

Great Basin Cold Desert Shrublands and the Desert Experimental Range

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The Great Basin

The Great Basin is a vast, internally drained region of the Western United States, bounded by the Sierra Nevada and southern Cascade Mountain ranges to the west and the Wasatch Mountains and western rim of the Colorado Plateau to the east. Although less discrete, northern and southern boundaries are generally defined by the drainages of the Columbia and Colorado Rivers. Included are most of Nevada and major portions of Utah, California, and Oregon. Contrary to what the name implies, the Great Basin is composed of not one, but many closed basins or valleys separated by over 100 relatively narrow mountain ranges arranged with a more or less north-south orientation. This geography is characteristic of the larger Basin and Range Province extending from southern Oregon and Idaho to Sonora, Mexico, of which the Great Basin occupies the northern and most elevated third. Valley floor elevations range from 86 m below sea-level in Death Valley, California, to approximately 2,000 m above sea-level in central Nevada. Mountain elevations also vary with the summits of 33 mountain ranges exceeding 3,000 m. The mountains of the Great Basin began forming approximately 17 million years ago when a complex series of normal faults began forming in the earth's crust in response to continental stretching (Morris and Stubben 1994). Mountains ranges (horsts) and valleys (grabens) formed as blocks of crust were vertically displaced along those faults. As the mountains eroded, the surrounding valleys filled with their debris. The cores of many eastern Great Basin ranges are composed of limestone, dolomite, and quartzite; rocks derived from Paleozoic marine sediments. Younger Mesozoic and Cenozoic volcanics such as granite, tuff, basalt, and breccia are found throughout the Great Basin but dominate in the west and north. The physical and chemical characteristics of valley soils from massive sand dunes to fine-textured playas reveal the diversity of these parent materials.

The climate of the Great Basin is arid to semiarid with cold winters and warm summers except in the southern, low-elevation valleys where winters are mild and summers hot. Seasonality of precipitation varies along a geographic

gradient with the importance of winter and spring Pacific frontal storms decreasing and summer monsoons increasing as one travels from north to south and from west to east (Peterson 1994). Precipitation increases and temperature decreases with increasing elevation resulting in fairly distinct vegetation zones. Higher elevation forest and alpine landscapes are relatively small and isolated; subsequently, these mountain ecosystems function as ecological islands separated by a sea of desert (Billings 1978; Wells 1983).

The distribution of plant species in the Great Basin has changed substantially over time with changes in climate. During the late Pleistocene (20,000 to 16,000 years b.p.), over 100 lakes filled valley bottoms indicative of the much colder and wetter climate than today (Wells 1983; Peterson 1994). Plant macrofossils found in preserved woodrat (*Neotoma* spp.) middens and pollen sediment records suggest that subalpine coniferous forests and sagebrush-dominated shrub-grass steppes covered foothill and valley locations surrounding these Pleistocene lakes (Wells 1983; Thompson 1990). Tundra occupied upper elevations and northern latitudes. With Holocene warming, alpine communities and subalpine conifers retreated to high elevation refugia on the tallest mountains, and more thermophilic conifers migrated from the south and formed mid-elevation forests and woodlands. While sagebrush communities remained dominant on many low to mid-elevation landscapes, salt-desert shrubland-grassland mosaics now fill the driest valley locations especially on the fine-textured, salty soils that were once lake bed sediments.

Stop 1: Pigmy Rabbit Colony and Habitat

Pigmy rabbits (*Brachylagus idahoensis*) are the smallest known leporids, living or extinct (Oliver 2004) and are unique in the practice of digging their own burrows though they will use burrows dug by other animals. Pigmy rabbits are almost always associated with dense stands of tall big sagebrush (*Artemisia tridentata*), which they rely on for both food (especially during winter) and concealment from predators. The scampering or scurrying mode of travel used by pigmy rabbits differs from the bounding and leaping characteristic of other members of the rabbit family and is well suited for the complex structure of the preferred habitat. Although members of the rabbit family are generally silent, except when captured, pigmy rabbits demonstrate a unique capacity to produce warning calls, a trait well suited for a species with populations clustered in dense shrubby

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habitat with poor visibility (Green and Flinders 1981). High densities of characteristically small (diameter 2-5 mm) fecal pellets concentrated near burrow openings are diagnostic of pigmy rabbit colonies. Although appropriate legal status for the species across its range is currently unresolved, concern for the species is growing due to extensive loss of suitable sagebrush habitat on western North American landscapes (Oliver 2004).

