Second American Dendrochronology Conference

University of Arizona

Laboratory of
Tree-Ring Research

AmeriDendro 2013

Grand Canyon
Excursion

May 10 – 12, 2013

Trip leaders and guides:

- Paul Sheppard: dendrochronology, forest ecology, environmental history of the Southwest, Sense of Place.
- Gary Huckleberry: geology, archaeology, environmental history of the Southwest, Sense of Place.
- Patrick Pfeifer: Grand Canyon, environmental sustainability, Sense of Place.

Grand Canyon Excursion Daily Schedules

Friday, May 10			time
6:00 AM	6:30 AM	arrive LTRR, stash stuff	0:30
6:30 AM	7:40 AM	drive: Tucson to rest area	1:10
7:40 AM	7:50 AM	rest area	0:10
7:50 AM	9:50 AM	drive: rest area to exit 287	2:00
9:50 AM	10:10 AM	gas, restrooms, lunch pick up	0:20
10:10 AM	11:00 AM	drive: exit 287 to I-40	0:50
11:00 AM	11:22 AM	drive: I-40 to Sunset Crater view	0:22
11:22 AM	11:32 AM	group photo Sunset Crater	0:10
11:32 AM	11:35 AM	drive: to SC Visitor Center	0:03
11:35 AM	12:35 PM	lunch and SC Visitor Center	1:00
12:35 PM	12:40 PM	drive: SC VC to Lava Trail	0:05
12:40 PM	1:40 PM	Lava Trail	1:00
1:40 PM	2:10 PM	drive: Lava Trail to Wupatki VC	0:30
2:10 PM	3:40 PM	Wupatki	1:30
3:40 PM	4:40 PM	drive: Wupatki to Kachina	1:00
4:40 PM	5:40 PM	dinner	1:00
5:40 PM	5:50 PM	drive: Kachina to motel	0:10
5:50 PM	6:15 PM	check in, change	0:25
6:15 PM	6:26 PM	drive: motel to Lowell	0:11
6:26 PM	7:00 PM	Lowell exhibits, gift shop	0:34
7:00 PM	7:45 PM	Lowell talk	0:45
7:45 PM	9:30 PM	Lowell star/planet gazing	1:45
9:30 PM	9:40 PM	drive: Lowell to motel	0:10
Saturday, May 11			**time**
6:00 AM	7:40 AM	breakfast at motel	1:40
7:40 AM	8:00 AM	drive: motel to Gus Pearson	0:20
8:00 AM	9:00 AM	Gus Pearson forest ecology	1:00
9:00 AM	10:00 AM	drive: GP to Tusayan	1:00
10:00 AM	10:20 AM	restrooms, lunch pickup	0:20
10:20 AM	10:30 AM	drive: to GCNP entrance, pay	0:10
10:30 AM	10:35 AM	drive: to Visitor Center	0:05
10:35 AM	5:00 PM	Grand Canyon	6:25
5:00 PM	5:15 PM	drive: VC to Tusayan pizza	0:15
5:15 PM	6:15 PM	dinner	1:00
6:15 PM	6:30 PM	drive: Tusayan pizza to VC	0:15
6:30 PM	6:55 PM	shuttle: VC to Yaki Point	0:25
6:55 PM	8:00 PM	Sunset @ 7:24 PM	1:05
8:00 PM	8:25 PM	shuttle: Yaki to VC	0:25
8:25 PM	8:40 PM	drive: VC to Tusayan	0:15
8:40 PM	10:00 PM	drive: Tusayan to motel	1:20
Sunday, May 12			**time**
6:00 AM	7:20 AM	breakfast at motel, checkout	1:20
7:20 AM	8:25 AM	drive: motel to Exit 287	1:05
8:25 AM	8:45 AM	gas, restrooms, lunch pick up	0:20
8:45 AM	8:50 AM	drive: 287 to 289	0:05
8:50 AM	9:00 AM	drive: 289 to Montezuma Castle	0:10
9:00 AM	9:50 AM	Montezuma Castle	0:50
9:50 AM	10:08 AM	drive: Castle to Well	0:18
10:08 AM	10:53 AM	Montezuma Well	0:45
10:53 AM	11:05 AM	drive: Well to V-Bar-V	0:12
11:05 AM	12:05 PM	V-Bar-V lunch and rock art	1:00
12:05 PM	3:45 PM	drive: V-Bar-V to LTRR	3:40
3:45 PM	3:55 PM	pick up stuff at LTRR	0:10
3:55 PM	4:00 PM	drive: LTRR to DoubleTree	0:05

Published by Western National Parks Association

The net proceeds from WNPA publications support educational and research programs in the national parks.

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Written by Sue Fischer, National Park Service Designed by Theresa Reindl Bingham

Front cover by Tom Bean

Printing by Commercial Printers

ISBN 13: 978-1-58369-097-0

WESTERN NATIONAL PARKS ASSOCIATION

www.wnpa.org

ISBN 1-58369-097-2

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Lava Flow Trail

Sunset Crater Volcano National Monument

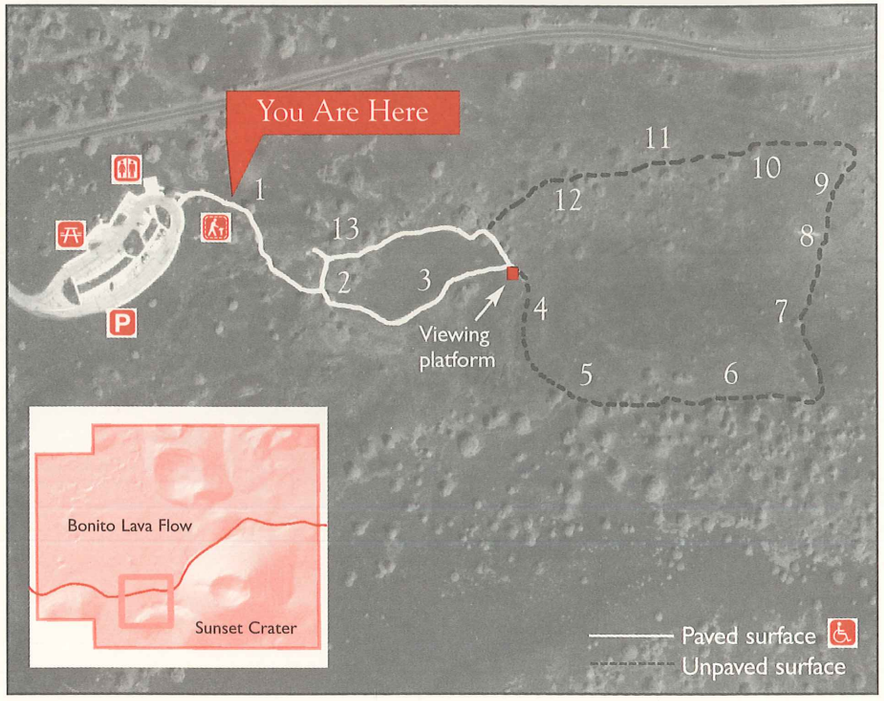
Price: $1.00

Trail Information

This moderate (1 mile, 1.6 km) trail has rough surfaces and takes you through lava flows and cinder barrens to the base—not to the top—of Sunset Crater. You'll need water and sturdy footwear. There is an alternate ¼-mile (.4 km), easy, accessible paved loop.

Please:

- Stay on the trail
- No pets
- No hiking or climbing on Sunset Crater



1

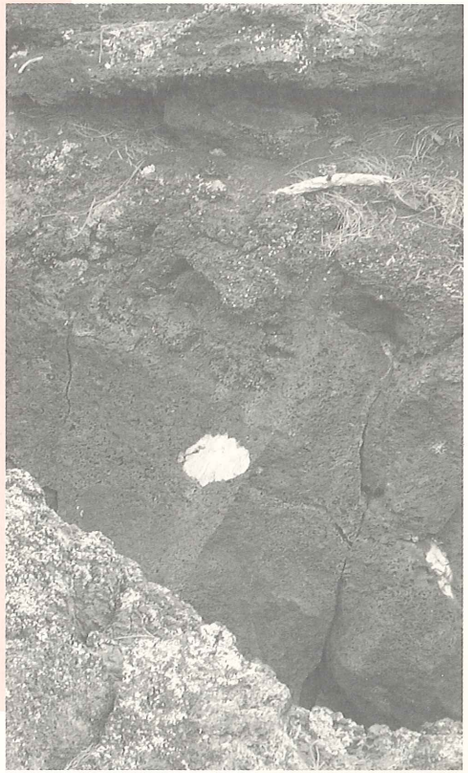
Our Dynamic Earth

Alpine slopes, forests, and grassy parks disguise the fiery, molten, and often explosive history of this region's landscape. But here, amidst the Bonito Lava Flow and Sunset Crater's cinder fields, the land's volcanic origin is revealed in stunning clarity.

As you walk the trail, use this guide to explore the powerful forces—rapid and violent, slow and patient—that continually shape our planet. These forces also affect our lives and provide for life in ways we may not realize.

Patterns often reveal forces otherwise invisible to us. As you cross the bridge, look to your right for a small light-colored rock embedded in the dark basalt rock. This is a xenolith (zee-no-lith), a rock fragment foreign to the body of rock in which it occurs. When magma rose to the surface, it brought up pieces of limestone from 700 to 1,000 feet below us.

Uplift and erosion have exposed this rock (known as Kaibab limestone) elsewhere: at the rims of Grand Canyon and nearby Walnut Canyon and in cliffs at Wupatki National Monument.

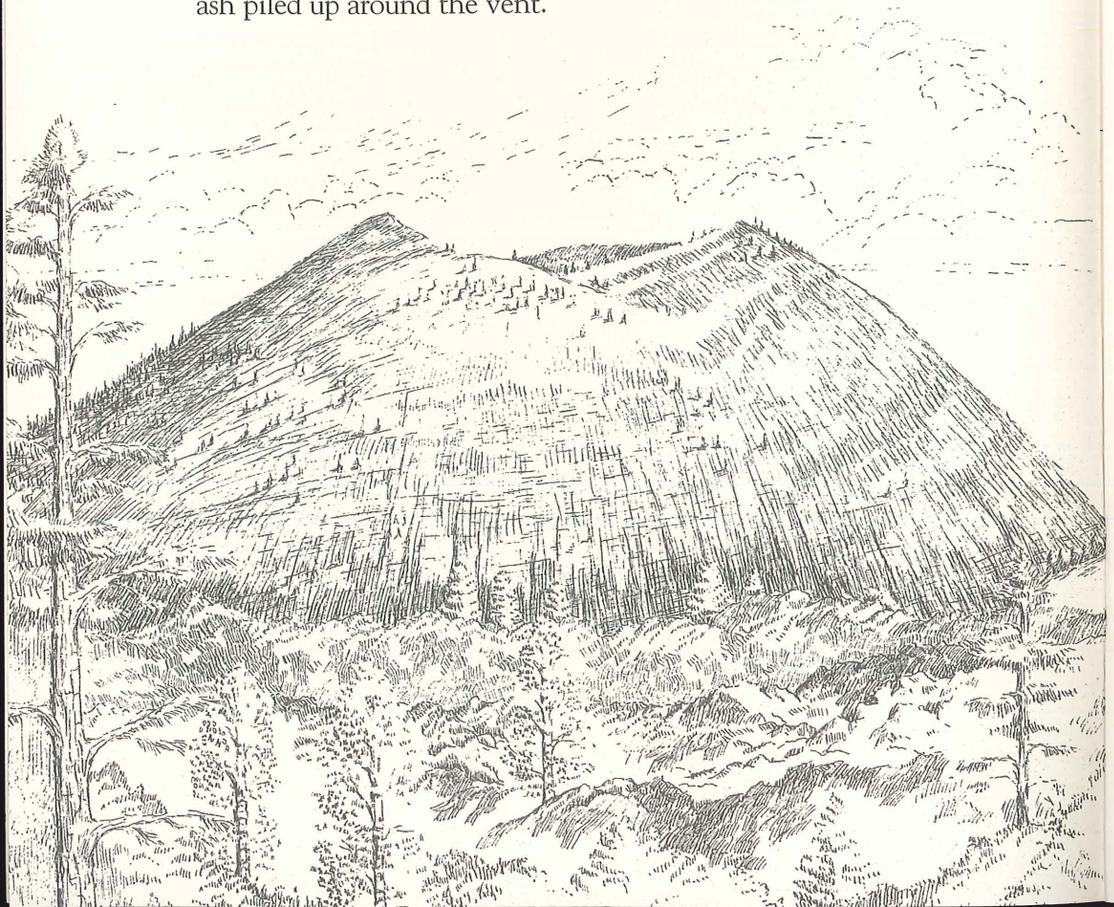


2

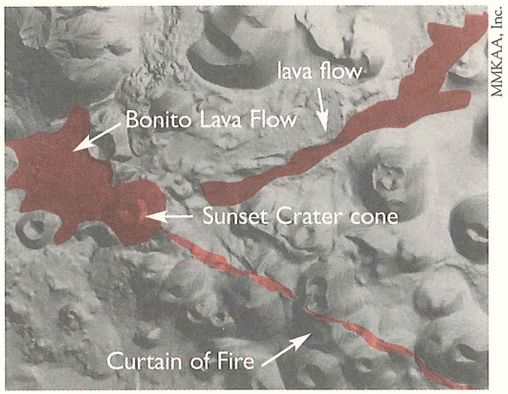
A Complicated History

Sunset Crater rises before you, a nearly symmetrical cone. Its perfect shape suggests a simple eruption history, but that was not the case. In fact, it wasn't until the 1980s that scientists began to understand the complexity and extent of the eruption.

First, molten rock (magma) and gasses pushed up to the earth's surface along a six-mile-long weak spot or fissure in the earth's crust. Volcanic fragments, called pyroclasts, shot upward along the fissure in a "curtain of fire" as gasses escaped violently. Small cinder cones formed along this fissure before the magma became focused and erupted as a lava fountain from a primary vent. A large cone (Sunset Crater) grew as the shower of cinders and ash piled up around the vent.



Meanwhile, lava broke out of the base of this side of the cinder cone, forming the Bonito Flow all around you. The lava pooled, trapped by surrounding older volcanoes, and accumulated to perhaps 100 feet (30 m) thick during at least three separate flows. On the opposite side of the cone, lava flowed more than six miles (10 km), filling a narrow valley.



MMKAA, Inc.

When the volcano coughed out its last cinders—after several months or perhaps several years—they were colored by the oxidation of iron in the magma. Similar to the way metal rusts, the magma came in contact with water-rich gasses emitted during the final stages of the eruption. These red cinders rim the top of the cone.

Sunset Crater Facts

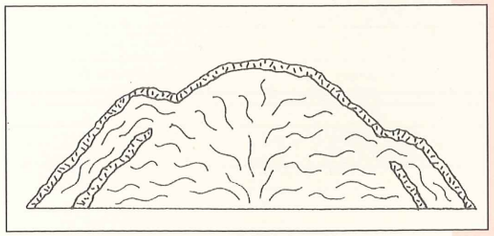
- Eruption date: sometime between 1040 and 1100
- Height: 1,000 feet (305 m)
- Elevation at summit: 8,029 feet (2,447 m)
- Diameter at base: 1 mile (1.6 km)
- Diameter at top: 2,250 feet (868 m) from rim to rim
- Depth of crater: 300 feet (91.4 m)
- Extruded material: approximately 1 billion tons
- Extent of ashfall: approximately 800 square miles (2,072 sq km)

3

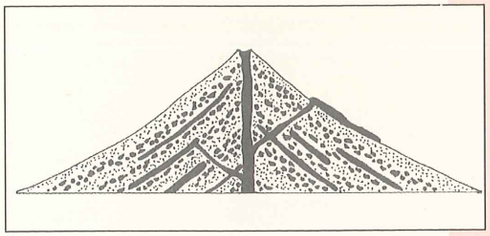
One Volcano Amid Many

At nearly 1,000 years young, Sunset Crater volcano is a geological infant, the latest development in a series of eruptions that have taken place here over the past 6 million years. It is only a small part of the impressive San Francisco Volcanic Field of northern Arizona.

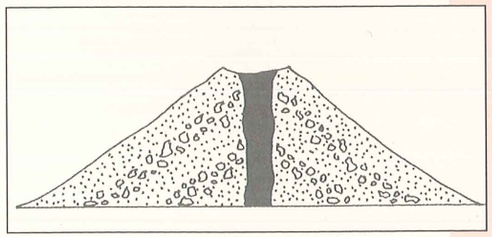
From this point, three different types of volcanoes are visible. What makes a volcano tall or short, steep or gentle, or an eruption more or less violent? Mostly the magma's stickiness or viscosity, which is determined by its chemical composition and gas content.



Dome volcanoes tend to have steep sides and a rounded shape. Look for a dome volcano (O'Leary Peak) on the horizon in front of you.



Composite or stratovolcanoes have sharp peaks and less steep sides. Mount St. Helens, Mount Fuji, and the San Francisco Peaks, in the distance to your left, are examples of this classic volcano type.



Cinder cones, like Sunset Crater and most of the 600 or so volcanoes in this field, tend to be cone shaped with sides not steeper than 33 degrees. A cinder cone is literally a pile of loose fragments. It is easily eroded and will change shape, becoming less steep as it ages.

4

Ropes and Clinkers

At this point, you are on the southern edge of the Bonito Lava Flow. Magma, periodically relieved of gas pressure, squeezed out of the base of the cone as glowing liquid lava (magma that has reached the surface). Lava oozed off and on many times creating a very structurally complex flow, covering about 2 square miles (5 sq km).

Lava flows tend to form either jagged blocks, known as aa (ah-ah), or a smooth, ropey surface of pahoehoe (pa-hoy-hoy). Flows usually start as pahoehoe, thin and runny. As the lava cools and becomes more thick and pasty, it can change into an aa flow. The Bonito Flow is mostly aa lava.

When aa is forming, cooled, hardened blocks are rafted along the surface of hot, moving lava, making clinking noises as they tumble into each other. Sometimes called clinkers, these hardened blocks would still make a clinking sound if you knocked them together. You can try this with samples at the visitor center.

Although its structure is complicated, the flow's composition is uniform throughout. The lava and cinders around you, whether black or red, ropey or jagged, are basalt.

Aa (ah-ah) flow

Pahoehoe (pa-hoy-hoy) flow

5

Dating Debates

What if scientists always agreed, never argued, or changed their minds?

Clues in Buried Homes

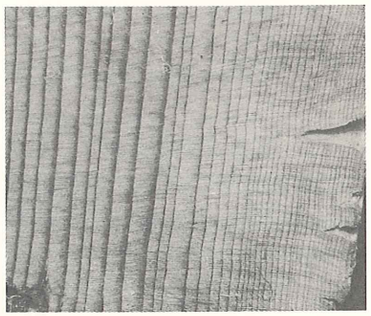
Until archeologists discovered Sinagua-style pithouses beneath the cinders, scientists did not suspect Sunset Crater was so young. Knowing the age of the pithouses from tree-ring dates and pottery types found in these homes, they concluded the eruption occurred after 1046 and before 1071.

Museum of Northern Arizona

Ash layers revealed in excavated pithouse

Patterns in Tree Rings

Trees near an erupting volcano, if they are injured but continue to live, show a growth disturbance in their rings. Based on the growth pattern seen in three wood specimens from nearby Wupatki Pueblo, scientists hypothesized that the eruption occurred between the growing seasons of 1064 and 1065. But, this evidence is limited and inconclusive.



Detail of growth disruption in tree rings

Magnetism in Rocks

Geologists have taken more than 100 core samples from the Sunset Crater lava flows for paleomagnetic studies. Using both paleomagnetic dating and stratigraphic evidence, geologists currently restrict the Sunset eruption to sometime between 1040 and 1100.

