will be updated. The current fire management plan details burn units, prescribed fire use, and wildland fire use. For now, all human-caused, non-prescribed fires in the park are suppressed. The updated plan will follow the new Wildland Fire Decision Support System, which will improve the park's ability to manage all fires to achieve multiple resource objectives, regardless of whether the fire was ignited naturally or by humans.

The Warner Valley Comprehensive Site Plan (see earlier references in "Resource Management Highlights" on pages 8 and 9, as well as page 44 of "Cultural Landscapes and Historic Structures"), scheduled for completion in June 2010, will outline steps needed to achieve desired conditions with regard to natural and cultural resources, aesthetics, and the quality of the visitor experience in this area of the park. The plan will also address the current natural and cultural resource management conflict surrounding the Dream Lake dam. Built in 1932 to create a fishing and boating lake for guests at Drakesbad, the dam is a historic structure and component of the Drakesbad Guest Ranch Historic District. It is also a man-made alteration disrupting the natural flow of water. Currently, the dam is in poor condition and could fail if it is not repaired. However, there are

concerns that construction equipment could harm the environment if the dam is rebuilt or altered. The Warner Valley Comprehensive Site Plan Draft Environmental Impact Statement was released for public review in August 2009. It can be found by clicking on the "Management" link on the park's website: www.nps.gov/lavo. Public comments on the draft must be submitted to the Park Service by November 21, 2009. A similar comprehensive site plan for Manzanita Lake will proceed as funding becomes available.

The park's bear management plan dates to 1992, and a study to estimate population size, food habits, and habitat use of black bears that inhabit the park and adjacent Lassen National Forest has not been funded.

To better protect resources and provide management directives, the park needs an updated wilderness management plan. Even though most of the park is designated "wilderness," Lassen Volcanic lacks a full-time wilderness coordinator; wilderness management is collateral duty for the park's chief of natural and cultural resources management. Although the park would like to have the wilderness plan completed by 2011, without a fully dedicated wilderness coordinator at Lassen Volcanic, this plan will likely go undone. In 2009, the park adopted guidelines that require special analysis and consideration for all projects proposed within wilderness, another reason why a full-time wilderness coordinator would benefit the park.

In 2009, the park completed an emergency operations plan that addresses all hazard management (e.g., eruptions, catastrophic fires). It provides a risk assessment, identifies vulnerabilities, and details emergency operations. The park is also working with the U.S. Geological Survey on a volcanic hazard plan.

RESOURCE EDUCATION AND OUTREACH—PARK PROGRAMS POPULAR WITH VISITORS

Because of its volcanic origins and dynamic nature, Lassen Volcanic National Park is a unique outdoor classroom for studies on ecological succession and geothermal resources. In summer 2008, Lassen Volcanic offered 25 different educational programs, including Junior Ranger and Junior Firefighter programs. An intern from California State University–Chico will soon complete a new "Green Ranger Program," which will be the first such program offered within the National Park System. The program encourages children to practice environmentally friendly habits. The number of interpretive and school programs has increased over the past two years, due to the addition of two seasonal interpretive staff funded through the Park Service's Centennial Challenge as well as three more visitor center positions funded through the park's base budget.

Lassen Volcanic serves public and private school groups in 36 California counties, offering ranger-led programs for grades kindergarten through college. These educational programs—which include an introduction to the park, its volcanoes and geothermal features, and its habitats—are immensely popular and reservation spaces fill up quickly.

Some school groups elect to take instructor-led field trips in the park. An activity guide for teachers—with detailed lesson plans on geology, American Indians, pioneers, and the National Park Service—is available online. School groups can apply for an entrance fee waiver using a form available on the park website.

For those students who can't visit the park in person, Lassen Volcanic offers "Traveling Trunks"—assortments of geological specimens, multisensory materials, and activity suggestions—that provide teachers with different themes for interpretation. Traveling trunks can be shipped to any classroom anywhere in the United States.

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Educational and interpretive programs are very popular with students and other visitors of all ages.

Internships in the park are available to motivated older students. Lassen Volcanic National Park, in cooperation with Shasta College and the Sacramento River Discovery Center, has developed an interpretive internship that has been in place for 14 years. High school and college students in 23 area counties are eligible for this program. Lassen Volcanic and the National Aeronautics and Space Administration (NASA) have also developed Spaceward Bound Lassen, a program that allows students and teachers to study side-by-side with NASA scientists. Spaceward Bound Lassen researchers search for life-forms in the park's extreme geothermal environments, which could resemble the conditions found on other planets. This partnership has led to an internship program in astrobiology for high school students.

