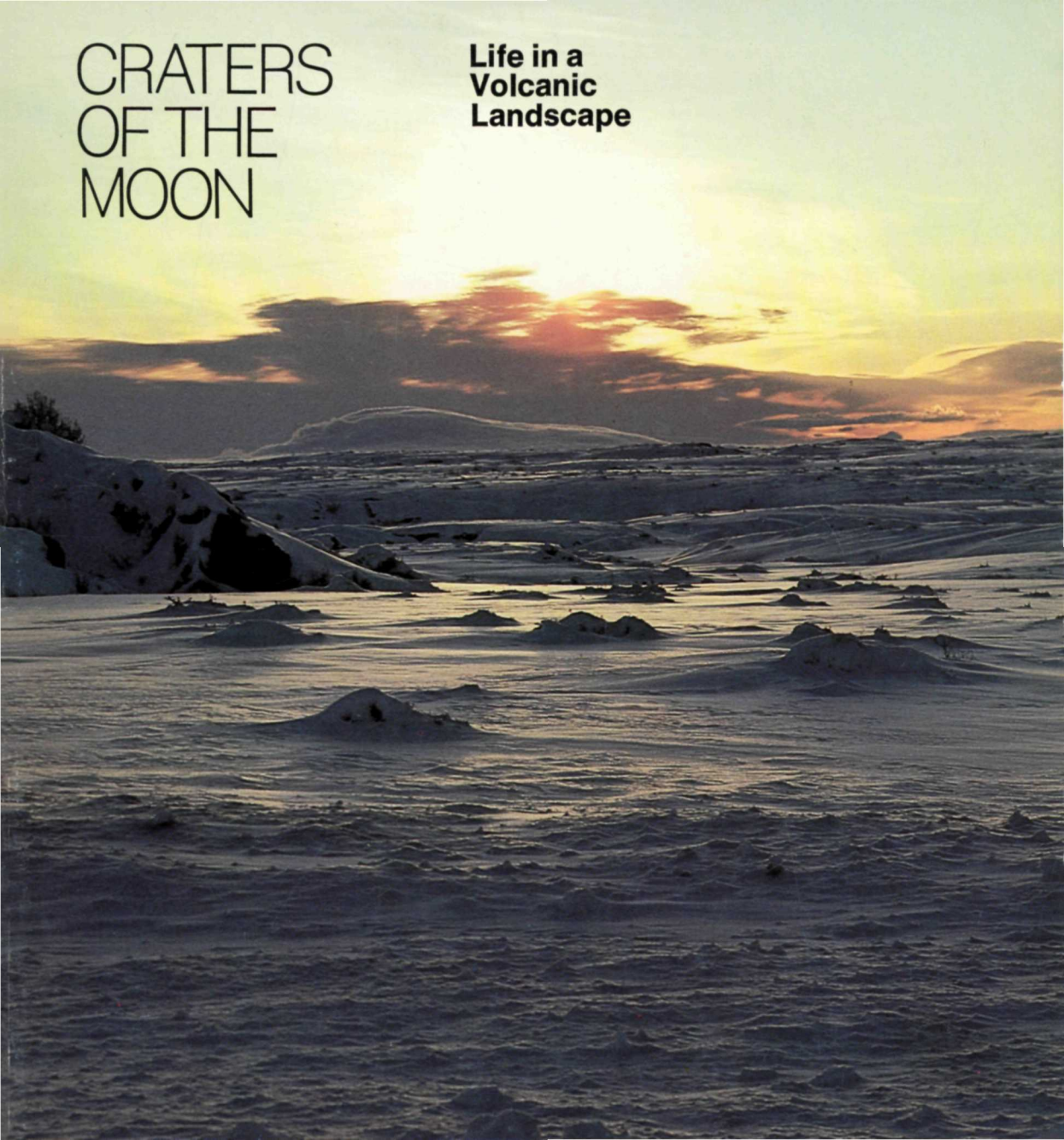
CRATERS OF THE MOON

Life in a Volcanic Landscape



CRATERS OF THE MOON

Life in a Volcanic Landscape

by

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We Idahoans have always recognized the many-faceted complexity and splendor of our geography. But to many Americans, Idaho is a rather hazy entity. "Idaho" means big potatoes, and the familiar panhandle-shaped outline on maps; it evokes such historical associations as Lewis and Clark, Sacajawea, and the Oregon Trail; it calls up images of sparkling alpine lakes, deep river canyons, and conifer-clad mountains.

Less familiar is one of our most fascinating and mysterious regions, the vast lava wilderness that occupies an area larger than Rhode Island north of the Snake River and south of the mountainous Panhandle. It is wild indeed and is often described further as barren and desolate. Yet this land is neither as lifeless nor as forbidding as one might think.

One section of this lava realm, named "Craters of the Moon," has been set aside as a National Monument. Embracing picturesque buttes, symmetrical cinder cones, and many-colored lava flows, it is a unique scenic and scientific resource. Most of the Monument is protected from development by its status as Wilderness; but in the northwest sector, the National Park Service provides access to some of the finest examples of lava-flow phenomena and to panoramic vistas of great beauty.

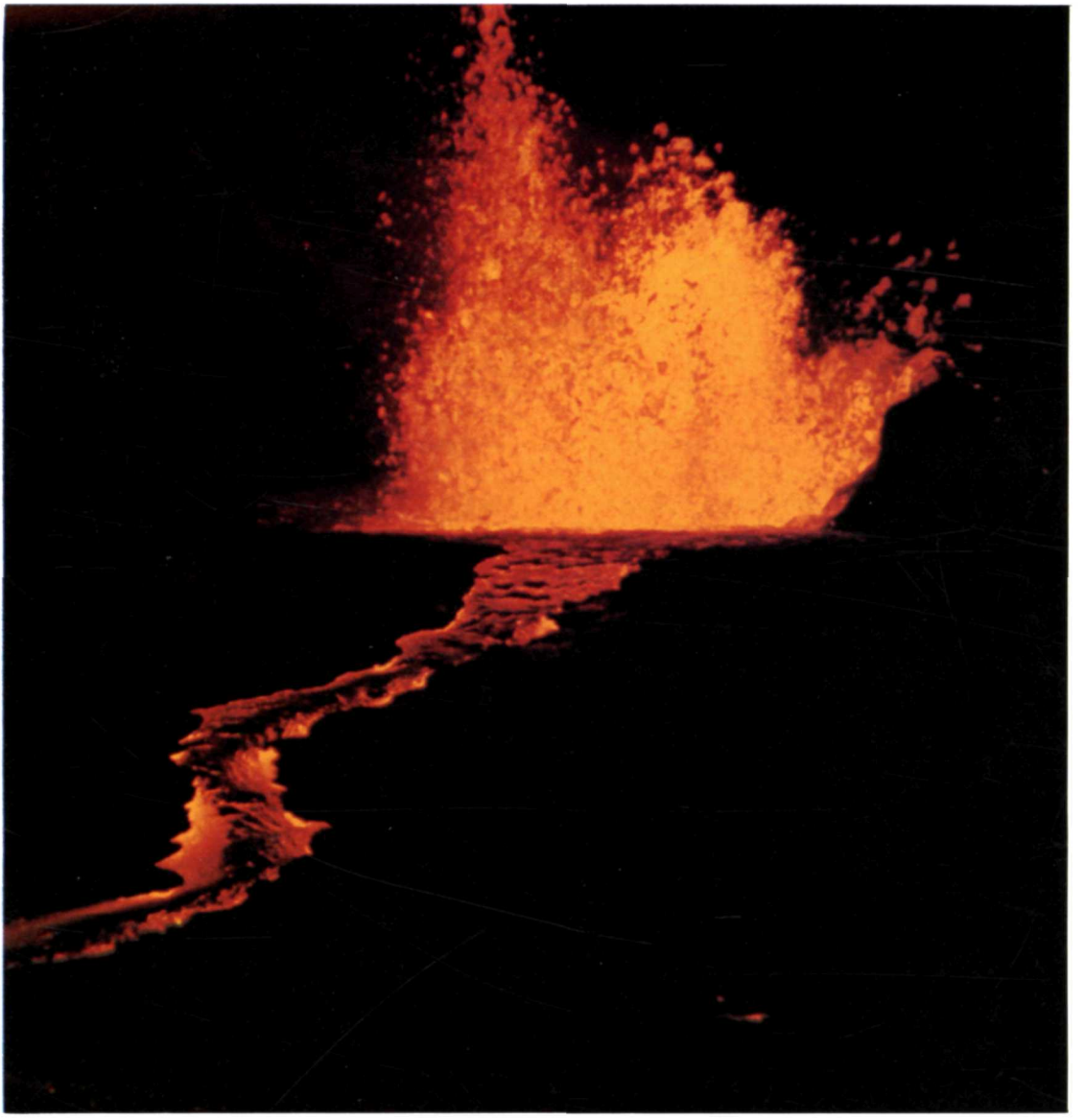
The story of how the plants and animals have adapted to the aridity, the temperature extremes, the exposure, and the meagerness of soil here is an intriguing one. This booklet, written by Vern Crawford and published by the National Park Service, tells that story.

Welcome to Craters of the Moon.

Cecil D. Andrus

Contents

Features



Upheaval

Suddenly the tiny gray-green leaves of sagebrush shake violently in the quiet dawn air. Pebbles rattle down the slopes of dry, sparsely vegetated hills, and the ground rumbles with earthquake convulsions. A dark-furred pocket mouse, its cheek pouches bulging with seeds gathered from grasses and maturing wildflowers, fearfully bounds into its burrow in the soft, powdery soil. The pocket mouse has completed another night of routine foraging, but the day to follow will be unlike any the long-tailed little rodent has ever seen. Today the earth will crack open, and volcanoes will erupt upon this land.

For many hours warnings have been felt. Greater and lesser shudders and jolts have frightened the wild animals of the area. With increasing frequency earthquake shock waves have shaken the Pioneer Mountains and rippled out across the Snake River Plain. Now the tremors are striking several times every hour, and a strip of land two kilometers* long has bulged upward slightly.

At sunrise a violet-green swallow, diving low to snap up slow-flying insects, crisscrosses a wide expanse of black rocks. The austere lava surface below her, erupted by earlier, now silent volcanoes, provides innumerable small crevices and pockets where herbs and shrubs can find shelter from the dry winds and clear, hot sun. Humming from plant to plant, in the warmth of the rising sun, flying insects zigzag across the black lava rock. In precise aerial maneuvers, the violet-green swallow picks them easily from the air. Nestlings await her return with fresh insect food.

Until today, the swallow has been little affected by the trembling earth. Now, however, as she swoops over the steep flank of a hill composed of volcanic cinders, she skillfully detours around a thin gray cloud of steam hissing from the rocks. A deep crack already several centimeters wide gapes open near the base of the hill and extends across a thick lava flow in the direction of the Pioneer Mountains. Wisps of steam rise at four vents along the crack. The earth trembles again, shaking loosened rocks and dust into the slowly widening fissure. Suddenly a clot of red-hot lava spatters up through the billows of steam and plops down on the edge of the fissure, where it sags and solidifies in the cool air. More lava clots soon follow. The swallow, still intent on its insect prey, veers sharply to avoid being hit. Her white breast slices upward

* See metrics message on page 68.

through the swelling gas cloud hanging over the fissure. Sulfurous fumes irritate her lungs. Annoyed and nervous, the swallow flees to her nest of fledglings in the safety of a nearby lava cave.

Soon the fissure's eruptive activity increases. Lava, frothed by its own gases and shot upward by the escaping outrush, grows into a four-meter-high incandescent shower. Particles and clots of the molten shower cool as they shoot upward, half-solidifying in the air; then they shower down, adding to a ring of cinders and lava spatter forming around the growing lava fountain. Nearby along the same rift other lava fountains are breaking through the earth. Sulfurous gases escape hoarsely from the vents, while the rain of glassy cinders around each vent clatters like shattering china.

Lava fountaining continues all day, and by nightfall yellow-hot jets of lava roar 30 meters into the sky. The prevailing southwest winds carry away a cloud of fine volcanic dust. Medium-sized particles are also driven northeastward by the wind, piling up into elongated, asymmetrical cinder cones about ten meters high at each vent. Occasionally small trees and shrubs near the cones catch fire and blaze in the darkness, but it is the roaring "fire fountains" themselves—composed not of fire, but of incandescent lava—that illuminate the surrounding terrain. The ground constantly trembles near the fissure. Pocket mice and other rodents huddle nervously in their burrows, awaiting the end of this unexpected "storm." Coyotes and jack rabbits, abandoning their usual feeding ranges, flee into the shadows of the nearby hills. A great horned owl launches itself into the night from a rock shelf in a cave and flies away into the old lava plains, seeking its prey of mice and rabbits far from the scene of eruption. From their mountainside sanctuaries mule deer snort fearfully and flick their ears and tails as they look down upon the brilliant eruption below.

Near dawn, 24 hours after the initial eruption, the fountains quickly subside. Each wind-skewed cone continues to spatter and fume quietly, but the night's violent effervescence has been spent. Relative peace lies on the land. Each newly created cinder cone stands sharply etched against the Snake River Plain.

With the decline of the fountains, however, a new phase of eruption is set to begin. Within hours the lower flank of one cinder cone bulges and bursts open, extruding a thin tongue of glowing lava. The lava flows rapidly to the base of the cone and gathers in a pool. Its viscous mass soon acquires a dark crust that insulates its still molten, 1100°C interior. After a few minutes,

a series of sharp jolts in the ground accompanies a much larger outpouring of lava. The second flow spreads out across the first and, having overrun the lava pool, is soon oozing out upon the rocky landscape. It gradually divides into separate channels of orange, flowing melt whose surface becomes patchy with gray crust. Wherever the flowing stream of lava thins, patches of the pliable crust become pleated and drawn, stiffening to resemble bunting festoons or coils of hemp rope.