Mark Elson

Coring lava and recording magnetic orientation

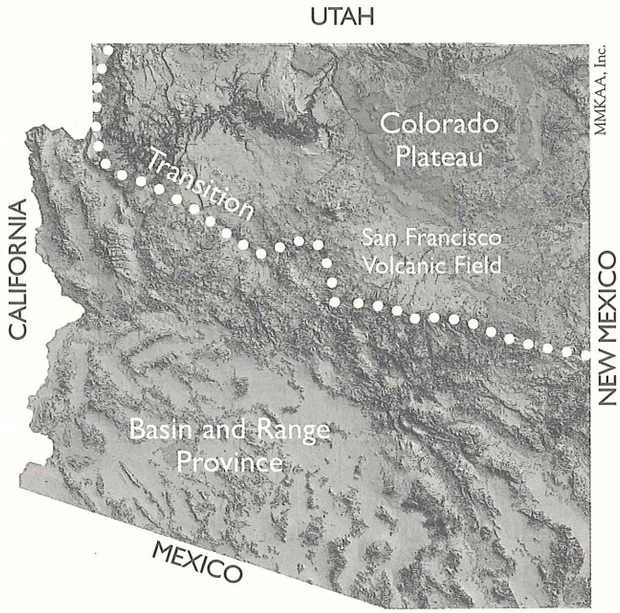
6

Why Are Volcanoes Here?

Most volcanoes are found along tectonic plate boundaries where continents and seafloors collide or move apart. We are far from a plate boundary; consequently, geologists debate why volcanoes occur here.

One theory proposes that the North American plate is moving over a stationary "hot spot." But this theory does not explain why there are young volcanic fields all along the southern margin of the Colorado Plateau and then east to New Mexico and Oklahoma.

Another more accepted theory focuses on a disruption in the flow of Earth's mantle at the boundary between the Colorado Plateau, where the Earth's crust is very thick, and the Basin and Range region (to the south and west), where the crust is very thin.

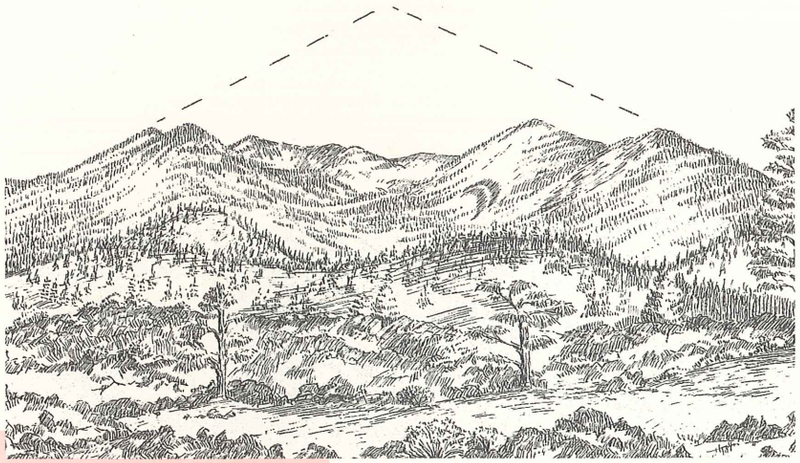


At this transition, heat from the mantle rises and melting occurs. Ancient faults, activated by stretching of the North American plate (which has created the Basin and Range and is extending into the Colorado Plateau), serve as pathways for magma to move to the surface.

7

An Explosive Past?

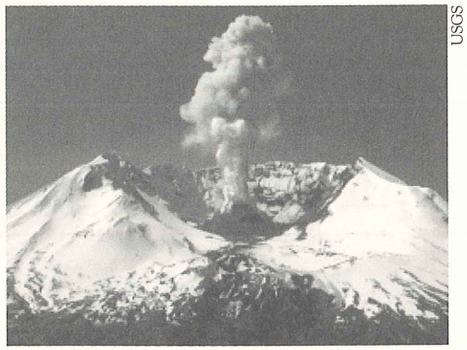
On the horizon, the San Francisco Peaks rise as the highest mountains, forming the dominant feature of the San Francisco Volcanic Field. Imagine the sides continuing up to form one 16,000-foot-high mountain. This may be what the stratovolcano looked like about 500,000 years ago. The summit and flank of the volcano may have exploded and collapsed, much like Mount St. Helens. Erosion over thousands of years has created several peaks from the original volcano. Humphreys Peak, standing at 12,633 feet, is the tallest and is the highest peak in Arizona.



San Francisco Peaks

How Did They Get Their Name?

The peaks were named in 1629 by a group of Franciscan missionaries in honor of St. Francis of Assisi. In 1847, a small West Coast settlement on the verge of becoming a boom-town changed its name from Yerba Buena to San Francisco. This happened more than 200 years after the Arizona peaks were christened.



USGS

Mount St. Helens, May 19, 1982

Volcanic eruptions may seem destructive but they are among the beneficial forces of a living planet: forces that build mountains, create oceans, and provide for life. Only when our planet has finished cooling will there be no volcanoes. Then, Earth will be a dead planet much like Mars.

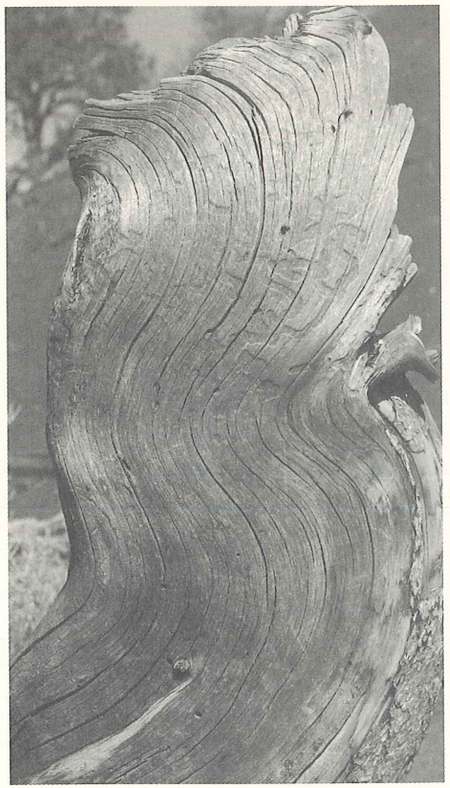
Eruption of Parícutin in Mexico, 1943, is considered the modern day equivalent of the Sunset eruption.

8

Taking Root

When the lava flowed and the cinder cone formed, all plant life within a several mile radius was destroyed. The oldest ponderosa pine trees here today, like this fallen giant, are about 400 years old and are probably not the first generation to return. Plants struggle to grow.

Unlike Hawaii where abundant moisture promotes plant growth soon after eruptions, precipitation here averages only 16 inches (41 cm) a year. Furthermore, soil is sparse in this dry climate where water limits plant life and organic material breaks down slowly.



National Park Service

Notice the massive trailing root system of this dead tree. Trees growing on these cinder slopes face extraordinary challenges, in finding anchor in loose, unstable cinders and in capturing water as it drains rapidly through them. Notice also how this tree spiraled as it grew. Ponderosa pines grow either straight or dextrally (spiraling to the right).

Spiral growth reduces the overall strength of a tree but increases its flexibility. The spiral grain also provides an even distribution of water from a single root to all of the needles and of nutrients from a single branch to all the roots.

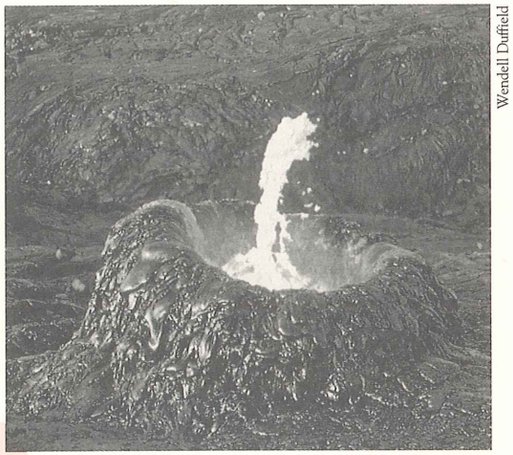
In a straight tree, wind-damaged branches or damaged roots would deprive water and nutrients to the roots directly below and branches directly above. By spiraling, this tree was better adapted to the stresses of its environment: lack of water, high winds, and occasional heavy snow. But it wasn't able to remain anchored when its roots were exposed by erosion from foot traffic.

9

Miniature Volcanoes

On the slope below you is a small spatter cone. Do not leave the trail; protect this fragile feature by viewing it from a distance.

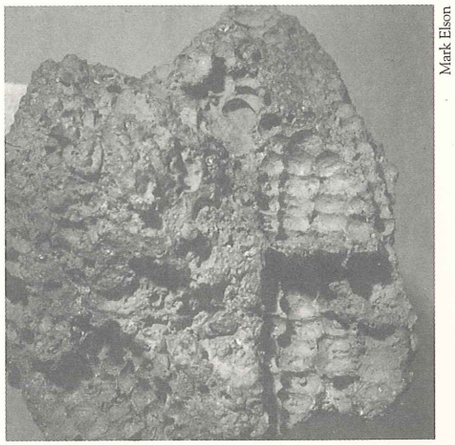
Spatter cones, or *hornitos* ("little ovens" in Spanish), form when lava is forced up through an opening in the cooled surface of a lava flow. They are "rootless," fed by the underlying flow rather than a deep magma conduit. Can you picture fluid fragments of liquid lava spurting upward, flattening, congealing, and mounding around the opening?



Wendell Duffield

Spatter cone

Can you imagine approaching an erupting spatter cone? Unique artifacts found nearby—corn casts in lava rock—suggest people did. Experiments conducted in Hawaii demonstrated that "corn rocks," like the one on display in the visitor center, can form when ears of corn are covered by fluid blobs of spatter. It appears people intentionally ventured close to an active hornito, maybe this one, to leave corn—perhaps as an offering. More than 50 rocks with corn casts have been found in homesites attributed to the local Sinagua cultural tradition.



Mark Elson

Corn rock

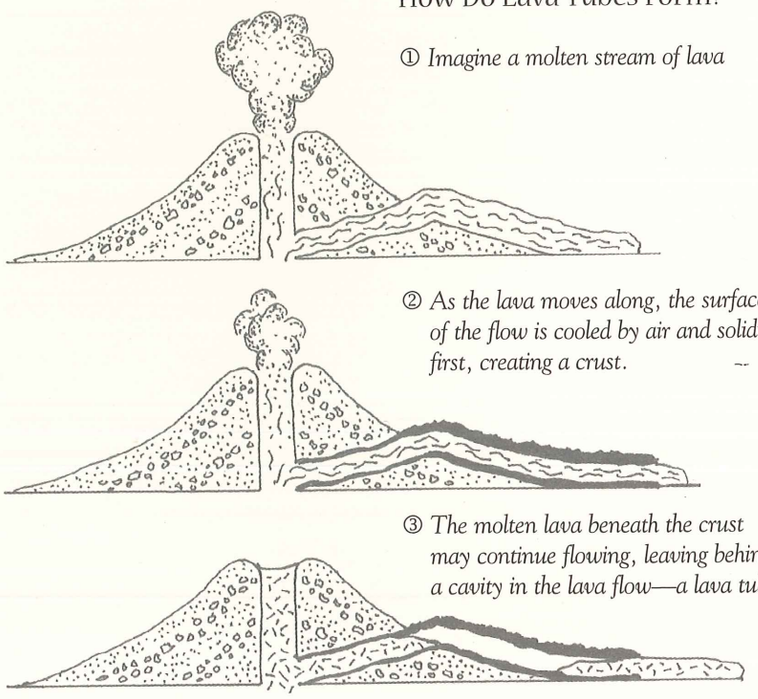
10

Undercurrents

Beneath the lava you now stand on are perhaps dozens of caves. As lava flowed, the top surface cooled first due to contact with air. A hardened crust formed. Meanwhile, rivers of lava continued flowing below, periodically breaking through the crust to form the spatter cones you saw earlier. When the flows ceased, the remaining lava drained out the downhill end of the crusted-over channels, leaving behind tube-like caves.

Most of these caves were sealed with hardened lava and have no openings to the surface. A collapse created the opening you see here.

How Do Lava Tubes Form?



① *Imagine a molten stream of lava*

② *As the lava moves along, the surface of the flow is cooled by air and solidifies first, creating a crust.*

③ *The molten lava beneath the crust may continue flowing, leaving behind a cavity in the lava flow—a lava tube.*

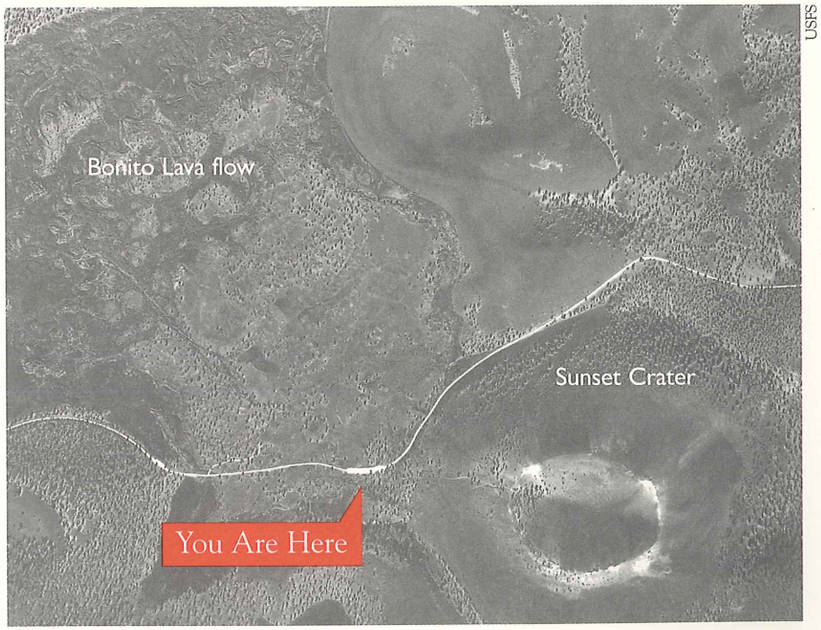
11

Surface Currents

Looking beyond the lava and spatter in front of you, and just beyond the line of trees, can you see a reddish hill? This is an agglutinate mound or pile of welded pyroclastic material.

In the early stages of the eruption, a cone began to form next to a major explosive vent. The cone became armored by welded deposits. Then a column of dense magma broke through the base of the cone, causing the upper part of the cone to collapse onto the top of the flow. The slumped pieces were then rafted away by the flowing lava. You are looking at a large piece of an early-stage cone of Sunset Crater.

Perhaps within weeks or days after breaching, the cone was rebuilt, creating the symmetrical cone of Sunset Crater we see today. Any remnants of the earlier cone lie buried beneath tons of cinder.



USFS

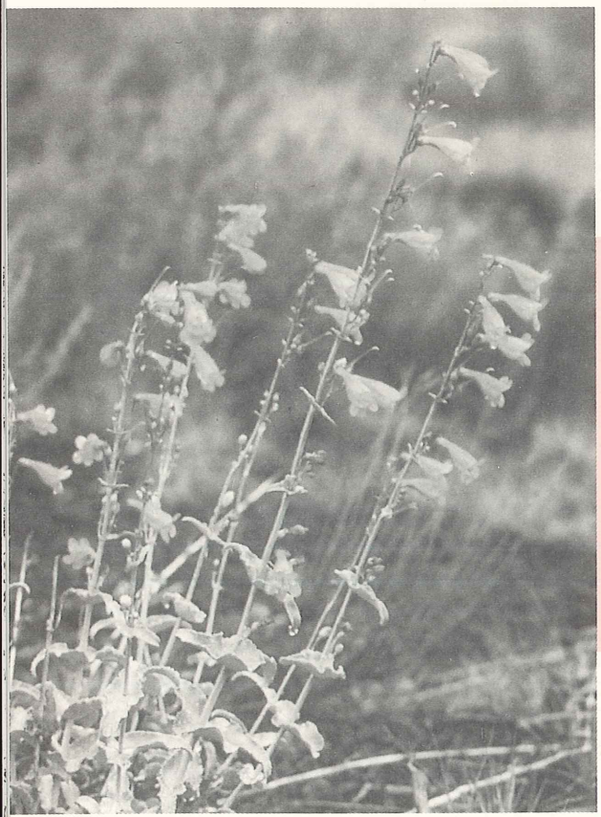
Aerial view

12

Survival in Extremes

Notice the different patterns of vegetation around you. Volcanic eruptions alter plant communities, destroying some, creating new habitat for others, and changing growth rates of those remaining.

On the lava flow in front of you most soil has come from wind-blown material that collects in cracks and holds water. Consequently, soil and moisture vary dramatically across the flow. And, since seeds blow in, colonization is quite random. Classic succession with lichens breaking down rock into soil, and then plants returning in predictable sequence is not occurring here.



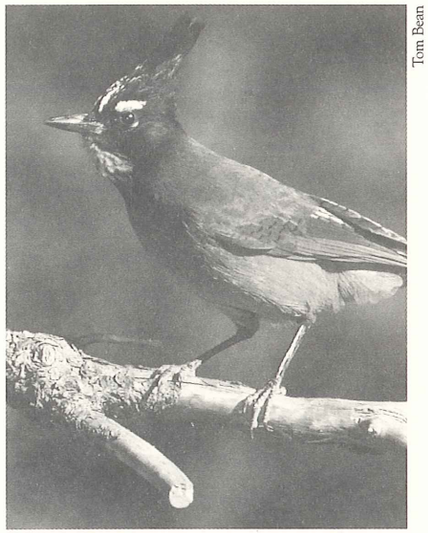
Tom Bean

Sunset Crater penstemon

As plants return to the barren landscape, so do the animals that use the plants for food and shelter. Many animals that live here are nocturnal. Some take shelter in the lava flow. Others blend in so well with their surroundings that they are difficult to spot. A careful observer may see evidence such as tracks or droppings.

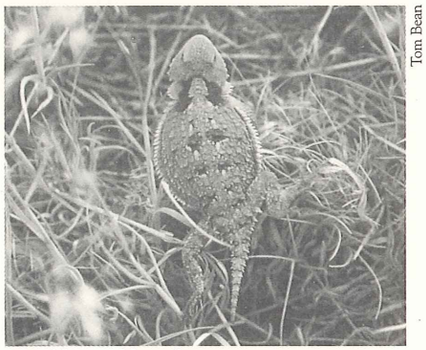
Along the perimeter of the flow, a unique microhabitat for plants exists. In places, water collects on the surface of the flow and is then channeled through fractures to the edge where it locally benefits plants. White-barked aspen trees grow around the perimeter of the flow and along fracture systems.

In areas of deep cinder, like the dunes in the distance to your left, specialized plants have evolved. The Sunset Crater penstemon evolved new traits which allow it to live on cinder soils but also make this endemic plant dependent on this habitat. It cannot survive elsewhere.



