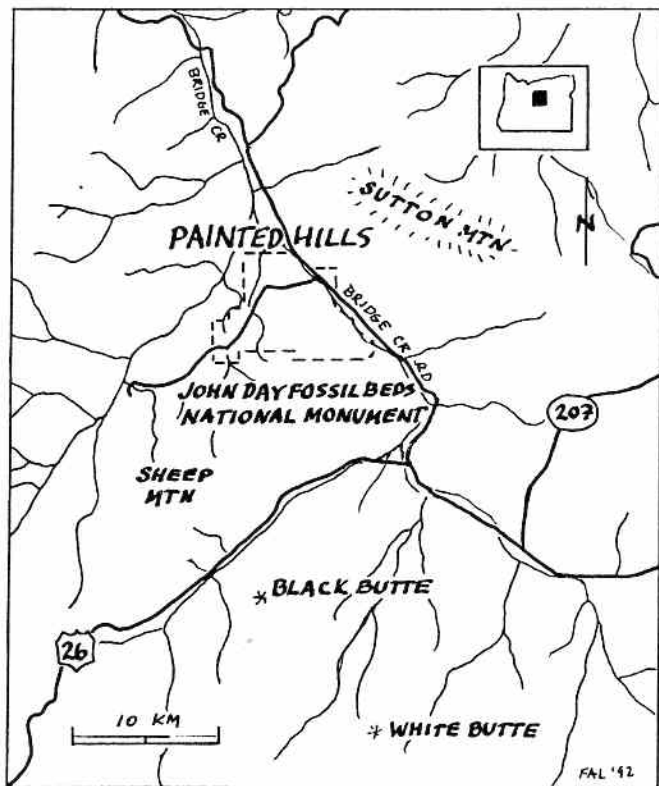


The Painted Hills: Thirty Million Years of Phylogeography

By Stuart Garrett and Berta Youtie

The Painted Hills Unit, John Day Fossil Beds National Monument lies at 600 meters (1970 ft.) above sea level about 15 km. (9 mi.) northwest of Mitchell, Oregon along Bridge Creek, a tributary of the John Day River.



This area is a spectacular combination of unusual geological features and varied plant life. The climate is semi-arid with most precipitation occurring during winter. It is hot and dry in summer.

The 5,668 hectare (14,000 acre) John Day Fossil Beds National Monument is administered by the Department of the Interior through the National Park Service. In 1947, the Howard and Avery families deeded 2.5 hectares (13 acres) at Painted Hills to the State of Oregon as a state park. This initial acreage was expanded and added to the National Monument when the National Park Service took over management in 1975.

The National Monument consists of the Painted Hills, Clarno and Sheep Rocks units. The 1,247-hectare (3,080 acre) Painted Hills unit is an excellent area in which to study the effects of climate, geological forces, and humans

on plant life. Fossils in local geological formations allow observations of more than 30 million years of earth's history.

Human History

Native Americans lived in John Day Valley for at least 8,000 years. The Painted Hills area divided Plateau and Great Basin (Paiute) cultures. Both groups made extensive use of plant resources in the area. The roots, nuts, seeds and berries of a variety of plants were used for food, medicine, shelter, cordage and ceremony. Biscuitroot (*Lomatium* spp.), also called wild celery or, in Indian terminology, "kouse," was an important staple of the Indian diet. Bitterroot (*Lewisia rediviva*) roots were peeled and boiled prior to eating. Camas (*Camassia quamash*) bulbs were dug as flowers faded and were baked in underground pits lined with balsamorhiza (*Balsamorhiza* spp.) leaves. Even the stems, fruits and roots of prickly-pear cactus (*Opuntia* sp.) were consumed. Fiber was obtained from willow (*Salix* sp.), Indian hemp (*Apocynum* sp.) and cattail (*Typha latifolia*). Bows were manufactured from juniper (*Juniperus occidentalis*) (Zucker et al. 1983)

Native Americans developed a pattern of seasonal travels which allowed them to visit particular sites for selected resources. Spring was a time for root digging and salmon harvest. Summer was used for travel to sites to take advantage of ripening fruits and seeds and for collection of fiber materials. Berry gathering and drying occurred in the fall. Winter saw reduced travel. Stored plant foods provided sustenance during this season of scarcity.

From a paleobotanical standpoint, Native Americans were the first people known to appreciate the plant fossils of John Day country. In the 1980's an archaeological research team from the Oregon Museum of Science and Industry found five small rock slabs with fossil leaf impressions in the corner of a house pit being excavated (Ashwill 1987).

The initial contact between Plateau culture Native Americans and Euro-Americans was with the Lewis and Clark expedition in 1805. The first Euro-Americans to extensively travel and explore the region were trappers. The Astorians, a group of fur trappers sent out by John Jacob Astor, followed in 1811. An unfortunate member of this party gave his name to the John Day River. John Day, a trapper from Virginia, became lost and was robbed by Native Americans near the mouth of the river that now bears his name (Brogan 1964).

¹ One of Oregon's great treasures is its biological diversity. "Oregon Plants, Oregon Places," a regular feature of *Kalmiopsis*, highlights Oregon's natural diversity. We will emphasize important geological, cultural and biological qualities of special Oregon places. Use these articles as guides to explore our remarkably diverse state.

In the summer of 1864 Captain John M. Drake of the US Army, stationed at Camp Maury on the upper Crooked River, noted that some of his cavalry had found fossil sea shells and mammal bones while pursuing "Snake Indians" (Paiutes). A minister named Thomas Condon accompanied soldiers to the area in 1865. Condon's interest in paleontology and geology eventually led to his appointment as the first Professor of Geology at the University of Oregon. Condon found fossils on Bridge Creek that would later make him and the area famous. He noted in a letter to geologist Dr. John Strong Newberry (Clark 1989), "On my last visit to the place of the outcrops I found some new things, new leaves, new fruit... as the region when I was there was infested with hostile Indians whose fresh tracks were on the trail I traveled, I could examine but little of the surroundings." Condon's correspondence with renowned paleontologists eventually catapulted the John Day Basin into international fossil fame.

The first settlers of the Painted Hills area were ranchers exploiting rich plant resources. Lowlands held stands of giant wild rye (*Elymus cinereus*). The uplands were rich with other native bunchgrasses. Large numbers of cattle and sheep were introduced to provide meat for gold miners in the Canyon City country to the east. Alterations of native plant communities began then and continued until the National Park Service fenced livestock from the Monument in 1980.