The tour stopped near a known pigmy rabbit colony located a short distance from the Parowan Gap turnoff from State Highway 130. At this site pigmy rabbit burrows appeared to be restricted to the sides of a shallow ravine where soils were loose and sagebrush plants relatively large. Tour participants located several burrows and about six pigmy rabbits were identified moving through the sagebrush cover.

Big and Black Sagebrush Habitat Comparisons

North of the Parowan Gap turnoff, Highway 130 begins a gradual climb up a broad bajada on the south side of the Black Mountains. Several distinct examples of ecotones between big and black sagebrush (*A. nova*) communities are apparent near the road. Black sagebrush has darker foliage and generally lower stature than big sagebrush and transitional boundaries between stands of the two species are generally easy to distinguish (McArthur and Stevens 2004). Solid stands of black sagebrush indicate shallow or rocky soils; thus, the pattern of these two sagebrush communities on this slope are an indication of variability in the development and structure of the alluvial soils that support them.

Stop 2: Mountain Big Sagebrush Burn Site/Utah Prairie Dog Rehabilitation Site

Scattered Utah juniper (*Juniperus osteosperma*) trees occur imbedded within the sagebrush matrix on the upper reaches of the Black Mountain bajada. Tree density increases with elevation and trees dominate much of the steeper slopes and ridge-tops on the rolling hills above the bajada. Just south of the summit, the road passes through the burn area of the 1988 Coyote Pond Fire. Here a large transplanted colony of the threatened, Utah prairie dog (*Cynomys parvidens*) can be observed along a dirt road extending east from the highway. The numerous animals and burrows encountered along this road suggest that this colony is doing well.

Most sagebrush species are easily killed by fire. Recovery is from seeds that either survive the fire or are dispersed from plants located on nearby unburned areas. Post-burn sagebrush recovery occurs more rapidly on mesic sites (such as those occupied by mountain big sagebrush (spp. *vaseyana*) than on xeric sites (Kitchen and McArthur 2007). This stop (1,980 m) was near the lower elevational limit of mountain big sagebrush (spp. *vaseyana*) in this region and could be considered a moderately mesic site with mean annual precipitation of approximately 330 mm. Differences in sagebrush and understory density and cover as affected by slope position, aspect, and post-burn seeding treatments were observed at

this site 18 years after disturbance. Distinct size classes of big sagebrush plants suggest that establishment has been episodic, likely related to sequential climatic patterns favorable for seed production and seedling survival.

The tour turned northwest on state road 21 at Milford, Utah. On this route Wyoming big sagebrush (spp. *wyomingensis*) soon gives way to black sagebrush, juniper woodland, and salt-desert shrubland and grassland vegetation. Near the southern end of the San Francisco Range the highway passes a part of the old San Francisco Mining District and the remnants of the once booming town of Frisco—more about that later—and quickly descends towards the Wah Wah Valley floor dissecting an atypically large stand of Nevada ephedra (*Ephedra nevadensis*) that occupies several hundred hectares of the west-facing bajada. The salt desert communities below the Lake Bonneville shoreline in Wah Wah Valley (1,600 m) are highly degraded as a result of heavy overstocking with domestic sheep in the late 19th and early 20th centuries (Murdock and Welsh 1971). Introduced annuals dominate where shrublands of shadscale (*Atriplex confertifolia*) and winterfat (*Ceratoides lanata*) were once abundant. Pedestaled plants are an indication that wind erosion is still a problem.

Stop 3: Wah Wah Summit— Juniper Expansion into Desert Grasslands and Shrublands

On the western side of the valley the highway passes the irrigated circles of the Wah Wah Ranch and begins an ascent from the valley floor, up an alluvial slope to Wah Wah Mountain Pass. Relatively young Utah juniper trees are scattered within the shorter shrub and grass vegetation growing a short distance up this slope, increasing in density with elevation. South of the highway about 2 km from the summit (1,800 m elev.) is a good place to stop for a closer examination. Here, understory species included the shrubs black sagebrush, Nevada ephedra, broom snakeweed (*Gutierrezia sarothrae*), winterfat, and the perennial grasses needle-and-thread (*Hesperostipa comata*), Indian ricegrass (*Achnatherum hymenoides*), and bluegrass (*Poa* spp.). The introduced annual cheatgrass (*Bromus tectorum*) is ubiquitous. Aging of several small to moderate sized juniper trees from this location reveals that most are young, having established during the latter half of the 20th century. Trees that appear to be several centuries old are restricted to the shallow ravines and rocky ridge-lines that dissect the alluvial slope. Charred remnants provide evidence that fire played a role in shaping this plant community in the past, including the suppression of tree expansion.

