Many-storied Mountains

The Life of Glacier National Park

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Many-storied Mountains

The Life of Glacier National Park

Written and
photographed by
Greg Beaumont

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About This Book

This natural history of the mountain wilderness called Glacier National Park is not a guidebook, but provides an overview of the ecology of the region. At the same time, it is a personal statement, revealing one individual's response to this rugged, delicate land.

For their consistent cooperation and helpfulness, I wish especially to thank Chief Naturalist Ed Rothfuss and his capable staff. Technical and field assistance came from many; for special thanks, I would like to single out Art Sedlack, Francis Singer, Bert Gildart, Walt Martin, Craig Kuchel, and Danny On. The manuscript profited greatly from the criticism of Douglas Chadwick, to whom I am deeply grateful.

—G.B.

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The landform of Glacier National Park is a monument to the power of moving ice. This view from Stoney Indian Pass (preceding page) is startlingly different from the scene of a million years ago, when the glaciers of the Pleistocene were sculpturing the land. Only the higher peaks would then have been visible above the blanket of ice that flowed like a slow-moving river down into the Mokowanis Valley and out into the Great Plains beyond.

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Illustrations by Celia Strain/Morgan-Burchette Assoc.

Song of the High Peaks

April again and the wind turns on the Great Plains. Wedges of geese, high and determined, began this storm of spring, their voices sharp as the morning frost. Sicklebills cry to claim the land, sandhill cranes wheel and talk overhead, and everywhere the killdeer shout. Pasqueflowers push the bleak soil aside, beginning the westward rush that I must join, seeking again the sight of mountains.

In Glacier National Park the land is folded up. On the east, Chief Mountain, Curly Bear, and Rising Wolf break the prairie's hold. When the early French fur trappers saw these peaks glistening in the distance with summer-long snows and perpetual ice, they named this region "the land of shining mountains." But for all the ice and snow that reflect the summer sun, the park's present glaciers are but snowflakes compared to the mighty rivers of ice that carved this land. Glaciation, the magnificent sculptor, left its bold signature everywhere, and this park honors with its name the force that shaped it.

But the essential excitement of this land is more than cliff face, spire, and sudden storm. It comes to you when you realize that here is an aggregation of dramatically differing life zones, where a day's walk can easily take you from prairie and forest to treelimit and tundra; where a dense forest of redcedar and hemlock, similar to the rain forests of the Pacific coast, exists a score of kilometers from the great prairie sea.

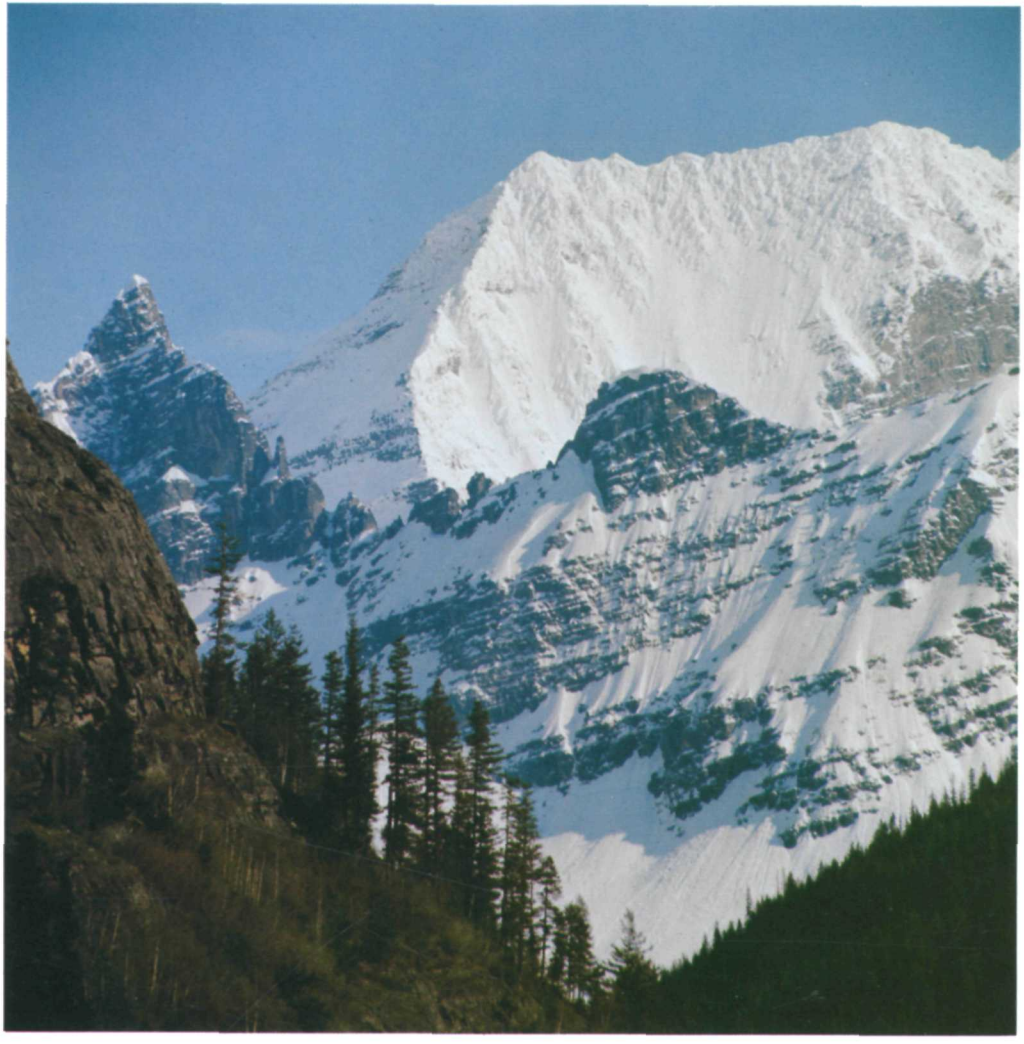
Or it comes when you discover that these mountains—young and sharp with shadows, snow-jeweled and newly gowned with forests—are chiseled from the oldest unaltered sedimentary rocks on earth.

I come from the prairie and love its broad strokes; I've learned to hear the singing in the grass and to see those long, slow seasons soar the level horizons like gliding hawks. But here I learned to match my days against a wild earth, and in me grew the mysterious need to know a mountain from its every side. Mountains that wear the dawn like yellow hats, repeated in the named and nameless lakes. Mountains that stretch the storms between them and balance rainbows ridge to ridge.

I must see again the secret forest places, where the paleflowered wood-nymphs hover like a breath, and know once more the endless meadows painted camas blue.

I need the perfect freedom of this land, to be able to say, *today I will climb Siyeh*: to stand, for a time, on the rugged shoulders of this upright earth.

The sharp spire of little Matterhorn and the broad face of Mt. Edwards loom above Going-to-the-Sun Road in the upper McDonald Valley. During warm days in spring the valleys of the park resound with the thunder of avalanches.



Cycles and Seasons

Bedrock: The First Story

On the trail that connects the Logan Pass visitor center to Hidden Lake overlook there is a shallow pond. Near Hidden Pass, it collects its meltwater from the Continental Divide and sends it down the shallow gorge that drains the Hanging Gardens; as a waterfall it plunges into the upper St. Mary Valley where it becomes Reynolds Creek; joined by other tributaries, it continues its long journey to Hudson Bay.

The surface of this pond is seldom still, for the wind treats it like a sea. Because the water is shallow, the wave action wrinkles the bottom mud into ripple patterns, mimicking the churning waves.

I like to come here early in the morning. Sometimes, arriving before the wind awakes, I catch reflections of the surrounding mountains. Beyond the low bench of Logan Pass the Garden Wall begins, running northward with the Divide. In the eastern valley the pitched peak of Going-to-the-Sun hunkers in the morning light like a tensed warrior. To the south, the incisor Bearhat, beautiful cloud cutter of Hidden Lake Valley, juts above the nearby saddle of the pass. But over this place, standing as fresh monuments to an age of ice, tower the cliffs of Clements and the pyramid Reynolds.

I am sitting on a wedge of red rock. Its surface exhibits a wrinkled pattern identical to the ripples in the soft mud of the shallow pond. The distance is not great; with a stick I could reach out and touch the mud. Yet this represents a gulf no bird can fly, for between the ripples of this rock and the ripples of this mud lie billions of vanished mornings, a constellation of years.

These red, green, tan, white, black and purple bands of rock that layer Glacier's mountains comprise the oldest unaltered sedimentary rocks on Earth. They were laid down in Precambrian time, more than a billion years ago, when life was just beginning, as the deposits of an inland sea.

For millions of years, sand, mud and carbonates washed into the ancient sea, compressing the lower layers into mudstones and limestones, building up a sediment thickness that may have been as much as 10,000 meters (*see* metric conversion table on page 136).

When we look at the sharp contours of Glacier's mountains, we see the evidence of uplift, overthrust and glaciation. But on the geologic clock these are recent events, a mere eyeblink of time ago. For the vast majority of years, the rocks lay undisturbed and level beneath the sea and land.

To understand better the tremendous time scale these rocks represent, we need a way to visualize the vast collection of years. If we were to make a movie of these geologic events, we would first need to determine how many years each minute should represent. Since the Pleistocene lasted about 3,000,000 years (its four ice ages sculpting the present muscle of this land), let us make

each minute portray a million years. To chronicle these rocks we will then need a film 60 hours long!

Not until the fifty-seventh hour of our film will the Mesozoic lowlands begin to bulge with the coming Rocky Mountain chain. During the long preceding hours we would have seen little else but sea—withdrawing, advancing, deep and shallow; yellow, green, and brown with great colonies of algae. Unseen below the water, lava has spilled out occasionally on the sea bottom; once, it intruded between the rock layers below, forming the conspicuous, 60-meter-thick band of black diorite that we see today on many mountain faces in Glacier.

During this time of initial uplift an amazing process is going on deep underground. A major fault has developed, fracturing the buckled layers of rock. A vast mountain plate begins to slide eastward, over-riding and submerging the rock layers to the east and opening the wide trench that is today the North Fork Valley. Known as the Lewis Overthrust, this gigantic earth-force has created an unusual situation: ancient rock strata lying atop recent rock strata.

Now less than 3 minutes of film remain. The arrival of the ice is imminent. We look at the landscape of featureless mountains and wonder at the dramatic difference that this last 3 million years will make. We do not see the familiar forests and lakes, the savage peaks, and the broad, deep valleys of this present land. These mountains are gentle, arid, and shallow-valleyed. The vague outlines are there; we recognize the general alignments of the drainage systems, the bloated domes from which sharp peaks will be cut. The mountains are connected to one another by blunt ridges and smooth saddles, and the shadows they cast are dull, dunelike.

Suddenly the ice is there, filling the landscape, with only the mountaintops protruding. Four times in these last 3 minutes of film the ice sheets advance and retreat, each time leaving an altered landscape. Strange lakes and forests fill the gaps between the glacial invasions. Then we see the mountains we now know come into being rapidly, as if the land were being hacked into shape by giant cleavers.

After this flicker of Pleistocene time, the film ends, the forests return, and familiar lakes shine beneath the sun again—these lakes and forests we had thought to be timeless.

■

Up springs the morning wind from Hidden Valley, making the nearby alpine fir branches whiz with its passing and shattering the perfect reflection of Bearhat Peak on the pond. From where I sit, it is a short distance to Hidden Pass; so I leave the pond and walk to the overlook to see again the fine basin quarried by an ancient glacier.

Hidden Lake, deep, far below, so blue,

fits into its cliffed, crooked valley like a polished boomerang. Closely ringed by ridge and peak—distant Sperry Glacier and pointed Gunsight peering up from the southern jumble, and broad Bearhat impossibly close—this lovely lake is almost lost amid such sharp proclamations of rock. Its outlet gorge gives a narrow view across the angled, hidden valleys of Avalanche and McDonald, past the pyramid of Stanton, to the low, faraway undulations of the Whitefish Range.

Glaciation is a cruel master of mountains, biting deeply into their bulk and leaving sheer, spectacular contours when the glaciers disappear. The landforms here attest to their power, everywhere exhibiting the effects of glaciation.

In eating back the mountain headwall, alpine glaciers formed rounded depressions, called cirques. Unlike the narrow clefts left by running water, these broad, deep basins look as though they were made by ice-cream scoops gouging into the rock. Hidden, Ptarmigan, Iceberg, and Avalanche Lakes sit in well-developed cirque basins, and many mountains are dimpled by the beginnings of other cirques—the conspicuous amphitheater on the south shoulder of Heaven's Peak, for example.

Occupying all major drainage systems, glaciers modified the contour of the valleys, changing them from their narrow, stream-cut V-shapes into broad U-shapes. Into these wide main valleys, waterfalls plunge from higher, smaller valleys. Like rivers, flowing glaciers have tributaries. Lacking the ice mass and cutting power of the main glaciers, these tributary ice fingers could not bite as deeply into the bedrock. When the ice melted, hanging valleys were left stranded high above the main valley floor. Hidden Lake sits in one of these hanging valleys, and from it Hidden Creek plunges 750 meters into Avalanche Basin toward McDonald Creek.

On my many previous visits to this pass I have been too busy enjoying the wildflowers, the weather, or the scenery to realize what an open textbook of glaciation is everywhere displayed.

I stand here on a small saddle of a pass. Wherever glaciers met, passes, or cols, were created. A high, notched pass like this one (or Swiftcurrent or Gunsight) reveals recent connections. Broad, lower passes, such as Logan, resulted where the ice early overran the mountain ridge and had a chance to work longer.

Where two glaciers worked on opposing sides of a ridge and failed to meet, they formed an arête—a thin, steep-walled remnant resembling a saw blade. Another ice age would probably consume the park's many thin arêtes, such as the Garden Wall and Ptarmigan Wall; but it would also create new ones from existing ridges.

Further testimony to the sculpting power of ice is presented by Mt. Reynolds, looming to the east. The most dramatic

feature of a glaciated landscape is the pyramid-shaped mountain called a horn—and Reynolds is a perfect example. Horns were formed when three or more glaciers cloaked the mountain, excavating its sides toward its core and gradually transforming its original domed shape into a sheer-sided peak. Glacier has many remarkable horns, from the sleek spire of St. Nicholas in the south to exquisite Kinnerly in the northern Kintla valley.

Sperry Glacier stares back at me from the flank of Gunsight. Glaciers found in the park today are not remnants of the last ice phase, which ended here about 8,000 years ago, but are newly formed, having come into existence some 4,000 years ago. They reflect a cooling trend in the present climate.

Shrinking steadily from their period of greatest extent in the middle of the last century, these modern glaciers finally stabilized in the late 1940s and since then have shown only a slight increase in area.

Movement distinguishes glaciers from icefields, and the movement of ice is a force on as well as a feature of a landscape. A glacier excavates by abrading and plucking at the rock. Alternately melting and freezing, ice at the headwalls plucks out blocks of rock. Utimately the rocks are deposited along the sides or at the feet of the glacier as moraine debris. But as they move in the grip of the ice, they constantly abrade the rock surfaces they encounter. Polished rock beds of past glaciers show striations—grooves gouged by rock fragments imbedded in the moving ice.

Flow rate of a glacier depends upon the thickness of the ice and the degree of slope. Under tremendous pressure, ice becomes plastic, like thick taffy. Unlike kilometer-thick continental glaciers, which may move a hundred meters a day, small alpine glaciers seldom progress more than two or three centimeters per day.

Although a glacier moves, it gets nowhere if in a state of equilibrium—when annual melting equals annual accumulation. Snow mass gained at the sun-shielded headwall is usually lost as melt at the exposed snout. Glaciers such as Sexton or Weasel Collar, whose snouts perch on cliff edges, also lose mass by calving. Thunder you hear on a late-summer day near such a glacier may actually be the sound of ice pushed off from the lip of a cliff.

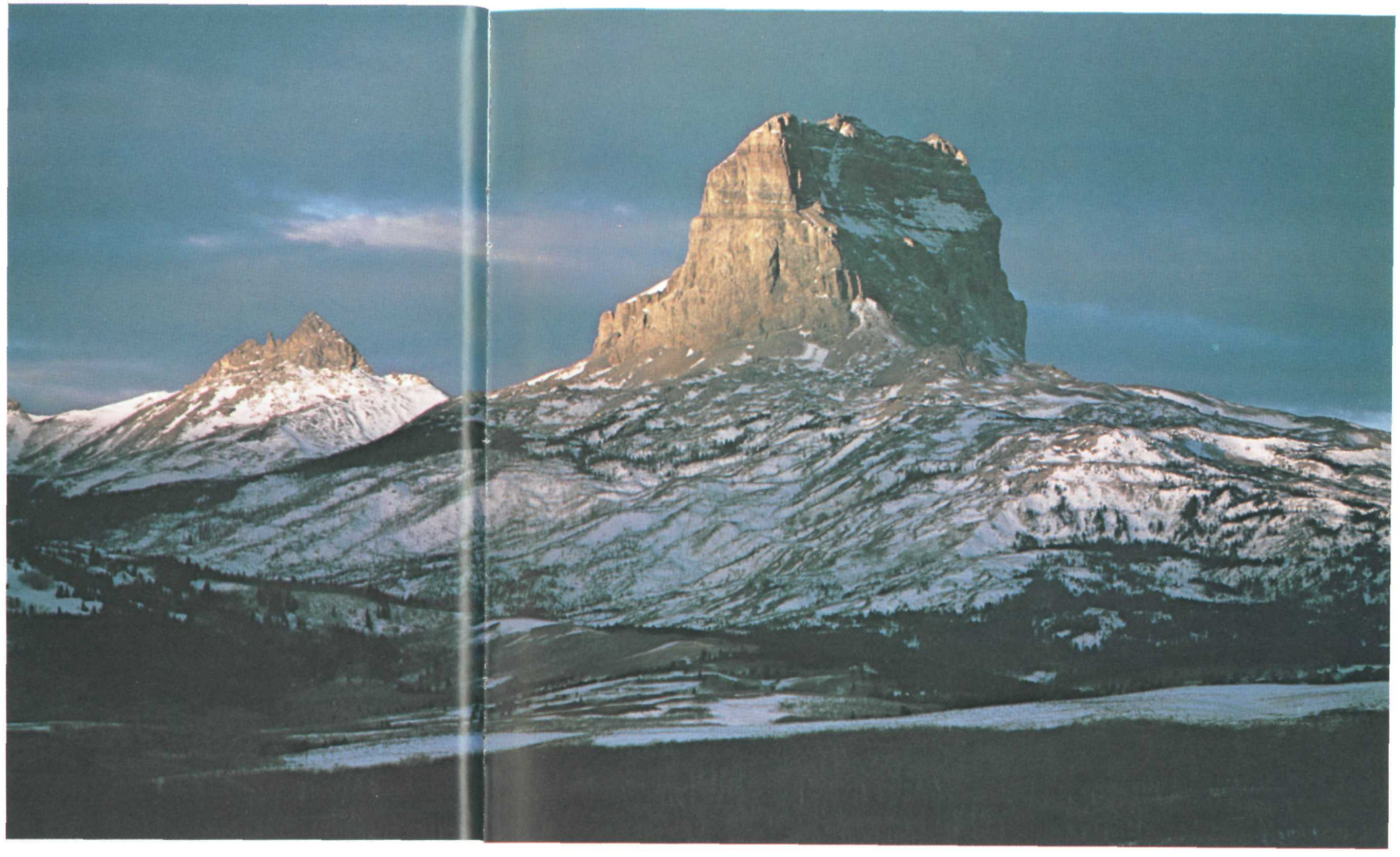
Walking back to the visitor center, I suddenly stop where the trail skirts the steep moraine of Mt. Clements. From the opposite side of the moraine five mountain goats have appeared. Spotting me on the trail below, they also halt. But before I can get to my camera they are off in a stiff-legged gallop, running in single file along the crest of the moraine to the distant safety of the mountain face.

Moraines are ridges of rock debris piled up along the edges and terminuses of glaciers. Like a bracelet lying against the wall

Continued on p. 38

The Mountains of Glacier

Lying astride the Continental Divide in the Northern Rockies, Glacier is above all else a mountain park. The special beauty of its lakes, streams, and forests derives from the microclimates and varied topography and soil produced by mountain-building and mountain-eroding forces.



Overthrust Mountains

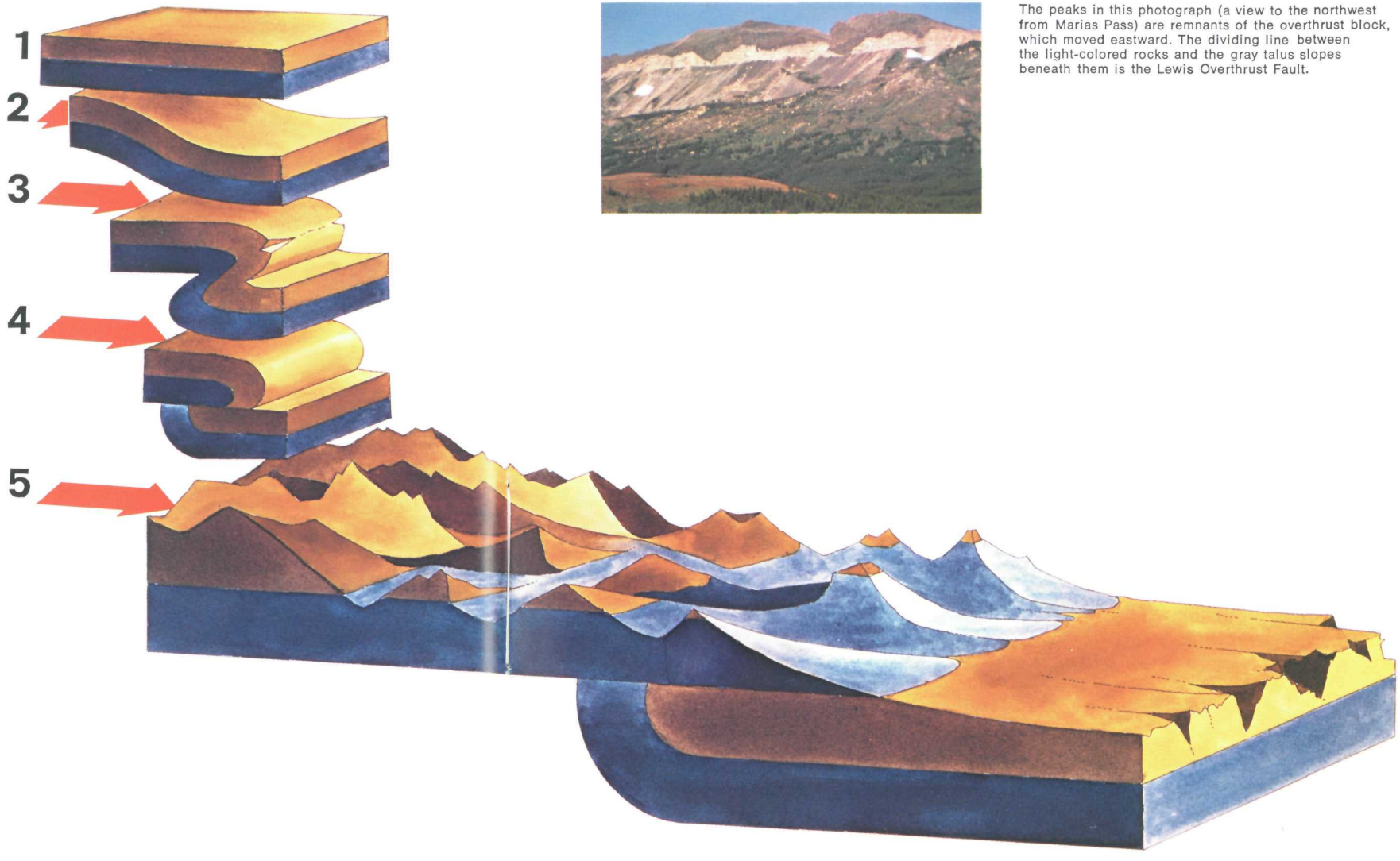
1 A hypothetical block of the Earth's crust in the region of Glacier National Park as it existed more than 60 million years ago. The two layers shown actually represent many strata of sedimentary rocks.

2 Lateral pressure begins to force the rock layers to buckle.

3 A large fold has been created, forcing the rock strata to double over and overturning some layers. A break, or *fault,* is forming at the plane of greatest stress.

4 The break has been completed and the strata west of the fault have slid eastward, up and over the rocks east of the fault.

5 The Glacier landscape today. Throughout the millions of years during which the folding, faulting, and overthrusting have been taking place, the process of erosion has continued; a thousand meters of stratified rocks have been worn away, so that only a remnant of the overthrust layers can be seen today. Because Glacier's eastern slope represents the eroded face of the overthrust block, the mountain range rises precipitously from the prairie, with no foothills breaking the abrupt transition from open prairie to mountain valley.

