National Park Service
US Department of the Interior

International Dark Sky Park Designation
Great Basin National Park

Nomination Package

Prepared by
Kelly Carroll
Deanna Stever

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Executive Summary

Great Basin National Park was established by an act of Congress on October 27, 1986. Lehman Caves National Monument was abolished in that act, and the lands surrounding the cave incorporated into the new park. More than just Lehman Caves, Great Basin National Park encompasses over 77,000 acres that include several bristlecone pine groves, cultural history sites, mining history, the southernmost glacier in the United States, and Wheeler Peak, the tallest peak contained in the state of Nevada. Great Basin National Park is also one of the darkest locations in the continental United States.

Great Basin National Park lies along the eastern border of Nevada within a large geographic region known as the Great Basin. The Great Basin is an area defined by water though water itself is scarce. Consisting of a seemingly endless expanse of mountains and desert valleys, the Great Basin is aptly named because it is the only region of North America where water has no outlet to the sea. The Great Basin is also the largest desert in the United States. Great Basin National Park preserves a significant segment of this broader, diverse landscape.

Rising from the sagebrush flats on the desert floor, through extensive conifer forests at the park's middle elevations, and all the way to the alpine peaks of the Snake Range, the park exemplifies ecological diversity. Given its island-like setting amidst the desert landscape, the park is home to many uniquely evolved plants and animals, including ancient groves of bristlecone pines, the oldest living trees on earth. Crowned by Wheeler Peak, at 13,063 feet in elevation, Great Basin National Park also showcases an exceptional combination of geologic features and processes, such as Basin and Range topography, numerous glacial features, and a large collection of caves, including the celebrated Lehman Caves. Collectively, the park's diversity, remoteness, and challenging environmental conditions highlight the importance of adaptation—for plants and animals as well as for people.

The park's geology and hydrology provide the "canvas" for the many living communities that inhabit the park. This canvas consists of mountains, rock formations, caves, lakes, streams, and springs. The landscape in and around the park is a good example of what is found throughout the Basin and Range geologic province, an area characterized by long mountain ranges separated by equally long, flat valleys. During the ice ages, alpine glaciers, or cirque glaciers, were present in several locations along the Snake Range peaks. Great Basin National Park is home to the only remnant glacier in Nevada and one of the southernmost glaciers in the United States. Great Basin National Park encompasses most of the South Snake Range, one of the many ranges in this geologic province. Past and ongoing uplifting contributes to an ever-changing landscape. Geologic faults in the park and region are still active, with the mountains continuing to push upwards and basins continuing to widen.

Due to its remote location, Great Basin National Park provides one of the best opportunities within the national park system for people to experience dark night skies, expansive views, peaceful natural sounds, solitude, and clean air.

Figure 1. Bristlecone Pine and the Perseids Meteor Shower (Photo by K. Carroll)

UNIVERSITY OF Redlands

Department of Physics

November 3, 2015

Dear IDA Board Members:

It is with a pleasure that I recommend Great Basin National Park as an International Dark Sky Park. In the last eight years I have travelled extensively through America's national parks giving talks to the public and park employees about the importance of protecting dark skies. Over that period I spent considerable time outside at night in approximately 30 different national parks and monuments (including the 2007-2008 academic year in which I spent a 14-month sabbatical in the parks), photographing the sky and taking measurements as to its quality of darkness. Based on that experience, the quality of Great Basin National Park ranks possibly only second to Big Bend International Dark Sky Park. However, this is a ranking with an asterisk.

In Big Bend, the standout feature is that in the backcountry area south of the Chisos Mountains it is possible to observe the sky, and to the eye, see no apparent sign of light pollution. In Great Basin, because the park sits higher than the surrounding basin, the field of view is farther and so occasional lights are visible. However, because of the high altitude (over 7000 feet) the clarity of the atmosphere is far greater than at Big Bend, and the views of the Milky Way far superior. In fact, the view is so spectacular that I still remember might first sight of the Milky Way there six years later. I had arrived after dark driving a rented convertible. While driving up to the entrance road to the park with the top down (my eyes nowhere near fully dark adapted due to the lights of the car) I looked up and saw the Milky Way in far more detail than almost anywhere else I have ever seen it under fully dark adapted conditions. At that moment I had to pull off the road and let my eyes fully adjust.

This is precisely the quality of visitor experience the IDA had in mind when it first created the Dark-Sky Park program. And at Great Basin it's available right at the entrance without need for four-wheel-drive or an 8-hour trek into the backcountry. It doesn't require a Sky Quality Meter to tease out magnitudes per arcsecond down to the tenths of a decimal place or two-hours for the eyes to adjust to see that last wisp of nebulosity.