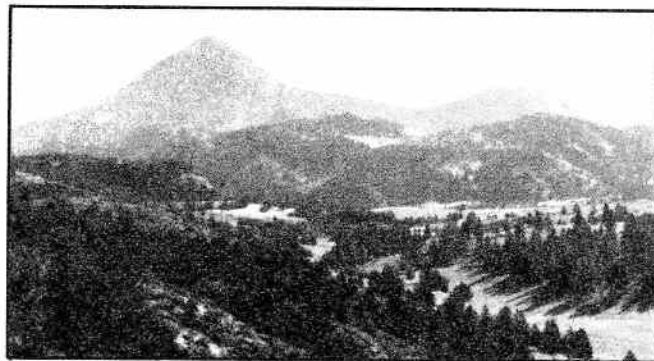
Geologic History

Bridge Creek Basin geologic formations are arranged like a layer cake. All strata located at, or visible from, Painted Hills are volcanically derived or are the result of erosional reworking and soil building of volcanic deposits. From the older (40 million years ago [mya]) and lower elevation Clarno Formation to the younger (15 mya) and higher elevation Columbia River basalt flows, these rocks form a remarkable geologic sequence that is internationally recognized for its contributions to paleontology and volcanic stratigraphy (Baldwin 1976).

Cenozoic Age of Mammals	Holocene	10,000 yrs. ago	Landslides
	Pleistocene	3 mil. yrs. ago	Rattlesnake Formation
	Pliocene	12 m.y.a.	Mascall Formation
	Miocene	25 m.y.a.	Picture Gorge Basalt
	Oligocene	40 m.y.a.	John Day Formation
	Eocene	60 m.y.a.	Clarno Formation
Mesozoic Age of Reptiles	Cretaceous	100 m.y.a.	Goose Rock Conglomerate

Eocene — Clarno Formation

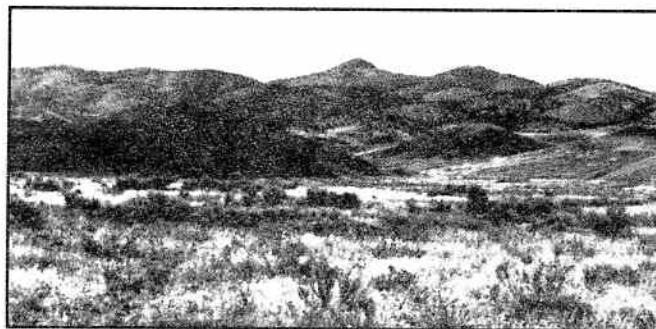
The oldest rocks, about 40 million years old, found at Painted Hills are from the Eocene. These are from the Clarno Formation, named for the pioneer crossing over the John Day River at Clarno. This formation is a sequence of lava flows, mud flows and ash tuffs that are Late Eocene to Earliest Oligocene. Local tropical to sub-tropical conditions



Black Butte, one source of Clarno Formation ash.

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of 40 million years ago, as revealed by fossil flora, contrast sharply with today's arid environment. The present High Cascade Range was absent during deposition of the Clarno Formation. Warm, moisture-laden storms from the Pacific Ocean swept unimpeded across this part of what is now central Oregon. Up to 254 cm (100 in.) of rain may have fallen per year. The Pacific Ocean covered most of western Oregon. Today, parts of India may approximate the climate of 40 million years ago at what is now Painted Hills.



Bare hills of the John Day Formation, vegetated Clarno Formation hills beyond.

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Through analysis of fossil nuts, fruits, seeds and leaves from other nearby fossil localities, we know that palms, tree ferns, avocados and catalpas grew here. Early horses, ancestral tapirs, primitive rhinos, crocodiles and oreodonts inhabited the lush forests. Volcanic ash from nearby active volcanoes (possibly White Butte and Black Butte to the



Eocene Mammals of Clarno time. Harold Comber Smith.

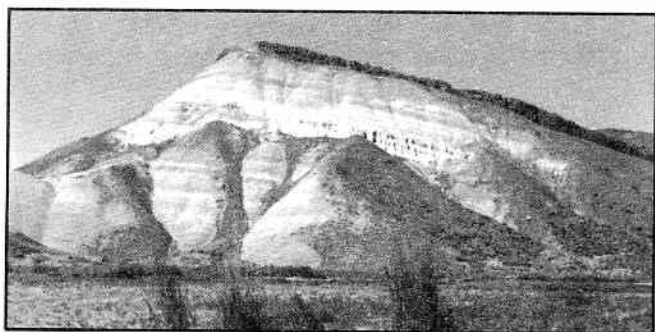
south) fell consistently in the region. This ash buried plant and animal remains and preserved them as fossils. The Eocene was a prelude to increasing volcanism to the west in what is now the Western Cascade Range.

Oligocene — The John Day Formation

Most landscape in the Painted Hills unit is composed of John Day Formation rocks and soils. Deposition of the John Day formation began about 34-36 million years ago. There were at least three sources for these strata: ancestral Cascade volcanoes, local eruptive centers and other volcanoes east of the current Cascade Range. Some eruptive centers may have been located near Powell Butte and Gray Butte to the west. These and other volcanoes spewed out light-colored rhyolitic ash high in silica (70%).

Products of these very explosive eruptions accumulated in the Painted Hills area as airfall and stream-carried material in lake and stream environments. These accumulations formed the cream-colored layers in the John Day Formation (Bishop 1989).

The Picture Gorge Ignimbrite is the 30.5 m. (100 ft.) thick ash flow sheet that caps Carroll Rim at Painted Hills.

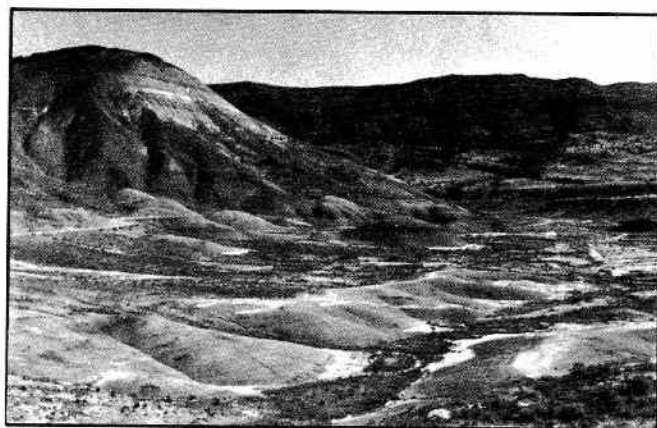


Great Basin wildrye below Carroll Rim.

This particularly violent eruption spread super-heated, gaseous ash over a large area. It was hot enough to melt together the pumice fragments in it. The rim is in the middle of the John Day Formation with about 245 m. (800 ft.) of ash above it and almost 305 m. (1,000 ft.) deposited below it. The John Day Formation is sandwiched between the overlying Columbia River basalts and the underlying Clarno Formation.