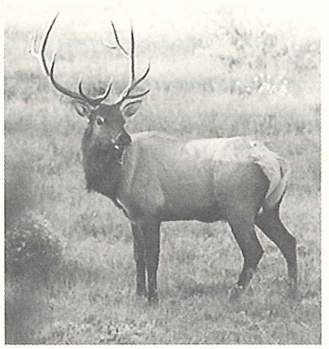
Tom Bean

Steller's jay



Tom Bean

Regal horned lizard



Tom Bean

Elk

Tom Bean

Abert's squirrel

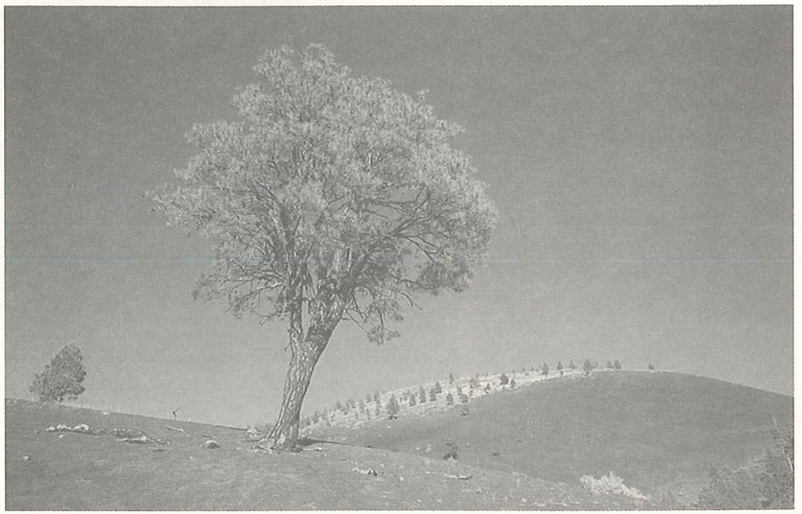
13

Give and Take

From the earliest times, people have enjoyed the long-term benefits of volcanic eruptions. In the past, people journeyed long distances to volcanic areas to gather materials for their daily lives, including important minerals, raw materials like obsidian for tools, and building supplies. And always, in return for these benefits, people have paid a high short-term price in the form of volcanic disasters.

Our culture influences how we forecast events, choose to prepare and adapt to catastrophes, and how we explain our world and its phenomena. Some of us look to science, some to religion, and some to traditional knowledge. It is not surprising that worldwide, when people live near volcanoes, they often develop related rituals and belief systems. This eruption was a significant event in the lives of the native peoples of the Southwest, and today all of the region's American Indian groups consider this a sacred landscape.

Regardless of our worldview, places like Sunset Crater Volcano National Monument help us to better understand each other and the forces that continually affect our lives.



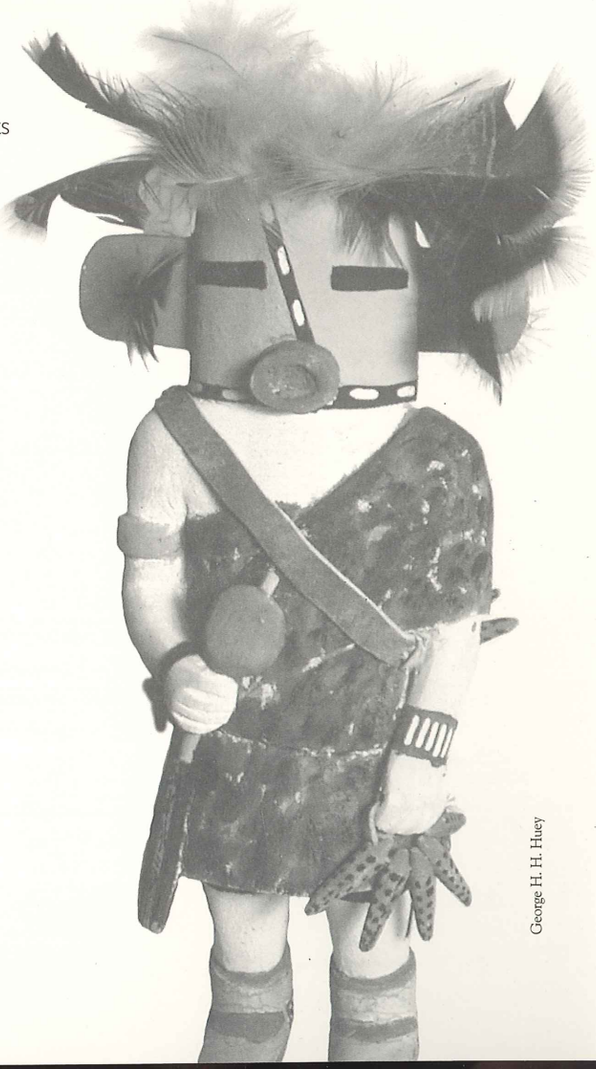
Traditions

The ancestors of today's Hopi and Zuni Indians witnessed the eruption.

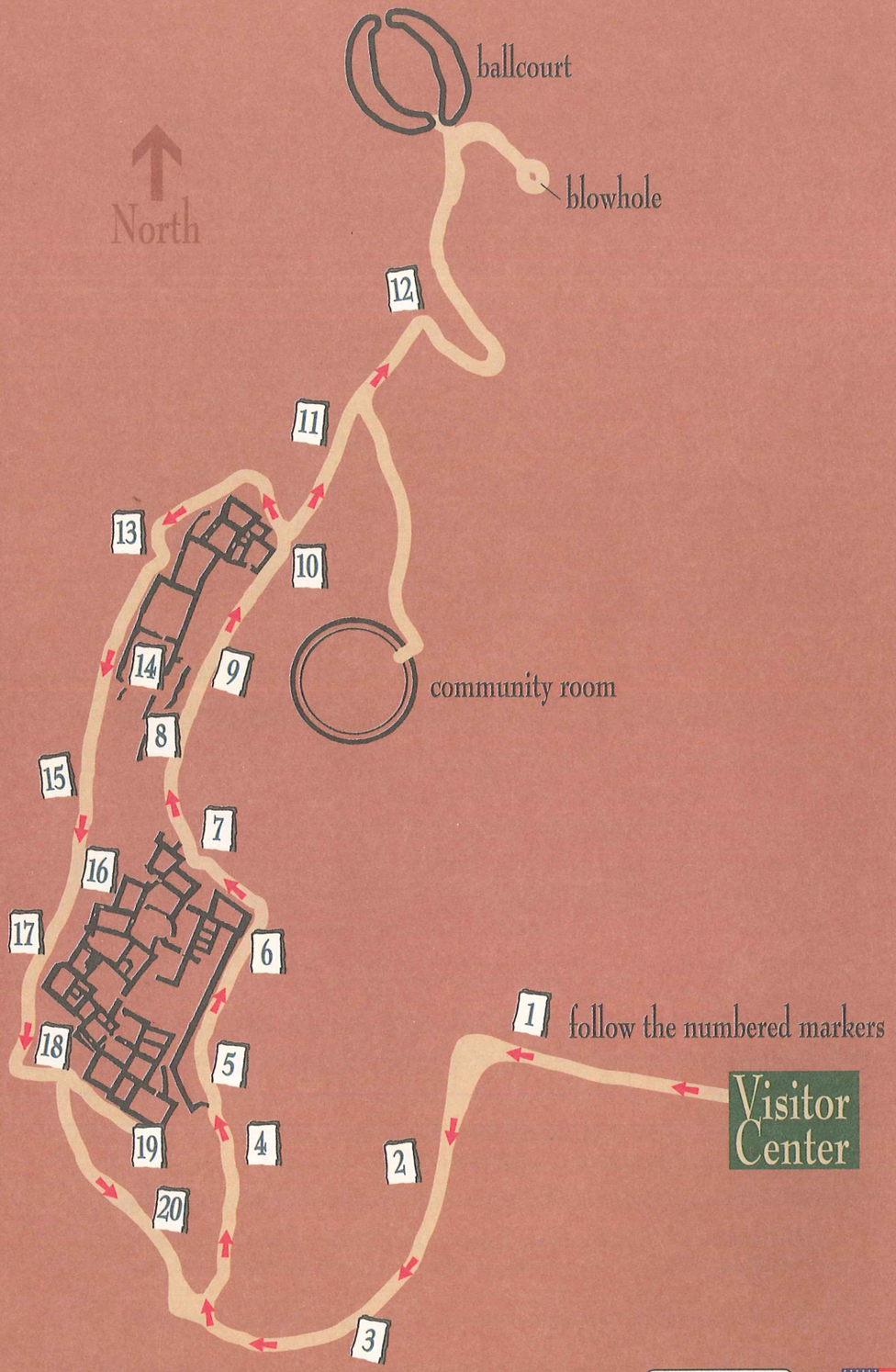
In some Hopi accounts, the Qa'na Katsina caused Palatsmo (Sunset Crater) to erupt after people engaged in *koyaanisqatsi*, a life out of balance. For Hopi people, Palatsmo is a living reminder: if people stray from their religious ideals and lifeway, there may be another eruption.

In Zuni traditions, stories of the eruption were carefully guarded because of the belief if people continually dwell upon negative events those events will happen.

Qa'na Katsina

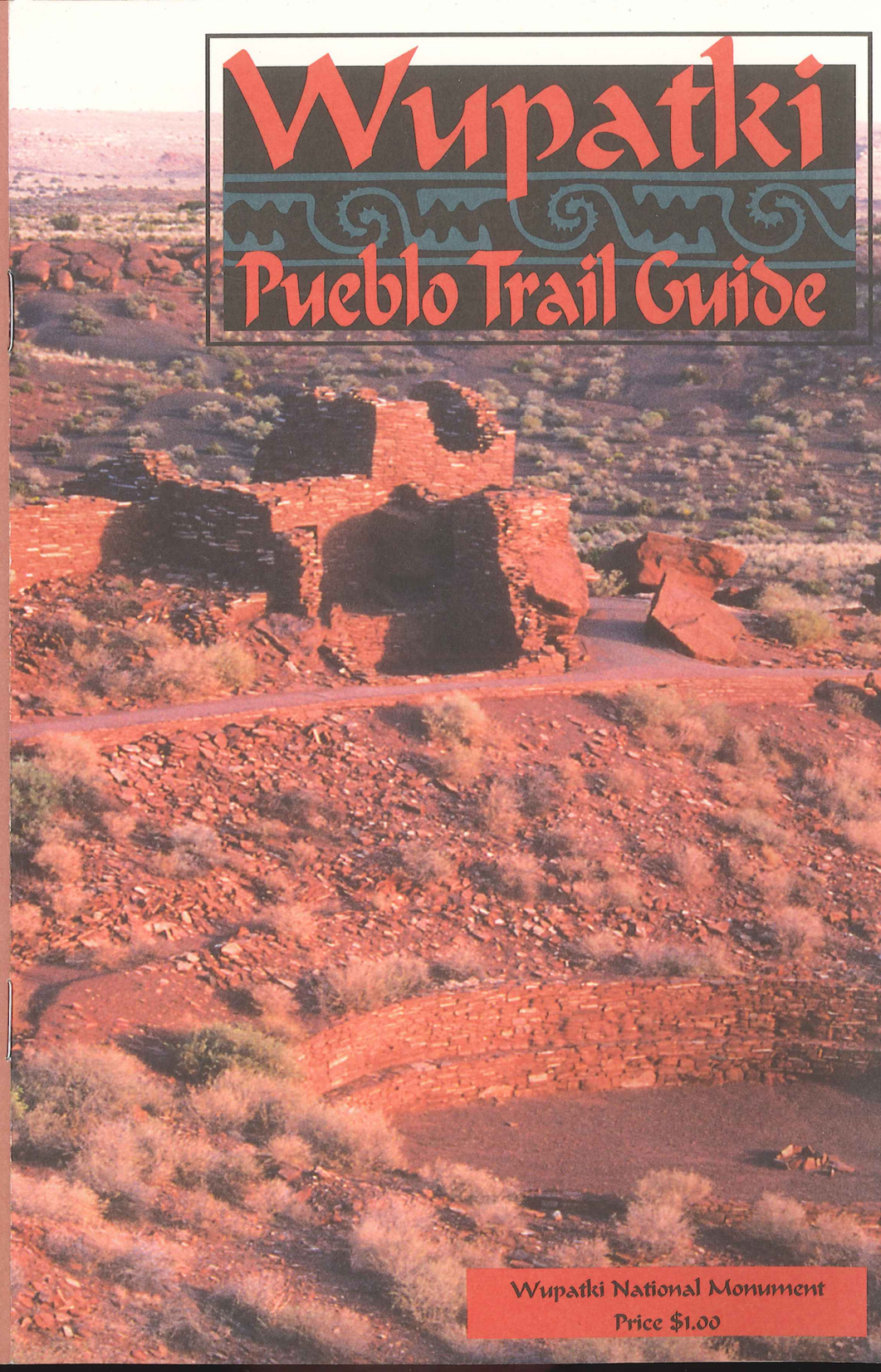


George H. H. Huey



Printed in USA

Wupatki
Pueblo Trail Guide



Wupatki National Monument
Price $1.00

Wupatki Pueblo Trail Guide

Description of trail

Length: ½ mile (.8 km) round trip
Time required: 45 minutes
Terrain: Paved with some steps and inclines. Wheelchair accessible to an overlook, with assistance.

Safety

- Beware of uneven steps and irregular surfaces.
- Watch for ice on the trail in winter.
- Lightning and severe weather can move in rapidly—return or remain inside during summer thunderstorms.
- Always carry water on the trail.

Preservation

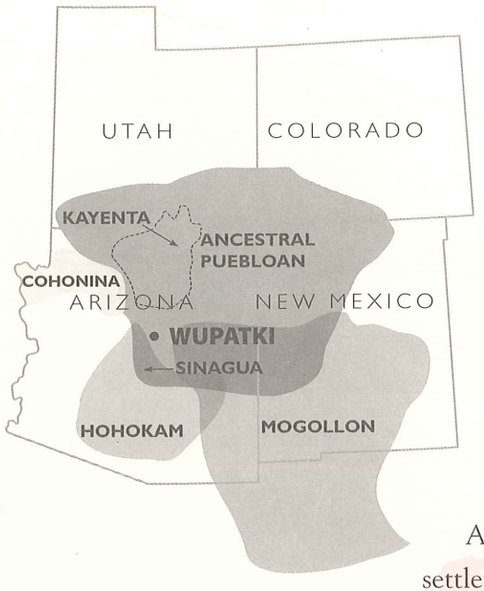
To preserve these sites for current and future generations, you can do your part by staying on the trail and leaving everything in its place (moving artifacts destroys archeological information).

Preserve your memories by taking photographs that you can share with friends and family.

"Every drop of water was precious, and there was never enough. From infancy we were taught to drink sparingly; even then, there were times when we were thirsty...Were the water supply to diminish and the population increase, what would become of the people?"

–Helen Sekaquaptewa, Hopi,
Village of Old Oraibi,
from "Me and Mine"

Introduction



In the history of the Southwest, the farming settlement of Wupatki (wuh-POT-kee) was unique. To appreciate why, we have to start by thinking big. From roughly 400 to 1700 CE (Common Era), cultures in the Southwest were distinguished by farming, pottery, villages, pueblos, seasonal moves, and large scale migrations.

Across this vast area, major settlement systems were in place by 1100 CE in Chaco Canyon (to the northeast), in the Phoenix Basin (to the south), and in northern Mesoamerica. With decades of unusually favorable climates for agriculture and room to grow, the Southwest's farming population was reaching a peak.

Until the mid-1100s, the landscape of Wupatki remained a "frontier" between established groups, defined by archeologists as Sinagua, Cohonina, and Kayenta. Then, in one of the warmest and driest places on the Colorado Plateau, life flourished. This became a densely populated landscape supporting a complex society where people, goods, and ideas converged. Today, Wupatki National Monument protects an exceptional record of an extraordinary effort in an improbable place.

"For its time and place there was no other pueblo like Wupatki. It was in all probability the tallest, largest, and perhaps the richest and most influential pueblo in the area."

—E. Brennan and C. Downum

1 People gathered here during the 1100s, what began as family housing grew into this 100-room-pueblo with a tower, community room, and ceremonial ballcourt. Located near the crossroads of east-west and north-south travel routes, the pueblo evolved to serve a community heavily engaged not only in farming but also in ceremony, trade, and crafts specialization. By 1190, as many as 2,000 people lived within a day's walk and Wupatki Pueblo was the largest building for at least 50 miles.

It is difficult to define a cultural identity for Wupatki Pueblo with its intriguing blend of Kayenta and Sinagua architectural styles and more than 100 pottery types.

2 A curious place to build a farming community…summers are hot, dry, and windy, a climate very similar to today. Yet 800 years ago, agricultural plots would have been carefully placed in small pockets of soil across the landscape.

A farmer's faith was tested regularly as rainfall came at the wrong time or not at all, and dry winds parched the soil and crops. Each field was at the mercy of where rain fell; no surface irrigation was possible. One field might produce while another withered, so the planting effort was extensive.

Then, as now, water was limited. Across the area, a few seeps and springs existed; catchments held water for a time, and the Little Colorado River provided a seasonal water source.

Still the abundance of storage pots suggests water had to be acquired and managed to be available when needed. Perhaps people derived strength from this challenging land.

The name Wupatki derives from Hopi words that translate literally into "it was cut long," and recalls an event in the histories of Hopi clans. According to one story, it is said that people prospered here. But in time men began gambling and ignored their crops and prayers for rain. Concerned, their leader severed a ritual object and then went into exile. When he returned the people awoke from their decadence.

Ties to the Present

For today's Hopi people, the villages of Wupatki remain among the most important "footprints" of the ancestral clans. It was on this landscape, in the shadow of the San Francisco Peaks, that a number of migrating clans met and merged. Significant events, and new traditions and ceremonies resulted. The Hopi, Zuni, and other Puebloan groups (Acoma, Laguna, and Rio Grande) share Wupatki's history as they share a belief in a common origin that begins with their ancestors. Stories of Wupatki also exist among non-Puebloan groups (Havasupai, Yavapai, Hualapai, Southern Paiute, and Navajo) whose ancestors interacted with Puebloan ancestors. The dates for these interactions are unknown.

3 The black cinders blanketing the ground around you remain from the eruption of nearby Sunset Crater Volcano in approximately 1080 CE. The construction and settlement of Wupatki Pueblo followed the eruption but it's uncertain if there was a direct cause and effect.

People may have been drawn by the eruption and stayed. Or, perhaps those displaced by the eruption moved to this lower elevation. However, as many as three generations may have passed before anyone decided to live here.

We do know that ash from the eruption, in a thin uniform layer, retained precious soil moisture providing a window of improved farming potential in this semi-arid landscape.

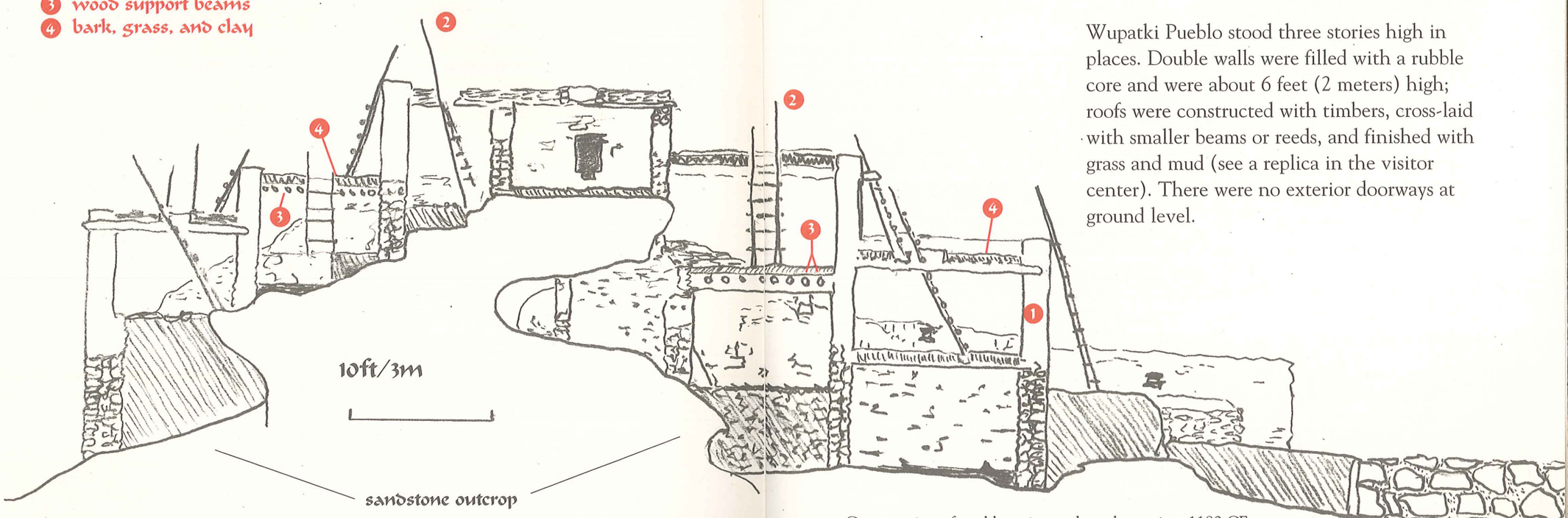
Can you find a small petroglyph on the large stone between the two benches? What does the petroglyph look like? Please do not touch—petroglyphs are fragile and degrade easily.