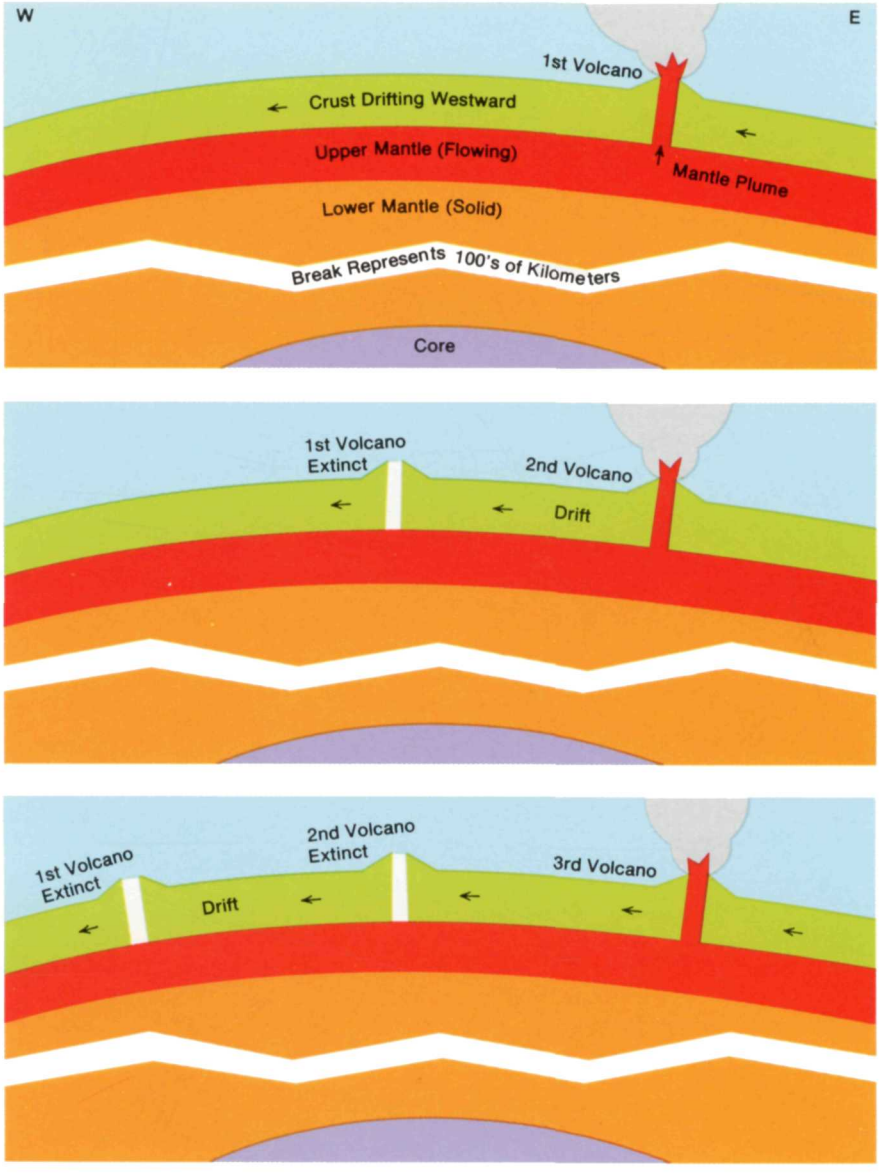
Beneath its dark insulating crust, the incandescent lava remains fluid and flowing at more than 1100°C. Still fed from the fissure, it continues to surge in subsurface channels—lava tubes—for 2 or 3 kilometers across the rocky plain. At the nose of the flow, bulges and breakouts of the sticky rock advance the leading edge. Plants, rocks, and unsuspecting animal life are engulfed and buried. Flows from this single vent continue erratically for two days, adding an extensive layer of fresh, smooth rock that paves the landscape in gentle undulations. When hardened, the lava displays a thin coating of rich blue glass, a feature uncommon to lava flows elsewhere in the world.

Then the volcanic eruption seemingly dies. Although lingering fumes still rise from the cones and flows, neither fountains nor flows reappear. Months will pass before the interior of the new flow, insulated by thick crusts, is completely cool. A red-tailed hawk wings down from its perch in the Pioneer Mountains, sailing out over the fresh lava surface. Its eyes search for unwary voles, ground squirrels, and pikas among older flows nearby. A chipmunk, its attention fixed on a beetle seared by the lava, barely feels the hawk's talons and the sudden swish of the raptor's wings. Thus in many ways the volcano has already affected the lives of its wildlife neighbors.

Few earthquake tremors occur during the next five days. Suddenly at mid-afternoon of the fifth day, however, new jolts shake the area. A gopher snake dives from its sunny rock into the deeper recesses of the outcrop, and a startled young family of black-and-white magpies explodes from perches in a limber pine, squawking loudly. Fresh lava immediately bursts from beneath a quiescent cinder cone, breaching the cone's side and rafting away tall chunks of its crumbly wall. Only one small fountain accompanies this new flow, for the earlier eruptions had largely released the lava's pent-up gases. The new lava emerges as a river of orange melt, but unlike the earlier, more fluid, smooth-surfaced flows, this new flow quickly becomes a sluggish mass of spiny rubble. As it creeps forward, sand-sized particles and coarse chunks tumble down its steep face to be buried by its slowly advancing front. After

six hours, the jumbled lava has flowed less than a kilometer from the vent. Then the eruption ceases altogether.

That night on an older, grassy cinder cone, the yellow blossoms of the blazingstar open in the moonlight for visits by pollinating moths. As morning approaches, its blossoms fold shut. Nearby, a fat yellow-bellied marmot appears from its burrow, yawns at the sunrise, stretches its body, and begins nibbling leaves and stems as if nothing earthshaking has happened. Like others of the squirrel family, it is preparing for dormancy through the snowy months of winter. The fresh volcanic cones stand stark and mute.



Mantle Plume and Continental Drift

Some geologists picture lava of the Snake River Plain as rising from the earth's upper mantle, penetrating the earth's crust, and then extruding upon the surface. In this still-tentative view, a great upwelling, called a mantle plume, carries the molten rock upward. At the same time, but over a period of millions of years, the earth's crust slowly drifts across the upper mantle, while the plume remains stationary. Thus, volcanoes erupt and then become extinct as the moving crustal "conveyor belt" *carries them away from* the mantle plume upwelling. Meanwhile, new volcanoes form above the plume, also to be carried away later on the drifting crust. Each drawing represents leaps in time of thousands or millions of years.

"Where's the Volcano?"

Today as you approach and initially tour Craters of the Moon National Monument, your impression may be only of barrenness and desolation, with few hints of the park's catastrophic origins. Let us say you are visiting the park at about 11 a.m. on a summer day. You have most likely been traveling north across the Snake River Plain of south-central Idaho. This flat, featureless expanse is broken only by two or three high buttes formed by volcanic activity millions of years ago and by an occasional fence or ranchhouse. The rough, rocky land is loosely carpeted with gray-green shrubs of sagebrush and rabbitbrush. Several species of grass sprout among the shrubs. The precise term for this plains plant association is *shrub-steppe*. To the north the plain breaks abruptly into high mountain ranges: the Pioneer, White Knob, and Lost River Mountains.

It is dry and hot. The road seems endless. Here the climate is classed as semi-arid. Yet already the temperature is near 25°C and the heat of afternoon is yet to come. The sky is spotlessly blue. The air is desiccatingly dry. Total annual precipitation in this region amounts to only about 45 centimeters. (By contrast, New York City receives about 130 centimeters and Chicago about 80 centimeters.) Most of it falls as winter snow and late spring rain. Summers are extremely dry, with only about one centimeter of rain falling in July. When visiting the area in summer's heat and drought, one can hardly

Crescent Butte is a cinder cone in the Craters of the Moon Wilderness Area.

Winter softens the craggy contours and lends long-shadowed beauty to the landscape at North Crater.

imagine a blanket of snow 75 centimeters deep and winter temperatures as low as −25°C! Wind nearly always plays across the lava plains, especially at Craters of the Moon, which stands higher than the surrounding land and seems to intercept the prevailing southwest air currents.

Near the boundaries of the park the highway meets fresh fields of lava. In places the road runs through dark rocks that appear totally lifeless and barren. Ahead you see signs announcing the park. Anticipation runs high! You expect to see a real volcano—steep-sided, symmetrical, with a crater in its top, perhaps resembling Mount Fuji. In short, you probably expect to see what geologists call a stratovolcano.

Instead, you encounter a confusing assemblage of rugged black rocks, hills of reddish-purple cinders, and stretches of sand and abrasive pebbles dotted with shrubs and pines. A quick auto tour persuades you that here is a badland, good for neither farming nor building—nor even walking.

Thus, if one relied only on the initial impressions of a quick visit, he would likely wonder, "Where's the volcano?" and feel somewhat disappointed. This would be unfortunate, for the volcanoes—scores of them—offer unexpected rewards at Craters of the Moon. First impressions are misleading; one needs a little time to explore this landscape, variously described as weird, barren, exciting, awe-inspiring, monotonous, astonishing, curious, bleak, colorful, and mysterious.

Today's park, reaching southeastward from the Pioneer Mountains, encloses a series of fissure vents, volcanic cones, and lava flows known locally as the Great Rift Zone. This line of weakness in the earth's crust can be traced 100 kilometers across the Snake River Plain. Recent volcanism marks much of its length.

At the foot of the Pioneer Mountains the Great Rift Zone displays a few of its volcanic features, but this northwestern portion of the park is not accessible to general public use. The larger central portion, however, including an 11-kilometer loop drive, is the area most often enjoyed by park visitors. Here one finds spatter cones, cinder cones, lava flows, lava caves, and an unexpected variety of wildflowers, shrubs, trees, and wild mammals and birds. The much larger southern portion of the park—the Craters of the Moon Wilderness Area—is a vast, untraveled region of stark volcanic features flanking the Great Rift Zone. It offers an invitation to the hiker and explorer.

Two challenges face nearly every person who enters the park for the first time: how to recognize and understand the natural features and how to acquire respect and admiration for the land's alien starkness. This booklet is designed to help you meet these challenges. From the geologic beginnings to the ecology of the park's plants and animals, the story of Craters of the Moon is one of discovery and growing wonder.

The Land Nobody Wanted

Washington Irving, the Nineteenth Century writer, pictured this landscape in *The Adventures of Captain Bonneville:* "An area of about 60 miles in diameter, where nothing meets the eye but a desolate and awful waste, where no grass grows nor water runs, and where nothing is to be seen but lava." Irving drew this impression from the diary of U.S. Army Capt. B. L. E. Bonneville, who had explored the region in the early 1800s. No doubt later explorers and settlers reacted much the same. Even the prehistoric Indians did not inhabit the area in large numbers, despite their sharper knowledge of how to survive in it.

Early fur trappers in the West skirted the lava flows along the base of the Pioneer Mountains. There they followed Indian trails that later became a portion of Goodale's Cutoff, an alternative route on the Oregon Trail. Wagon trains carried many early pioneers along Goodale's Cutoff in the 1860s, some bound for Oregon, others for the booming gold rush in Idaho's mountainous terrain to the north.

Everyone avoided the lava flows. Later the surrounding Snake River Plain was grazed extensively by cattle and sheep, and mines were claimed in adjacent mountains. Yet throughout this early period, Craters of the Moon itself was bypassed. It offered no mineral wealth, hunting here was difficult, and grazing was better elsewhere.

Many persons early recognized the special values of the area, and calls were made for its preservation. As a result of the growing effort to preserve the rocks, animals, and plants of this unique area, in 1924 Craters of the Moon National Monument was established by proclamation of President Calvin Coolidge. In 1965 much of the park was designated a Wilderness Area, to be kept roadless and undeveloped. These governmental actions, supported by the care and concern of today's visitors, are helping to preserve the volcanic landscape and its wild animals and plants for future generations. Craters of the Moon is a national treasure that belongs to all of us.

"Is This Petrified Wood?"

Craters of the Moon. Its essence is surprise. Does the Moon's surface look like this? No, but the mood is right. Is this petrified wood strewn about? No, but the lava forms can fool you.

Lava in its various forms is the main material underfoot. Most of it has issued upon the Earth's surface as incandescent molten flows, which have slowly cooled to form extrusive rock. (By contrast, intrusive rock, such as granite, has cooled and hardened deep underground, since it did not ascend to the earth's surface.) The extrusive rock here is a variety called basalt. Fresh basalt lava is dark and heavy and is often honeycombed with small cavities, called vesicles, formed by bubbles of hot gases in the still-liquid lava. During its extrusion, some basaltic rock, containing iron, was oxidized—"rusted"—to an orange-red or purple-red color; and on some of the park's flows, such as North Crater Flow and Blue Dragon Flow, a thin, glassy film gives the lava surface a delightful blue color. These blue basalts are rare among the world's lava flows.

Besides lava flows, much of the basalt at Craters of the Moon accumulated as hills of particles surrounding the lava fountains. During eruptions, gas-charged lava, jetting high into the air, showered back down to build up distinctive hills, or low mountains, called cinder cones. Cinder is a light-reddish or black rock derived from lava that was rapidly cooled while falling through the

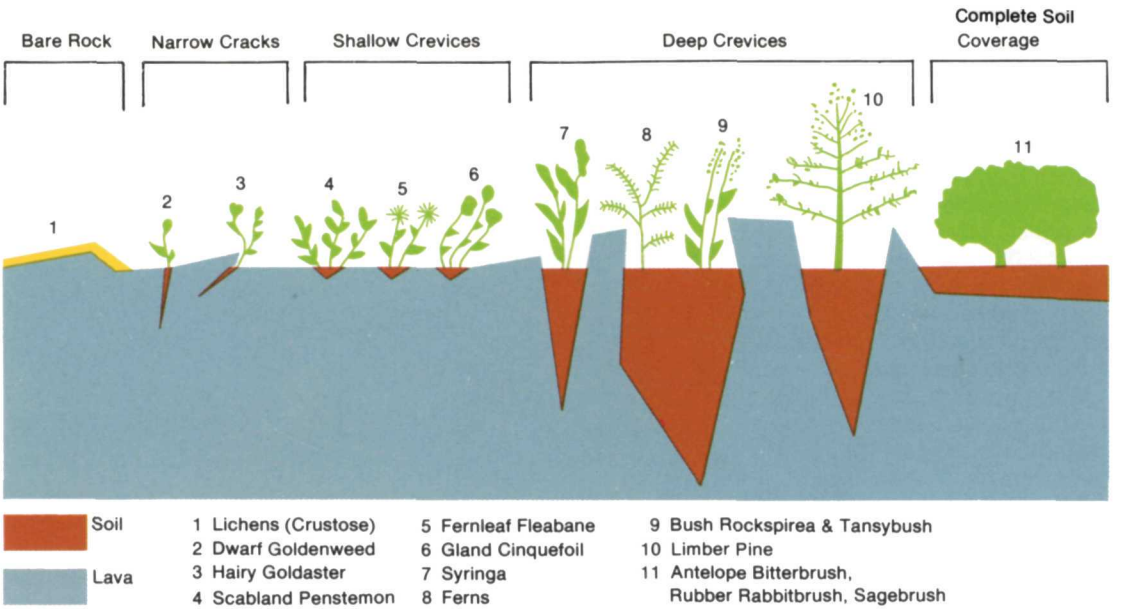
The upper object is lava; the lower is wood.

A paved trail provides access to the spatter cone in the foreground. Big Cinder Butte is in the distance.

air; it is highly porous with gas vesicles. Cinder cones often form early in a volcanic episode, sometimes building to a height of 300 or 400 meters. On the other hand, if the lava becomes less frothy and more tacky, it may be tossed out of the vent as globs or clots of lava paste, called spatter, that partially weld together to build up spatter cones. Spatter cones are typically much smaller than cinder cones.

Some of the lava thrown aloft by fountains solidifies in air and falls on the slopes of cinder cones as volcanic bombs. Many bombs become rounded or spindle-shaped from the smoothing action of their flight, but only rarely do they actually blow up. Breadcrust bombs are an interesting type that expands just enough to fracture the thin crust into segments that remain pasted to a vesicular interior. In this way they come to resemble a loaf of fresh homemade bread. Most volcanic bombs are less than 10 centimeters thick; but large bombs up to one meter thick have been found in the park.