The spectacular red hills at Painted Hills are part of the lower John Day Formation and are colored, in part, by iron oxides. The green colors may indicate the clay celadonite (blue), the zeolite clinoptilolite (yellow) or reduced iron. The buff colors are close to the original color of the ash. Almost all of these layers have been reworked and altered by pedogenic (soil-building) processes.

The Oligocene climate was warm-temperate and drier than that of Clarno times. The ancestral Cascade Mountains were then high enough to begin to exert their rain-shadow effect on lands to the east. Plant fossils from Painted Hills provide a good idea of local vegetation and climate 32 million years ago.



Painted Hills, Carroll Rim, with Sutton Mountain beyond.

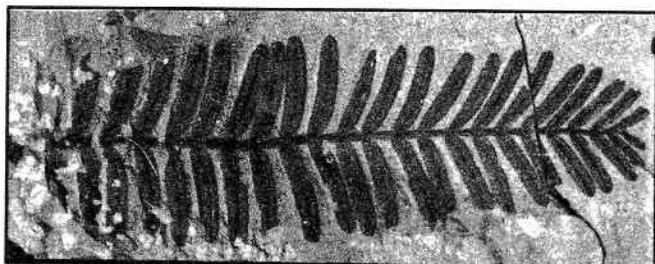


Bare John Day Formation Hills with Clarno Formation hills beyond.

The classic Bridge Creek fossil flora locality is at Painted Hills. Radiometric dating of the volcanic ash that buried the plants indicates these fossils are about 32 million years old. These plant fossil beds are somewhat below the strata where the best animal fossils are found (Manchester 1987). In some Bridge Creek shales, there are heavy concentrations of fossils with up to 210 fossil leaves per cubic foot of rock (Orr 1981). In 1883, Dr. John Strong Newberry published the first scientific descriptions of fossil plants from the John Day Formation. The Reverend Thomas Condon sent fossils collected at Painted Hills in the 1860's to Newberry, an experienced paleontologist and the first geologist on the faculty of Columbia University, New York City. He had traveled through central Oregon in 1855 as a geologist/botanist for the US Army's Williamson-Abbott Expedition which was part of the Pacific Railroad surveys (Garrett 1985).

Condon's and Newberry's work has been augmented by subsequent scientists. A picture has emerged of a temperate forest of deciduous hardwoods receiving up to 152 cm. (60 inches) of rain a year. The current forests of eastern Asia may approximate the Painted Hills forests of 32 mya. Alder (*Alnus*), Oregon grape (*Mahonia*) and oaks (*Hydrangea* and *Quercus*) were present. Eight species of maple (*Acer*) are found in the local fossil record. One of the extinct species was named *Acer ashwilli* after Melvin Ashwill, a noted paleontologist from Madras, Oregon. An extinct, five-needled pine is also present (Manchester 1987).

Original investigators identified coast redwood (*Sequoia*) from these strata. Subsequent researchers, however, named this taxon *Metasequoia*, a tree with deciduous, evergreen, opposite leaves, rather than the alternate, non-deciduous foliage of today's coastal redwood (*Sequoia sempervirens*). *Metasequoia* is referred to as the "dawn redwood." However, the title is misleading, because *Metasequoia* is not an ancestor to modern redwoods (Orr 1981). Although originally only known from fossils, *Metasequoia* was discovered growing in an isolated valley in Szechuan Province, China in 1947. This "living fossil" has been introduced into domestic cultivation.

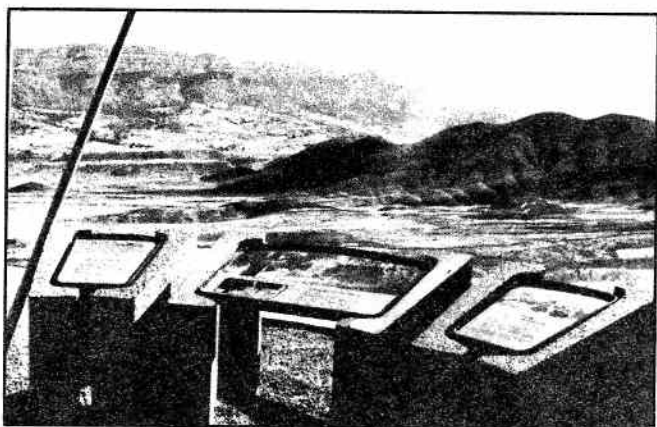


Metasequoia fossil.

Today, 15-20% of the fossil plant genera known from Painted Hills are globally extinct or are no longer found in central Oregon (Manchester 1987). The moist climate of Oligocene times contrasts markedly with the modern, dry climate. In these times, oreodonts, titanotheres, tapirs and early horses grazed under the forest canopy and on adjacent grasslands.

Middle Miocene — Picture Gorge Basalt

Absent from the Painted Hills Unit, but easily visible on the skyline east of Painted Hills.



View from Painted Hills overlook.

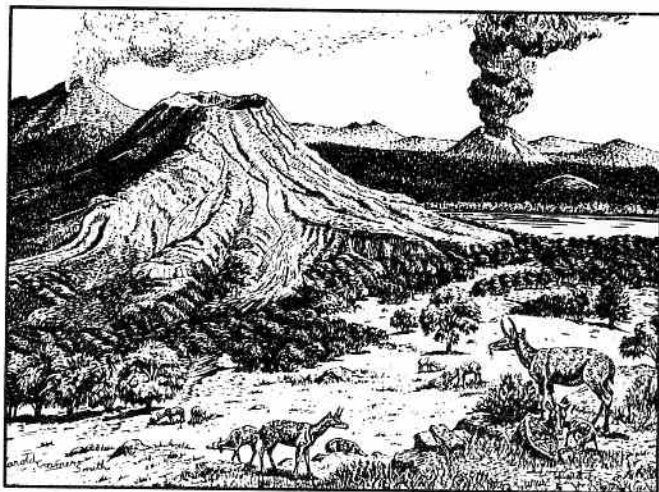
In the early Miocene, the rising Cascades caused a drop in rainfall to perhaps 76 cm. (30 in.). Forests were more temperate, with beech, birch, oak and chestnut replacing earlier forms. Saber-toothed tigers, cow-sized rhinos, miniature deer, oreodonts and intermediate horse forms lived in the forests and grasslands. During this time, about

16-12 mya, voluminous eruptions of relatively low silica (50%) basalt flows covered much of eastern Oregon and Washington, to depths of three miles. These are collectively referred to as the Columbia River basalts. Individual flows have been tracked for over 323 km. (200 mi.), and some even flowed in river canyons through the Cascades as intracanyon flows in the ancestral Columbia River, to the coast, forming some of the dramatic headlands there. Locally, the prominent Picture Gorge basalt flow erupted about 16-15.5 mya. In the Painted Hills Unit, these overlying flows eroded and are visible today only east across Bridge Creek Valley, where they make up the dark, imposing upper layers of Sutton Mountain.

