A Late Miocene Flora from the Southern Margin of the Western Snake River Plain

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View of the Owyhee Mountains from the fossil sites

Introduction

The Pickett Creek fossil beds are 13.3 miles south of Murphy and 6 miles west of Oreana, Owyhee County. Leaf remains, similar in matrix and floral composition to those described here, were found in Charles J. Smiley’s collection at University of Idaho. Excellent preservation of the specimens and uncertainty regarding the location and age of the fossil layers prompted our search for the site, which we rediscovered in spring of 1996. Excavations were done during the 1996/97 field seasons.

Local setting

Sandy outcrops (possibly beach sand) and water-affected basalt flows near the Pickett Creek fossil sites suggest an ancient lake shoreline at an elevation of 1260 - 1280 m. The two fossil sites were deposited in a 500 - 700 m wide channel between the lake's western shoreline (similar to the south-western margin of the present Snake River Plain) and two offshore islands. When its fossils were deposited, Site I was situated about 500 m off the mainland shore, only 100 m away from an island coast, under about 20 m of water. Site II was about 200 m offshore and close to a small river mouth, and at a depth of 10 - 15 m water. It is likely that Pickett Creek lake was part of a larger body of water, possibly a pre-stage of Miocene - Pliocene Lake Idaho. The fossil beds are stratigraphically connected to a deposit of pure diatomite, which is typically 3.7 m thick and extends over an area of probably more than 100 acres. Site I is situated directly below the diatomite. Site II lays 528 cm above the lower diatomite boundary.

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Methods

Rock was removed from a 50 x 100 cm plot with a chainsaw and chipped down with hammer and knife to an average thickness of < 1 cm. All megafossils were recorded as a function of depth (a total of 293 cm at Site I and 22 cm at Site II). Recovered were a total of 3,133 specimens, 1992 (64%) of which could be assigned to a taxonomic group.

Age

Volcanic ash samples were analyzed and age-correlated with Middle to Late Miocene Ar/Ar-dated fallout tuffs from the same general region. They closely resembled tuffs from the Twin Falls region which have an age range of 10.5 – 8.5 Ma. Flora composition suggests an age close to the Middle Miocene – Late Miocene transition (10.4 Ma). The thickness of some seemingly varved layers at Site II and varved diatomite at Site I suggests the examined part of the Pickett Creek sediments may represent a time interval between 1000 and 2000 years.

Leaf flora

Leaf floras of Site I and Site II comprise a total of 72 taxa. Sixty-one could be assigned to an established fossil species or to some higher taxonomic category. Preservation varied from fair to excellent. Some specimens had organically-preserved cuticles on petioles and parts of the midvein, which allowed determination of the average epidermal cell size for an on-going study in fossil polyploidy levels. The following list gives the seven most abundant taxonomic groups in order of decreasing frequency (% of total specimens).

Oaks (6 Quercus spp., including acorns and cupules) 64%
Willows (5 Salix spp., including 2 catkins and 1 stipule) 7.9%
Maples (5 Acer spp., including samara) 6%
Pea family (5 Fabaceae spp., including 2 pea pods) 5.7%
Horsetail family (1 Equisetaceae sp.) 4.8%
Birch family (2 Betulaceae spp.) 2.6%
Poplars (6 Populus spp.) 2%

Flora compositions at the two collection sites were distinctly different. The small sample size at Site II (73 specimens), however, does not allow a quantitative comparison. The difference in floral composition may have been caused in part by environmental changes related to basalt flows (topographical changes and forest fires), and because Site II was closer to the river mouth.

Quercus columbiana Chaney from Site I
Palynoflora

Twenty-one pollen taxa were found in a non-quantitative survey. They confirmed the presence of most of the leaf families and suggested additional taxa blown in from higher elevation and dry sites (Abies, Pinus, Amaranthaceae, Chenopodaceae). Tricolpate pollen of various sizes with a clear exine and no other obvious characteristics were dominant. Pine and oak pollen were abundant. All other forms were rare.

\[1000 \times\]

*Pinus* pollen

Diatom flora

Three samples from Site I, one from the pure diatomite and two from different-fossil bearing layers, contained a total of 45 diatom taxa and various forms of sponge spicules. Most fossil diatoms closely resemble modern species, but three or four forms may represent new taxa. *Aulacoseira* spp. were dominant or abundant in all three samples, but each sample had a different composition. Fifteen diatomite samples were taken from different sites in the local area. Their floral composition was the same over a distance of almost 3 km in a north–south transect. Diatomite from Reynolds Creek, about 30 km north-west of Pickett Creek, contained a distinctly different flora and therefore probably did not originate from the same ecosystem.

\[1500 \times\]

*Aulacosira* sp.
Fauna

Faunal remains comprised fish (five partially complete specimens and four single bones or scales), gastropods (four operculae and one shell) and insects (one entire specimen and three single wings). Fish were sent to the Museum of Zoology at the University of Michigan (Dr. G. Smith) for identification.

Unidentified insect

Paleoecology

Based on the predominance of white oaks and the presence of deciduous hardwoods including Juglans, Carya, Populus, Ulmus, and Acer, the most similar modern flora is the Mixed Broad-leaved Deciduous Forest of eastern North America and, to a lesser extent, the flora of the Temperate Broad-leaved Deciduous Forest in eastern China.

The most common members of the canopy in the Pickett Creek forest were deciduous oak species, similar to modern Quercus lobata Née (California) and Q. prinus L. (eastern U.S.A.), and a large-leaved maple similar to modern Acer macrophyllum Pursh (West Coast, U.S.A.). The subcanopy contained mainly oak, maple, hophornbeam (Ostrya sp.) and elm species. The lake shore and streamside vegetation (upstream from the Pickett Creek lake, the floras of Site II) included willows (Salix spp.) and poplars (Populus spp.). Smaller willows similar to modern S. lasiolepis grew in smaller creeks with seasonal droughts. Small-leaved trees of the pea family (Fabaceae spp.) and evergreen oaks similar to the Californian Quercus crysolepis Liebman may have grown in drier locations, on slopes above the lake or river.

Paleoclimatology

A CLAMP (Climate-Leaf Analysis Multivariate Program) analysis was performed at the University of Arizona using 31 leaf characters of 41 species from Site I. Estimates for climatic parameters are: mean annual temperature = 13.4°C ± 1.9°C and the mean annual range of temperature = 21.2°C. These estimates are within the climatic range of the modern Appalachian Mixed Broad-leaved Deciduous Forest. They most closely resemble the present climate of eastern Tennessee and western North Carolina, at approximately 35° northern latitude.

Future work

The Pickett Creek fossil beds still hold many interesting avenues to explore. More research at Site II, for example, could give insights in the recovery of a flora after catastrophic volcanic eruptions. Other future tasks are: a more detailed study of diatom succession through the whole range of local strata and a search for other fossil sites in the area.
Biological Soil Crusts and Their Importance in Arid and Semi-arid Ecosystems

Biological soil crusts are composed of cyanobacteria, algae, fungi, lichens and mosses (St. Clair & Johansen 1993; Evans & Johansen 1999). These crusts are found throughout arid and semi-arid areas of the western United States. They are found both in the southern ecosystems of the Chihuahuan, Sonoran and Mojave deserts (Nash et al. 1977; Rychert et al. 1978) and cold desert shrub-steppe ecosystems of the Colorado Plateau, Columbia Plateau and Great Basin (Johansen 1993).

The specific organisms comprising biological soil crusts vary regionally. On soils of the Colorado Plateau Microcoleus vaginatus (Vauch.) Gom., a cyanobacterium, is a dominate organism (Belnap 1990; Belnap & Gardner 1993). Lichens also contribute significantly to biological soil crusts of the type found in southwestern Idaho (Rosentreter 1984; Kaltenecker & Wicklow-Howard 1994). Biological soil crusts can also include mosses, which tend to flourish in areas that receive significant annual precipitation during the cool season (Rincon & Grime 1989). Biological soil crusts in southwestern Idaho can include several moss species (Rosentreter 1984; Kaltenecker & Wicklow-Howard 1994).

Biological soil crusts stabilize soil surfaces (Brotherson & Rushforth 1983; Williams et al. 1995a &1995b), trap wind-borne particles (Danin & Ganor 1991), affect soil nitrogen and carbon availability (Beymer & Klopatek 1991; Evans & Ehleringer 1993; Belnap & Harper 1994) and influence surface hydrology (Brotherson & Rushforth 1983; R. Rosentreter, Idaho State Office, Bureau of Land Management, Boise and D. J. Eldridge, Centre for Natural Resources, Department of Land and Water Conservation, Sydney, Australia, pers. comm.) These crusts can also affect seedling establishment of some vascular plants (Jaques 1984; Scarlett 1994; Larsen 1995; Kaltenecker et al. 1999).

Stabilization of Soil Surface

Biological soil crusts can form a continuous but friable mat that is resistant to erosive forces. Biological soil crusts stabilize the soil surface by holding soil particles together. Filaments, sticky with polysaccharide, of the cyanobacterial crust organism, *M. vaginatus*, stick together soil particles making them resistant to wind and water erosion (Belnap & Gardner 1993). Rhizenes, root-like structures of lichens, and lichen thalli can also physically restrict soil particle movement. Rhizoids, thread like root structures of mosses, inter-twine to form mats that hold soil particles.

To investigate these phenomena Williams et al. (1995a) constructed a wind tunnel over scalped, undisturbed and chemically killed biological soil crusts composed of cyanobacteria, lichens and mosses. They found that a soil surface covered with biological soil crust resisted loss of soil particles to wind erosion. Williams et al. (1995b) also found
that soil loss was less on plots inhabited by biological soil crusts when subjected to simulated rainfall.

Biological soil-crust organisms produce micro-topography at the soil surface which can reduce sheet erosion, pond water and prevent rill erosion by disrupting directional flow paths (Brotherson & Rushforth 1983). An irregular soil surface also disrupts wind flow at the boundary layer resulting in greater wind velocity requirements to dislodge fine soil particles (Williams et al. 1995a; Belnap & Gillette 1997, 1998). The irregular surface of biological soil crusts will also trap wind-borne particles (Danin & Ganor 1991). Danin and Ganor (1991) noted that individual moss stems trapped fine soil particles among living leaves in the upper 1-2 mm of the moss cushion. As moss grew, fine particles continued to accumulate.

Nitrogen

Nitrogen is a key element controlling species composition, diversity, dynamics and function of many terrestrial ecosystems (Vitousek et al. 1997). Nitrogen availability has been shown to be a primary mechanism for controlling succession after disturbance (McLendon & Redente 1994). Many of the native plant species living in semi-arid ecosystems are adapted to function optimally in soils with low levels of available nitrogen (Vitousek et al. 1997; Evans & Belnap 1999).

Biological soil crusts provide semi-arid ecosystems with nitrogen that is of benefit to perennial vascular species (McLendon & Redente 1994). Nitrogen fixed by cyanolichens, is released through a semi-permeable thallus during wet/dry cycles. Additional nitrogen can become available when organisms decay after death (Belnap & Harper 1994). The lichens, Collema tenax (Sw.) Ach. and Peltigera rufescens (Weiss) Humb., growing with the free-living cyanobacteria (Nostoc spp.) were shown to be potential nitrogen fixing organisms at several locations in the arid west (Snyder & Wullstein 1973). Biological soil crusts, composed of cyanobacteria, lichens and mosses, were shown to be the predominant source of nitrogen in juniper woodland ecosystems (Beymer & Klopatiek 1991; Evans & Ehleringer 1993).

Nitrogen and water are the limiting abiotic variables that dictate plant growth in arid and semi-arid systems (Evans & Ehleringer 1993). Loss of biological soil crusts through disturbance is likely to cause changes in species composition similar to those associated with too much nitrogen (Evans & Belnap 1999). Pendleton and Warren (1995) noted improved growth and higher nitrogen content of vascular species grown in soil amended with pulverized biological soil crust. These biological soil crust organisms were shown to release nutrients to the soil upon decay, and serve as a nitrogen pool when living. Increased nitrogen availability in shrub steppe ecosystems results in increased abundance of annuals and increases the length of time they dominate (McLendon & Redente 1994). The end result is an alteration of nitrogen cycling through these ecosystems (Evans & Ehleringer 1993; Vitousek et al. 1997). Destruction of biological soil crust results in a release of nitrogen to the soil that would otherwise be released over time, this may hasten conversion of landscape to exotic annual grassland.
Carbon

Carbon can serve as an energy source for nitrogen fixation by cyanobacteria associated with bryophytes (During & Van Tooren 1990). Carbon can become available in the soil by leaching of photosynthetically created carbohydrates (Beymer & Klopftek 1991). To illustrate this Beymer and Klopftek (1991) exposed samples of biological soil crust, to radioactive CO$_2$. They noted that soil below the biological soil crust received radioactive carbohydrates to a depth of 15mm. Beymer and Klopftek (1991) attribute leaching of carbohydrate to excessive watering, however, small amounts of carbohydrate leached under natural conditions could be a potential source of energy for heterotrophic soil organisms (including nitrogen fixers).