4 Notice how people shaped their lives to this land. Sun, water, wind, and earth influenced decisions. Using the red sandstone outcrop as a backbone, and its naturally fractured blocks as bricks, masons laid stone rooms up and down the length of the formation. High walls on the north and west sides blunted prevailing winds. Terraced rooms to the south and east bathed in winter sun. Flat roofs served as water systems, collecting precipitation and directing it to storage pots.

Built out in the open, Wupatki is far more typical of 12th century structures than a cliff dwelling. Cliff dwellings make up only a fraction of known southwestern archeological sites.

> "...The family, the dwelling house and the field are inseparable, because the woman is the heart of these, and they rest with her. ...The man builds the house but the woman is the owner, because she repairs and preserves it."
>
> –A Hopi view of the community, presented to "the Washington Chiefs," 1894

1. stone walls with clay mortar
2. roof entrances and ladders
3. wood support beams
4. bark, grass, and clay



Wupatki Pueblo stood three stories high in places. Double walls were filled with a rubble core and were about 6 feet (2 meters) high; roofs were constructed with timbers, cross-laid with smaller beams or reeds, and finished with grass and mud (see a replica in the visitor center). There were no exterior doorways at ground level.

Cross-section of pueblo as it may have been circa 1180 CE.

Compare the pueblo to this photo using the tall corner wall on top of the rock as a reference. These rooms were buried beneath rubble cleared during excavations beginning in 1933.

5 When occupied, this mud and stone building would have required periodic maintenance. Once people departed, natural forces prevailed—mortar eroded, roofs collapsed, walls tumbled.

The modern iron beam and plate above you support the upper walls. The low wall in front of you exhibits cement used from the 1930s to 60s and newer stabilization mortars that more closely duplicate original materials. Although walls stand in their original location, virtually all the mortar you see is modern. Stabilization has compromised the historical architecture, but helps an excavated building withstand natural and human-induced erosion. You are one of hundreds of thousands of visitors to this site every year—please, do not lean, sit, or walk on any walls.

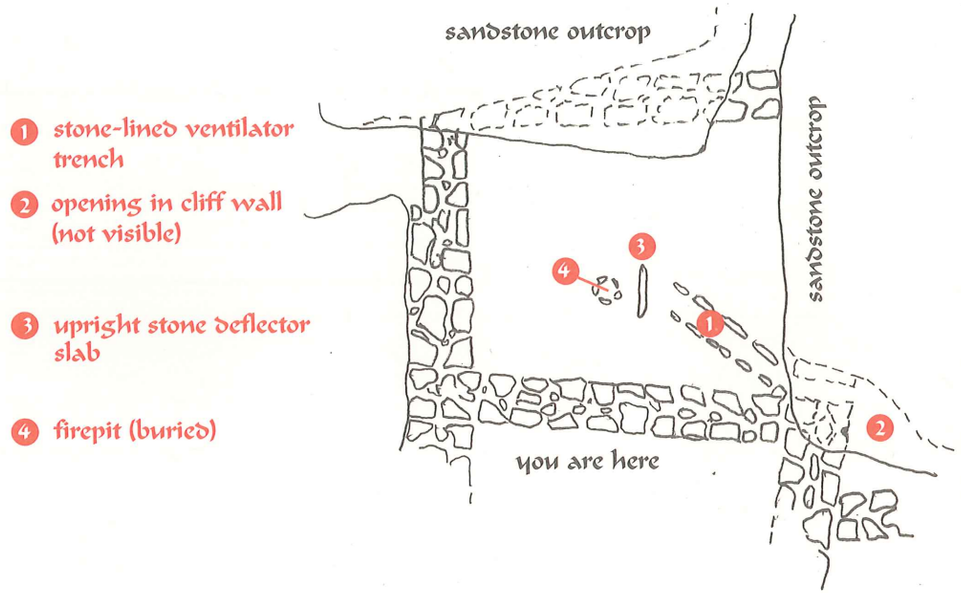
6 Numerous storage rooms within the pueblo attest to a constant preparedness for crop failure. People likely had some of last year's corn on hand at this year's harvest. Perhaps this room served for storage and food processing.

Imagine corn stacked like cordwood, or gathered foods such as piñon nuts, rice grass seeds, and juniper berries secured in clay seed jars. Water jars undoubtedly sat here too. Hours spent at these grinding stones reduced corn and seeds to flour.

Look for a Wupatki water jar on display in the visitor center.

7 In this room, someone designed an innovative air circulation system to allow for an indoor fire. (Dirt fill in the room makes it hard to see, so use the diagram below). Can you locate the stone-lined ventilator trench on the floor? It connected to an opening in the base of the cliff wall to your right (not visible).

The upright stone slab at the end of the ventilator trench deflected incoming air so that the draft would not pass directly across the firepit. Smoke would exit through a roof opening.



Note how preservation efforts have changed this building: original floor surfaces, as with this room, are much lower—dirt placed in the rooms after excavation protects floor features and keeps walls from collapsing.

Throughout the dwelling you'll see a variety of modern drains that keep water from standing in rooms. In some cases the architecture has been altered. For example, the square and round holes in this front wall were placed for drainage, and the large masonry column built in the back corner supports the upper wall.

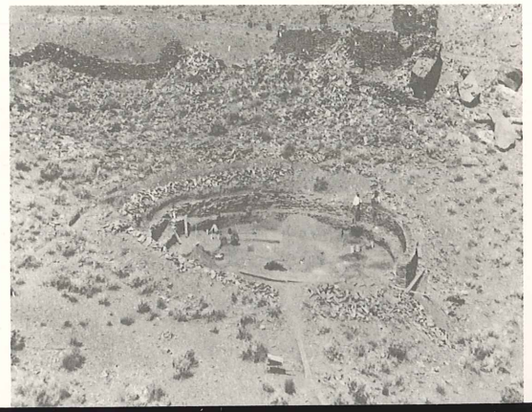
8 This section of the pueblo remains unexcavated. These rooms represent an opportunity to learn more about the past. However, excavation is costly and is only looked upon as a last resort for preservation. National Park Service sites, like Wupatki National Monument, are here to preserve and protect for current and future generations. Excavations are only implemented if the area cannot be preserved in place.

In the past, few people challenged the purposes of archeological investigation, but today many voice concerns about disturbing sites. Should rooms be excavated, unearthing pots and other items? Possessions were intended, by those who buried or left them behind, to remain as placed, weathered by the elements over time. Excavation represents a curiosity foreign to American Indian cultures and is often considered culturally offensive. Do objects from the past serve as legitimate educational tools, or is that notion unimportant or even wrong?

Look for a wall that fell intact with the stone courses retaining their original positions.

9 The reconstructed circular structure below you resembles a great kiva, a special room used for rituals and ceremonies. However, excavators found no evidence of a roof or other floor features typical of a kiva. Archeologists speculate that this open-air community room could have served as a central gathering place. Imagine voices carrying to others assembled on the pueblo roof tops.

People may have come from nearby and distant villages to participate in ceremonies held here. Maybe rituals focused the community and solved problems, or served to redistribute materials and food.



Excavation of community room, 1933. Photo courtesy of Museum of Northern Arizona.

These 1930s reconstructions were removed in 1950.

10 Other people have come and gone since the original occupants. During the late 1800s, Basque sheepherders stayed here briefly, enlarging this doorway and occupying the room beyond. Local prospector Ben Doney pothunted Wupatki, amassing a large collection of artifacts. Today, unauthorized removal of any natural or cultural objects from a National Park Service area is illegal.

Rooms on this end of the pueblo were excavated and reconstructed to serve as an office and museum. The National Park Service now has a policy of stabilizing buildings in their existing state.

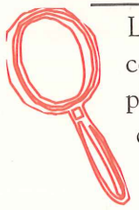
Concern over looting at Wupatki led to its protection as a national monument in 1924. Later expansion of the monument included some land historically used since the mid-1800s by Navajo *naat'áanii* (headman) Peshlakai Etsidi and his descendants. These Diné families grazed sheep here, moving seasonally between numerous camps, leaving behind more than 60 residential sites. Their history is intertwined with that of the monument. They remain intimately tied to the Wupatki landscape.

Continue down the trail to the ballcourt and blowhole; or continue to your left, back to the visitor center. The trail to the right takes you into the community room.

11 The extent of this community is not obvious, but hundreds of small family dwellings surround us forming a cluster. Another cluster exists on the uplands to the west (where you may visit Citadel and Lomaki Pueblos). We don't know if the Wupatki and Citadel communities were autonomous, cooperatives, or competitors.

> "We found...all the prominent points occupied by the ruins of stone houses of considerable size...They are evidently the remains of a large town, as they occurred at intervals for an extent of eight or nine miles, and the ground was thickly strewed with fragments of pottery in all directions."
>
> –Journal entry, Sitgreaves Expedition, October 8, 1851

From this point, you can see two other nearby homes. These sites are not open to visitation. Remember to stay on designated trails.

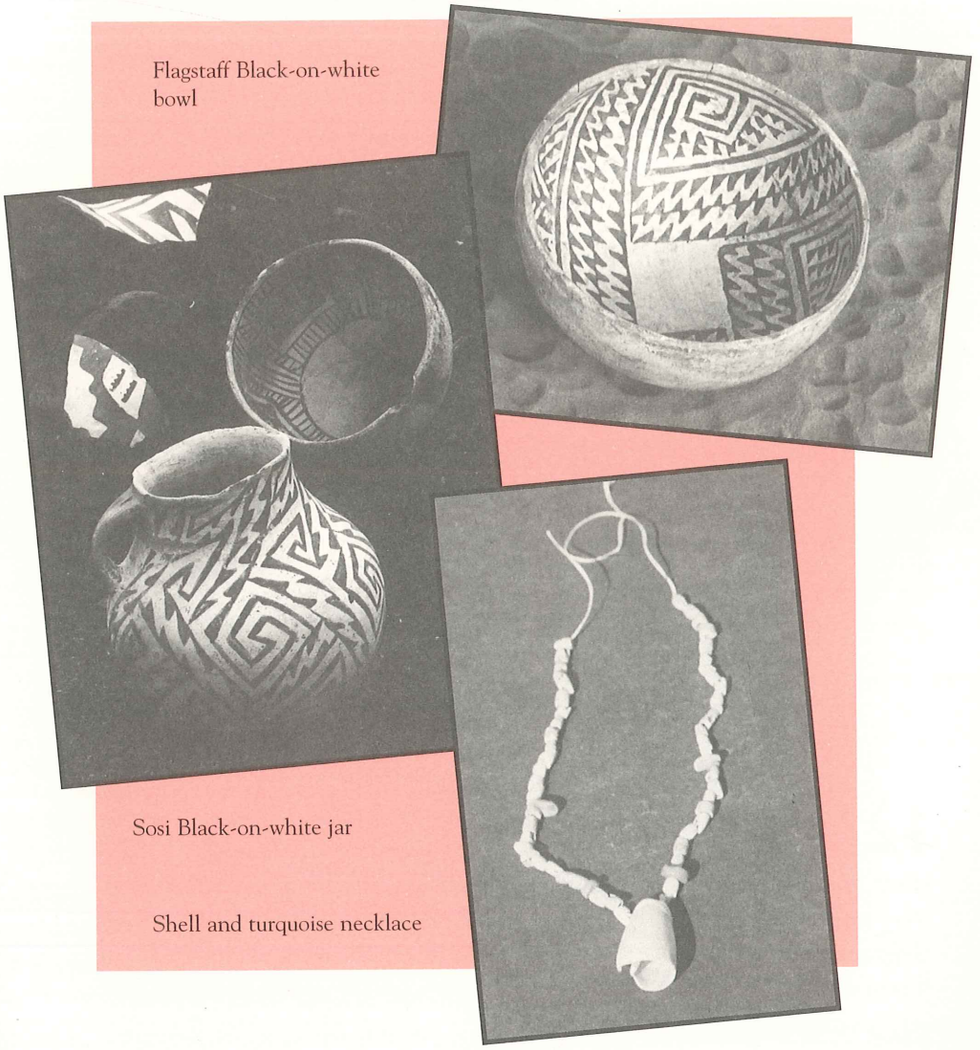


Look, "Swiss cheese" rocks! The grains in this sandstone are cemented with calcite which dissolves with rain water. Weathering pits form, which collect more water, enlarging the pits. The dissolved calcite moves downward into any porous rock or soil. Concentrations build, then moisture creates capillary action which draws the solution to the surface where it precipitates out, creating the white deposits on soil and rocks.

12 The reconstructed ballcourt below you is an unusual structure. Known ballcourts in the Southwest were not masonry. This court may have had multiple functions: a place where special ceremonies were held, where competitive games took place for socialization, or where children played a game with a stick and ball, similar to hockey. After rains, it may have served as a reservoir.

Some archeologists think valuables changed hands through ritual events such as ball games. People living to the south (Hohokam tradition) had shells, salt, cotton, and a ballcourt in every town. People to the east in the Chaco region (Ancestral Puebloan tradition) had Mesoamerican macaws, copper, and turquoise to trade. A ballcourt at Wupatki could function as a link between distant regions. Trade valuables from both regions ended up here.

Sandals trod far and wide, maintaining trade networks that helped meet mutual needs and improved the quality of life. When materials, innovation, and ideas came to communities, all knew what others had to offer.



Flagstaff Black-on-white bowl

Sosi Black-on-white jar

Shell and turquoise necklace

Be sure to check out the blowhole next to the ballcourt. Ask at the visitor center if you'd like to learn more about this intriguing geological feature.

13 Archeological sites are important and meaningful to people in different ways. For archeologists and other scientists, such as ethnographers and anthropologists, learning about how people lived, adapted, and survived provides insight and understanding. For visitors, it is seeing and experiencing unique places that are part of our ongoing human history. And for American Indians, it is a connection to the past and history of their ancestors.

The Native American Graves Protection and Repatriation Act of 1990 (NAGPRA) asserts that the present day American Indian tribes affiliated with archeological sites have rights and beliefs to be protected. This Act helps ensure that decisions about these places reflect the values and wishes of those who were here before. The National Park Service protects these special places for all people and also helps educate others about its resources.

Look for a doorway filled in with stones. Why would the occupants close off a doorway?

14 This open plaza area may have been the hub of village life and work. Ethnographic evidence suggests most activities were gender specific, and everyone contributed. Children learned by watching, listening, then doing. Surely there were no idle hands.

Women worked clay into necessary utensils. They mortared the pueblo, knowing clay as they did. As the herbalists, gatherers, and protectors of stored crops and seeds, women were vital to the community.

"...the man cultivates the field, but he renders its harvest into the woman's keeping."

–A Hopi view of the community, 1894

Men hunted and farmed. The entire growing season may have been spent away from home tending fields. Winter brought with it time to weave. Fine cotton textiles and abundant tools suggest weaving was an important, highly developed skill at Wupatki.

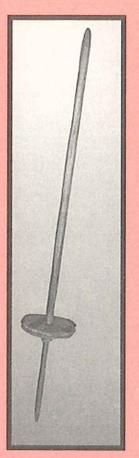
15 Along this side of the pueblo, people discarded no longer needed items, forming a pile called a midden. Refuse tells us much of what we know about past life. Each layer of food debris yields facts about diet, nutrition, and changing reliance on resources throughout the history of the village. Broken pottery and worn out tools reveal relative dates of occupation and technological changes through time.

When Wupatki was excavated, artifacts and food remains were collected and stored but not studied for years. Today, rather than excavating new material, we study old collections to learn how people altered or managed plant and animal populations to their advantage.

This midden has not been excavated. Walking off trail here, or through any midden, mixes the upper layer of trash with lower levels, destroying the context that is so important to understanding past lifeways. Please, stay on the paved trail.

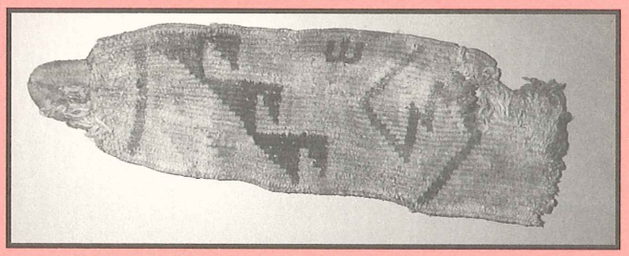
"No woman ever sat at the Hopi looms. The men were expert weavers; they wove diligently all winter long in the various kivas. Hopi woven items were known far and wide, and people of other tribes came to barter for them."

–Helen Sekaquaptewa, from "Me and Mine"



Above left: Disc spindle whorl
Above right: Reverse twill weave cotton cloth

Fragment of a carrying strap



16 You may enter this room. The rock outcrop around you provided an almost ready-made room, initially used for household trash. Roughly 5 feet (1.5 meters) of debris accumulated here before the first floor was laid and the space used as a living room. Can you tell where a second story room began?

This room provides a special opportunity to experience the pueblo in an intimate way. Generally, you should not enter rooms unless invited. Everyone has a responsibility to know the "ground rules" when visiting an archeological site.

17 Park rangers once lived in this pueblo. The two rooms above you were reconstructed to house employees Jimmy and Sallie Brewer, and Davy and Corky Jones during the 1930s. They hauled water from the nearby spring, but had the luxury of cooking with propane. Jones excavated a small adjoining storage room to house a gas refrigerator; commercial electricity did not arrive until 1959. The government, of course, charged them rent—$10 per month!

Like other reconstructions, these walls and roofs were removed in the 1950s.

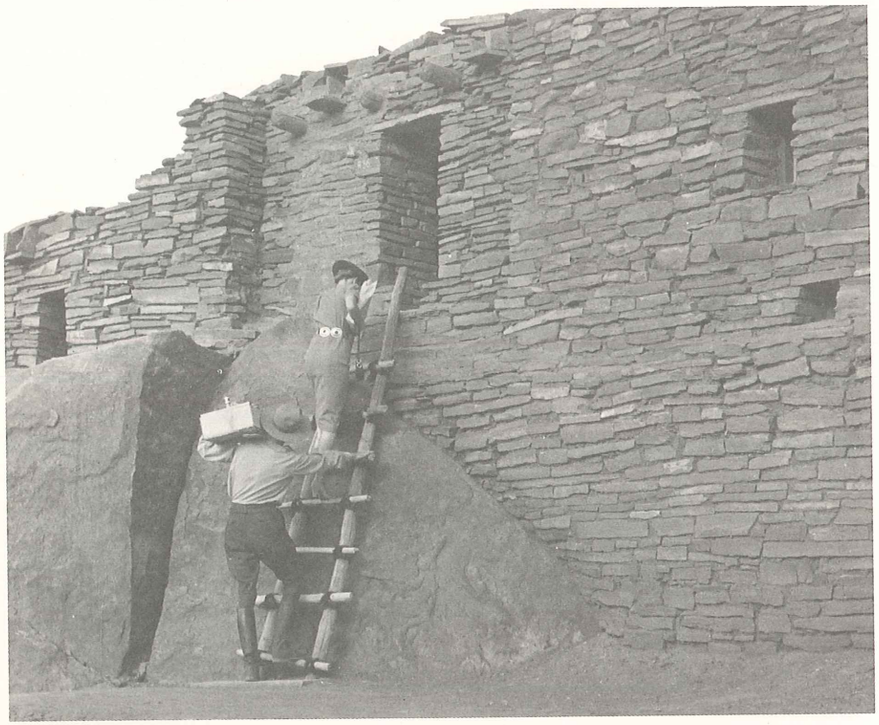


photo courtesy of Tad Nichols

"Those were the two rooms we were to live in. At the top of the ladder was the room used as a bedroom and office, and (to the right) the beautiful sunny little kitchen. The water was in a barrel behind a niche in the kitchen wall. ...Davy pumped the water in once a week, fifty-five gallons, and that sufficed for everything. We took our baths there unless it was a special occasion, when we would go down to where the spring ran out to the sheep troughs. There was more water that way, but there were apt to be sheep and Navajos, too."