Stop 4: Desert Experimental Range Headquarters

The Desert Experimental Range, consisting of 22,530 ha, was set aside in 1933 by President Herbert Hoover “as an agricultural range experiment station.” Events that led to its designation began some 60 years prior to official establishment. In the 1860s, Euro-American settlers began using

the desert valleys of the Great Basin as pasturelands for domestic livestock. They soon discovered that many grasses and shrubs that dominate the landscape make excellent livestock forage, even in winter. Use of this resource during warmer months was restricted due to a scarcity of surface water; however, during winter and early spring, livestock often met their water requirements from unmelted snow allowing for widespread herd distribution.

The public rangelands of the Great Basin presented an open invitation to livestock owners; they were viewed as commons where grazing was free on a 'first come first serve' basis with no bothersome regulation. Cattle came first, then, beginning in the 1880s, large numbers of sheep followed. Sheep herds spent summers in well-watered mountain pastures that surround the Great Basin. Several weeks in spring and autumn were spent trailing up to 300 miles between mountain and desert ranges. Livestock numbers soon exceeded what the land could bear by several times, resulting in serious erosion and long-term damage to preferred plant species. Livestock numbers remained high and desert rangelands continued to degrade for several decades. Finally, during the drought years of the 1930s, the nation began to address the need for change. With passage of the Taylor Grazing Act in 1934 the era of unrestricted grazing on public lands came to an end. By this time it was clear that knowledge necessary for wise management of these desert shrublands was lacking. The Desert Experimental Range was created to help fill that knowledge gap.

In 1933 a large camp of the Civilian Conservation Corps., or CCC's, was established a few hundred yards from the current site of the DER headquarters. Under the direction of federal researchers, their mission was to establish and begin operation of the Desert Experimental Range. By 1935 they had completed construction of the headquarters facility with an office, three dwellings, shop, ice house, horse barn, garages, a 600-foot well, tennis court, and 45 miles of telephone line from Milford. Initial plant surveys were conducted and vegetation maps completed. Crews also constructed 118 miles of fence using hundreds of rolls of woven field fence and barbed-wire and over 40,000 'cedar' posts cut by hand from Utah juniper woodlands located in the foothills to the south and west. The straightness of the fence-lines and uniformity of post top-cuts attest to the precision employed in this work. Most of the original posts still stand, evidence of their longevity and of the dryness of the climate. Fencing was located primarily along the outside boundary and on the perimeters of experimental pastures and ungrazed exclosures.

Long-term grazing experiments were designed to examine the economic and ecological impacts of sheep grazing on salt-desert shrublands using different grazing practices, and have continued with only minor alteration to the present. Eventually research broadened to include the evolution and ecology of several of the plant species adapted to the harsh environment. Desert animals have also been subjects of research with studies focused on pronghorn antelope (*Antilocapra americana*), kit fox (*Vulpes macrotis*), American kestrels (*Falco sparverius*) and various rodents. Additional studies have addressed ecosystem processes and mechanisms of ecosystem change through time. The Desert Experimental Range remains a valuable site for research and education in the ecology and management of salt-desert shrublands.

Stop 5: Desert Research Natural Area

A 740-ha parcel of land was set aside for protection from livestock grazing in 1934. This parcel was officially designated a Forest Service Research Natural Area in 1972. Although several smaller 0.4 and 1.6 ha fenced exclosures are scattered within and near the Desert Experimental Range, they are too small for investigations in salt-desert shrubland ecology requiring protection from livestock grazing at larger spatial scales. The size of the Research Natural Area and its history of continuous protection from livestock use make it unique in the Great Basin. The soils of the Research Natural Area are a loose mix of gravel, sand, and clay particles to a depth of 20 to 40 cm (Tew and others 1997). Below this, a 20- to 40-cm thick cemented calcite layer acts as a barrier to root development and water penetration below this point. This semi-impermeable layer is a typical feature for stable alluvial soils with a calcareous parent material and dry climate.