But a dark-sky park is more than its skies, it is also what it is doing to promote and preserve those skies. Rangers at Great Basin mount frequent night-sky programs and an annual night-sky festival that rival those of more famous parks. In addition, over the last several years the park has moved to construct the first research-grade telescopic observatory in the National Park System. This observatory is designed to take advantage of great Basin's unparalleled darkness to provide the public and small universities with a research tool for deep-sky imaging. Images from the observatory will be displayed in the visitor center, and results from projects using the observatory will inform ranger programs. The Great Basin Observatory will break ground in 2016 for the Centennial Celebration for the NPS and the 30th anniversary of Great Basin National Park. The observatory, together with Dark-Sky Park designation, will be a centerpiece to protecting one of the largest remaining dark-sky regions in the West.

Sincerely,

Tyler Nordgren
University of Redlands

United States Department of the Interior

NATIONAL PARK SERVICE
Great Basin National Park
Baker, Nevada 89311

IN REPLY REFER TO:

November 13, 2015

Board of Directors
International Dark Sky Association
3223 North First Avenue
Tucson, Arizona 85710-2103

To the International Dark-Sky Association (IDA) Board of Directors

Visitors travel across the high deserts of Nevada or Utah to visit Great Basin National Park. They come to see the ancient bristlecone pine trees, hike above 13,000 feet on Wheeler Peak, visit alpine lakes, explore Lehman Caves, find solitude in the backcountry, enjoy expansive vistas, and experience, most for the first time, a truly dark sky. Due to the park's remote location, high elevation, clear skies, and low humidity it offers some of the most pristine night sky viewing opportunities in the National Park System. The area is almost untouched by light pollution allowing visitors to appreciate the illumination of starlight. This IDA Dark Sky Park nomination reflects our growing dedication and commitment to preserving and sharing this outstanding resource. The Great Basin Dark Sky Park will continue to partner with federal agencies, tribes, private lands owners, and local communities to preserve the night skies while also expanding visitor opportunities and interpretive programs.

The National Park Service has established policies to protect the night sky as a valuable resource, and Great Basin National Park has incorporated these into our management practices and interpretive programs. Our recent Foundation Document identified night skies as a fundamental resource and value of the park, which reinforced the park's commitment to protecting its night skies.

Our astronomy programs are intensely popular and are offered up to three days a week during the summer, fall and spring. Visitors also love our Full Moon guided hikes, interpretive Star Train ride with the historic Nevada Northern Railway, solar telescope viewing, and the annual three-day Astronomy Festival.

Future plans and programs include the construction of a research-class astronomical observatory, the first in a National Park, to conduct novel and fundamental astrophysics and cosmological research, which, in addition to the scientific goals, will be used to develop unprecedented and innovative interpretative programs. The park also plans the construction of a permanent star gazing area/amphitheater that will help meet the tremendous demand for astronomy based interpretive programs at Great Basin National Park. This site will not only be utilized for the

park's formal astronomy programs, but it will encourage park visitor to immerse themselves in the primeval night sky on their own in a safe and welcoming environment.

The park recognizes that outdoor lighting is a valuable indicator of its commitment to the importance of dark night skies as a natural resource. To this end, the Park commits to an aggressive timeline to replace or remove all legacy lighting fixtures with full cutoff fixtures to ensure 100% compliance to IDA-DSP-GOL lighting standards by the end of 2017.

I support this nomination for the IDA International Dark Sky Park designation. Dark skies are symbolic of Great Basin National Park's values that encapsulate the remoteness and solitude into one encompassing experience. Thank you for your consideration of this nomination as we strive to preserve these dark skies and to bring awareness and appreciation of the importance of night sky resources.

Sincerely,

Steven Mietz, Superintendent
Great Basin National Park

Friday, November 6, 2015

Board of Directors
International Dark Sky Association
3223 North First Avenue
Tucson, Arizona 85710-2103

To the International Dark Sky Association (IDA) Board of Directors

The Great Basin National Park Foundation fully supports the application of Great Basin National Park to become an International Dark Sky Park. Indeed, we provided funds this year (2015) for an Intern to help the Park complete its application.

Great Basin National Park is one of the last truly dark night sky sites in the contiguous U.S. Because of this, the Park has developed an Astronomy Program with several weekly presentations, guided full moon hikes, meteor shower watching parties, an annual three-day Astronomy Festival, and even rides on a Star Train with the Nevada Northern Railway where passengers travel with Park Rangers trained in astronomy and take part in presentations, viewings and family activities. Numbers of visitors attending these programs have increased annually and this year, 2015, visitors attending astronomy programs exceeded 10,000.

In recent years, the Great Basin National Park Foundation, which I chair, has donated portable telescopes for the program and a trailer for astronomy outreach transportation as well as a backdrop for screening astronomy-related slides and videos. But as the natural resource of darkness has become rarer and thus more valuable, the scientific community and the general public have encouraged the Park to capitalize more deeply and permanently on the opportunities presented by this site.