–Corky Jones (above), from Letters From Wupatki

Reconstructed rooms may help us to visualize the past and identify more closely with the inhabitants. But, the mental images we construct and conclusions we draw likely mirror our present rather than reflect the world in which they lived.

Reconstructions lead us to believe we know the past, when in reality, so much will never be known.

18 The two beams at the rear of the room above you have been in place for 800 years. Tree-ring dates obtained from various beams in the pueblo span from 1106 to 1220 CE but cluster around three periods: 1137, 1160, and 1190. This suggests specific periods of construction, or at least beam cutting. Many room walls also abut one another—evidence that a room was added on to one already in place. Perhaps the various building phases mark the arrival of clans, each bringing something different to the community, resulting in the "cultural brew" that makes Wupatki so unusual.

Some archeologists see cultural traditions, such as Sinagua and Kayenta, not as "people" or mutually exclusive genetic or ethnic groups, but rather as inhabited geographic regions experiencing a dynamic ebb-and-flow of populations. Migrations brought people together creating cultural dominance in some areas, and shared cultural traits in others. Seen this way, specific traditions such as black-on-white pottery and T-shaped doorways could have been maintained over centuries by peoples of different linguistic and ethnic backgrounds.

19 This room, on the southeastern corner of the pueblo, is one of the largest in the village, yet no household tools or utensils were found inside. This suggests it was a special space, perhaps a ceremonial room known as a kiva. However, a kiva would have a single bench on the north side of the room. There is no record of this, but early excavations may have missed such a feature. In a village this size, one or two kivas would be expected. They may have been used for the private aspects of ritual, while the larger, open community room served public ceremonies.

Today, rectangular clan kivas persist in Hopi villages, while larger, round community kivas endure in the eastern pueblos. Kivas are an integral part of Puebloan society and remain a cultural trait that can be traced from past to present.

20 Villages like Wupatki were purposely settled and left for reasons we may never fully understand. After roughly 150 years here, maybe life ceased to be good. Perhaps the rumor of a better life in another village was worth investigating. Maybe, as some Hopi believe, the people stayed too long here and failed to lead moral and responsible lives. Ensuing social and environmental catastrophes were signals to resume migrations.

By 1300, across the region people had moved into villages even larger than Wupatki. Those living here joined others at places like Homol'ovi along the Little Colorado River (near present day Winslow, Arizona) or at villages south of Walnut Canyon. According to clan histories, some went directly east to the Hopi Mesas. A few undoubtedly chose to stay behind.

Today this village rests silent but not forgotten. Though it is no longer physically occupied, Hopi and Zuni people believe those who lived and died here remain as spiritual guardians. Descendants visit periodically to enrich their personal understanding of their clan histories. Wupatki is remembered and cared for, not abandoned.

> "...for us life is shrouded in mystery and the world defies explanation...humans do not need to know everything there is to be known. The human past, we feel, is a universal past. No one can claim it, and no one can ever know it completely."
>
> –Rina Swentzell, Pueblo Santa Clara

WESTERN NATIONAL PARKS ASSOCIATION

www.wnpa.org
January 2012

Net proceeds support educational and research programs in your national parks.

Consultation provided by: Hopi Tribe Cultural Preservation Office; Navajo Traditional Culture Program, Historic Preservation Dept., Navajo Nation.

Cover photograph courtesy of Bernard A. Natseway, NPS archeologist.

Introductory quote from Report of Findings Prestabilization Documentation for Wupatki Pueblo, E. Brennan and C. Downum

Visit Lowell

General Information

Things to Do

Special Events

Getting Here

Private & Group Programs

Starry Skies Shop

Uncle Percy's Kids Camp

Uncle Percy's Tykes Camp

ACRONYM LIST

Day or night, adults and kids alike can explore the Universe at Lowell Observatory.

Peer through the telescope that Percival Lowell used to sketch Mars or visit the telescope that helped Clyde Tombaugh discover Pluto. Tour our facility with friendly, knowledgeable guides. Experience the Universe though widescreen multimedia shows, exhibits, live presentations, and "SlipherVision, our new immersive space theater."

Your visit here begins in the 6,500-square-foot Steele Visitor Center, where our team will get you started on your journey of exploration. In addition to our tours and multimedia shows, we offer traveling exhibits such as "Pluto and the Planets," through Thursday March 14th, 2013. Best of all, in the evening you can enjoy Flagstaff's beautiful dark skies and spectacular views through the Alvan Clark Telescope.

Come up and see us on Mars Hill, 1 mile west of downtown Flagstaff, Arizona. And welcome to Lowell Observatory.

IMPORTANT REMINDERS: Lowell is located at 7200'. You will want to pace yourself if you're not accustomed to the high elevation. Avoid becoming dehydrated by drinking plenty of water. Dress in layers; evenings can be cold, even in the summer. In the daytime, wear sunscreen to protect against sunburn. Please note that while people walk their dogs in the nearby forest and several employees who live on Mars Hill own dogs, only service dogs are allowed in the areas of campus open to public visitation.

Month	Days	Hours
Jan-Feb	Mon, Wed, Fri, Sat	Noon - 9:30 PM
	Tue, Thu, Sun	Noon - 5:00 PM
Mar-May	Mon, Wed, Fri, Sat	9:00 AM - 9:30 PM
	Tue, Thu, Sun	9:00 AM - 5:00 PM
Jun-Aug	Daily	9:00 AM - 10:00 PM
Sep-Oct	Mon, Wed, Fri, Sat	9:00 AM - 9:30 PM
	Tue, Thu, Sun	9:00 AM - 5:00 PM
Nov-Dec	Mon, Wed, Fri, Sat	Noon - 9:30 PM
	Tue, Thu, Sun	Noon - 5:00 PM

DISCOVERY CHANNEL TELESCOPE

Visitor Info

Admission

Covers day and evening programs; no reservations needed

Adults: $12

Seniors, AAA, college students: $10

Ages 5–17: $5

Under 5: free

Members: Free

Hours

Mon,Wed,Fri,Sat 9 AM – 9:30 PM

Tue, Thu, Sun 9 AM – 5:00 PM

Click here to see seasonal hours.

Arizona observes Mountain Standard Time year round.
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Closed at 5:00 PM: Nov 21 and Dec 31

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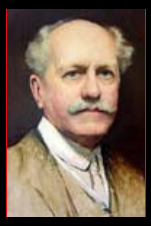

Lowell Observatory is a private, nonprofit, research institution founded in 1894 by Percival Lowell.

Since then, Lowell astronomers have conducted fundamental research that has led to the discovery of Pluto, the first evidence of the expanding Universe, and exhaustive measurements of the motions and basic properties of stars, among other achievements. Today, our staff of nearly 90 continues this tradition of discovery in all areas of astronomy and planetary science.

In 1994, in celebration of our centennial, we opened the Steele Visitor Center; today, well over a million people have passed through its doors. Some 80,000 visitors each year enjoy our tours, telescope viewing, exhibits, multimedia shows, and more. Percival Lowell inspired millions with his tireless advocacy of astronomy in the public eye, and we continue this commitment today.

In 2012, we embarked on our greatest adventure yet with the completion of the 4.3-meter Discovery Channel Telescope (DCT). This new facility vastly expands the breadth of research capabilities for our astronomers. Even more exciting, Discovery Communications brings our results to hundreds of millions worldwide through programming using the DCT's breathtaking images.

ACRONYM LIST

Rapid technological advances have made the past few decades a golden age for astronomy. The DCT will usher in Lowell's golden age, and you can be part of it by joining the Friends of Lowell. Join and share the marvels of the cosmos with us.

DISCOVERY CHANNEL TELESCOPE

Media Info

PDF Downloads

- 2011 Annual Report
- Discovery Channel Telescope fact sheet
- Film Access Policy
- Lowell Observatory fact sheet

Ecological Restoration Experiments (1992-2007) at the G.A. Pearson Natural Area, Fort Valley Experimental Forest

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Abstract—*In 1992 an experiment was initiated at the G. A. Pearson Natural Area on the Fort Valley Experimental Forest to evaluate long-term ecosystem responses to two restoration treatments: thinning only and thinning with prescribed burning. Fifteen years of key findings about tree physiology, herbaceous, and ecosystem responses are presented.*

Introduction and Background

Prior to fire exclusion in the late 19th century, ponderosa pine forests in northern Arizona and the Southwest were described as a matrix of grass-dominated openings interspersed with smaller groups or stands of pine (Cooper 1960, Pearson 1950). Today, most southwestern ponderosa pine forests have a closed overstory canopy intermixed with a few fragmented, remnant grass openings (Covington and Moore 1994, Covington and others 1997). This study was initiated in 1992 at the G.A. Pearson Natural Area (GPNA) on the Fort Valley Experimental Forest (FVEF) to restore a reasonable approximation of the presettlement ponderosa pine structure and function and to evaluate long-term ecosystem responses to two restoration treatments (Covington and others 1997). This "presettlement or pre-fire-exclusion model" quickly returned tree structure to what it was in pre-Euro American settlement times through thinning postsettlement trees, and re-introduced low-intensity surface fire (Covington and others 1997). Ideally, these treatments would reduce the threat of unnaturally intense crown fires and bark beetle attack, and allow this ponderosa pine ecosystem to respond adaptively to climate change. Tree physiology,

In: Olberding, Susan D., and Moore, Margaret M., tech coords. 2008. Fort Valley Experimental Forest—A Century of Research 1908-2008. Proceedings RMRS-P-53CD. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 408 p.

Treatments and Patch Types

In 1992, five 0.2-0.3-ha plots were established in each of three treatments: 1) thinning from below (thinning; see Figure 2); 2) thinning from below plus forest floor manipulation with periodic prescribed burning (composite); and 3) control. The five control treatment plots were located non-randomly on one side of the study site, while the thinning and composite treatment plots were assigned randomly. This design was necessary so that the fuel break created by the treated plots would protect the historical buildings of the adjacent FVEF.

Figure 2. Repeat photographs of a thinning treatment photo point (photo point 302) in the GPNA in 1992, prior to treatment (top photo), in 1998, 5 years after thinning (middle photo), and in 2004, 11 years after thinning (bottom photo). The arrows highlight the same tree (approx. 15 cm at dbh) in each photo. All photos were taken in early autumn (September to early October). Note the difference in herbaceous standing crop between 1998, an average year in precipitation, and 2004, which was > 40% below normal. Photo credits: Ecological Restoration Institute, Northern Arizona University. From Moore and others (2006).

Each treatment plot contained four patch types: presettlement tree groups, unthinned postsettlement trees ("postsettlement retained"), thinned postsettlement trees ("postsettlement removed"), and remnant grass openings (Figure 3). Presettlement tree patches consisted of groups of two or more large trees (mostly > 30 cm) that established prior to 1876. Postsettlement retained patches consisted of a group of small-diameter (< 30 cm) trees that established after 1876. Postsettlement removed patches consisted of an area where most or all postsettlement trees were thinned and removed from the site, thereby creating an opening. Remnant grass patches were located within open areas between patches of trees.

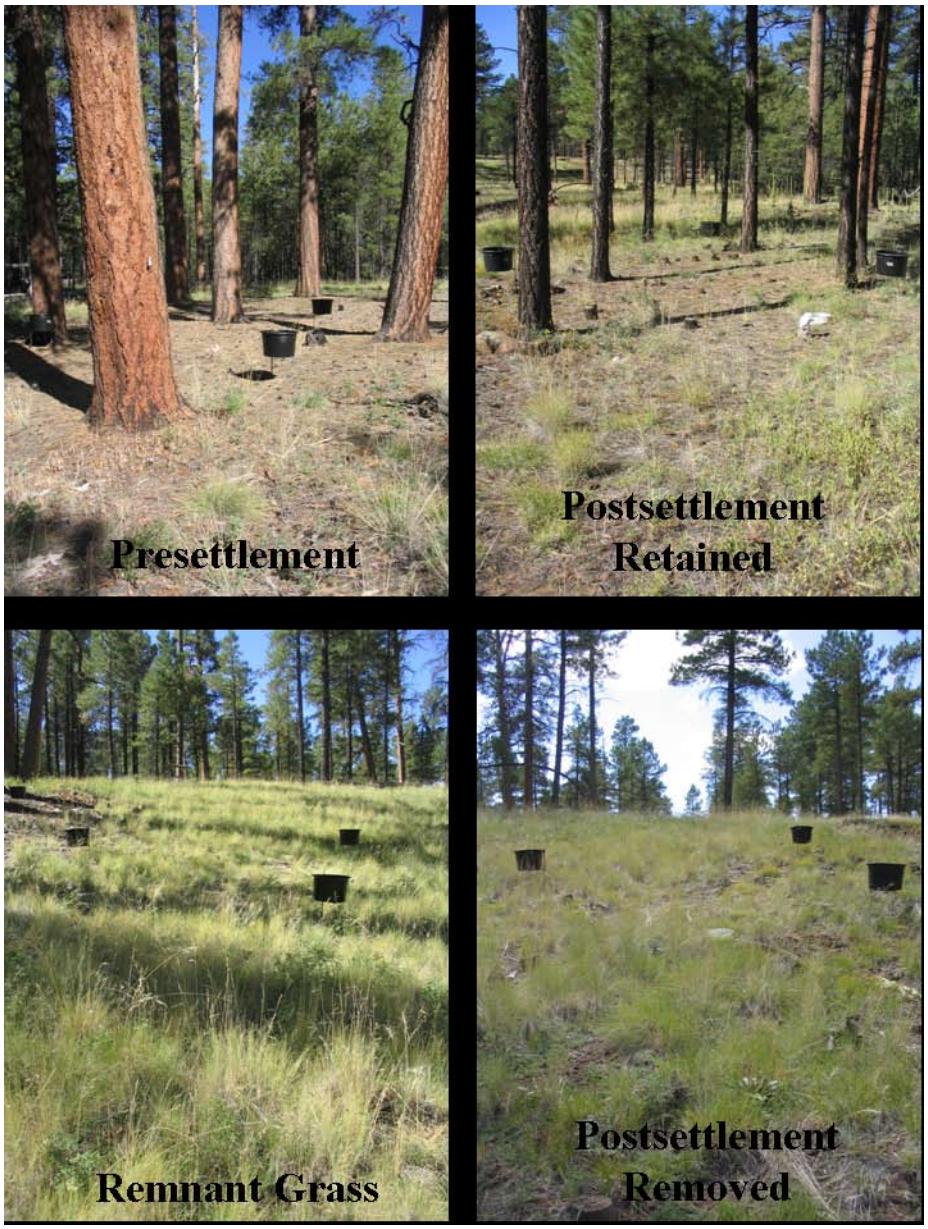


Figure 3. Example photos of each patch type used in this study: (a) presettlement, (b) postsettlement retained, (c) remnant grass, and (d) postsettlement removed. Plot centers for smaller subplots are located between black buckets. Photo credits: Ecological Restoration Institute, Northern Arizona University. From Laughlin and others (2006).

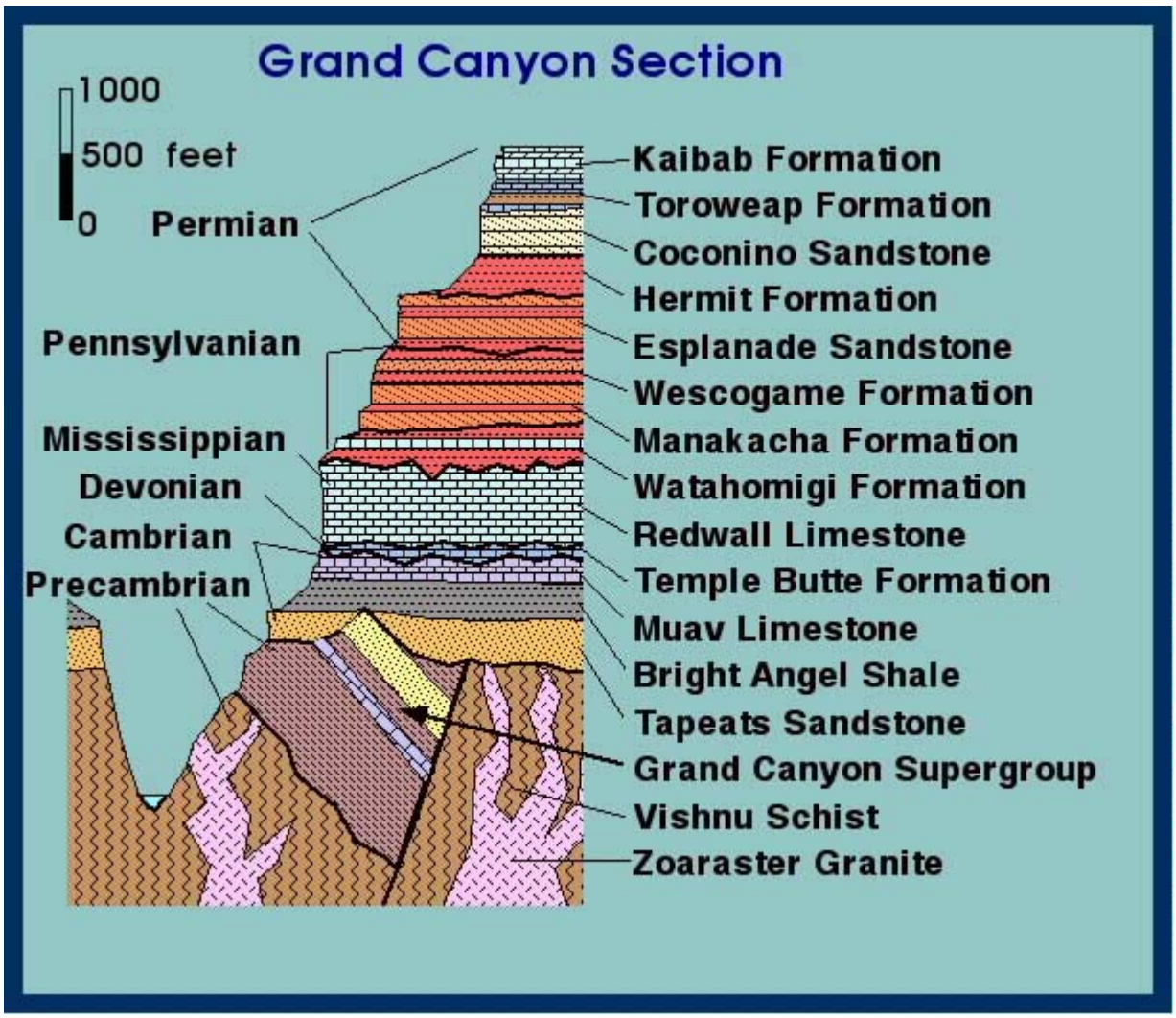
Simulation modeling with the ecological process model FIRESUM showed that repeated surface fire was predicted to maintain the open forest structure of the composite treatment. In contrast, the thin-only treatment was forecast to return to high forest densities similar to those of the control within a century. These simulation results suggest restoration of disturbance process, as well as characteristic forest structure, are both important for sustaining the function of these forests (Covington and others 2001).