The great majority of cinder cones, spatter cones, and lava flows of Craters of the Moon are aligned along a belt of fissures known as the Great Rift Zone. Also aligned with the belt are elongate depressions called trenches. These are fissures over which tall cones of cinders or spatter did not build. Instead, since the vent was elongate, any spatter that was ejected from the trench accumulated into mounded rims called spatter ramparts. A good place to see well-



formed trenches, together with lava trees, is at Trench Mortar Flat in the northern portion of the Wilderness Area.

Some vents are marked by neither cinder cones nor trenches. Lava from these vents was so fluid that it quietly added layer upon layer to the surrounding plains and finally ceased flowing without having produced a tall cone or open trench. To find the source of these flows, one looks on the horizon for broad, slightly raised elevations whose silhouettes mark the greatest depth of lava. These low-profile vents are called lava cones. Although not conspicuous, lava cones are very important geologically, since most of the lava flows of the Snake River Plain and Craters of the Moon extruded from just such unimpressive volcanoes.

You may be wondering how long ago these eruptions occurred. Is the lava as young as it looks? Because it appears so fresh, some pioneering geologists guessed that its age might be only a few hundred years. Furthermore, Indians reported that their distant ancestors had seen strange fires in the lava flows. Could these prehistoric fires have been volcanic eruptions?

Geologists now doubt it. At least no known flows or cones could have extruded that recently. But in the geologic time frame, all eruptions at Craters of the Moon are recent, and careful radiometric dating has given us some fairly precise ages. Digging beneath fresh-looking *pahoehoe* flows and into the depths of lava

Lava Flow Microhabitats

Both plants that evade drought and resist drought are able to grow in lava flows. Yet, because of differences in microhabitat, each must "choose" a particular place to grow, if it is to survive. Depth of soil and shelter from sun and wind are vital factors in the suitability of each microhabitat. Only when the deep crevices have filled with soil can a complete soil cover and a complete vegetative cover develop.

trees, geologists have collected carbonized roots of plants buried by the lava. By measuring the remaining radioactivity of Carbon 14 (a form of carbon found in all living things), they have been able to determine that the youngest of these flows was extruded about 2,000 years ago—contemporary with the reign of Julius Caesar!

An earlier age estimate made by counting the annual growth rings in an ancient limber pine had yielded 1,650 years as a likely age for one of the fresh flows. Although geologists prefer the 2,000-year age, the estimate from the pine shows that trees soon colonized the new flows.

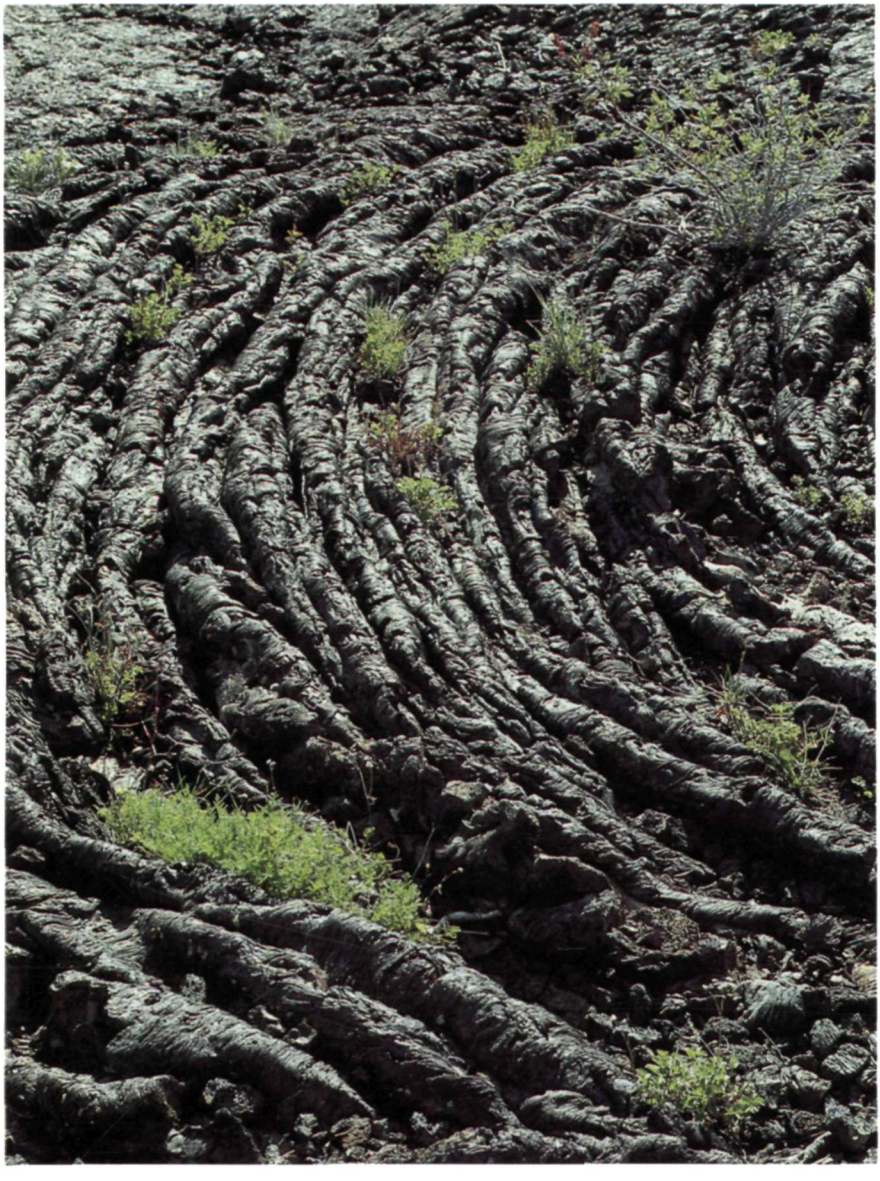
Of course, the flows and cones have various ages. The landscape was not shaped in a single giant cataclysm. The 2,000-year figure may accurately date the youngest but not the oldest eruptions. Flows and cones also suggest their age differences by the amount of vegetation and geologic weathering that has occurred on them, as well as by their place in the sequence of layers (older beneath, covered by younger lava above). Sunset Cone and Grassy Cone, for example, support thick stands of shrubs and trees, and the soil-covered flows at their bases have been weathered reddish. These appear to be relatively old features. By contrast, the Spatter Cone chain and the Blue Dragon Flow are largely devoid of both vegetation and soil, and their surfaces remain fresh and detailed. They rank among the younger volcanic features of the park. *Aa* and *pahoehoe,* however, differ in their aging rates. Some of the older

The Triple Twist Tree is a limber pine, now dead, that can be seen along the North Crater Nature Trail.

aa flows at Craters of the Moon appear to be younger—showing less weathering and vegetation—than the actually younger, well vegetated pahoehoe flows.

Besides the startling youth of the lava, its total volume is also remarkable. One estimate for Craters of the Moon (excluding cinder cones) totals 38 cubic kilometers. Where does so much lava originate in the Earth? Why did volcanoes erupt here recently rather than somewhere else? Although geologists are not yet in agreement on the answers, one line of investigation utilizes the new theories of plate tectonics, a blossoming branch of the geological sciences.

Some geologists now surmise that Craters of the Moon lava came from a depth of scores of kilometers,



These shallow-crevice plants are growing in *pahoehoe*.

originating below the Earth's crust in the upper part of the Earth's mantle, which is about 2,900 kilometers thick and is believed to be rich in iron and magnesium. By composition, basalt is more closely related to mantle rocks than it is to the overlying crust. Since the mantle lies tens of kilometers beneath the surface, some special condition or process must have brought molten material to the surface here in Idaho. That mechanism may have been a mantle plume.

A mantle plume is conceived to be an upwelling of very hot, molten portions of the mantle material. The Hawaiian Islands, themselves immense mid-ocean volcanoes, are believed by many geologists also to emanate from an upwelling plume of mantle material. On the continents, as in Idaho, deep faults or cracks may perforate the overlying crust, allowing the molten rock to ascend. It is theorized that a mantle plume now underlying the region of Yellowstone National Park 270 kilometers to the northeast may once have been positioned beneath the Snake River Plain. In this view, the Snake River Plain is the telltale track left behind from the Yellowstone plume as the drifting continental plate of North America moved across the spot where the plume ascends from the mantle. Thus, while the continent was drifting over the mantle plume, periodic breakthroughs poured out lava flows, first in western Idaho, then in eastern Idaho, then in northwestern Wyoming (Yellowstone), where today's plume-effects include earthquakes. Though it is an intriguing concept, the continental-drift and mantle-plume explanation is still in its formative stages.

Four years' growth of this young limber pine shows above the snow.

Will volcanoes erupt here again? No one knows for sure. But we do know that elsewhere long-dormant volcanoes have unexpectedly awakened, and we know that the Craters of the Moon eruptions are, geologically speaking, brand new. If another eruption were to burst forth today, no one acquainted with volcanoes would be surprised.

Once the volcanoes have erupted, waned, and cooled—what then? How do the volcanic landscape and its wild inhabitants change with the passing years?

Fresh flows are immediately beset by weather and living organisms. In warm, humid climates, basalt lava

weathers down rapidly; by contrast, the dry climate of south-central Idaho works much more slowly, thereby preserving the details of volcanic features much longer. Here lava weathers to soil by unimpressive processes: small chips and grains are broken loose by the expansion of freezing water; surfaces gradually "rust" as oxygen in the air combines with iron in the lava; plants and animals contribute from their bodies acidic matter that slowly etches the rock surface.

Part of the present soil material, however, has blown in from elsewhere on the Snake River Plain. Frequent winds sweep up dust across great distances; the dust particles ride air currents until they settle into the innumerable crevices and pockets of the lava. There the dust combines with particles of lava and organic debris to form a scant soil. Shallow crevices, as in folds of ropy-textured pahoehoe, hold a few centimeters of soil. Smooth lava surfaces are swept clean of soil by daily winds. Only the deep crevices of pahoehoe flows and the myriad pockets in aa flows accumulate much soil, and it is only after these "sinks" have filled up that the general flow surface can accumulate a significant soil cover.

Amount of soil, type of lava flow, and the climate are factors limiting the abundance of lava-flow vegetation. Sparseness of vegetation in turn limits the abundance of animal life able to live in the lava landscape. Thus, plant seedlings that happen to sprout on the fresh lava flows of Craters of the Moon encounter extremes of soil and climate: almost no soil, low annual precipitation, low humidities, drying winds, short growing season, intense summer sun, and bitterly cold winter nights. Lava flows at Craters of the Moon are an inhospitable environment.

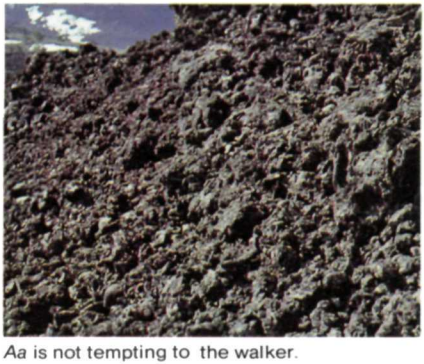
Similarly inhospitable are the slopes of cinder cones. Rainwater and snow melt do not collect in pools in this land, but immediately sink in. Since cinders are full of vesicles and cracks, they are very porous, like dry sponges, and much of the water sinks down too far for plant roots to reach. Some groundwater remains in the near-surface layers of cinders, however, and is available to plant roots throughout the spring. By late June very little water is left at a depth of 15 centimeters. By August there may be no water available even at one meter below the surface! Add to this the harsh directness of sunlight on slopes facing the southern sky, and one can see that plantlife must be especially hardy to live on the cinder cones. And where the plants go, so go the animals that depend on them for food and cover.

Sunken *pahoehoe* near Indian Tunnel

Pahoehoe exhibits a variety of textures.

Pleated *pahoehoe* on Broken Top

Blocky lava.



Aa is not tempting to the walker.

Knowing Your Lavas

Flows of basalt lava at Craters of the Moon, like those of Hawaii and many other Western states, can be grouped into three types, according to their outward appearance.

Pahoehoe, pronounced "pa-hoy-hoy" (Hawaiian for **rope or ropy**) is the park's most common type. It is very fluid when extruded, and being the gassiest lava it is usually accompanied by beautiful, effervescent lava fountains. *Pahoehoe* flows easily and hardens with a relatively smooth surface. It may be billowy, hummocky, or flat, depending on the irregularity and steepness of the land over which it flows. Surface details vary widely, too. Some *pahoehoe* has a texture like tree bark or weathered wood, hence the common inquiry, "Is this rock petrified wood?" (*NO petrified wood has been found in the park.*) Typically, the extruding *pahoehoe* streams along beneath a stiffening, but still plastic, surface crust. This undercurrent motion drags the cooler crust into folds and corrugated surfaces that resemble a jumbled throw rug or a coiled pile of hemp rope. Shelly *pahoehoe* forms when gas bub-

bles larger than vesicles collect just beneath a thin, fragile crust. The feet of curious, unsuspecting visitors who stray from designated pathways can do irreparable damage to shelly *pahoehoe.*

Aa, Pronounced "ah-ah" (Hawaiian for "rough surface") is a form of lava much more rugged than most *pahoehoe.* Its surface is highly irregular, consisting of jagged rubble encrusted with stubby spines. It is often impassable to foot travelers and will tear up a pair of hiking boots in short order. The interior of an *aa* flow is a thick mass of lava. *Aa* is more viscous than *pahoehoe,* and for this reason it usually forms shorter and smaller flows. Because it contains less dissolved gas at the time of its eruption, it usually extrudes without impressive lava fountains. However, terrifying explosions sometimes occur at the vents of *aa* flows.

A few flows at Craters of the Moon are *blocky lava.* These consist of large, smooth-sided, slightly glassy boulders that differ from both *pahoehoe* and *aa.* Sometimes these flows are wholly a mass of angular blocks up to one meter wide; other times they are a bed of blocks riding on a solid core of lava.

Although *pahoehoe* is typically the smoothest lava, it too can produce a rugged terrain. This happens when forces within a flowing lava stream buckle the overlying *pahoehoe* crust into fractured slabs or plates, rather like an ice jam on a winter river. Pressure-ridges—long lanes of such upheaved slabs—may extend for one-half kilometer. Small round or oval pressure ridges perhaps 20 meters wide are called *tumuli.* Sometimes these little hills spout driblets of pahoehoe that was forced up between the slabs of their cracked domes. Rugged *pahoehoe* may also result when a crusted-over lava pool suddenly drains away, leaving its unsupported roof to collapse in a heap of slabs.

Flows of *pahoehoe* distribute their lava to the advancing flow front primarily through subsurface channels called lava tubes. These are rivers of lava with a solid, frozen crust on top; concealed beneath this crust, the lava continues to flow. Downstream, the tubes branch, rebranch, and sometimes rejoin, as the flow front advances. When the feeder vent ceases erupting, some tubes clog with cooling lava and slowly freeze solid. Others, however, drain out, leaving empty lava caves. The cooled interiors of these caves bear flow marks, lava stalactites, lava cascades, and other interesting features. Subsequently, sections of the cave roof may collapse, opening up skylights that let in year-round sun, air, and precipitation. Winter snow and freezing air sift through these skylights and are trapped in the cave by its rock walls (vesicular lava rock is a very good heat insulator). In this way permanent ice deposits can accumulate. These natural ice-boxes, called ice caves, may remain below freezing throughout the hottest months of summer. Indeed, this is a land of extremes: molten lava rivers have helped create perennial ice deposits!