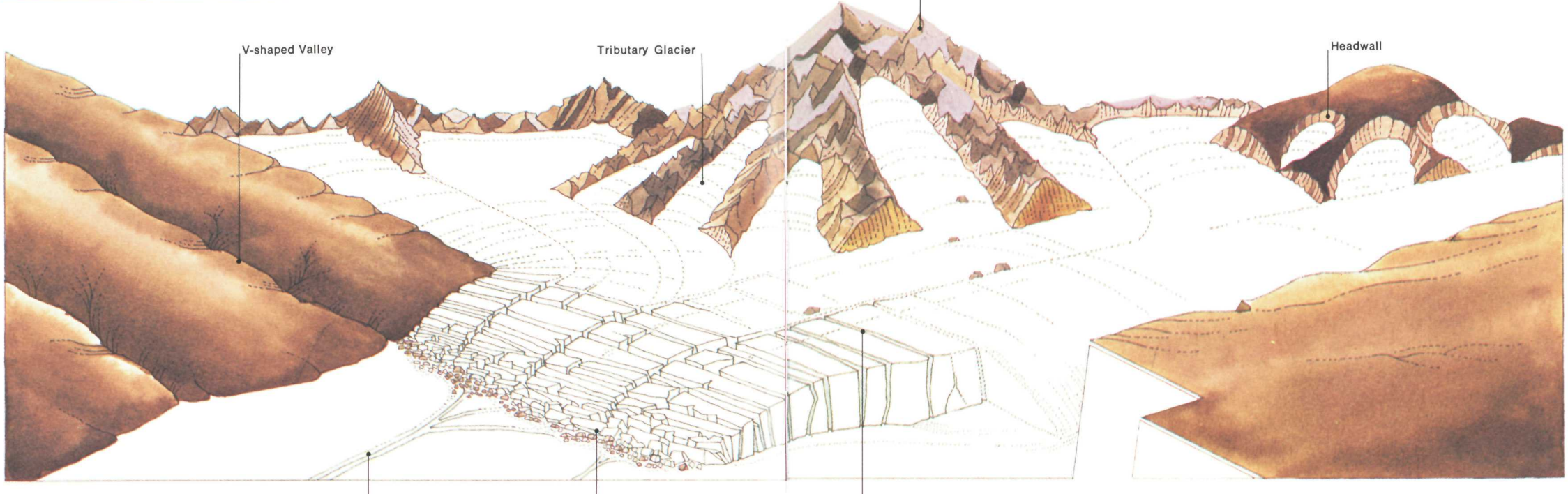


The peaks in this photograph (a view to the northwest from Marias Pass) are remnants of the overthrust block, which moved eastward. The dividing line between the light-colored rocks and the gray talus slopes beneath them is the Lewis Overthrust Fault.

1

2

3



Glaciation

1 This is how the landscape in this region might have appeared before the onset of the Pleistocene, millions of years ago. Note the stream-eroded, V-shaped valleys. The climate at that time was dry.

2 Glaciers began to form high on the peaks, crept downward, and joined to form larger glaciers.

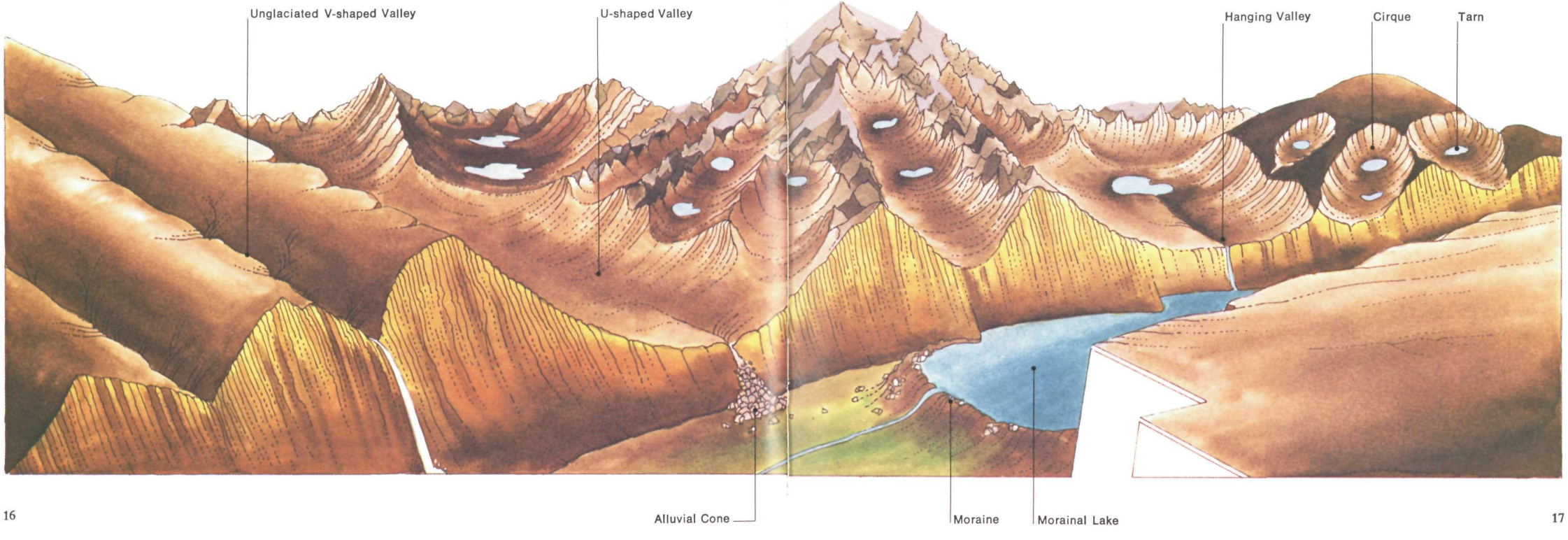
3 After many centuries of glaciation, tributary glaciers have cut back into the peaks, forming basins called *cirques.* Thick glaciers, moving rapidly and carrying rock fragments, have abraded the main valleys' floors and sides, widening and deepening the valleys into characteristic U-shapes.

4 In the present landscape, free of all but remnant glaciers, small lakes called *tarns* occupy many of the cirque basins; and waterfalls plunge into the main valleys from higher, shallower, tributary valleys, called *hanging valleys. Alluvial cones*—recent accumulations of rock debris—have begun to build along the valley walls. In the main valley, a *moraine* (a deposit of rock materials left by the retreating glacier) has formed a dam that holds back a large lake.

During all this time, all parts of the terrain not buried under ice and snow have been weathered and eroded by nonglacial forces. Thus the contours of the jagged peaks and sheer cliffs have been softened.

Glacial landforms can be identified in this view of the Mokowanis Valley.

4

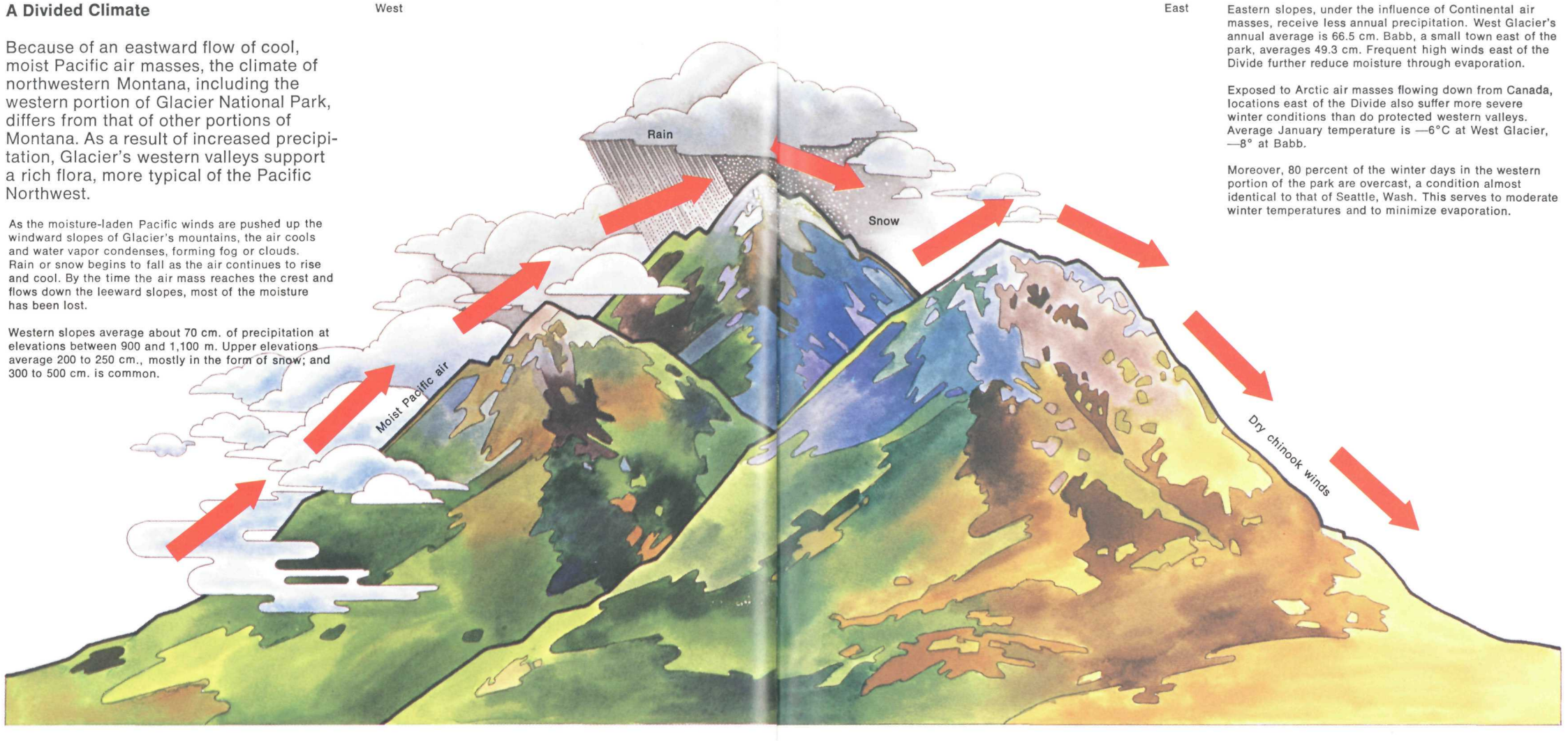


A Divided Climate

Because of an eastward flow of cool, moist Pacific air masses, the climate of northwestern Montana, including the western portion of Glacier National Park, differs from that of other portions of Montana. As a result of increased precipitation, Glacier's western valleys support a rich flora, more typical of the Pacific Northwest.

As the moisture-laden Pacific winds are pushed up the windward slopes of Glacier's mountains, the air cools and water vapor condenses, forming fog or clouds. Rain or snow begins to fall as the air continues to rise and cool. By the time the air mass reaches the crest and flows down the leeward slopes, most of the moisture has been lost.

Western slopes average about 70 cm. of precipitation at elevations between 900 and 1,100 m. Upper elevations average 200 to 250 cm., mostly in the form of snow; and 300 to 500 cm. is common.



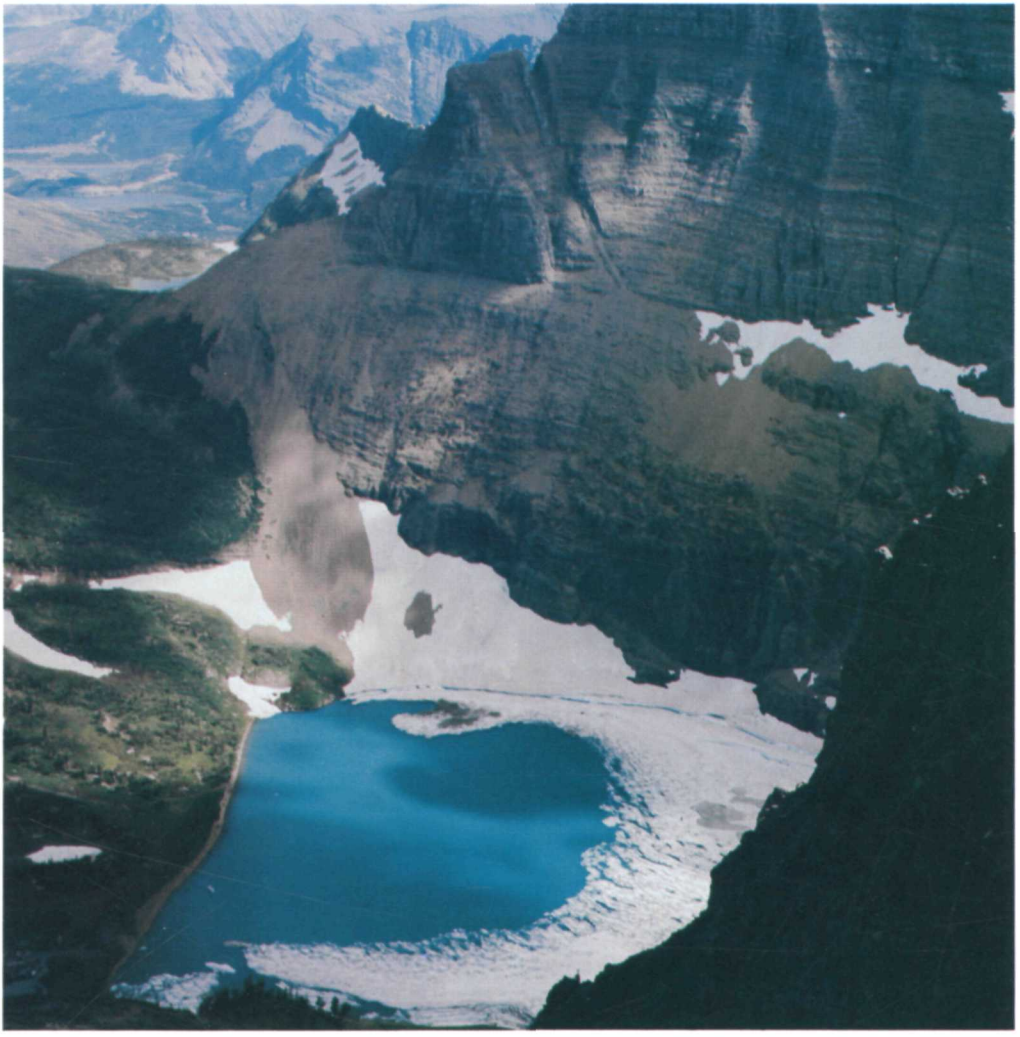
Eastern slopes, under the influence of Continental air masses, receive less annual precipitation. West Glacier's annual average is 66.5 cm. Babb, a small town east of the park, averages 49.3 cm. Frequent high winds east of the Divide further reduce moisture through evaporation.

Exposed to Arctic air masses flowing down from Canada, locations east of the Divide also suffer more severe winter conditions than do protected western valleys. Average January temperature is —6°C at West Glacier, —8° at Babb.

Moreover, 80 percent of the winter days in the western portion of the park are overcast, a condition almost identical to that of Seattle, Wash. This serves to moderate winter temperatures and to minimize evaporation.

Moss campion and mountain forget-me-not colonize a fellfield. Fellfields are rocky alpine sites that are slightly less than 50% bare rock, interspersed with such plant pioneers as cushion plants, mosses, and lichens.

High lakes generally occupy cirque basins. These depressions in the valley bedrock, quarried by glaciers, are deepest near the headwall where ice thickness was greatest. Cold and deep, and ice-free only weeks each year, tarns cannot support vascular plants or vertebrates. Iceberg Lake, shut off from the sun most of the year by the encompassing 1,000-meter walls of Mt. Wilbur and the Ptarmigan Wall, is never completely free of ice.



Lake McDonald, 16 kilometers long, 2 kilometers wide, and 134 meters deep, is the largest lake in the park. Its basin is the classic U-shaped glacial valley. Forested lateral moraines on either shore gently rise 600 meters above lake level. Going-to-the-Sun Road snakes along the eastern shore, and Logan Pass lies near the center of the photograph, behind the peaks of the Lewis Range.

Subjected to the drying and shaping effects of wind both winter and summer, this Douglas-fir, growing in the prairie community near St. Mary, will attain neither the symmetrical shape nor the great size of the Douglas-firs growing in moister, more sheltered sites on the western slopes of the Continental Divide.

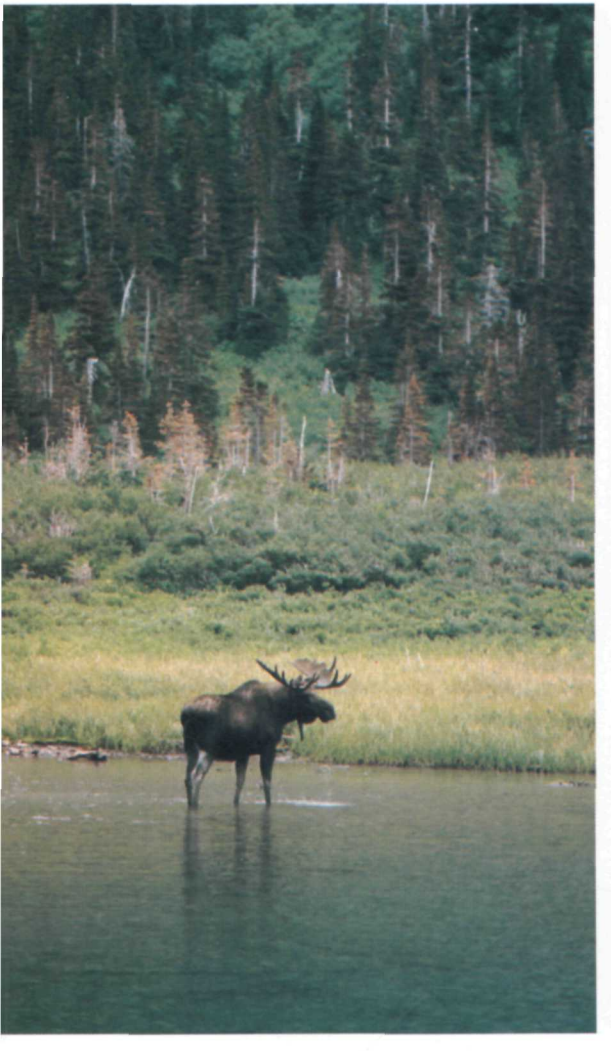
Freeze-and-thaw cycles continually fracture and loosen rocks along joints, making them subject to removal by the actions of water, gravity, and avalanche. The resulting fans of rock debris (talus cones) indicate the extent of erosion since the withdrawal of the Pleistocene glaciers.

Although moving water is an agent of erosion—the primary destructive force of mountain masses—it also permits life. Even small watercourses, such as this freshet, abound with plant and invertebrate life.

Going-to-the-Sun Mountain, towering above the St. Mary Valley, from the trail to Siyeh Pass. The coniferous forest at its base and the alpine tundra plants at its summit are closely juxtaposed in space; but if these two communities grew at the same elevation they would be separated by thousands of kilometers. Hiking from St. Mary Lake up to Siyeh Pass is going, in effect, from Montana to the Arctic Circle; but here the life zones are compressed and sharply divided rather than extended and overlapping.

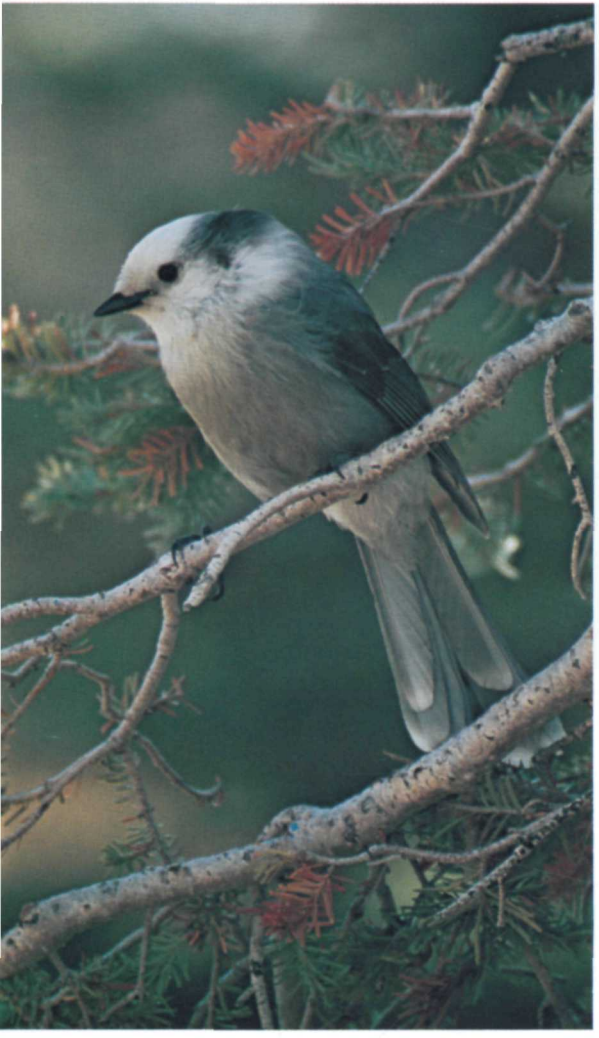
Setting moon and snow shelf near the summit of Heavens Peak. Note stratification of Precambrian sediments.

Western redcedars line the shores of Lake McDonald. Because of prevailing air currents from the Pacific coast, winters in the protected western valleys are moist and comparatively mild, and this deep body of water freezes over an average of only one winter in four.



Moose often follow the spring snowmelt upwards to the headwarters of drainages. This bull will remain at Thunderbird Pond, at the base of Brown Pass, until autumn, when it will return to its Waterton Valley wintering ground.

Because of the high reproductive capacity of insects and small mammals, if all their offspring survived the earth's plant life would be consumed within one year. This is prevented by natural controls such as predation and parasitism. The American kestrel ("sparrow hawk") feeds primarily on large insects and on small rodents such as the meadow vole here.



Gray jays are found in the deep coniferous forests of the park. In some parks gray jays, or "camp robbers," loiter about campgrounds and picnic areas begging or stealing food. In Glacier, however, they are seldom noticed as they search out seeds, berries, and insects.

A generalized predator, the coyote will eat almost anything, from berries to carrion. When man eliminated most of the coyote's enemies and competitors, including the wolf, grizzly, and cougar, it enlarged its range to fill the void. Intelligent and social, the coyote thrives despite man's persecution. Although most numerous in the prairie community, it ranges up to timberline.

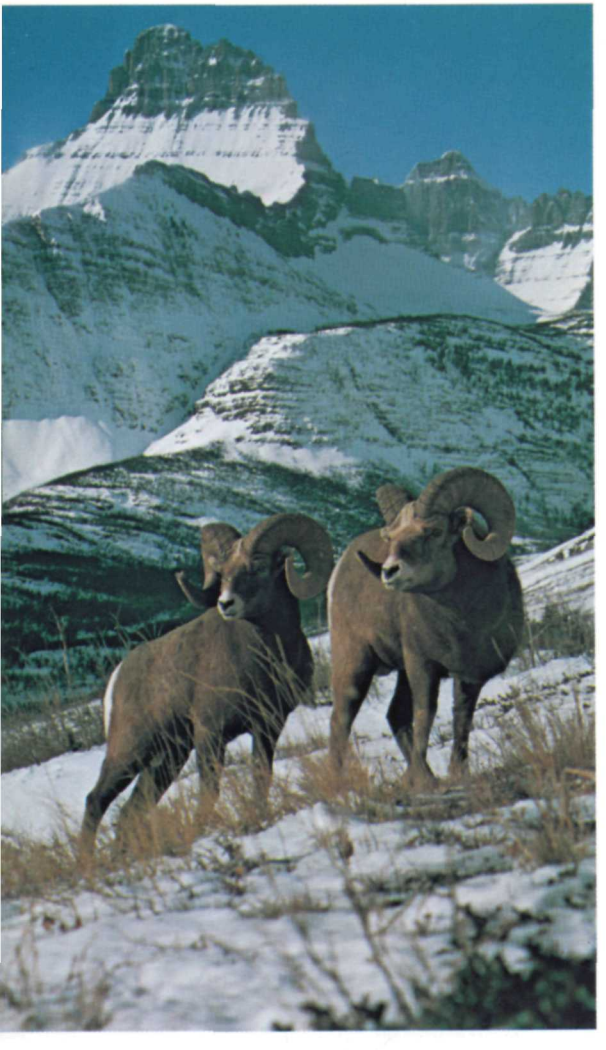
The spruce grouse is a year-round resident of the spruce/fir and lodgepole communities. It forages on the ground for seeds and insects, in winter turning to needles. Several other species of grouse occupy different habitats in Glacier.

Chipmunks are found in every community, from prairie to tundra, in Glacier. Each of the park's three very similar species has its preferred habitat. The diurnal counterpart to nocturnally active mice, which have the same diet of seeds, berries and occasional insects, chipmunks adapt easily to the presence of people and become nuisances if encouraged by handouts. Feeding rodents is dangerous and is harmful to them. By altering their diets and blunting their cautious instincts, daily exposure to "free lunches" makes the animals less fit to face the harsh realities of their natural environment.

Unlike whitetail deer, which remain in lowland areas all year, mule deer range upward into high meadows during the summer. The bucks, especially, are wanderers and travel together. Velvet antlers, worn during *the time of summer sociability, presage the autumn* contests to come.

The checkerspot butterfly belongs to the most diverse group of animals on the planet—the insects, whose importance can hardly be overestimated. They not only help recycle nutrients in the living community and provide an abundant food base for other lifeforms, but are instrumental in pollinating most of the earth's terrestrial plants.

Alpine vegetation must be able to survive freezing temperature during the growing season, since winter conditions are possible even in summer. Early bloomers, such as the glacier lily, endure repeated snowfalls during the unstable weather conditions of June.



Unlike mountain goats, these bighorn rams will desert the alpine zone at the approach of winter; they will join other bighorns congregating in the lower valleys.