Late Miocene — Mascall Formation 14 million years ago

Very Late Miocene — Rattlesnake Formation 6 million years ago

Both of these formations, if they were present, have been eroded in the Painted Hills vicinity. They deserve mention because they tell an important part of the story of the increasingly arid climatic conditions that have led to today's vegetation in the region.



Eastern Oregon in the Mio-Pliocene. Harold Comber Smith.

To the east, the 14 mya Mascall Formation, composed mostly of tuffs, erupted at the close of Columbia River basalt volcanism. The Mascall Formation records a time of increasing aridity (but still moister than today), with some freshwater lakes. The area was inhabited by early deerlike antelope, horses, wolves and camels. Willow (*Salix* sp.), Ginkgo, aspen (*Populus*), cottonwood (*Populus* sp.) and fir (*Abies* sp.) grew in the area.

The even-younger Rattlesnake Formation (6 mya) records predominately grassland vegetation (with juniper and sage appearing), with more modern forms of the horse, antelope, camel and ground sloth present. Rhinoceroses, mastodons and peccaries grazed beneath scattered trees. This formation includes an ash-flow tuff ejected from a

huge caldera located near Burns. Remnants are found west to Smith Rock State Park and east to John Day and Seneca.

Modern Vegetation

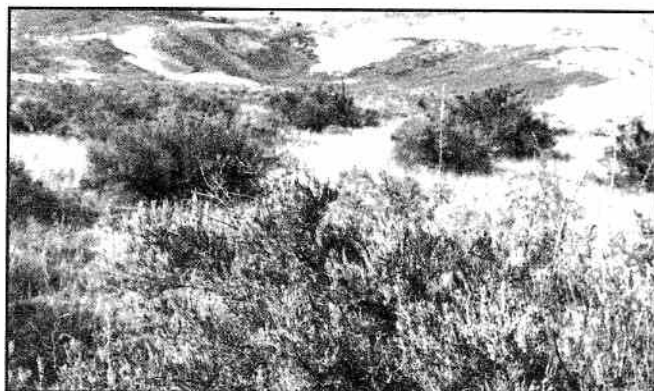
Painted Hills lies in the Blue Mountain physiographic province of Franklin and Dyrness (1973). The first vegetation analysis of John Day Fossil Beds National Monument was conducted in 1976 by Berta Youtie and Al Winward for the National Park Cooperative Research Unit at Oregon State University. They mapped and quantified vegetation types and identified threatened and endangered plant species. Seven plant associations with communities in various seral stages and ecological conditions (as a result of grazing, fire suppression and agricultural practices) were identified at the Painted Hills Unit (Youtie and Winward 1977). The park is no longer grazed by domestic animals, and fire is being reintroduced, but recovery has been slow. Vegetation transects established in 1976 and resampled in 1989 showed a slight increase in perennial bunchgrass species (B. Kauffman, pers. comm.)

A description for each community follows. These community divisions may be considered as habitat types or plant associations of the shrub steppe, meadow-shrub steppe or juniper woodland zones.

Current Vegetation

Plant Associations:

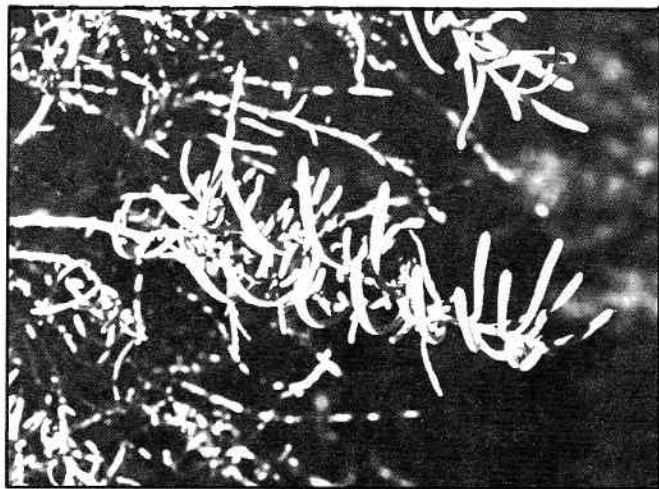
1. *Sarcobatus vermiculatus*/*Elymus cinereus* — *Distichlis stricta*
Greasewood/Great Basin wildrye — saltgrass



Greasewood and cheatgrass.

Greasewood is a large shrub that loses its thick, bright-green foliage in winter and is protected by sharp thorns. This vegetation type occurs in saline soils in bottomlands adjacent to Bridge Creek. Dominant understory species once included basin wildrye in the slightly-saline areas and saltgrass on the moderate- to highly-saline sites. Some flat, deep-soiled areas along the drainages may have supported nearly pure stands of basin wildrye or stands of big sagebrush/basin wildrye. Areas that traditionally supported

this vegetation have been farmed and heavily grazed. Exotic annuals such as cheatgrass (*Bromus tectorum*) and bulbous bluegrass (*Poa bulbosa*) now dominate the understory. It is believed that as Great Basin wildrye, one of our largest species of native bunchgrasses, was reduced by wintering livestock and native hay production, greasewood density increased on these sites. However, there are no historical data to evaluate shrub density changes.



Black greasewood with succulent leaves and spines.

2. *Atriplex confertifolia*/*Poa sandbergii*
Shadscale saltbush/Sandberg's bluegrass

At Painted Hills, the sites that support this vegetation are on the alkali clays of weathered John Day Formation ash. Soil pH as high as 8.5 has been recorded. This vegetation type tolerates the edges of the John Day Formation habitat, which is generally devoid of all vegetation. Plants on these sites must tolerate high alkalinity and the shrink-swell properties of montmorillonite clay. Even weeds such as cheatgrass have a difficult time invading, although bluebunch wheatgrass and a greater diversity of perennial forbs may have inhabited these sites at one time.

Because these habitats are found at low elevations and close to water at Painted Hills, past livestock use may have been a major influence.

This vegetation type is more widespread in the salt-desert shrub zone of the Great Basin and is found only in a few areas in the Pacific Northwest. Shadscale saltbush appears as a medium-sized shrub with lateral branches forming sharp spines. Domestic animals and wild ungulate grazers utilize this shrub for winter forage.

