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History of the Greater Yellowstone Ecoregion

The wrinkled surface of northwestern Wyoming and adjacent Idaho is a complex myriad of mountainous uplifts and basins, of varied ages and origins. In a somewhat fanciful way it resembles the imprint of a raccoon's right forefoot that, having been pressed into sticky clay, was withdrawn to form a series of ridges and peaks that subsequently solidified into ranges of mountains extending southward from the northwestern corner of Wyoming.

In this imagined view, the Yellowstone Plateau of northwestern Wyoming represents a gigantic if somewhat fanciful paw print, which rises more than a thousand feet above the surrounding lowlands. The plateau has been pushed upward over long periods of time by pressures from the gigantic cauldron of molten magma that lies some fifty miles below and is the geological source for all of Yellowstone's thermal

PREVIOUS PAGE. *A four-month-old cougar kitten sleeping against its mother, National Elk Refuge, Jackson Hole, Wyoming* features and the cause of Yellowstone's frequent earthquake activity. From the Yellowstone Plateau the Bridger Plateau extends southeastwardly like a narrow forefinger as the Owl Creek and Bridger Mountains, which approach the "thumbprint" of the Bighorn Mountains. Between them the Bighorn River flows northward through the Bighorn Basin to join the Missouri River. To the south of the Owl Creek and Bridger Mountains is the Wind River Basin, where the Shoshone and Arapahoe Indians now live in relative obscurity and where the great Shoshone chief Washakie lies buried on the parched and shrub-covered hillsides.

The middle "finger" of the landscape's topography is made by the Wind River Range, the longest and highest of the Wyoming ranges. Along its crest runs the Continental Divide, and over such passes as Union Pass and South Pass came the earliest explorers, mountain men, and finally emigrants on their way west. At its western base is the Green River Basin, whose waters drain into the Colorado River and whose sedimentary rocks bear the fossil imprints of Eocene fish, reptiles, birds, and mammals interred there some fifty million years ago.

The fourth landscape "finger" is formed basally by the jagged upthrust of the Teton Range and farther south by the more gently folded overthrust ridges of the Wyoming and Salt River ranges, which nearly parallel the Wyoming-Idaho border.