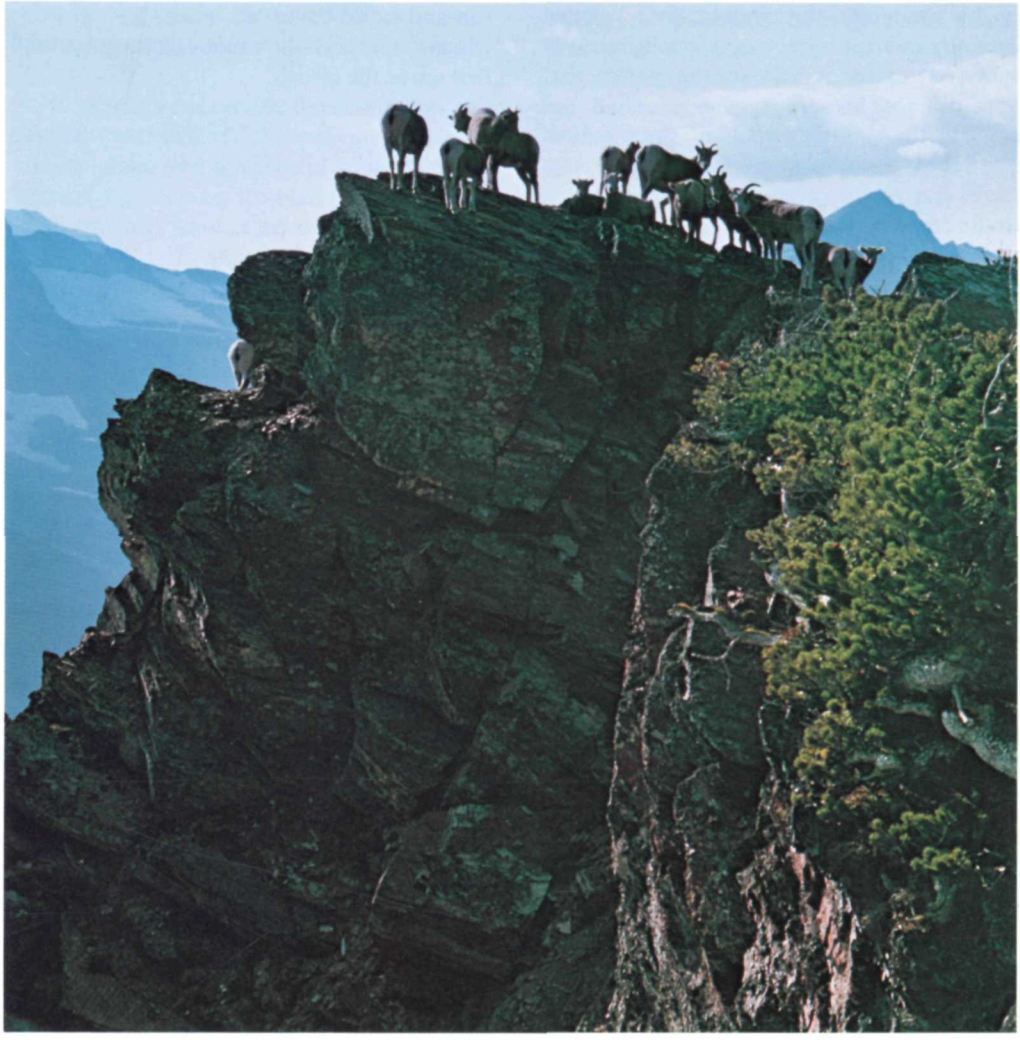
In November bighorn sheep rams end their summer-long isolation from the ewes, move down from the higher slopes, and begin a bloodless but taxing ritual of strength and endurance to determine the harem master. The sharp reports of clashing horns may carry for kilometers, and the contests continue for weeks until the dominant ram emerges. (Note the Many Glacier hotel complex in the valley below.)

Hummingbirds, like shrews and other small-bodied, warm-blooded animals, exist at the theoretical threshhold of life. Because of their small size, body volume is not large enough in relation to surface area to prevent a rapid loss of body heat. To compensate for this, metabolic rates must be high; food is rapidly processed and used up. Thus, since fat reserves are not practical on such small animals, they must eat at frequent intervals.

Two species of hummingbirds—the rufous and the calliope—are found in Glacier. Pictured is a female rufous (which weighs about the same as a dime) landing on its lichen decorated nest to feed its two young on a protein-rich mixture of nectar and small insects.

The insect-eating yellowthroat prefers moist habitats. Unlike many of its treetop-dwelling relatives, this tiny (10-11 cm.) warbler is usually seen near or on the ground.

Bands of bighorn ewes and lambs do not summer as high as the rams and are often encountered in the scrub-forest zone. Note the gnarled limber pine in the foreground of this photograph taken on the south face of Altyn Peak.



of this mountain, the circle of steeply piled debris marks the extent of a small, recently vanished glacier. Ghost of the power that once resided here, a stagnant icefield lies beneath the confining walls of the moraine. The recent accumulation of these rock fragments is a mighty accomplishment, attesting to the force of moving ice.

Reaching the mountain wall, the goats scramble upward to a ledge, sending scree streams pouring from several clefts. Encountering a narrow, steep snowbank, they do not hesitate but continue across the slope. Above the rock fingers of this peak the gathering clouds grow black. A sudden crack of thunder hurries me down the trail.

Although geologically young, the Rocky Mountains in Glacier are composed of soft sedimentary rocks that are easily assailed by the many agents of weathering and erosion. If not rejuvenated by continual uplift, these magnificent peaks will glimmer but briefly in the long memory of the planet.

Already the sharp countenance of this land is being softened by the ongoing forces of erosion. Chief among these is water, which attacks the mountains everywhere. In addition, frost action continually exploits rock fractures, breaking down blocks of rock into talus and scree. Avalanche and rockfall sweep down the slopes. Layers of softer rock erode quickly, undercutting more resistant rock and creating overhangs which gravity, in time, will collapse.

The lashing rain catches me on this sun-and-storm-contested pass. Ice, gravity, wind, and especially water—all attack a land that dares the clouds.

The Rising of the Sun and the Running of the Deer: A Glacier Year

As if to make up for the days-long darkness of this last blizzard, the peaks today wear snow plumes—long, graceful trails of white, curving up into an ice-blue sky. Yesterday the snow-mad wind raced through the forest. Today the motionless trees are cloaked in heavy, glistening robes, the leafless aspen and young larch bent down.

Moderate snowfall helps many plants and animals survive the winter. For ground dwellers it provides insulation from the wildly fluctuating winter temperatures encountered east of the Divide, protecting the hibernators and providing cover for the many small mammals that remain active during the winter. Wind-swept ground freezes deep; but under a mantle of snow life-sustaining heat is trapped, permitting many animals to survive and allowing the work of decomposers to continue.

But this has been a winter of too much snow and too many temperature extremes. The heavy snowpack has forced the sharp-hoofed deer to yard up in great numbers; unable to range freely in deep snow, they are forced into smaller and smaller confines where their numbers allow them to break and maintain trails. But in time they exhaust the food supply. Younger deer, unable to reach the increasingly higher browse line, starve first. Then the does, heavy with unborn fawns, grow weak and fall to predators. So the imprisoned herds dwindle quickly this year, sometimes less than a kilometer from plentiful browse.

Deep snow is also death for many seed-eating birds. As they are unable to scratch for food, their body furnaces quickly fail, and during a night of cold wind their fluffed corpses drop into the snow.

Exposed to the noon sun, the snow surface thaws; when refrozen, it is restructured to crystalline ice. If snow repeatedly thaws and freezes, an ice barrier is formed, shutting off vital air exchange. Plants are then subject to rot, and micro-animal life is smothered. Travel beneath the snow is made more difficult for mice and shrews and they are deprived of food and cover. Under such conditions their numbers rapidly decline.

But while many starve in a winter of deep snow, others benefit. The exposed traffic of small mammals is to the owl's advantage. Foxes and coyotes more easily run down rabbits and hares on crusted snow. Deer and, to a lesser extent, wapiti and moose—their hoofs punching through the snowpack—swiftly tire in deep snow and become helpless before cougar or wolf, whose lighter weight is supported by the crust.

Grim as this winter's toll becomes, enough will survive to begin the process of renewal in spring. Last winter, a season of light snow, was a time of hardship for predators. The deer remained strong, the wapiti remote on high, windswept ridges, and the

small mammals hidden.

Only the water ouzel, winter after winter, seems not to notice the hardships of the season. Lord of his small world of open water, he sings in February, wading and swimming his diminished stream to find a never-failing supply of water insects and small fish. It is a voice of spring—glad, wild, continual as the moving water—an incongruous song in this winter-shrouded land.

But with the growing stature of the sun, the grip of winter softens. The firs and spruce send their loads of snow sliding to the ground. Streams begin to sing again and soon the lakes increase, the booming of splitting ice breaking the silence of the valleys. Avalanches thunder down the steeper slopes, carrying trees to the swollen streams. Rivers hiss and rage, speeding the debris along. A spring that comes too suddenly will bring flood to lower elevations.

Snow geese thread through the valleys, and ground squirrels tunnel up through snow to find invasions of birds returning from the south. Soon the three-petaled wakerobins appear, chasing the snowline up the ridges. Glacier lilies and Calypso orchids are next, and with the shooting stars spring arrives.

The melting snow releases a new group of animals to populate the winter-thinned land. Up come chipmunks. Bears reappear. Young red squirrels, helpless and blind, squirm in their nest holes. Hidden dens rustle with pups and kits. Soon warm days will bring them out and the business of learning to cope with their world will begin.

All life responds irresistibly to the growing strength of the Sun. Cottonwood, willow, and maple come into flower and unfold new leaves; green needle clusters spot the limbs of larches that in winter had seemed lifeless snags among the other conifers. Beneath the soil of prairie, meadow, and forest, in the mud of lakes and ponds, other life stirs; armies of insects, spiders, crustaceans, amphibians, and fish will strive to complete their life cycles against the formidable odds of a predatory world.

Spring reaches higher up the mountains, the lowlands passing into summer. Wapiti and mountain sheep follow the rising tide of succulent browse up to the high meadows. In forest, grove, and meadow and along the stream new fledglings appear—thrush, vireo, hummingbird, waxwing, harlequin duck, bluebird, osprey, and flicker—as holes, nests, and cavities brim with begging mouths.

In the alpine meadows, where snow overlaps the spring and winter follows hard behind the summer, the growing season is short and the climate unstable. Sensing the stronger light, flowers push up impatiently through the snow and hasten into bloom. Pikas and marmots scurry and sunbathe among the rocks of scree slopes.

Summer matures in ripening huckleberries, and the bears that grazed the spring grasses now gorge themselves fat. Dry days of August bring probing lightning, threaten-

ing the forests with fire.

Sweeps of beargrass reach their climax now in the highest meadows. In dizzy succession wildflowers set seed. Fat and sluggish, marmots and ground squirrels disappear beneath the rocks. The golden eagle must search longer each day to find prey within its vast domain.

Autumn lingers in the valleys and on the flanks of low ridges. The morning sun glints on hoarfrost, firing the yellow leaves of larch, aspen, birch, maple, and cottonwood, and shines on the blood-red berries of mountain-ash. Soon a night of killing frost will bring down the corpses of insects and spiders by the millions. The reptiles and amphibians, being cold-blooded animals, seem out of place in this long-wintered land. Unable to maintain body temperatures appreciably above their surroundings, they are the first to seek the protection of hibernation, collecting in dens or burying themselves beneath the ooze of pond bottoms.

Songbirds gather and leave the valleys. The harsh cries of jays sound ominous now in the forest. Only the chickadees seem to ignore the long tree shadows; their ceaseless conversations carry through the leafless underbrush as they busily search for seed.

Velvet has gone to bone, and in these final noon-warm days the rut runs through the land. It begins in the valleys in September with the joustings of deer and moose and the buglings of bull wapiti puncturing the forest silence. By November the higher meadows ring with the collisions of bighorn rams who compete for ewes by smashing together their massive, curled horns. On high slopes mountain goat billies posture and swagger; head to tail, they circle, threatening each other with dagger-like horns.

From Flathead Lake, 100 stream kilometers to the south, kokanee salmon return to spawn in the clear, cold shallows of McDonald Creek. Gathering bald eagles surround the stream, again and again lifting vulnerable fish from pool and riffle. Perched by the hundreds along the stream course, their white heads and tails glistening against the dark trees, they stand out like lanterns strung for a banquet.

Now the stinging wind comes down from the peaks and shuts the lakes. Life slows or sleeps. Ptarmigan, snowshoe hare, and longtail weasel, all wearing winter white, seek shelter and food in a silent land where spring and yellow lilies seem forever lost.

■

All life faces one ultimate challenge: to survive or not, to reproduce or fail, to bring one's kind to tomorrow's sun or vanish forever. This land is harsh. To survive in nature demands skill in the individual, excellence in the species, and a chance from the environment.

The mink, a solitary predator associated with low-elevation watercourses, preys on anything it can catch and subdue (next page).

Plant-and-Animal Communities

Over Going-to-the-Sun Road

I like to begin with St. Mary, a lake the whitecaps love to run. From the far passes the several winds gather and collect, arranging long lines of white waves for the race downlake. Past the purple scree of Mahtotopa and Little Chief they go, white as the headdress of Going-to-the-Sun Mountain, colliding, collapsing along the promontory snares about the Narrows. Onward they press, spreading out and setting sail for the straight rush to the final shore where a line of cottonwoods sings with a sound like applause.

Across the lake the timbered ridge starkly contrasts the finger of prairie that claims the north shore. This is a flower-glad place, a meeting-ground for mountain and prairie plants. Along the road the grassland holds the conifers back, allowing only scattered clumps of aspens.

Finally, at Rising Sun, beneath the shadow of Goat Mountain, the prairie ends and wind-seasoned Douglas-firs announce the coming forest.

There's excitement now, with the prairie heat gone, the wind scent raw with fir and high meadows, honed by waterfall and tall, dank rock. Our mountain thirst is never extinguished, and a road that tightens down to cliff face and sudden turn brings back to our blood the ancient need to go to the highest place.

There is sword-edged Citadel, and the snow-flanked spike of Fusillade holding court like a queen in this valley of peaks; then the dome of Jackson and the Gunsight notch. Our eyes are kept high, transfixed at last by looming Heavy Runner and the distant promise of Reynolds.

Looking for mountain goats, we scan the walls around the sweep of Siyeh Bend, catching a glimpse of the trail that crosses the scree to hidden Piegan Pass.

Beargrass heads lean out above the road like old men conferring on the view. The purple trumpets of penstemon crowd the rocks, and spots of Indian paintbrush lead like a blood-trail to the higher slopes.

Intoxicated now, feeling the fresh full force of the wind from Logan Pass, we race on. We hardly notice the struggle of the forest in Reynolds Creek far below, how it thins and loses strength in its own hard climb. We sweep past it on the broad magnificence of this pass.

Level but a moment, the road dips to a shelf on the headwall above Logan Creek and swings over the great sculptured cliff of the Garden Wall. For several kilometers this masterpiece of a road glides down a constant grade, squeezed between rock face and space, twisting into tight drainages—a road for storm lovers, wet with spray and snow-seep, its quick turns concealing sudden winds.

Mighty, snow-robed Heaven's Peak appears, taking our attention from the Pass-group mountains and the hanging valley

that spills Birdwoman Falls. Northward is the great array of peaks encircling distant Flattop, jumbles of mountains and glaciers. How are we to notice the forest far below?

Not until we have passed the Loop and are moving past the blackened snags of a recent burn do we realize the stature of this forest. The long road down will take us into a valley much deeper than any on the eastern side. Near Avalanche Creek are trees we have seen nowhere else in the park—giant western redcedars, western hemlocks with their nodding tops, monstrous black cottonwoods with bark so deeply furrowed that it looks hewn by hatchet.

We take a long ride down the valley, past the low pyramid of Mt. Stanton, final peak in the Livingston Range. Near the outlet end of Lake McDonald, birch and aspen again appear in numbers, and the road enters a crowded stand of lodgepole pine.

Our memories cluttered with mountains, waterfalls, and snowfields, we do not quite realize the significance of this 80-kilometer journey. We have crossed the boundaries of several different plant-and-animal communities, spanning a range of climate that would be encountered on a 5,000-kilometer north-south journey at sea level.

At first glance the various trees, wildflowers, and animals seem randomly distributed, scattered about like the distant mountains. But mountainous terrain represents an organized high-rise approach to life. From the lowest, most protected valley to the highest wind-and-ice-cut summit, the life-forms align themselves, each according to its own climatic tolerance.

Here too can be seen the great cycles of nature: fire and regrowth, the building of soil and its erosion, the incessant duel of the eaters and the eaten.

In the following sections we will spend some time in these various communities, from prairie to tundra.

Groves and Grasslands: The Prairie Sea

There is something about spring on the prairie that gets me up before dawn. I like to watch the seasons change their guard over the landscape, from the wintry cold of pre-dawn dark to the spring-scented morning air to the hot summer-foretaste of the noon May sun.

Hoarfrost surrounds these patches of pasqueflowers, blue goblets on downy stems. On this windless night, frost has formed everywhere, reclaiming for a time its vast winter range, sparkling over the green handiworks of spring.

But the god of the growing grasslands is the sun, and it now proclaims itself, stretching out to make the mountains shine. With its assault the frost collapses, becoming bright beads on grass tip and leaf joint by which a beetle might refresh itself.

Spring is best perceived ant-level, at its ground beginnings, where the bright yellow-green tips of new grass shoots reclaim the winter-blighted land. I look closely at a drag line of spider silk; a necklace of dewdrops slides down, collects to a moment's greatness, in which I briefly see a curved horizon, the morning sunburst, and myself, before it falls away.

Getting up from my prone position, my belly damp from the prairie earth, I startle a whitetail jackrabbit; bounding high, it zigzags off. The commotion disturbs a distant badger, which faces about from its diggings to confront danger in whatever form it might take. It swings its snout to scent the air. Somewhat uncertainly, it returns to the business of hunting, then hesitates, swings about once more and waits, myopic, patient.

Satisfied at last, the spurt of the now distant rabbit lost in its brain, the creature snorts a defiance at the mystery and resumes its morning gopher hunt.

Overhead a marsh hawk skims past, its flight erratic as a butterfly's. Far away a magpie rattles at the passing hawk and takes flight, briefly flashing black and white.

■

It is easy to see only pieces in the natural puzzle—a badger throwing dirt, horned larks dipping into wind, black ants dragging the rosette of a dead spider—and be satisfied with the scattered scenes. But at last, to make it meaningful, we must complete the picture. There is that special joy in discovering larger schemes: green plants utilizing sunlight; a rabbit building its days at the plants' expense; the falcon tearing the rabbit meat for its young; magpies picking at the fallen falcon; and then, in the end, all returning to the earth.

Here on the prairie, as in every plant-and-animal association, the ancient drama repeats itself over and over; the distant tundra is a drastically different stage with different actors, but the cycle is the same. Life depends upon the interaction of all its

many forms. Unseen bacteria are as necessary to the land as green grass; the meadow vole and the coyote are as much a part of the prairie as the grasses.

The secret of life rests in the wonder of photosynthesis. Only green plants can manufacture food from the earth's raw minerals. This is the vital first step upon which the great pyramid of animal and plant life is built. Using energy from the sun, green plants combine water and carbon dioxide to synthesize sugar, and give off oxygen as a by-product. The caterpillar takes its energy from the plant tissue, converting to protein the sugar and minerals in its body. The caterpillar is then food for a spider or other predator. A yellow warbler may take the spider and in turn be ambushed by the prairie falcon. Thus the energy produced by the plant travels through the food chain. When the prairie falcon dies, scavengers—including insects and other invertebrates, birds, and mammals—redistribute its wealth among themselves; the rest is decomposed by bacteria. Thus, eventually, the nutrients on which the plants depend return to the soil.

When we look at any living organism, whether it is plant, herbivore, carnivore, parasite, scavenger, or decomposer, we are soon made aware of its associations with other living things, each puzzle piece leading us to another and another. We begin to see a picture whole—the fox, meadow mouse, grasshopper, bunchgrass, and sparrow hawk—all interlocked.

Geologically speaking, grasslands are a recent development. As the Rocky Mountains were being uplifted, the prevailing warm, moist climate began to change. The rising mountain mass intercepted moisture-laden winds that blew in from the Pacific, creating a rain shadow that lengthened eastward as the mountains rose higher. A continental climate, characterized by severe winters and dry, wildfire summers gradually took shape, extinguishing the great forests that had grown across the continent's interior. Herbaceous plants, which had been evolving amid the forests, inherited the land.

Unlike trees, grasses die back to the ground each winter, hoarding their life-germ beneath the protecting soil. Growing not from the tip but from the joints, grasses regenerate quickly after fire or grazing. Suspension of the normal metabolic processes enable the grasses to go dormant and thus survive periods of severe heat and drought.

Although the great prairie sea washes up against Glacier's eastern boundary, with estuaries probing into the mountain valleys on the drier, south-facing slopes, the grassland community comprises less than 5 percent of the land area of Glacier National Park. This includes the puddles of prairie west of the Divide that interrupt the dense coniferous forests along the North Fork of the Flathead River.

From the pasqueflowers that bloom in early May to the asters and goldenrod of September, these summer-long gardens of

Continued on p. 68

The Forests of Glacier

From the lush redcedar-hemlock forest in the McDonald Valley to the subalpine fir, whitebark pine, and Englemann spruce struggling for existence near treeline, the forests of Glacier reflect the conditions of temperature, exposure, soil, and drainage prevailing; and each forest has its characteristic association of understory trees and shrubs, herbaceous ground cover, and vertebrate and invertebrate animal life.

Life Zones

Many physical and climatic factors determine the range of Glacier's plant-and-animal communities. Boundaries between communities are seldom sharply defined, but rather merge together in broad zones of transition.

With elevation gain, average daily temperature drops at the rate of 5° per 900 meters. Precipitation, wind velocity, and evaporation loss increase. Soil thins. These factors, along with others such as fire frequency, north or south exposure, and availability of moisture, combine to determine the range of each community.

In the forest community below 1,800 meters, Douglas-fir, lodgepole pine, and western larch predominate. In the valleys, Engelmann spruce and subalpine fir are found. The somewhat lower and much better watered western valleys of the park support western redcedar and western hemlock.

Treeline is the upper limit to which the tolerances of trees to environmental conditions permit them to grow. Because there are so many controlling factors (wind, temperature, exposure to sunlight, snow cover, etc.) treeline in the diagram is only approximate. In Glacier it averages 2,000 meters. Avalanche chutes or sheer cliff walls may suppress it to below 1,500 meters; on protected slopes it may be as high as 2,150 meters.

At the eastern edge of the park below 1,200 meters, the forest gives way to the prairie community, composed mostly of soft-stemmed plants adapted to the conditions of low precipitation that prevail here in the rainshadow of the mountain range. Clumps of aspen, found in the prairie in sheltered spots, occur here in the transition zone between prairie and forest.