Among the astonishing variety of lava-flow formations are tree molds and lava trees. Tree molds were created when trees of undetermined species were engulfed by liquid lavas that hardened around them without completely burning away their trunks. Eventually the remaining wood and charcoal rotted out, leaving empty, cyclindrical molds where the trees had been. The walls of some tree molds preserve detailed impressions of charred wood. Clearly this was a landscape of living trees during past eruptions. (No animal remains have been found within the lava, but unquestionably wildlife also inhabited the area.) Similar but less detailed tree molds formed when lava spatter, sprayed from certain vents, piled up around the trunks and lower limbs of trees.

A horizontal tree mold

A "lava tree"

The tree trunks have burned or rotted away, but the upright hollows remain, standing .3 to 1.5 meters above the surrounding land. At Craters of the Moon this kind of tree mold is called a lava tree. Charcoal has been found deep within some of the lava trees. Park rangers can direct you to fine examples of both tree molds and lava trees.

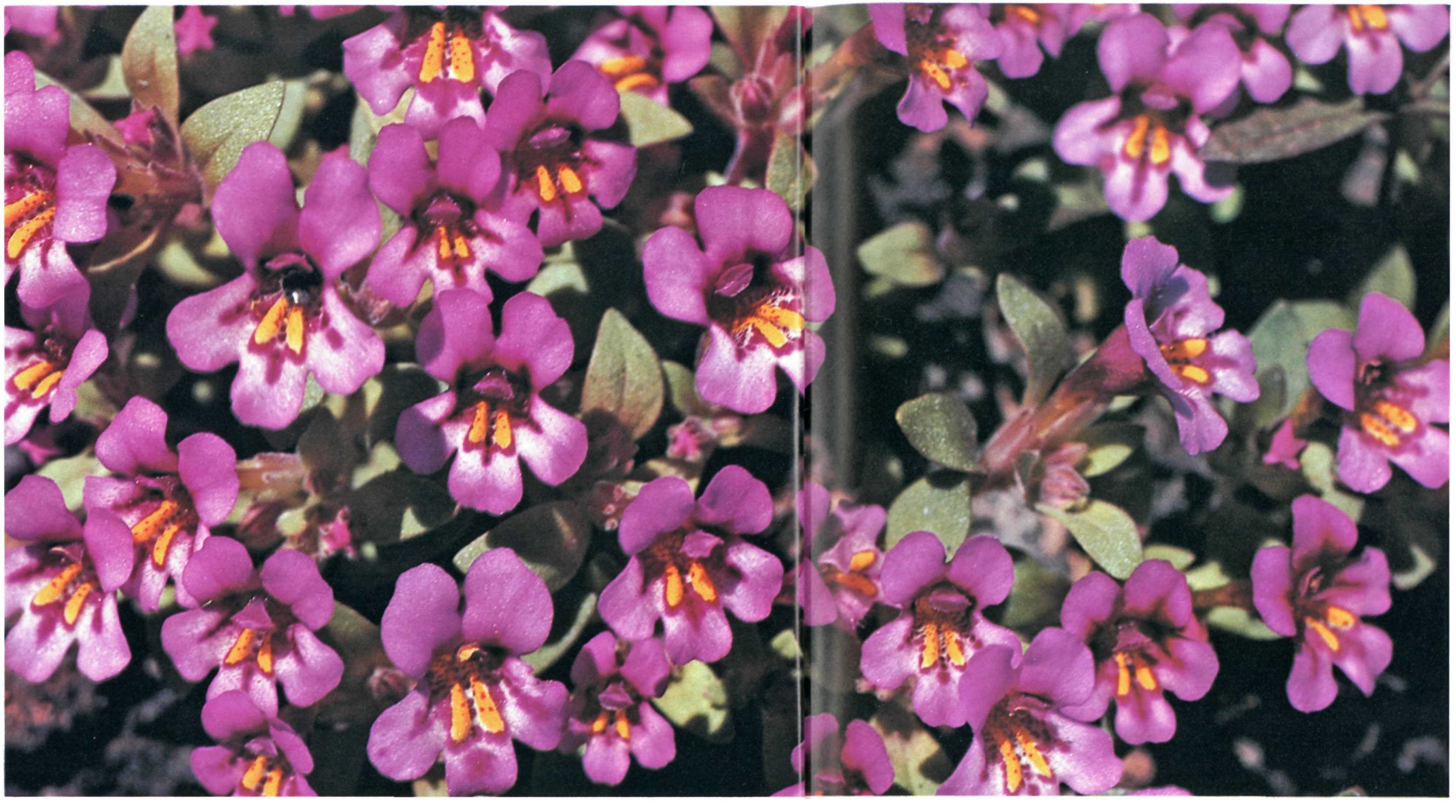
"Does Anything Live Out Here?"

Despite its seeming barrenness, Craters of the Moon is home to a surprising diversity of plants and animals: more than 300 plant species, 20,000 insects, 1 amphibian (the western toad), 6 reptiles, 140 birds, and 26 mammals. For a "barren" landscape, this is an impressive tally! These numbers are derived from a variety of differing habitats, ranging from soilless pahoehoe flows to sun-baked cinder cones to forested slopes of the Pioneer Mountains. In each habitat different species make their homes, thus enriching the diversity of the park. Before looking at the fauna, or animal life, first let us focus on the environmental stresses to which the flora, or plantlife, has adapted in the volcanic landscape.

Winter and summer, nearly constant winds, zephyr-to-gale in strength, sweep through. Prevailing from the southwest, the winds pass across the leaves and needles of plants, carrying away moisture much needed by their tissues. Because the summer air here is hot and very dry, the wind desiccates all living things exposed to it—much more, for example, than in an Eastern deciduous forest or a California redwood grove. We have already seen other environmental stresses on the land: scant soil, low precipitation, the cinder cones' high porosity to rainwater. Much of the world's vegetation could not survive here.

How can certain plants live under these conditions? No one really understands the whole story, for not enough careful study has yet been

The great horned owl, found all across America, is at the top of the food chain in the communities of Craters of the Moon.



There are many species of monkeyflower, some adapted to dry habitats such as the lava beds.

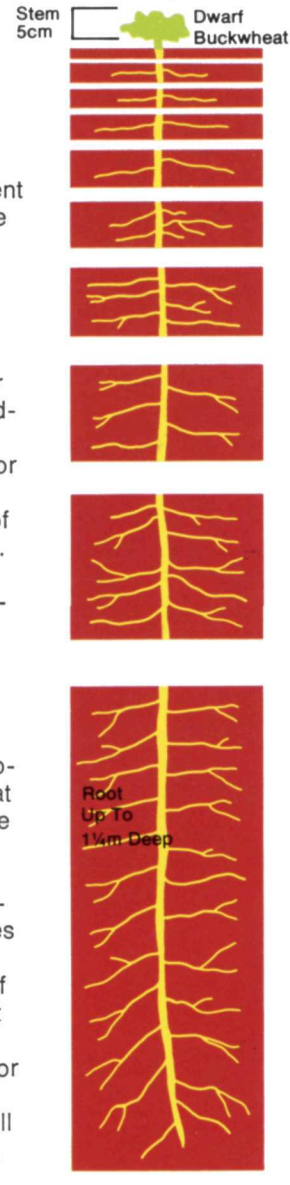
done. It is clear, however, that plants have evolved a variety of adaptations to get along in this demanding environment. In general, we can say that they are adapted either to evade or to resist the extremes of the semi-arid climate; some plants do both.

The evaders, it is fair to say, do not actually live in the semi-arid climate. Instead, they largely avoid it—either by growing only when the conditions are most hospitable or by living in a sheltered site. For example, some evaders, such as the little magenta-flowered mimulus, remain dormant as seeds in the soil until conditions of rain and temperature favor their growth. Then they spring to life, grow, blossom, mature their seeds, and die back, all within a few weeks during which the desert climate is most mild and the soil remains moist—in other words, when desert conditions do not prevail. Evaders of this kind are usually annuals, plants requiring only one growing season to mature and set seed.

Other evaders, the biennials and perennials, retain their leaves and stems through more than one growing season. Many of them grow very long roots that drink up hidden moisture from deep in the soil. Roots almost 1¼ meters long have been discovered on dwarf buckwheat, a common plant of the cinder cones. Its stem and leaves, by contrast, stand less than 5 centimeters tall!

These and other drought evaders often grow rather evenly spaced across the expanses of cinders. Their spacing stimulates many curious persons to inquire, "Who planted those little flowers?" The truth is, they naturally grow that way. One theory that may explain this apparently even spacing points to competition for water: roots from adjacent plants seek out and use up moisture throughout the soil around them. Consequently, a new seed cannot find enough water to survive in the space already occupied by other plants' roots. Scarcity of moisture thus limits the nearness of neighbor plants; it becomes a botanical standoff. This explanation is merely the best guess, however; competition for water in this manner has not been widely confirmed either at Craters of the Moon or in any other dry region. Another theory suggests that poisonous chemicals produced by certain plants can suppress growth of other plants in their immediate neighborhood.

The other typical way to evade extremes is to "choose" where to live. Plants commonly do this by producing copious seeds. We know that many plant seeds never find suitable soil and eventually perish. For example, a seed windblown to a soilless, sunbaked slab of black pahoehoe has no future at all. Neither does one carried by a mouse to the scorched south-facing exposures of a cinder cone—unless it can sprout and rapidly grow deep roots during the period in late spring when rain or snow water is still available. Fortunately, of course, some seeds do fall into soil-filled pockets in lava flows,



This shrub, a Lewis mockorange, is rooted in a deep crevice.

or onto shaded north-facing slopes of cinder cones. Here, in their protected sites, they sprout and flourish, having evaded many of the region's extremes of wind and sun and lack of soil. For example, Douglas-fir and quaking aspen, normally trees of the mountains, are able to grow in a few of the better-protected, well-watered north slopes of cinder cones. Likewise, delicate ferns are able to grow in some of the better-protected lava-flow crevices. Had these plants not "chosen" certain sites, they could not have survived here. Of course, their "choice" was largely a matter of chance.

In contrast to the evaders, the drought resisters are adapted for "toughing it out," whatever the environmental stresses. Succulence, the storing of water reserves in fleshy tissues, is one way of resisting drought. Cacti are famous for this. They are more characteristic, however, of hotter deserts, such as the Sonoran Desert of Arizona; only one kind, the pricklypear cactus, can be found here.

Another means of resisting is to shed leaves whenever drought persists. Sagebrush and bitterbrush, both normally clothed in tiny, three-pointed leaves, stand naked and deadlike after shedding their leaves during an exceptionally dry spell. With renewed moisture, they grow new leaves.

Leaf shedding cuts down the plant's loss of water. Each leaf bears microscopic holes, called stomates, through which air flows in and out of the plant. This exchange of air, like our own breathing, also exchanges moisture, transferring it from the plant's humid interior tissues to the dry outer atmosphere. Some water loss is unavoidable, but anything that limits it may help the plant survive a critically dry period. For example, some plants are able to shut their stomates during the heat of day when water loss is greatest. The park's limber pines, on the other hand, simply grow fewer stomates than other pine species do.

Many scientists have long believed that waxy or sticky coatings on stems and leaves provide a reverse waterproofing, keeping moisture inside the plant. It has also been surmised that leaves noted for downy naps, pale "desert" colors, or diminutive size are specially adapted to limit loss of water from their surfaces. These long-held beliefs about plant adaptations are now being critically reexamined. They may be true of certain plants in certain places, but many exceptions show that one cannot glibly generalize about them. Nonetheless, at Craters of the Moon you *can* find examples of all these features: sticky leaves on tansybush, hairy leaves on scorpionweed, pale leaves on dwarf buckwheat, tiny leaves on sagebrush, plus many other examples. And this area does have a semi-arid climate. Many puzzles of plant adaptation remain unsolved.

A Frozen Fantasy

In view of its incandescent creation and its barren rockiness, this landscape may strike one as alien, unlovable, and "cold"—even in summer at 35°C! This impression can be dispelled by boldness and curiosity, for beautiful color and texture, mystery and grandeur are there if one seeks them.

Consider the variety of colors. The sensitive eye soon perceives red, orange, purple, and rich chocolate where before were only dull cinders. Some of the black cinder particles show a shiny iridescence at close range. The flows stand forth in velvet black, steely gray, or—on the Blue Dragon-type flows—pale-to-rich cobalt blue. Sunsets and sunrises cast deep purplish shadows among hills rimmed by orange, red, and gold. In winter, crisp, clean blue skies backdrop soft white contours of snowy cinder cones, and everywhere the delicate pencilling of pine trees and flow surfaces delight the eye.

Walking upon this land of frozen lava motion, where textures and colors and fragrances and wind-sounds are so new and unfamiliar—here one can rediscover his bonds with the earth. Here one can feel the mystery, the antiquity, the awesomeness of nature—and perhaps gain a little humility.

Plant-and-Animal Communities

Plants are not evenly distributed over the park. They usually grow in associations that reflect varying conditions. Including the wildlife that inhabits them, these plant associations form recognizable communities of living things in which each species has its own niche or ecological role. Let us briefly scan the common associations of plants at Craters of the Moon. These include cinder gardens, lava flows, limber pine stands, sagebrush-grasslands, and Douglas-fir stands.

Cinder gardens. Younger cinder cones and expanses that were showered with cinders typically support a variety of small herbs. Trees, shrubs, and grasses are in the minority. Colorful spring blossoms with their apparently even spacing logically invite comparison to a garden. The best month to see the herbs in blossom is June, before the soil moisture is exhausted. The most abundant species is dwarf buckwheat, with small, pale lemon-to-red pompons radiating outward from silvery leaves held near the cinder surface. The leaves of another common plant, dusty maiden, form a snowflake pattern on the ground during the first year. The plant shoots up and displays pink blossoms during early July of its second year. Scorpionweed, a phacelia, has recurved flower stalks that suggest the tail of a scorpion. Otherwise this plant has nothing to do with scorpions. Bitterroot, the state flower of Montana and once a staple in the diet of many Indian groups, displays its radiant

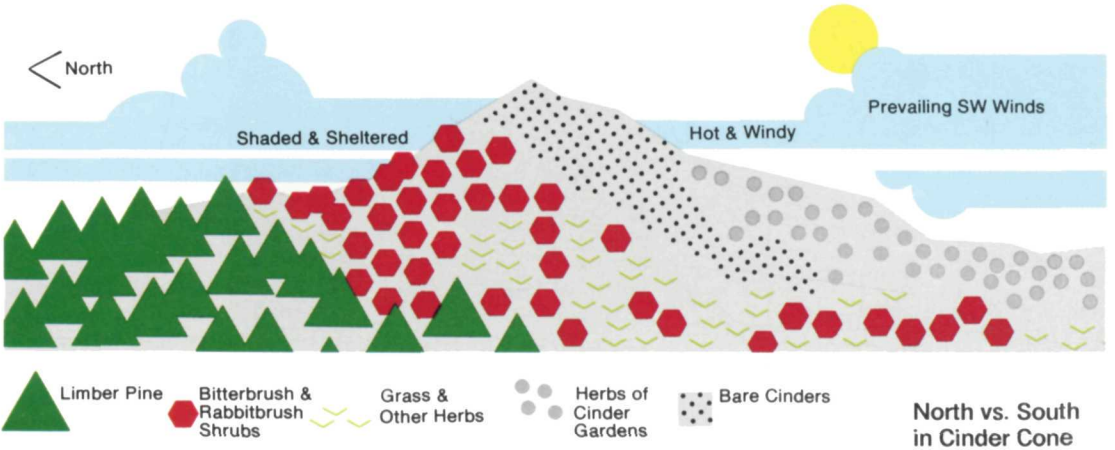
The least chipmunk eats nuts, berries, seeds, mushrooms, insects, and spiders—and in turn is preyed upon by a variety of predators, including owls, weasels, and snakes.

white blossoms after its leaves have begun to shrivel. Bitterroot blossoms are brightly conspicuous against the dark texture of sunlit cinders; at night their tender petals close together. After summer rains, dwarf monkey-flower, or mimulus, carpets the cinder gardens with magenta blossoms. It grows best where dust has settled, as on old roads and pathways where the cinders have been crushed beneath wheels, feet, or hooves. Fine examples of cinder gardens flank the 11-kilometer Loop Drive as it winds around Paisley Cone and Inferno Cone. The trail to the summit of Inferno Cone not only traverses the cinder gardens, but also offers exhilarating views of the park.