Surface Hydrology

Brotherson and Rushforth (1983) indicated a difference in infiltration rate between moss and lichen biological soil crust. They suggested that biological crusts composed predominantly of mosses showed quicker infiltration because moss thalli acting as a conduit to lower soil layers. Biological soil crusts also maintain structural integrity of soil pores to provide a stable mechanism for infiltration (Eldridge 1993). Buried moss stems and decomposition of moss leaves increases organic matter in the soil and water holding capacity of the soil under mosses is increased because of accumulation of organic material (Danin & Ganor 1991). Recent experiments utilizing an infiltration device have shown that infiltration is likely affected by all the factors mentioned above (R. Rosentreter, Idaho State BLM and D. J. Eldridge, Centre for Natural Resources, Department of Land and Water Conservation, Sydney, Australia pers. comm.). Biological soil crusts also exhibit properties of mulch, e.g., slowing water loss from soil (pers. obs.)

Relationships with Vascular Plants

Biological soil crusts can enhance growth and vigor of vascular plant species. Belnap and Harper (1994) provided evidence for the importance of biological soil crusts composed of cyanobacteria and the lichen C. tenax to vascular plants. Vascular plants growing in soil with these organisms had greater tissue-nutrient. St. Clair et al. (1984) observed a trend of higher seedling establishment among seeded graminoids (Agropyron elongatum = Elymus elongatus [Host] Runnem., E. cinereus Scribn. & Merr. and E. Junceus Fisch.) on soils with intact biological soil crust.

Biological soil crusts can act as a mulch-layer preventing establishment of some weeds. Biological soil crusts composed of mosses that form perennial colonial mats of stems and intertwined rhizoids, can provide a physical barrier to the large florets produced by cheatgrass, hindering their germination and subsequent establishment (Jaques 1984; Larsen 1995; Kaltnecker 1997). Cheatgrass densities were reported as
minimal in some Snake River plain plant communities with intact biological soil crusts, even when abundant seed sources were nearby (Kaltenecker et al. 1999).

Conclusions

Biological soil crusts help conserve the soil resource by preventing erosion and trapping fine particles. These crusts are also involved in the cycling of nitrogen and carbon through arid and semi-arid ecosystems. Biological soil crusts also affect surface hydrology and the biology of some vascular plants. These often-obscure organisms of the soil surface are important members of arid and semi-arid ecosystems.

Literature Cited


GEOLOGIC FEATURES IN BRUNEAU AND JARBIDGE CANYONS, OWYHEE COUNTY, IDAHO

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Introduction

Here, we discuss the character and origin of the canyons of the Bruneau and Jarbidge Rivers in the eastern part of Owyhee County, southwestern Idaho, and of the rhyolite rocks displayed in their sheer walls. The Bruneau River and its principal tributary, the Jarbidge River, have incised imposing canyons that extend northward from the Jarbidge Mountains area of northern Nevada, almost to the Snake River. Both canyons vary from about 700 to 1300 feet deep, but seldom are more than a half mile across. Because of their deep narrow character, the reddish and dark-colored volcanic rocks in the canyon walls are exceptionally well exposed as cliffs, and the small rivers that flow at the bottoms of the canyons are quite secluded from the surface of the uninhabited plateau into which they have been carved. These canyons are unspoiled places that have been changed very little by mankind’s impact. These attributes of scenic beauty and unspoiled seclusion are features that have brought this area to the attention of people interested in permanently sequestering portions of southwestern Idaho into some sort of nature preserve, such as a National Monument. As an aid to help evaluate such a prospect, the following discussion outlines what some of the geologic features exposed in the Bruneau and Jarbidge Canyons are, how these features formed, and why they are important to geologists as a unique place to make observations relevant to understanding Earth processes.

The Snake River Plain-Yellowstone Volcanic Province

The Owyhee Plateau of southwestern Idaho is part of an extensive zone of volcanism commonly referred to as the Snake River Plain-Yellowstone volcanic province. The Owyhee Plateau is at the southwestern end of this volcanic province and consists principally of volcanic rocks of basaltic and rhyolitic composition that range from Miocene to Pleistocene in age. The Owyhee Plateau is at the previously active southwest end of this volcanic zone, whereas the Yellowstone area is at the northeastern, presently active, end of the zone. Geologists regard the Snake River Plain-Yellowstone zone to be a hot-spot track. It usually is called the Yellowstone hot-spot track. It has formed as the North American tectonic plate has drifted southwestward for the past several million years over a zone deeper within the Earth from which copious amounts of magma have ascended to the surface. Eruption of some of this magma formed a broad plateau made of volcanic rock layers. The canyons in southwestern Idaho have been carved into this plateau and clearly show the types, distribution, and age succession of these volcanic rock layers.

This hot-spot style of volcanism is one of the fundamental types of volcanism that has occurred throughout geologic time as the Earth has evolved. The Yellowstone hot-spot track is one of the few hot-spot tracks that occur on the continents; most, such as the Hawaiian hot-spot track, are in the ocean basins. The Yellowstone hot-spot track, in contrast, occurs in a readily accessible part of the Earth’s surface. Since it currently is active, the Snake River Plain-Yellowstone region constitutes the best region on Earth where geologists can develop an
understanding of how drifting continents and hot spots interact to yield enormous amounts of volcanism within geologically short intervals of time. Because of the volcanic rock exposures in the deep canyons of southwest Idaho, the Owyhee Plateau is the best place within the Yellowstone hot-spot track in which to see down into the rocks units that were formed. In the eastern part of the Snake River Plain and in the Yellowstone Park region, erosion of an extensive canyon system has yet to occur, so our view in those regions is much more limited. For those regions, we need to infer conditions at depth from the observations that can be made in the canyons cutting Owyhee Plateau.

The Canyons: Their Origin and the Rocks Revealed in their Walls

A wide valley, the western Snake River Plain, extends northwestward from the central part of the Yellowstone hot-spot track. This valley is a graben, a fault-bounded, down-dropped portion of the Earth's surface, which developed while the hot-spot track formed. The down-dropping of the Earth's surface in the western Snake River Plain graben created a topographic basin that held a large lake system for much of the time since the Miocene epoch. Geologists generally refer to this prehistoric, long-lived lake system as Lake Idaho. Extensive lake sediments that occur in the western Snake River Plain indicate that this lake, although it waxed and waned in depth, was large. When at its high-stand it had an area at least as great as present-day Lake Ontario. About the end of the Pliocene epoch Lake Idaho drained away permanently, as Hells Canyon of the Snake River was eroded deeper and deeper, eliminating the outlet barrier to the lake. During the draining-away phase of Lake Idaho's existence, its level dropped by at least a thousand feet.

The precipitous lowering of Lake Idaho's level caused all of the rivers and streams that were draining into the lake to start eroding downwards. The rivers on the southwestern margin of the lake, such as the Bruneau River, have cut deep, narrow canyons into the volcanic layers that underlie the Owyhee Plateau. These canyons are similar in depth to the amount of lowering of the surface of Lake Idaho that occurred. This incision of the pre-existing rivers and streams on the southern side of Lake Idaho into the volcanic plateau as the lake drained away is the fundamental reason that the canyons of the Bruneau-Jarbridge river system exist. The same can be said for the canyons of the Salmon Falls Creek system, the Owyhee River system, the Jacks Creek system, and many other canyons that formed on streams that drained into Lake Idaho.

Three main groups of volcanic rocks, basalt lavas, rhyolite lava flows and rhyolitic welded tuffs, are exposed in the canyon walls of the Bruneau-Jarbridge River system. The youngest group is basalt lava flows that mainly were erupted from the numerous low-profile shield volcanoes scattered about the Owyhee Plateau. These basalt flows are thickest and most conspicuous in the northern segment of Bruneau Canyon, where they comprise the entire depth of the canyon. Lying beneath the basalt, and constituting the middle stretches of the canyon system, are a series of extraordinarily thick and voluminous rhyolite lava flows that erupted passively from fissures now buried beneath the plateau. Rhyolite is formed when magma is erupted onto the Earth's surface, and has the same composition as granite, its deep-seated equivalent. Exposed in the southern reaches of the canyon system are a series of welded-tuff layers of rhyolitic composition, the Cougar Point Tuff, which are older than the rhyolite lava flows. Tuffs are formed by the aggregation of small particles that are created during explosive eruptions. When such aggregation occurs at a high temperature the individual particles become merged, or welded together, with one another to form the type of hard rock known as welded tuff. On the other hand, if such volcanic particles are cool, such as commonly is the case if they are transported long
distances from their sources by atmospheric winds, they accumulate to form layers of loose, non-welded tuff.

The Bruneau-Jarbidge Eruptive Center and the Cougar Point Tuff

During the last several million years a series of large volcanic centers, each several tens of miles across, were active, first erupting a series of welded tuffs, then a succession of rhyolite lava flows. In southwest Idaho, these are the Owyhee-Humboldt eruptive center, the Bruneau-Jarbidge eruptive center, and the Twin Falls eruptive center. They were active in the order listed, as the focus of rhyolitic volcanism shifted from southwest to northeast, while North America moved over the Yellowstone hot spot. The Bruneau-Jarbidge eruptive center is the one from which the Cougar Point Tuff was erupted. This center was active from about 12.7 million years ago, when the first welded tuffs were formed, to about 8.1 million years ago, when the last of the rhyolite lava flows within it was erupted. The Owyhee-Humboldt center was active earlier and the Twin Falls center formed later. Even later, additional centers of voluminous rhyolitic volcanism formed in the eastern Snake River Plain and Yellowstone areas.

The Cougar Point Tuff is a series of ten or more, welded-tuff layers, or units, that dip gently northward. They can be best seen in the East and West Forks of Jarbidge Canyon, and in the West Fork of Bruneau Canyon. The Cougar Point Tuff units were erupted explosively from a region that underlies much of eastern Owyhee County. Each of the Cougar Point units is the product of a separate set of eruptions, and these sets were separated by many thousands of years, as indicated by the development of thin intervening sediment layers. This region where these explosive eruptions occurred has been named the Bruneau-Jarbidge eruptive center. This center is a structural basin that is elliptical in outline and measures about 59 by 34 miles. Its eastern and northern boundaries are covered by younger volcanic rocks and are imprecisely known; but its western and southern boundaries are traceable as a series of faults that down-dropped the interior of the basin. A large depression formed during the one or two million years when the Cougar Point Tuff eruptions were occurring, but it has since been filled by lava flows and sediments. The depression had developed as a gigantic collapsed crater because of the hundreds, or even thousands, of cubic miles of volcanic rock that were erupted from beneath the region. The Bruneau-Jarbidge eruptive center can be described as a complex of calderas, rather than a single caldera. Its size is larger than almost any other caldera complex known on Earth, with the notable exception of some of the other eruptive centers within the Yellowstone hot-spot track.

Each Cougar Point Tuff layer was produced from a separate eruption that probably came out of long, now-buried fissures. Each of these violent events consisted of an enormous, prolonged explosion similar to that in the 1980 Mount Saint Helens eruption, but on a scale immensely larger. In view of the Cougar Point Tuff’s much greater volume, each eruption was hundreds of times more destructive than the Mount Saint Helens event. Each Cougar Point Tuff eruption blew tens to perhaps hundreds of cubic miles of red-hot ash high into the atmosphere, perhaps higher than 20 miles. When these columns of fiery material collapsed and fell back to earth it was much like an avalanche, and the ash cloud picked up incredible speed. The incandescent, hot-ash cloud, or ash flow, spread across the land surface away from the source area at tens, or even hundreds, of miles per hour. The ash was still so hot when it came to rest that the individual particles welded themselves together to form the solid rock layers that we can see now. The set of eruptions that formed each of the Cougar Point Tuff units probably lasted for weeks, if not longer. Each of the Cougar Point eruptions is tens to hundreds of times larger than any volcanic eruptions that have ever been witnessed by man. These eruptions would have buried hundreds to thousands of square miles, killing all life in that zone. The largest of the
Cougar Point Tuff units may have volumes of a few hundreds of cubic miles; consequently they are among the largest welded-tuff units on Earth known to have formed from single eruptions.

In addition to forming the welded tuffs, the large explosive eruptions from the Bruneau-Jarbridge center produced huge volumes of fine volcanic ash that was spread by atmospheric currents around the globe, and especially downwind to the central part of North America. These eruptions would have had a major impact on the Earth’s climate for many years, and they would have had a major impact on all life where substantial amounts of ash fell. During the last couple of decades evidence for this has been found in eastern Nebraska, more than a thousand miles from southwestern Idaho. At Ashfall State Historic Park, in northeastern Nebraska, an impressive find of mammalian fossils, especially of Miocene rhinoceroses, has been excavated. These animals were killed by a massive ash fall. Considerable scientific evidence suggests that the ash in these Nebraska deposits was blown by winds from eruptions in the Bruneau-Jarbridge center. More details of the relationship between the mammal kill site in Nebraska and the massive rhyolite eruptions in the Bruneau-Jarbridge center in southwestern Idaho were recently presented in a BBC film documentary, entitled "Supervolcanoes", which was released in 2000.