As a result, the Foundation joined with the Park and four universities----University of Nevada Reno, Western Nevada College, Concordia University (California), and Southern Utah University---to build and operate a world class astronomical observatory sited at Great Basin National Park. We are currently in the last stage of fundraising for the initial phase of this project, the construction, equipping, and installation of the Great Basin Observatory (GBO). We expect to launch operation of the GBO in 2016, commemorating the 100'h birthday of the National Park Service and 30'h anniversary of the founding of the Park.

P.O. Box 181, Bai,:er, Nevada 89311

Stargazers have always searched for views of the night sky that are accessible, clear and dark. But as you know in recent decades these have become more difficult to find. With the global population growing and the advance of electrification, astronomers have had to seek out some of the world's most remote locations that afford maximum views of the heavens without significant degradation from manmade light.

Great Basin National Park's dark, clear, and stable night skies are already among the very best in the lower forty-eight states. They are truly nearly natural, with few sources of artificial lighting anywhere in the Park. The Park is fully aware of the benefit of good lighting and already includes messages in its on-site, online, and outreach interpretation programs about dark night skies, the critical importance of preserving them unimpaired, and ways to improve night lighting. The natural resource of dark night skies is one of the central themes communicated through interpretation. Furthermore, the Park is located in an extremely sparsely populated area. The local town is five miles down the hill from the boundary where Park headquarters, Lehman Caves visitor center, and employee housing are located at 6,825 feet elevation. The town has one streetlight and very few other night lights with a population of less than 100 people. Finally, the Foundation is seeking funds to help the Park implement its lightscape Management Plan.

The Board of Directors of the Great Basin National Park Foundation is excited about Great Basin becoming an International Dark Sky Park. We are hopeful that you will find that the Park meets all of the eligibility requirements and that you will designate it an International Dark Sky Park. Although we have already obtained wonderful financial support and endorsements for the Great Basin Observatory, the designation, as you can imagine, will be a critical achievement and new element of support for the GBO just as the GBO, as it operates for many long years in the future, will help the Park to preserve its unparalleled dark night skies.

If we can help in any way please let me know. I'm enclosing a brochure, list of science partners, and endorser list for the Great Basin Observatory.

Sincerely,

Rebecca Mills, Chair
Great Basin National Park Foundation

P.O. Box 181, Baker. Nevada 89311

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GREAT BASIN HERITAGE AREA PARTNERSHIP

Post Office Box 78; Baker, Nevada 89311

October 27, 2015

Board of Directors
International Dark-Sky Association
3223 North First Avenue
Tucson, AZ 85719

To the IDA Board of Directors,

As the Executive Director of the Great Basin Heritage Area Partnership (GBHAP), I would like to express my support for Great Basin National Park's effort to be recognized as an International Dark Sky Park. GBHAP is the coordinating entity for the Great Basin National Heritage Area, a 20,000 square mile area straddling the Nevada-Utah border that was designated by Congress for its superb natural and cultural features, including night skies. When describing the heritage area, I often reference photographs of Earth at night taken from space. I point out the large dark area in the western U.S. and say, "The Great Basin National Heritage Area is right in the middle of that." Great Basin National Park sits in the center of the heritage area and is the epicenter of that beautifully dark region.

Great Basin National Park does much more than occupy a dark corner of our country. The park is also dedicated to interpreting this ever-diminishing resource through its astronomy programs. Ranger programs given three times a week throughout the summer have reached thousands of visitors, and the annual astronomy festival has reached thousands more. Great Basin's Dark Rangers also partner with local organizations in activities such as the Nevada Northern Railway's "star train" in Ely, NV. These programs do more than teach visitors about our night skies: the local businesses now recognize our skies as a key to their economic health. They see a direct correlation between night sky tourism and increased spending in the community, moving them from appreciators of this resource to defenders.

The Great Basin Heritage Area Partnership fully supports Great Basin National Park's recognition by the International Dark-Sky Association for its pristine night skies and its efforts to teach about and protect them.

Sincerely,

Brandi E Roberts

Brandi Roberts
Executive Director
Great Basin Heritage Area Partnership

Dave Tilford
P.O. Box 150301
Ely, Nevada 89315
775-289-0578
wprealty@mwpower.net

October 29, 2015

Kelly Carroll
Supervisory Park Ranger
Great Basin National Park
Baker, NV 89311

Dear Kelly,

Over the past 60 years I have seen many changes in the environment and landscapes around Great Basin National Park and Eastern Nevada. The one thing that has changed very little, especially over Great Basin National Park, is the Dark Night Sky.

Dark Night Skies are fast disappearing from around the world. It is imperative that the Dark Night Sky over this park be preserved and designated by the IDA as a Dark Night Sky Reserve.

Thousands of visitors a year visit Great Basin National Park for the many natural resources it has to offer including beautiful Lehman Caves, the high mountain range with the ancient Bristlecone Pine and growing in popularity more and more each year the weekly summer astronomy programs. Without the dark night sky over Great Basin Park the astronomy program will fade away as will the stars if we fail to preserve the level of darkness we now have. I urge the IDA to grant this designation.