Lava flows. Flows have a variety of microhabitats: solid surfaces, thin cracks, shallow crevices, and deep crevices. On solid flow surfaces, only lichens can grow. At Craters of the Moon these are typically crusts of orange, chartreuse, or gray clinging to the rocks. Internally, lichens are a partnership between individual green algae cells and a network of fungus. The algae and fungus share food, water, and shelter; probably neither alone could survive here in the lava. In the narrowest lava cracks, on the other hand, two flowering plants, hairy goldaster and dwarf goldenweed, sometimes gain a roothold. Apparently other plants either cannot force their roots into these thin cracks or cannot obtain sufficient water, air, and minerals within them.

Shallow crevices (up to 60 centimeters deep) are a third microhabitat of lava flows. In them soil is present, but not deep, and supports hardy plants such as gland cinquefoil, fernleaf fleabane, and scabland penstemon. Although rooted in crevices, the stems and leaves of these plants are nonetheless exposed to the rigors of sun and wind. In deep crevices (steep-walled depressions more than 60 centimeters deep) conditions are better. Here the soil is deeper, water-storage is better and—most important—plants are shielded from desiccating sun and wind. The deep-crevice association is characterized by tansybush, bush rockspirea, and Lewis mockorange or syringa (State flower of Idaho). Ferns and herbs also grow here. Normally these plants grow in moist mountain environments; they seem out of place here in the shrub-steppe. Examples of lava flow microhabitats and their characteristic vegetation are well displayed along the trail to the monoliths near North Crater and along the trail to the Caves Area.

Limber pine. This species is scattered throughout the park. Distinguished by a shrubby growth form, yellowish-green needles held in clusters of five, and long, supple limbs, this tree is recognized as one of the hardiest of conifers. It is also one of the slowest growing and least competitive of all conifers. Typically, it grows in places too severe for other trees, as here in the shrub-steppe or at timberline in the mountains. At Craters of the Moon it is the only widespread tree, standing here and there singly, or growing more abundantly on



North vs. South in Cinder Cone Vegetation

Although certain cinder cones are fully vegetated and others almost free of vegetation, most show distinct differences in amount and kind of vegetation on north and south exposures. Wildlife species that depend on the plantlife for food and shelter correspondingly differ.

rugged aa flows. It congregates in lean stands on protected north-facing slopes of cones. On exposed, windblown slopes, limber pines are "flagged"—that is, their branches have been stunted on the side of the tree buffeted by the wind and swept out in the opposite direction. Typically, as in the Devil's Orchard, limber pine is accompanied by antelope bitterbrush, rubber rabbitbrush, grasses, and a few other herbs. Blossoms of the bitterbrush spread their fragrance throughout the park in early June; the odorless, yellow blossoms of rabbitbrush add rich color to the landscape in late summer.

Sagebrush-grassland. Sagebrush and grasses cover both the Snake River Plain and the older flows and cones at Craters of the Moon. Here soils are deepest and best developed. Rabbitbrush, bitterbrush, certain buckwheats, and phlox also occur in this association. The native grasses include bluegrass, wheatgrass, bottlebrush squirreltail, and needlegrass. In disturbed areas, the nonnative cheat-grass dominates.

Broken Top Cone and the nearby trail to the tree molds provide examples of sagebrush-grassland, as do also Grassy Cone and Sunset Cone.

Douglas-fir and quaking aspen stands. Aside from the Pioneer Mountains, only Silent Cone, Grassy Cone, Sunset Cone, and Big Cinder Butte, out of several dozen cones in the park, support stands of Douglas-fir. These stands lie in slightly moister, protected pockets on the leeward, north-facing sides of the cones. Only one cinder cone, Big Cinder Butte, bears extensive groves of the broadleaf quaking aspen. Both species are trees of the moist mountains, reaching the limits of their tolerance for drought here on the cinder cones.

Cinquefoil, related to the wild strawberry, is adapted to existence as a shallow-crevice plant.

Recognize limber pine by its cylindrical cones and needles in bundles of five.

Aspen leaves touch the landscape with gold in autumn.

Wild onion grows on Inferno Cone and other cinder beds.

Thus the landscape at Craters of the Moon is a mosaic composed of basaltic rocks and vegetation. This mosaic, which might seem disordered on first impression, gradually reveals its pattern to us. The ground presents a pattern of recent flows, trenches, and cones along the Great Rift Zone. Depending in part on their age, these volcanic features are to different degrees weathered down, buried by soil, and inhabited by plants. The vegetation, reflecting both the climate and the substrate, forms several distinct associations, as we have just seen.

Any such plant association, with its resident wildlife and the animals that visit it to hunt or forage, makes up a *plant-and-animal community.* Let's take a look at some of the wild animals of these communities.

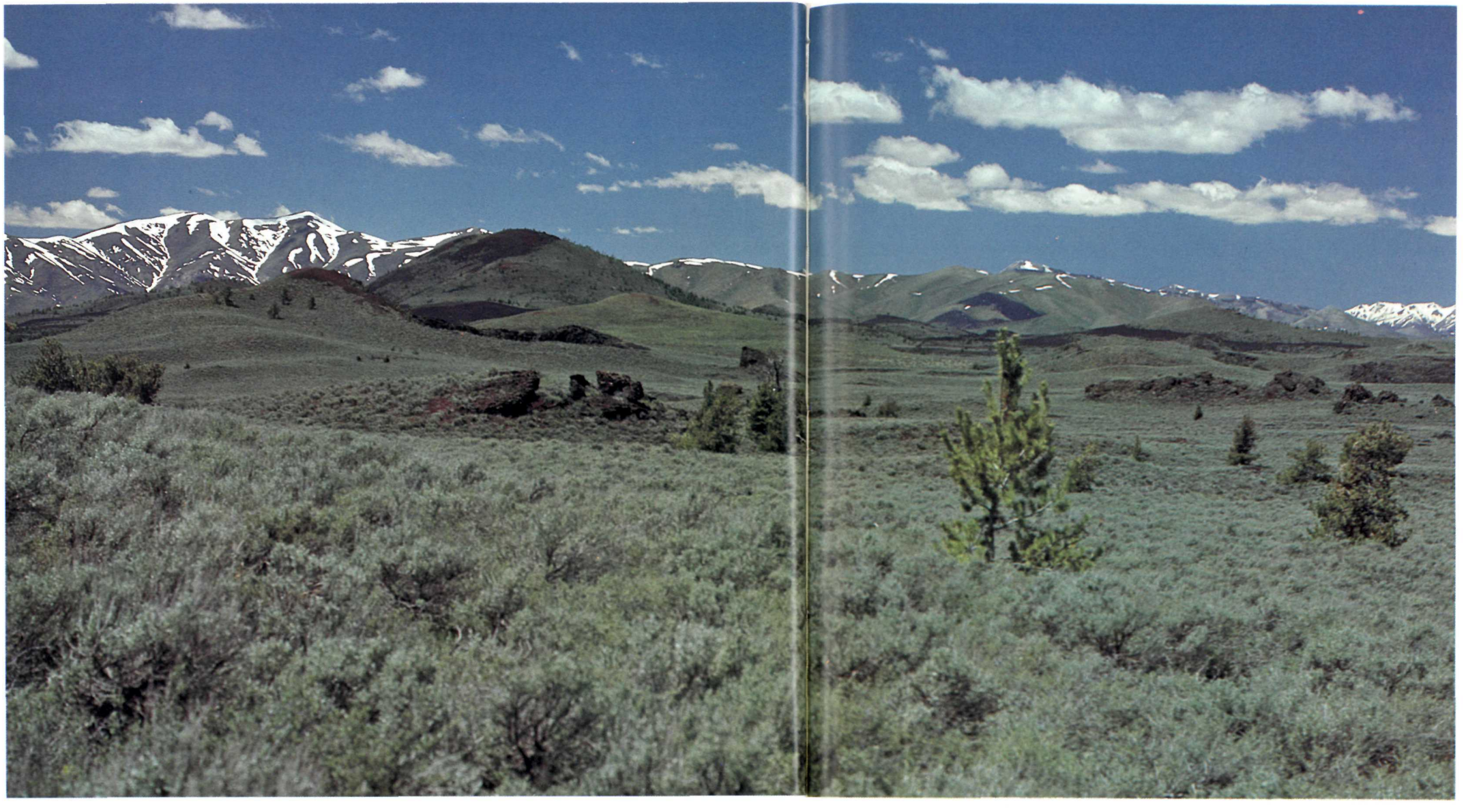
A pika at Devils Orchard harvests bitterbrush leaves.

Lava Flow Community

In the rugged flows of aa and pahoehoe, the grayish-brown rock wren bobs up and down on the rocks as it keeps watch for predators or searches for insects and spiders among rocky recesses. Its sweet song, repeated on different pitches mockingbird-fashion, sounds like "chew, chew, chew, chur-we, chur-we, chur-we, flee, flee, flee" and so on. Stone chips and pebbles carpet the entrance to its nest, concealed within a hole in the basalt. During the heat of summer days it retreats into deep, cool crevices; it is most often observed in morning or evening hours.

Pikas also inhabit the lava flows. These small, "tailless," rabbitlike mammals (about the size of guinea pigs) gather piles of vegetation at their dens as provision for winter. For this they are called "little haymakers." When large predators such as hawks or coyotes approach, the pika warns its neighbors with cries of "aynk." It stays in its den and repeats the alarm frequently as long as the predator is in sight. By contrast, the weasel elicits no warning at all; any sound would give away the pika's location to this animal, which is capable of invading its rockbound home. The lava-beds pika, known only from the Snake River Plain, is the darkest-furred race of pika. Its fur provides camouflage on dark rocks, a protective adaptation also evolved by the lava-beds pocket mouse.

High overhead, the red-tailed hawk rides warm updraft air currents. The



Sagebrush-grassland vegetation clothes older volcanic landscapes where soils are best developed.

hawk surveys the lava landscape for any prey that may expose itself: pikas, rabbits, gopher snakes, chipmunks, ground squirrels, marmots, and others. The hawk, like many desert predators, obtains most or all of its moisture from the flesh of its prey.

Yellow-bellied marmots, or rockchucks, are relatives of the Eastern woodchucks. They live in or near lava outcrops but only where grasses and other herbs provide plentiful food. Largest of the squirrel family, the marmot spends much of the spring and summer gorging itself. It becomes roundly fat; and at the approach of winter, the season of scant food, it crawls into its burrow to enter hibernation. This state of suspended animation—low body temperature, slow breathing, low pulse rate—slowly draws upon its reserves of stored body fat. When hibernation ends in April, the marmot awakes lean and hungry. Eagerly it resumes an active life as part of the lava flow community.

Limber Pine Community

Certain wild animals utilize the seeds of the limber pine as a major source of food. The very common, light- and dark-striped yellow pine chipmunk climbs trees to get the seeds; the similar but larger golden-mantled ground squirrel eats pine seeds that have fallen to the ground. Clark's nutcracker, a gray, white, and black bird with a sizable beak, moves about in flocks during late summer, working the tree tops for pine seeds.

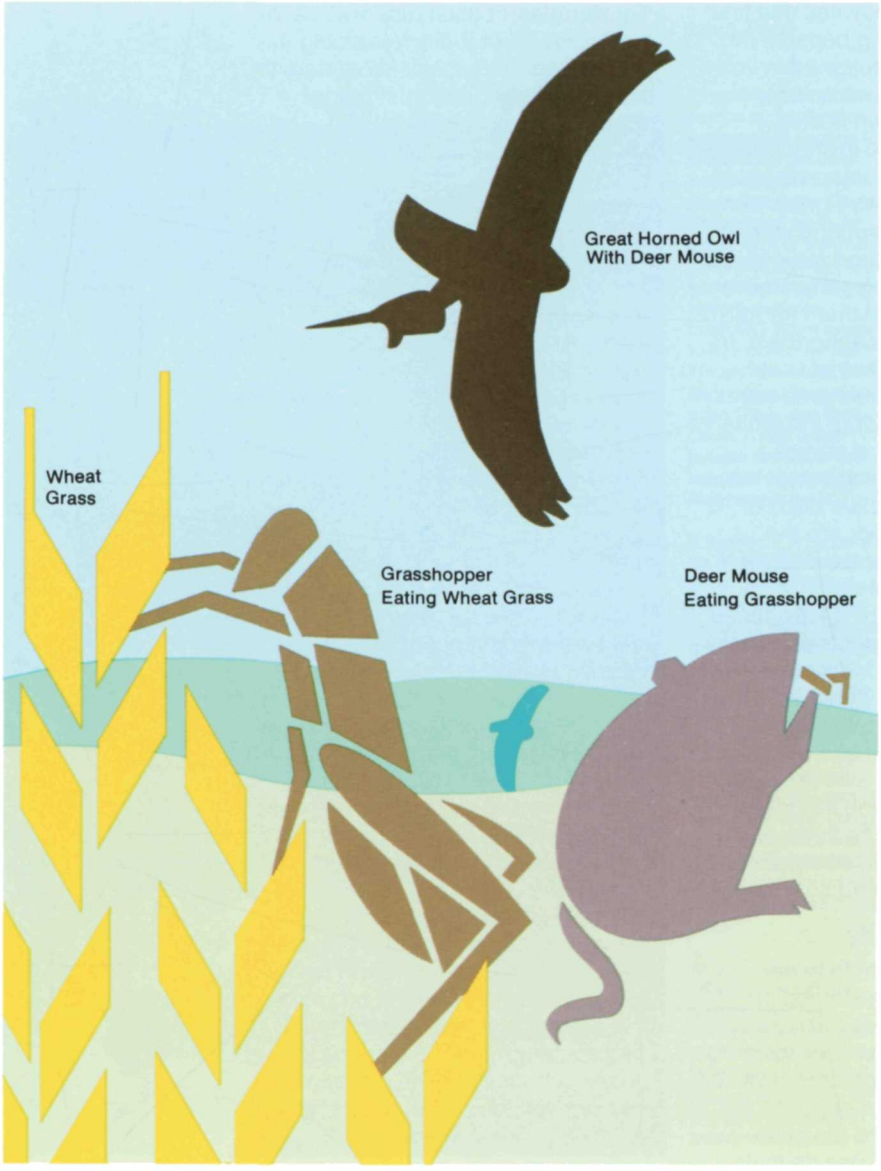
A common summer woodpecker, Lewis' woodpecker, builds its nest in holes in dead pines. It uses the pines as watchposts for flying insects which it catches on the wing—unlike most woodpeckers, which peck holes into bark and wood to obtain their insect food. Lewis' woodpecker and Clark's nutcracker were named in honor of Lewis and Clark, the famous explorers of the American West.