The Giant Rhyolite Lava Flows

Imagine an enormous blob of molten lava, hundreds of feet thick, oozing outward in all directions and rolling over everything until it had buried an area large enough to include Boise, Nampa and Caldwell. This volcanic scene was played out again and again in southwestern Idaho during the last few million years when gigantic rhyolite lava flows erupted from fissures and spread across the land. Nowhere is the evidence for such events more vividly displayed than in Bruneau and Jarbridge Canyons. During eruption, a rhyolite lava flow resembles an expanding pancake just after being poured onto a griddle. It is molten in the middle but is becoming solid on the top, bottom, and margins. Prongs periodically push out here and there through the edges as magma is pumped into the flow from underneath. The last-formed prongs are preserved at the margins of the flow as irregular lobes separated by zones of volcanic rubble. These lavas must have moved slowly, perhaps at only a few feet per day. Because the rhyolite lava was so stiff, it did not form thin flows and did not travel more than a few miles before it had cooled enough to stop, in contrast to basalt lava that is much more fluid and that commonly flows many tens of miles.

Three distinct vertical zones occur in the southwestern Idaho rhyolite lava flows. These are a rapidly cooled, commonly glassy, basal zone, a thick central zone of massive crystalline rhyolite, and a variably complicated upper zone. The interior parts of the flows typically are 300 feet thick, or more. Flow margins contain bulbous lobes of massive rhyolite lying on fragmental basal layers and separated by chaotic-looking zones of jointed or fragmented rhyolite. The flows thin toward their margins, but few become less than 200 feet thick there. The marginal zones typically are up to a mile wide and grade into the flow interiors as the amount of structurally complex rhyolite between adjacent lobes diminishes. Many interesting and instructive, but poorly understood, types of small-scale structures occur in the rhyolite lava flows.

Several gigantic rhyolite lava flows are beautifully exposed in the walls of Bruneau and Jarbridge Canyons. In Jarbridge canyon the largest and most widespread rhyolite lava flow is the Dorsey Creek flow. It is about 8.1 million years old and extends 26 miles in the canyon walls. This flow contains at least 18 cubic miles of lava rock and is more than 650 feet thick in the middle. The Sheep Creek flow is the largest rhyolite lava flow in the Bruneau-Jarbridge area. Containing at least 48 cubic miles of lava, it covers more than 300 square miles and is nearly 800
feet thick in Bruneau Canyon. It was erupted about 9.9 million years ago. The Bruneau River has sliced a sheer-walled gorge through the Sheep Creek rhyolite lava flow for a distance of about 24 miles. In addition to the Dorsey Creek and Sheep Creek lava flows, many other rhyolite lava flows have been identified in southwestern Idaho, and adjacent parts of Oregon and Nevada.

Prior to about 1980 very few geologists in the world realized that enormous rhyolite lava flows existed. In fact, it was widely held that large masses of rhyolite, like those exposed in the southwestern Idaho canyons, were thick sequences of welded tuff that had been formed by explosive eruptions. Many reasons for this belief had been expressed in the geologic literature. However, based on geologic investigations in the canyons of the Bruneau and Jarbridge Rivers, where the large cliff exposures and lack of alteration or deformation make the geologic relations very clear, a better interpretation emerged. There, it was shown that the rhyolite was truly formed from passively-emplaced lava flows, rather than from explosively-emplaced welded-tuff accumulations. Furthermore, since both rhyolite lava flows and welded tuff layers occur in the southwestern Idaho canyons, it has been possible to establish scientific criteria by which to distinguish between these alternate origins for large masses of rhyolite. The development of this knowledge truly was a scientific revolution, as regards the origin and possible modes of emplacement for rhyolite. In these ways the geologic interpretations gleaned from the volcanic phenomena so well exposed in the southwestern Idaho canyons have been very helpful worldwide in interpreting the modes of emplacement of rhyolitic rocks. Thus, the rhyolitic rocks are type examples of these contrasting styles of volcanism, and have gained worldwide importance in this regard.

Conclusions

1. The canyons of Owyhee County and vicinity owe their existence to the draining of Lake Idaho and deep incision of already existing streams in the past few million years, as both the lake level and stream base level dropped a thousand feet or more.

2. The principal rocks exposed in Bruneau and Jarbridge Canyons are basalt flows, passively-erupted rhyolite lava flows, and explosively-erupted welded tuffs that formed from large to enormous eruptions that had a major, worldwide impact.

3. The volcanic rocks exposed in the canyons of southwestern Idaho are unique and offer geologists a wonderful laboratory where a better fundamental understanding can be obtained of how the Earth processes operate.
INTRODUCTION

This paper discusses the large-scale landforms of the Owyhee-Bruneau canyonlands. Geomorphology encompasses surficial deposits, soils, and imprint of events of the late Quaternary (the last ice ages), but for brevity these will only be mentioned and referenced to other studies of the region.

The Owyhee-Bruneau canyonlands lie just north of the extended and block faulted region of the Basin-Range geologic province of western North America. In comparison to the mountainous Basin-Range, the canyonlands are relatively-flat plateaus dissected by spectacular canyons into volcanic

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Figure 1. Shaded-relief physiography of the northern Basin-Range region and the Owyhee-Bruneau canyonlands of Idaho. Map shows the relatively smooth plateaus of the Owyhee region of southwestern Idaho and adjacent Oregon and Nevada at the northern extent of block-faulted mountains of the Basin-Range. Base map from Thelin and Pike (1991)
rocks. The Basin-Range is expressed by a pattern of regularly-spaced, north-and-north-northeast trending, block-faulted mountains. On a physiographic map the Basin-Range region has the appearance of ragged corduroy cloth, or to some folks, an army of caterpillars crawling northward. For curious reasons this pattern comes to a halt near the Idaho border (Figure 1). The north side of the Owyhee canyonland region is bounded by the western Snake River Plain, a great rift in the North American continent that started founndering about 11 million years ago. The resulting basin became great Lake Idaho, a lake the size of modern Lake Ontario. Many geologic events and the spectacular mountain and canyon scenery of this region owe their existence to the migration of the Yellowstone hot spot. The hot spot torched its way to the surface of the earth for the first time, near the present borders of Oregon, Idaho and Nevada, about 17.5 million years ago (Pierce and Morgan, 1992). Many of our ideas on hot spots are new and controversial, and we are just beginning to understand how this part of the earth works.

THE OYHEE PLATEAU

The relatively smooth topography of the Owyhee plateau region coincides remarkably with eruptive centers of rhyolite magma associated with the migrating “Yellowstone hot spot”. On Figure 1, two plateau regions are outlined that coincide with eruptive centers. These two plateau regions are similarly about 5,300 feet in elevation, and are surrounded by 6,500-foot mountains and some reaching above 8,000 feet. Bill Bonnielsen (1982) recognized the Bruneau-Jarbridge region as a rhyolite eruptive center and a broad basin which subsided and filled with rhyolite lavas over the interval 12.5 to 8 million years ago. Following the rhyolite, basalts erupted onto the basin, and the fluidity of these basalt lavas allowed them to flow and spread giving the relatively smooth surface we see today.

A similar origin of the low-plateau topography of the “Owyhee-Humbolt plateau” was suggested to me by Curtis Manley. This was a region that saw rhyolite eruptive activity earlier than the Bruneau-Jarbridge region. Ages of major rhyolite eruptives in this region are about 14 million years, and the subsequent basin was similarly covered by younger basalt flows (Manley, these proceedings).

Why are these regions not faulted into basin-range mountains? Malde (1991) suggested that this region resisted faulting because it is underlain by a large and strong remnant of the Idaho batholith. However, coincidence with rhyolite eruptive centers may be a better explanation. When magma invades the deep crust beneath regions of the crust that are extending, the block faulting characteristic of extending regions does not occur (Parsons and Thompson, 1991). This was first appreciated in the eastern Snake River Plain where block-faulted mountains occur on both sides of the plain, but within the plain are many aligned basalt volcanic rift zones, such as Craters of Moon and the Great Rift, that seem to replace the mountains (Parsons and others, 1998). The area of eastern-plain volcanism is also a subsiding lowland, subsiding not along faulted margins, but as a sag, or downwarp. Thus, the migrating hot-spot has significantly altered the crust and the brittle-faulting characteristics along its path, and it leaves basins in its track.

THE OYHEE MOUNTAINS

The Owyhee Mountains are an irregular northwest trending range with a steep northeast side bordering the western Snake River Plain. The northeast side was produced by downwarping and faulting as the western plain subsided. However, the range stands high along the edge of the plain, Cinnabar Mountain is 8,403 ft high. Continental rifts such as the western plain are commonly flanked by ranges, attributed to a poorly understood process of rift-flank uplift. Rocks of the Owyhee Mountains are diverse, but we are fortunate to have a reconnaissance geologic map of the area published by Ekren and others (1981). Granite rocks associated with the Idaho batholith core the mountains, and a pendant of older metamorphosed sediments makes up South Mountain, a mineralized area. Flows and intrusive dikes associated with the Eocene Challis volcanism occur in the upper Poison Creek area. A lone occurrence of Oligocene volcanic rocks in the Salmon Creek area has been a subject of research on changing magma types related to plate tectonics in the western U.S (Norman and Leeman, 1989, 1990).
Figure 2. Shaded-relief map showing young faults and older fault patterns in southwest Idaho. Numerous young faults in basalt trending N 70°W are parallel to the fault of Halfway Gulch shown to be active by Beukelman (1998). Prominent landforms are the N 20°W trending Grasmere fault on the west edge of the Bruneau-Jarbidge plateau, and many parallel faults trending through Duck Valley. Just west of South Mountain is a group of N 35°W trending faults cutting 14 million year old rhyolite. Map was produced by Amy Haak, Spatial Dynamics, Inc., Boise, from the 30-meter digital elevation model data.
Figure 3. Outline of Lake Idaho inferred from distribution of lake deposits around the margins of the western Snake River Plain (from Wood, 1994). The lake overtopped the spill point into Hells Canyon at some time between 4.5 and 2 million years ago. Paleontological studies suggest the lake, at one time, had a connection with the Klamath River drainage (Smith and others, 1982).

In the Silver City area are several rhyolite domes about 15 million years old, and this period of volcanism is thought to be the age of much of the precious metal mineralization in the range (Panzse, 1975). About 14 million years ago, rhyolite erupted from the Juniper Mountain area, and the lobate forms of these flows are still partly preserved in the topography of the area (Manley, 1995; 1999, Ekren and others, 1984). About 11 million years ago rhyolite began erupting along what is now the northwest edge of the Owyhee Mountains producing the Jump Creek rhyolite flows and several smaller but distinctive flows. This is a rhyolite center different than the Bruneau-Jarbidge center, possibly related to the early fracturing that formed the western plain graben (Bill Bonnichsen, personal communication, 2000). By 9 million years, the basin of the western plain had formed, and lake deposits were accumulating in the basin and along the northeast side of the Owyhee Range. However, at least one rhyolite eruption occurred beneath the lake, and its record is preserved as a layer of giant pumice blocks in Chalk Hill Formation sediments south of Marsing (Wood and Wood, 1999).

THE WESTERN SNAKE RIVER PLAIN
In contrast with the eastern plain, the western plain is not along the track of the hot spot. It is a true graben, meaning that it is a normal-fault bounded basin. Some of its depth is also produced by downwarping, which is displayed as the tilting of sedimentary and volcanic rocks down toward the center of the plain. Clemens (1991) showed that much of the north-west-trending faulting to produce the basin and the relief of the surrounding mountains occurred between 11 and 9 million years. However, Beukelman (1998) shows that faulting is still active in the vicinity of Halfway Gulch (Figure 3), where a 7.7-meter scarp cuts alluvial fan deposits. Trench study of an associated fault
shows 5 earthquake events over the last 26,000 years (estimated time from soil carbonate development).

The basin filled with a great lake referred to as Lake Idaho (Figure 3). The lake deposits are well exposed along the Owyhee Mountains, and the sedimentary layers contain a fascinating history of the last 9 million years of geologic history of this region (Smith and others, 1982, and Smith, this symposium, Kimmel, 1982; Wood and Clemens, in press). Much more is to be learned from these deposits as new techniques and scientific instrumentation develop in the future. The deposits may contain a history of climate change that led to the beginning of the ice ages about 2 million years ago.

Chronology of the deposits and lake history is still uncertain. The disagreements in the literature are mostly over the timing of events, but the following history is my present understanding. The lake filled and then for reasons poorly understood, the lake receded about 6 million years ago. About 4.5 million years ago it filled again, this time to the spillover elevation and flowed into ancestral Hells Canyon (Repenning and others, 1994; Wood and Clemens, in press). Since then, the lake basin slowly filled with sediment and cut down the outlet elevation, and by 1.6 million years ago, rivers flowed across the plain to the outlet near Weiser. About 2 million years ago, basalt volcanism spread lavas over the lake and river deposits of the western plain (Bonnichsen and others, 1997). The river has now incised about 300 feet into the lake deposits.

THE CANYONS

The steep and colorful canyons of the Owyhee, Bruneau, and Jarbridge Rivers are cut about 1000 feet into volcanic rocks of the plateau country. It is tempting to tie the history of cutting these canyons to the lowering of the Snake River into which they are tributary. Wood and Clemens (in press) believe that the Snake River lowered its outlet and deepened Hells Canyon at an average rate of 120 meters (400 feet) per million years, over the past 4 million years. The response of the tributary rivers to this lowering of base level, and the importance of bedrock knickpoints (bedrock rapids and waterfalls) has yet to be studied.