I have been a resident of Eastern Nevada (White Pine County) for over seventy years and have set on the Great Basin National Park Foundation Board for 17 years and on The Great Basin National Park Observatory Project committee as well as the Great Basin National Heritage Area board of directors since its inception.

I am here to help in any way.

Respectfully,

Dave Tilford

2. Description of Great Basin National Park Night Sky Resources

Location and Description of the Park

Hidden among a seemingly endless desert of mountains and valleys is one of the darkest places left in the United States. Protected by its considerable distance from human populations, high elevation, lack of humidity and air pollution, Great Basin National Park is a premier location to experience the glow of starlight. Great Basin National Park was established by an Act of Congress on October 27, 1986 because it "preserves an outstanding segment of the Great Basin including old-growth bristlecone pines, rich biodiversity, Lehman Caves and other distinctive geologic features, expansive scenic views, 13,000 years of human history for the inspiration, enjoyment and scientific understanding of current and future generations." (Great Basin National Park, 2015)

Figure 1. Bristlecone Pine. (Photo by NPS)

77,000 additional acres are included in the park that covers most of the Southern Snake Range of eastern Nevada. Elevations begin at 5300 feet in the valley and rise above 13,000 feet at Wheeler Peak, one of the tallest peaks in Nevada. Great Basin National Park is located near the eastern border of Nevada within the Great Basin physiographic region. This region is dominated by abundant mountain ranges separated by expansive valleys. The boundary of this area is also defined by water, which, unlike the rest of North America, does not drain into the ocean.

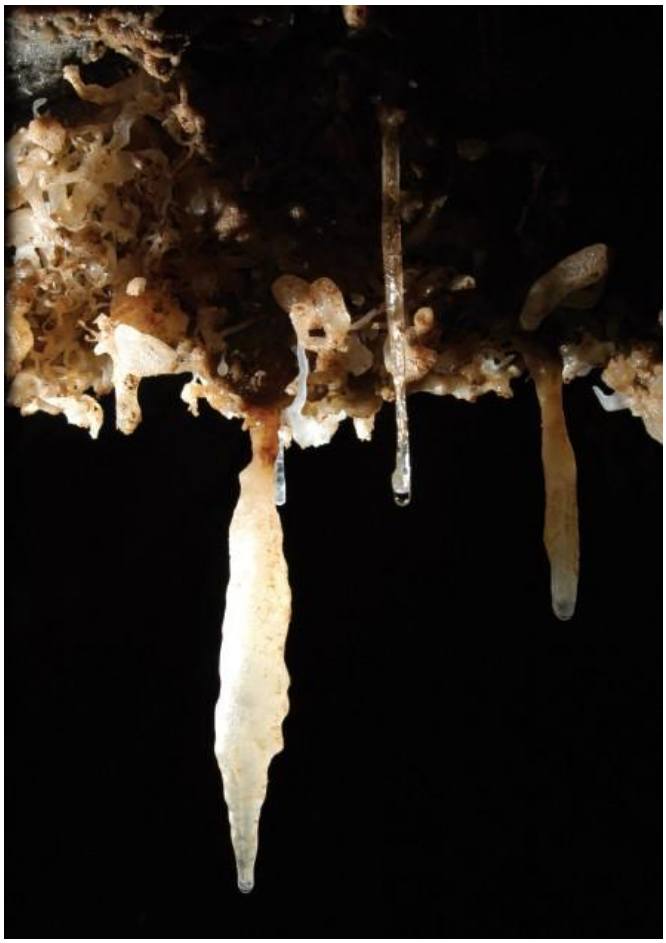


Figure 2. Lehman Caves (Photo by NPS)

The park's geologic history is recorded in a combination of extraordinary geologic features and processes that span over 500 million years. These characteristics include alpine mountain peaks, igneous intrusions, metamorphosed rock, caves (including the popular Lehman Caves), alpine lakes, streams, and springs. The park is located in the Basin and Range Tectonic province where the earth's crust is experiencing tensional forces from the east and west. This stretching causes the crust to break into north-south trending faults that border the resulting mountains. Alpine glaciers were present along the peaks during the ice ages and the proposed Great Basin Dark Sky Park still contains the only remnant glacier in the state.

Humans have lived in the Great Basin for over 13,000 years and have successfully adjusted to significant environmental changes. The climate has changed from a post-glacial landscape during the Paleo period to a desert environment during the Archaic period. Living on park lands and the surrounding areas, Fremont, Paiute and Shoshone peoples have left us traces of their past in archeological sites, rock art and traditional cultural places that provide an illustration of their way of life. People of European descent, miners, sheepherders, cattle ranchers, and farmers arrived later and built homes and lives, leaving their traces on lands protected by the park. Today ranching, farming, and mining activities on private and other public lands continue to support the population of communities surrounding the park.