Visitors of any age can participate in daily ranger-led hikes and programs in the summer and fall. In 2008, through its extensive interpretive offerings, Lassen Volcanic reached an estimated 6,448 visitors through a total of 236 separate programs.

Because the park is open all year and is popular with skiers and snowshoers, interpretation doesn't end when the Park Highway closes in autumn. Ranger-led winter programs are presented in the southwest area from January through April. Area students in grades two through 12 take part in a winter survival/snow shelter program, which draws participants from eight counties. The general public can attend the survival program, as well as the park's winter ecology snowshoe program.

While a ranger-led program is a valuable part of a national park experience, not all visitors are able to attend one. For that reason, a park's visitor center—usually the first stop for guests—is their primary source for information. In fall 2008, the park opened its first year-round visitor center at Lassen Volcanic's southwest entrance. The Kohm Yah-mah-nee Visitor Center was designed to be environmentally friendly and has received a "platinum" Leadership in Energy and Environmental Design (LEED) certification—the highest certification possible. The Kohm Yah-mah-nee Visitor

Center is the first year-round National Park Service building to be certified at this level. Remnant materials from the Lassen Chalet ski lodge—torn down to make way for the visitor center—were reused in the new construction. In addition, the center is built with lumber from local, sustainable forests. The building design also incorporates decorative stone from local sources near Red Bluff, and features countertops made of 90 percent recycled glass.

The Kohm Yah-mah-nee Visitor Center features a new film titled *The Story Behind the Landscape* that explores the geological forces that shaped the park and continue to influence it today. Interactive and conventional exhibits interpret the themes of geology and volcanism, Mountain Maidu history, local history, resource stewardship, and the creation of the national park. Three self-directed education programs are available at the visitor center—the Volcano Club, the Discovery Hunt, and the Chipmunk Club. These programs help guests develop an understanding and appreciation of the Earth's volcanoes and teach stewardship of the natural world. Participants complete seven of 11 activities in a printed brochure to become members. The visitor center also serves as an orientation point for those seeking information on recreational opportunities

In 1999, the final phase of permanent exhibits was installed in the historic Loomis Museum at the park's northwest entrance. The exhibits incorporate geological history with museum artifacts, such as Atsugewi baskets and the cameras and equipment Loomis used to photograph the historic eruption of Lassen Peak.

Through a partnership with the Lassen Park Foundation (see "External Support" below), in 2000 Lassen Volcanic National Park and Lassen National Forest opened the Lassen Crossroads. The interagency pavilion—located at the park's northern entrance—provides an orientation point for visitors to the Lassen area, offering recreational and historical information. The pavilion is not staffed, though it is maintained and cleaned by park staff, and is accessible only during the summer season. The park's Discovery

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In fall 2008, the park opened its first year-round visitor center at its southwest entrance. The Kohm Yah-mah-nee Visitor Center is very environmentally friendly and is the first year-round National Park Service building to receive a "platinum" Leadership in Energy and Environmental Design (LEED) rating.

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Participants in the park's Junior Ranger program learn about hydrothermal activity at Bumpass Hell.

Center, a hands-on educational facility designed for children, opened at Manzanita Lake in 2002. Visitors to Lassen Volcanic also learn from 80 wayside interpretive exhibits that were installed in the park in 2004. These exhibits are strategically positioned along the Park Highway and on hiking trails.

Living history demonstrations would enhance interpretation at Lassen Volcanic National Park. While demonstrations of Atsugewi basketry were performed at the park as recently as the 1970s, descendants no longer show an interest in demonstrating this practice. In the view of tribal consultants, recreation and tourism is at odds with religious practice; Lassen Peak is viewed as a sacred site and a destination for quiet reflection. Basket-weaving demonstrations were filmed, however, and oral histories were collected in conjunction with the park's 2004 traditional use study. The practice may be resurrected in the future.

EXTERNAL SUPPORT—PARTNERSHIPS PROVIDE ESSENTIAL RESEARCH

Because most of the appropriated base funding provided to Lassen Volcanic National Park is used to cover fixed costs such as salaries and benefits for permanent staff, the park relies on devoted volunteers, strategic partnerships, and private contributions to provide additional services and fill needs associated with unfilled staff positions.