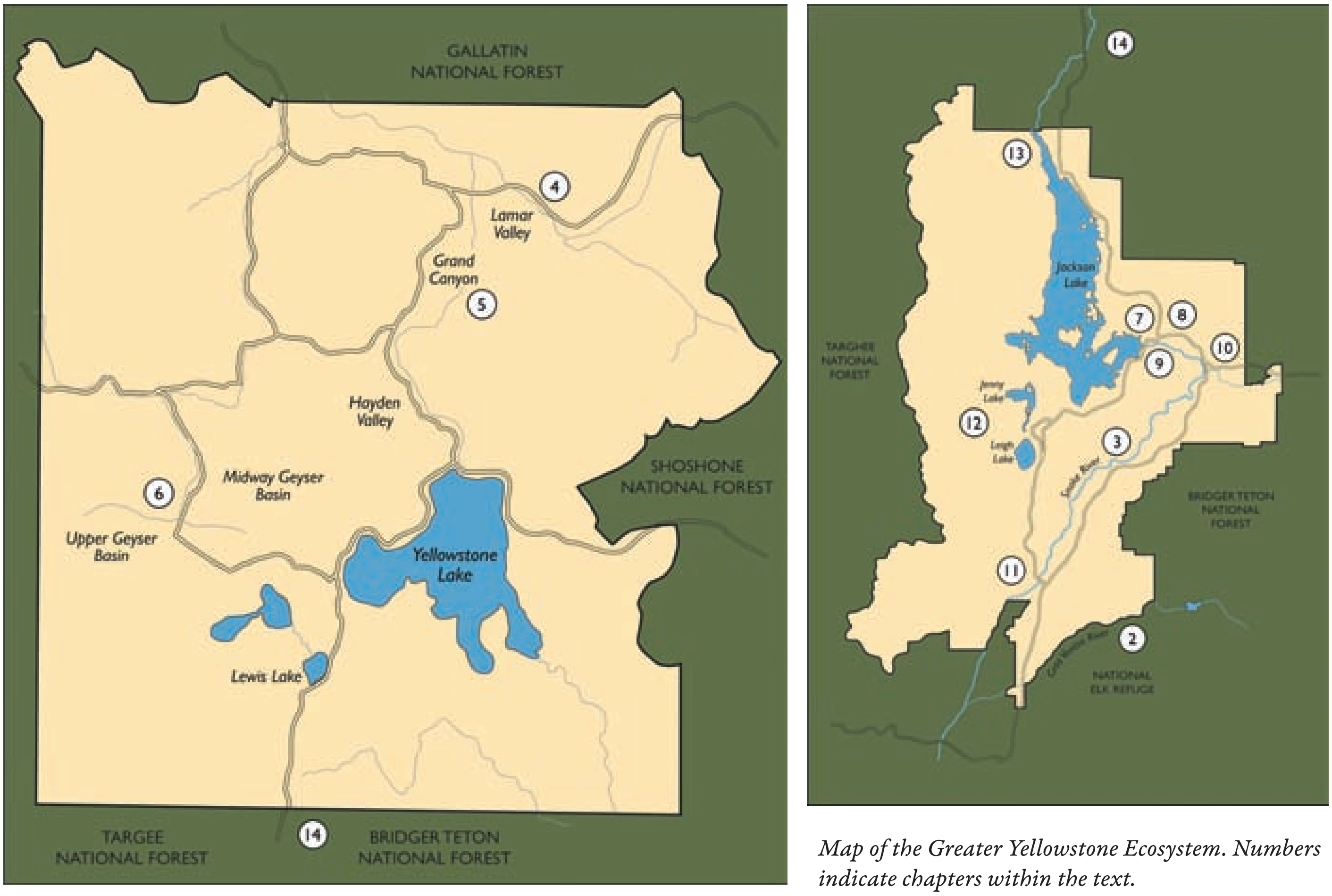
Finally, protruding at nearly right angles westward from the Tetons and associated mountains is a small fifth "finger." This is the Centennial Range of the Idaho-Montana border, along which the Continental Divide continues westwardly.

Of all these mountain groups in the Yellowstone region, by far the most recent is the Teton Range, whose dramatic eastern face was exposed less than ten million years ago by a fault in the earth's crust, where the mountains were tilted upward and the adjoining valley floor of Jackson Hole dropped downward in a relatively rapid series of earthquake tremors. The Tetons are thus among the youngest and most spectacular of all the Rocky Mountain ranges, with their peaks and ridges having been subsequently eroded and sculpted by a variety of glacial processes, especially by ice. As the eastern escarpment of the Tetons rose and the floor of Jackson Hole dropped, rock strata that were deposited over long periods of geologic time came into view. Indeed, the slopes of the range thus exposed to view provide a sequence of rock layers representing more than half of the earth's geologic history. The most ancient of these strata are banded Precambrian layers more than 2.5 billion years old, some of the oldest exposed rocks on the North American continent. Above these archaic rocks are sedimentary deposits less than a billion years old, which formed from materials deposited along the margins of Paleozoic seas that then inundated the area. On the northern slopes of the Tetons and adjacent Gros Ventre Mountains the reddish sandstones, blue-gray limestones, gray dolomites, and black and green shales lie stacked on top of one another where layer after layer of deposits were added to older strata below, interring with them the remains of Paleozoic animals such as trilobites and brachiopods.