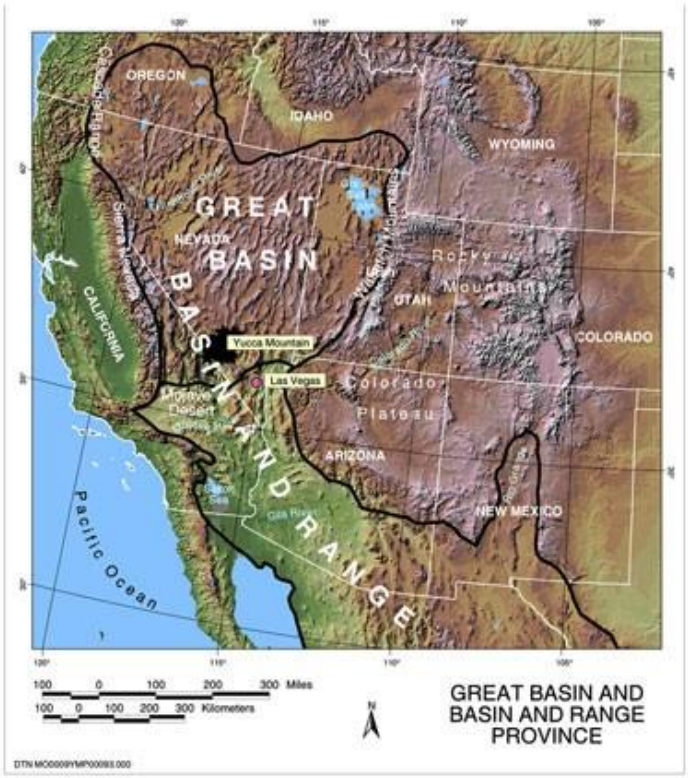


Figure 3. Basin and Range Province (Photo by NPS)

Biological diversity is extraordinary within the park, which lies within the Great Basin Desert, the largest and only "cold" desert in the United States where the majority of precipitation falls as snow. Basin and Range topography have caused the Snake Range to be isolated among the broader desert creating "island biogeography." Plant and animal species are insulated from other regions in the desert, forcing them to adapt and evolve separately. With an elevation ranging from 5300 feet to 13,063 feet, and a vertical gradient of 8000 feet, Great Basin National Park is home to 800 different species of plants, including the ancient Bristlecone Pines, and abundant animal life. (Great Basin National Park, 2015)