In 2008, Lassen Volcanic benefited from 14,846 volunteer hours donated by 188 individuals. The services provided by these participants are myriad: They assist with campground hosting, visitor contact, natural resource field surveys, non-native plant removal, cultural resources research, clerical and library work, photography, search and rescue, ski patrols, and trail maintenance.

The Lassen Park Foundation, a private nonprofit, supports projects in Lassen Volcanic National Park and Lassen National Forest. The foundation has been instrumental in providing

interpretive and educational activities, assistance with wildlife research, and trail restoration. For example, the foundation currently provides a grant to support reforestation efforts in the park. The foundation also funds camping trips for at-risk students. In 2008 the Lassen Park Foundation's challenged youth program awarded a record number of grants, allowing 17 student groups to experience camping trips in the park. Applicants for grants from the Lassen Park Foundation include underfunded public schools, group homes, foster care agencies, and youth mentoring groups.

The Lassen Association operates the park bookstore. Publications, maps, and other educational material can be purchased at the bookstore or online through the Lassen Association website (www.lassenassociation.org). Proceeds from bookstore sales fund on-site events and programs, additional publications (including the park newspaper), and field seminars.

Many research projects at Lassen Volcanic are conducted with help from within and outside of the National Park Service. From 1997 to 1999, Lassen Volcanic National Park—in a partnership with Lassen National Forest and the Point Reyes Bird Observatory—conducted population monitoring of songbird communities within the park and national forest. The mist-netting station used for this purpose at Drakesbad Meadow was converted at study's end to a permanent station for long-term monitoring. Monitoring at the Drakesbad location will continue indefinitely.

In 2007, a small archaeological crew from Redwood National Park conducted an archaeological testing project in Warner Valley, where a proposed leach field for Drakesbad overlapped with an archaeological site. Park staff shifted the layout of the leach field to avoid areas that were highly likely to contain artifacts. The leach field was installed in July 2009. The park also partners with Redwood for museum collection management. Most of

ERIN MCPHERSON

Lassen Volcanic and the National Aeronautics and Space Administration (NASA) developed Spaceward Bound Lassen, a program that allows students and teachers to study side-by-side with NASA scientists. Spaceward Bound Lassen researchers search for life-forms in the park's extreme geothermal environments, which could resemble the conditions found on other planets.

Lassen Volcanic's collections are stored at a shared facility in Orick.

Much natural resources research has been and continues to be done through the Klamath Inventory and Monitoring Network (e.g., species inventories, aquatic monitoring at park lakes, monitoring of land birds, and vegetation mapping). Some of the park's other research partners include the California Waterfowl Association and volunteers (bufflehead duck surveys); U.S. Forest Service Southwest Experimental Station (spotted owl surveys); Crater Lake National Park, Craters of the Moon National Monument, Lava Beds National Monument, and the Upper Columbia River Basin Network (pika monitoring); the Bureau of Land Management Special Weeds Action Team, Sierra Club, and American Conservation Experience (invasive plant control); Lassen National Forest and the California Department of Game and Fish (Columbian black-tailed deer monitoring); the U.S. Geological Survey Western Ecological Research Center in Arcata (hydrological studies and monitoring); and the U.S. Geological Survey Volcano Hazards Division (volcanic and geothermal monitoring).

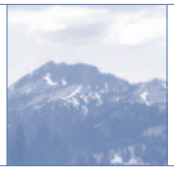
Additionally, in September 2007 researchers from Humboldt State University, California State University–Chico, and Portland State University received a National Science Foundation grant to conduct a 5-year project focusing on Boiling Springs Lake in the south-central portion of the park. Boiling Springs Lake is the largest hot spring in North America and provides a unique opportunity for ecological researchers to investigate the factors that control the abundance, diversity, and activities of thermophilic archaebacteria in a natural environment, as well as to assess the stability of their populations over time.

NATIONAL PARK SERVICE

A volunteer assists visitors at the Loomis Museum.

WHAT YOU CAN DO TO HELP:

- **Participate in park planning efforts.** The public is invited to provide input on all park plans and studies. Check www.nps.gov/lavo for information on park planning work and ways to participate.
- **Support or become a member of a group helping to protect the park:** The Lassen Park Foundation (www.lassenparkfoundation.org), Lassen Association (www.lassenassociation.org), or NPCA (www.npca.org/support_npca).
- **Volunteer in the parks.** Many parks are looking for dedicated people who can lend a helping hand. To learn about opportunities for volunteering at Lassen Volcanic, visit the park's website (www.nps.gov/lavo) or contact the park's volunteer coordinator at 530.595.4444, extension 5130.
- **Become an NPCA activist and learn about legislative initiatives and protection projects affecting parks.** When you join our activist network, you will receive *Park Lines*, a monthly electronic newsletter with the latest park news and ways you can help. Join by visiting www.npca.org/takeaction.