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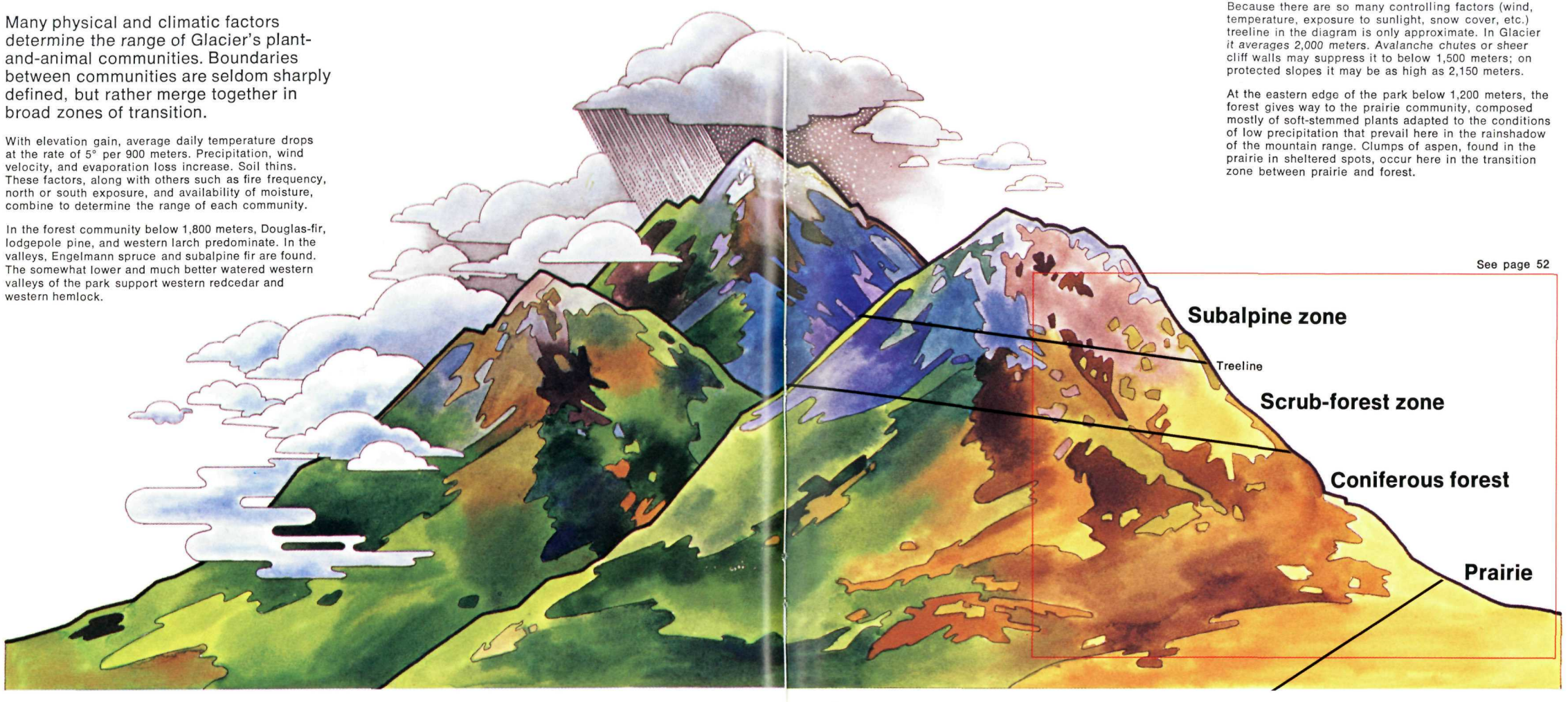
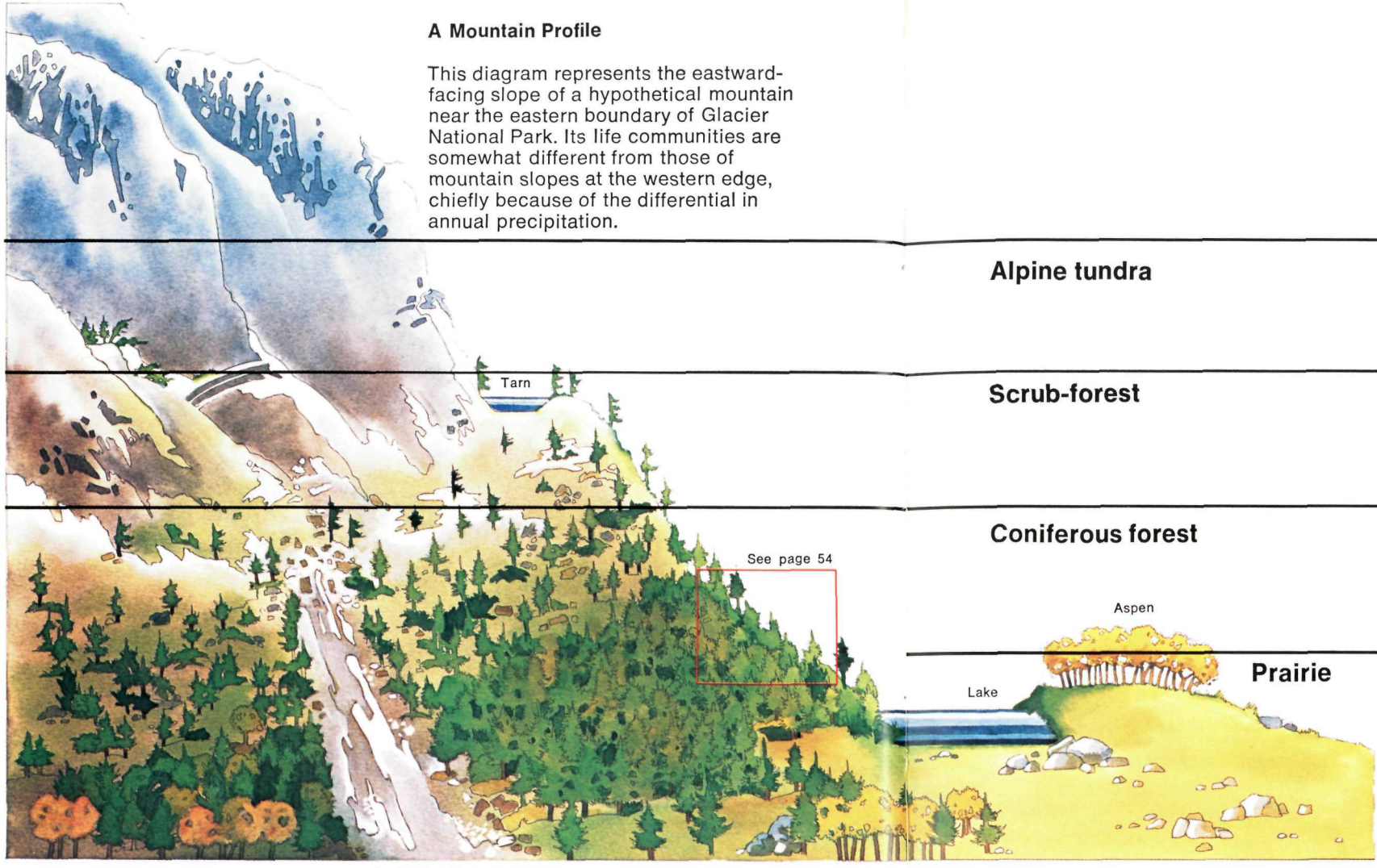


A Mountain Profile

This diagram represents the eastward-facing slope of a hypothetical mountain near the eastern boundary of Glacier National Park. Its life communities are somewhat different from those of mountain slopes at the western edge, chiefly because of the differential in annual precipitation.



Avalanche Chute

Alpine tundra

Here, above approximately 2,750 meters, in a realm of ice, snow, and barren rock, there is little life.

Scrub-forest

Below 2,750 meters and above 2,000 meters, depending on other factors such as exposure to sun and wind and steepness of terrain, exists the alpine tundra community, with vegetation similar to that of the vast, essentially level, treeless zones of the Arctic.

Coniferous forest

Roughly between 1,800 and 2,000 meters, the dominant vegetation is scrub-forest. Trees here are stunted; except in sheltered spots they are more or less prone rather than upright. Net growth is slow, not only because of the short growing season but also because of the pruning effect of icy mountain winds. Very few tree species can survive in this harsh habitat.

Prairie

In the forest community below 1,800 meters, Douglas fir, lodgepole pine, and western larch predominate. In the valleys, Engelmann spruce and subalpine fir are found. The somewhat lower and much better watered western valleys of the park support western redcedar and western hemlock.

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The Forest Community

A forest is organized vertically like an apartment house or office building, with layers corresponding to stories. The *canopy* is the branches and foliage of tall trees that form a roof over the community. Below the canopy are the *understory* trees: young individuals of the canopy species; and small, shade-tolerant trees that will never become part of the canopy. Beneath the understory branches is the *shrub layer,* occupied by knee-high-to-man-high woody plants; beneath that is the *herb layer,* where most of the ferns, wildflowers, grasses, and smaller woody plants grow. The *forest floor* is the zone of mosses, mushrooms, creeping plants, and forest litter (leaves, twigs, needles, feathers, bits of bark, animal droppings, etc.). The forest has a "basement," too, interlaced by plant roots, mycelia of fungi, and tunnels of myriad animals.

Each layer of the forest has its characteristic animal species, but most forage over more than one level. Some nest in one story and feed in another. The red squirrel races back and forth from the forest floor to the highest branches.

The forest community also has a socio-economic organization. Every animal (and plant) takes up space and consumes a portion of the available nutrients. Each has a place in the community food chain—as, for example, *herbivore, carnivore,* or *scavenger.* Each directly or indirectly affects all the other organisms.

Forest Niches. The role of a species in *the community, like the job and social* function of a person, is its *niche.* Similar species of animals have different niches, thus lessening competition for food and living space. Thrushes hunt close to the ground; vireos and kinglets hunt among the branches; flycatchers snap up airborne insects. The flicker feeds upon insects, excavates nesting holes that are later occupied by other species such as squirrels and owls, and is preyed upon by the great horned owl; its niche is *insect exterminator/food for carnivores/ homebuilder.* The great horned owl, hunting mammals, birds, and reptiles by night, preys on species different from those hunted by the goshawk, and thus occupies a parallel niche. When it dies, its remains, like those of other animals, are decomposed and return to the soil.

Sun, Green Plants, and Animals

The sun is the source of energy for any plant-and-animal community. Green plants draw nitrogen and minerals from the soil, and in a process called *photosynthesis* use sunlight to convert raw materials (carbon dioxide and water) into carbohydrates (sugar, starch, cellulose), giving off oxygen as a by-product. Besides burning oxygen, animals depend on plants for food.

Green Plants, trees and shrubs, grasses and sedges, wildflowers, ferns, mosses, algae and lichens—are fed upon by animals, which are unable to manufacture their own food.

The Redback Vole, like other rodents, pikas and hares, seed-eating birds, grazing and browsing hoofed animals, and herbivorous insects, derives its energy from the seeds and other parts of green plants that it eats.

The Garter Snake, feeding upon the vole, is dependent upon plants even though it does not eat them.

The Great Horned Owl, preying upon the garter snake, is one more step removed from the green plants—but still dependent on them.

Scavengers such as carrion beetles feed upon the carcass of the owl; the remains are then attacked by **Decomposers,** primarily bacteria, that break down the animal tissues into basic organic compounds.

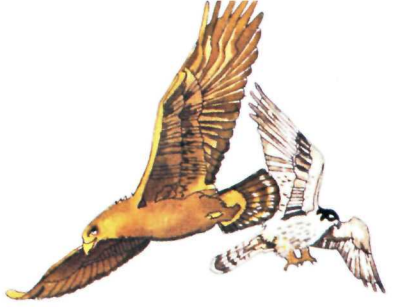
The Soil, enriched by the minerals and carbon and nitrogen compounds added to it by the decomposers (and by other processes such as fire) supports new green plant growth.

Thus energy derived from the sun flows through the ecosystem in a *food chain.* A plant-and-animal community is a complex, interlocking web of such food chains.

A Pyramid of Numbers

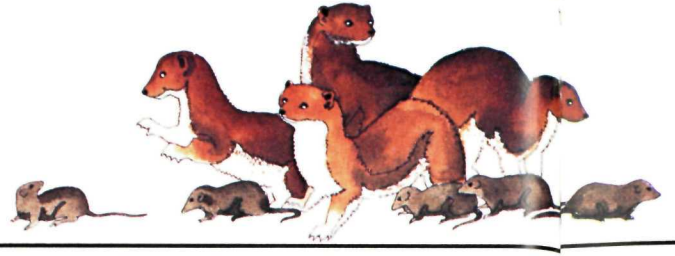
Necessarily, the number of plants in an ecosystem far exceeds the number of plant eaters, and the number of prey species must exceed the number of predators. During its lifetime, a golden eagle will consume a vast number of lesser animals. The combined mass of prey animals necessary to sustain an eagle greatly outweighs the eagle itself. Ecologists refer to this proportional relationship of mass between each link in the food chain as the *pyramid of numbers.*

The diagram represents a numbers pyramid for the alpine zone. Because of its limiting environment, the alpine zone supports a lesser plant mass than the forest zone. As a result, the carrying capacity of the alpine is less than that of the forest.



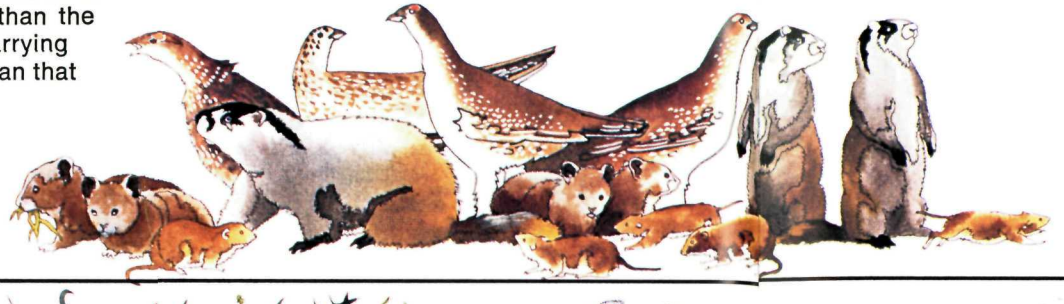
Tertiary (third-order) *consumers* are the predators (Golden Eagle, Swainson's Hawk, etc.) that feed upon other predators. Because of the 90% loss of energy at each level of the food chain, there will be very few hawks and eagles in comparison to the numbers of marmots.

1 Kilo



Secondary consumers are the predators (weasels, shrews, carnivorous insects and birds, etc.) that eat herbivores. The animals at this level of the pyramid are often—though not always—larger than the animals they feed upon. But they are much less numerous, because it takes many prey animals to sustain one predator.

10 Kilos



Primary consumers (plant eaters, or herbivores) convert plant tissue into animal flesh. In the process about 90% of the energy stored as plant food is lost, mostly as heat energy. In the alpine community the herbivores include pikas, marmots, ground squirrels, and ptarmigan, as well as herbivorous insects.

100 Kilos

Producers are the green plants at the base of the food pyramid, manufacturing food for the animals of the alpine community. The *biomass* (total weight) of each level of the food chain is ten times (more or less) the weight of the stage above it: 1,000 kilos of green plants will produce only 100 kilos of primary consumers.

1,000 Kilos

Great horned owls are the nocturnal equivalent of Cooper's hawks and goshawks in the low-elevation forests of the park. Large and powerful, they are capable of taking prey as big as skunks. This young bird, disturbed on its day roost, clacked its bill and fluffed its feathers in a menacing manner.

The only sizable mature stand of ponderosa pine found within the park is along the North Fork truck trail. A scattering of old ponderosas growing at the lower end of Lake McDonald suggests that at one time ponderosa forests were more extensive in this region than at present.

A black bear near treelimit. Bears will eat almost anything, from ants to carrion, grass to garbage. Color phases include brown and blonde bears. Unlike the larger, more aggressive grizzly, which ranges out onto the plains, black bears are strictly forest creatures.

The water ouzel, or dipper, a creature of fast mountain water, is admirably outfitted to cope with its demanding environment. Stubby wings, chunky body, short tail, and oily plumage allow it to walk under water, where it scavenges for aquatic insect larvae and small fish. In flying up- and down-stream, ouzels never shortcut but follow the winding streamcourse.

As long as there is open water, the dipper suffers no hardship from the mountain winter. Then, when the land is shut down and lakes are frozen over, this little bird carries on in its mountain-stream habitat, plunging into the cold water to find food, and pausing occasionally to sing.

Ouzels construct their nests of living moss on cliff faces or ledges where constant spray keeps the moss moist. At fledging, the four young of this nest in Avalanche Gorge tumbled one by one into the torrent below, to be collected by the adults in quieter water downstream. Within a day they appeared to have mastered the underwater gymnastics and were feeding on their own.

From their lowland wintering grounds, wapiti move up to higher elevations in spring. Summer range in the park is abundant, but winter range is limited; as a result, wapiti have a tendency to increase their populations beyond the carrying capacity of available winter range. In a severe winter many starve. But in a balanced ecosystem such loss is not waste, for the carrion helps sustain scavengers; it is an important initial food source for bears emerging from hibernation.

Cedar waxwings nest in moist areas of low valleys where fruits and berries are abundant. Although they also subsist on insects (which they can capture on the wing), their weakness for fruit is so pronounced that the birds will sometimes gorge themselves until rendered incapable of flight.

The Columbian ground squirrel is found at all park elevations, from prairie to alpine meadow. Hibernation occupies almost three-quarters of its five-year lifespan. Unlike other park ground squirrels, it lives in colonies. Although not as tightly structured as a prairie dog town, the association is beneficial to all members in that danger is readily detected.

The tundra community is encountered above Preston Park on the Siyeh Pass trail. Mt. Reynolds, a classic example of a horn, dominates the distant Logan Pass area.

Camas blooms in the prairie community along the Red Eagle road. An important staple, camas bulbs were gathered as food by Indians.

grasses and flowers lean with the wind. Here are timothy, oatgrass and the bunchgrasses—rough fescue, bluebunch fescue, and bluebunch wheatgrass. Among the grasses bloom bitterroot, blue camas, lupine, gaillardia, balsamroot, cinquefoil, sticky geranium, and wild rose.

Conspicuous also are many insects—including grasshoppers; flies; ants, wasps and bees; butterflies and moths; bugs; and beetles—which fulfill important roles as herbivores, carnivores, and scavengers while also acting as pollinators for flowering plants and providing an abundant food source for other animals.

Below the ground are the tunnels. Burrowing is an important means of survival on the open prairie, and life underground is extensive. Some of the animals are rarely seen—the northern pocket gopher, for example, with a diet of underground insects, grubs, worms, and roots, spends most of its life tunneling just below the surface. Others, like the badger, leave their burrows during the day to dig for rodents. Most conspicuous of the burrowing animals in the park's grasslands is the Columbian ground squirrel. Its alert upright stance has earned it the nickname "picket pin." When danger approaches from the air or on land, its shrill alarm whistle passes the warning to others of its kind.

Where prairie and forest meet, a never-ending struggle for dominion is waged. The isolated patches of prairie that dot the North Fork Valley near Polebridge hold the great forest of the park's northwest region at bay.

This broad valley, floored with coarse glacial outwash and terraced downward to the deep channel of the North Fork River, presents a graphic battleground between grass and tree. Lining the upper terraces, from which they glower down on the dry, well drained grass flats like a line of warriors, are the Douglas-fir, western larch, and ponderosa pine. Seedling trees continually invade the prairie. But most perish early, their shallow roots no match for the extensive root systems of the fast-growing, moisture-greedy grasses. If encouraged by a series of wet summers, however, the young lodgepoles quickly gain stature. They had made significant inroads at Big Prairie when the disastrously dry summer of 1967 killed most of these 15-year-old pioneer trees.

These North Fork grasslands and the immediately surrounding lodgepole pine forests are an important spring range. Deer, wapiti, and grizzly—and, in the wetter areas, moose—graze or browse here. And here, low on the western slopes of the Livingston Range, are the park's only stands of ponderosa pine, a tree that prefers warm, dry habitats. As a result, at low elevations it often merges with the prairie community.

Groves of aspen colonize the eastern prairies in areas where there is sufficient water and protection from wind. These aspen parklands are important havens for

animals. Wherever two differing communities interact, a phenomenon known as "edge effect" occurs. Here wildlife exists in abundance; the animals that favor forest cover mingle freely with those that prefer open areas. Aspen groves—supporting grasses, herbs, and shrubs beneath their thin canopies—are favored haunts for grouse, varying hare, deer, and wapiti, all of which find among the trees abundant food, shelter and concealment. Populations of insects, small mammals, and birds, which are high for the same reasons, attract a wide range of predators.

Isolated aspen groves are characteristically dome-shaped. Because aspens are capable of reproducing themselves vegetatively, the grove slowly expands outward from the parent tree. As a result, most of these groves are either exclusively male or exclusively female.

Since quick-growing aspens provide a bountiful food source for beaver, streams near these trees are often dammed by the rodents flooding lowlands and creating additional habitat in the form of willow flats. Another "edge effect" is established, attracting animals found near water. Waterfowl, marsh birds, moose, mink, muskrat, skunks, amphibians, and many others find such areas to their liking.

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Before the appearance of the white man, these eastern prairies were a paradise for animals. Once, on the summit of Rising Wolf, light-headed from the climb and the view of endless prairie, I fancied that I saw that vast, undisturbed animal panorama spread before me.

Principally there were the bison, darkening the uneven land. Pronghorn bands flashed white on ridgetops, and moose moved through the long fingers of willow that extended eastward with the rivers. Caribou and wolves inhabited the shadows. Among vast cities of prairie dogs, swift fox and grizzly roamed. There were the clamorings of sandhill crane, and white clouds of trumpeter swans.

This land, endowed with a wealth of wild grass, wore its wilderness well.

The Forest

On Gunsight Pass, the rain lancing down, I found a sharpedged rock that split the continent in two. On both sides the rain rivulets ran down, a fraction of an inch determining the stream's destination: Pacific or Atlantic.

The Continental Divide is a mighty barrier, a line of consequence that does more than determine watersheds. Its effect in Glacier is dramatic, as a look at the forests will reveal.

Obstructing the eastward flow of the moisture-laden Pacific winds, the Divide extracts a heavy annual tribute of precipitation from the air mass, forcing it to rise up the mountain chain, where it cools and condenses. Chief benefactors are the low western valleys, which respond with a lush growth of Pacific coastal-type forests.

The eastern valleys, however, deprived of abundant annual moisture and exposed to the wind and temperature ravages of the prairie's continental climate, support a dramatically different kind of forest. Here Englemann spruce and subalpine fir are the climax trees, contrasted with such trees as the western redcedar and western hemlock of the mild and moist McDonald valley.

Elevation exerts an additional restriction on the distribution of tree species. Since climatic conditions vary with change in elevation—lower temperatures resulting in shorter growing seasons, and increased wind exposure resulting in greater loss of moisture through evaporation—we would expect to find the forest composition change as we ascend a mountain slope. In Glacier, eastern valleys average 240 meters higher than western, and thus even if they had more moisture they would not sustain the redcedars and hemlocks. All plants have range limits, some narrow, some broad; and they excel where their particular set of preferences as to moisture, soil, sunlight, and wind exposure are best met. On sites that do not meet their optimum requirements, they face being crowded out by species better adapted to the prevailing conditions.

Physical features of the land determine vegetation also. Certain trees prefer the moist areas along a streambed—the great black cottonwoods, for example. And on steep hillsides, avalanches prevent the growth of climax trees, permitting instead only shrubby, pliant growth—mountain-ash, mountain maple, alder, menziesia.

Forest communities are named for their dominant tree species. Thus, an area in which Douglas-fir dominates is called a "Douglas-fir forest." Glacier does have forests in which Douglas-fir is the climax species; these are chiefly dry areas, below 1,800 meters, with south and west exposures. But we usually associate the park with its Englemann spruce-subalpine fir forests, found extensively between 1,200 and 2,100 meters, and with the western redcedar-wes-

tern hemlock forests in the McDonald valley.

Because forests mature slowly and change is usually imperceptible, we are tempted to think of them as static and eternal. But since a forest is a community of living things, it responds to changes in the environment. Subtle physical or climatic changes, such as a rising or falling water table or a slight increase or decrease in annual precipitation, will favor some species of trees and hinder others, eventually altering the composition of the forest.

Other changes are more dramatic. Most notable of these is fire.

From Fire to Forest

Heat lightning, glimmering soundless behind the western peaks. Then the first low rumble. At first the flashing had been from cloud to cloud, but now, as the storm nears, the first ground-spears appear, lighting up the night. Here is a big storm, many-celled, engulfing more and more territory beneath its angry bulk. Lightning dances into the dry August forest. In their towers the lookouts stay awake.

Close strike and a flare-up! The ridge snag burns like a Roman candle, sending bright embers down. Valley, ridge, and peak blink on and off with blue light as the storm roars like night-firing artillery.

Passing overhead, the low cloud belly brings a sudden lash of rain. But it is not enough: tomorrow will mean long hours of fire watch.

The next day dawns clear, a morning of heavy dew. The ridge strikes did not ignite the forest. Inspecting the storm path, aircraft and lookouts find no evidence of fire.

But two days later, in a morning of high wind, thin smoke plumes rise upward. Smoldering in the thick duff of the forest floor, a lingering hot spot explodes with the fanning wind. It quickly spreads from a hectare to ten while the quadrants are called in and the hot-shot crews dispatched; then to a hundred, bringing in the smoke jumpers and mobilizing the vast fire-control network. A thousand hectares, perhaps ten thousand might burn this week of big fires.

In the resulting skeleton forest, the scene of devastation is almost overpowering: life seems forevermore excluded from this blackened ruin. But fire is nothing new to forest communities. We may think fire demonic because it takes from our life span this block of mature forest, a sight we will never again see in this place. But nature does not operate in terms of human time scales. This forest is simply pushed back closer to its starting point, to begin again its long progression toward a climax vegetation cover.

Forest Succession

Through a series of complex vegetation stages, each characterized by different herbs, trees, and shrubs, the forest slowly returns

to the type of vegetation best suited to the physical and climatic conditions of the site; this is called a climax community. The fact that most of Glacier's forests are in some stage of recovery from fire accounts in part for the mosaic of forest cover found here.

The forest of Huckleberry Mountain on the Camas Creek road was consumed in the 1967 fire. By 1969, among the charred, lifeless trunks of the former forest, lush grass and sunloving fireweed, thistle, and paintbrush were growing. And by 1974 lodgepole pine seedlings along the road were a meter or two high. Lodgepole is a fast-growing tree that requires full sun to germinate. Forest fire is necessary for the regeneration of these trees: the intense heat causes the tightly closed cones to open, releasing the seeds that will establish the forest. So young pines developed among fireweed, spiraea, willow, and mountain maple shrubs.

The lodgepole forest near the western entrance to the park has been developing since 1929, when fire destroyed the redcedar-hemlock forest in the area between Apgar and West Glacier. Beneath the scattered spires of old larch that survived the burn, the lodgepoles have now grown up, forming a canopy that shades the forest floor. Because lodgepole live only about 80 years and will not germinate in shade, this forest will not exist long. Shade-tolerant Douglas-fir, white pine, Engelmann spruce and western redcedar seedlings are now taking hold. But the physical characteristics of this area—the climate, terrain, and soil—are ultimately most favorable for western redcedar and hemlock; and unless other disruptions intervene, this area will eventually again become a dense redcedar-hemlock forest.

But this will not happen quickly. The soil after hundreds of years of collecting debris will again become rich and moist. Young hemlocks will germinate on and near decaying logs. When old larches, firs, and pines fall, the slow-growing redcedars and hemlocks will take their places in the canopy.

Forest succession is a more complicated story than this; it is a fascinating study involving herbs, shrubs, small and large trees, and animal populations. From location to location it will vary; only in its broad outlines is it predictable. It is based on the observation that, given time, a forest—or any other plant community—will progress until it reaches climax—that is, the stage that will perpetuate itself.

■

How then are we to think about fire? Increasingly, experts are concerned not so much with fire suppression as with fire management. For suppression has at least three disadvantages: it allows the accumulation of unburned fuels that can result in "fire storms" when they are finally ignited; an undiversified climax forest is more vulnerable to disease than is a mixed forest;

and a dense forest canopy discourages shrub growth, an important food source for deer, wapiti, moose, and smaller animals.

As the well-being of the deer herd depends on the predators that thin its numbers, so the long-term well-being of the forest depends on fire to rejuvenate it periodically. We must realize that wilderness is identified with fire, landslide, avalanche, windfall, and flood. Nature not only has learned to cope with these agents of change—she depends upon them for maintaining the delicate balances between landscape and life. There is in the business of nature, after all, more than the pleasing of man's eye.

Spruce Morning

Of all times to get a rock in my boot! I had just started out, the morning was still cool in this eastern valley, and the heavy pack was not yet biting into my shoulders. Sitting down beside the trail, I leaned the pack against the base of an old spruce and began unlacing.

I could hear the scratching of the red squirrel descending to investigate, but I didn't look up until it let go with long indignant chatter at finding its territory invaded. I plunked out the pebble and began relacing my boot. Cautiously the squirrel came down, pausing frequently to scold, its lower jaw quivering with rage and exposing yellow rodent teeth. Neighboring squirrels joined in and soon the trees danced with flicking tails.