3. *Artemisia tridentata*/*Agropyron spicatum* — *Poa sandbergii*
Big sagebrush/bluebunch wheatgrass — Sandberg's bluegrass

In much of the low elevation habitat of Painted Hills, the bluebunch wheatgrass component is no longer apparent. Snakeweed (*Xanthocephalum sarothrae*), a small half-shrub

resembling rabbitbrush (*Chrysothamnus* spp.), and annual forbs and grasses such as cheatgrass now dominate the understory. Sandberg's bluegrass has persisted under heavy grazing, while bluebunch wheatgrass has been nearly eliminated. At sites greater distances from livestock water, or on sites with steep topography, or more moist conditions due to higher elevation, the ecological condition improves. Bluebunch wheatgrass increases and big sagebrush cover decreases.

Big sagebrush is one of the icons of the desert west. It is remarkably well-adapted to its habitat. It has both shallow spreading roots and deep taproots to take advantage of available moisture. It sports long ephemeral leaves which appear early in the growing season and afford an early photosynthetic start by taking advantage of accessible spring moisture. Three subspecies inhabit Oregon; that at Painted Hills is subspecies *tridentata*.

4. *Juniperus occidentalis*/*Artemisia tridentata*/*Agropyron spicatum*
Western juniper/Big sagebrush/Bluebunch wheatgrass



Less than 50-year-old junipers invading big sage shrub steppe.

This vegetation type is very similar to the previous big sagebrush type with the addition of western juniper as the overstory component. Bluebunch wheatgrass is still present on some sites, although cheatgrass and Sandberg's bluegrass are dominant in lower seral stages. Idaho fescue (*Festuca idahoensis*) may also have been present in areas with a northern aspect.

At Painted Hills, junipers are found at higher elevations with stringers extending down the ravines. Junipers occur naturally on these sites, but have likely increased in density under the past management regime. Western juniper population expansion has been correlated with precipitation change in Pleistocene climatic conditions by Mehringer and Wigand (1984). Also, understory fuel reduction by livestock and suppression of wild fires by humans has allowed western juniper to invade adjacent areas (Burkhardt and Tisdale 1974).

5. *Artemisia rigida*/*Poa sandbergii*
Scabland sagebrush/Sandberg's bluegrass

One small site supporting this habitat type was found at Painted Hills. This vegetation type is quite common on

higher elevation scablands in the Columbia Basin and Blue Mountains. Scabland sagebrush is particularly well adapted to shallow, gravelly soils where its relatively deep taproot can extract moisture from cracks in the underlying bedrock. Also it is able to tolerate these xeric conditions by being drought-deciduous, dropping its leaves during the late summer months. Sandberg's bluegrass also has the ability to thrive in these shallow soils. The only other common species on this site is cheatgrass. Squirreltail grass (*Sitanion hystrix*) is a short-lived perennial bunchgrass often found in this habitat.

6. Riparian Vegetation

There is an intermittent spring east of Painted Hills Overlook with a diversity of hydrophytic plant species such as cattail (*Typha latifolia*), oatgrass (*Arrhenatherum elatus*), celery-leaved buttercup (*Ranunculus sceleratus*) and an array of rushes and sedges.

Recently, the BLM acquired the lands adjacent to Painted Hills along Bridge Creek. In 1976, there was only exposed, down-cut stream banks with no stabilizing woody vegetation. Today a major restoration project is underway to restore the riparian ecosystem along the creek. Through livestock exclusion, stream bank protection and planting of cottonwood, alder and willow, regeneration can be observed along the stream. Beaver dams are altering the hydrology of the area.

7. Mountain Brush Vegetation

Vegetation dominated by shrubs was identified on a talus slope adjacent to the scabland sagebrush/Sandberg's bluegrass site. Franklin and Dyrness (1973) referred to these shrub sites on talus slopes as shrub garlands. Western Serviceberry (*Amelanchier alnifolia*) and golden and wax currants (*Ribes aureum* and *R. cereum*) were the major species found and were present only at this location.

Endemic Species

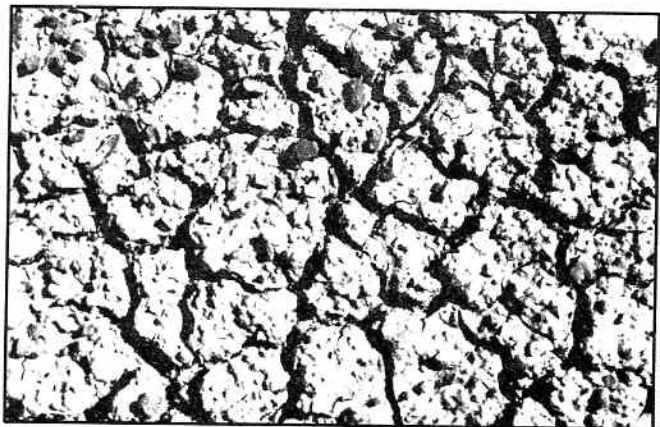
John Day Basin is home to several plants found nowhere else in the world. Native plants of restricted distribution are referred to as endemic. They may be endemic to a continent, a state, a particular mountain or even a single locality. Endemics are separated genetically from their ancestors by adaptations in response to differences in soil, climate, geographic isolation or a combination of these and other factors.

Cretaceous seas receded from central Oregon over 60 mya. Terrestrial plants have had a long period to establish themselves in this region. As noted, a number of species evolved, only to suffer extinction over geologic time. The series of cataclysmic volcanic eruptions in the Painted Hills area and climatic changes caused by the Cascadian rainshadow undoubtedly influenced the species of plants found here. We know from the fossil record that many genera once growing here are gone from central Oregon (*Metasequoia*, *Platanus*, *Morus*, *Ulmus*, *Juglans*, etc.). Others are still represented in central Oregon (*Acer*, *Pinus*, *Mahonia*, *Abies*, *Rubus*, *Amelanchier*, etc.), if not actually at Painted Hills

(Manchester 1987). One aspect of Painted Hills is the fact that the area continues to support several plant species not found anywhere outside the John Day River Valley.

There are a number of reasons why the six locally endemic species discussed below have restricted ranges. Geographic isolation is one probable factor. Over the last 40 million years, a series of massive and destructive volcanic eruptions not only intermittently destroyed much local vegetation, but also made it difficult for other plants to immigrate into the area. Unlike the relatively small eruption of Mt. St. Helens (small, at least, on a global geologic scale), the Miocene basalts, the Picture Gorge ignimbrite or the Rattlesnake ignimbrite were orders of magnitude greater than the eruption of Mt. St. Helens, and would have totally destroyed all life in the areas where they were deposited. Obviously, this scale of eruption limits immigration of species from outside the destroyed area.