Salt-Desert Shrublands

Plant species that inhabit salt-desert shrubland communities must be adapted to long periods of drought, moderate to high levels of soil-salt content, summer heat, and extreme winter cold (Blaisdell and Holmgren 1984). Mean annual precipitation for the Desert Research Natural Area is 165 mm. Dominant plant forms include short-statured shrubs such as shadscale, winterfat, budsage (*Artemisia spinescens*), and low rabbitbrush (*Chrysothamnus Greenei*), and perennial grasses such as Indian ricegrass, needle-and-thread, squirreltail (*Elymus elymoides*), purple three-awn (*Aristida purpurea*), sand drop-seed (*Sporobolus cryptandrus*), and blue grama (*Bouteloua gracilis*). Numerous short-lived forbs add floristic diversity and are periodically abundant (Harper and others 1996). Gooseberry-leaf globemallow (*Sphaeralcea grossulariifolia*) is the most common of these forbs at the Desert Experimental Range. Representatives of these plant forms are blended in an ever-changing mosaic across the landscape. The short plants help to hold water and nutrients in the soil and protect the soil surface from erosion caused by wind and pounding summer rains. Bare soil between plants is protected by tightly-fitted surface gravel, or 'desert pavement' and by an erosion-resistant soil crust glued together by fungi and algae living near the surface. Improper grazing practices destroy these microbiotic crusts and disturb desert pavement resulting in increased erosion.

Burrow Island Ecology

A variety of animal inhabitants of salt-desert shrublands require burrows for nesting, hunting, hiding from predators, and thermoregulation in summer and winter. Desert animals that make or use burrows in this desert include pocket gopher (*Thomomys bottae*), kangaroo rat (*Dipodomys ordii*), deer mouse (*Peromyscus maniculatus*), skunk (*Mephitis mephitis*), badger (*Taxidea taxus*), kit fox, burrowing owl (*Speotyto cunicularia*), Great Basin rattlesnake (*Crotalus viridis lutosus*), and a variety of lizards. On landscapes with well developed calcite layers, burrows are restricted primarily to scattered patches or 'islands' where somewhat continuous

burrowing has prevented the formation of a calcified barrier. These burrow islands occupy about 10 to 15 percent of the landscape and are somewhat evenly scattered across the landscape varying from 3 to 15 m in diameter (Kitchen and Jorgensen 1999). They are easily identified by an abundance of holes and soil mounds and by a marked change in plants species present when compared to surrounding vegetation. Vegetation on the burrow mounds differs from that of the surrounding landscape because of frequent soil disturbance, higher soil fertility, and deeper water penetration. Burrow mounds in Pine Valley, as in other parts of the Great Basin, have been invaded by Russian thistle (*Salsola* spp.), cheat-grass, and the poisonous succulent halogeton (*Halogeton glomeratus*) (weedy herbs introduced from Europe and Asia) (Kitchen and Jorgensen 1999, 2001).

Sheep Grazing Studies

The effects of domestic sheep grazing on salt-desert shrubland ecosystems have been under study at the Desert Experimental Range since 1934. In that year, specific grazing treatments were assigned to 20 paddocks, each 97 to 130 ha in size. Treatments combined one of three levels of grazing intensity with one or more seasons of use. Originally, seasonal treatments were autumn, winter, spring, autumn/winter, autumn/spring, and winter/spring. Later, autumn and winter grazing were combined into a single mid-December to mid-January dormant-season treatment. Spring grazing occurs in late March and early April when many plants are actively growing.

Two 0.4-ha exclosures are located inside each of 16 of the paddocks and serve as ungrazed reference areas. Vegetation changes are periodically measured using permanent plots located as paired series inside and outside each exclosure. The study design allows scientists to evaluate long-term patterns of salt-desert shrubland succession and response to climate variability with, and without, the different grazing treatments (Chambers and Norton 1993; Kitchen and Hall 1996; Alzerrca and others 1998). Research suggests that the salt-desert shrubland ecosystem is relatively insensitive to grazing intensity during winter months when plants are dormant. Conversely, spring grazing at all intensities causes ecosystem instability and the loss of important shrub species and a proliferation of annual weeds (Harper and others 1996).

Stop 6: Near Pine Valley Playa: Halogeton Invasion of Winterfat Shrublands

Winterfat also known as whitesage, is a dominant, evergreen shrub in Great Basin salt-desert shrublands. It is generally long-lived and extremely tolerant of drought. Winterfat is readily eaten by livestock and wildlife. The high nutritive value of this plant during winter was recognized by early livestock operators and is reflected in the common name. Though common throughout salt-desert communities, winterfat often occurs as near monocultures in the deep heavy-textured soils common to valley bottoms (Blaisdell and Holmgren 1984).