SURFICIAL FEATURES OF QUATERNARY AGE

Climate was considerably colder and wetter during the cold periods of the ice ages (We are presently in a 11,000 year long interglacial pause, but still within what is generally considered the ice age). The highest Owyhee Mountains were glaciated in the ice ages* (Piper and Laney, 1926). Cirque-like cliffs are on Turntable Mountain (8,122 ft) and Hayden Peak (8,403 ft) of Cinnabar Mountain. It appears that moraine-like forms may have extended down to about 6,800 ft, but the glacial forms and deposits have not been mapped. Periglacial features and effects of perennial snowbanks of the former glacial periods are no doubt also present. The Jarbridge Mountains (10,800 ft.) in Nevada were more extensively glaciated, and the glacial deposits of three distinct stages identified, but not studied in detail by Coats (1964).

Stone stripes, stone polygons, and rock streams occur in many areas of the region. They have been attributed to colder periglacial conditions of the past, but their origins are still controversial (Malde, 1964; Fosberg, 1965, McIntyre, 1972). Much of the silt component of the thicker soils of Owyhees accumulated from the settling of wind-blow dust, but the history of these important wind-blow-silt soils (loess) in southwestern Idaho has not been studied, although Pierce and others (1982) show that the loess soils of southeastern Idaho accumulated over the past several hundred thousand years. Superposed on the soils are the formation of soil clay horizons and carbonate soil horizons with a complicated history (Blank and others, 1998).

As erosion proceeded in the Owyhee Mountains and plateau regions, the eroded debris accumulated at the foot of mountains as alluvial fans. Several dissected older fan surfaces are preserved as gravel capped mesas along the northeast side of the Owyhee Mountains, and fan deposits are accumulating elsewhere at the present time.

Many young landform features of the relief of the region are beautifully displayed on the map just produced by Amy Haak (Figure 3), and we have not even begun to study all the new fault patterns,
depositional and volcanic features that this display of the 30-meter digital elevation data set has portrayed.

About 14,500 years ago, a truly unique catastrophe occurred in the canyon of the present Snake River. The Pleistocene Great Salt Lake (known to geologists as Lake Bonneville) rose to a spill point at Red Rock Pass, south of Pocatello (Malde, 1968; Jarrett and Malde, 1987). The spill point was soft rock, and over a period estimated to be less than one year, the spillover water cut down and drained 400 vertical feet of water from the lake. Flow through the Snake River canyon was about that of the Amazon River for nearly a year (O’Conner, 1993). The floodwater was 300 feet up the canyon walls of Swan Falls gorge, and 250 ft above the present river at Walters Ferry, and about 200 feet deep over Marshing, as is spread out in the broader river valley below the gorge. The flood did not break out of the Snake River canyon, but it did leave a group of unique giant boulder bars and “melon gravels” as deposits along the river canyon (O’Conner, 1993).

*note: I thank Mary N. O’Malley for pointing out to me that that earlier workers determined that the highest Owyhee Mountains were glaciated. In my talk I incorrectly asserted that they were not glaciated.

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The Great Basin Population, Owyhee subpopulation of
THE COLUMBIA SPOTTED FROG
(Rana luteiventris)

Janice Engle

Columbia spotted frogs are considered stable within the Northern population (#1) of the species’ range from Alaska to Wyoming, but the three disjunct populations in the southern and western part of their range (#2. Wasatch Front and #3. West Desert in Utah; #4. Great Basin in Nevada, southwestern Idaho, and southeastern Oregon) are either severely declining, nearly extirpated, or faced with significant threats (Gomez 1994). The Great Basin population (#4), which contains the Owyhee subpopulation, and the other two southern populations (#2 and #3), were elevated to USFWS “candidate” status (for listing as Threatened or Endangered) in 1993 based on the loss of subpopulations in a number of areas of Nevada (Turner 1993). The Northern population (#1) and the Wasatch Front population (#2) are found in wetter, montane habitats. The West Desert (#3) and Great Basin (#4) populations, however, are found in habitat that is characterized as shrub-steppe. Water sources are separated by large expanses of arid matrix and spotted frogs are limited to movement within watersheds and along riparian corridors (Engle and Munger 2000). In all three of the southern populations, extensive loss of habitat has occurred from conversion of wetland habitats to irrigated pasture and dewatering of river areas by irrigation practices; in addition, there has been extensive impacts on riparian habitats primarily due to livestock grazing (Gomez 1994).

During the past ten years, concern about global amphibian declines has reached an all-time high. Many studies have been initiated to determine if and why populations are declining (e.g., Blaustein 1990; Phillips 1990; Wake 1991). Amphibians are potentially sensitive indicators of environmental change (Wake and Morowitz 1990) and they often make up a significant amount of a system’s biomass, both as predators and prey (Peterson et al. 1992). Thus, the need to understand their biology, their habitat requirements, and impacts of current management activities has become increasingly important.

Similar in size to the leopard frog (2-4 inches), the Columbia spotted frog is light to dark brown or olive above with varying numbers of dark spots on its back. There is a light-colored jaw stripe, and the underside can be yellow, orange, or white with or without mottling. Coloring on young is less distinct. Adult males have swollen and darkened thumb bases. The dorsolateral folds found on leopard frogs are also conspicuous on spotted frogs. Spotted frogs are usually found near permanent water such as marshy edges of ponds or lakes, in algae-filled overflow
pools of streams, spring complexes, or in wet areas of emergent vegetation. After breeding, they may move considerable distances to new foraging areas including seeps, moist meadows, small pools, or other areas of permanent water (Gomez 1994).

Four habitat components are necessary for spotted frog persistence: (1) hibernation sites protected from disturbance and freezing, but near suitable breeding areas; (2) shallow, slack water for breeding that maintains a constant level at least until eggs develop (with a connection to deeper water that persists until tadpoles transform); (3) foraging areas rich in insects with vegetative protection from predators; and (4) safe, wet corridors to travel between the first three. In the Owyhee Mountains, spotted frogs have not been observed outside of riparian areas (Engle and Munger 2000).

Spotted frog hibernacula can be holes near springs or other areas where water remains unfrozen and oxygenated. Historically in the Owyhees, spotted frogs probably utilized habitat created by beaver, but presently they have been observed overwintering at springs (and improved springs) in the soft, muddy substrate under willows and banks.

Breeding occurs in a short burst in April or May (depending on the thawing of breeding sites) frequently in an area immediately adjacent to the hibernaculum. Males emerge from hibernation first and calling groups of up to 20 individuals have been observed in the Owyhees. Within a week, egg masses are laid in communal clusters in shallow water (less than 30 cm), usually on the northeast side of ponds, in backwash areas of streams, or in oxbow pools. Some individuals then leave the overwintering and breeding sites to forage in wet meadows and travel along riparian corridors, while others stay at the breeding site all year. In late May and early June, capture numbers peak and locations are most widespread. Garter snakes (Thamnophis elegans) are commonly observed feeding on tadpoles and subadults. In late summer, suitable habitat is reduced from wide, wet meadows to spring complexes and permanent streams, with a sharp reduction in captures in August and September. Although a few metamorphs have been observed on the ice at ponds that serve as hibernation sites, no adults have been observed active after October, but some late season movement has been detected by identifying individuals found in the substrate of a hibernaculum.

In order to assess the long-term health of the Owyhee subpopulation, increased monitoring efforts were needed to determine the interconnectedness between occurrences (Koch et al. 1997). Beginning in 1997, survey efforts focused on studying movements of individuals throughout the Rock Creek drainage and developing a baseline inventory (Engle and Munger 1998). While this four-year survey identified over 40 breeding sites, several potential hibernacula, and PIT-tagged 2094 individuals, all movements observed were limited to within watersheds and along wet corridors (Engle and Munger 2000). Most frog movements detected were within 200m of their original capture location. It appeared that there was little or no connectivity between the 49 isolated occurrences, and the Owyhee subpopulation of spotted frogs could be considered a “metapopulation”.

Levins (1970) metapopulation model, developed to determine the level of stability of a system that was discontinuous, led to the realization that “hope for future perpetuation of many species rested upon maintaining many habitat patches and having animals disperse among them” (McCullough 1996). If the rate of recolonization exceeds the rate of extinction of isolated habitat patches, then a discontinuous population can persist over time. So, not only is it necessary for individuals to be able to occasionally move over the inhospitable matrix between suitable habitat, but it is also necessary that many suitable habitat patches are available for
successful dispersers to recolonize. Thus the paradox that we face today for spotted frogs in the Owyhees is the challenge of maintaining numerous suitable habitat patches and facilitating movement between these discrete patches while continuing land use practices that do not provide the conditions needed for widespread movement to occur.

To conserve populations with small numbers of individuals, it is increasingly important to determine the extent to which an adequate network exists to maintain the genetic integrity necessary to facilitate persistence over time. For species where individual movement ranges are limited, the colonization rate of empty patches has been typically found to decrease with increasing isolation (Hanski 1999). By accurately determining the distribution of individuals, the extent of their movements (and barriers to them), and the associations in demographic rates between subunits, we can develop a plan to facilitate conservation and management of a species.

Our work identified the distribution of spotted frogs and analyzed the movement patterns we observed. While one juvenile frog did travel 6.5 km downstream, that distance was the exception and not the rule. Females frequently traveled further than males and many frogs migrated seasonally between foraging, overwintering and breeding sites. Only one individual (the same juvenile mentioned above) out of 631 recaptures was observed to successfully travel between two occurrences. Barriers to movement were observed to be upland habitat, ephemeral stretches when dry, heavily grazed areas, canyons, reservoirs stocked with non-native fish, and severely eroded gullies. Because the barriers to frog movement in the Owyhees limit the potential for individual frogs to move between occurrences, it does not appear that an adequate network of connectivity exists to facilitate spotted frog persistence over time. According to Levins’ (1970) model, the system would not be considered stable; the rate of recolonization does not exceed the rate of extinction of isolated patches. The barriers that exist fragment the spotted frog distribution and current land use practices increase the isolation distances, decreasing the potential for movement between occurrences. The ideal goal is to avoid anthropogenic creation of fragmented habitat; but if it is inevitable, we need to manage for conditions favorable to metapopulation persistence (McCullough, 1996).

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WESTERN Owyhee Volcanism:
Big lavas, big disagreements

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The geological uniqueness of the Owyhee Plateau is due its wide range of volcanic rocks, their excellent preservation and exposure, and their scientific importance in teaching us about the plumbing of large volcanoes, the tracks of hot spots, and the behavior of voluminous lava flows.

A bit of background for those who are not geologists: Lava isn't all the same. It has a range of composition, and this controls its physical properties and thus its behavior. Basalt lava, such as that in Hawai’i and at Craters Of The Moon National Monument, has a low viscosity and tends to erupt by fire-fountaining, in which molten clasts of lava are thrown high into the air. The clasts are hot enough when they land that they weld together into a cone or ridge of spatter, or they may recombine into a liquid to form a "secondary" lava flow. Basalt lava flows can range in size up to huge sheets hundreds of miles in length that cover thousands of square miles. It has long been known that Washington state's Columbia Plateau is underlain huge "flood basalt" lava flows.

Rhyolite lava is richer in silica, and this makes it more viscous; it also tends to be cooler than basalt. The high viscosity of rhyolite often prevents steam from escaping gently, so violent eruptions where steam explodes the lava into volcanic "ash", are common. If the steam can escape quiescently before the magma comes out of the vent onto the surface of the Earth, a lava flow or lava dome can form. The high viscosity of rhyolite lava has in the past been erroneously cited as precluding the existence of extensive rhyolite lava flows, but over the past 20 years voluminous rhyolite lavas have been documented in SW Idaho and around the world.

The rhyolitic volcanic rocks of the Owyhee Plateau have played an important role in volcanologists' understanding of large lava flows and voluminous eruptions. In the 1980s, rock units in the Bruneau-Jarbridge (Eastern) portion of the Owyhee Plateau were unequivocally described by Bill Bonnichsen as large lava flows. But similar units in the Owyhee River (Western) portion of the Plateau, mapped by other geologists, were described as having erupted as ash-flows (huge clouds of hot volcanic ash spreading in all directions from the vent) that then welded themselves into dense rock units that mimicked lava flows. Whether a great volume of magma erupts (slowly) as a lava flow or (nearly instantaneously) as an ash-flow has important implications for how the magma was formed, the amount of water dissolved in it, the size of the magma chamber, and how the eruption proceeded. My field work in and around the canyons of the Owyhee River was intended to answer questions such as these and to determine which units were lava flows and which had erupted as ash-flows. I found that the area was a marvelous and stunning natural laboratory for studying these topics. The variety of volcanic units is even greater than that in Yellowstone National Park, and the exposures of the units are nearly unsurpassed.