These endemic species grow in unusual soils. Some are paleosols, ancient soils which have been re-exposed, are rich in elements such as titanium and deficient in others, such as selenium. The roles of these factors in developing endemic plants of the John Day Valley have yet to be scientifically investigated. Physical characteristics of these soils are also unusual. Montmorillonite clay soils characteristic of the John Day Formation in Painted Hills have remarkable properties of expansion with hydration and contraction with drying. This gives the soils the so-called "popcorn" texture they exhibit in their dry state. This physical soil fluctuation makes germination and growth difficult for some plants. Expansion of the surface of these soils when rain falls tends to seal them and makes moisture penetration to deeper layers difficult.



John Day Formation clay.

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Endemic Plant Species Found at Painted Hills

Liliaceae, many-flowered onion (*Allium pleianthum*). Flowering white to pink in April and May, this perennial onion is found only on the sticky, clay soils at low elevations. This taxon remains on the Oregon Natural Heritage Program review list due to the lack of information on its status as a sensitive species. This species is often confused

with Tolmie's onion (*A. tolmiei* var. *tolmiei*). The majority of occurrences are in Wheeler County between Mitchell and the Clarno Basin.

Fabaceae, John Day milkvetch (*Astragalus diaphanus* var. *diaphanus*). The small, biennial milkvetch with white flowers tinged with purple blooms in the spring. It has been collected from Grant County to the mouth of John Day River. It grows on very poorly developed soils and on scabland areas. This variety has recently been recognized as distinct from the var. *diurnus* growing on the south fork of John Day River, mainly due to fruit morphology.

Scrophulariaceae, John Day paintbrush (*Castilleja xanthotricha*). The common name of this taxon does an excellent job of describing the species. This yellow-flowered paintbrush is confined to John Day Valley and can be seen blooming from April through June in Wheeler County. It grows on the low elevation sagebrush-covered hills from river elevations to 765 meters. It is hemi-parasitic and grows in conjunction with sagebrush, snakeweed or bunchgrasses. In drought years, which are quite common in its range, this perennial paintbrush may be found in reduced populations.

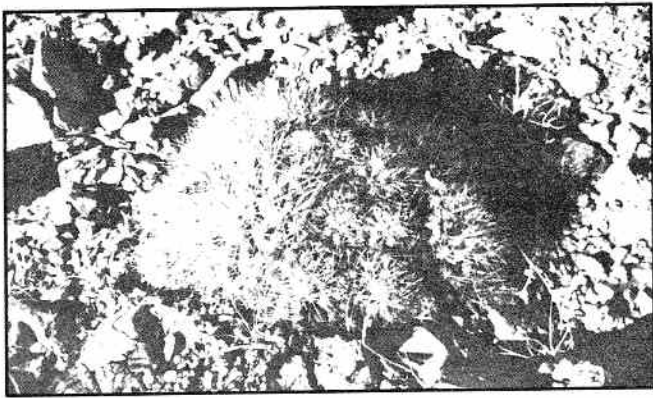
Asteraceae, John Day chaenactis (*Chaenactis nevii*). This yellow-flowered chaenactis is most often found in red clay soils of the John Day Formation in Wasco, Wheeler and Grant Counties, blooming in May and early June. The only yellow-flowered chaenactis in Oregon, this annual is very sensitive to moisture conditions. In relatively wet years, this species may grow profusely in small valleys among the red hills at the Painted Hills Unit. It is usually associated with golden cleome (*Cleome platycarpa*), another very unusual plant.

Scrophulariaceae, crested tongue penstemon (*Penstemon eriantherus* var. *argillosus*). This perennial penstemon is endemic to central Oregon and can be found blooming in June and July. It is locally common and seems to thrive on disturbed sites. Look for this species on road cuts.

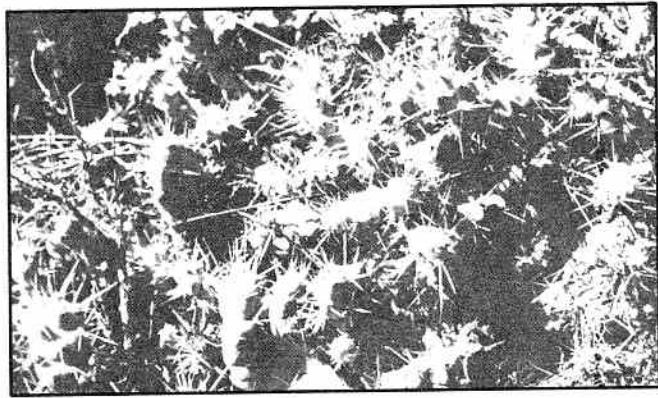
Rosaceae, belled cinquefoil (*Potentilla glandulosa* var. *campanulata*). This variety of perennial cinquefoil is characterized by petals that are erect instead of spreading and longer than the sepals as compared to other varieties. At Painted Hills, it inhabits rocky dry washes and blooms in May and June. It has also been collected on talus slopes and basalt cliffs in John Day Valley.

Other Interesting Species Found at Painted Hills

Cactaceae, hedgehog cactus (*Pediocactus simpsonii*). Although not endemic to John Day Valley, this barrel cactus can be observed in dry washes and rocky ridges at Painted Hills. It only occurs in a few places in Oregon. The cactus grows in clumps with flower shades ranging from yellow to pink to magenta, blooming from the end of April to the beginning of May. Another cactus, plains prickly pear (*Opuntia polyacantha*), is also found at Painted Hills but is more common throughout eastern Oregon.



Hedgehog cactus.



Prickly pear cactus.

Lamiaceae, purple desert sage (*Salvia dorrii*). This very fragrant shrub with blue-violet flowers and silvery herbage grows on barren hillsides in John Day Valley. When in bloom, these conspicuous shrubs can be identified from a long distance. The low-elevation, harsh sites are devoid of almost all other vegetation. Purple sage has a limited range within the Pacific Northwest.

Pallid milkweed (*Asclepias cryptoceras*). This species of milkweed is quite rare in John Day Valley. It is most often collected on the barren red clays of the John Day Formation. However, it has also been found on rocky clay sites with greater vegetative cover. The prostrate milkweed emerges on the hills in May from an enlarged, woody root. The inflorescence appears decumbent and almost artificial, as if someone had planted a plastic flower.