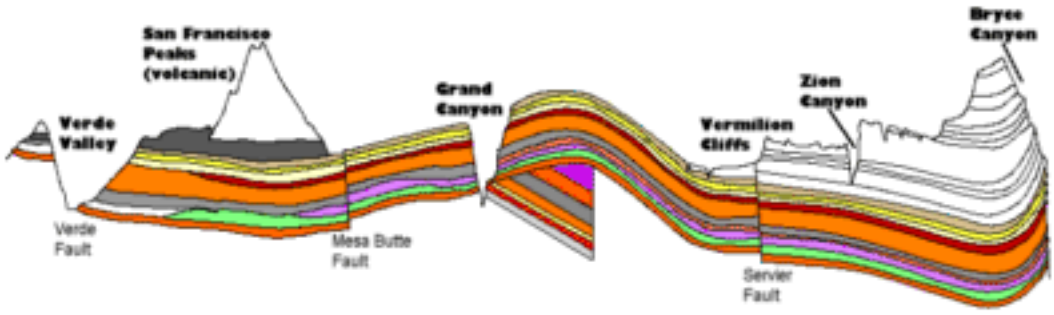
Summary

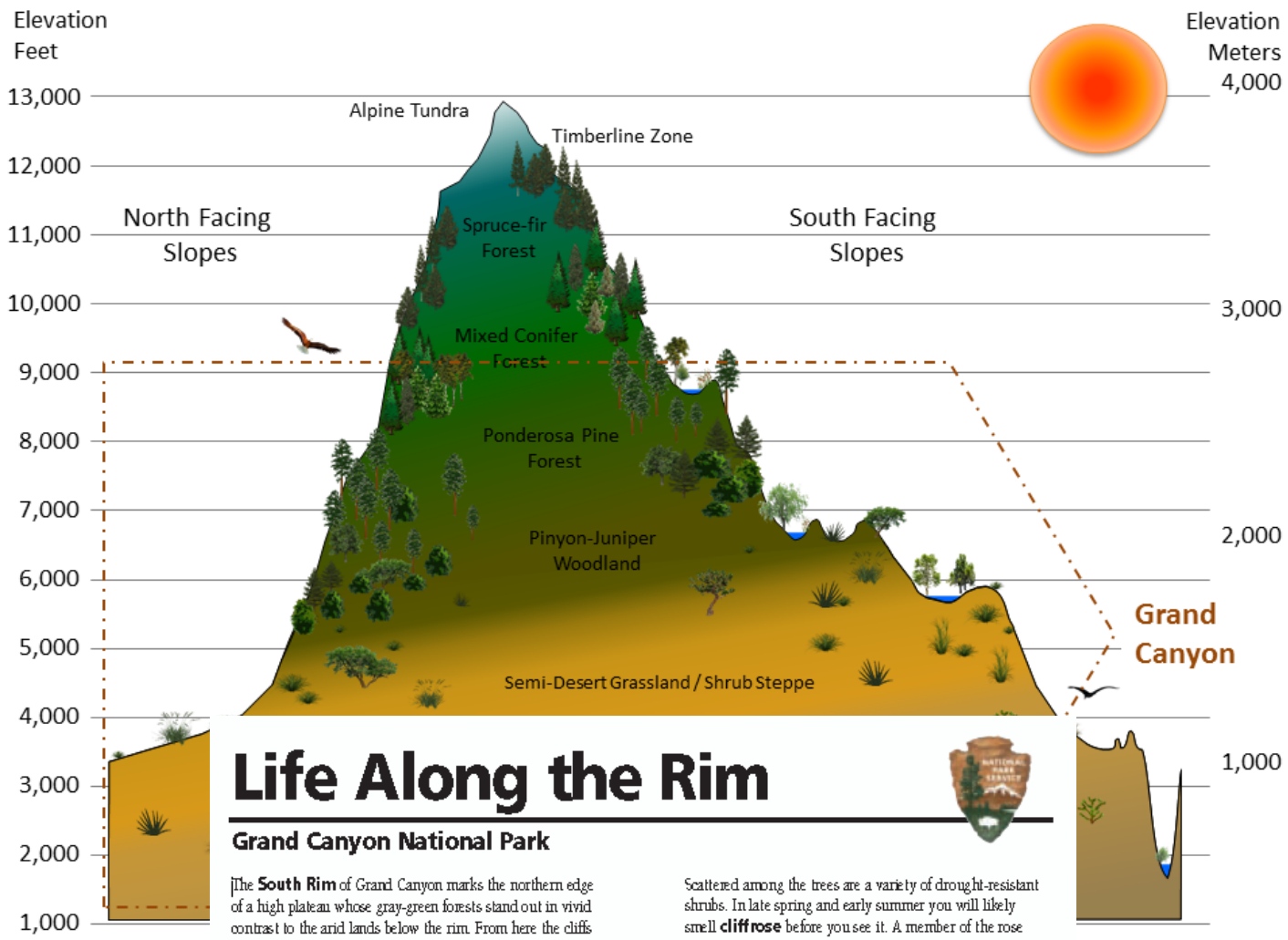
The "presettlement model" restoration approach quickly returned tree structure to what it was in pre-Euro American settlement times through thinning postsettlement trees. Low-intensity surface fires were also re-introduced every four years. Surprisingly, few differences were found between the thinned and composite (thinned and burned) treatments, although the treated plots did differ from the untreated control. Old-growth tree growth, herbaceous standing crop, net N mineralization and nitrification rates were higher in restored compared to control plots. Subtle but important variables such as resin flow defense against bark beetles and soil enzyme activities were higher in the composite treatment. Patch type had a greater influence than the treatment on specific variables such as herbaceous standing crop. A major role of fire in maintaining ecosystem function is as a manager of vegetation structure rather than as a direct mineralizer of nutrients "tied-up" in detritus (Hart and others 2005). Thinning and composite treatments both do a good job "returning" ecosystem function but repeated fire maintains the structure while thinning alone will eventually allow the ecosystem to return to its pretreatment state. Inter-annual variability in climate plays a key role in how the ecosystem responds to any treatment.

Acknowledgments

We thank Carl Fiedler and Jason Kaye for reviewing an earlier version of this paper. We also thank the staff and students of the Ecological Restoration Institute (ERI) at Northern Arizona University (NAU) for collecting data, processing samples, and maintaining the database for the G.A. Pearson Natural Area experimental treatments. Particular thanks go to J. Bakker, J. Barber, M. Behnke, S. Boyle, C. Casey, D. Chapman, R. Cobb, S. Curran, M. Daniels, S. Feeney, D. Guido, B. Housely, J. Kaye, B. Kerns, L. Labate, D. Laughlin, M. Luce, L. Machina, J. Roccaforte, K. Skov, J. Springer, M. Stoddard, J. Stone, J. Thomas, and K. Wallin. A special thanks to the USDA Forest Service Rocky Mountain Research Station, especially C. Edminster, for helping establish the experiment, and to Coconino National Forest for assistance with prescribed burns. Funding was provided by a National Science Foundation grant (DEB-9322706), McIntire-Stennis appropriations to the NAU School of Forestry, and additional funding from the Ecological Restoration Institute. Funding for remeasurement and analysis in 2004 was provided by the USDA Forest Service (#03-22 DG-11031600-088).


Grand Canyon Section
1000
500 feet
0
Permian
Pennsylvanian
Mississippian
Devonian
Cambrian
Precambrian
Kaibab Formation
Toroweap Formation
Coconino Sandstone
Hermit Formation
Esplanade Sandstone
Wescogame Formation
Manakacha Formation
Watahomigi Formation
Redwall Limestone
Temple Butte Formation
Muav Limestone
Bright Angel Shale
Tapeats Sandstone
Grand Canyon Supergroup
Vishnu Schist
Zoaraster Granite


San Francisco Peaks (volcanic)
Verde Valley
Verde Fault
Mesa Butte Fault
Grand Canyon
Vermilion Cliffs
Zion Canyon
Bryce Canyon
Sevier Fault



Life Along the Rim

Grand Canyon National Park

The **South Rim** of Grand Canyon marks the northern edge of a high plateau whose gray-green forests stand out in vivid contrast to the arid lands below the rim. From here the cliffs of Grand Canyon drop 5,000 feet/*1,500 meters* to the Colorado River, crossing several biotic zones. This is a landscape characterized by abundant sunshine, extremes of temperature, and long periods of drought, punctuated by downpours in summer and snow in winter. Precipitation on the South Rim averages fifteen inches/*38 centimeters* per year, twice that received at the river but half that received on the North Rim, just ten miles across the canyon. Even here at 7,000 feet/*2,100 meters* above sea level the climate is semi-arid.

It is not what most plants and animals would call a paradise. The soil is thin; bedrock lies just a few inches below the surface. The competition for moisture in this arid land is keen. All the plants and animals that live here must adapt to the lack of moisture and extremes of temperature that characterize the region.

Rugged as it looks, it is a fragile land whose scars persist for many years. Walk softly. Be alert to the sights, sounds, and smells that surround you, for there is much to experience here.

The plants and animals described here are common throughout the South Rim and may be seen wherever you choose to walk along the Rim Trail. There are no numbered stops to follow. Use caution near the edge—humans are among the less surefooted creatures at Grand Canyon.

The tallest tree on the South Rim is the **ponderosa pine**. It has an extensive root system to acquire as much moisture as possible. Stiff competition for water results in an open, park-like forest. The bark on young trees is dark (hence the name "black jack" often applied to younger ponderosas), but by the time ponderosa pine trees mature, the bark is cinnamon in color and smells faintly of vanilla. This is the only long-needled pine in the park.

Wherever you see ponderosa pines, look for evidence of the **Abert squirrel**. It is one of two varieties of tassel-eared squirrels found in the park—the other being the **Kaibab squirrel**, found only on the North Rim. Both are entirely dependent upon ponderosa pines for food and habitat.

Scattered among the trees are a variety of drought-resistant shrubs. In late spring and early summer you will likely smell **cliffrose** before you see it. A member of the rose family, this evergreen shrub produces fragrant cream-colored flowers. These blossoms give way to seeds whose feathery white plumes allow the wind to scatter them some distance. Also common here is the **banana yucca**, one of the most common and useful plants in the American Southwest. Native Americans have traditionally used it in the manufacture of soap, as a source of fiber for rope and sandals, and for its edible fruits that resemble small bananas.

The **mountain chickadee** and the **nuthatches** are small, acrobatic birds common in these coniferous forests. The mountain chickadee is easily recognized by its black bib and the white stripe over its eye. Gleaning insects from the outer branches of conifers, this small bird will often hang upside down in search of insects. The nuthatch similarly uses its slender bill to search for insects in the bark of trees, but it is unusual in that it will scurry down a tree headfirst.

Only the most observant and cautious hikers are likely to see the **bobcat**, a shy creature who frequents the North and South Rims but is rarely seen. **Mule deer**, on the other hand, are among the most readily seen mammals on the South Rim. Surefooted and nimble, they travel in and out of the canyon with ease as food and water dictate. The earliest trails into the canyon were likely built along deer paths. Mule deer are readily distinguished by their large ears.

The **coyote** is relatively common and ranges throughout the park from rim to river, but you must be alert to spot one. This close relative of the domestic dog is primarily nocturnal; their late night or early morning howls are among the most distinctive songs of the canyon region. Their diet consists mainly of rodents and insects.

At elevations below 7,000 feet/*2,100 meters* the **pinyon pine** and **Utah juniper** become the dominant members of the South Rim forest. The short-needled pinyon is prized for its edible seeds. The juniper, with its shaggy bark, is particularly well adapted to this arid climate: leaves have been reduced to scales covered by a waxy cuticle, both of which

Explore This Park

- Park Home
- Plan Your Visit
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- Nature & Science
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    - Amphibians
    - Birds
      - California Condors
        - Get the Lead Out
        - Re-introduction & Recovery Program
        - Condor Updates (since 2008)
      - Cowbird Survey 2008
    - Crustaceans
    - Fish
    - Insects, Spiders, Centipedes, Millipedes
    - Mammals
    - Mollusks
    - Reptiles
    - Keep Wildlife Wild
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  - Environmental Factors
  - Natural Features & Ecosystems
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- For Kids
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Condor Re-introduction & Recovery Program

Why did Condor Numbers Decline?

Condor #87 gets wet in Pipe Creek along the Tonto Trail in Grand Canyon National Park.

NPS Photo by Michael Quinn

Today, the California condor is regarded as one of the rarest birds in the world. In Pleistocene times, condors ranged from Canada to Mexico, across the southern United States to Florida, and north on the east coast to New York. During that period, condors were a common resident of the Grand Canyon judging by bones, feathers and eggshells found in caves where they once nested. A dramatic range reduction occurred about 10,000 years ago, coinciding with the late Pleistocene extinction of large mammals such as mastodons, giant ground sloths, camels, and sabre tooth cats that condors fed on.

By the time Europeans arrived in western North America, condors had retreated to a stronghold along the Pacific coast from British Columbia to Baja California. The birds managed to maintain a strong population until shooting, egg collecting, poisoning by cyanide traps set for coyotes, power line collisions, general habitat degradation, and especially lead poisoning began to take a heavy toll. Lead poisoning from ingesting fragments of lead ammunition in the carcasses and gut piles they feed on remains the greatest threat to California condors today

From the 1880s to 1924, there were scattered reports of condors in Arizona. But by the late 1930s, no condors remained outside of California and by 1982, the total population had dwindled to just 22 birds. Extinction loomed

What's Being Done to Save the Condor?

As a result of the continued downward spiral of the condor population, one of the longest wildlife recovery efforts ever attempted began. The California condor was placed on the federal endangered species list in 1967. Critical habitat was identified and mortality factors were studied.

The U.S. Fish and Wildlife Service began a captive breeding program in 1983, teaming with the Los Angeles Zoo and the San Diego Wild Animal Park. (Additional breeding facilities were added later at The Peregrine Fund's World Center for Birds of Prey in Boise, Idaho and at the Oregon Zoo in Portland, Oregon.) But in the wild, condor numbers continued to decline until by 1985 only nine wild birds remained

A controversial decision was made to bring all remaining condors into captivity, and the last wild bird was captured on April 19, 1987. All hope for recovery was now placed on the captive breeding program and the task was formidable.

Condors aren't capable of reproducing until they are about six years old and once a pair mate, only a single egg will normally be produced every year or two. Because of these factors, recruitment into the population is very low. To offset this, captive breeding techniques were developed in which eggs are removed as they are laid, usually causing the captive condors to lay a second and sometimes a third egg.

The extra eggs are incubated and the chicks are raised by caretakers using a hand puppet shaped like a condor head. The puppet prevents the young condors from imprinting on people, a phenomenon in which a bird will identify more with humans than its own species. Some condor chicks are also allowed to be raised by their parent birds. As a result, the captive condor population increased dramatically from 27 birds in 1987 to the 177 or so that are currently being held

Best of all, captive bred condors were being released back into the wild in California beginning in January 1992. Today, more than 127 condors fly free in the state of California, from the Ventana wilderness and Pinnacles National Monument down to the Sespe Condor Refuge and Los Padres National Forest north of Los Angeles.

In December of 1996, six young captive-bred condors were released into the wild in Arizona by The Peregrine Fund from a site in the Vermilion Cliffs, 30 miles north of Grand Canyon National Park. For the first time since 1924, condors were flying free in Arizona skies. Subsequent releases have occurred every year since then.

In October of 1992, three condors were released into the wild on the Baja peninsula of Mexico. It was the first flight of California condors there since 1937.

The world total of California condors today is around 400, more than half of which are in the wild. Although still endangered and facing ongoing challenges such as lead poisoning, they've come a long way since numbering just 22 in 1982

California Condors Have Adapted Well to This Area

As of April 2013, 73 condors soar over northern Arizona and southern Utah. Many of them frequent Grand Canyon, especially during the summer. They come from all four captive breeding locations. But more importantly, a number of them come from wild nest caves in and around the Grand Canyon.

The first California condor chick to fledge in the wild anywhere since 1982 was seen leaving its nest cave deep in the Grand Canyon on November 5, 2003. Unfortunately this youngster died in March of 2005, apparently of starvation. But his parents have bred successfully in the same nest cave twice since then. In fact, as of this writing in April of 2013, there are a total of seven wild-bred condors flying free in Arizona and Utah. There are also five active nest caves in the Grand Canyon and the Vermilion Cliffs right now. For updated information, read our latest NOTES FROM THE FIELD, Condor Update.

If You See a Condor

California condors, being curious, are attracted to human activity. If you see a perched condor, do not approach it or offer it food. If it is perched close to people in a spot where they can reach it, please report the situation to park staff immediately.

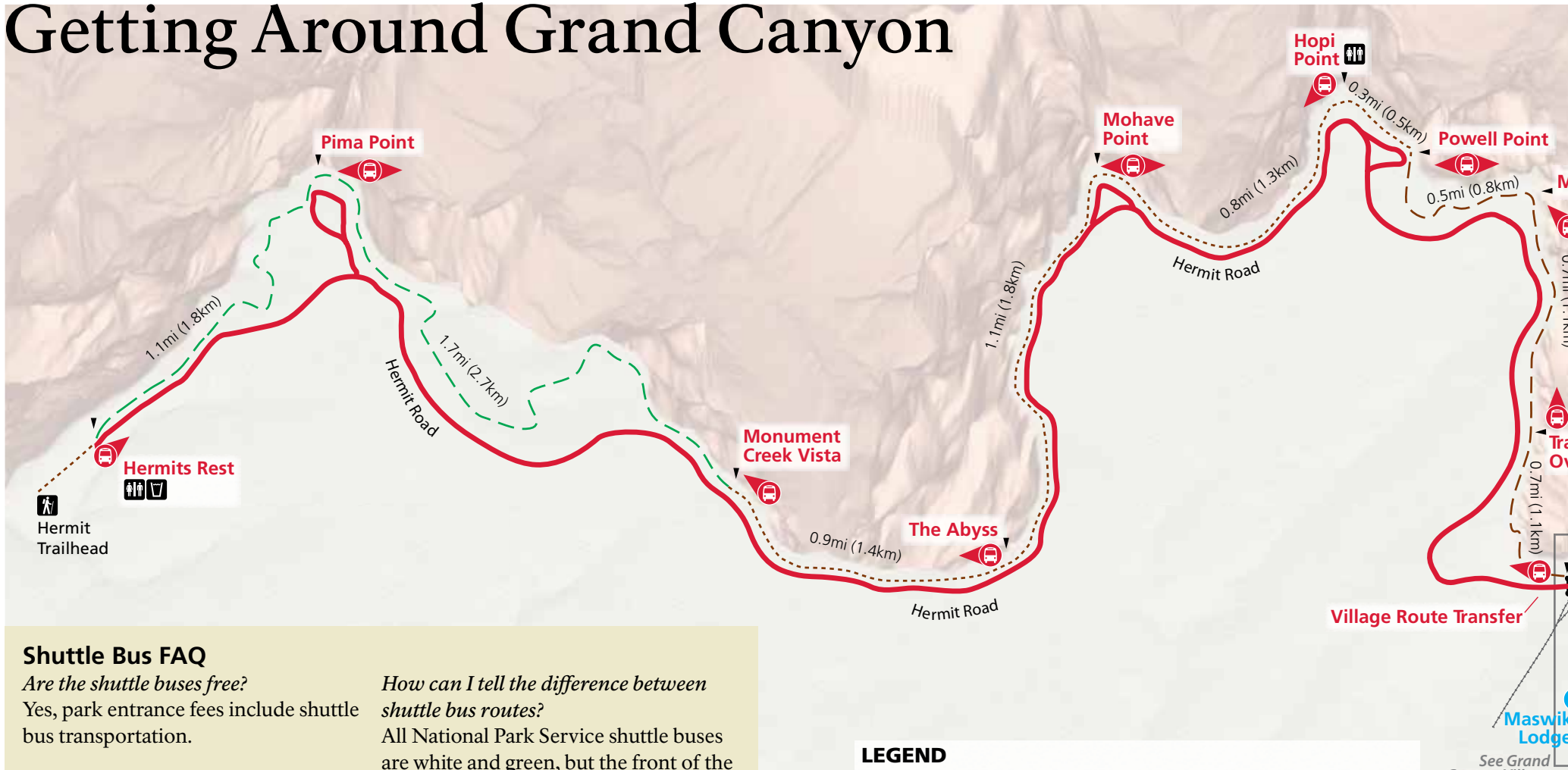
If you see a condor flying or perched at a safe distance, enjoy this remarkable sight! If it is close enough to read the numbered tag, which nearly all the condors wear, you can look up more information about your particular condor in the CONDOR TAG CHART, which may be downloaded from the **most recent Condor Update.**

If you haven't yet seen a condor in the wild, keep on the lookout from your next Grand Canyon viewpoint. You may appreciate the majestic scenery of Grand Canyon all the more for knowing that it provides important habitat for one of the world's most majestic-and most endangered-birds.