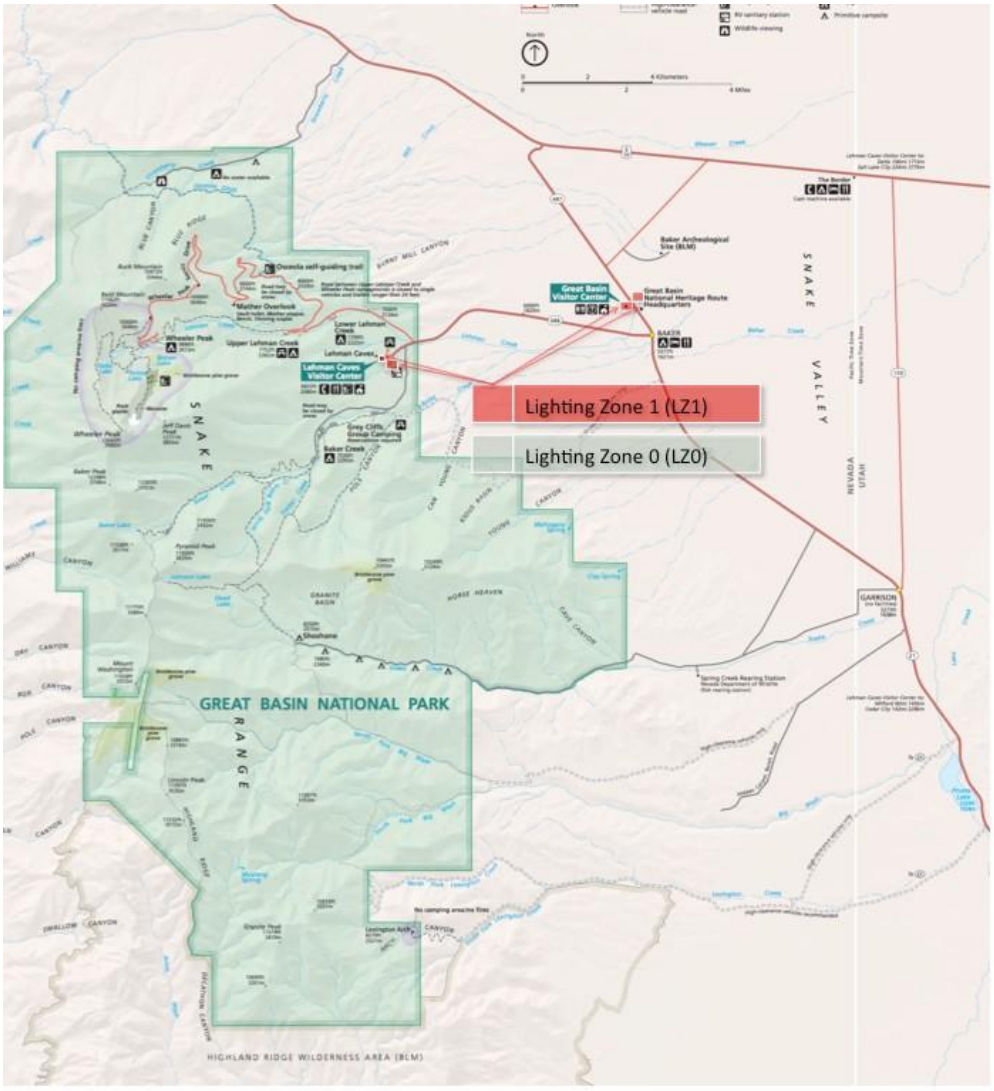


Figure 4. Map of Great Basin National Park

Visitation

The park is located in a remote part of the western United States with limited services so visitors must come prepared. The nearest major airports are located in Salt Lake City (234 miles) or Las Vegas (286 miles). Those who make the journey are offered extraordinary recreational and educational experiences. Visitors can enjoy a paved scenic drive to Wheeler Peak, rugged alpine hiking, stargazing, stream fishing, cave tours and wild caving, astronomy programs, camping in developed campgrounds or primitive sites, picnicking, biking, wildlife viewing, and numerous ranger-led programs. The location of the park is far from developed and urban areas and provides the visitor with an opportunity to find solitude, discovery and admiration of an untouched landscape and sky. The limited artificial lighting in the park and surrounding area, lack of interfering noises and minimal air pollution provides excellent conditions for the enjoyment of dark night skies, natural sounds, and clean air. Visitors can access the dark skies of the park every night of the year with no entrance fee to get in the park.

Visitation has increased tremendously over the last five years. In 2010 total park visitation was approximately 80,000 per year, in 2015 visitation is expected to surpass 125,000. There are many factors involved in this increase, but the seeking of a truly dark night sky and the popularity of the park's night sky interpretation program have been significant factors in choosing the park as a destination.

Figure 5. Remote Hiking in Great Basin National Park (Photo by NPS)

3. Ecology

The Park supports a diverse group of plant communities, wildlife and aquatic habitats that spread across its 8,000 feet of topographic relief. Elevation variation and variety in microclimates are supportive of immense biological diversity.

Intermountain Cold Desert Scrub

Present in most valleys of the Great Basin is Intermountain Cold Desert Scrub, the most extensive habitat in Nevada. The most prominent plants are of the goosefoot family including shadscale, greasewood, and winterfat. Kit fox, dark kangaroo mouse, long-nosed leopard lizard, and pallid bats live among these dense shrubs.

Sagebrush Grassland

The sagebrush habitat, found from 4,500 to 10,000 feet, is typically mixed in a mosaic of other habitats. Nevada is home to twenty-seven different species of sagebrush and eight animals dependent on the plant for their lifecycle. Pygmy rabbit, Great Basin pocket mouse, sagebrush vole, sagebrush lizard, greater sage-grouse, sage thrasher, Brewer's sparrow and sage sparrow all rely on the sagebrush and their undergrowth of bunch grasses.

Pinion/Juniper Woodlands

The largest forests in the area are dominated by singleleaf pinion pine and Utah juniper, found between 6,000 and 8,000 feet. Often called PJ, the pinion /juniper woodland provides habitat for pinion jays and cliff chipmunks. Sprinkled in pockets is another hardy evergreen known as mountain-mahogany. Some of these stands are old-growth with trees over 1,000 years old. The nuts of the pinion pine, called pine nuts, provided a valuable food source for early humans and still provide food for many animals**.**

Figure 6. Pinion-juniper woodland (Photo by K. Carroll)

Mixed Conifer and Subalpine Forest

These mixed conifer forests live up to their name with Douglas-fir, white fir, ponderosa pine, quaking aspen, green-leaf Manzanita, mountain snowberry, mountain mahogany, creeping barberry, mountain big sagebrush, and common juniper. This forest, found from 8,000 to 11,800 feet, creates critical habitat for the American Three-Toed Woodpecker, Dusky Grouse, Northern Goshawk, Inyo Shrew, and Vagrant Shrew.

The subalpine forest is home to Engelmann spruce, limber pine, and the famous Great Basin bristlecone pine with an understory of common juniper, currant, Ross's sedge, and Fendler's meadow-rue. Inhabitants of this forest include golden-mantled ground squirrels and Clark's nutcrackers.

Figure 7. Rocky Mountain Big Horn Sheep at Great Basin National Park (Photo by NPS)

Alpine

Found above the tree line, 10,500 to 13,063 feet, is the alpine habitat. Devoid of larger plants, cryptogrammic crust composed of lichens, mosses, fungi and cyanobacteria provide subsistence for the black rosy finch and gray-crowned rosy-finch. Other animals such as rock wrens, Piute ground squirrel, and bighorn sheep are encountered.