MANAGEMENT ISSUES

Fire

Fire has been a regular occurrence in the Painted Hills area, although no definitive data exist as to its frequency. The return frequency cycle probably ranged from a few years to a few decades. Fire probably occurred as a mosaic. Native Americans were known to use fire intentionally to enhance certain plant resources. There is no reason to

think they didn't do this in the Painted Hills area, but there is no documentation of such activities. Fire suppression has been practiced since Euro-American settlement. Suppression substantially changed the plant communities, favoring woody tree and shrub species over forbs and grasses. Recent prescribed burns on the monument demonstrate that grasses and forbs increase after burning, while juniper and sage decrease in burned areas.

Grazing

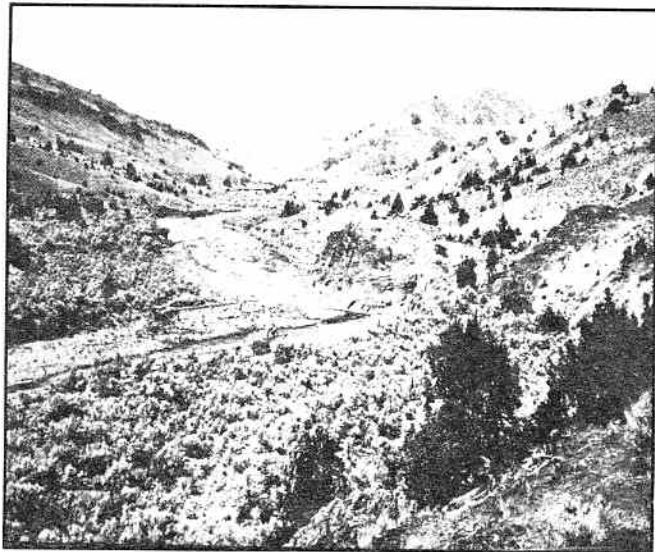
Perhaps no other land use in central Oregon generates more controversy than grazing. Perhaps no other use of the steppe has had the impact caused by grazing. Large numbers of Euro-Americans first traveled through the Bridge Creek area during the gold rushes of the 1860's. The first ranches were founded to provide beef for these miners. Native stands of grass were lush. The bottoms provided Great Basin wildrye and native hay. The uplands had intact stands of Idaho fescue (*Fescue idahoensis*) and bluebunch wheatgrass (*Agropyron spicata*). Early pioneer accounts refer to "grass up to the stirrups," or even to the saddlehorn.

When settlement occurred, large numbers of cattle, horses and sheep arrived in a relatively short time, perhaps 10 to 20 years. Large herds of livestock had been built up west of the Cascade Mountains, so stock no longer had to be trailed from California or the eastern states. It is inaccurate to place *all* the blame on the livestock industry for use and appropriation of all surface waters in central Oregon, the takeover by exotic species of much of our rangeland, dramatic increase in woody species and consequent decrease in grasses, and the severe alteration of riparian ecosystems and fisheries. However, the impacts of grazing have been significant and long-lasting. Current grazing practices attempt to avoid this damage, with the long-term goal of restoration of native plant communities on public land.

The most damage was probably done in the first few decades of grazing. By the 1920's and 30's, altered ecosystems showed impacted riparian areas, increased woody species and decreased native bunchgrasses. The general trend since then has stabilized or improved. It is remarkable how long it takes native grasslands to recover. In areas with heavy cheatgrass invasion, there is concern that original native vegetation can *never* be restored, or that cost of restoration will be prohibitive.

The Prineville District BLM, in conjunction with local ranchers, National Park Service and conservation groups, is working to reduce juniper, to reintroduce fire, to protect riparian areas and to enhance fish habitat.

Photos from Princeton Expedition of 1889 show substantial impacts in vegetation from grazing by that time — Princeton then and now.



PRINCETON UNIVERSITY

Compare the 1889 Princeton University Paleontologic Expedition photograph of the Bridge Creek Valley (above) with the same scene in 1989. Notice the increase in juniper.



GARRETT

Exotics

One of the more alarming aspects of Painted Hills flora is the extent to which exotic plants have invaded the area. Cheatgrass (*Bromus tectorum*), Russian thistle (*Salsola kali*), knapweed (*Centaurea repens*), tumbling mustard (*Sisymbrium altissimum*) and whitetop (*Cardaria pubescens*) are all found in greater or lesser degrees in many parts of the park. Tall wheatgrass (*Agropyron elongatum*) has been seeded.

Cheatgrass is perhaps the most noticeable foreign invader. Introduced in the 1870's from Eurasia, it spread rapidly along rail lines. By 1900, it was well established in many parts of the west. Some accounts indicate that cheatgrass was intentionally brought in as an annual feed; others say it was introduced as a contaminant in hay or wheat, or was carried in by cattle from Eurasia.

In any event, it exists in nearly solid stands in some areas.

This is particularly evident on the lower hills west of Sutton Mountain along the east side of Bridge Creek. Cheatgrass, a winter annual, can germinate any month of the year, providing a competitive advantage over many native plants which are spring germinators. It grows during wet periods during winter, extracting necessary moisture from the soil. By the time native perennials germinate and begin growing in spring, moisture has been depleted. Cheatgrass also seems to tolerate fire well. It burns readily and reseeds vigorously following fire. Grazing doesn't seem to retard its spread. Some enclosures in eastern Washington still have the same dominant cover of cheatgrass that they had when fenced 50 years ago. Land managers have yet to figure out a way to restore native systems in the face of heavy cheatgrass infestation.

Riparian Issues and Restoration

Bridge Creek drainage suffers from degraded riparian areas due to poor grazing management during the last century. This has subsequently impacted the native runs of anadromous (salmon and steelhead) fish which inhabit John Day Valley, the largest undammed drainage in Oregon. Increases in woody upland species have increased soil loss and siltation. Spawning beds erode or silt over. Grazing in the riparian areas increases stream downcutting, destabilizes stream banks and decreases shading vegetation. Water temperatures are higher than anadromous fish can tolerate. Beavers have been reintroduced to Bridge Creek. Beaver dams and ponds are restoring an essential element of riparian communities. The future seems bright for this drainage.

Plant List

The following list of plants is selective rather than comprehensive. We have listed those plants which are dominant, likely to be observed or are of particular interest. Those who wish further information are referred to the work by Youtie and Winward (1977) for a complete list. Species listed here cover a variety of plant communities and include the most common and some rare species. Almost all of them can be seen along one or more of the trails listed below.

"RTE" indicates that this plant was or is on the Rare, Threatened or Endangered List for Oregon.

denotes a non-native species.