One of the prettiest birds of the park is the mountain bluebird, State bird of Idaho. Males are sky-blue. Though not restricted to any one natural community, the mountain bluebird prizes old woodpecker holes in pine trees as nesting sites. It also nests in crevices near lava tube openings. When winter approaches, it leaves the park.

Sagebrush-grassland Community

The sagebrush-grassland on the older flows and cones grows the greatest amount of plant life and, consequently, the greatest abundance of animal life. Here one occasionally sees the pronghorn (popularly but incorrectly called "antelope"). This handsome, fleet animal of the plains visits Craters of the Moon but does not stay permanently. While in the park, it feeds chiefly on sagebrush and spring herbs. Able to outrun even the coyote on dry ground, adult pronghorns are generally safe from predators except when handicapped by deep snow.

Coyotes, ranging through the sagebrush-grassland, search for rodents, such as voles. Voles are short-tailed, short-eared, mouselike rodents that live wherever sufficient food and cover are available in the



Food Chains

We can recognize food dependencies among shrub-steppe animals and plants. A series of food dependencies is referred to as a food chain. It begins with green plants—which can manufacture their own food by photosynthesis—and proceeds through plant-eating animals and flesh-eating animals. One food chain at Craters of the Moon is: wheatgrass → grasshopper → deer mouse → great horned owl.

Since diets are varied, each species takes part in several food chains. Thus each food chain interconnects with many other food chains. The result is a complex of interdependencies among species that we call a food web. The term is a comparison to the interconnectedness of all parts in a spider's web. Descriptions, drawings, and photographs cannot reveal the total complexity of the food web; in fact, ecologists are still discovering many of the strands and links in this amazing network of nature.

park. Even in winter coyotes can find voles actively tunneling beneath the snow blanket. Also interested in voles are the gray marsh hawk and the multi-colored American kestrel ("sparrow hawk"). The former cruises low over shrubs and rocks; the latter scans the sagebrush and grass from atop a fence post, telephone wire, or tree branch. Voles reproduce prolifically; coyotes, hawks, and other predators have hunted them for milleniums without eradicating them. In fact, when man does not interfere, predator and prey populations usually adjust so that both endure indefinitely.

The sage grouse, the size of a small turkey, and the sage thrasher, a fine singer, are distinctive birds of this community. So, too, are the green-tailed towhee and the Brewer sparrow, both seedeaters. The chukar, a wary game bird introduced from Europe, now flourishes on rocky slopes of the Pioneer Mountains.

An exciting sight in summer is the golden eagle, largest avian predator of the park. Seen against a blue sky, its majestic wings are awe-inspiring. In soaring flight from the Pioneer Mountains it crosses the flows and cones of the Great Rift, where it searches for food to feed its young.

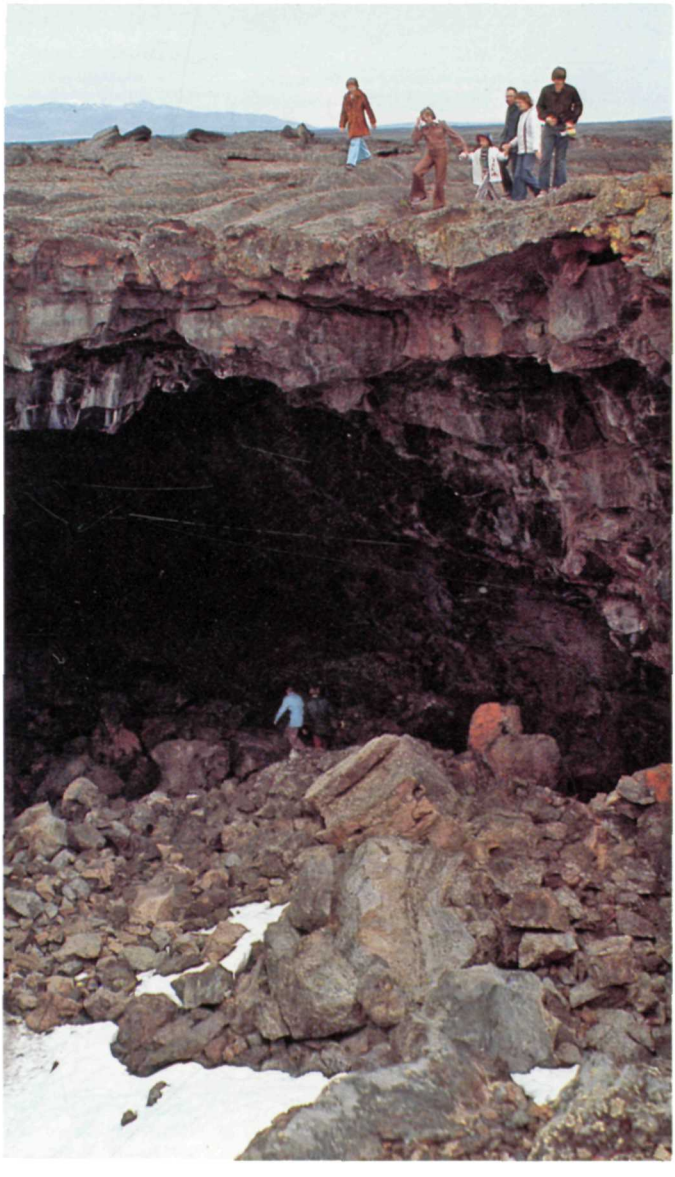
Douglas-fir Community

Examples of this community are limited to north-facing slopes. In them one may see birds such as chickadees, red-breasted nuthatches, brown creepers, and golden-crowned kinglets. Here one also sees the red squirrel and sometimes the quill-bristling porcupine. These animals, like Douglas-fir itself, are atypical of the Snake River Plain. We would expect to find them many kilometers to the north among Idaho's interior mountains.

Lava Tubes

When pahoehoe lava erupted, it was distributed to the leading margins of the flow by crusted-over lava streams. When the molten lava drained away, empty corridors, called lava tubes, were left. Today the lava tubes provide shelter to some interesting wild creatures. In winter, rosy finches retreat to the caves to roost, thereby avoiding winter storms. In summer, violet-green swallows, Say's phoebes, and mountain bluebirds build nests in protected recesses near the cave openings. The great horned owl roosts year-round in certain caves. Bushytail woodrats also inhabit the lava tubes, finding shelter from weather and refuge from predators.

The most astonishing cave creature is a blind cave insect, the Idaho lava tube beetle. First discovered in a lava tube on the Snake River Plain in 1965, it was later found in lava tubes at Craters of the Moon. This eyeless, reddish-brown insect, about six millimeters long, lives only in the darkness of lava tubes. Its origin and distribution are a mystery. How many centuries has it lived in these caves? How does it find its way from older caves into distant new caves following fresh eruptions? How does it find food—without eyes—in caves where seemingly nothing else lives or grows? Nature has many mysteries.



Exploring a *Lava Tube*

Exploring a lava tube can be an exciting adventure; but caution is required. A group of easily accessible lava tubes lies in the Caves Area, about one kilometer east of Inferno Cone just off the 11-kilometer Loop Drive. Here a walk across fresh lava flows leads to five caves: Indian Tunnel, Dewdrop Cave, Boy Scout Cave, Surprise Cave, and Beauty Cave. These tubes helped distribute the lava that erupted from a nearby lava cone.

A flashlight is required for all lava tube exploration, except in Indian Tunnel where natural skylights illuminate the floors and walls. A light jacket is comfortable inside these cool passageways. Since slippery ice is common in lava tubes, even in summer, in order to avoid a fall you should take great care. Loose rocks underfoot and low ceilings with sharp projections are additional hazards to the unwary.

As you descend into a lava tube, watch for nesting swallows, phoebes, and bluebirds near the opening. White urine deposits or piles of sticks may betray the habitation of a bushy-tailed woodrat.

Notice that wherever ample light reaches the walls, lichens paint vast swaths and streamers of orange and chartreuse on the rocks.

Once inside the caves, imagine the great orange-hot river of liquid lava that drained away to create the empty tube. Notice flow marks on the walls that record temporary levels in the subsiding lava stream. Beam your light to the ceiling where dripping lava often hardened into short lava stalactites, or "lava-cicles". Except where rocks, called breakdown, have collapsed from the ceilings, your path is the hardened surface of *pahoehoe* or *aa*. Their textures—ropy or clinkery—are the same as aboveground.

Caves are always places of mystery and wonder. Dark, echoing, aromatic with dampness and woodrat odors, crusted with ice, tinted with orange, chartreuse, brown, and bluish-gray—the lava tubes are always exciting to explore.

Mule deer

Golden-mantled ground squirrel

Yellow-bellied marmot

Clark's nutcracker

Watching Wildlife

The best times of day to see most wildlife are early morning—one hour before sunrise until two hours after sunrise; and evening—up to three hours after sunset. Try a leisurely drive around the 11-kilometer loop road, or follow the trails leading to North Crater, Devil's Orchard, and the tree molds area; and into the Wilderness Area. If you go on foot, make stops of 15-30 minutes for silent observation. During these times, stand or sit quietly; make no rapid movements or disturbing sounds.

Binoculars are a great help in "getting close" to wildlife.

Deer: Watch for them around Paisley, Inferno, and Broken Top Cones. Since they follow well-worn paths through the cinder gardens, waiting near one of these is a good way to spot them.

Pikas: Though secretive, pikas are frequently seen or heard in the lava flow along the Devil's Orchard Trail.

Chipmunks: Watch for them around the campground and among limber pines throughout the park.

Golden-mantled ground squirrels: See them most often in the campground area. *Do*

Prairie falcon

not feed any wild animals, as this disrupts the diet to which they are adapted.

Yellow-bellied marmots. Visitors see these large rodents among rocks along the highway into the park and along the edges of lava flows elsewhere in the park where green vegetable food is abundant.

Black-billed magpies: Small flocks of these daytime birds are observed during almost every visit to the park. White and black, with an extra-long tail, the magpie is unmistakable. Typically it scolds intruders with jaylike chatter, but during the nesting season it becomes conspicuously silent and secretive. It enjoys almost any animal food it can find, from insects to birds' eggs to carrion.

Clark's nutcrackers: Ranging throughout the park, these birds will be found among pines. Watch for them near the campground.

Rock wrens: Quietly stroll on the Devil's Orchard Trail in morning and evening hours, listening for its song.

Hawks: Watch the skies for soaring golden eagles and red-tailed hawks. Kestrels will most often be spotted perched near grassy or shrubby areas, while marsh hawks can be glimpsed skimming low

Rock wren

Deer mouse

Kestrel

Mountain bluebird

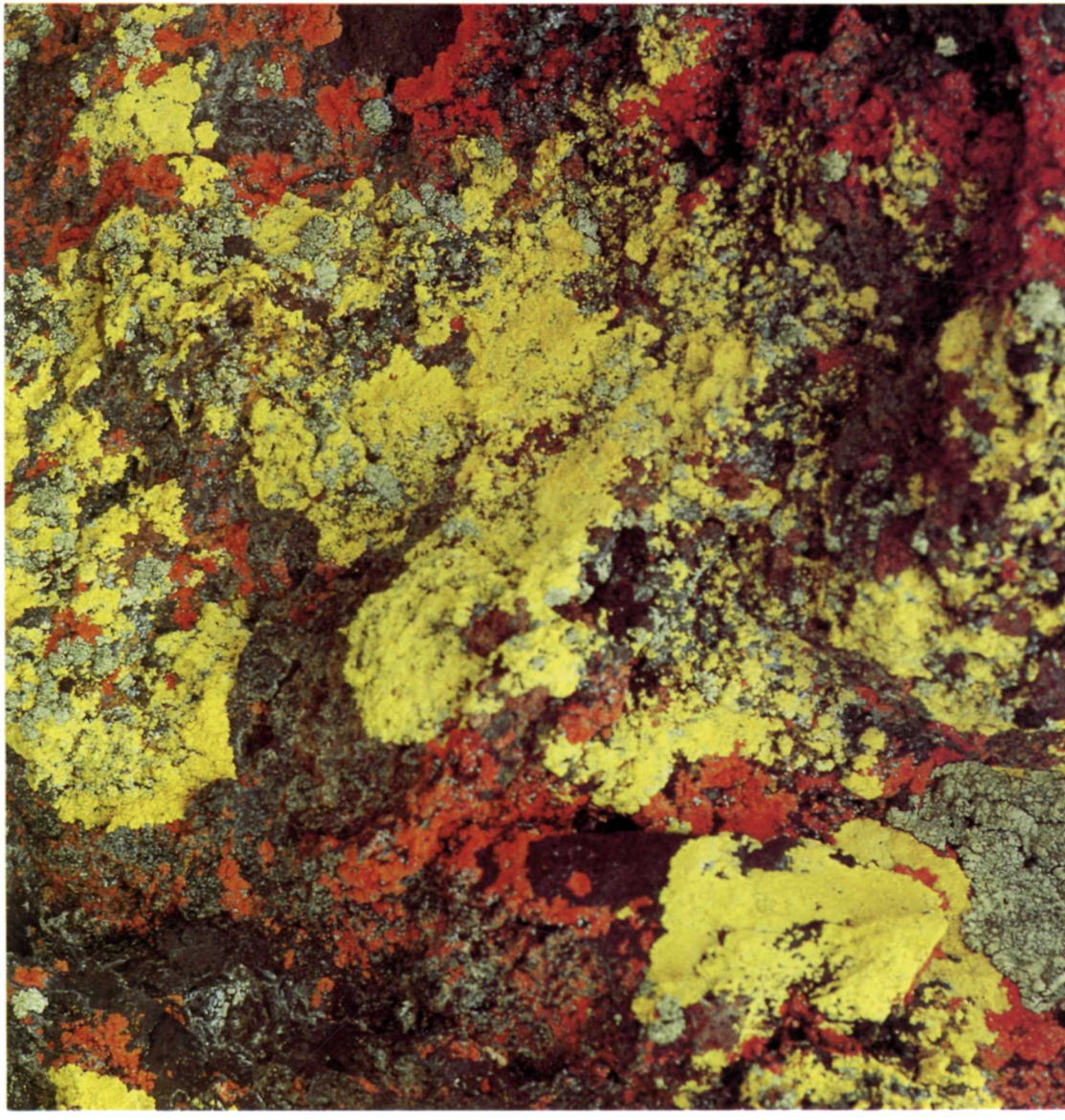
over the tops of sagebrush and other shrubs.