Down the squirrel came, almost to the ground, then raced back up the tree, stopping at each lateral branch to deliver a vocal broadside. Finding no danger to themselves, the other squirrels soon quit the uproar and went about their morning business. I was beginning to suspect that I was committing some graver offense than the mere exercise of squatters' rights—perhaps I threatened its cache of fir cones. Then into the corner of my vision shot another form, streaking soundless as a shadow; the squirrel also saw it—but too late. With a thin terrified squeak, the rodent started to go higher; but the pine marten was above it. The squirrel quickly reversed itself, sending bits of bark showering down.

As the squirrel leaped from the tree in desperation, the marten overtook it in mid-air; they came down together. Clamping the limp creature firmly in its jaws, the marten strode up the incline of a fallen spruce. Before it hopped off onto a shelf of higher ground to disappear, it looked briefly back at me. I fancied I could read, fixed in its eyes, a certain recognition of my having distracted its prey.

A breeze made me shiver, snapping me back from that swift vision of luxuriant fur, that blinding grace which flashed its orange throat-patch through the trees, and I realized I was sweating. For a moment I had been that squirrel, eyes wide with terror, seeing fate bear down, and powerless before the natural order of things.

The incident got the other squirrels singing again; but the confidence was gone, and soon it was quiet. What dreams do squirrels dream, I wondered, looking around. I saw that place more clearly then, having been caught between a marten and its prey. I saw each spruce: its age, its condition, the onslaughts it had borne; the beargrass coming up in an opening; and down the trail a meadow that was yellow, white, and red with sulphur plant, mariposa, and Indian paintbrush. Bees, flies, spiders, and butterflies worked that little garden tucked among the crowding trees. Countless forms of life beneath the soil and bark, in tunnel, crevice, hole, and pocket, working unseen to sustain their lives, and somehow, when all were added up, maintaining the forest as well.

A flicker called, its loud *Klee-yer* breaking the forest hush. Birds, mammals, plants, insects—all hide together here, their lives so skillfully embroidered that no loose thread exists that my mind might grasp to unravel and understand the work.

The forest had once been a place that obstructed my view, a great blank to stride through, a few hours of necessary blur before the high lake or pass was reached. Now I was quite content to remain awhile beneath these great-boled trees.

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A forest, like the mountains themselves, supports various levels of life. The floor and substratum are a great processing plant where bacteria, fungi, and insects work, decomposing the plant and animal litter, recycling dead and discarded tissue back to simpler organic compounds, gases, and minerals, thereby providing sustenance for growing plants. As spiders, shrews, wrens, and thrushes seem to know, there is good hunting on the forest floor.

Just above the forest floor is the herb layer, a seasonal layer of growth including flowers, mushrooms, grasses, and other small plants.

Above that grows the shrub layer, then the understory of young trees awaiting their chance to take a place in the forest's canopy high above. From the swaying canopy, exposed to the full force of sun and wind, to the dim, moist floor, the forest provides a wide range of habitat.

Relatively few animals live in the treetops. The almost incessant motion makes nesting too hazardous for birds. Red squirrels venture up to cut cones in the canopy, but store their booty and make their nests farther down.

In the mid-range between canopy and understory, goshawks and Cooper's hawks nest. Woodpeckers, nuthatches, and sapsuckers forage on the tree trunks and nest in cavities they excavate or appropriate. Red squirrels and the nocturnal flying squirrels create a major traffic here, along with the martens and owls that hunt them.

The understory and shrub layers house

the greatest numbers of nesting birds. Here the effects of storm and rain are minimized and protective cover is greatest. Vireos, thrushes, warblers, hummingbirds, bluebirds, flycatchers, and others can be found among the tangle of this sometimes impenetrable layer.

The most populated area, the forest floor, supports an astonishing abundance of organisms. Below the busy traffic of mice, shrews, and larger animals is a bewildering array of insects and other invertebrates. The attrition rate in the litter of the forest floor—a continual battleground difficult to comprehend—is enormous. The smaller the organism, the greater its numbers are likely to be. This humus-rich, moist soil teems with bacteria, and a handful will contain surprising numbers of small spiders, pseudoscorpions and almost microscopic mites.

Each year some two to three thousand kilograms, dry weight, of falling material litter an average hectare of forest. All this plant and animal waste—twigs, leaves, limbs, fallen trees, feathers, hair, feces, and carcasses—is processed by the armies of decomposers that thrive on the forest floor. With the aid of larger creatures that break up the plant and animal tissue, most microscopic bacteria are able to decompose from a hundred to a thousand times their own weight every day.

Few trees die of old age in the forest. The seedling mortality rate is necessarily high, since far greater numbers of seeds germinate each year than can reach maturity. Of those that do, many fall victim to the ever-present dangers of disease, insect infestation, windfall, stream erosion, and fire. Insects alone present a formidable threat to trees, for they have evolved every means of attack—chewing and mining leaves, boring into twigs, eating cambium and heartwood, sucking sap, triggering galls. If the insect world did not police itself, aided by spiders, insectivorous birds and other animals, forests and other plantlife would quickly fade before the chewing, boring, sucking horde.

■

Through the trees the light on Citadel shows the morning slipping by. As I start to get up I see a garter snake sliding out into the dusty trail, seeking the sun-warmed earth. Moving slowly, alert for danger, it probes the air frequently with its sensitive tongue. But against the lightcolored duff its dark shape offers a fine target, begging attack. A chipmunk, watching from a nearby lookout stump, twitches its tail nervously over its back, curious—perhaps suspicious—at the sight of a snake. Very slightly the snake's head goes up, its tongue flickering. For a few seconds reptile and rodent regard each other. Then the chipmunk drops back soundlessly into its hollow stump, and the snake lowers its head onto warm ground.

Some day soon, a sparrowhawk or weasel will interrupt the snake's morning sun-

bath. The snake will fuel bird or mammal for a time, as mice, fledgling birds, and insects now sustain the snake. The chipmunk too, rummaging nearby, lives in shadows of talon and tooth.

Until that time of sharp encounter, each has its own niche, a way of life, a shaft of sun, and food enough.

A Walk in the Redcedar Forest

Climax! The word takes on a true significance here, among these broad-based trees. When you enter this forest the road noise does not follow far—as, when you walk into a cave and turn a corner, sound and light are left behind. There is a surprising spaciousness, a feeling of openness in a mature western redcedar forest. With scant understory and the canopy so far above and everywhere complete, it seems like some vast, high-ceilinged catacomb, pillared by the huge, shaggy-barked cedars and the deeply scored trunks of the black cottonwoods. The floor is strewn with fallen giants in magnificent disarray, uplifted roots still grasping fractured rock.

A rainy day is a good time to walk a cedar trail, when the dull light seems to shine from the wet moss, making the underleaves of devil's-club and Rocky Mountain maple glow. Wind and rain, like light, penetrate with difficulty the latticework of this canopy; thin lines of fog develop over the bogs. The air is fresh with growing plants, snow-cold still when the first spring flowers appear.

Fiddleheads of unfolding lady ferns line the trail in May, pushing up from the hub of last year's leveled, lifeless fronds. Beds of trillium shine their white, three-pointed flowers like flashlights in the dark recesses. Unlike the small, hidden calypso orchid, which bears its purple spikes and yellow throat low above the moss, the trilliums make no secret of spring growth. They are bold, handsome plants, broad-leaved and tall, with waxy white petals that tinge to purple in their month-long bloom.

Moss covers everything. Boulders are green and weightless-looking, resilient and topped with miniature forests of cedar seedlings. Ancient fallen trees are disguised with blankets of moss, sprouting hemlock here and there. The rich greens that characterize Glacier's summers seem to begin here amid the moisture-glossed leaves of twinflower, bunchberry and beadlily.

Later, the spiders will spin thousands of kilometers of gossamer filament among the trees. The orb-weavers will hang their webs high and low, suspended in every opening. Walking through the forest then, you will see shafts of sunlight whirling in the higher webs until they seem like tops set spinning among the treetrunks.

Indianpipes, the "ghost flowers" that need no light to grow, will break through the forest soil. Like mushrooms, with fruiting bodies that are nourished by under-

ground mycelia, these saprophytes absorb their nutrients from a fungus that covers their roots.

Receiving an average of about 18 centimeters more annual precipitation than forests east of the Divide, Glacier's redcedar-hemlock community hoards its moisture. Its dense growth and the surrounding mountain walls inhibit the circulation of drying winds. Mosses and ferns transpire their moisture, which you can feel; place your hand close, and you will sense a coolness like the air exuding from an ice cave. Draped from the tree limbs are long filaments of squawhair and goatsbeard, black and grey lichen strands that flourish in the damp air.

Except for the black bear, few large animals inhabit the deep forest. Grizzlies find better forage in meadows or along the forest edge. Since shade discourages shrubby undergrowth, deer and wapiti will search elsewhere for browse. In summer, wapiti, grizzlies, and mule deer bucks tend to wander up into high meadows.

Contrasted to the noisy, conspicuous birds of the prairie—meadowlarks and bobolinks—birds of the forest seem elusive and secretive. Although numerous, the varied thrushes, Townsend's solitaires, and Swainson's thrushes are seldom seen; but when approached, they fly silently off and are swallowed by the forest shadow.

There seems to be serenity in a mature forest, as though the struggle for life is somehow suspended, the needs of the animals here less urgent, muffled. The towering redcedar forest seems to be no battlefield at all, but rather a monument to what Earth can do.

The Perpendicular Night

Behind Avalanche campground a trail leads back toward Lake McDonald Lodge. I decided to follow it one June evening, to experience the sensation of the deep forest changing into night. With the nearby mountain wall intercepting the sun, dusk comes early to this valley. On the prairie, night passes across the landscape in an even line, forthright as a waxing tide; you can almost feel the globe in its turning from the sun. There is reassurance in the night's coming, its steady purple doming over the sky.

But here darkness seems to sprout from the earth. It collects beneath the hemlock clumps, bridges the creekbottoms. It seems to flit from place to place. You look about, uneasy, trying to catch it here or there, but always miss its infiltrations. It captures the narrow clearings when you look away; pockets of tree-darkness join together, forcing the light upward until the tree-tops seem impossibly bright and distant.

Through the trees I could see a dozen fires dance in the growing shadow, woodsmoke and camp sounds filling the air. Turning uptrail, I felt a reluctance to leave the presence of those fires—a senseless feeling, but strong. A growing forest-dread im-

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The Vital Predator

The merciless law of predation might at first thought seem cruel; but the predator plays a vital part in maintaining the balance of the biotic community. Without the controlling factor of predation, prey species quickly enlarge their populations. If plant eaters are not checked, the resulting excess population exceeds the carrying capacity of the range. Food supply rapidly diminishes. In a damaged range, competition and stress result, usually culminating in a massive die-off through starvation and disease.

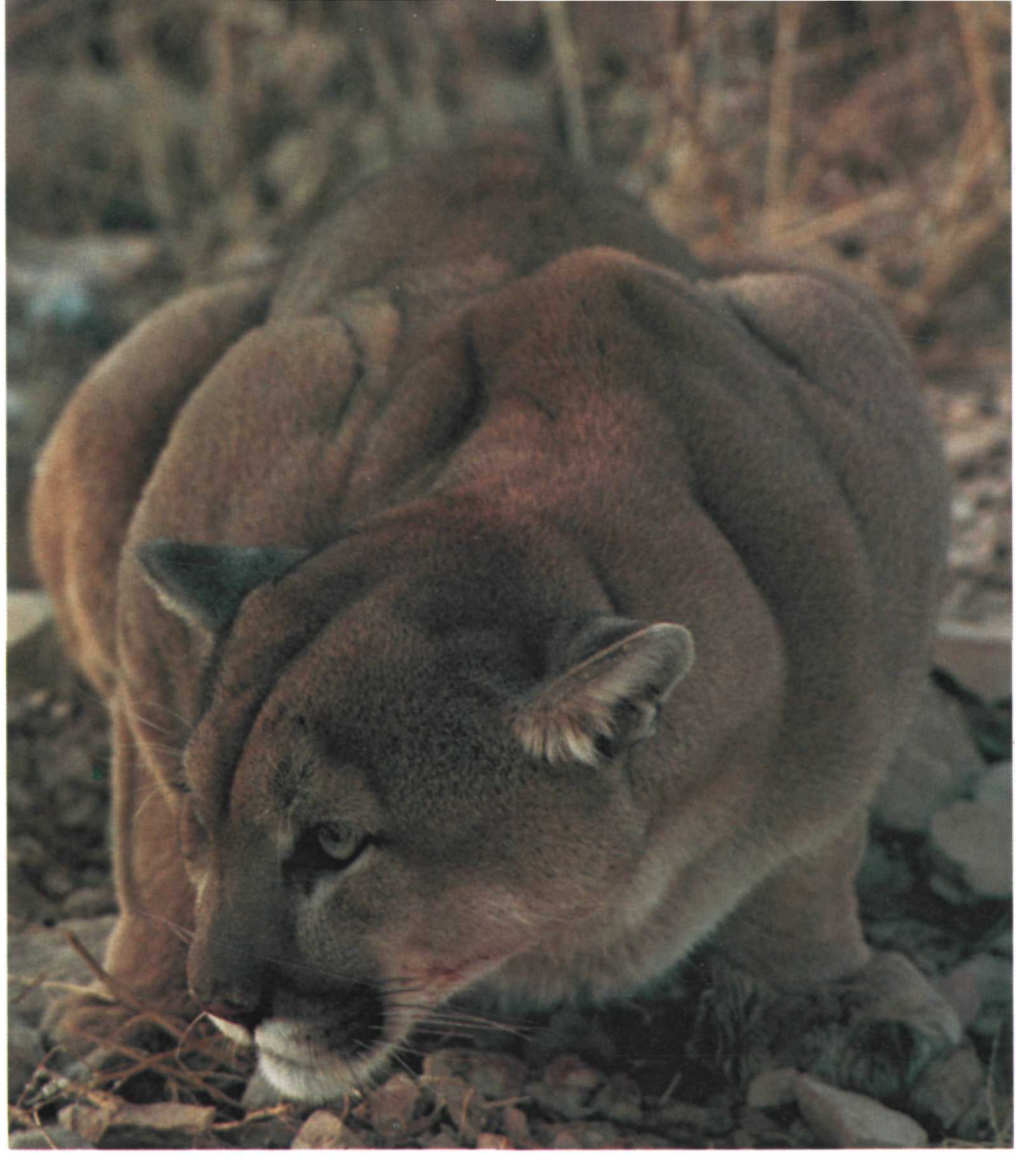
Ironically, predators thus provide a service to their prey. First to fall to the predator are the old, the diseased, the unwary, and the young. By removing many young and old deer from a typical herd, cougars lessen competition among the deer for choice range, thus tending to keep herbivore numbers at parity with the land's carrying capacity. Only the strongest and wariest deer survive, ensuring that the fittest will continue the species. When man upsets this delicate balance—destroying predators in the hope of increasing numbers of game animals—the result is ecological disaster. In the 1930s, in a misguided attempt to "preserve" the whitetail deer herds of the park's North Fork area, many coyotes and cougars were exterminated. In 1935 alone, 50 cougars were killed. Relieved of the pressure of predation, the deer flourished. In a few years, however, the normally adequate range was severely overbrowsed. Suffering also from this imbalance were wapiti ("elk") and moose, ungulates that share the winter range with deer.

Some predators are more specialized than others. The Canada lynx, for example, has oversize feet, an adaptation that helps it move across deep snow without breaking the surface. As a result, it is an efficient predator of the snowshoe hare, another large-footed animal. Relying on this adaptation, the lynx feeds almost exclusively on snowshoe hares. Consequently, its numbers inevitably fluctuate with the 10-year "boom and bust" cycle of the snowshoe.

The coyote, on the other hand, is a generalized predator, exploiting whatever prey is currently abundant. Should mice or ground squirrels be in short supply, it will subsist on anything from grasshoppers to berries until favored prey again becomes available. (Animals that normally eat both plant and animal food are referred to as *omnivores.)* Generalized predators are thus better equipped to survive temporary ecological imbalances, maintaining their numbers at relatively consistent levels from year to year.

Carnivores all, the animals on these pages illustrate various adaptations for capturing prey.

The population of the Canada lynx, which is widely distributed in Glacier's coniferous forests, fluctuates in cycles. The lynx is abundant or scarce depending on the population condition of its chief prey, the equally cyclic snowshoe hare.



The cougar, which feeds primarily on deer, requires a large territory. Because of its strength, stealth, and speed, American folklore has given this wary cat a false reputation as a man-stalker.

The red fox depends largely on a well-developed sense of smell to locate its prey; it also relies on its keen eyesight, speed, and agility to capture mice, hares, birds, and whatever else it can run down or surprise.

To feed its demanding young, the Swainson's thrush hunts for insects along the forest floor and in the dense underbrush. This thrush relies on its secretive behavior to protect its nest near the ground from detection by other predators.

Armed with enlarged forelegs, the crab spider waits on or near flowers to ambush visiting bees, flies, or other insects. Its venom produces a quick kill, allowing it to attack insects many times its own size.

The spotted frog is a large-mouthed predator that not only eats water striders and other insects but also gulps down smaller frogs and small fish.

Protective Coloration

To escape extermination, each species must in some manner foil its enemies. Protective coloration is one of the more common adaptations helping to do this. Most animals resemble their environment to some extent. The conspicuous markings of some, like the bitter-tasting monarch butterfly or the striped skunk, seem to function as a warning to prospective predators that it is in their best interest to look elsewhere for a meal.

Some animals, such as the white-tailed ptarmigan and the snowshoe hare, have seasonal changes in plumage or pelage, wearing white in winter and brown in summer. Even predators, such as longtail and shorttail weasels, benefit from seasonal camouflage. Protective coloration makes them less noticeable to prey species and to larger predators.

Many insects, too, change coloration with the season. Bright green grasshoppers of early summer become more brown with each molt, matching the changes in the surrounding vegetation.

Obliterative shading is especially important to animals that frequent more than one habitat. Seen from above, turtles match their dark background; from below, because of their lighter underbody shading they blend into the bright skylight.

Disruptive coloration aids in breaking up an animal's outline. Butterflies and moths commonly have disruptive wing markings. The distinctive shapes of eyes can be concealed. Eye coloration may mimic body color—as in the green katydid —or the eye may continue disruptive body markings.

Ground-nesting birds are especially vulnerable to attack. Their eggs tend to be heavily blotched with earthy colors, making them less conspicuous. Chicks also carry these disruptive colorations on natal down.

Most mammals, with coats of brown or gray, are inconspicious when motionless. Deer fawns are endowed with speckled coats, mimicking the sun-flecked forest floor; this disruptive coloration, coupled with absence of scent and their instinctive "freezing" behavior, makes it difficult for predators to detect them.

The whitetail deer not only uses its white "flag" to warn others in the herd of danger; it also allows a pursuing predator to use it as a target. When the tail is suddenly dropped—abruptly obliterating the bright white patch—the deer seems to disappear into its dim surroundings.

Since overly conspicuous animals are prone to predation, natural selection favors *development of appropriate camouflage.*

For such ground-dwelling birds as the white-tailed ptarmigan, camouflage is an important survival adaptation. The ptarmigan changes its plumage to match its surroundings: it is white in winter, speckled in summer. Moving slowly and refraining from flight, it is less likely than more-active birds to be detected by sharp-eyed, motion-conscious predators.

Birds that when hatched are covered with down and are able to move about freely are called *precocial.* They are less dependent upon their parents than are *altricial* young, which are naked and helpless when they hatch; but they must rely heavily on a resemblance to their surroundings for survival during their first flightless weeks. This spruce grouse chick, which blends into its sunflecked forest-floor habitat, is an example of a precocial bird.

The bold disruptive pattern of the killdeer chick's plumage helps this precocial bird avoid detection in its open-prairie environment. This adaptation, coupled with the chick's instinct to freeze at the approach of danger, ensures that enough young will survive to perpetuate the species.

Ursus arctos horribilus: The Vulnerable King

At the apex of the food pyramid, this great beast is unquestionably the king of Glacier's biotic community. Yet the long-range future of the grizzly bear is uncertain. With the grizzly exterminated from most of its former range—which once extended into the midcontinent and south into Mexico—its numbers have dwindled in proportion to its diminished range. Present concentrations in the contiguous United States remain in and around Yellowstone and Glacier National Parks. Probably fewer than 200 of these magnificent creatures live in Glacier National Park.

Grizzlies are easily distinguished from the more common black bear. In addition to larger size and heavier build, grizzlies have a characteristic shoulder hump; long, conspicuous claws; and a broad, concave face that gives them a "dished-in" appearance. Fur is usually brown; like the fur of the black bear, however, color may range from black to yellowish. Light tipped hairs make the fur appear frosted, giving rise to the nickname, "silvertip."

Grizzlies, popularly considered arch predators, are more accurately described as omnivores. Carrion, grasses, cow parsnip, and several species of berries, bulbs, and tubers make up a grizzly's diet, along with insects, small mammals, and an occasional ungulate that it can catch. As a result, grizzlies play several roles in the biotic community, functioning as herbivore, scavenger, and predator.

Ranging widely in all life zones, grizzlies follow the spring snowmelt up to the alpine meadows, returning to lower elevations to hibernate from November until April. One to three cubs are born in midwinter during hibernation. Since the maternal bond lasts two years, a sow will accept a mate only every other year. Mortality of subadults is high, resulting principally from competition among the bears themselves. As with most animals, range—habitat—appears to be the limiting factor of grizzly populations.

The grizzly is normally shy and fearful of man—but highly unpredictable. Wounded or sick bears, sows defending cubs, young adults, and bears that have become conditioned to human scent are the most dangerous. As humans continue to encroach on grizzly territory, odds of confrontation also increase. Recent fatalities and personal injuries inflicted by grizzlies pose a vexing problem to the National Park Service, which is charged with visitor safety on the one hand and protection of the park's remaining grizzly population on the other. Continuing study of grizzly ecology and increasingly enlightened bear management programs will, it is hoped, allow man and bear to co-exist in a wilderness both require.

Grizzlies are fond of succulent spring grasses.

Traversing all life zones in the park, the grizzly is a true opportunist, eating anything from ants and berries to wapiti.

Seldom will a grizzly exceed 225 kilograms in Glacier. This is a young adult.

Bald Eagles and Kokanee Salmon: A Recent Gathering

In 1916 the kokanee salmon, a small, land-locked form of the Pacific coast species, was planted in the Flathead drainage. With the first planting augmented by additional stockings, the fish thrived in cold, deep Flathead Lake, and, to a lesser extent, in Lake McDonald. The salmon fed almost exclusively on zoöplankton.

By the mid-1930s, salmon runs were becoming established. The outlet of Lake McDonald provides an ideal spawning site for the salmon. The fast-flowing water is clear, cold, and shallow, and the creek bed is gravelly.

Averaging 0.3 meters in length and weighing less than a half-kilo, the 4-year-old adult salmon cease feeding and begin to migrate. Many thousands swim the 100 kilometers from Flathead Lake to McDonald Creek. Males appear in the creek first, arriving in late September, and are soon followed by the females.

Using her tail to dig a redd (a shallow nest depression), the female deposits about 650 eggs. After fertilization by the male, the eggs are covered over. The adults die within three weeks after spawning, their bodies exhausted from the rigorous migration journey and the weeks-long lack of sustenance.

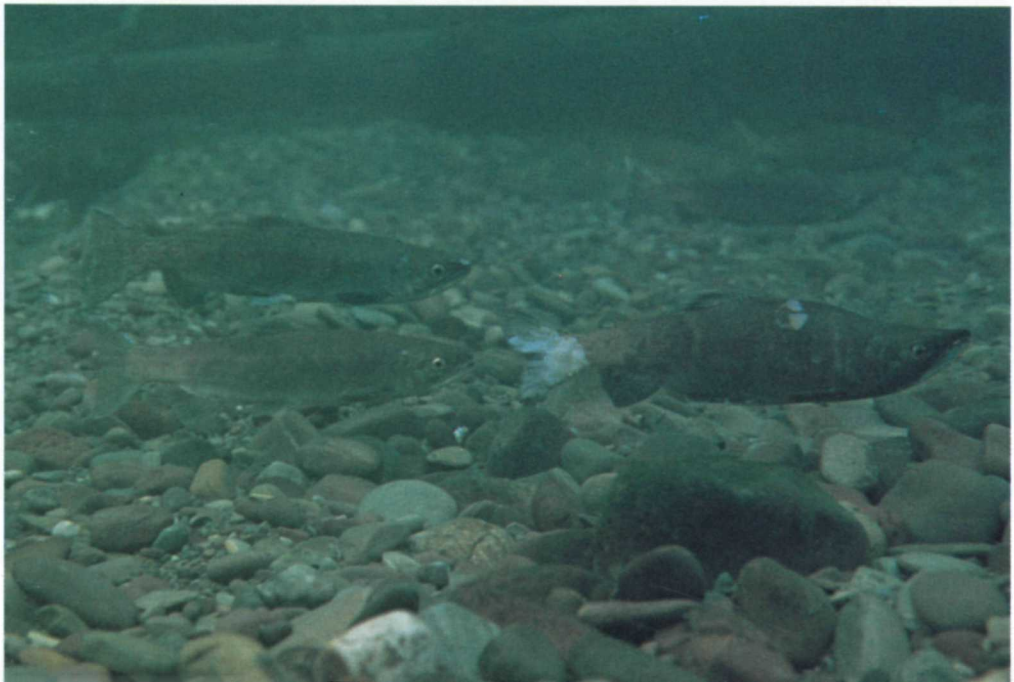
Egg fatalities are high, due to stream erosion and disturbance by other spawning salmon. Hatching in late March, the fry work their way out of the gravel and migrate downstream.