THE SNAKE RIVER PLAIN

The Snake River Plain (SRP) trend of rhyolitic volcanism from southeastern Oregon (about 17.5 million years ago) to Yellowstone National Park (2 million years to present) reflects movement of the North American tectonic plate over an essentially fixed hot spot beneath the crust. Except for Yellowstone, most of the siliceous volcanic rocks along the eastern part of the SRP have been buried by sediments and basaltic lava flows. In SW Idaho, the higher elevation led to the erosion of deep river canyons that expose rhyolitic volcanic units in the Bruneau-Jarbridge
eruptive center (active from 12 - 9 million years ago), and in the Juniper Mtn. volcanic center (JMVC; active from 14.5 - 13.7 million years ago). Juniper Mtn. itself is the sole constructional volcano that rises above a large, flat, poorly-explored area that reaches into Nevada.

Ekren and others (1981, 1984) highlighted the geology of the Juniper Mtn. region, but since they mapped at a reconnaissance level, they interpreted all the rhyolites as densely-welded ash-flow tuff deposits (ignimbrites) and not lava flows. The otherwise ubiquitous presence of physical features and textures indicative of lava flows were cited as evidence that most ash-flow textures had been destroyed during welding. The publications of Ekren and his co-authors were both controversial and influential, but because of the area's remoteness few other geologists visited to see the units themselves.

In my own work, which I began in 1989, I recognized previously unmapped units and reinterpreted several units described earlier by Ekren and others (1981, 1984). Here I present a current overview of the volcanic history of the area in and around the Owyhee canyons, based on published and unpublished mapping and seventeen new $^{40}$Ar/$^{39}$Ar dates on rhyolitic units.

**MAGMATISM OF THE JUNIPER MOUNTAIN VOLCANIC CENTER**

The general history of the greater Juniper Mtn. magmatic system can be summarized as follows: Between 14.5 and 14.1 million years ago, low-silica (69 to 74 weight % $\text{SiO}_2$) rhyolite magmas erupted as voluminous lava flows and possibly ash-flows over a large area of southwestern Idaho, southeastern Oregon, and northern Nevada. Over the next 600,000 years, magma compositions evolved to 78 wt. % $\text{SiO}_2$, erupted volumes and magmatic temperatures both decreased, and eruptive mode was solely extrusion of lava, which formed voluminous rhyolite lava flows. Heat input into the deep magmatic system was apparently declining, leading to crystallization and differentiation; the compositions of dated samples imply the existence of a single large magma reservoir erupting at a rate lower than its rate of crystallization.

Volcanism had nearly ceased by about 13.8 million years ago, when two or three uncommon fountain-fed rhyolites erupted on and near Juniper Mtn., followed at 13.7 million years by the large Badlands Lava Flow, which shows evidence its magma was partly derived by the melting of previously solidified rhyolite. It seems likely that a final pulse of hot basaltic magma into the base of the magmatic system caused the remelting of material crystallized on the magma chamber's walls, serving to temporarily rejuvenate the system. The Badlands Lava Flow was the last eruption near Juniper Mtn. Rhyolite volcanism then moved eastward, with the Buneau-Jarbridge area becoming the next major locus of activity along the Snake River Plain trend.

After rhyolite volcanism ended, the area south of Juniper Mtn. subsided, becoming a lowland that was then filled with lake sediments, gravels, and younger basalt lava flows. This burial served to nearly halt erosion until the Owyhee canyons cut their way upstream onto the Plateau. Cutting of the canyons and stream gullies has exposed the interior structure of the volcanic units while the delicate features of their outer portions have been relatively well preserved. The Owyhee Plateau was not glaciated and is much more sparsely vegetated than Yellowstone National Park, where Ice-Age glaciers both eroded and buried the volcanic units, and where dense forest cover hides significant geologic features. Nonetheless, due to only minimal canyon exposures in some areas, the dimensions and details of emplacement of many of the Owyhee rhyolitic units will remain unknown until future detailed mapping.

**OVERVIEW OF THE MAJOR ROCK UNITS NEAR JUNIPER MTN.**

edifice as composed of two units, with the lowermost one a broad, tabular bench they interpreted as an ash-flow tuff deposit. More recent mapping indicates that the lower unit is a single huge rhyolite lava flow with a volume of roughly 230 cubic km. Compositions, and new dates of 13.95 ± 0.06 and 13.89 ± 0.11 million years ago from samples 30 km apart, are consistent with the unit being a single lava flow.

**Upper Lobes Lava Flows** -- Ekren and his co-authors described the summit shield of Juniper Mtn. proper as composed of one or more ash-flow tuff deposits based solely on exposures on the southeastern flank of the mountain. The rocks on the southeastern flank are tuffaceous, but are a different unit (the Beaver Creek Tuff -- see below), Juniper Mtn. itself is actually a sequence of overlapping rhyolite lava flows or flow lobes. I have renamed the unit the Upper Lobes Lava Flows. Dates of 13.90 ± 0.05 and 13.83 ± 0.06 million years ago have been determined for samples at the base and summit of Juniper Mtn., respectively.

The **Beaver Creek Tuff** is a rhyolitic, welded fall unit formed by fire-fountaining on the southeastern flank of Juniper Mtn. It was the first clearly non-lava flow unit erupted from the Juniper Mtn. magma chamber, and has been dated at 13.82 ± 0.05 million years old.

The **lava flow of Rough Mtn.** is as yet undated and incompletely mapped. It overlies the Beaver Creek Tuff at that unit's highest point, assumed to be at or near its vent. The oxidized pink color of the rock, the extremely low pre-eruptive water content, and the unit's association with the Beaver Creek Tuff all suggest that the lava flow of Rough Mtn. is a secondary lava flow -- the product of a fire fountain eruption in which the clasts thrown from the vent recombine into liquid and flow away as a lava flow. While it is very common for basalt eruptions to form secondary lava flows in this way, rhyolite examples are extremely rare.

The **Carter Spring Rhyolite** consists of two contrasting eruptive units: an oval-shaped welded spatter ring formed by fire-fountaining, and an effusive lava flow largely confined to the interior of the ring; it has been dated at 13.89 ± 0.05 million years ago. The Carter Spring Rhyolite retains the original morphology of its welded tephra deposit, and so is better preserved and exposed than units of the Taylor Creek Rhyolite in western New Mexico, which is presently the best-known silicic fountain-fed unit on Earth.

The **Badlands Lava Flow** had an original volume of at least 15 cubic kilometers and erupted from a fissure 7 km long. The unit is both irregular and asymmetric, with large and small lobes that flowed as far as 9 km down-slope from the vent. Although the evidence that the unit is a lava flow is unequivocal, many samples of the lava's glassy top and base show microscopic fragmental textures created by comminution and welding of pumice from the brecciated carapace. Identical textures in outcrops of the other Juniper Mtn. rhyolites convinced Ekren and his co-authors that those units were ash-flows...

The exposed vent area of the Badlands Lava Flow is a beautiful, larger version of the vent areas of small lava flows. Initial explosive activity produced unwelded ridges of pumice and ash up to 60 m high. As the explosions subsided and lava extruded, the pumice ring was both covered and shoved out of the way. These pumice deposits are among the most geologically important outcrops in the Juniper Mtn. area and because of their small extent and friable nature are also the most susceptible to erosion and damage.

The vast majority of the Badlands Lava Flow is rich in large (up to 2.5 cm long), fractured
phenocrysts (crystals) that appear to represent the magma chamber's partially remelted and disrupted crystalline rind. A small portion of the Badlands Lava Flow has no crystals whatsoever and yields small nodules of high-quality obsidian that were utilized by prehistoric Native Americans. This is probably the only usable obsidian in all the huge expanse of the 14 million year old Owyhee units, and the only obsidian in SW Idaho south of the Owyhee peaks.

SILICIC FIRE-FOUNTAINING ON THE OYWYHEE PLATEAU

Fire fountaining is commonly considered an eruptive mode confined solely to basalts. Nevertheless, before my work in the Juniper Mtn. area, two or three fountain-fed silicic units had been well described in the geologic literature. Such units seemed to have erupted with lower than average amounts of water dissolved in their magmas. These low water contents would have led to the production of less fine ash than usual during an explosive eruption -- clasts would have been larger, would have been ejected ballistically from the vent, and would have remained hot enough to weld back together when they fell to the ground, forming a welded fall deposit.

The units in the Juniper Mtn. area that show physical evidence of fire-fountaining activity during their emplacement also have low eruptive water contents. The lava flow of Rough Mtn. apparently had the lowest H2O contents (averaging 0.76 weight percent) yet determined for any rhyolite. The fountain-fed rhyolites of Juniper Mtn. are better preserved and exposed than those in Yellowstone and New Mexico -- they are truly "world-class" units of their type. Their further physical and compositional study should provide valuable information on the significance of such eruptions wherever they have occurred. Future study will also help determine the overall dynamics of magmatism in the Juniper Mtn. area as well as in the greater Owyhee region.

REFERENCES & SOURCES


The Owyhee-Bruneau Canyonlands are a landscape that holds values that we would like to underscore in your establishment of the Monument. They include five categories of biological, cultural, paleontological, geological, and recreational values as following.

**Biological:**

* A nationally significant habitat for California bighorn sheep.
* Critical habitat for Idaho's largest population of antelope.
* Uplands are an immense "sagebrush ocean" that is an unfragmented core habitat for sagebrush-dependent wildlife.
* The last place in the Interior Columbia Basin where sage grouse are predicted to occur 100 years in the future. Numerous known sage grouse leks.
* Streams contain redband trout specifically adapted to harsh desert environments.
* Contains numerous centers of Biodiversity, Endemism, and Rarity including, 145-million acre shrub-steppe of the Interior Columbia Basin, hotspots in the Horse Hill-Sugar Valley, rare and endemic communities in the Succor Creek and Owyhee Front regions and in intermittent streams and playas.
* A unique ecoregion between the northern Great Basin and the Snake River Plain.
* Important habitat for species of special concern including, spotted bat, interior redband trout, Columbia spotted frog, Mojave collared lizard, loggerhead shrike.
* Has over 36 identified sagebrush communities - complex and varied.
* Extensive ancient juniper woodlands, including a National Park Service proposed Western Juniper National Natural Landmark.

**Cultural:**

* One of the richest cultural landscapes in the West, including National Register quality rock shelters, petroglyph panels, rock alignments, and historic cabins.
* Pole-Camas Creek Archaeological District - has over 500 sites, and is one of the largest archaeological districts in the West.
* Historical significance with cultural sites reaching back over 12,000 years.
* Importance in the culture of the Shoshone and Paiute Tribes of Duck Valley - A traditional homeland and sacred cultural landscape.
* Colorful western history and historical characters include:
  - Euro-American fur trappers (Donald MacKenzie, Peter Skene Ogden).
  - Basque immigrants, cattlemen, miners.
  - Snake Wars: military forays against Native Americans.
  - Late 19th century settlements such as Silver City, Wickahoney, Murphy Hot Springs.
  - "The Queen of Diamonds," Kittie Wilkins, a famous wide-ranging horse woman.

**Paleontological:**

* Lake Idaho Sediments contain the richest fish faunas known from western North America in both geological history and the modern record. These fossils are associated with dramatic volcanic rocks and unique lacustrine deposits.
* Fossils provide important insights into the evolution of spectacular flocks of mollusks, ostracods and sculpins, and important insights into evolution of western American char, trout, salmon, whitefish, minnows,
suckers, catfish, sunfish and sculpins, and record of the largest extinction of fishes known in the history of North America.
* Fossils include the large salmonid - "the saber-toothed salmon".
* Lake Idaho deposits are well-exposed along the Owyhee Mountains and contain a fascinating history of sculptured oolitic deposits.
* Birch Creek has rich mammalian floras spanning a large portion of the Pliocene, and significant fossil floras are found at Pickett Creek and Succor Creek.

**Geological:**
* History of the track of the Yellowstone hot spot as it moved from southeastern Oregon to Yellowstone National Park.
* Cutting of canyons has exposed the interior structure of the volcanic units while well preservation the delicate features of their outer units.
* Bruneau-Jarbridge has deep, narrow canyons (700 to 1300 feet) with exceptionally well-exposed volcanic rocks.
* Gigantic Bruneau-Jarbridge rhyolite flows, including the Dorsey Creek flow, and Sheep Creek flow (covers more than 300 square miles and is nearly 800 ft. thick).
* Bruneau-Jarbridge Cougar Point Tuff - Ten layers from separate eruptions. Each of these eruptions from the hot spot produced a mass of molten rock and ash 1000 times greater than the eruption of Mount Saint Helen's, blew tens to hundreds of cubic miles of red-hot ash high into the atmosphere, and then the incandescent hot ash clouds fell to earth and flowed at tens or even hundreds of miles per hour across the earth's surface in all directions. Each was larger than any eruption ever witnessed by man.
* Lake Idaho was located in lower elevations of the Owyhee Front. It was an inland lake as large as present-day Lake Ontario. At the end of the Pliocene, as Hells Canyon cut into the Snake River, Lake Idaho drained with a precipitous lowering of it's level by 1000 ft. This resulted in Lake Idaho's tributary rivers (Owyhee, Bruneau, Jacks Creek, others) incising their present-day spectacular deep, narrow canyons.
* The Owyhee-Bruneau canyonslands are the largest concentration of exposed rhyolite canyons in the world.
* Geologic interpretations gleaned from volcanic phenomena so well exposed in SW Idaho canyons have been helpful worldwide in interpreting modes of emplacement of rhyolitic rocks. The rhyolitic rocks here are Type Examples of contrasting styles of volcanism, and have gained worldwide importance.