Nocturnal Wildlife: Wait patiently in a quiet spot at night. Keep a flashlight by your side, shining it only when sound or motion draws your attention in a particular direction. Insects, white-footed mice, pocket mice, voles, weasels, snakes, coyotes, bobcats, and deer may sometimes be observed in their nightly activities.

When photographing in the lava, be careful about proper exposures. If you want lava details in scenes containing both sky and ground, take meter readings off the lava only. At certain angles, lava has strong highlights, despite its overall dark color.

For wildlife photography in twilight illumination, high speed film is recommended. With 35-mm camera, a lens of 100-500 millimeters focal length is very useful for wary wildlife. Use a tripod to minimize camera movement (remember that breeziness is prevalent in the park). In wildlife photography, patience is as important as equipment and skill.

Bobcat



The Succession Story

Ecologists now know that plant associations and the substrates they grow upon follow orderly patterns of change through time. Consider for a moment that the basalt lava flows, when they were freshly extruded, were at first barren. It becomes obvious that plants subsequently must have colonized them. Yet today we find that older flows bear plant associations different from those of younger flows. The process by which vegetation initially colonizes fresh lava and then changes through time is called *natural succession.*

Defined, succession is the orderly stage-by-stage replacement of one plant association by another, caused by modifications that each association helps bring about in its environment. In short, given enough time each plant association assists its own eventual decline and replacement by another association.

What are the patterns of ecological succession at Craters of the Moon? Since cinder cones and lava flows differ considerably, it is not surprising that their initial plant associations also differ. It is surprising, however, that their plant species become more and more similar through time, until on the oldest flows and oldest cones the associations come to be nearly identical.

On fresh lava flows, development of soil is the key to plant succession. The first, or pioneer, plants may colonize in any of the microhabitats mentioned above. Lichens are not the only plants to colonize bare rock in volcanic areas. It is believed that other plants play a more important

Crustose lichens colonize bare rock, thus beginning the process of natural succession in a new landscape.

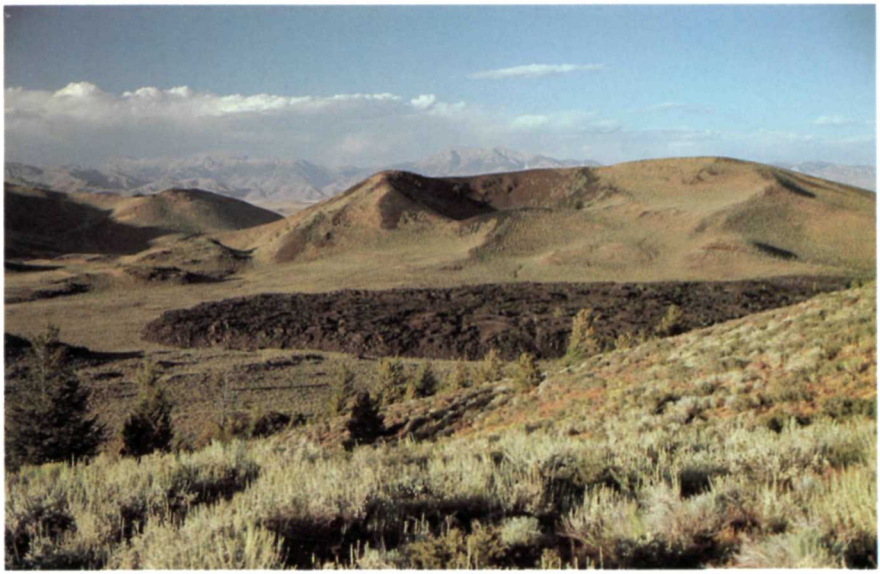
role in soil building and succession than do the lichens, especially in arid regions such as Craters of the Moon. On bare lavas, natural succession is nearly at a standstill. Likewise, in the narrow-crack microhabitat the hairy goldasters and dwarf goldenweeds contribute little to soil formation. Even in the shallow-crevice microhabitat, where some windblown dust collects, relatively few plants flourish and most of the dead matter from the sparse vegetation is blown away to be trapped in deeper crevices. It is, therefore, primarily in the wind-deposited soils of the deep crevices that important lava-flow succession proceeds.

Within the deep-crevice microhabitat, plants such as tansybush, Lewis mockorange, and bush rock-*spirea find protection from direct* wind and sun. Dead leaves and stems from these plants, plus debris blown in from the other microhabitats, contribute decomposed organic matter, or humus, to the windblown dust trapped by the crevice. This mixture forms a fertile soil. Gradually the soil fills up the crevice. Ironically, this decreases the protection from wind and sun, creating conditions resembling those of the shallow-crevice microhabitat. As the original deep-crevice species (mostly drought evaders) dwindle, they are succeeded by drought resisters, such as sagebrush and rabbitbrush. The new plants, more tolerant of the increased exposure to wind and sun, flourish in the deep soil of the deep crevices.

As the new plants—many of them shrubs—gain height, their own dead leaves, plus windblown soil, collect around them. When all the lava-flow crevices are filled with soil, wide expanses of lava flow can then gather a layer of soil in which the drought resisters may flourish. Extensive tracts of sagebrush-grassland appear. Thus, the pattern of succession has proceeded from deep crevice evaders to shallow-crevice resisters to sagebrush-grassland.

On cinder cones, succession begins differently. The pioneer plants on bare cinders are the herbs mentioned earlier for the cinder-garden association: dwarf buckwheat, mimulus, dusty maiden, bitterroot, giant wildrye, and others. On the north-facing cinder slopes, water from lingering snow banks, greater shade, and shelter from winds favor gradual

Rabbitbrush, a drought-resistant plant, can grow in exposed situations if its roots are in a soil-filled deep crevice.



A variety of habitats is visible in this view. Note the trees in the crater of Sunset Cone.

replacement of these pioneer herbs by a limber pine-bitterbrush association. Once pines and shrubs are established, organic matter gradually accumulates beneath them. This, plus windblown dust, increases the water-holding capacity of the north-slope cinders. Under the best conditions, Douglas-fir can replace and dominate the pine; under extended drought, sagebrush and grasses will succeed the pine and bitterbrush.

Around on the south-facing cinder slopes, an association dominated by bitterbrush (antelope brush) succeeds the pioneer herb gardens as the soil slowly builds there. Pines are sparse. By growing rapidly upward, bitterbrush can withstand partial burial by wind-drifted cinders. Its upreaching branches intercept dust particles, thus gradually adding to a soil favorable to the next plant association, which is dominated by sagebrush and grass.

Bitterbrush improves the soil also by helping to add nitrogen. Small knobs on its roots contain bacteria. These microscopic organisms have the ability, which flowering plants lack, to remove nitrogen gas from the air. They fix the gas into usable nitrogen compounds that eventually become available to plant roots. Plants such as sagebrush can then absorb the nitrogen compounds, which are a natural fertilizer, or nutrient.

Eventually, as erosion levels out steep slopes and the soil matures, a sagebrush-grassland covers the cinders. Thus, over most of the cone's

surface, succession has proceeded from cinder-garden herbs to bitterbrush and pine and then to sagebrush-grassland.

Beginning with very different substrates supporting different pioneer plants, lava flows and cinder cones have proceeded from one stage of succession to another until, converging, they have both developed a sagebrush-grassland association. Ecologists believe that this final stage is a stable, long-lasting one that will not significantly change unless Idaho's climate changes or wildfire or humans intervene. It is called a climax association: the end of the line, so to speak, for succession in this region and under this climate.

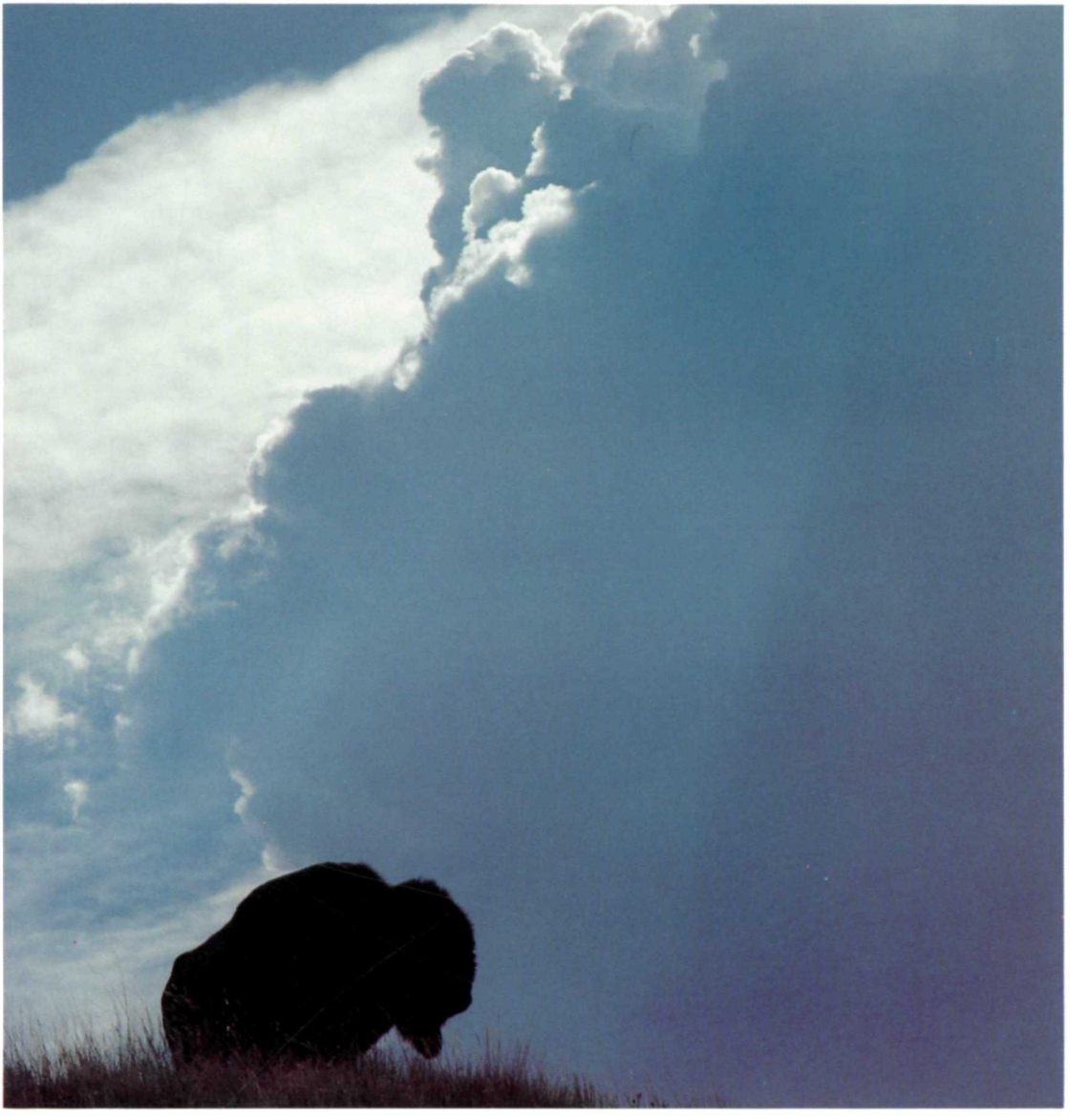
Of course, humans and their domestic animals have intervened greatly in the Snake River Plain. Burning, grazing, and plowing have removed the successional climax in many areas. Fortunately, a few isolated kipukas, or "islands," in the lava flows were neither inundated by the most recent eruptions nor disrupted by humans. One of these, Carey Kipuka, lying within a remote corner of the park, clearly preserves the regional climax. Apparently this kipuka has existed here for thousands of years without suffering much disturbance. Its climax association is sagebrush, various grasses, and other less common plant species. It is one of the rare standards with which ecologists can compare the whole process of plant succession at Craters of the Moon.

The plant community of Carey Kipuka is a valuable resource for ecological research.

Adaptation for Summer Survival

During the day, human visitors to the park respond to high temperatures by sweating. Perspiration cools their bodies by drawing away excess heat in the process of evaporation. In contrast, the small wild animals of the park, such as mice, cannot sweat to cool themselves. Because they have small body volumes in relation to their surface area, their bodies contain too little water to permit the luxury of sweating. Furthermore, they usually live far from water and would not be able to replace the moisture they would lose as perspiration. Only larger creatures such as humans can afford to evaporate water from their bodies to avoid heat prostration and death. Yet even sweating may not be enough, and many desert animals use other means—such as nocturnal habits—to help maintain favorable body temperature.

The coyote does not sweat but cools by panting. The longtail weasel is a nocturnal animal.



"Did Indians Ever Hunt Here?"

The answer is, "Yes." The land could not support large numbers of the native people; therefore, only small groups penetrated the lava flows along the Great Rift Zone. Evidence of Northern Shoshoni culture has been discovered at many archeological sites. Goodale's Cutoff of the Oregon Trail followed Indian trails through the park. Arrowheads and the small chips of waste rock produced during their fashioning, as well as hammerstones, choppers, scrapers, and bits of pottery, are widely dispersed in the park. Open campsites located, for protection from wind, in the lee of cones and slopes, were supplemented by stone windbreaks at the mouths of lava tubes and by stone hunting blinds overlooking game trails. In addition, these stone-age people quarried basalt and volcanic glass from eroded crater walls for making stone implements. Most of this archeological evidence is hidden to the undiscerning eye, but the stone windbreaks at Indian Tunnel are easily examined.

Use of native stone for tools and shelter; use of lava flow waterholes for water; gathering of berries, seeds, and roots from wild plants and the hunting of wild game for food—all these are adaptations of the Northern Shoshoni to the volcanic ecosystem. These people were directly dependent upon what nature offered, without reliance on the technology that transports, feeds, clothes, and amuses people in our own time.

The very earliest Indians in Idaho saw, and no doubt hunted, certain wild animals that vanished before the

first white explorers had arrived. These prehistoric species disappeared as the great Ice Age waned in North America and the climate warmed, and they were probably extinct before the volcanoes at Craters of the Moon began to erupt. They included strange camels, sloths, giant cats, and wild horses. (The horses ridden so expertly by Indians of the Great Plains in historic times were descended from horses brought to the New World by Europeans.)

Indians also hunted certain big game species that, although known to early frontiersmen, are rare or absent from Craters of the Moon today: wapiti ("elk"), bison, grizzly and black bear, cougar. Whether the white man's intrusion is solely to blame for their decline may never be known, but certainly the coming of miners, stockmen, and farmers did nothing to encourage these species. The black bear and cougar may still stray into the lava flows from the nearby mountains, and wapiti also infrequently enter the northern portion of the park.

One species absent from the park since the second decade of this century is the bighorn. Also called mountain sheep, it is known to most of us by the large, curled horns of the male. Handsome and surefooted, these mammals may someday be restored to the park by introducing individuals captured elsewhere.