As the Paleozoic seas gave way to those of the Mesozoic era about 200 million years ago, soft reddish, iron-rich sediments as much as 1,000 feet thick were laid down and now may be seen on the northern flanks of the Gros Ventre Mountains. These more brightly colored rocks were subsequently covered by a much thicker layer of dull-hued silt, sand, and clay toward the end of the Mesozoic era, leaving a flat and featureless floodplain as the Mesozoic sea finally retreated eastwardly. At the very end of Mesozoic times, starting about sixty million years ago during the Eocene epoch, mountain-building in the area began as the Wind River Range was thrust upward and westward. During the last sixty-five million years, the Cenozoic era, massive mountain-building occurred in North America, and most of the modern groups of birds and mammals evolved. Uplifts in several areas of what is now Wyoming (the Laramide mountain-building period) produced the first of the Rocky Mountains, while erosion simultaneously began to bury the adjacent basins.

A new geologic element was added to the massive and generally widespread forces of mountain-building and basin-filling when volcanic eruptions from the Yellowstone and Absaroka region dropped enormous amounts of lava and other volcanic debris on the adjacent landscape. The present-day, relatively flat Yellowstone Plateau has been shaped by the thousands of feet of volcanic materials that were deposited on the land surface over the past several million years and lies over a veritable cauldron of molten magma located deep within the earth. This magma chamber, or "hotspot," has been the breeding grounds of the supervolcanoes that have exploded in the Yellowstone region at least three times over the past two million years and has a much longer volcanic history, going back nearly twenty million years.

The entire Pacific Northwest was affected by these volcanic eruptions, which have resulted from shifting tectonic plates far below the surface. Volcanoes associated with this magma chamber have periodically spread ash and volcanic debris over much of western North



Map of the Greater Yellowstone Ecosystem. Numbers indicate chapters within the text.

America, beginning about eighteen million years ago in what is now northern Nevada. Since then a series of volcanic centers have seemingly moved northeastward, periodically erupting as one edge of one of the several tectonic plates that constitute the land mass of the North American plate moved southwest at about an inch per year above the plume, continuously feeding the volcanism of Yellowstone. As the edge of this plate has been forced under that of an adjoining massive plate, a series of supervolcanoes have erupted along a junction line roughly paralleling Idaho's upper Snake River Valley. Beginning in north-central Nevada (sixteen to eighteen million years ago), and as a result of the surface crust of western North America inching slowly southwestward, the hotspot marking the edges of the tectonic plates has correspondingly shifted northeastward across southern Idaho over a period of about twelve to fourteen million years before reaching the what is now the Yellowstone region. By about two million years ago this subterranean center of superheated magma was centered under what would become the present-day Yellowstone Plateau. The plateau was created by three giant supereruptions at 2, 1.2, and 0.63 million years ago. Since then it has risen more than a thousand feet and spread across a distance of about 125 miles, as a result of the pressures of the molten magma below, making it potentially the largest volcano in the world if it were to erupt again. The Yellowstone Plateau is the unique geologic product of the youthful Yellowstone hotspot and the buoyancy of the Yellowstone mantle plume. The Yellowstone

Plateau has two magma bodies, a deep mantle plume and a shallower crustal magma reservoir. The integrated plumbing of the magma from the plume into the crust has fueled the Greater Yellowstone region and produced its unique combination of volcanic elements, soil, and climate.

Major volcanic eruptions that occurred about 2.1 and 1.3 million years ago in what is now northwestern Wyoming and adjacent Idaho were violent precursors to one that occurred 600,000 years ago, or about the time that early humans (*Homo erectus*) were colonizing Eurasia. Then a caldera some 1,000 square miles in area literally blew the Yellowstone region apart. With a force perhaps a thousand times greater than the Mount St. Helens eruption of 1980, it sent ash over most of western North America and across the Great Plains. It cast deadly volcanic materials all the way to the Gulf of Mexico and deposited incalculable amounts of debris over the regional landscapes. The present-day geysers, hot springs, and other thermal phenomena in the Yellowstone region are modern evidence of the region's volcanic history, as are small but recurrent earthquakes, which are more frequent here than anywhere else in North America.