Riparian

These habitats are located around the thousands of springs and dozens of streams in the region, yet makeup only a small percentage of the overall habitat. They are extremely diverse and are home to Wood's rose, narrowleaf cottonwood, water birch, redosier dogwood, willow, quaking aspen and a variety of herbs. Animals living in these areas include wandering garter snake, water shrews, MacGillivary's warbler, American Pipits and many more.

Caves and Mines

Naturally formed caves and man-made mines provide similar habitat for those who specialize in underground living. These include millipedes, springtails and pseudoscorpions that live their entire lifecycle underground. Other cave dwellers like bats, crickets, and beetles rely on the protection of the underground for only a portion of their life. (Baker, 2012)

Figure 8. Pseudoscorpion in Lehman Caves (Photo by NPS)

Threats to the Ecosystem

Though Great Basin National Park strives to balance the ecosystem within its borders, it is still connected to the rest of the world and subject to many threats. Proposed ground water pumping of bordering Spring Valley and Snake Valleys have the potential to drop the water table and cause spring and streams to dry up. Nearby coal-fire power plants degrade air quality and water quality. The invasion of cheat grass menaces the success of native species and global climate change threatens to modify the plant and animals communities of the Great Basin entirely.

4. Cultural History and Significance

Three separate prehistoric culture periods are represented within the proposed Great Basin Dark Sky Park: the Paleo-Indian Period (12,000 BC-9,000 BC), Archaic Period (9,000 BC–500 AD), and Fremont (500 AD–1300 AD). Caves, rock shelters and large-scale ground surveys have provided most of the known prehistory of the Great Basin.

Paleo-Indian Period (12,000 BC-9,000 BC)

The Paleo-Indian people were big game hunters who lived in small nomadic groups with the ability to follow the animals they hunted. They used large fluted and unfluted projectile points such as Clovis, Folsom and Plano points to hunt now extinct Pleistocene fauna such as camel, bison, mammoth, ground sloth and horse. Paleo-Indian sites often are found in the open as "kill sites" or along terraces adjacent to dried paleo-lakes as sites preserved in caves and rock shelters.

Figure 9. Paleo-Indian Points (Photo by Univ. of North Carolina)

Archaic Period (9,000 BC- 500 AD)

As the climate changed and the lakes dried, many of the larger Pleistocene game animals disappeared in the Great Basin, causing an extensive food gathering pattern to evolve called the Great Basin Desert Archaic. This pattern employed the use of a broader range of plant and animal goods. Manos and milling

stones, seed-grinding implements, were used to grind hard-shelled grass seeds. Basketry, netting, fiber and hide moccasins, spears and digging sticks are other artifacts connected with this period.

Archaic sites are mostly found in open areas adjacent to springs and preserved in caves and rock shelters. Danger Cave, Newark Cave, Swallow Cave, Amy's Shelter, and Kachina Cave are adjacent to the park and excavations have recovered various archaic components. There are many sites scattered around the park that include caves, rock shelters, campsites, stone manufacturing areas or lithic scatters, artifact scatters, pictographs, petroglyphs, and burial areas.

Fremont Period (500 AD- 1300 AD)

During the Fremont Period, the Great Basin was inhabited by peoples of a more sedentary nature. The Fremont were small-scale farmers that lived in little villages or farmstead communities and supplemented their diet with hunting and gathering.

The Fremont people have a distinctive artistic style represented in their pottery, clay figurines and rock art. They also built residential and food storage structures that were quite substantial and are preserved near the park. Within and around the park other Fremont sites include antelope drives, hunting blinds, cemeteries, and plant food processing stations along with Fremont style rock art. The park lies on the western edge of the Fremont frontier, and it is likely that they did not arrive in the Great Basin until 700-1100 AD.

Figure 10. Upper Pictograph Cave Pictographs (Photo by NPS)

Shoshone

The ethnographic territory of the Numic-speaking Western Shoshone (1300 AD-present) includes the proposed Great Basin Dark Sky Park. When the Euroamericans first came to the area, seven Shoshone villages were present in the Snake Valley area.

The Western Shoshone seasonally lived in small detached kin groups near water sources. Several times a year multiple groups would gather together for ceremonies and group hunts. Food gathering activities focused on collecting vegetal food and on animal hunts. In the fall pinion nuts were collected and stored, and communal rabbit and antelope drives were performed with other groups. In the winter families gathered in the pinion pine forests to live in villages until spring and summer came, and they could scatter into the lower valleys to collect grass seeds, tubers, and small mammals.