Attracted to the 75,000–150,000 salmon concentrated in a 3-kilometer stretch of shallow water, bald eagles begin gathering at McDonald Creek in October. It is not known where the eagles come from or where they go after the spawning run. Glacier has fewer than 20 summer-resident bald eagles, and these are distributed among the remote lakes of the North Fork area.

In 1939, 37 bald eagles were counted along the creek. By 1969, 373 were reported, representing approximately 10 percent of that year's estimated winter population for the contiguous United States. Since 1960, the count has averaged 240 birds. (In 1977 there were 444.)

Eagles feed by swooping down to pluck salmon from the water or by wading out to grab a fish stranded on a shallow riffle. An eagle may consume as many as six fish a day. Immature birds are not as adept at catching fish and may harry adults or other immatures into releasing their catch.

From its vantage point, this mature bald eagle examines the waters of McDonald Creek. Average weight is 5.7 kilograms; average wingspan is 2.2 meters. Females are slightly larger than males.



This immature bald eagle lacks the familiar white head and tail of the adult birds. It will not acquire those markings until it is several years old.

Breeding male and female kokanee salmon are easily distinguishable; as spawning time approaches, they change appearance. The dark gray backs turn red; heads become green, and the males develop humped backs and hooked jaws.

Swooping upward with a fish, a mature eagle heads for a convenient perch to consume its catch. A strategically located tree may contain 30 birds.

A Triumph of Many Colors

Grassland, meadow, tundra, or any other area in Glacier suitable for plant growth and supplied with abundant sunlight produces an extravagance of wildflowers. This display of various shapes and colors is neither an accident nor a mere decoration of nature. Nor would Earth's recent explosion of mammal and bird species have been possible without the evolution of flowering plants.

Two hundred million years ago, early in the Age of Reptiles, angiosperms (flowering plants) had not yet evolved. Plant reproduction still relied on spores and cones. Then, during the Cretaceous Period, the last sediments were being laid down in the inland sea that covered most of Montana. (It was these sediments that the ancient Precambrian rocks of Glacier's mountains later overrode, forming the Lewis Overthrust.) During this period the evolutionary miracle occurred: flowering plants—grasses, vines, shrubs, broadleaf trees, wildflowers—inherited the Earth.

The timing was important. As Earth's tropical climate gradually changed to temperate extremes during this period, the domination of cold-blooded dinosaurs ended and the moisture-demanding coniferous forests that had covered the earth in green monotony began to shrink. Angiosperms provided a solution to the ecological void: grasses and forbs grew where trees no longer could. Most important, relationships evolved between this new class of plants and the relatively few species of insects then existing.

Insects began to use the pollen of flowering plants; the angiosperms, in turn, evolved bright petals and nectar that exploited visiting insects for the plants' own reproductive purposes. This partnership allowed insects to diversify rapidly, evolving new, specialized forms such as bees, moths, and butterflies. As a result, predatory forms of insects and arachnids also rapidly diversified.

The most dramatic change, however, involved warm-blooded birds and mammals, whose high rates of metabolism required high-energy fuels. Unlike gymnosperm seeds, which contain no protective covering, angiosperm seeds are surrounded by a fruit. The development of these highly nutritious seeds, and the attendant explosion of insect species, ensured survival of the newly evolved birds.

As birds diversified into seed-eaters, insectivores, and carnivores, mammals, then uncertain little ratlike creatures darting among the feet of dinosaurs, began a rapid rise to dominance; grasslands promoted an explosion of herbivorous and carnivorous species.

The evolution of angiosperms, and the animal revolution it made possible, came with amazing speed. Most significant, it was a vital first step upon which the meteoric rise of man depended.

Indian paintbrush (on page 97) is common at all elevations below tundra. It may be white, yellow, orange, pink or red. The actual flowers, inconspicuous and green, are surrounded by brilliantly colored bracts. Semi-parasitic on other plants, paintbrush is normally found growing in conjunction with other wildflowers; its roots steal sustenance from neighboring plants.

Yellow stonecrop, widely distributed in forest and scrub-forest zones, is one of the park's few plants having succulent leaves, an adaptation that helps it survive in such situations as dry, rocky outcrops.

The Calypso orchid grows in the cool, shadowed forest where light is dim. It lives in partnership with certain fungi that exist about the orchid's roots and seem to help nourish it.

Silky lupine, a legume, has nitrogen-fixing nodules on its roots, thus allowing it to grow in nitrogen-poor soil. It is widely distributed in grassland and forest communities.

Fire Succession: Key to Continuity

Most of Glacier's fires are lightning-caused. Strikes may flare up immediately; or fires may smolder in the forest duff for days until fanned into flame by wind. *Ground fires* may race through the forest understory, causing minor damage; or they may bridge the understory and reach the canopy, thus becoming rapidly spreading *crown fires.* Under certain conditions, uncontrollable infernos may develop, generating terrific winds and heat. These rare conflagrations are called *fire storms.*

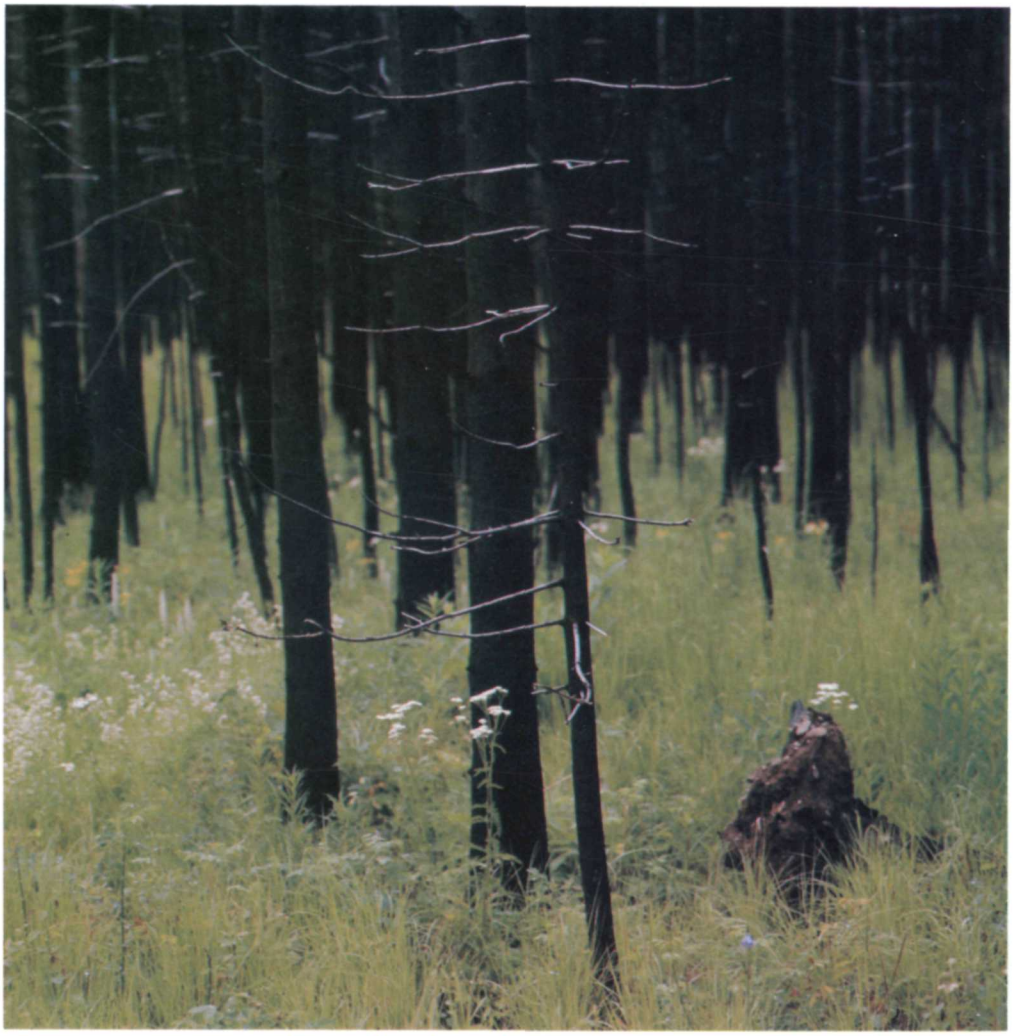
Every type of forest habitat has *climax vegetation*—trees and shrubs that are best suited to the site and thus maintain themselves indefinitely if not disrupted.

After a major fire, habitat conditions are usually so altered that the site must pass through several *seral stages* before conditions are such that climax vegetation can return. A *sere* is a series of plant communities that follow one another in orderly fashion until climax conditions are again reached.

Lightning fires occur most often during the hot, dry weeks of late summer.

When the forest is dry, lightning often causes quick flare-ups.

The forest may continue to burn for days after the main conflagration has passed.



After a major fire, sun-loving grasses, shrubs, and wildflowers quickly invade the former forest. Deer and wapiti benefit from these new food sources.

Lodgepole pine, a pioneer species quick to take over burned areas at lower elevations, grows rapidly. These trees are five years old.

This is a Glacier National Park forest 80 years after a major fire.

pelled me almost physically backward to those circles of firelight. I felt the need to be near a fire, to be reassured by heat and light. Fire was our greatest friend, our greatest weapon. With it we beat the long ages of ice and held the forest gloom away. There was no harm here, only silence; yet the longer I walked, with beard-moss hanging down like daggers all around, the more I craved the comradeship of fire.

Sudden hammering made me jump. Above the forest darkness, a pileated woodpecker leaned out from a high larch snag, braced against the trunk by its specialized, stiff tail feathers. This was the first time I had seen this big white-and-black bird, the "cock-of-the-woods." There was ample evidence of his work: the deep, oblong excavations in the trunk and the pile of large wood chips at its base, both characteristic of this species. Again he hammered, and I could see the chips falling. After a little edgework around the hole, he extracted a grub and flew off, yammering against the advancing dark.

Near a stream I stopped to sit down, to listen to the water and maybe catch sight of some small animal. Across the narrow defile, from a slope dense with young hemlock, came the buzzing note of a varied thrush. Several notes followed, all on a different pitch, all drawn out, level and clear; the quality was pure but songless, disjointed, deliberate, like someone testing the reed of a strange woodwind. There seemed no gladness in the heart of this thrush. The song was dark, haunting, lonely.

On the trail ahead I could make out a bird hopping rapidly along. After passing the spot I could hear its song. There couldn't be a hundred meters between us, yet it seemed to be coming from a great distance. I listened for as long as it would sing. I tried to hear it for what it was, a male Swainson's thrush proclaiming its territory. But the ethereal, flute-like phrases seemed an evensong made not for man's ears but only for the forest itself.

I hurried on after the bird had ceased. It was getting dark beneath the trees, but I was beginning to be aware of creatures underfoot, the mad dartings of shrew and vole, more imagined than seen. When a deer mouse jumped away I got out my flashlight. Soon the beam caught a woodrat sitting atop a fallen log. The light didn't bother him in the least; as I approached, he picked up his bushy tail in his forepaws. Whiskers twitching, he looked more caricature than real. Then he bounded off the log with graceful, arching hops, and disappeared into the night.

Against a patch of sky that appeared in a clearing, I could make out bats, circling and dipping like swallows. Locating a hovering moth, I kept the light beam on it until it vanished into a furry streak of silence. It was time to head back.

By now it had become utterly dark within the trees, a moonless, sightless, alien

world, given over to the marble-black eyes of the small night mammals and the creatures that hunt them. I thought of the strange, unseen societies of the flying squirrels, the nocturnal counterparts of red squirrels; of the great-horned owls, inspecting the same ground the goshawks scanned during the day. Perhaps a foraging red fox moved through the darkness nearby, or a coyote on night patrol.

The flashlight beam probed ahead along the trail. The exposed roots were given unnatural shading and they seemed to thicken and squirm as I approached. On either side the tree trunks appeared to step backward from the dim glow of the light. I felt lost in this night, thinking of the great darkness in all the timbered ridges that ran westward from the Divide. In this vast cathedral of crowded tree and peak, night was stood on end, the stars shrunken to a circle overhead, as if seen from the bottom of a well. Mouselike, shivering, insignificant in this wilderness, I scurried back to find a fire and fill my empty senses with its heat and snap and light, holding off the fright of night and thinking of tomorrow's sun.

Scrub-Forest

The crowning beauty of Glacier—the high, cirqueheld meadows that scent the wind with wildflower and waterfall—belongs to the zone of scrub-forest.

At Logan Pass you are introduced to the highlands. Here an exquisite upland basin holds the Hanging Gardens, a wildflower-clothed gradient laced with stair-step bogs and lines of wind-bent subalpine fir. In the dawn sun, before the first engine noise, it shines unbroken, dewbright and sagging like a spider web secured to the circle of surrounding peaks.

This is the region the hiker remembers best. The tall mountains wear this zone close to the cliffs, and the trails encounter it near the passes or follow it for long, level stretches, as along the Garden Wall. I remember Preston Park and Fifty Mountain, the fire-touched bench of Granite Park and the first sight of Sperry chalet, built on a brow of rock at the upper reach of trees. But most of all I remember the terrible waterfall that becomes Bowman Creek, the plunge of nearly a kilometer that drains the magnificent upland bench called Hole-in-the-Wall.

Hole-in-the-Wall

September. The season is growing late, the meadow-rue dying and the leaves of the wild strawberry failing at last. Everywhere the red contagion of autumn surrounds the

vital green. The lower valleys have lost the whistle of ground squirrels. They sun themselves no longer these late, mild days. Ripe, sluggish, and hawk-vulnerable, they sensed the need of hibernation.

It has been eight years since I last visited Hole-in-the-Wall, but I retain its dimensions and hear its dozen waterfalls at will. Once you have seen this basin you have a measure by which to judge the high country and a thirst for the meadows at tree-line.

In Glacier, treelimit ranges between 1,850 and 2,300 meters, depending on local conditions. The upper limit of tree growth—rarely an even, horizontal line—is generally an indistinct band running erratically across a mountain's face: a tension zone reflecting variations in wind and sun exposure, degree of slope, snowpack accumulations, and the presence of adequate soil and water.

Subalpine fir, whitebark pine, and Engelmann spruce do not relinquish easily their upward climb; where conditions become severe, their growth is retarded and their stature dwarfed. Deformed and pruned by wind, their leaders winter-killed when they outreach the protection of the winter snowpack, trees become shrubs, forced to hug the ground. Size belies age in these elfin forests, or krummholz, where the growing season is painfully brief and progress is always uncertain. A twisted, gnarled little bush, more snag than live branch, bearing a single cone or two, may be senior by a century to the giants of its race in the valley below, which yearly shower the ground with an abundant crop of cones.

This time I will come from Goathaunt, passing Lakes Janet and Francis, reaching Brown Pass from the east, and camp in the spectacular garden between Brown and Boulder Passes.

Meadows and rock slides break the forest as the trail gains elevation and distance through the valley. The spruce and fir thin out rapidly at the valley head, the trail climbing the grassy slope to low, broad Brown Pass. Below the pass is Thunderbird Pond, which receives the meltwater from a glacier high on a shelf of Thunderbird Mountain and is bordered by a low jungle of willow. In the water stands a bull moose, its heavy, fully formed antlers ready for the season's impending business.

I was hoping again to see Cassin's finches and Audubon's warblers on the pass; but the fir grove is quiet. Sitting down to rest and listen, I become aware of a strange silence. No birds sing or flit among the trees, no alarms pass back and forth among alert ground squirrels. There is no wind—an odd condition for the Continental Divide. This place seems to be holding its breath. High overhead, a veil of cirrus cloud arranges long spears across the sky.

Moving off the pass, along the dome of Mt. Chapman, I experience anew the old excitement of this high country. Abruptly the gorge of Bowman valley opens up, revealing

the twisting blue snake of Bowman Lake far down the narrow, cliff-imprisoned valley. Here again are the northern titans—Numa, Peabody, Boulder, Thunderbird, and Rainbow; and Carter, with its high glacier baring blue ice teeth to the sun.

It is not the climb that makes your heart pound now; the trail is suddenly narrow and cliff-defiant, cut by the plunging waters of snowbanks far above. These are splendid peaks, unmatched in a land of muscled, brutal earth. Even the air seems to retain the scent of glacier work.

At last the view of Hole-in-the-Wall, a staircase cirque excavated between the gigantic spread ribs of Mt. Custer. The slopes of beargrass are seed-spotted and gaunt now, the white fullness gone. Western pasqueflowers have accomplished their magic transformation; known in this season as old man's beard, they nod their tufts of grizzled seedhead silk in the wind. Red and yellow monkeyflowers bloom yet, crowding along the many stream courses, and waterloving sedges and mosses surround pools of collected water on the broad horseshoe tiers.

A spur trail drops down into the campground on the last ledge. Through a cleft in its lip plummets the gathered water of the basin. From the valley below, the waterfall appears to be springing from a hole in the headwall, giving this basin its name. Down, down, down, roars the water where once a mighty glacier ground its teeth.

I leave until later the making of camp; by now the sharp shadows of Boulder Peak stab the valley forest and are beginning the upward assault of Thunderbird.

Around the basin headwalls, last winter's snowbanks remain formidable. Snow caves send out meltwater torrents. Glacier lilies and patches of spring beauty line their fringes. Pasqueflowers bloom in pockets. Here, among the asters of August, bloom also the first flowers of spring, shooting up as the snowbanks shrink, making these spots of snow-free ground a patchwork of May and July, August and June. The shrubs that line the furious water are willows, still bud-swollen this tenth day of September. The coming days will bring a sharp surprise.

Winter will soon stop the melting of this snow. Could it be that I am seeing the first year of a reawakening ice age? If so, each year the snowfields would grow thicker and broader, connecting the shelves into one ice mass again, lilies and willows entombed, the summer heat failing to rescue them, until the ice at last began to slide, stripping the soil and once more plucking at living rock.

Then these dwarfed fir, which cling precariously to the cliffs and hide behind the backs of boulders, would be in more danger than they were from their recent antagonists. Engulfed by ice, they would know the shearing wind no more. Their skeletons would rain down into the valley below, signalling another long forest retreat. But they have waited out the mountain ice before and would send their seeds again to this valley,

changed however it might be, as they have always done.

Evening brings out two sleek mule deer does. As they graze, their large ears stand erect, sorting out the lesser sounds from the ceaseless roar of water. Both raise their heads and point their ears, statue straight, at the scuttle of a porcupine. A noise among the rocks draws a backward glance and focus of those ears. I would like the sensitivity of such fine equipment, to hear what deer have always heard.

Setting about the business of camp, I wonder about those animals that watched me for a while, then moved off, having seen a tent go up before. With the appearance of the moon the wind increases and they test the air more often now. Do they have visions of cougar or grizzly with every snap the wind delivers?

In summer these high meadows see a surprising variety of animal life. Briefly out of hibernation are marmots and the handsome golden-mantled ground squirrels. Mice, voles, shrews, and woodrats run among the shadows, feeding on the season's feast of seeds and insects. A nightmare for these are the fierce little weasels that haunt the rocks.

Tracks of cougar and wolverine are sometimes seen, often teasingly fresh; to glimpse either of these elusive predators is to taste the finest wine of wilderness.

Before the berry season, grizzlies grub the meadows for the tasty bulbs of glacier lilies and the tubers of spring beauty; often distracted by the scent of a ground squirrel in its burrow, they sometimes make a huge excavation for a small reward.

White-crowned sparrows sing in July from the low tops of the battered trees, though their nests are on the ground below. Grey-crowned rosy finches patrol the drier ground for seeds while water pipits hunt insects in the wet areas. High above, a golden eagle scans the basin again, circling slowly before following a ridge south to sight another likely slope in its 10,000-hectare territory.

The moon shines through the tent top. The wind, blowing more violently now, shivers the nylon and interrupts the voice of the waterfall. I have followed the pasqueflower run from the April prairies here to its highest bloom near treeline. I think about the triangular seed pods of the glacier lillies, colonies of steep-throated blue gentians, and the season's last glory of goldenrod. Indian paintbrush, from white to fire red, blazes the slopes that light the fringes of sleep.

I awake to a determined rain, the moon gone and the tent shuddering with windblast. I try not to think of the steel-cold air, and slip into a fitful sleep that seems an endless treadmill of rocky trail.

Stiff and unrefreshed, I look out into the dawnless morning. The tip of Thunderbird is detached from its base by grey clouds swirling at its throat. A wave of sleet slants down, dancing on the rocks, chanting tri-

umph over the buried, bent, and broken flowers of yesterday.

So I must make my escape, short of Boulder Pass. Unattainable now, invisible above the cirque, that high pass grows in my memory. This testament to what a glacier can do, to the struggle of trees and the life-pioneers that invade such harsh places, is at my feet but shrouded with snow. My hands grow stiff and numb in the blunt work of packing up.

I had wished to see Kinnerly Peak again, rising from the western Kintla valley, and walk along black ledges of the lava that floors the pass. Beyond it grows a grove of subalpine larch, stately, seldom encountered, the least common tree species in Glacier. Confined to this narrow zone between forest and alpine, it reaches up tall and proud, impervious to the gruelling climate that makes cowering shrubs of other trees.

But all must wait another year, for this season comes down hard. And the will of winter is to erase whatever summer had devised.

Tundra

Porcelain-cold, the November sun dawns in the southeast sky. The ledges, ice-encrusted, layered with sleet from a recent squall, whistle the cold morning wind aside. Rattling down, a slide of rock plunges off the final ledge, seconds passing before the hollow sounds of impact clatter back. Like an apparition of winter itself, white beard bent sideways by the wind, a mountain goat steps to the precipice edge. Looking out across the vast white void, its long belly hair and pantaloons streaming with the ceaseless wind, this strange animal, product of some unfathomable ingenuity, hesitates but a moment; dropping down from step to invisible step along the sheer rock face, fracturing the ice glaze as it goes, it turns a wall and disappears. A nimble, eight-months-old kid follows.

Blinking and twisting in the dull light, the shower of shattered ice clinks softly downward against rock, fading away like the short summers of this place.

But while the wind chants winter, life has made a passage here, and also waits, hidden in seed and root and den.

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The nanny and her kid have bedded down now, looking across the deep, snowy basin below. Their ledge shines with the first spear of sunlight.

Far below the pass that connects Mount

Siyeh to the snow-giants Matahpi and Going-to-the-sun, three male white-tailed ptarmigan emerge from their night's huddle within a snowbank and step out to peck at an exposed mat of willow. Ptarmigan, the only birds on the winter tundra, wear white plumage in this season, helping to camouflage them in the snow, just as their mottled brown summer plumage makes them difficult to detect among bare rocks. There are few predators here to hunt them now, but they move with habitual slowness; quick movement can be fatal when summer brings numerous eyes to scan the slopes. With legs and feet heavily feathered and sharp claws to scratch for food beneath the snow, the ptarmigan live at truce with winter. When blizzards rage between the peaks, they nestle together in snow dens, beyond the reach of the winds. Ptarmigan hens winter lower in taller willow thickets, but the males prefer to take their winter as high as possible.

Now they crouch behind the wind-deflecting rocks, dozing in the meager warmth of the morning sun.

Near the snowless summit crags, a flash of brown fur zigzags among the rocks. That would be a pika. Only for a moment does it show itself, so quickly does it move.

Also called the rock rabbit, the diminutive pika belongs to the order of hares and rabbits. Resembling a small guinea pig, this sturdy creature spurns hibernation as a way to beat the challenge of winter. Instead, it spends the summer laying in a store of hay for the lean season, spreading cut grass to cure upon the rocks and tending its "haystacks," on which its survival hangs.

Winter is a great peril to small mammals. Their small bodies, because of a large surface area in relation to volume, retain heat poorly, and their high metabolic fires consume calories quickly. Great amounts of energy are required to sustain an active animal in rough terrain, placing further demands on the animal's capacity to survive the cold. The pika may need to stack as much as 25 kilos of hay; to keep its furnace burning during winter it will have to fuel its stomach almost hourly.

Small animals of cold climates often show distinctive body adaptations. On the pika the small, rounded ears lie flat along the head, the tail is inconspicuous, the legs are short; heat loss from exposed surfaces is thus reduced. Fur insulates the soles of the pika's feet while at the same time providing good traction on steep rock faces.

Hidden below these rocks are the hibernating marmots and the sleeping ground squirrels. Beneath the snow the mice, shrews, and pocket gophers struggle on with their lives. But above ground, directly confronting this arctic climate, are the pika, the ptarmigan, and the mountain goat.

A triumph of adaptation, the mountain goat faces the winter day without benefit of either the pika's den or the ptarmigan's snow roost.

The nanny and kid descend from their

ledge to search out browse at treeline with other members of a loose band—yearlings, young males, other nannies with kids. At the fringes of the band a solitary adult billy only grudgingly associates with other members of his kind; for this is the season of rut.

Not really goats at all, these relatives of the European mountaineering chamois are insulated from the wind by coats of long, hollow-haired fur overlying wooly underfur. They are stocky, stiff-legged, and deliberate, able to negotiate the walls and pinnacles with their superbly adapted hoofs. The unique design of these hoofs gives the animal great traction and stability on precarious crags. Opening towards the front, the cleft between the two hoofs spreads each outward as the animal descends a slope, helping to grip the rocky surface. In addition, the large, rough, and pliant sole of each foot conforms to the bare rock, increasing traction.

There is little need for the goat to leave its steep sanctuaries; it can subsist on lichens and mosses if browse is not available. It depends on the inaccessibility of the cliffs for its security. Accidents, avalanches, and rockfall are greater enemies than predators. Golden eagles sometimes attempt to knock newborn kids from ledges and a young goat quickly retreats under its nanny when an eagle soars by. With the protection of sharp spike horns and a terrifying terrain, adult goats seldom fall victim to cougar or grizzly.

It will be a long time before the snow releases this land and wapiti, bighorn, grizzly, and cougar wander back into these high basins. In this winter minimum of life, the spring songs of rosy finches, water pipits and white-crowned sparrows seem an impossible extravagance.