**Recreation:**
* A maze of rivers and canyons offering world-class whitewater recreational opportunities.
* More than 700,000 acres of recognized BLM Wilderness Study Areas.
* Canyons with innumerable rock spires and pinnacles creating a myriad of fantastic formations known as "hoodoos".
* Sweeping scenic plateau vistas.
* Opportunities for solitude.
* Notable, charismatic wild horse herds.

Even as we identify the values of these lands there are threats. A few of them are the following.

**Threats:**
* Proximity to burgeoning population of SW Idaho
* Irresponsible Off-Road Vehicle Use
- Lack of administrative focus on ecosystem
- Invasion of weedy exotic plants (cheatgrass and others)
- Native species declines/habitat fragmentation
- Unwise livestock grazing/overuse of riparian areas/construction of livestock facilities
- Road expansion
- Vandalism/looting of cultural sites
- Fire and unwise fire rehab.
- Mining
- Lack of Baseline information and systematic studies
- Mixed land ownership/land use practices
Population Dynamics of California Bighorn Sheep in Owyhee County, Idaho

Dale E. Toweill

Introduction

Wild sheep apparently evolved in Asia within the past two million years. Although the fossil record is scanty, it appears that populations of wild sheep entered North America across Beringia during the great Ice Ages of the Pleistocene (Toweill and Geist 1999). Early populations of wild sheep were forced southward as glaciers expanded; as the climate warmed and glaciers retreated, relict populations of wild sheep were stranded on isolated mountain ranges and among a variety of low-elevation habitats that provided sufficient steep, rocky terrain for them to escape their predators. Although the earliest fossil record of wild sheep in North America appears to date from ~750,000 to 900,000 years ago, the first definitive records of modern bighorn sheep dates from ~100,000 years ago, a period immediately prior to the Wisconsin glaciation.

Bighorn sheep were one component of the great Ice Age fauna that included not only the Columbian mammoth but also a large number of now-extinct predators—an American lion, an American cheetah, saber-toothed and scimitar-toothed 'tigers,' dire wolves, and the great short-faced cave bear—as well as many persistent predators such as coyotes, modern wolves, mountain lions, grizzly bears, and black bears (Toweill and Geist 1999). This assemblage of predators provided a major influence on bighorn sheep evolution, as resulted in an ungulate that favors open vistas (where potential predators can be detected from long distance) and steep rocky terrain (which allows efficient escape from pursuers). Bighorn sheep were well established in western North America by about 12,000 years ago (Toweill and Geist 1999).

The term 'California bighorn sheep' refers to the race of bighorns that occupied primarily low elevation habitats of the Great Basin and higher elevations in California's Sierra Nevada Range. This group of bighorn sheep was recognized as 'lava-bed bighorns' by Clark (reprinted in 1964). They occupied habitats described by Bailey (1936): "Originally, mountain sheep occupied every canyon, cliff, and lava butte as well as many of the rough lava beds of Oregon east of the Cascades Mountains..."—and by inference, similar habitats in southern Idaho and northern Nevada. The term 'California bighorn sheep' was applied by Cowan (1940) in his review of wild sheep taxonomy, as by that time the best—and very nearly only—remnants of this race was found in California's Sierra Nevada Range. However, remnant populations also were found in the basin country of south central British Columbia (see Sugden 1961). The British Columbia animals provided the 'parent stock' for most California bighorn sheep herds in North America today (Toweill and Geist 1999).

Loss and Re-establishment

Historic records indicate that bighorn sheep may have been the most abundant large ungulate in Idaho at the beginning of European exploration of western North America soon after 1800. Archaeological evidence and abundant rock art depicting bighorns clearly demonstrates their importance to native American peoples, and records of early trappers and settlers indicates that bighorns were avidly sought for food. California bighorns typically occupied low-elevation habitats where they were particularly vulnerable to hunters.
However, limited evidence indicates that the greatest threat to California bighorns in Owyhee County resulted from competition with domestic livestock. The low-elevation bunchgrass ranges of southern Idaho were tremendously attractive to early settlers. Domestic sheep were trailed through the region, from California to Montana, in the 1850s, and in 1865 from California to the Boise Basin mines. By the 1880s Owyhee County was grazed by a large number of sheep. Cattle were also grazed in large numbers. Con Shea trailed a large herd of Texas cattle into the region in 1869. Within 20 years, by 1889, over 100,000 cattle grazed Owyhee County. However, many cattle died during the winter of 1889-1890 (Drewek 1970). Following the catastrophic winter of 1889-1890, sheep dominated the rangelands. Records dating from 1898 indicate that more than 150,000 domestic sheep were present in Owyhee County, while cattle numbers had dropped to 15,000 (Drewek 1970).

Competition between wild sheep and domestic livestock for forage was doubtless a factor in reducing numbers of bighorns, but it is believed that diseases introduced by domestic livestock had an even more devastating impact on native herds of bighorn sheep. A bighorn sheep die-off during the winter of 1884-1885 was attributed to scabies; a later die-off of bighorn sheep in the drainages of the East Fork Owyhee River was recorded in 1902 (Bailey 1936).

Bighorn sheep numbers continued to decline early in the twentieth century. The last records of native California bighorn sheep include a "few" in the Red Canyon area near the East Fork Owyhee River near the Oregon state line in 1915, and a herd of 18 animals in lower Battle and Deep Creeks in 1920 (Drewek 1970).

Restoration of California bighorn sheep in their native habitats began in the 1960s. In 1963, 19 California bighorn sheep trapped near Williams Lake in British Columbia were released into the East Fork Owyhee River drainage just below the mouth of Battle Creek. These animals were supplemented with 9 more in 1965, and 10 in 1966 (Drewek 1970, Toweill 1985). In 1967, 12 bighorns from British Columbia were released in Little Jack Creek in Owyhee County (Toweill 1985, Oldenburg and Nellis 1994).

There was little information on how the newly-established herds were doing until 1968-1969, when graduate student John Drewek conducted an evaluation of the transplanted herd in the East Fork Owyhee in 1968-1969. Drewek (1970) reported that herds had become established within 15 miles of the release site with at least 80 bighorns present. Herds were believed to be expanding by 20-25 percent per year.

Encouraged by the success of initial efforts to restore California bighorns in western Owyhee County, officials released 12 bighorns captured from the East Fork of the Owyhee River into the West Fork Bruneau River (also in Owyhee County) in 1982. These animals were supplemented with 11 more in 1984, 1 in 1985, and 28 in 1990. A Nevada effort to restore California bighorns into the upper Jarbridge River area resulted in the release of 10 California bighorns near Murphy Hot Springs in Idaho in 1984 (Oldenburg and Nellis 1994). These two groups merged in the mid-1980s.

Failure of California bighorns to colonize the South Fork Owyhee and Little Owyhee River drainages resulted in release of 9 bighorns in the South Fork drainage in 1985 (Toweill 1985, Oldenburg and Nellis 1994). Similarly, failure of bighorns to colonize Big Jack Creek resulted in a release of animals there in 1988 (Toweill and Geist 1999).

Efforts to restore California bighorns to Owyhee County were successful; by 1990, less than 7 decades after the loss of the last native herds and less than 3 decades after the first reintroduction, bighorn herds occupied every major canyon complex in the county. Restoration efforts in the neighboring states of Nevada and Oregon were also successful. Newly established
herds in those states intermingled with Idaho herds to occupy most identified suitable habitat. The number of California bighorn sheep in Owyhee County grew from an estimated 90 in 1970 to 570 by 1985, 1,180 by 1990, and 1,440 by 1997 (Toweill and Geist 1999).

**Management**

Idaho was not alone in losing its wild sheep resource in the late nineteenth and early twentieth centuries; similar losses were experienced by most western states. The years 1912-1974 marked the beginnings of restoration management focused on wild sheep populations nationwide (Toweill 1999b). Protection and harvest management was the focus of most early efforts, while re-establishment of extirpated herds was a continued emphasis after about 1960. Funding for these efforts came primarily from federal wildlife restoration (Pittman-Robertson Act) funds and hunting license dollars.

The last quarter of the twentieth century was significant in terms of wild sheep management because of the pronounced increase in funding for wild sheep restoration and management (Toweill 1999b). The non-profit Foundation for North American Wild Sheep, founded in 1974, solicited funding from sportsmen and outfitters and provided most of that funding to state wildlife management organizations and federal land managers to aid in wild sheep restoration and management (Schultz et al. 1999). Most state agencies participated in these fund-raising efforts by providing a special bighorn sheep tag to be auctioned at the annual convention, with most monies returned to the state to assist in wild sheep management projects. The sale of a single bighorn sheep tag at auction annually has raised nearly one million dollars in Idaho since 1988, some of which has been used to support trap-and-transplant operations in Owyhee County.

Hunting of California bighorn rams under a strictly limited quota system was initiated in Owyhee County in 1969 (Toweill 1985), and has continued to the present. In addition to limited harvest, over 400 ewes and young rams were trapped for transplant to other areas between 1980 and 1993 (Toweill and Geist 1999).

A study of the ecology of California bighorns in Owyhee County was initiated by the Idaho Department of Fish and Game in 1984 (Toweill 1985). Objectives included assessing population dynamics and interactions with range and livestock grazing practices, effects of harvest, and determination of habitat use patterns. Results of that work have been published (Bodie et al. 1990, Bodie and Oldenburg 1994, Bodie et al. 1995). Of particular note, this effort resulted in development of a model to estimate population size (Bodie et al. 1995). Management objectives were detailed in bighorn sheep management plans (Anonymous 1981, Hanna et al. 1990, Parker and Scott 1985). A review of fundamental data and basic tenets of management of California bighorn sheep was presented by Toweill (1999a).

**Population Trends**

California bighorn sheep herds quickly became established in Owyhee County (Drewek 1970) and grew at very high rates through the early 1990s (Fig. 1), in a manner typical of population growth in an unlimited environment. Animals in an environment where resources, such as food, are unlimited tend to grow rapidly, reproduce at a young age, and die at a relatively young age (Geist 1971); i.e., their body size (phenotype) and their behavior reflect their environment. Geist (1971) used the term "dispersal phenotypes" for these kinds of animals. He
hypothesized that populations of such animals would demonstrate not only rapid body growth but also a high degree of resistance to disease, high rate of reproduction and lamb survival, and a tendency toward exploratory movements into unoccupied territory (Toweill 1999a). California bighorn sheep in Owyhee County seemed to fit that model well until the mid-1990s, based on largely anecdotal experience with bighorn sheep harvested or trapped for transplant. In particular, most of the harvested animals and those captured for transplant were healthy, large-bodied and even fat. There is almost no evidence of disease or incapacity associated with parasites. In addition, Idaho Fish and game Department biologists received a number of anecdotal reports of wandering groups of sheep dispersing from established herds. In one well-documented instance, a group of 10-12 ewes and rams dispersed from a home range damaged by wildfire in Oregon's Leslie Gulch area in 1986, and moved southeastward into Idaho, where they re-located into vacant habitat in the Reynolds Creek drainage. That group founded a herd that remains in the Reynolds Creek area 15 year later (Toweill 1999a).

However, beginning in 1993, bighorn sheep populations throughout Owyhee County began to experience an apparent decline in population size (Toweill 2000, see Fig. 1). Apparent declines (determined from population estimates resulting from surveys flown alternate years) occurred in all herds, from the East Fork herd established in 1963 to the Big Jack Creek herd established in 1988. Declines dropped the estimated population size of some herds to just over 100 animals, considered the threshold for a "minimally viable" population. Simultaneously, lamb survival in the largest herds declined (Fig. 2). (Lamb survival in the Bruneau-Jardibidge herd remained nearly constant; lamb survival in the recently-established Big Jack Creek herd increased just slightly.) The simultaneous decline in herds established at widely different times and in separate areas makes it highly unlikely that population declines were associated with herd-specific events, such as disease. Additionally, there was no evidence (anecdotal or otherwise) of disease among living sheep in the affected herds, nor did the number of dead animals found by recreationists in bighorn sheep habitat (skulls of animals found dead must be presented to the Idaho Department of Fish and Game by law) increase.

At about this same time, it appeared that bighorns from the Little Jack Creek and Big Jack areas began to intermingle, with animals moving from drainage to drainage—something that had not been documented previously. In addition, there were other anecdotal reports of bighorns appearing in other (previously unoccupied) areas, suggesting that herd ranges were expanding even while populations were declining.

Although the underlying reasons for the apparent decline remain unknown, it should be noted that Owyhee County experienced extended drought associated with El Nino weather conditions between 1987 and 1993. Although bighorn sheep numbers increased steadily during that period (due in large part to an aggressive program of releasing bighorns into unoccupied habitat), range conditions deteriorated steadily. I hypothesize that California bighorn sheep, forced by relocation or declining forage availability to range more widely for food as a result of the drought, experienced an initial period of herd growth followed by declines associated with declines in range productivity. Expansion into previously unused habitat accounted for the apparent time lag between cause (drought) and effect (population decline). The observed decline in annual lamb survival is consistent with this hypothesis. Pregnant and nursing ewes, in poor body condition because of poor forage condition, may have been less successful carrying lambs to term; lambs, under conditions of less milk and poor range condition, may have been less likely to survive than in previous years. If the hypothesis of drought-related influences on bighorn sheep numbers is correct, populations should rebound as conditions improve. Population
increases will most likely also be subject to a time lag, a result of healthy lambs surviving to reproductive maturity.