Did You Know?

John Hance, early Grand Canyon guide and storyteller, said of the Canyon, "It was hard work, took a long time, but I dug it myself, with a pick and a shovel. If you want to know what I done with the dirt, just look south through a clearin' in the trees at what they call the San Francisco Peaks." More...

Getting Around Grand Canyon



Shuttle Bus FAQ

Are the shuttle buses free?
Yes, park entrance fees include shuttle bus transportation.

How do the shuttle buses work?
Running like a city bus system, three shuttle bus routes stop at shops, visitor centers, and popular viewpoints around the South Rim. Just wait at any bus stop and enjoy the ride.

What are the shuttle bus rules?
1. No eating or open drink containers.
2. No pets, except service animals.
3. Collapse strollers prior to entering the bus. No oversized or jogging strollers. Remove baby-back carriers when seated.

How can I tell the difference between shuttle bus routes?
All National Park Service shuttle buses are white and green, but the front of the bus will say the route color and name.

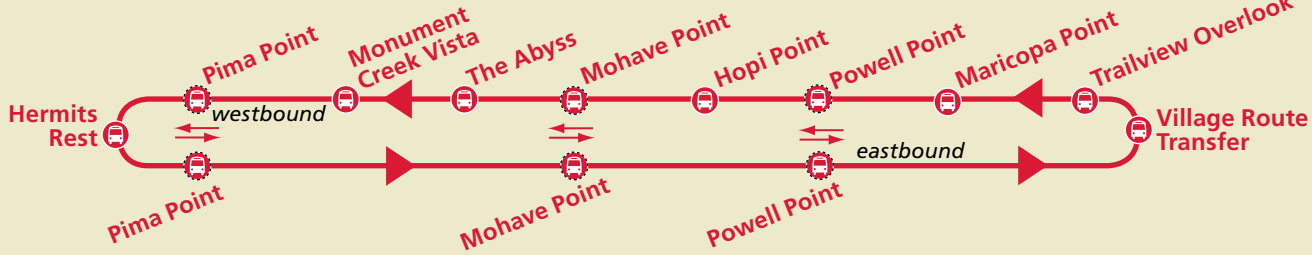
Will my wheelchair fit on the bus?
Buses are equipped with ramps to accommodate passengers in wheelchairs smaller than 30 inches wide by 48 inches long (76 by 122 cm). Most motorized scooters will not fit on buses.

The Scenic Drive Accessibility Permit allows visitors with mobility issues entry to some areas closed to public traffic. The permit is available at entrance gates, visitor centers, and hotel lobbies.

LEGEND

- Drivable park roads
- Village Route and bus stop
- Kaibab/Rim Route and bus stop
- Hermits Rest Route and bus stop
- Arrows indicate direction of travel
- Shuttle bus gate
- Paved Rim Trail
- Unpaved Rim Trail
- Paved Greenway Trail
- Drinking water
- First aid
- Information
- Parking
- Picnic area
- Restrooms
- Telephone
- Theater
- Trailhead

4. Shuttle buses can accommodate two or three adult bicycles, but not tag alongs, baby trailers, or children's bicycles. Riders must load and unload their bicycles.
5. Shuttle buses only stop at designated bus stops.



Ride the Free Shuttle Buses

Reducing air pollution and taking nearly a half-million vehicles off park roads each year, shuttle buses offer a hassle-free transportation option.

HERMITS REST ROUTE—
RED ON MAP ABOVE

- 80 minutes round-trip
- Nine overlooks
- Restrooms at Hopi Point
- Water, snack bar, restrooms, and gift shop at Hermits Rest
- Buses run every:
  - 30 minutes 4:30–7 am
  - 15 minutes 7 am to sunset
  - 30 minutes sunset to an hour after sunset

VILLAGE ROUTE—
BLUE ON MAP ABOVE

- 50-minutes round-trip
- Scenic canyon views are a short walk from some stops
- Grand Canyon Visitor Center, hotels, restaurants, campgrounds
- Buses run every:
  - 30 minutes 4:30–6:30 am
  - 15 minutes 6:30 am–7:30 pm
  - 30 minutes 7:30–10 pm; visitors should be at a bus stop no later than 9:30 pm.

KAIBAB/RIM ROUTE—
ORANGE ON MAP ABOVE

- 50-minutes round-trip
- Five viewpoints
- Grand Canyon Visitor Center and Yavapai Geology Museum.
- Access to South Kaibab Trailhead
- Buses run every:
  - 30 minutes 4:30–6:30 am
  - 15 minutes 6:30 am to one hour after sunset

HIKER'S EXPRESS
NOT SHOWN ON MAP ABOVE

Service to South Kaibab Trailhead. Bus begins at Bright Angel Lodge, then stops at Backcountry Information Center, Grand Canyon Visitor Center, and South Kaibab Trailhead.

Bus leaves Bright Angel Lodge at:
March—7, 8, and 9 am
April—6, 7, and 8 am
May—5, 6, and 7 am

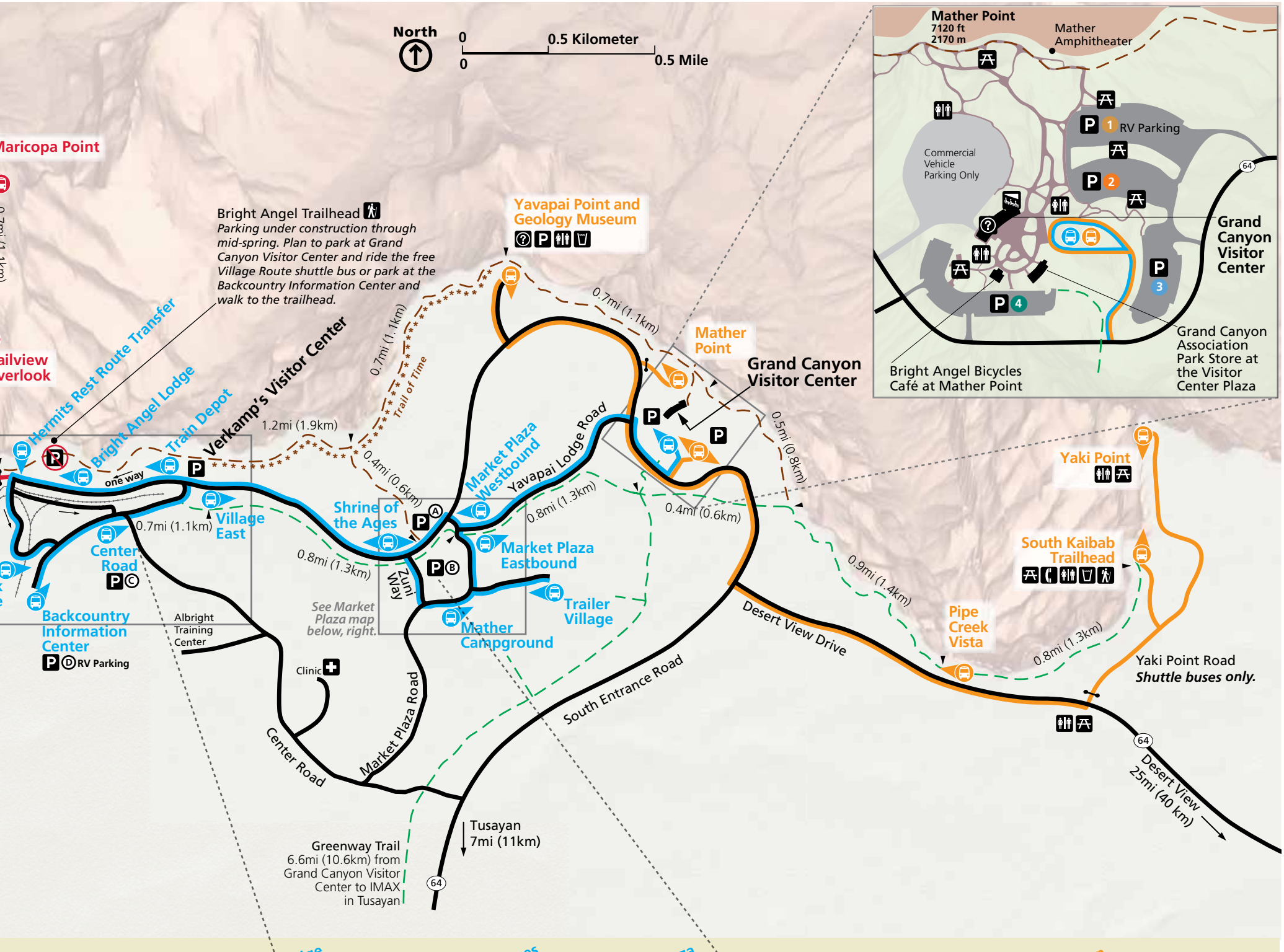
Explore in Your Car

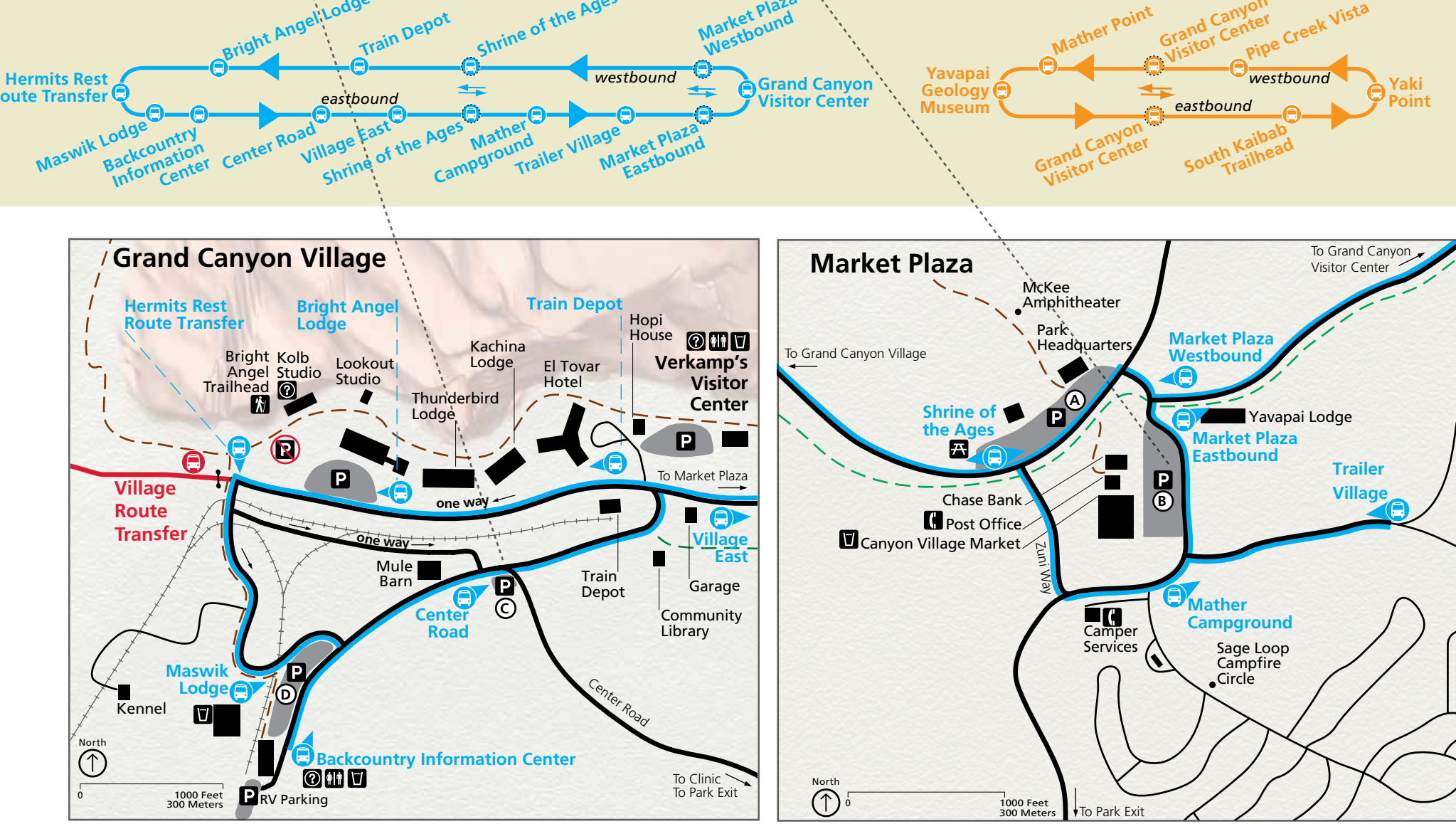
You can drive anywhere there is a solid black line on the maps in this Guide. You cannot drive the Hermit Road or Yaki Point Road; a free shuttle bus provides access. If you would like to explore by vehicle, consider driving to Desert View (see page 8). Use extra caution during inclement weather; park roads may temporarily close during spring snow storms.

Do not park along the roadside, except where signs or lines on the road indicate it is permissible. Use pull-outs and overlooks to take pictures and view wildlife.

Parking

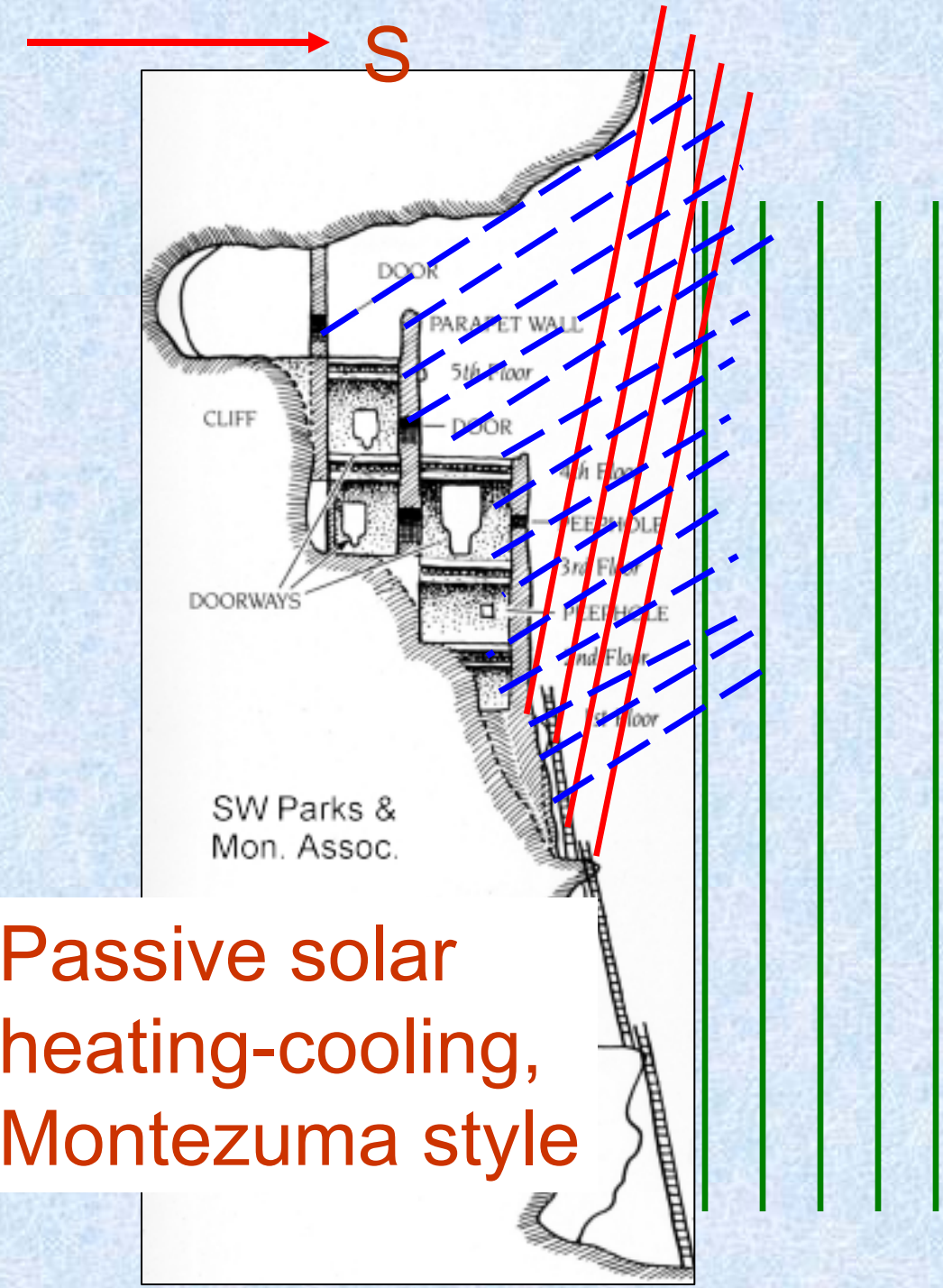
All parking lots in Grand Canyon Village are located near free shuttle bus stops. Parking lots 1–4 are at Grand Canyon Visitor Center. Lot 1 includes auto, RV, and trailer parking. Parking lots A (Park Headquarters) and B (Market Plaza) are large. Parking lot C (near Center Road in Grand Canyon Village) is small; lot D (Backcountry Information Center) offers auto parking in the north end and RV and trailer parking in the south end.


North
0
0.5 Kilometer
0
0.5 Mile
Maricopa Point
Bright Angel Trailhead
Parking under construction through mid-spring. Plan to park at Grand Canyon Visitor Center and ride the free Village Route shuttle bus or park at the Backcountry Information Center and walk to the trailhead.
Yavapai Point and Geology Museum
Hermits Rest Route Transfer
Bright Angel Lodge
Train Depot
Verkamp's Visitor Center
one way
1.2mi (1.9km)
0.7mi (1.1km)
Trail of Time
0.4mi (0.6km)
Village East
0.7mi (1.1km)
Center Road
Backcountry Information Center
RV Parking
Albright Training Center
Clinic
Shrine of the Ages
Market Plaza Westbound
Yavapai Lodge Road
0.8mi (1.3km)
Market Plaza Eastbound
Zuni Way
See Market Plaza map below, right.
Trailer Village
Mather Campground
Market Plaza Road
Center Road
Greenway Trail
6.6mi (10.6km) from Grand Canyon Visitor Center to IMAX in Tusayan
Tusayan
7mi (11km)
64
Mather Point
Grand Canyon Visitor Center
0.7mi (1.1km)
0.5mi (0.8km)
0.4mi (0.6km)
Mather Point
7120 ft
2170 m
Mather Amphitheater
RV Parking
Commercial Vehicle Parking Only
Grand Canyon Visitor Center
Bright Angel Bicycles
Café at Mather Point
Grand Canyon Association Park Store at the Visitor Center Plaza
Yaki Point
South Kaibab Trailhead
0.9mi (1.4km)
Pipe Creek Vista
0.8mi (1.3km)
Yaki Point Road
Shuttle buses only.
Desert View Drive
South Entrance Road
Desert View
25mi (40 km)



Page 6 lists the specific locations and hours of operation for lodges, restaurants, shops, and services shown on the maps above.