■

I am drawn to the spring tundra—to the vigor and tenacity of its sparse life—where survival itself seems ceremony enough. But it is a strange world, where a man is out of perspective. Here the plant cover is carpet-high, and distance, for the lack of trees, tricks the eye. Here the wind, snow, and sun quickly burn skin, and the intense light, reflected from snowbanks, stabs at the eyes. Almost instantly, a sandwich is sucked dry of its moisture. The desiccating wind probes the ears until it seems at last to pierce your brain. Except for fearful mountain walls the only shadow is your own. Animals seem somehow remote and unknowable, as if seen through glass. A day on the tundra and you feel the want of a company of trees.

Yet once exposed, you acquire a craving for the look of tundra. Nowhere else is there such an impatience for spring—the flowers rush into bloom; the male water pipit soars, its skylark song crystal sharp in the thin air. The nesting birds are restless, for sun-days and warm days are few, precious, and quickly spent. Insects and spiders abound—flying about the peaks or crawling

among the rocks.

Summer brings bands of bighorn rams up from the valley to explore the highest meadows. Though not so sure-footed as the goats, they too have hoofs adapted to climbing steep faces, and they walk the slopes not far below the goats.

Marmots, which whistle sharply when threatened, spend their days sunbathing and grazing; they must fill out their now loose-hanging fur coats with life-sustaining fat for the coming winter.

Alpine animals are blessed with mobility and can choose their weathers, retreating to burrow, den, or rock-harbor to escape the worst fury of storms. But what about the plants, rooted forever in one spot, assaulted by an untempered sun and a drying wind, and facing the almost daily threat of freeze and storm?

Alpine plants, through their design and growing habits, have adapted themselves to the rigorous demands of this climate in many ways. Most plants are perennial: there just aren't enough days or nutrients available for the growing of entire plants each year from seed. And they have the ability to grow and carry on photosynthesis at temperatures just above freezing, thus extending their season. In this zone, temperatures are rarely above 15° C; the mean summer temperature is about 10° C. But a flower such as the alpine buttercup, which is found at treeline or above, can grow through several centimeters of snow; heat given off during the plant's respiration will create an opening through which it can emerge.

Plants have various adaptations to meet the demands of the alpine environment. Yellow stonecrop, not restricted to this zone, is nevertheless able to survive here because of its fleshy succulence and a waxy covering that prevents water loss. On some plants, protective hairs covering leaves and stems help retard the burning effects of wind and sun. Often this pubescent foliage looks more grey than green, for the soft hairs mute the color.

Cushion growth is another alpine adaptation. The moss campion cushion, covered with delicate pink flowers, grows to about one-third of a meter across and only 3 to 5 centimeters high. Spreading out close to the ground, the plant avoids the major violence of the wind and hoards moisture like a sponge.

The dryad, growing abundantly on the windy sweep of Siyeh Pass, shows alpine adaptations in several ways. The energy of the mature plant is channeled primarily into reproduction: its large flower, supported by a short stem, matures quickly; and it produces many seeds, ensuring germination of a few. An evergreen, it begins to synthesize water and carbon dioxide into food as soon as the snow is gone; and its rolled leaves prevent rapid evaporation. It grows as a low and woody mat that year by year extends itself through the production of new shoots that carpet the rock. Mat growth has the advan-

tage of retaining dead plant material and capturing wind-blown grains of soil, allowing the plant slowly to enlarge its soil base.

Compared to the forest, the heartbeat of the tundra is painfully slow. Here a plant may grow for a quarter of a century before it has acquired the reserves necessary for flowering. Contrasted with the progress on the tundra, forest succession races by with dizzying speed. Yet imperceptible as the change may be the alpine plant community also passes from pioneer to climax.

Beyond the limit of other plants, lichens thrive, encrusting rocks with their rainbow colors. A lichen is actually a primitive and highly successful association between a fungus and an alga, working together for mutual benefit. The fungus protects the delicate alga, trapping and holding moisture; the green alga, in turn, produces enough food to sustain the needs of the fungus.

Generating rock-disintegrating acids that help secure this partnership to the rock, lichens, along with physical weathering, help break down the rocks into soil particles. Collected in pockets by run-off or wind, rudimentary soil is slowly invaded by cushion plants. After centuries of colonization by these, while the meager soil is deepened and enriched and moisture retention is increased, other plants move in, climaxing at last in hardy grasses and sedges. As in the forest, pioneer species change the environment to their detriment, creating a habitat better suited to other species.

Although it will progress with geologic slowness, the rocky ground of Siyeh Pass—its plant cover presently scant and windrowed by frost-heave and relentless wind—will in time develop grasses and sedges, the climax vegetation of the alpine meadows.

■

Simplicity rules the alpine zone. Here life is reduced to bare essentials. Chief controlling force is climate; but the plants and animals that live here are well adapted. Compared to the lower realms, where both competition and predation are fierce, life here looks secure.

There is a penalty to simplicity. In the lowland, the long food chains and diversity of species, the long growing season, and the abundant food supply give the forest an adjustment mechanism and healing power not found on the critically balanced tundra. The greater the variety in a plant and animal community, the greater the stability. So in the alpine world there exists a paradox: the most durable life forms constitute the most fragile community.

The Water Communities

Snowfields begin again their summer-long melt. The alpine stream, vocal again, collects its water from a thousand places. Miniature gorges drain the meadow, gurgling with the sparkle and rush of meltwater in the lengthening spring days.

Gathering volume, the stream seems to hurry faster; at the first rock staircase, it begins to sing. I follow the gully downward, drawn like the water. There is excitement in the growing dash and roar, a wind-gust sweeping spray into the air. A rainbow appears, holding steady to the swirling cloud of spray, then doubles and abruptly disappears.

At the first great plunge the water lunges outward over the lip. Like glass at shattering, long shards lance out. But the wind feathers the sharp edges as they fall.

The close thunder of a waterfall beats at your head, and your mind must shout to think. Here is water, a most amazing and most important substance. Perhaps some of this same water was once part of the ancient sea in which was laid down the mudstone of this ledge; was once drunk by dinosaurs; has coursed the globe countless times; and has flowed in this very stream before. In solid, liquid, or gaseous form, it goes through its own cycle. Together with sunlight, water makes possible and maintains all life on Earth.

Ouzel Music

A glacier might cling to a winter snow a hundred years and turn it to ice, a blue tool to rasp and pluck at rocks, before letting it go. Lingering summer snowfields might delay its passage for a time. But the water always wins at last, becoming, in one decisive instant, liquid again, and beginning its long journey to the sea. Plants and dry air will intercept some of its molecules, sending them back into the atmosphere to bloom as fog and cloud; but as rain, snow, or dew, these are soon commissioned to the land again.

Water is so familiar to us that we seldom think about it. We know that fish swim in the lower lakes, and we are vaguely aware of the bewildering assortment of life-forms abounding in a pond. But life begins in the streams.

Even cups of cold meltwaters, scooped out of a rivulet only a few meters away from its snowbank source, contain some life. Snow algae, which grow on the snowbank surface, often sufficiently dense to give the snow a distinctive red complexion, are released into the meltwater. In summer, small invertebrate life can be discovered in the standing pools of even the highest cirque.

But conditions are not good for the development of complete aquatic food chains in the streams and lakes of higher elevations. Alpine lakes, or tarns, support little visible life. Often flanked by high ridges and peaks, many tarns receive scant

direct sunlight during the day. Since these lakes occupy basins that capture tremendous amounts of snowfall, the snowbanks persist in the mountain shadows, and summer makes little progress in warming the water. Iceberg Lake, for example, is seldom free of floating ice, and its temperature never rises above 4° C in summer, even at the surface.

Moving out of the cirque lakes, water is soon churning again, dashing downward many hundreds of meters to the valleys below, in rapids, cascades, and breathless waterfalls. Not surprisingly, few plants and animals are adapted to life in fast-moving water.

Algae can be found covering streambed rocks and stranded, water-polished tree trunks. Securely attached by holdfasts, these small plant forms survive the rigorous stream flow that would destroy the larger vascular plants. Several species exist, from microscopic forms to branched filamentous algae whose long hairlike strands wave in the current.

A surprising number of insects live on the stream bottom, finding a measure of protection from the current in the jumble of rocks. Underwater beetles live under the gravel or among the debris at the stream-edge, or cling to stones and sticks. Scurrying and creeping among the rock-crannies are the larvae of stoneflies, mayflies, and caddisflies. These and the small fish that venture up from lower lakes are the food of the water ouzel, a creature that loves the places where the waters thunder.

■

The noise of the water is overpowering. A slip into this boiling rage would mean quick death. Looking 10 meters across the dim, mist-slippery, water-scoured canyon, I see a young water ouzel peering out of its unique nest, on the lookout for its parents. Clouds of spray keep the nest of living moss continually wet; but this bird is waterproofed with an oily plumage and keeps its vigil at the nest opening. Peering into the torrent below, then upstream and downstream, it awaits patiently the delivery of the next meal.

With the approach of one of the adults, three other heads crowd the opening, begging yellow mouths agape. Flying low, the ouzel parent zeros through the heavy spray, alighting on a slippery boulder below the nest ledge. Preparing to fly up to the nest with its load of insect larvae, the ouzel spots me across the water. At its sharp *jigic, jigic* alarm, the bills of the young snap instantly shut. Nervously the bird regards my close presence, dipping its entire body rapidly up and down, as if keeping time with the surging torrent.

Discovering no danger, the dusky blue-grey bird bobs more slowly. The other adult, returning from an upstream forage, alights on the same rock, occasioning a new outcry from the fledglings. Each in turn, the parent

birds fly up to feed their young, beating their wings to maintain their position at the perchless nest. Not pausing to regard me further, they split the stream between them again, one flying upstream and one down, to continue the hunt. Blinking and shaking the collected mist from its bill, the single young sentry renews its watch.

In Shallow Waters

Life abounds in the shallow lakes and ponds. Calm, protected Johns Lake offers a fine example of how a complex aquatic plant-and-animal community can exist in balance in a confined space. The water teems with the microscopic algae, protozoans, and rotifers that sustain the barely visible zooplankton. Dancing, flitting, hopping, and swaying through the water, these zooplankton in turn support the larger plankton-eating animals.

Dragonflies and damselflies shoot past, crackling their wings, and perch in the bog grass. Looking into the shallow water, you will see a wealth of small animal life. A spotted frog swims into view, floating to the surface beside a lily pad so that its eyes protrude above the water.

The ribbonlike form of a leech swims across the bottom toward deeper water. Looking closer, you see that the water swarms with bizarre shapes—water boatmen propelling themselves with oarlike appendages, a gliding mayfly nymph, then a predacious diving beetle surfacing, grasping a bubble of air beneath its shiny brown wing plates and disappearing downward again—the bubble's edge shining silver—into the brown bottom debris. Suddenly a whirligig beetle sets the surface to spinning, wrinkling the view below.

Everywhere in the water there is animal life, forms that are attached, free-swimming, crawling on the bottom, and clinging to or swimming on the surface film. The gray, slimy encrustation on a sunken log looks like a covering of lichen but is really a freshwater sponge, a colonial animal that feeds by filtering minute plankton from the water. Another attached creature is the barely visible hydra; this twig-shaped predator, related to marine jellyfish, captures water fleas and other small animals in its several poisonous tentacles.

Water beetles, backswimmers, water boatmen, and many other creatures move about more or less freely in the water, propelling themselves along with jerky movements. Suspended between surface and bottom are the zooplankton, the tiny water fleas, cyclops, daphnia, and others, which feed by filtering minute algae. On the bottom and below live scavenging worms. Water striders skate on the surface film.

Along the shore, frogs, salamanders, garter snakes, and water shrews are hunting. Dabbling and diving ducks patrol about, tipping or submerging for the bottom plants. Moose tracks circle the muddy shore.

Because it produces vegetation abundantly, John's Lake sustains a great diversity of animal life.

Beaver Ponds

Fully 10 percent of all the present meadow area in the Rocky Mountains is estimated to have been created by beaver, the only animal besides man that engineers extensive changes in the environment to suit its own needs.

When beavers dam a stream, they set in motion another form of succession. If the resulting backwater floods a forest area, the trees are soon killed, creating a broad opening in the forest canopy. Water-associated plants and shrubs quickly invade the pond and shoreline, creating favorable habitat for waterfowl, moose, blackbirds, amphibians, wading birds, warblers, marsh hawks, and a score of other animals.

After many years the water becomes shallow, filling in with silt and plant debris. When the beavers abandon the site, the dam may rupture for lack of maintenance and the pond will rapidly drain. Or it may continue to hold, delaying for several more years its slow conversion to meadow. Stimulated by the nutrient-rich mud, the water grasses, sedges, and shrubs finally choke the water with their accumulating debris, transforming the area into a bog.

Gradually the ground firms as more humus is created and more silt is trapped. The area becomes meadow, supporting grasses, sedges, and other flowering plants. Trees begin to reinvade the drier ground, and eventually the meadow reverts to forest. Centuries may be required to see this cycle through, from forest to pond, to bog, to meadow, to forest again. At each stage many of the animal inhabitants change: the song of the western robin and the chatter of a red squirrel in the original, pre-beaver forest give way to the croak of a heron; the heron is replaced by the insect-and-berry-eating cedar waxwing; the waxwing is followed by the tree-dwelling western robin and red squirrel.

Lakes Cold and Deep

Seeming to skate on its own reflection, a spotted sandpiper comes in low over the quiet water, wingtips almost touching the surface of the lake. It alights at the shore and folds its wings. Amid the rounded rocks, this plain but elegant little shorebird is all but swallowed up. Teetering constantly on long legs, it sets off along the water's edge, pecking here and there, coming closer and closer, never forgetting to stop and curtsy, as if acknowledging, while hurrying offstage, the applause of an audience.

As it draws near, several water striders skate away from the shore. A stonefly, scuttling between two rocks, is deftly speared. So large a morsel makes the bird

pause and rough its feathers, then scamper into the water to take a drink. Teetering again, it passes in front of me and continues down the shore, where I soon lose sight of it rounding a rocky point.

I am sitting at the foot of Lake McDonald, watching the darkness gather over the valley, seeing the last light slide upward to the tips of the distant mountains. As daylight dissolves, this long fleet of familiar peaks seems almost to glide toward darkness, slow and silent as sailing ships.

The sheet of motionless water stretches many kilometers away between tree-covered moraines. The water is deep and cold. No emergent plants line the barren shore. It would seem that no life, except for the single gull that rests on the water far away, exists in this nearly thousand-meter-high lake.

■

Considering the great volume of Glacier's large, deep lakes, the life they support is indeed meager. A large part of the reason lies with the nature of their shores, where almost no plants grow. A combination of factors prevents the development of a lush shoreline growth.

Contoured like bathtubs, these steep-sided lakes exhibit narrow or non-existent shoreline shallows, which are vital for the production of rooted plants. Strong wave action and extensive seasonal fluctuations in the level of these natural reservoirs prevent the development of emergent water plants in locations where they might otherwise be expected.

Since sunlight cannot penetrate to the bottom of these deep lakes, they are deprived of bottom-anchored plants in midlake as well. As a result, herbivorous animal life must depend almost wholly on algal growth. Wave action inhibits the spread of free-floating algae by washing much of it onto the shore. Deep lakes are also low in available oxygen, preventing the development of bottom decomposers, which would rapidly release nutrients as they break down the accumulating debris washed into the lake. Without a steady supply of nutrients, plant growth is retarded.

Since the food chain depends upon green plants, the ability of a lake to support higher animals such as fish depends upon its ability first to produce adequate plant growth. The production of one kilo of trout requires that a lake produce about 1,000 kilos of plants to support 100 kilos of herbivorous invertebrates, which are eaten by 10 kilos of carnivorous insects, on which the trout feed.

Compared to smaller shallow lakes, which teem with visible life, cold, deep, nutrient-poor lakes such as McDonald appear to be watery deserts. Yet because of their great volume—Lake McDonald contains 5 or 6 cubic kilometers of water—these large lakes do sustain significant numbers of fish. Of the 22 kinds of fishes found

within the park, most are coldwater species. Trout, whitefish, grayling, suckers, minnows, and carp fill the roles of herbivore, carnivore, and scavenger. Agile, highly mobile, and acutely sensitive, fish represent the most successful total adaptation to the aquatic environment.

Through the stocking of nonnative species, including plantings in formerly fish-free lakes, the natural aquatic communities of many of Glacier's lakes and streams have been permanently modified.

Aquatic food chains are not confined to the water. Ospreys, ducks, mergansers, otter, mink, and many other semi-aquatic or terrestrial birds and mammals utlilize the plants and animals of the water. In fall, a remarkable spectacle occurs along the outlet of Lake McDonald. Attracted to the kokanee salmon concentrations, which run from Flathead Lake to spawn and die in these clear, shallow waters, bald eagles collect to exploit the vulnerable fish. In 1977, 444 eagles were counted in one census. This food resource is also exploited by grizzlies, coyotes, skunks, gulls, loons, and other animals. On occasion, even whitetail deer have been observed swallowing salmon!

Shooting Stars

This park is very special. The people who know it well feel proprietary toward its mountains, scattered lakes, and glaciers. Perhaps it is the arrangement of the land, an unsurpassed concentration of American wilderness. Time and again I have thought, as I regarded some aspect of this country, *yes, this is exactly right*—almost, it would seem, as if some magic existed that could translate thought and emotion into rock and bark.

Glacier remains largely unexploited, bearing still the aspect of the Earth the Indians knew for 500 generations—a land where it is yet possible to feel a sense of discovery, sense that a single man matters. On too many mountains, man has tarnished whatever he has touched; but here the land has shed, as a fir sloughs snow, a long succession of traders, trappers, explorers, hunters, surveyors, prospectors, loggers, settlers, and tourists.

You may walk the same trail a dozen times and not tire of the view. I have given up wondering why. I know only that these are mountains a man might grow old with, and that mountain-fever never diminishes but only changes its look, as a forest does over many years.

Repeatedly I have noticed that this park creates an instant bond between strangers. A certain pause intrudes at the first mention of Glacier National Park, and a look of distance comes, as Red Eagle becomes real again, or the wind at Firebrand is remembered, or the flowers of Fifty-Mountain converge once more upon the senses.

Never are we quenched. If a goshawk rushes past, straining upward with its squirming load of ground squirrel, forever afterward our blood demands more. The sight of a wolverine running is not enough. Nor the magnificent assemblage of bald eagles feasting on November salmon. More days of this: mountain goats leaping impossible ledges, wave tracks from a beaver reaching out on dawn water. There are messages here, loud as kingfishers. The land has languages, stories to tell.

But in wilderness there is no moral, save that it must continue. For all our probings and plottings we discover no adequate interpretation of the forces we find swirling about us. A larch you must touch to know; your neck must feel the ache of too much looking up. Watch its treepoint pirouette. Then, looking back at the world level, you will find that you have lost all answers. We have learned the art of building bridges, cataloging plants, predicting what a shrew might do. Of the essential mystery, we know nothing.

For nature assigns no "roles" to its creatures; there is no "reason" for a forest fire, which burns mightily but with no intent. Life's only "purpose" is the feeding of life, and the beauty we see therein is but its lack of guarantee: for the chipmunk and the weasel, and the man who measures his life to theirs, no assurance of long days

and tempered seasons, abundant seeds, ample meat. In wilderness there is mystery yet, unsimplified, not reduced, resplendent and immense.

Whatever the conclusion of this planet, however many the acts to follow in this consuming drama—mountains coming up, mountains going down, forests, lakes, and seas skimming past like wind-driven scud clouds before a storm—at least in the scant shadow of this present age there is an achievement of sorts. For now, with this creature man, such things as mountains can be loved. And men have memories to fill.

Tomorrow I will look for shooting stars—purple spring flowers that point their fire down, always down toward the center of the Earth, as if to give in their brief term beneath the sun a tribute to this most excellent mystery.

Today I can say nothing more, neck-sore now from looking at larchtops swaying with the wind of this splendid morning.

Shooting star.

Appendix

Mammals of Glacier National Park

Distribution information was obtained from *Meet the Mammals of Waterton-Glacier International Peace Park, by* Robert C. Gildart (*see* Reading List). Nomenclature follows, for the most part, *a Field Guide to Mammals,* by William H. Burt and Richard P. Grossenheider.

Key to symbols:

E — occurs east of Continental Divide (spruce-fir forest; aspen; bunchgrass meadows)

W — occurs west of Continental Divide (redcedar-hemlock-lodgepole-fir-larch forest; some meadows)

A — occurs in alpine areas (above upper edge of continuous forest)

R — rare in Glacier National Park

Shrews

Masked shrew, *Sorex cinereus*
E, W, coniferous forests, meadows, pond and stream edges

Vagrant shrew, *Sorex vagrans*
E, W, A, moist forests and grasslands, marsh and stream edges

Northern water shrew, *Sorex palustris*
E, W, stream edges

Bats

Little brown myotis, *Myotis lucifugus*
E, W, coniferous forests, often around buildings, caves; nocturnal

Long-eared myotis, *Myotis evotis*
E, W, A, R, coniferous forests, meadows; nocturnal

Long-legged myotis, *Myotis volans*
E, W, A, coniferous forests, meadows; nocturnal

Big brown bat, *Eptesicus fuscus*
E, W, coniferous forests; often around buildings, caves; nocturnal

Silver-haired bat, *Lasionycteris noctivagans*
E, W, coniferous forests; meadows; nocturnal

Hoary bat, *Lasiurus cinereus*
E, W, coniferous forests; mostly nocturnal

Cats

Bobcat, *Lynx rufus*
E, open forests, brushy areas

Lynx, *Lynx canadensis*
E, W, coniferous forests

* Cougar, *Felis concolor*
E, W, coniferous forests

Raccoon, bears

Raccoon, *Procyon lotor*
E, W, R, open forests, stream bottoms

Black bear, *Ursus americanus*
E, W, A, forests, slide areas, alpine meadows

Grizzly, *Ursus arctos*
E, W, A, forests, slide areas, alpine meadows

Canines

Red Fox, *Vulpes vulpes*
E, grasslands, open forest

* Coyote, *Canis latrans*
E, W, A, forests, grasslands

Gray wolf, *Canis lupus*
E, W, R, coniferous forests

Mustelids

Striped skunk, *Mephitis mephitis*
E, W, open forests, grasslands

Badger, *Taxidea taxus*
E, W, grasslands

River otter, *Lutra canadensis*
E, W, R, rivers, lakes

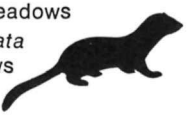
* Wolverine, *Gulo gulo*
E, W, A, coniferous forests, alpine meadows

* *illustrated*

Least weasel, *Mustela rixosa*
E, R, open forests, grasslands

Shorttail weasel, *Mustela erminea*
E, W, A, coniferous forests, meadows

* Longtail weasel, *Mustela frenata*
E, W, A, open forests, meadows



Mink, *Mustela vison*
E, W, creek and lake edges

Marten, *Martes americana*
E, W, A, coniferous forests

Fisher, *Martes pennanti*
E, W, R, coniferous forests

Lagomorphs

Pika, *Ochotona princeps*
E, W, A, rockslides

Snowshoe hare, *Lepus americanus*
E, W, coniferous forests

Whitetail jackrabbit, *Lepus townsendii*
E, W, R, grasslands

Squirrels

Hoary marmot, *Marmota caligata*
E, W, A, rocky areas, alpine meadows

Richardson ground squirrel, *Spermophilus richardsonii*
E, R, grasslands

Columbian ground squirrel, *Citellus columbianus*
E, W, A, open woodlands, grasslands, alpine meadows

Thirteen-lined ground squirrel, *Spermophilus tridecemlineatus*
E, R, grasslands

Golden-mantled squirrel, *Spermophilus lateralis*
E, W, A high, open forests; rocky areas

Least chipmunk, *Eutamias minimus*
E, W, A, high, open forests; brushy, rocky areas; alpine meadows

Yellow pine chipmunk, *Eutamias amoenus*
E, W, open forests; brushy, rocky areas

Redtail chipmunk, *Eutamias ruficaudus*
E, W, open forests; brushy, rocky areas

Red squirrel, *Tamiasciurus hudsonicus*
E, W, coniferous forests

Northern flying squirrel, *Glaucomys sabrinus*
E, W, coniferous forests; nocturnal

Pocket gophers

Northern pocket gopher, *Thomomys talpoides*
E, W, A, meadows

Beaver

* Beaver, *Castor canadensis*
E, W, streams, lakes

Voles and kin

Deer mouse, *Peromyscus maniculatus*
E, W, A, forests, grasslands, alpine meadows

Bushytail woodrat, *Neotoma cinerea*
E, W, A, rocky areas, old buildings

Northern bog lemming, *Synaptomys borealis*
W, R, coniferous forests

Mountain phenacomys, *Phenacomys intermedius*
E, W, A, coniferous forests, alpine meadows

Boreal redback vole, *Clethrionomys gapperi*
E, W, coniferous forests

Meadow vole, *Microtus pennsylvanicus*
E, W, open forests, meadows; along streams; marshy areas

Longtail vole, *Microtus longicaudus*
E, W, coniferous forests, grasslands

Water vole, *Arvicola richardsoni*
E, W, A, high-elevation stream and lake edges

Muskrat, *Ondatra zibethica*
W, streams, lakes, marshy areas

Western jumping mouse, *Zapus princeps*
E, W, A, grasslands, alpine meadows

Deer

Wapiti (American elk), *Cervus canadensis*
E, W, A, open forests, meadows

Mule deer, *Odocoileus hemionus*
E, W, A, open forests, meadows, often at high elevations

Whitetail deer, *Odocoileus virginianus*
E, W, coniferous forests, meadows, creek and river bottoms

Moose, *Alces alces*
E, W, coniferous forests, lakes, slow streams, marshy areas

Bovids

* Mountain goat, *Oreamnos americanus*
E, W, A, high peaks and meadows

Bighorn, *Ovis canadensis*
E, A, open mountainous areas

Reptiles and Amphibians of Glacier National Park

Note: This check list is based upon actual specimens in the Park and other collections, according to Dr. Royal Brunson, Montana State University.