There are alternative hypotheses. One of the most common is that observed declines in California bighorn sheep herds are a direct result of increases in predator numbers. This hypothesis correctly identifies an apparent increase in mountain lion (potentially a highly effective predator on bighorn sheep) populations in Owyhee County, but fails to demonstrate an increase in other, more common predators such as coyotes and bobcats. Further, the hypothesis that decline are predator-driven fails to account for a mechanism by which there can be a long-term increase in predator (mountain lion) numbers while their primary food source (bighorn sheep and mule deer) is decreasing. (Even if one predator, such as the mountain lion, increases while another, such as the coyote, declines, the net effect on the prey base should be relatively constant.)

These hypotheses remain to be tested. Efforts are underway to document bighorn sheep population change and range conditions, using available data on bighorn sheep and other wildlife populations as a natural experiment that can provide much-needed management information.

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Prehistoric Archaeology of the Owyhee Uplands

Mark G. Plew

The southcentral Owyhee Uplands are one of the most intensively studied archaeological areas in Idaho. Between 1975 and 1982, a series of reconnaissance surveys and test excavations were conducted within an area of some 200 square miles. The area which is bounded on the east by Battle Creek and on the west by Deep Creek extended to the Owyhee River. The area is characterized by open flats and several small open and steep walled canyons. Survey was focused within and adjacent to canyon rims with additional transect and sampling surveys conducted in areas between major drainages. A total of thirteen archaeological sites were excavated. Data derived from survey and excavation served as the basis for establishing a prehistoric chronology (Camas Creek I-IV) and settlement pattern. Four archaeological phases spanning some 6,000 years of prehistory document a continuous though variably intensive settlement of the area. The greatest intensity of occupation occurs during the Camas Creek III phase (Plew 1980) dating between 1350 and 750 B.P. It is notable for intensive seasonal use of relatively small drainages and is characterized by a range of site types documenting a diverse resource base. Hunting and plant collecting were extremely important and varied on a seasonal basis. The use of larger adjacent drainages for winter and spring activities were situated in higher elevations near multiple resource localities (Plew 1985; Plew and Woods 1982). The Camas Creek IV phase dating into the historic period was similar to the preceding phase though intensity of settlement was decreased.
Camas Creek II-III Phase Settlement Pattern

The natural environment and its resource potentials are considered to have remained relatively constant over the last 2,000 years. In the broadest terms, it is further assumed that the ethnographic settlement pattern of the Snake River Shoshoni, White Knife Shoshoni and the Northern Paiute of Southwestern Idaho/Northern Nevada (see Harris 1938; Steward 1938; Steward and Wheeler-Voegelin 1974) reflect resource utilization similar to that of the late prehistoric period. Micro-environmental zones include alluvial stream terraces (1) located along most of the major tributaries of the area and occupying only a narrow strip of land along streams, bench terraces/talus slopes (2) located above the stream terraces and extends in gentle slope from the canyon floor to rimrock, a rimrock zone (3) encompassing the canyon rim and an adjacent area of approximately 100-200 meters and open flats (4) comprised of the large open areas between the rimrock canyons of major drainages. Within these zones are located archaeological areas having specific resource associations. The distribution of sites with micro-environmental zones provides for the description of the settlement pattern.

Campsites were located within the alluvial terrace zone whether or not the sites were situated in relatively open or deeper canyons. Hunting locations associated with rock alignments constitute 87% of the sites in the rimrock zone. The remaining 12% are distributed equally between zones 1 and 2. There is a 100% association of workshop locations with the rimrock zone. A relatively equal distribution of lithic scatter locations in zones 1, 2, and 3 was noted as was the absence of sites in zone 4. Only two probable plant processing locations were identified. These were located on Camas
Creek and overlap zones 1 and 4.

Three major catchment areas were defined and include a wide variety of resources available within a 0.8 km radius of the site. These included greens, wild onions, grasses, currants, berries, deer and pronghorn, small mammals, waterfowl, small birds, and because of the proximity to water, small fish, crayfish and mussels. The canyon would have provided shelter, building materials, firewood and clay deposits for pottery making. Lithic material for tool manufacturing was also available. Prehistorically, slopes would have provided caching areas, and locations for hunting blinds and burials within a 1.6 km radius of the site. This area was marked by a continuation of resources found within the initial site catchment but including major camas and biscuitroot meadows. Pronghorn were found regularly within the area since much of it was open and close to water. Raw materials were available for acquisition. Using Binford's terminology, campsites were designated central camps, while plant collecting/processing sites, hunting sites, and workshops are locations. Some rock alignments and petroglyph sites are stations. Within the uplands, the camp range was probably restricted to a 2 km radius from the central camps.

Ames (1982) analysis of southwestern Idaho settlement describes small bands of hunter-gatherers living in small transitory camps positioned to exploit a broad range of resources. The uplands were characterized by a similar pattern of winter and spring-summer-fall camps, associated with a variety of locations and stations, representing highly specific activities. A central camp and a number of closely situated spring, summer and fall field camps were residential sites surrounded by locations which had special functions and a variety of stations. Faunal and artifactual associations as well as
seasonal availability of resources suggest a spring-summer occupation for many of the upland sites. The spring-summer field camps were placed near major root crops, while fall field camps are found in the constricted and brushy areas of canyons where deer and a range of berries and fruits were available.

Seasonal ethnographic activities are thought to mirror use locations within the micro-environmental settings. The distribution of these activities suggest an overlap in some areas for procurement as may have been the case with fishing. Hence, some of the same field camps may have been used at different seasons of the year.

Very specific camp ranges were observed for the upland sites. These ranges are within the limits of the catchment descriptions which are approximately 2.4 km from the limits of the residential camp. This pattern applies to all seasonal encampments. The central winter camps and spring-summer-fall field camps are separated by 15-20 miles, a pattern characteristic of the White Knife Shoshoni and The Northern Paiute. The pattern is one of wintering on the East and South Forks of the Owyhee River and its major tributaries during the mid-December to mid-March period with movement to the higher plateau areas in early spring. Because the plateau sections of the uplands contained productive high yield resources such as camas and biscuitroot, supplemented by game and fish, spring through fall was spent moving from one field camp to another to exploit specific resources. In this model, the same field camps were used during different seasons with some sites being returned to on an annual basis and others during alternate years. Territorial range or logistical range for the area is probably 60 square miles. Within the Owyhee Uplands, there may be several such
territorial ranges having more restricted camp ranges. Territorial ranges probably characterize the areal movements of individual bands; a pattern generally characteristic of the Snake River Shoshoni, Northern Paiute, and in particular the White Knife Shoshoni. In each case native groups had restricted wandering limits.

The settlement pattern may be described as a dual-central-base pattern characterized by major winter and spring summer camps. The upland pattern is somewhat different in that it sees repeated seasonal use of the same sites. This pattern is probably the result of aboriginal weighting of resource availability and importance. The Owyhee River and other larger and deep canyon areas of its major tributaries were selected for winter encampments for shelter, wood, for house construction and fires, and aggregations of wintering animals. At other times of the year, access to and from the canyon, particularly in the spring was probably an impediment to use.

The Owyhee River, with its steep walls, lies at elevations between 4,000 and 4,500 feet, some 1,500 feet below elevations in the uplands where high site densities are noted at elevations of 5,600 to 5,800 feet. These are optimal areas for such major resources as camas and biscuitroot and a diverse faunal community. The spring-summer crops of the uplands are not available along or near the Owyhee River. A decision regarding use of the area would have required weighing the potential of each resource base. The upland faunal and flora communities are abundant, relatively dispersed and provide resources which can be easily transported to winter camps and stored. In contrast the resources of the Owyhee River are locally concentrated along the course of the stream. This relative density would have facilitated rapid depletion of available resources and made extended use of the
area during the spring and summer extremely difficult. Further, the resources of the Owyhee River are short-term, low yield resources (see Plew and Woods 1982).

An additional reason for upland use may be associated with fishing. Salmonids, suckers, and minnows would have been found in great numbers within the Owyhee area. If fishing were a major subsistence activity, it would have been restricted during much of the year to the upper reaches of the primary and secondary tributaries of the Owyhee River. Access to and use of the Owyhee River for salmon fishing would have been considerably more difficult than on the Snake River. The steep rock walls coupled with the absence of shoals, riffles, etc., would have made spring salmon fishing difficult. High water may have precluded spring access while low fall water levels may have inhibited salmon runs. Nonetheless, non-game fish are abundant in the Owyhee and its tributaries. Utilization of suckers and sculpins on the Owyhee River may not have been very important since these species are available in great numbers adjacent to areas where root crops are predominant.

The upland settlement pattern is characterized by winter camps located in the Owyhee River canyon and near the mouths of its larger tributaries and field camps associated with spring, summer and fall activities. Individual camp ranges appear to have a radius of about 2.4 km with the annual territorial or logistical range for specific groups being about 60 square miles. Field camps are thought to be overlapping on a seasonal basis as groups returned to use different resources within the same general catchments. Emphasis appears to have varied seasonally but focused upon utilization of high yield plant resources.
The archaeology of the southcentral uplands suggest the presence of a formable Archaic occupation centered around the utilization of tubers...seasonally supplemented by hunting and other seasonally productive collecting. The upland area suggests an increase in intensity of settlement in the period between 1350 and 750 B.P. and a dual base settlement pattern in which camps were alternately occupied at different seasons with wintering occurring in the Owyhee canyons. The model reflects the ethnographic models of “white knife Shoshoni” groups described by Harris (1940).

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Distribution and habitat associations of Loggerhead Shrikes on the north front of the Owyhee Mountains

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North American shrikes (Lanius spp.) occupy a unique position in the food chain as both passerines and top level vertebrate predators. The Loggerhead Shrike (L. ludovicianus), smaller and more widespread of the two North American species, was relatively common across most of the continent early in this century (Miller 1931, Morrison 1981). Interest in the Loggerhead has increased in recent years as dramatic population declines have been noted in many geographic regions. The migrans race, for example, is nearly extirpated in Canada east of Montreal, and is entirely absent from its historic breeding range in the New England states (Milburn 1981, Telfer 1988, Novak 1989). It is widely accepted that some shrike populations are declining, and researchers have recommended placement of those populations on state threatened or endangered species lists. In fact, the Loggerhead Shrike is currently on state endangered species lists in Indiana, Michigan, Ohio, and Wisconsin, and threatened lists in Illinois and Minnesota (Fraser and Luukkanen 1986). Furthermore, the Loggerhead was recently listed as a Category 2 candidate for protection under the Federal Endangered Species Act (Federal Register 56:5881, November 21, 1991).

The gambeli subspecies of the Loggerhead breeds in the Pacific Coast states, as well as Idaho, Montana, Wyoming, and British Columbia, although the southern edge of Idaho is a zone of integradation between L. l. nevadensis and gambeli (Miller 1931). The shrike is considered a common summer resident in southern Idaho (Burleigh 1972), and in 1991 I initiated a three-year study to determine ecological characteristics of shrikes breeding in sagebrush-dominated (Artemesia tridentata) habitats characteristic of south-west Idaho and much of the western states (Woods 1994). I surveyed the north front of the Owyhee Mountains to ascertain shrike population size and habitat associations for shrikes there, and carefully monitored pairs that bred in the Wilson Creek drainage, inside the proposed Owyhee-Bruneau Canyonlands.

The Wilson Creek site, where breeding shrikes were monitored, is 50 km southwest of Boise, at an elevation rising from 900 to 1375 m, and occupies part of a rugged 1000 ha bowl of sagebrush habitat centered on the primary basin in that drainage. Wilson Creek, which bisected the bowl, is one of many intermittent streams draining the north front of the Owyhee Mountains, and it remained dry through the two years of the study, with the exception of runoff in the spring and following occasional heavy rainfall. In the lowest elevations, sagebrush and some greasewood occurred together, generally varying between 0.5 and 2 m high. Vegetation was similarly tall at higher elevations in the drainage, but the greasewood was largely replaced by bitterbrush, again with sagebrush the dominant shrub. In addition, thin, dry creekbeds occurred throughout the area, and the vegetation was somewhat taller in the creekbeds, with sagebrush occasionally reaching nearly 3 m in height, and widely-spaced willow (Salix sp.) and cottonwood (Populus sp.) 5 m or taller, as well. Rock outcrops as high as 10 m occurred throughout the basin and served as prominent perches for both breeding Loggerhead Shrikes and wintering Northern Shrikes.