Since its major eruption the caldera has been relatively quiet, except for some smaller eruptions occurring as recently as 70,000 years ago. The now-inactive crater has gradually filled in through erosion and ash deposits. Lake Yellowstone now covers part of the southeastern edge of the crater's remains, which are some forty-five by thirty miles across. Its edges reach west from Lake Yellowstone nearly to the Idaho boundary and extend north to Mount Washburn. Much of the now-dormant crater is filled with a thick layer of rhyolite, a granite-like mineral commonly extruded from western volcanoes. The Yellowstone rhyolite bed covers much of the park and has fault zones forming subsurface channels that distribute and circulate hot water to the geyser basins and other parts of Yellowstone's vast thermal system.

After the eruption of 600,000 years ago, the area occupied by today's Grand Canyon of the Yellowstone River was also covered by rhyolite. Later heating chemically altered this material, making it brittle, relatively soft, and erodible. Much later, during one or more of the several glacial periods, the entire area was also covered by thick sheets of ice, probably leaving only the highest peaks of the Yellowstone region exposed. At the end of the last glacial period, 14,000 to 18,000 years ago, glacial melting formed Yellowstone Lake at the south end of the crater basin. It is believed that at the north outlet of that lake a huge ice dam may have formed. When that dam broke, immense volumes of water rushed out of the lake, cutting the V-shaped canyon that exists today. The yellow to russet colors of today's canyon walls are the result of oxidation of the iron compounds present in the thermally altered rhyolite, although the Yellowstone River is named for the similar color of riverside sandstones that are located far downstream.

Similar volcanic effects extended south into the Teton region. About eight to ten million years ago a large freshwater lake that had formed at the eastern base of the newly emerging Teton Range gradually began to dry up and be filled with volcanic sediments. Analysis of these lake sediments indicates that the area was inhabited by a variety of marsh and aquatic animals, such as snails, frogs, and beavers, and with adjacent forests of fir, spruce, pine, and associated plants.

FACING PAGE. *A common raven overlooks the Grand Canyon of the Yellowstone River, Yellowstone National Park, Wyoming*

OVERLEAF. *Bull elk crossing the Madison River, near a fire-killed stand of lodgepole pine, September, Yellowstone National Park, Wyoming*

Also about this time, movement along the Teton fault at the base of the mountains' eastern face initiated the tremendous uplift of the Tetons. Displacement of nearly 30,000 feet eventually occurred, lifting the eastern slope of the Tetons high over Jackson Hole and exposing their craggy surfaces to erosion by wind, water, and ice. At the same time, tens of thousands of large earthquakes of magnitude 7 or higher occurred. Later, Jackson Hole was covered twice by lakes for long periods of time. The first lake was eventually drained by additional warping and faulting of the earth's crust. The second lake persisted until less than a million years ago and perhaps almost until the initial glaciation that scoured the area and sculpted the Tetons into their present-day form.

The first and most widespread of these glaciations (the Buffalo Glaciation) probably occurred about two million years ago. Its ice centers were in the Beartooth Mountains northeast of Yellowstone National Park and in the adjacent Absaroka and Wind River Ranges. Ice sheets up to 3,000 feet deep streamed slowly southward over the Yellowstone Plateau, past the eastern face of the Tetons, over Jackson Hole and the canyon of the present-day Snake River. Their meltwaters ultimately drained into the Pacific Ocean via the Columbia River. A second and considerably smaller glaciation (the Bull Lake Glaciation) may have occurred about 160,000 to 120,000 years ago, when glaciers from the Tetons and the Absaroka Ranges merged and spread onto the floor of Jackson Hole. The third and smallest glacial event, the Pinedale Glaciation, extended from about 18,000 to 14,000 years ago and covered much of what is now Jackson Hole with ice. It produced terminal moraines at the base of the Tetons that resulted in the formation of Jackson, Jenny, Leigh, Bradley, Taggert, and Phelps Lakes (Knight 1994). As it receded, its meltwaters cut through its terminal moraine, allowing the Snake River to form and to cross the Potholes area, skirt Signal Mountain, and establish its present channel southward. Furthermore, pothole-like wetlands such as Cow Lake, Hedrick's Pond, and Christian Pond formed in the remains of ice-filled depressions in the moraines left by the receding glacier.