GRASSES: *Agopyron spicatum* (bluebunch wheatgrass); *Bromus rubens* (foxtail brome); *Bromus tectorum* (cheatgrass)#; *Elymus cinereus* (giant wildrye); *Festuca idahoensis* (Idaho fescue); *Sitanion hystrix* (squirreltail).

FORBS: *Achillea millefolium* (yarrow); *Agoseris hereophylla*; *Allium macrum* (onion), *A. tolmiei*, *A. pleianthium* (RTE); *Amsinckia tessellata* (fiddleneck); *Antennaria dimorpha* (pussytoes); *Astragalus diaphanus* (milkvetch) (RTE), *A. filipes*, *A. misellus*, *A. purshi*; *Blepharopappus scaber*; *Calochortus macrocarpus* (mariposa lily); *Cardaria pubescens*

(white top)#; *Castilleja chromosa*, *C. xanthotricha* (John Day paintbrush) (RTE); *Chaenactis nevii* (John Day chenactis) (RTE); *Cirsium undulatum* (thistle); *Cleome platycarpa* (golden beplant); *Crepis occidentalis*; *Crocidium multicauli* (spring gold); *Cryptantha celosioides* (cockscomb cryptantha); *Delphinium nuttallianum* (larkspur); *Draba verna* (whitlow-grass); *Erigeron linearis* (fleabane); *Erigonum sphaerocephalum* (rock buckwheat), *E. strictum*, *E. vimineum*; *Eriophyllum lanatum* (woolly sunflower); *Erodium cicutarium* (storksbill)#; *Erysimum asperum* (prairie rocket); *Fritillaria pudica* (yellowbells); *Helianthus nuttallii* (Nuttall's sunflower); *Lepidium perfoliatum* (pepperweed)#; *Lesquerella occidentalis* (western bladderpod); *Lewisia rediviva* (bitterroot); *Lithophragma bulbifera* (fringecup), *L. glabra*; *Lomatium hendersoni* (yellow biscuitroot), *L. macrocarpum* (white biscuitroot), *L. triternatum*, *Malva neglecta* (cheeseweed); *Microseris troximoides* (false agoseris); *Mimulus cusickii* (Cusick's monkeyflower), *M. guttatus*, *M. nanus*; *Oenothera tanacetifolia* (tansy-leaf primrose); *Opuntia polyacantha* (prickly pear cactus); *Pediocactus simpsonii* (hedgehog cactus) (RTE); *Penstemon erianthus* (figwort) (RTE); *Phacelia hastata* (waterleaf), *P. linearis*; *Potentilla glandulosa* var. *campanulata* (gland cinquefoil) (RTE); *Ranunculus glaberrimus* (buttercup), *R. testiculatus* (horned buttercup)#; *Salvia dorii* (purple sage); *Sedum lanceolatum*; *Sisymbrium altissimum* (Jim Hill tumblemustard)#; *Sphaeralcea coccinea* (globemallow); *Tragopogon dubius* (salsify)#; *Trifolium pratense* (red clover)#.

SHRUBS: *Amelanchier alnifolia* (western serviceberry); *Artemisia rigida* (scabland sage), *A. tridentata* (big sage); *Atriplex confertifolia* (shadscale), *A. spinosa* (spiny hopsage); *Chrysothamnus nauseosus* (gray rabbitbrush); *Ribes aureum* (golden currant), *R. cereum* (red currant); *Salsola kali* (Russian thistle)#; *Sarcobatus vermiculatus* (greasewood).

TREES: *Juniperus occidentalis* (juniper).

RIPARIAN: *Typha latifolia* (cattail).

Hikes

The National Park Service has a number of trails for visitors to Painted Hills. Remember that the National Monument was set aside to protect the paleontological and geological resources of John Day Valley. **Taking any of these resources is prohibited, and violators will be prosecuted.** The park encourages recreation such as hiking, wildlife viewing, plant observation and nature photography. Visitors are asked to stay on the trails. Here are several of our favorites.

Painted Hills Overlook Trail

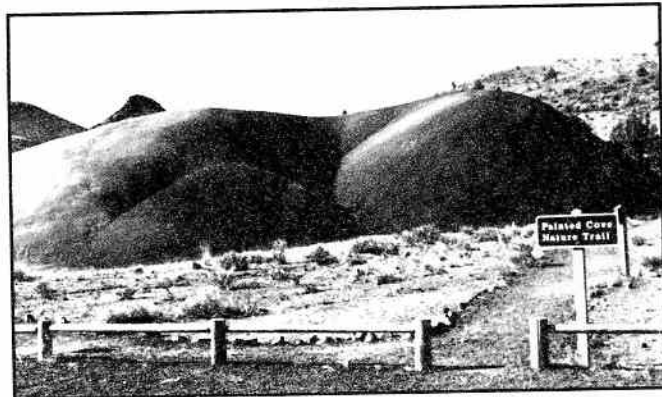
0.8 km. (0.5 mi.) one way

Start from the parking overlook for the hills. The red, gray, black, olive and tan of the hills are best early and late in the day. It traverses the big sagebrush/Sandberg's bluegrass community. John Day paintbrush is frequently seen in this area.

Carroll Rim Trail

1.2 km. (.75 mi.) one way

This highly-recommended short trail climbs steeply to the best overlook in the park. Sutton Mountain is to the east and the Bridge Creek Valley to the north. The north-facing slope near the top supports a stand of bluebunch wheatgrass that is in excellent ecologic condition due to its long distance from water and grazing. Nuttall's larkspur (*Delphinium nuttallianum*) is found growing in the talus at the summit.



Note tip of uncovered Oligocene hill in background.

Painted Cove Trail

0.4 km. (.25 mi.) loop

This short, easy trail winds through a small red hill formation. Interpretive displays are offered for the barren hills and other aspects of local geology. This is a good trail from which to see 30-million-year-old topography. There are two large Oligocene hills near here which have been uncovered by erosion and may represent original shapes (Fisher 1964). John Day chaenactis, bitterroot and golden cleome can be seen here.



Note dead junipers in prescribed burn in background.

Leaf Fossil Hills Trail

0.4 km. (.25 mi.) loop

Follow this trail to the type locality of the Bridge Creek

fossil flora where plant fossils were quarried from shale deposits. Big sagebrush, wheatgrass and juniper are found along the trail. Note the invasion of young junipers. The effects of a recent fire were still obvious in 1992. **No fossil collecting is permitted.**

Conclusion

In many ways, Painted Hills represents a microcosm of the plants and plant communities of central Oregon and the management challenges facing us. The complex history of human use of the area can be read in the changes on the land. How well we are able to restore these altered natural patterns will be judged by future generations.

Acknowledgements

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