APPENDIX: METHODOLOGY

To determine the condition of known natural and cultural resources at Lassen Volcanic National Park and other national parks, the National Parks Conservation Association developed a resource assessment and ratings process. The assessment methodology can be found online at NPCA's Center for State of the Parks website: www.npca.org/stateoftheparks.

Researchers gather available information from a variety of research, monitoring, and background sources in a number of critical categories. The natural resources rating reflects assessment of more than 120 discrete elements associated with environmental quality, biotic health, and ecosystem integrity. Environmental quality and biotic health measures address air, water, soils, and climatic change conditions, as well as their influences and human-related influences on plants and animals. Ecosystems measures address the extent, species composition, and interrelationships of organisms with each other and the physical environment.

The scores for cultural resources are determined based on the results of indicator questions that reflect the National Park Service's own *Cultural Resource Management Guideline* and other Park Service resource management policies.

Stewardship capacity refers to the Park Service's ability to protect park resources and includes discussion of funding and staffing levels, park planning documents, resource education, and external support.

RUSSELL VIRGILIO

A trail leads to Crags Lake in the northwest corner of Lassen Volcanic National Park.

For this report, researchers collected data and prepared a paper that summarized the results. The draft underwent peer review and was also reviewed by staff at Lassen Volcanic National Park.

NPCA's Center for State of the Parks represents the first time that such assessments have been undertaken for units of the National Park System. Comments on the program's methods are welcome.

ACKNOWLEDGMENTS

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Center for State of the Parks®
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OTHER REPORTS AVAILABLE

Adams National Historical Park (MA)
Andersonville National Historic Site (GA)
Andrew Johnson National Historic Site (TN)
Apostle Islands National Lakeshore (WI)
Appomattox Court House National Historical Park (VA)
Assateague Island National Seashore (MD, VA)
Big Bend National Park (TX)
Big Hole National Battlefield (MT)
Big Thicket National Preserve (TX)
Biscayne National Park (FL)
Bryce Canyon National Park (UT)
Cabrillo National Monument (CA)
Canyonlands National Park (UT)
Catoctin Mountain Park (MD)
Channel Islands National Park (CA)
Charles Pinckney National Historic Site (SC)
Chesapeake and Ohio Canal National Historical Park (DC/MD/WV)
Chickamauga and Chattanooga National Military Park (TN/GA)
Cumberland Island National Seashore (GA)
Death Valley National Park (CA)
Denali National Park and Preserve (AK)
Effigy Mounds National Monument (IA)
Fort Donelson National Battlefield (TN)
Fort Laramie National Historic Site (WY)
Fort Necessity National Battlefield (PA)
Fort Pulaski National Monument (GA)
Fort Sumter National Monument (SC)
Fort Union Trading Post National Historic Site (ND)
Frederick Douglass National Historic Site (DC)
Gateway National Recreation Area (NY)
Glacier Bay National Park and Preserve (AK)
Great Basin National Park (NV)
Great Smoky Mountains National Park (TN/NC)
Harpers Ferry National Historical Park (WV)
Hawai'i Volcanoes National Park
Hopewell Furnace National Historic Site (PA)
Indiana Dunes National Lakeshore (IN)
Isle Royale National Park (MI)
Joshua Tree National Park (CA)
Keweenaw National Historical Park (MI)
Knife River Indian Villages National Historic Site (ND)
Lake Clark National Park and Preserve (AK)
Lewis and Clark National Historical Park (OR)
Lewis and Clark National Historic Trail (various)
Little Bighorn Battlefield National Monument (MT)
Longfellow National Historic Site (MA)
Missouri National Recreational River (NE)
Mojave National Preserve (CA)
Nez Perce National Historical Park (WA, ID, MT, OR)
Olympic National Park (WA)
Pea Ridge National Military Park (AR)
Pictured Rocks National Lakeshore (MI)
Point Reyes National Seashore (CA)
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San Juan Island National Historical Park (WA)
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Waterton-Glacier International Peace Park (MT-Alberta)
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