Similarly, during the Pinedale glacial period a thick ice sheet covered nearly all of what is now Yellowstone Park until only about 12,000 years ago. This frigid era began to change only grudgingly. A very gradual warming trend followed, but ended as recently as 4,500 years ago. In recent decades warming has resumed and accelerated at an alarming rate under the influence of human-caused global warming.

During the past 10,000 to 15,000 years the local Yellowstone forest vegetation has remained more or less intact, but with warming the extensive alpine tundra that probably covered much of the park was replaced by a whitebark pine forest less than 12,000 years ago. This plant community was later replaced by a lodgepole pine forest over much of the Yellowstone region, and still later by an open Douglas-fir community, at about 6,600 years ago. Since then the Douglas-fir forest has become denser, and the lodgepole pines have greatly increased, eventually becoming the most common trees in the Yellowstone region. Periodic fires not only have helped to increase the extent of lodgepole pines but also have favored grasslands in areas of fine-textured river- and lake-bottom sedimentary soils, at the expense of fire-sensitive shrubs such as sagebrush. Recurrent fires have also helped to maintain scattered stands of aspens, even in the presence of large browsing mammals, as they regrow rapidly from their roots following fires.

Until the recent suppression of forest fires in Yellowstone Park, relatively fire-tolerant trees such as ponderosa pines and Douglas-firs probably benefited from occasional relatively cool ground fires, which didn't penetrate the thick bark of older trees. However, the fire-sensitive lodgepole pines paradoxically benefit from major conflagrations. Some of the region's lodgepoles produce typical coniferous cones, which over time gradually open and drop their seeds. However, most lodgepoles produce resin-coated cones that strongly adhere to the branches and are resistant to opening by squirrels or other seed-eating animals. When these trees are burned, the cones are sufficiently scorched to burn away their glue-like resinous coats and release the abundant seed crop that may have been stored there for many years. The seedlings germinate rapidly in the ashy substrate, and the young trees may be able to begin producing a new crop of seeds in as little as ten years. By being able to mature rapidly and reproduce on the nutrient-poor volcanic-based soils that predominate across most of the southern half of the park, lodgepole pines now thrive there.

By about 9,000 years ago, the Yellowstone–Jackson Hole region was apparently already occupied by aborigines, and this region, which by then was rich in elk and other large grazing mammals, doubtless provided excellent hunting grounds. Evidence of prehistoric use of the Tetons by humans is still very limited, but an inundated campsite at the north end of Jackson Lake suggests that Paleo-Indians may have been using the area as early as 10,000 or 11,000 years ago and quite certainly were present by 5,000 to 7,000 BC. They were probably culturally related to the Plains Indians who depended on hunting a prehistoric species of bison. This bison eventually became extinct during a warm and dry period that persisted until about 2,500 BC. Thereafter, the modern species of bison appeared on the Great Plains. With it came a culture of Plains Indians that exploited these herds. By about AD 500 these Indians shifted from the spear to the bow and arrow as their primary weapon. This transition marks the start of the Late Prehistoric period. Traps for bison and pronghorns, probably used by Shoshone Indians, have been found south of the Tetons. The Shoshones apparently made regular visits to the Yellowstone region to obtain obsidian, a volcanic glass, for weapon points and tools.

The first white man to see the area was probably John Colter, who came through Union Pass in 1807 and explored the Yellowstone Plateau in 1808. His incredible stories of the area (often referred to as "Colter's Hell") stimulated the arrival of explorers, trappers, hunters, and finally settlers. Jackson Hole was originally called Jackson's Hole, meaning Jackson's Valley, and was named after David Jackson, an early trapper. French-speaking trappers call the high, central peaks Les Trois Tetons, or "the three breasts." This was, perhaps, a less apt name than that of the Shoshones, who had hunted there for generations and referred to them as Teewinot, or "many pinnacles."