Reptiles

Great Basin Garter Snake, *Thamnophis elegans vagrans*
A large garter snake of mountainous areas, usually with large spots.

Great Plains Red-sided Garter Snake, *Thamnophis ordinoides parietalis* Dorsal stripes varying from yellow to blue or black. Usually found near water.

Hypothetical List:

Rubber Boa, *Charina bottae utahensis*
May occur in rock slides or, possibly, in forested areas, on either side of the Divide.

Gopher Snake, *Pituophis catenifer sayi*
May occur along eastern boundary (Great Plains).

Yellow-bellied Blue Racer, *Coluber constrictor mormon*
May occur on eastern boundary of Park along border of Great Plains.

Painted Turtle, *Chrysemys picta*
May occur in ponds and sluggish waters from Upper Sonoran Zone to Canadian Zone.

Western Skink, *Eumeces skiltonianus*
May occur in Transition Zone along western border of Park.

* Northern Alligator Lizard, *Gerrhonotus coeruleus principis*
May occur in Transition Zone along western border of Park.

Amphibians

Tiger Salamander, *Ambystoma tigrinum melanostrictum*
Ground color either black or bluish-black, with large spots or blotches of yellow.

Long-toed Salamander, *Ambystoma macrodactylum*
Ground color black or dark brown; wide band of yellow extends from back of head to tip of tail.

Northwestern Toad, *Bufo boreas boreas*
Widely distributed over entire Park. (Also known as Columbian, Northern, or Western Toad.)

* Western Spotted Frog, *Rana pretiosa pretiosa*
Widely distributed over entire Park. (Also known as Western or Pacific Frog.)

Green Frog, *Rana clamitans*

* *illustrated*

One specimen, from Bowman Lake. (Chicago Natural History Museum)

Tailed Frog, *Ascaphus truei*
Should be fairly common, although it is not often taken.

Pacific Tree-toad, *Hyla regilla*
Small size and disks on fingers and toes identify this species. Common throughout Park.

Fishes of Glacier National Park

Classification and common scientific names are from: "A List of Common and Scientific Names of Fishes from the United States and Canada," American Fisheries Society Publication No. 2, 1960.

Key to symbols:

N Species native to at least one major drainage of the Park.
I Non-native species, having been introduced into Park waters by man.
S A species of sporting qualities and valued for recreational angling.
1 Waterton Drainage
2 Belly River Drainage
3 Swiftcurrent Drainage
4 St. Mary Drainage
5 Two Medicine Drainage
6 Middle Fork Flathead River Drainage (exclusive of McDonald Valley)
7 McDonald Valley Drainage
8 North Fork Flathead River Drainage

Family *Salmonidae* (trouts, whitefishes, and grayling)

Lake Whitefish, *Coregonus clupeaformis* (I) (1,2,3,4,7)

Pygmy Whitefish, *Prosopium coulteri* (N) (7)

Mountain Whitefish, *Prosopium williamsoni* (N) (S) (1,2,3,4,5,6,7,8,)

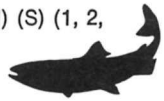
Kokanee (Sockeye) Salmon, *Oncorhyncus nerka* (I) (S) (3, 7, 8)

Cutthroat Trout, *Salmo clarki* (N) (S) (1, 2, 3, 4, 5, 6, 7, 8)

Rainbow Trout, *Salmo gairdneri* (I) (S) (1, 2, 3, 4, 5, 7)

Brook Trout, *Salvelinus fontinalis* (I) (S) (1, 2, 3, 4, 5, 6, 7)

Dolly Varden, *Salvelinus malma* (N) (S) (1, 2, 3, 4, 6, 7, 8)



* Lake Trout, *Salvelinus namaycush* (N) (S) (1, 2, 4, 5, 7, 8)

Arctic Grayling, *Thymallus arcticus* (I) (S) (2,8)

Family *Esocidae* (pikes)

Northern pike, *Esox lucius* (N) (S) (1, 2, 3)

Family *Cyprinidae* (minnows and carps)

Longnose Dace, *Rhinichthys cataractae* (N) (2, 3, 4, 5, 6, 7, 8,)

Northern Pearl Dace*, *Margariscus margarita* (N) (3,5)

* Redside Shiner, *Richardsonius balteatus* (N) (7, 8)

Streamline Chub, *Hybopsis dissimilis* (N) (1, 3)

Northern Squawfish, *Ptychocheilus oregonensis* (N) (7, 8)

Family *Catostomidae* (suckers)

* White Sucker, *Catostomus commersoni* (N) (1, 2, 3, 4, 5)

Largescale Sucker, *Catostomus macrocheilus* (N) (6, 7, 8)

Longnose Sucker, *Catostomus catostomus* (N) (1, 2, 3, 4, 5, 6, 7, 8)

* *illustrated*

Family *Gadidaie* (codfishes and hakes)
Burbot, *Lota lota* (N) (S) (1, 4)

Family *Cottidae* (sculpins)
Mottled sculpin, *Cottus bairdi* (N) (5, 6, 7, 8)
Spoonhead sculpin, *Cottus ricei* (N) (1, 2, 3, 4)

Birds of Glacier National Park

Key to symbols:
E — occurs on east side of the park (east of the Divide)
W — occurs on west side of the park (west of the Divide)
A — occurs in alpine areas
ab — abundant
c — common
u — uncommon
r — rare
i — introduced
a — accidental

Loons
* Common Loon E, W ab
Arctic Loon?
Red-throated Loon?

Grebes
Red-necked Grebe E, W, c
Horned Grebe E, W, ab
Eared Grebe E, W, c
* Western Grebe E, W, u
Pied-billed Grebe E, W, r

Pelicans, Cormorants
White Pelican E, W, u
Double-crested Cormorant E, r

Herons, Bitterns
* Great Blue Heron E, W, c

Black-crowned Night Heron a
* American Bittern, W, r

Swan, Geese, Ducks
Whistling Swan E, W, ab
Trumpeter Swan E, W, r
Canada Goose E, W, c
Snow Goose E, W, c
Ross' Goose E, W, r
* Mallard E, W, ab
Gadwall E, W, r
Pintail E, W, c
Green-winged Teal E, W, c
Blue-winged Teal E, W, u
Cinnamon Teal E, W, u
European Widgeon E, W. c
American Widgeon E, W, ab
Northern Shoveler E, W, c
* Wood Duck E, W, r
Redhead E, W, c
Ring-necked Duck E, W, u
Canvasback E, W, u
Lesser Scaup E, W, c
Greater Scaup?
Common Goldeneye E, W, c
Barrow's Goldeneye E, W, ab
Bufflehead E, W, u
Harlequin Duck E, W, c
White-winged Scoter E, W, r
* Ruddy Duck E, W, c
Hooded Merganser E, W, u
Common Merganser E, W, ab
Red-breasted Merganser, E, W, u

Vultures, Hawks, Eagles
Turkey Vulture E, W, r
Goshawk E, W, c
Sharp-shinned Hawk E, W, u
* Cooper's Hawk E, W, u
Red-tailed Hawk E, W, c
Red-shouldered Hawk a
Swainson's Hawk E, W, c

* *illustrated*

Rough-legged Hawk E, W, r
Ferruginous Hawk E, W, u
Golden Eagle, E, W, A, c
Bald Eagle, E, W, ab
* Marsh Hawk E, W, ab
Osprey E, W, ab
Prairie Falcon E, W, A, r
Peregrine Falcon E, W, r
American Kestrel E, W, c

Grouse, Ptarmigans
Blue Grouse, E, W, ab
Spruce Grouse E, W, ab
Ruffed Grouse E, W, ab
* Sharp-tailed Grouse E, r
White-tailed Ptarmigan A, c
Willow Ptarmigan ?
Ring-necked Pheasant E, W, r, i
Gray Partridge E, W, r, i

Cranes
Sandhill Crane E, r

Rails, Coots
Sora E, W, r
* American Coot E, W, ab

Shorebirds
Killdeer E, W, c
Black-bellied Plover E, r
Common Snipe E, W, c
Long-billed Curlew E, r
Upland Sandpiper E, r
Spotted Sandpiper E, W, A, ab
Solitary Sandpiper E, r
Willet, E, r
Pectoral Sandpiper E, r
Baird's Sandpiper E, W, r
Lesser Yellowlegs, E, W r
* Greater Yellowlegs E, W, r
American Avocet E, W, u
Northern Phalarope E, W, r

Wilson's Phalarope E, W, u
Black Turnstone ?
Long-billed Dowitcher E, W, r

Gulls, Terns
* Herring Gull E, W, r
California Gull E, W, ab
Ring-billed Gull E, W, c
Franklin's Gull E, W, c
Bonaparte's Gull E, u
Forster's Tern E, W, u
Common Tern E, r
Caspian Tern a
Black Tern E, W, u

Doves, Pigeons
Band-tailed Pigeon E, W, r
* Mourning Dove E, W, c
Rock Dove E, W, r, i

Owls
Screech Owl E, W, r
* Great Horned Owl E, W, ab
Snowy Owl E, W, u
Hawk Owl E, W, u
Pygmy Owl E, W, ab
Barred Owl E, W, c
Great Gray Owl E, W, u
Long-eared Owl E, W, r
Short-eared Owl, E, W, c
Boreal Owl E, W, r
Saw-whet Owl E, W, u

Nighthawks, Swifts
* Common Nightawk E, W, ab
Black Swift E, W, u
Vaux's Swift E, W, ab
White-throated Swift W, A, r

Hummingbirds
Broad-tailed Hummingbird E, W, r
Rufous Hummingbird E, W, A, ab

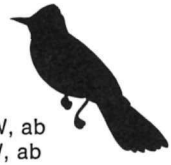
* *illustrated*

Calliope Hummingbird E, W, A, ab
Black-chinned Hummingbird E, W, r

Kingfishers
* Belted Kingfisher E, W, ab

Woodpeckers
Common Flicker E, W, ab
Pileated Woodpecker E, W, ab
Red-headed Woodpecker E, W, r
Lewis' Woodpecker E, W, c
Yellow-bellied Sapsucker E, W, ab
Williamson's Sapsucker E, W, u
Hairy Woodpecker E, W, ab
Downy Woodpecker E, W, ab
Black-backed Three-toed Woodpecker E, W, ab
Northern Three-toed Woodpecker E, W, ab

Flycatchers
Eastern Kingbird E, W, ab
Western Kingbird E, W, u
* Ash-throated Flycatcher a
Say's Phoebe E, W, r
Willow Flycatcher E, W, c
Hammond's Flycatcher E, W, ab
Olive-sided Flycatcher E, W, ab
Western Flycatcher E, r
Western Wood Peewee E, W, c



Larks
Horned Lark E, W, A, ab

Swallows
Violet-green Swallow E, W, A, ab
Tree Swallow E, W, ab
Bank Swallow E, W, ab
Rough-winged Swallow E, W, u
* Barn Swallow E, W, u
Cliff Swallow E, W, A, ab

Jays, Magpies, Crows
Gray Jay E, W, ab
Blue Jay E, W, r
Steller's Jay E, W, ab
Black-billed Magpie E, W, ab
Common Raven E, W, A, ab
* Common Crow E, W, ab
Clark's Nutcracker E, W, A, ab

Chickadees
Black-capped Chickadee E, W, ab
Mountain Chickadee E, W, ab
Boreal Chickadee E, W, r
Chestnut-backed Chickadee E, W, u

Nuthatches, Creepers
White-breasted Nuthatch E, W, u
Red-breasted Nuthatch E, W, ab
Brown Creeper E, W, ab

Dippers, Wrens
Dipper E, W, A, ab
House Wren E, W, u
* Winter Wren E, W, ab
Long-billed Marsh Wren a
Rock Wren E, W, u

Catbirds, Thrashers
Gray Catbird E, W, u

Thrushes, Bluebirds, Solitaires
American Robin E, W, A, ab
Varied Thrush E, W, ab
Hermit Thrush E, W, ab
Swainson's Thrush E, W, ab
Veery E, W, c
Western Bluebird E, W, r
* Mountain Bluebird E, W, A, ab
Townsend's Solitaire E, W, A, ab

Kinglets
Golden-crowned Kinglet E, W, ab
Ruby-crowned Kinglet E, W, ab

** illustrated*

Pipits
Water Pipit E, W, A, ab

Waxwings
Bohemian Waxwing E, W, ab
* Cedar Waxwing E, W, ab

Shrikes
Loggerhead Shrike E, W, r
Northern Shrike E, W, r

Starlings
* Starling E, W, c, i

Vireos
Solitary Vireo E, W, ab
* Red-eyed Vireo E, W, ab
Warbling Vireo E, W, ab

Warblers
Black and White Warbler W, r
Tennessee Warbler E, W, r
Orange-crowned Warbler E, W, r
Nashville Warbler E, W, r
Yellow Warbler E, W, ab
Yellow-rumped Warbler E, W, ab
Townsend's Warbler E, W, ab
Northern Waterthrush E, W, ab
MacGillivray's Warbler E, W, ab
Common Yellowthroat E, W, ab
Wilson's Warbler E, W, ab
American Redstart E, W, ab
Yellow-breasted Chat ?

Weaver Finches
* House Sparrow E, W, r, i

Blackbirds, Orioles
Bobolink E, r
Western Meadowlark E, W, u
Red-winged Blackbird E, W, ab
Northern Oriole E, W, r

Brewer's Blackbird E, W, u
Rusty Blackbird E, W, r
Yellow-headed Blackbird E, r
Common Grackle E, r
Brown-headed Cowbird E, W, c

Tanagers, Grosbeaks
Western Tanager E, W, ab
* Evening Grosbeak E, W, ab
Pine Grosbeak E, W, ab
Black-headed Grosbeak E, W, r

Finches, Sparrows, Buntings
Lazuli Bunting E, W, c
Lark Bunting E, W, r
Snow Bunting E, W, c
Cassin's Finch E, W, A, ab
Gray-crowned Rosy Finch E, W, A, ab
* American Goldfinch E, W, u
Common Redpoll E, W, c
Pine Siskin E, W, A, ab
Red Crossbill E, W, ab
White-winged Crossbill E, W, u
Rufous-sided Towhee E, W, u
Green-tailed Towhee E, W, r
Savannah Sparrow E, W, c
LeConte's Sparrow E, W, u
Vesper Sparrow E, W, ab
Tree Sparrow E, W, r
Chipping Sparrow E, W, A, ab
Brewer's Sparrow E, W, r
Harris' Sparrow E, W, r
White-crowned Sparrow E, W, A, ab
Fox Sparrow E, W, A, ab
Lincoln's Sparrow E, W, A, c
Song Sparrow E, W, ab
Dark-eyed Junco E, W, c
McCown's Longspur E, c
Lapland Longspur E, W, c
Chestnut-collared Longspur E, c

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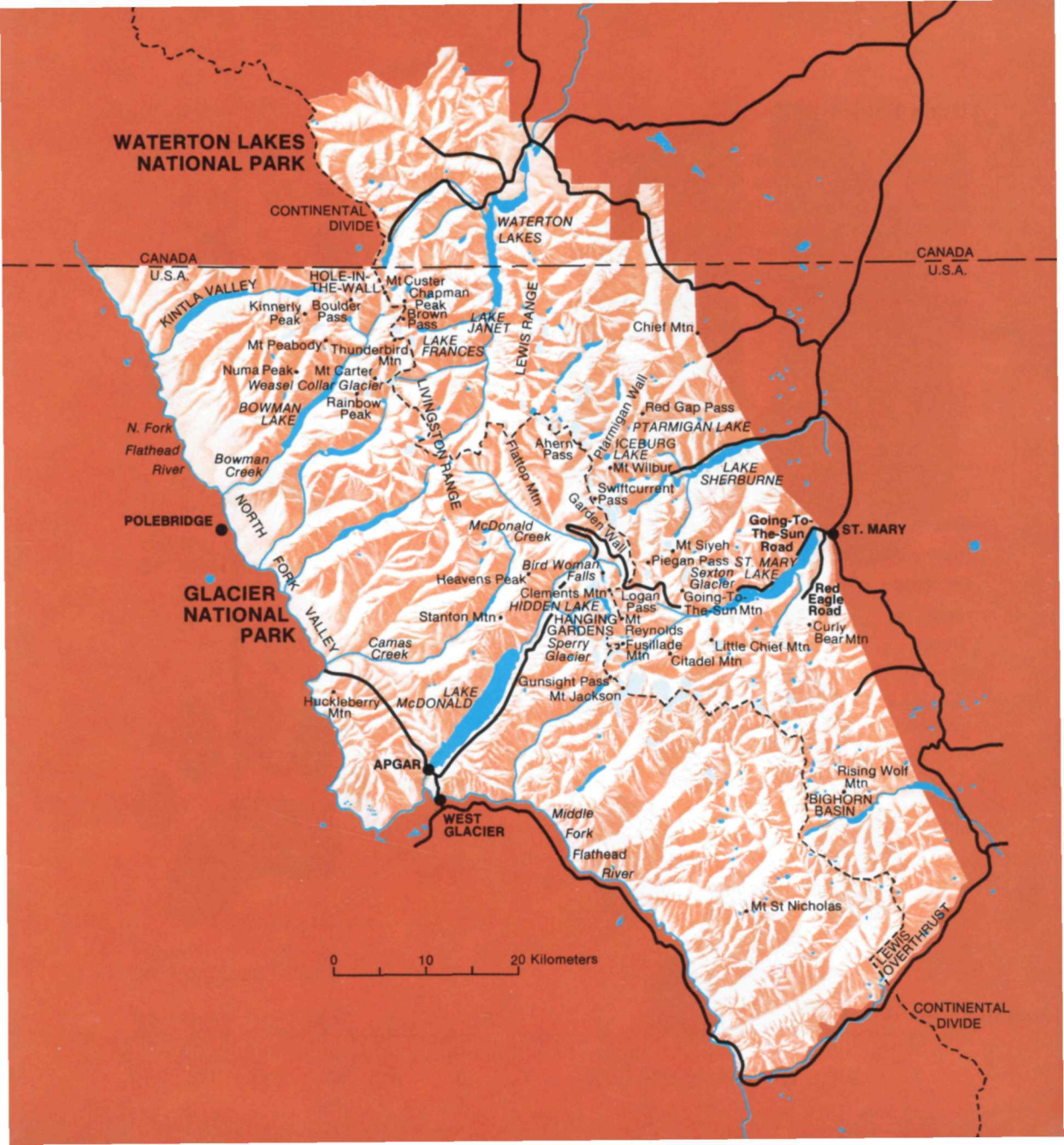
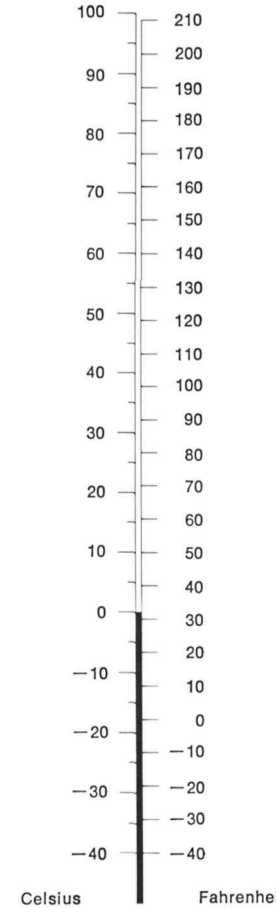

WATERTON LAKES NATIONAL PARK
CONTINENTAL DIVIDE
WATERTON LAKES
CANADA
U.S.A.
CANADA
U.S.A.
KINTLA VALLEY
HOLE-IN-THE-WALL
Mt Custer
Chapman Peak
Kinnerly Peak
Boulder Pass
Brown Pass
LAKE JANET
LEWIS RANGE
Chief Mtn
Mt Peabody
Thunderbird Mtn
LAKE FRANCES
Numa Peak
Mt Carter
Weasel Collar Glacier
LIVINGSTON RANGE
BOWMAN LAKE
Rainbow Peak
Ptarmigan Wall
Red Gap Pass
PTARMIGAN LAKE
N. Fork
Flathead
River
Bowman Creek
Ahern Pass
ICEBURG LAKE
Mt Wilbur
LAKE SHERBURNE
Flattop Mtn
Swiftcurrent Pass
Garden Wall
NORTH FORK VALLEY
POLEBRIDGE
McDonald Creek
Going-To-The-Sun Road
ST. MARY
Mt Siyeh
Piegan Pass
ST. MARY LAKE
Sexton Glacier
Bird Woman Falls
Heavens Peak
Clements Mtn
Logan Pass
Going-To-The-Sun Mtn
Red Eagle Road
GLACIER NATIONAL PARK
HIDDEN LAKE
Stanton Mtn
HANGING GARDENS
Mt Reynolds
Curly Bear Mtn
Camas Creek
Sperry Glacier
Fusillade Mtn
Little Chief Mtn
Citadel Mtn
Gunsight Pass
Mt Jackson
Huckleberry Mtn
LAKE McDONALD
APGAR
Rising Wolf Mtn
BIGHORN BASIN
WEST GLACIER
Middle Fork Flathead River
Mt St Nicholas
LEWIS OVERTHRUST
0
10
20 Kilometers
CONTINENTAL DIVIDE

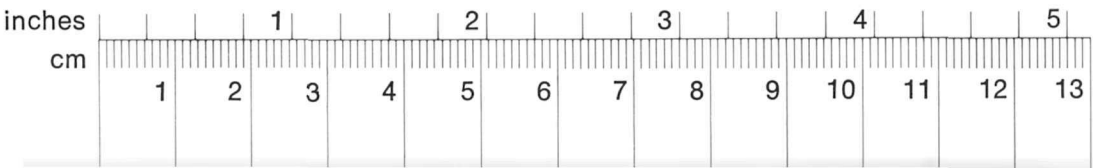
Using Metrics

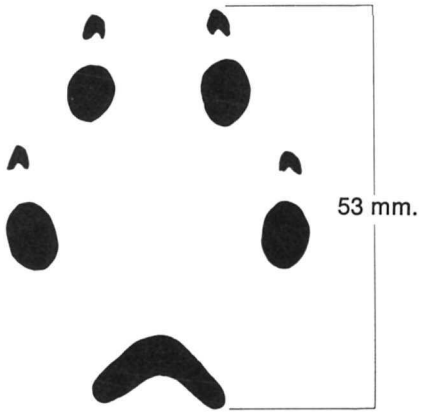
As we go to press with this book, the United States is in the early stages of conversion to the metric system of measurement, and though we urge you to think metric—for most of the world does—we provide this table to help you understand the measurements given in the book.

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	0.00386
Grams	Troy Ounces	0.0322
Kilograms	Pounds	2.2046
Degrees–Celsius	Degrees–Fahrenheit	1.8, and add 32

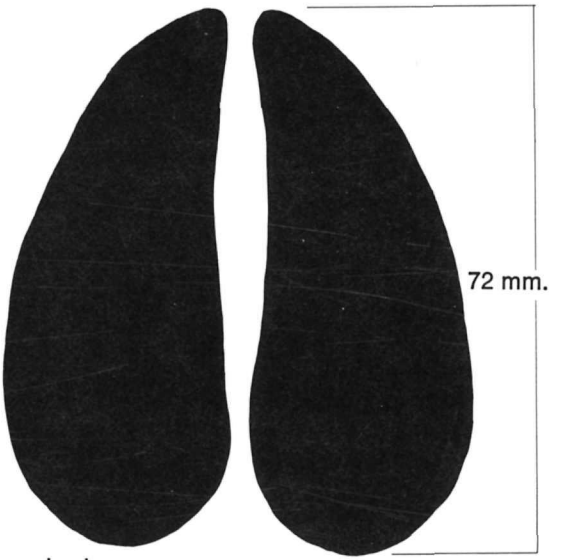
Temperature Conversion Chart



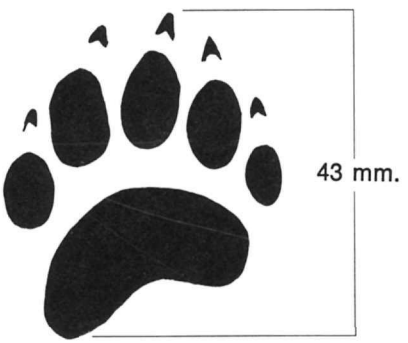




red fox,
hind foot, in mud

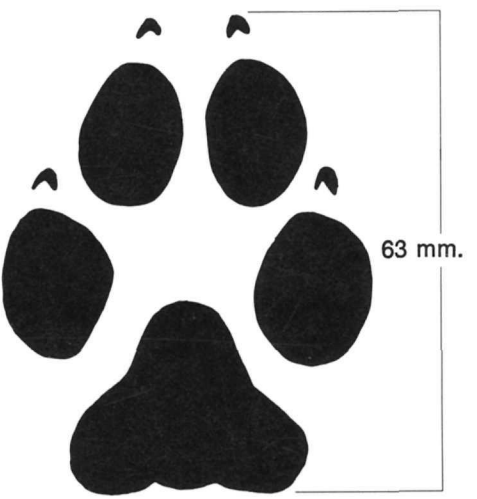


mule deer,
adult buck, in snow



badger,
left front foot, in mud

Drawings from David S. Shea,
Animal Tracks of Glacier National Park



coyote,
hind foot, in snow

About the Author

Greg Beaumont's interest in Glacier National Park dates from 1963, when he was a summer employee at Lake McDonald Lodge. In 1966 he and his wife were fire-control lookouts on Numa Ridge in the Bowman Valley. Now a free-lance writer-photographer, he lives with his family in Lincoln, Nebraska.

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

National Park Service
U.S. Department of the Interior