Numerous species of Eurasian plants are disruptive to North American ecosystems. Several of these aliens have successfully invaded shrublands of the Great Basin. Halogeton, a salt-adapted annual forb, is the most disruptive of these species on sites dominated by winterfat (Harper and others 1996; Kitchen and Jorgensen 2001). Although halogeton is a poor competitor in healthy perennial communities, it quickly occupies and dominates disturbances such as roadways, livestock bedding grounds, and rodent burrows. In good water years, large quantities of long-lived seeds are produced and dispersed by wind. Over time, halogeton can change the physical, chemical, and biological properties of soils making them unsuitable for most plants species (Harper and others 1996). The result is a form of desertification where winterfat-dominated shrublands are replaced by near pure stands of halogeton (Kitchen and Jorgensen 2001). Management of infested landscapes is further complicated by halogeton's toxic effects on livestock, especially sheep.

The first halogeton plants observed on the Desert Experimental Range were found near the playa in 1952. By 1958 it was widespread. Halogeton has increased in dominance with time as new disturbances presented opportunities for expansion. For example, spring mortality of winterfat was observed here at this stop west of the Pine Valley Playa in the early 1970s after intense thunderstorms caused late summer flooding. In the absence of perennial competition, halogeton quickly occupied the affected landscape. The halogeton stand has expanded episodically as more winterfat plants have died, effectively moving the winterfat-halogeton ecotone. Winterfat has failed to reoccupy halogeton-infested sites. Soils tests have quantified changes in soils 30 years after halogeton infestation (Duda and others 2003; Harper and others 1996; Kitchen and Jorgensen 2001). Current investigations focus on how halogeton-caused changes in the soil environment affect winterfat survival and seedling establishment. Strategies for restoring shrublands to halogeton-infested landscapes are also being tested. Studies evaluating the establishment and persistence of a variety of desirable shrubs on halogeton-infested landscapes are part of these tests.

Stop 7: Frisco Mine Town Site

The Frisco town site is located within the San Francisco Mining District near a low summit of the San Francisco Mountains approximately 27 km west of present-day Milford. It was established in 1876 after two miners discovered a large outcrop of ore on their way to work in September of the previous year. Believing the ore deposit was small, these miners sold their claim for \$25,000. Over the next 10 years the Horn Silver Mine would yield some \$60,000,000 silver, gold, zinc, copper, and lead (Anon. 2005). Reaching a population of approximately 6,000, Frisco emerged as the major residential and commercial center supporting the Horn Silver and smaller mines in the district. With no local source, water had to be freighted at least 20 km to supply the needs of the town. With over 20 saloons, brothels, and gambling halls, and frequent murders, Frisco gained a reputation of being a wild town even by mining town standards. A make-no-arrest lawman hired from Pioche, Nevada, is given credit

for creating a tamer environment by driving the lawless element from town.

Five large beehive ovens were constructed in 1877 to supply charcoal for the new Frisco Mining and Smelting Company smelters. Wood for the charcoal was primarily from pinyon pine (*Pinus monophylla*), Utah juniper, and curlleaf mountain mahogany (*Cercocarpus ledifolius*) growing on the slopes of the San Francisco Mountains. These ovens still stand and are in reasonably good condition. Other charcoal ovens were located elsewhere on the mountain at close proximity to good wood sources. The Utah Southern Railroad completed a line from Milford to Frisco in 1880. From the completion of the line, the ore was shipped to the Salt Lake Valley for smelting and the need for charcoal from the large smelters largely disappeared. A major cave-in at the Horn Silver Mine on February 12, 1885, marked the end of the mine and the town connected to it, although a small population persisted for a few decades. By 1920, 35 years after ore was first discovered, the mine and town were completely abandoned.

Stop 8: Greenville Bench Pinyon-Juniper Treatment and Reseeding Site _____

The final stop of the tour was at a pinyon-juniper treatment site, a few miles southwest of Beaver. This project is a cooperative effort between the USDI Bureau of Land Management, USDA Natural Resource Conservation Service, Utah Division of Wildlife Resources, and the non-governmental organizations, Beaver Conservation District and Sportsmen for Fish and Wildlife. The objectives of the project were to reduce sediment yields into the Beaver River and Minersville Reservoir and to improve wildlife habitat by reducing tree cover and increasing cover and production of preferred shrubs and perennial herbaceous species. Trees on treatment areas were individually reduced to piles of wood chips and shredded bark by a piece of equipment known as a bull hog. The distribution of these mulch piles provided an indication of pre-treatment tree density. Two separate seeding treatments were applied to adjoining areas using diverse seed mixes composed of either native or introduced species. Good herbaceous cover values were associated with both seed mixes. Tour participants were also able to compare treatment effects to untreated areas and ask questions of BLM project managers.

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