Shrikes in the Wilson Creek basin generally nest in sagebrush or bitterbrush; of 64 nest shrubs, 46 (64.8%) were constructed in sagebrush, 18 (25.4%) in bitterbrush, and 7 (9.9%) in
greasewood. Bitterbrush was chosen over sagebrush more often than would be expected by chance, as it accounted for only 9.2% of the shrubs available for nesting based on a random sample of 218 shrubs in the basin. Rather than reflect a preference for bitterbrush, however, these results indicate that shrikes chose from amongst the most mature shrubs available, since randomly selected bitterbrush was also significantly taller than its sagebrush counterparts ($t_{216} = 3.27, P < 0.001$). More to the point, however, the importance of relatively mature nesting shrubs for shrikes is underscored by the disparity with which all nest shrubs compare in height and diameter to randomly selected sagebrush or bitterbrush shrubs throughout the basin. Nest shrubs are both significantly taller and fuller than random shrubs, averaging 151 cm in height and 211 in maximum diameter, whereas randomly selected shrubs averaged only 73 cm in height and 110 cm in maximum diameter ($t_{280} = 15.91, P < 0.001$, and $t_{278} = 11.88, P < 0.001$, respectively).

Shrike nest themselves averaged 79 cm above the ground, although nests tend to vary between 1 and 9 m high elsewhere in the Loggerhead’s range (Miller 1931, Fraser and Luukkonen 1986). In fact, the lowest nest I found in Wilson Creek, 33 cm off the ground, is the lowest shrike nest reported in any literature (note, four young fledged from the nest). Moreover, shrikes did not nest in trees on any of my sites, although trees occurred sporadically in all three areas, and during one shrike survey in southeast Idaho I located two shrike nests in Russian Olive trees, one 2.6 m above the ground in a 6.7 m tall Russian Olive, and the other 1.3 m high in a 3.3 m tall tree.

Further distinguishing shrikes in southwest Idaho from those elsewhere is an important contrast in breeding distributions and density. Loggerheads in southwest Idaho sometimes occur at relatively high densities, consistent with a pattern of local abundance. Shrike pairs often nested in association with other shrikes; only 4.1% of all pairs in my study nested more than 2 km from known neighboring pairs, and most nested much closer. The Wilson Creek bowl supported one pair/25 ha, and average nearest neighbor distance was 328 m. In contrast, results of many studies suggest shrikes often breed at much lower densities. Siegel (1980), for example, found the distance between some shrike pairs in Alabama averaged 720 m, and in Virginia Luukkonen (1987) found only 5 of 56 pairs breeding in adjacent territories, separated by 395 to 819 m, and he felt the Loggerhead was widespread and rare. Similarly, shrikes in Minnesota and Illinois are scattered and breed at low densities (Brooks and Temple 1990, Anderson and Duzan 1978). Moreover, the distance between neighboring shrike pairs is not reported in most shrike studies, probably as a consequence of low nesting densities. The extent to which the Idaho population is like others is uncertain, but the lack of similar data from other studies strongly suggests shrikes in Idaho may nest at higher densities than is typically observed.

To discount the possibility that the high breeding densities which I observed in Wilson Creek and elsewhere were anomalous, during the 1993 breeding season I surveyed selected drainages along 140 km from Shoofly Creek, Idaho, to the Owyhee Reservoir, Oregon, to verify the occurrence of Loggerhead Shrikes across a broad area, more representative of the Owyhee front as a whole. To select survey drainages, I defined all areas which a 1:100,000 topographic map (Idaho and Oregon Atlas & Gazetteer, 1992, DeLorme Mapping, Freeport, Maine) illustrated as containing either steady or intermittent water flow 5 km or greater in length. I then located the 1200 m contour interval from the Owyhee Reservoir, Oregon, southeast to Shoofly Creek, Idaho. This contour was partitioned into 7 segments, each 20 km in length. Within each segment, I identified all drainages (as defined above) crossing the 1200 m contour, numbering each. This combination of elevation and drainage definition best represented the areas I studied breeding shrikes previously, and two drainages were then randomly selected in each of the 7
segments. Drainages were surveyed in random order.

Each survey was completed in one day, during which I hiked both the east and west sides of the drainage, remaining within 1 km of the creekbed on either side. Drainages were surveyed between 900 and 1700 m in elevation, as this range of elevation is the most representative of known shrike breeding in this area. I used a relative scale to visually evaluate three habitat characteristics in a 200 m radius where each shrike was seen, as well as at 30 min intervals throughout each survey. Those characteristics were Shrub Density (0 = intershrub distance < 1 m, to 10 = intershrub distance > 15 m), Shrub Height (0 = all shrubs < 0.5 m, to 10 = all shrubs > 2 m), and Emergent Vegetation (0 = no emergent vegetation < 1 m in height, to 10 = much emergent vegetation > 2 m in height).

In total, 84.1 km of drainage were surveyed, and my findings indicate that the nesting densities observed in Wilson Creek were not atypical for the Owyhee front in general. I found shrikes on 13 of 14 surveys (92.9%), and observed 95 shrikes in 65 distinct locations, or one shrike territory per 1.36 km of drainage. Moreover, shrikes sometimes occurred in apparently dense nesting associations, as in 4 of 14 drainages (28.6%) I located five or more shrike territories in close proximity. By extrapolating my findings to all drainages from which my surveyed sampled, and with conservative estimates for shrike densities outside of those areas, these findings suggest that between 1,000 and 3,000 shrike pairs may breed along the north front of the Owyhee Mountains, with perhaps 3,000 to 6,000 pairs in total breed at elevations below 1700 m throughout Owyhee County.

Overall, shrikes were found to occur with greatest regularity in landscapes characterized by mature sagebrush with abundant perches, tall shrubs for nesting, and open ground over which to forage. Both shrub height and emergent vegetation were significantly higher where shrikes were found than was available (t_{14} = 5.02, P < 0.001, and t_{18} = 3.82, P < 0.001, respectively), and shrikes were found in areas with reduced shrub density, albeit that difference was not significant (t_{35} = 0.35, P > 0.1). Although shrikes were seen to forage on the periphery of monocultures or open grasslands, they were conspicuously absent from the interior. Habitat associations in other regions also reflect the unwillingness of shrikes to forage in or over large areas of low vegetative structural height, with few perches and high grass, and the height and availability of foraging perches probably also influence shrike territory size (Carlson 1985, Yosef and Grubb 1992, Yosef 1993).

In total, these findings underscore some unique attributes of shrikes which breed in the sagebrush regions of southwest Idaho. Shrikes appear to be widely distributed throughout the Owyhee region, and often locally abundant there. The loggerhead is well-adapted to the opportunistic nature of life in southwest Idaho scrub (cf. Rotenberg 1980), and higher reproduction and breeding densities than elsewhere also suggest the shrike population in Idaho may be more viable than many other populations of this predatory songbird. Unfortunately, habitat loss has been correlated with shrike declines over parts of their range (Lynn and Temple 1991, Gawlik and Bildstein 1993, Prescott and Collister 1993, Cade and Woods 1997), and sagebrush habitat in southern Idaho is less abundant now than prior to human settlement. Likewise, notes from local birders indicate that the shrike's breeding range in many areas was larger even in the previous decade, and is presently reduced. The grazing of livestock and active eradication of sagebrush also resulted in substantial disturbance at several shrike territories I monitored during this study, contributing to nest failure at some. As Idaho's human population continues to grow, further loss of sagebrush is inevitable. Consequently, sound habitat management is necessary for the continued success of this shrike population, and the
establishment of the Owyhee-Bruneau Canyonlands would be an integral part of that management.

Literature Cited
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Literature Cited


The Interior Columbia Basin Ecosystem Management Project encompasses 59,000,000 ha in the northwestern U. S. Among 119 priority vertebrate species being considered under various management alternatives, 71 are birds. Sagebrush steppe has the most bird species of concern. A broad-scale analysis of terrestrial vertebrates, based on shared source habitats and 1-km² resolution vegetation maps, produced a species cluster consisting of Brewer’s sparrow (Spizella breweri), sage sparrow (Amphispiza belli), sage thrasher (Oreoscoptes montanus), greater sage-grouse (Centrocercus urophasianus), lark bunting (Calamospiza melanocorys), black-throated sparrow (Amphispiza bilineata), loggerhead shrike (Lanius ludovicianus) and three mammals. Source habitat for this group historically was widespread and continuous over much of the Basin but losses have been massive. Big sagebrush (Artemisia tridentata tridentata) has been reduced by 33%, mountain big sagebrush (A. t. vaseyana) by 35%, and salt desert shrub (Atriplex, Sarcobatus) by 34%. Declines are most pronounced in the Columbia Plateau (Oregon and Washington) and in the Upper Snake region (Idaho). Changes in the Owyhee Uplands have been much less dramatic. The largest transition of any terrestrial community from historical to current period is that of upland shrubland to agricultural (+9.0%). This group also has been affected by fragmentation, particularly in the Columbia Plateau, Owyhee Uplands and Upper Snake regions, and by invasion of non-native invasive plants. One critical strategy will be to identify and appropriately manage large remaining core areas of shrubsteppe vegetation where ecological integrity is still relatively high and where good populations of key species, such as sage grouse, still occur. The Owyhee Uplands may present the very best location for implementing this strategy.

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RE: Owyhee Symposium 11/18/00
Fr: Mike Medberry
To: All

The symposium went without a hitch on Saturday. All of the presenters were very good, gave their presentations very professionally, and wanted to do another round of presentations next year. I was impressed! All of them made it clear that they learned a great deal from their peers. And all will get us the written material that they promised in two weeks to distribute to other presenters. One presenter volunteered to gather signatures of other scientists who were willing to ask for a designation for the Canyonlands. I’ve given him a week and a half to do that. About 150 people attended the symposium. The Oregonian ran a story including the mention of the Symposium.

**Presentations**

Todd Shallat, a historian at Boise State University, gave a history of the Canyonlands from 1869. The Canyonlands history was highlighted by the statement that, “scientists never know what is ‘real’ and what is based on a political view, is only today’s view”.

Mark Plew, an archeologist at Boise State University, gave a history of Pole Creek and it’s Archeology. Lots of tools and brown stone pottery was found at Pole Creek, these findings were once abundant, but have since become increasingly rare.

Trish Klahr, a landscape ecologist with The Nature Conservancy, told about how TNC is working to preserve the country: division into ecoregions, ICBEMP, a portfolio of 337 plants, with the total area being protected in the Owyhee Canyonlands at 3%. Ms. Klahr also noted that, “the big landscape is what is important”.

Robin Jones, a scientist for Bureau of Reclamation specializing in biological crusts, talked about the important role that lichens, mosses and cyanobacteria have in stabilizing that land. Mr. Jones also recognized that much of these important species has been lost.

Steve Rust, an ecosystem biologist with the CDC, gave a true color photo presentation of southwest Idaho shown through several plant transits.

Chris Murphy, a plant biologist with the CDC, named the 16 rare plants in southwest Idaho, noting that each plant was rare for different reasons. Some of the plants were rare because of their unique soils, others because of their outright rarity.

Dr. Steve Novak, a biologist at Boise State University specializing in grass, showed how cheatgrass and medusahead have fundamentally changed the ecosystem in the West over the last few decades.

Walter Buechler, Late Miocene Flora of the Western Snake River at the Idaho Geological Survey, described the fossilized leaves and creatures that were found in the diatomite deposits south of Murphy.
Colleen Sweeney, a Department of Environmental Quality scientist specializing in birds of the Owyhee, gave a slideshow and presentation of 3-dozen birds that she had encountered in the Owyhee over the past 20 years.

Terry Rich, a Bureau of Land Management biologist specializing in Columbia Basin birds, talked about the different sage obligates such as sage grouse, sage thrasher, and sage sparrow in the Owyhee.

Jon Bart, a biologist at Boise State University, Population Trends of Shrub-Steppe Birds, showed his support of the Monument by describing the continuing decline of sage connected birds in the grazed lands of the Owyhee.

Mark Salvo, an attorney, talked about the decline of sage grouse throughout their western range.

Chris Woods, a biologist from the Dakotas, described the bizarre customs of Loggerhead Shrike, which is not very abundant within the Owyhee.

Bruce Zoellick, a fish biologist with the Bureau of Land Management, talked about redband trout in the Owyhee drainage and why they merited special species status.

Janice Engle, with the Idaho Department of Fish and Game, reviewed her study and findings on the Columbia Spotted Frog in an Owyhee stream. Janice found frogs separated by grazed ground and that the frogs favored the ungrazed ponds.

Dale Toweill, a big horn sheep biologist with the Idaho Department of Fish and Game, recounted the history of sheep reintroduction and some of the reasons why the sheep should be watched so carefully.

Bill Bonnichsen, a professor from the University of Idaho, talked about the Rhyolite features of Idaho beginnings, all coming from the drawback of Lake Idaho.

Curtis Manley, a geologist with the University of Montana, talked about the uniqueness of Juniper Mountain.

Martha Godchaux, Mt. Holyoke University, presented on volcanism in the Owyhee. Martha gave definitions of the different volcanoes (marr, shield, and pit) in the Owyhee, and also a description of what formed the volcanoes.

Dr. Spence Wood, a geologist from Boise State University, gave a description of the geomorphology of the Owyhee.

Amy Haak and Frank Jenk talked about recreation in the Owyhee, mainly about the Jarbridge, Bruneau, East Fork, Deep Creek, South Fork, and North Fork rivers within the
area. Both stated that the trends for recreation are increasing as apparent with the
spending that has taken place since 1990.

Ted Howard, Shoshone-Paiute- Duck Valley, “the Land is our land, and its never been
taken away”. As the public pressure increases the wildlife habitat will be reduced.