"Tepee circles" can be seen at Indian Tunnel.

Winter, the Critical Season

A visit to Craters of the Moon in summer gives no hint of the wind, snow, and cold that will transform the volcanic landscape.

When winter approaches, wild animals have three options: migrate, tolerate, or hibernate. Those animals that migrate, including the mule deer and most of the birds, seek a more congenial environment elsewhere. Deer migrate 30 kilometers; some birds migrate thousands of kilometers to the tropics.

Although low temperatures might seem the most obvious reason for animal migration, food is usually more important. Insect food is scarce, and seeds and fruits are usually absent or buried by snow. Yet the actual motivation, or trigger, that sets animals moving is neither cold nor hunger but *photoperiod* (duration of daylight). As days become shorter, the animals begin to migrate, whether or not they are cold or hungry.

Of the creatures that do not migrate, many either hibernate or go into a deep sleep. They burrow into soil or enter rocks and caves, there to become torpid during the cold, foodless winter months. In this state of inactivity their bodies require little nourishment. This group includes the western toad, gopher snake, rattlesnake, pocket mouse, chipmunk, ground squirrel, and marmot. One bird, the poorwill, is known to hibernate in the desert Southwest. It is not known whether, at Craters of the Moon, it hibernates in the shrub-steppe or migrates to warmer climates where insect food remains available.

Some animals can tolerate winter conditions. Just as in summer, many of these have nocturnal habits. Thus, after a fresh snowfall, the morning light illuminates the delicate tracks of the hunters and the hunted: deer mice, weasels, cottontail rabbits, snowshoe hares, jackrabbits, coyotes, bobcats. Voles continue to chew plant stems along the tunnels they have excavated beneath the snow. Pikas in their rocky dens nibble at the haystacks they gathered in summer. A few birds, such as the great horned owl, the magpie, and the horned lark, carry on with their roles in the volcanic ecosystem all year long. An exhilarating snowshoe hike or cross-country ski tour can reveal these animals to you.

Clearly, the "barren, lifeless" landscape of Craters of the Moon is neither barren nor lifeless. It appears desolate and alien only to those of us who do not know it intimately.

Under Cover of Night

Just before sunset, a pale, near-full moon floats onto the eastern horizon. In the deepening twilight, while the planet Venus gleams in the southwestern sky, the lunar face shines brighter and brighter. A mule deer doe, turning her large gray ears to the north, catches faint voices from the park campground beyond expanses of purple lava. A breath of soft air from the Pioneer Mountains settles down across the flows and cones and caresses the heat-weary summer landscape.

During the day the doe lay quietly in the shade of pines and shrubs. As with most animals of the shrub-steppe community, the dazzling heat and dry winds of midday are for her a hazard. The night is a refuge from heat, as well as a screen shielding her from sharp-eyed predators.

Now the doe is thirsty. Isolated pockets of water in the lava flows, however, do not interest her; tonight she and other deer will follow familiar paths northward to the mouth of Little Cottonwood Creek, almost ten kilometers away. There she will drink enough to sustain her for another day or two. Then she will return to Big Cinder Butte, nibbling leaves of bitterbrush along the way.

Through the cinder gardens the doe follows a powdery, well used path up an easy grade. She instinctively watches for predators — although cougars were long ago eradicated by man, and bobcats and coyotes are rarely dangerous to a healthy adult deer.

She pauses briefly. A large, black, smooth-shelled beetle, the tumblebug, appears on the path. At the deer's approach, the beetle stands on its head defensively, emitting a disagreeable odor from its abdomen. Then, sensing no danger, it stiffly ambles off the path to continue its search for soft plant food. High overhead an occasional bat flutters by, detecting twilight insects with its ultrasonic squeaks. The search for food also preoccupies a lone poor-will, a soft-feathered bird of the night whose gaping mouth scoops up flying insects during the bird's short, near-ground aerial maneuvers. Later, camouflaged by its plumage on the dry earth, the resting bird will speak its name in unforgettable notes: "poor-will, poor-will-it!"

At the edge of the cinder gardens, the mule deer steps onto the hard surface of a pahoehoe flow. The flat-lying rocks hold countless gas pockets and fractures where animals can hide by day. Crevices in the basalt support plants that the animals eat. On a rough ledge near the path, white urine deposits and a chaotic pile of sticks and pine cones betray the haunts of a bushytail woodrat. When the doe has passed by, the hiding woodrat reappears atop its sticks and resumes eating a juicy plant stem. Unlike many desert rodents, the woodrat requires a reliable water source or a good supply of juicy plant food for its survival.

A lava-beds pocket mouse bounds across the deer's path. It seeks neither water nor juicy food; its nightly goal is largely dry seeds, upon which it survives by its unusual ability to conserve its internal moisture. Like desert life in general, as well as humans, the pocket mouse produces water and carbon dioxide as waste products from the food it eats. But whereas with each breath it rids itself of the carbon dioxide, it retains as much of its body water as possible. Its urine—usually a major loss of water among mammals—is highly concentrated, thus expending a minimum of body moisture. Its droppings are dry; it never sweats; and it reduces general body evaporation by staying deep in its cool burrow during the day. Only after the sun has set does it venture forth to gather seeds in its fur-lined external cheek pouches.

One of the chief predators of the pocket mouse is the shorttail weasel. This nocturnal carnivore is fast, agile, and small enough to pursue its prey into holes in the rocks. Of the pocket mouse, the deer detects only a quick movement, for like some other animals of the volcanic landscape the lava-beds pocket mouse wears the darkest fur of its tribe—nearly black—which helps it to hide among the basalt rocks, especially at night. Its close relatives living on light-colored ground have buffy or tan fur.

On the slopes of Silent Cone, the doe pauses to nibble bitterbrush leaves. As she rests, she hears a rustle in a nearby bush. In the moonlight a deer mouse has run along a branch and, finding a roosting grasshopper, has seized it, only to lose its footing and fall with its prey to the sandy, cindery ground below. There the little predator chews up the insect.

Brown on top and white beneath, this diminutive, long-tailed, bright-eyed creature, the most abundant wild mammal in North America, is common throughout the park. It eats seeds and other plant parts, as well as insects. Sometimes, as the deer has witnessed, it climbs shrubs in its search for food. This night it is unlucky, for its tumble from the bush has been picked up by

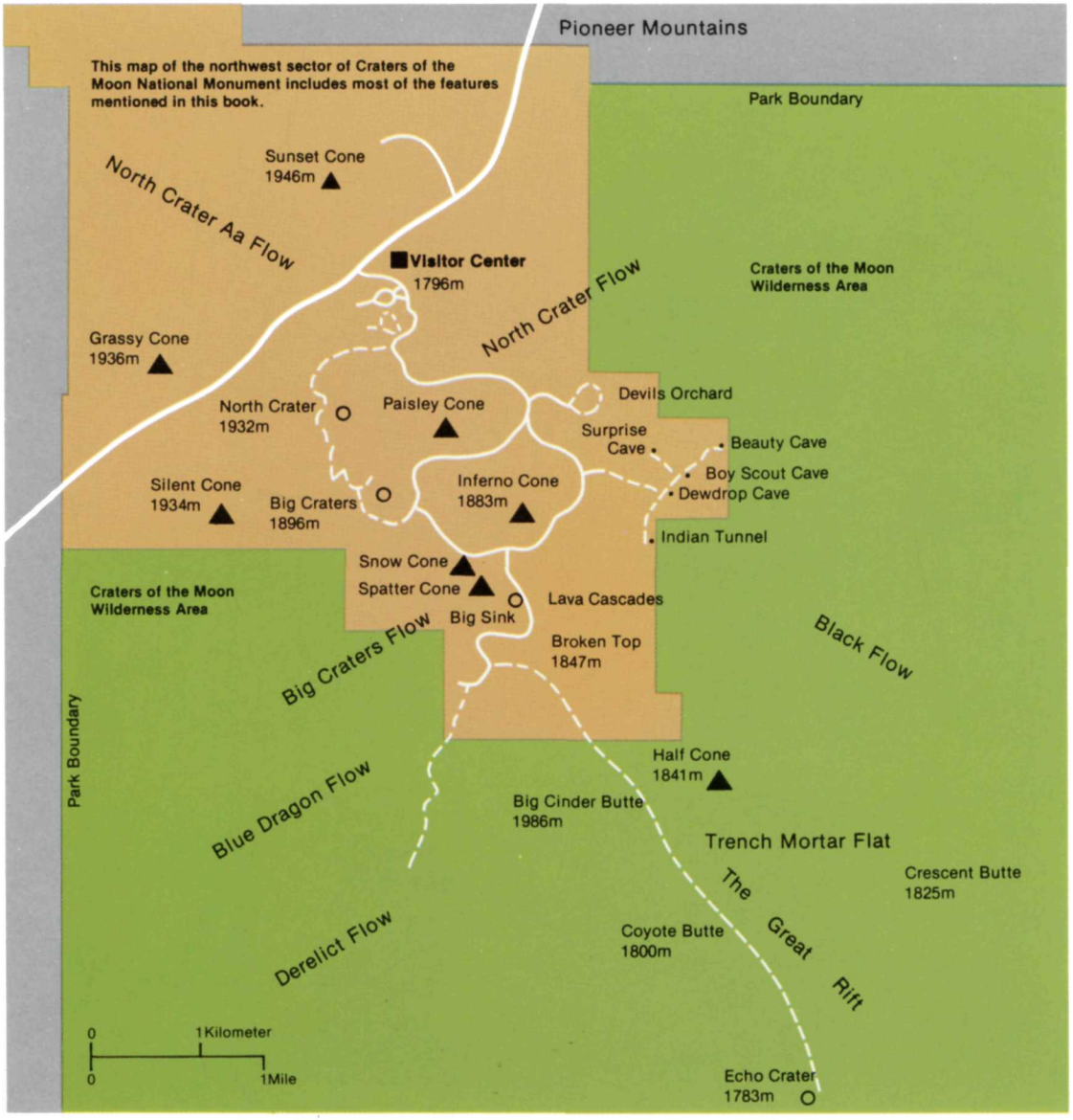
the sensitive ears of a great horned owl. Softly winging from its pine tree perch, the owl swoops down and carries away the mouse in its powerful talons. All is now silent. Nearby, golden blossoms of blazingstar await the visits of pollinating moths.

The doe continues toward the mouth of Little Cottonwood Creek. Her sharp hooves make clean, clear imprints in the soft earth. She stops briefly to scratch her neck by twisting her body to one side and reaching forward with her hind leg. Three buck mule deer and another doe join her, and together the little group cautiously crosses the highway—always a danger zone. As they approach the watering area, they traverse a swath of climax vegetation. The pungent fragrance of sagebrush hangs in the air. White blossoms of sego lilies glow in the moonlight. Patches of fur and scuffle marks in the earth are signs that a bobcat has captured a cottontail rabbit. For the bobcat, much waiting and many failures often precede a successful hunt.

The main deer herd's winter range lies 30 kilometers to the northeast; the herd migrated here in April. Most quartered in the brushy hills surrounding Little Cottonwood Creek, where food and water are easily found. The doe is part of a splinter group that moved on to Big Cinder Butte; hence only these deer trek north for water each day.

At the creek, the doe drinks deeply. This moisture will suffice for another hot day, perhaps two. Then she begins her long trek back to Big Cinder Butte. The night is alive with life and light. Crickets sing in choruses. Vega twinkles blue-white high in the sky. Low to the south, reddish Antares pulses in the heart of the constellation Scorpius. Insects buzz among the shrubs; a pocket mouse, cheek pouches full of seeds, scurries across the path and into its burrow. Far in the distance, like an island in the sea, looms the dark hulk of Big Southern Butte, largest volcano of the Snake River Plain.

Big Southern Butte looms over the lava flows.


Pioneer Mountains
This map of the northwest sector of Craters of the Moon National Monument includes most of the features mentioned in this book.
Park Boundary
Sunset Cone
1946m
North Crater Aa Flow
Visitor Center
1796m
North Crater Flow
Craters of the Moon Wilderness Area
Grassy Cone
1936m
North Crater
1932m
Paisley Cone
Devils Orchard
Surprise Cave
Beauty Cave
Boy Scout Cave
Dewdrop Cave
Silent Cone
1934m
Big Craters
1896m
Inferno Cone
1883m
Indian Tunnel
Snow Cone
Spatter Cone
Craters of the Moon Wilderness Area
Big Sink
Lava Cascades
Broken Top
1847m
Big Craters Flow
Black Flow
Park Boundary
Half Cone
1841m
Blue Dragon Flow
Big Cinder Butte
1986m
Trench Mortar Flat
Crescent Butte
1825m
The Great Rift
Coyote Butte
1800m
Derelict Flow
0
1 Kilometer
0
1 Mile
Echo Crater
1783m

Appendix

Suggested reading:

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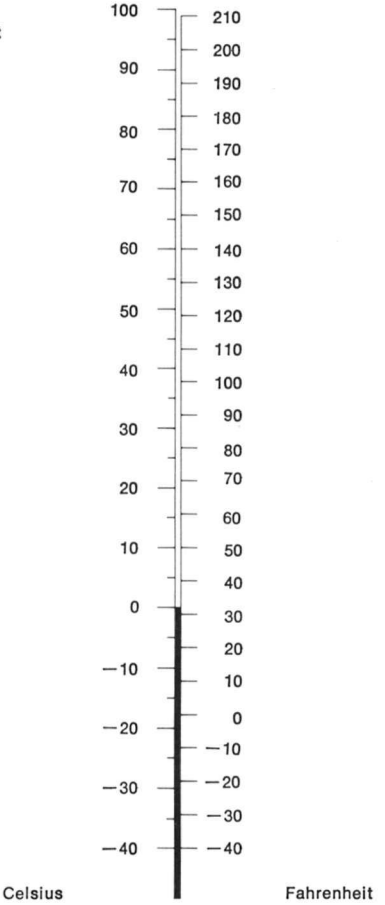
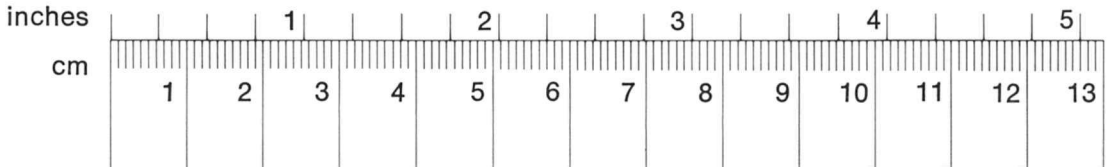
Using Metrics

As we go to press with this book, the United States is in the early stages of conversion to the metric system of measurement. And though we urge you to think metric—for most of the world does—we provide this table to help you understand the measurements given in the book.

To convert from	to	multiply by
Millimeters	Sixteenth-inches	0.6301
Centimeters	Inches	0.3937
Meters	Feet	3.2808
Kilometers	Miles	0.6214
Hectares	Acres	2.4711
Hectares	Square miles	0.0039
Grams	Troy ounces	0.0322
Kilograms	Pounds	2.2046
Degrees Celsius	Degrees Fahrenheit	1.8 and add 32





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National Park Service
U.S. Department of the Interior

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