Bright Angel Trailhead Note: Due to parking lot construction, water is not available in this location through mid-spring. Fill your water bottles at Verkamp's Visitor Center, Backcountry Information Center, Maswik Lodge or Bright Angel Lodge. The trailhead is open; look for detour signs to access the trail.



Passive solar heating-cooling, Montezuma style

Solar Noon

June Solstice

34°

-(+23)°

11°

Dec. Solstice

34 °

-(-23)°

57 °

Montezuma Castle

National Monument
Arizona

Exploring Montezuma Well

Cliff dwellings are perched along the rim of Montezuma Well.
NPS

The legacy of the Sinagua culture surrounds you during a visit to Montezuma Well. From cliff dwellings perched along the rim to large pueblo ruins and an ancient pit house, the variety of these archeological sites is a testament to the ingenuity of these people.

Take your time as you explore the trails at Montezuma Well and discover the tranquility of a site still considered sacred by many local tribes. The shaded forest along the trail near the swallet ruin and the outlet provides welcome relief from the unrelenting Arizona sunshine. The temperature difference at the outlet can be up to 20 degrees cooler than along the rim of the Well, making it easy to imagine the people of the Sinagua culture spending the hot summer days in this tranquil setting.

The constant supply of warm, 74 degree water was the life-blood of the people who made their home here. Over 1.5 million gallons of water flows into the Well every day, a rate that has not fluctuated measurably despite recent droughts throughout the state of Arizona. This water enters a "swallet" near the end of the trail into the Well and flows through over 150 feet of limestone before re-emerging from the outlet into an irrigation ditch on the other side. Sections of this ditch date back over 1,000 years. The value of this water is recognized still today, as many residents of nearby Rimrock, AZ, rely on water flowing through the irrigation ditch for their gardens and livestock.

The trail to the outlet at Montezuma Well brings you to a site of surprising tranquility.
NPS

Information in this booklet
was provided by the
U.S. Forest Service
and
Friends of the Forest, Inc.

Sedona
Friends of the Forest

December 2010

The V Bar V Heritage Site Tour Guide

The V Bar V Heritage Site

A Rock Art Legacy

A total of 1,032 individual petroglyphs have been identified. There are four main panels that correspond to naturally occurring faces of the sandstone bluff. As you approach the wall, the panels parallel to the outer fencing may have been the first to be used as they are the ones most visible to a person approaching the site. This primary set of panels contain 67% of all the elements.

The elements are outstanding examples of the Beaver Creek Style, consisting of a large number of anthropomorphic, zoomorphic and geometric forms. The Beaver Creek Style is found throughout the eastern half of the Verde Valley. The style is noted for its precise execution. Certain elements or combinations of elements occur frequently enough that they can be recognized as motifs characterizing the Beaver Creek Style.

During the recording of the site, the archeologists identified 105 element motifs within 15 style classes. Of the style classes, zoomorphs are the most common (20%) including elements resembling snakes, turtles, coyotes or dogs, and female deer or antelope.

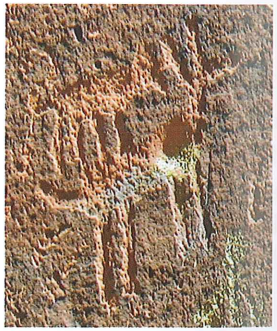
Unique to only a few sites in the Verde is the heron-like water bird, while the palm tree-like figure (now considered to likely be a representation of the frontal view of a heron with its feathers extended in alarm) are found nowhere else.

The next most prominent element classes include anthropomorphs, geometrics, random pecking and amorphous shapes. Stick-figured human or lizard forms, often with multiple sets of arms or legs, are common, as are stick figures with circular stomachs; foot prints or bear paws; crosses; and young girls, identified by hair whorls on the sides of their heads.

Other distinctive elements are walking figures with backpacks and a cougar-like animal on the back of a doe. Geometrical forms include a variety of lines, asterisks, rectangles, grids, spirals, concentric circles, and dots.

Another characteristic of the Beaver Creek Style is the pairing of elements, such as two humans, two turtles, and large female figures. Such turtles are particularly distinctive of Southern Sinagua rock art and, where present, are almost always in pairs with their legs bent upwards.

The V Bar V Heritage Site is unique in several ways. In addition to its sheer size, there is only one style present - the Beaver Creek Style - unlike most other sites in the Verde Valley. Rock art of the earlier Archaic Period and the later Yavapai and Apache peoples appear to be absent, although there is some debate about this. This would be particularly curious since other sites in the area have numerous Archaic, Yavapai and Apache elements.



Another unique aspect of the site is that, with only a few exceptions, petroglyphs are not pecked on top of others. There seems to have been a special effort to not overlap or cover any element.

While there is almost no overlapping of the elements, you can see numerous examples of connectivity, where numerous petroglyphs are linked by meandering lines or where great care was taken to make petroglyphs touch, but not overlap, as if to link them together into some story line or relationship. These are highly suggestive of the concept held by some archeologists that such lines indicate a history of events, clan migrations, or pathways of life. The frequency of connectivity here at is unique in the rock art of the Southwest.

You will also note that almost every foot/paw print, animal, and human figure has a circular depression, called a cupule, pecked and ground into it. This has been noted at a few sites in the Verde, but nowhere with the frequency seen here. There are 66 cupules that have been carefully pecked into the bodies of these elements. All cupules were produced using the same technique as the element on which they are located. They were probably created soon after the petroglyphs, most likely by other Sinagua people, since the depressions have weathered to about the same color as the petroglyphs themselves.

The purpose of cupules is uncertain, but similar cupules found in Hopi and Zuni suggest a link to fertility, rain making and other ceremonies. It is significant that the cupules occur on parts of the body typically associated as sources of power — head, heart, hands and feet..

So What Does It All Mean?

Many purposes and meanings have been proposed for rock art. Images related to religious beliefs are the most prominent. From Archaic through historic pueblo periods, rock art seems to have been a way to communicate with the gods and supernatural forces. In doing so, rock art could become infused with supernatural powers. Some older rock art images are found to have been repecked or retouched by later people perhaps to take advantage of or regenerate these powers. Alternatively, some rock art is found to have been defaced or have evidence of attempts to remove them entirely. This may have been done as attempts to remove bad spirits or omens represented by the images.

Ethnography is the study of a group of living people – how they live and interact, what they believe in, what kinds of objects they use, and what they do. Ethnography is frequently used by archaeologists to understand materials from the past. Since archaeologists cannot go back in time and directly study prehistoric cultures, they have to find other ways to understand how past cultures might have lived

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Sometimes information about present-day cultures (such as the Hopi and Zuni) is helpful because it gives archaeologists clues to questions they should ask about artifacts or rock art. Using ethnography in this way is known as using "ethnographic analogy." Suggestions of the functional purposes of rock art images are based on ethnographic analogies to ancestral and historic Pueblo agricultural and ceremonial activities.

Cupules, for example, were made by some historic groups to promote fertility or produce rain. Other suspected functions of rock art include:

- clan symbols, identifying the people who controlled land and water rights of the area
- certification by religious leaders that a ceremony was properly performed here
- initiation rites to instruct young men and women in their new adult responsibilities
- important events in the tribe's history
- hunting magic
- prayers to ensure abundance of game or rain for crops
- markers of territorial boundaries or other special places

However, these petroglyphs were made centuries ago, by people who had a culture and value system that was quite different from ours as well as those of modern Indian cultures. Consequently, we may never know exactly why they were made or what they mean.

Pictograph or Petroglyph

What's the Difference?

Pictographs are paintings or drawings made on rock. They were done in one or more colors. The colors were made from mineral pigments and natural dyes from plants. Pictographs were easier to make than petroglyphs. They tend to contain more complex designs than petroglyphs. However pictographs are also more fragile. The ones that have survived are in protected areas such as underneath rock overhangs as found at the Palatki and Honanki Heritage sites. Many rock art images were made using a combination of both techniques. However, today the paint material has faded, flaked, or washed away. There are no pictographs at the V Bar V site.

Petroglyphs are pecked, ground, or scratched into the rock surface. "Petro" is Greek for rock and "glyph" means drawing. Many petroglyphs are found on rock varnish (explained on Page 13). The V Bar V Heritage Site is the largest petroglyph site in the Verde Valley.

There are several techniques for making petroglyphs. Striking one rock with another is called direct percussion. The edges of petroglyphs created with direct percussion are often jagged.

Fine details are achieved with indirect percussion. Indirect percussion refers to pecking the surface of a rock by holding a pointed rock as if it were a chisel and striking that with another rock to peck evenly-sized, closely-spaced, circular dents.

Most elements at V Bar V were created by indirect percussion, although direct percussion and light abrasion also occurs.

How are Petroglyphs dated?

- Style — Identifying the style can establish date ranges associated with the culture that created it.
- Linking to artifacts — If the petroglyphs can be associated with other materials with reliable dates, the rock-art age can be inferred.
- Superimposed designs — Often petroglyphs are superimposed over one another. Such superimposed designs can provide a relative age.
- Repatination — The desert varnish through which the petroglyphs were created will begin to cover the glyphs. The color can at least be used to compare relative ages among the petroglyphs.

Desert Varnish and Lichens

What is the black on the rocks?

One of the most remarkable biogeochemical phenomena in arid desert regions of the world is desert varnish. Although it may be only a hundredth of a millimeter in thickness, desert varnish often colors entire desert mountain ranges black or reddish brown. Desert varnish is a thin coating (patina) of manganese, iron and clays on the surface of sun-baked boulders and cliff walls.

Desert varnish is formed by colonies of microscopic bacteria living on the rock surface for thousands of years. The bacteria absorb trace amounts of manganese and iron from the atmosphere and precipitate it as a black layer of manganese oxide or reddish iron oxide on the rock surfaces. This thin layer also includes cemented clay particles that help to shield the bacteria against desiccation, extreme heat and intense solar radiation.

Varnish bacteria thrive on smooth rock surfaces in arid climates. Perhaps 10,000 years are required for a complete varnish coating to form in the deserts of the southwestern United States. In fact, dating of varnished surfaces is of enormous importance to the study of desert landforms and to the study of early humans in America, since many artifacts lying on the ground become coated with desert varnish. And, as we know, several Indian cultures utilized desert varnish to create their marvelous petroglyphs.

What is the green and yellow on the rocks?

The colorful coatings on the rocks are produced by lichens. Structurally, lichens are among the most bizarre of all forms of life. That's because every lichen species is actually composed of two other distinct species of organisms. One species is a kind of fungus, and one is a species of algae. Lichens are a symbiotic association of a fungus and an alga.

Biologists think that both the fungus and the alga benefit from the symbiotic association. As a simple model, lichens are like gardens. The alga is similar to a plant that under optimal conditions produces simple sugars from atmospheric carbon dioxide and water by photosynthesis. The fungus, as the "gardener," tends the alga, providing shelter and protection from the extremes of the environment. The alga produces enough additional sugars to supply the fungus with nourishment.

In this association, the fungus benefits from the algae because fungi, having no chlorophyll, cannot photosynthesize their own food. A lichen's fungal part is thus "fed" by its photosynthesizing algae part. The algae benefit from the association because the fungus is better able to find, soak up, and retain water and nutrients than the algae.

There are several growth forms of lichens. The form that adheres to the V Bar V bluff is called Crustose. This crust-like lichen adheres tightly to the substrate by their entire lower surface. Some Native Americans used Lichen for a variety of purposes:

- Medicine – "yellow rock fungus" was applied to cheeks to reduce swelling after a medicine woman rubbed cheeks to extract "foreign things," also as cure for toothache and swollen cheeks.
- Dye Source – collected from rocks, ground, and mixed with Pinion pine resin for a deep yellow paint.
- Magical properties – "earth flower" lichen had religious meaning and was smoked, mixed with tobacco, at summer dances.

Why not remove the lichen?

Ecologically, lichens are important because they often occupy niches that, at least sometime during the season, are so dry, or hot, or sterile, that nothing else will grow there. For example, often the only plant growing on a bare rock will be crustose lichen. That crustose lichen will be patiently collecting around and beneath itself tiny amounts of moisture, minerals and organic fragments. When freezing temperatures come, the water collected by the lichen will expand as it forms ice. This expanding action may pry off a few mineral particles from the rock below the lichen, thus making more soil. The water itself is a bit acidic, plus the organic matter collected by the lichen will also be acidic. These acids will also eat away at the stone.

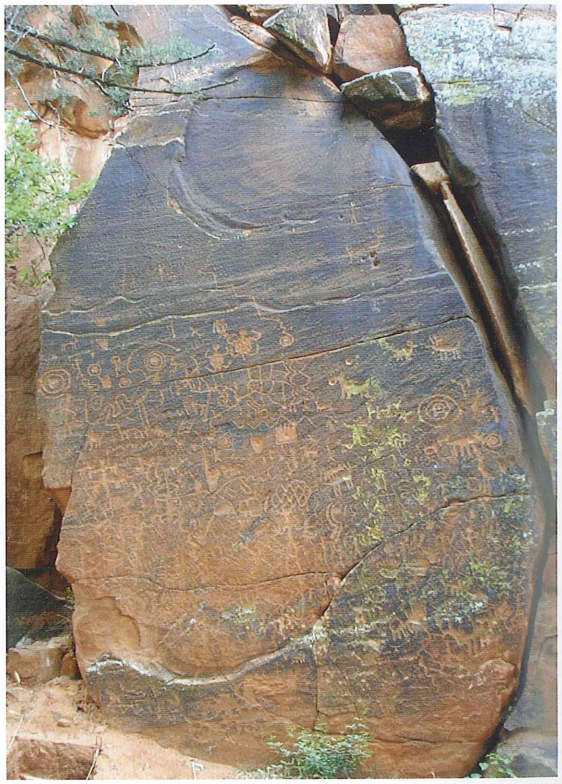
Over a period of many years, lichen gathers an extremely thin and fragile hint of a soil around it. As it grows, the processes just described speeds up and takes place over an ever-larger area. Eventually other more complex plants, such as mosses growing here, may take root in the modest soil and replace the crustose lichen. This can be observed in areas of Palatki where ferns appear to be growing out of shear rock.

Crustose lichens on bare rock often begin a succession of communities. Therefore, removing lichen from the V Bar V Heritage Site may be undoing the patient work of centuries. And in any event, the processes employed by the lichen have already "softened" or destroyed the underlying petroglyphs. Removing the lichen would not "restore" it.

Could There Be a Solar Calendar?

Archaeoastronomy is a field of archaeology that studies how prehistoric cultures may have used naked-eye sky observations to relate astronomically significant dates with the orientation of an ancient place, setting, structure, pictograph, petroglyph or rock. To determine what these cultures could have learned just from their observations of the heavens over many years, without the benefit of today's astronomical knowledge, we must look through their eyes. The Sinagua, for example, could have known with naked-eye observations when summer begins (the sun is the highest in the sky for the year, and the day is the longest) as well as when winter arrives (the sun is the lowest in the sky for the year, and the day is the shortest). They could also have determined the equinoxes (the time when day and night are about equal).

Sinagua sunwatchers, similar to historic Pueblo sunwatchers, most likely monitored the sun and anticipated the times of equinoxes, solstices and other dates by sighting sunrise or sunset locations on the horizon from a fixed observation position. In addition to using the horizon, they took notice at these important times by when sunlight entered their rooms or illuminated specific images. Solar calendars based on this imaging method have been identified at sites throughout the Southwest that were created by many prehistoric cultures.



The V Bar V site contains a number of images that are generally ascribed as having astronomical meaning. The "Solar Panel" (shown here) contains 10 of these concentric circle and snake-like glyphs. There is also a very unique image that incorporates a sun-like glyph with a pair of arched lines. Another petroglyph image that drew attention during the observations was a series of "centipede-like" images that have since been suggested as being "corn plants."

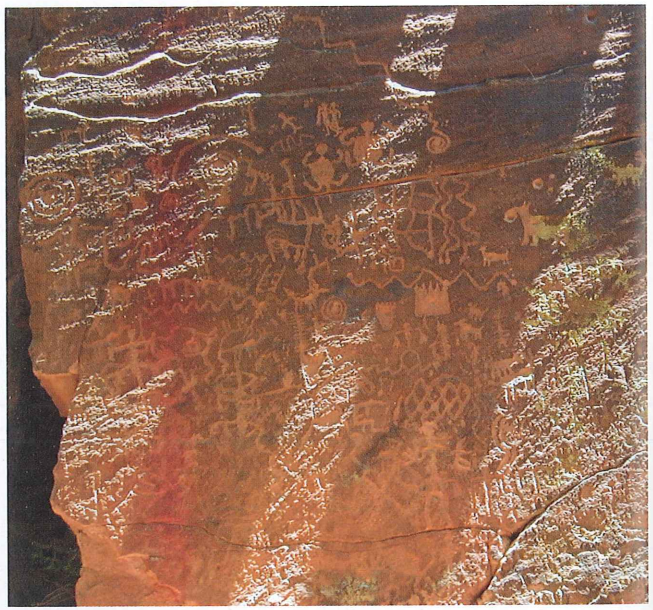
The light and shadow effects on the Solar Panel are created by a

trilogy of boulders wedged in a crevice in the rock face. When the sun crests the bluff, the sunlight strikes the protruding boulders. The resulting effect is a shaft of sunlight between two lines of shadow produced by the boulders.

Vernal and Autumnal Equinox

A study has documented the recording of time over a 12-month period through the play of light and shadow on petroglyph images and by the use of natural features on the bluff. It has been shown that the light and shadow patterns display their unique configurations at specific times. With years of observations, the Sinagua would have noted the repetition of certain events at regularly spaced intervals, most easily seen during the solstice and equinox events. These occur at regular and repeated intervals. It would have been a simple matter to organize the intervening days into equal periods of (30 days). The result was the creation of a full 12-month calendar.

The agricultural nature of the countryside surrounding the V Bar V site had been documented in earlier studies. As with their descendents, the historic Hopi, the development of the solar calendar for specific agricultural events by the Sinagua is a logical conclusion. Successful farming, especially in the drier climates, depends on knowing when to plant various crops. The corn connection was suggested by the inclusion of the corn plants on significant dates of planting and harvest. The third week of April is the planting time for the early corn crop of the historic Pueblos, and as the weather warms in the third week of May it is time for the main planting of corn, beans and squashes. On the summer solstice, also the beginning of the third week of June, the sun shaft may have indicated the time for a late corn planting when it again



Summer Solstice

touches a corn plant.

During the April through August observations, the petroglyph referred to as a "falling spiral" produced interesting effects. This image is composed of several features. First, there are two "dots" or markers – one at the top and another near the end. Between the dots are seven lines of varying lengths in a stair step pattern. Third, after the lower dot, four short lines in a tight pattern end in a loose clockwise spiral. Clearly, this glyph is tied to the sun shaft images in a very deliberate manner. Two plausible interpretations have been offered. The lines between the dots covers a 90-day period coinciding with the planting cycles, and the "lightning" and "water" after the dot coincides with historical averages for the beginning of the monsoon season.

Sun passes at the bottom of the "wedge" on the Winter Solstice

We will never know for sure if this was a Sinagua calendar, despite the very precise geometric alignment of images. What is more certain is that the V Bar V solar panel appears to have played an integral part of the Southern Sinagua complex that linked time with the ritual and agricultural cycles of the valley's population.

"Sun Dagger" at Winter Solstice

After the sun passes West of the pillar, it throws back another"dagger" that bisects the large concentric circle

The V Bar V is the most elaborate of the sun marking locations found to date in the Verde Valley. So far 10 other sites have been documented, with several other in various stages of investigation.