The Western Shoshone constructed domestic structures that were typically conical-shaped brush houses held up by wood pole frames with circular floors covered in grass or mats. Additionally the Shoshone used caves, rock shelters, brush lean-tos, and four post sunshades as domestic structures. (Unrau, 1990)

Historic

Beginning in 1869, Europeans settled in the Snake and Spring Valleys forming six mining districts. Ranching and farming activities began in the valleys during the mid-1800s. The most well-noted rancher and farmer was Absalom Lehman, who produced food for the miners in the area on his "Cave Ranch", named after he discovered Lehman Caves in 1885. He also grew fruit trees in an orchard that still stands today. Many of the communities surrounding the park remain the same size as they were 100 years ago with the support of continued ranching, mining, tourism, and government jobs. (Comer et al., 2015)

Figure 11. Tilford Cabin (Photo by K. Carroll)

5. Weather, Climate and Air Quality

The Park has an extreme high desert climate due to its location adjacent to the mountainous terrain of the Sierra Nevada, bordering to the west. These mountains capture the moist, mild Pacific air and cool it rapidly causing the moisture to condense into rain and snow. Once the air crosses the Sierra Nevada and descends across the Great Basin, the relative humidity drops. Moisture from the Gulf of Mexico is captured by the Rocky Mountains to the east resulting in a climate isolated from moderating oceanic climates with fairly high annual temperature fluctuations.

Variation in temperature occurs daily and annually with a tremendous difference between the mountaintops and valleys. The mountains are typically windier and cooler and then the valleys that heat up during the day. During the night, the valley air cools rapidly and the cold air sinks below the warm air, making both the high elevations and low elevations harsh environments.

When compared to the rest of the United States, the Great Basin has relatively clean air, mainly due to limited point sources of pollution and low population density. Greater Los Angeles creates a large plume of aerosol pollution that occasionally reaches the Great Basin and affects the park's visibility.

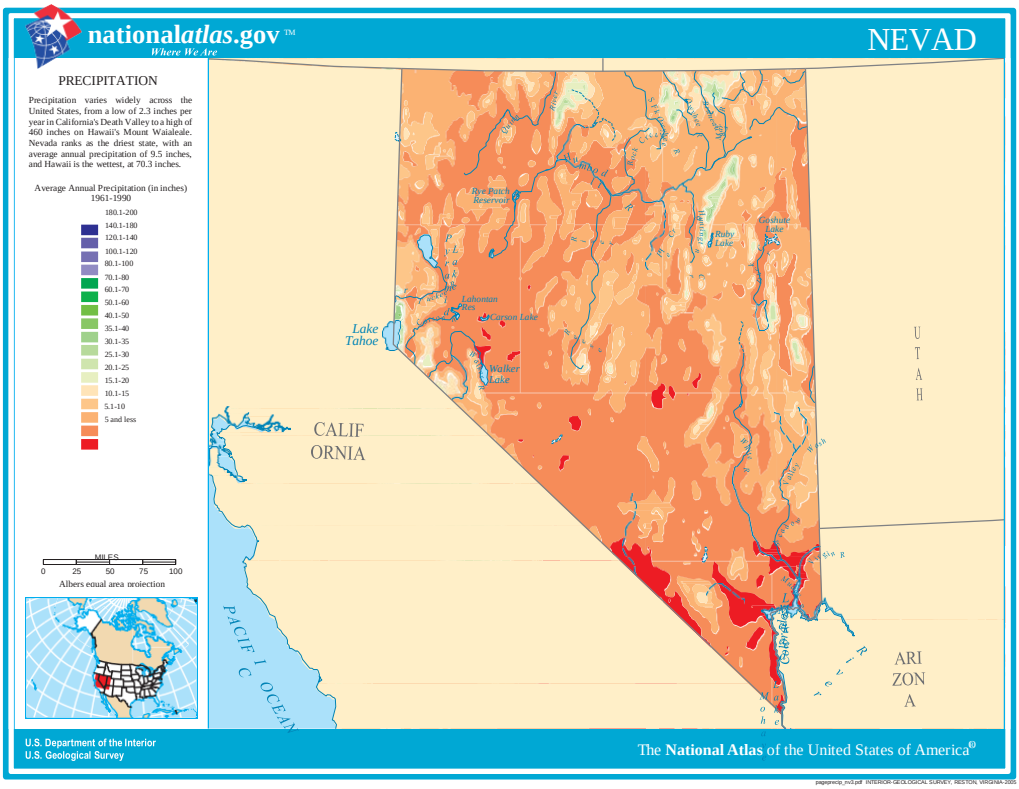


Figure 12. Average Annual Precipitation Map – Nevada (Source National Atlas)

6. Sky Quality Data

Great Basin National Park has one of the highest quality night skies measured by the NPS. In an expanding survey of 45 park units Great Basin ranks in the top five. Night sky quality is principally degraded by light pollution— emissions from outdoor lights that cause direct glare and reduce the contrast of the night sky--but atmospheric clarity also plays a role. The better the atmospheric clarity of the night sky the further the impact of a given light source.

Figure 13. Wheeler Peak Milky Way (Photo by D. Duriscoe)

The combination of clear air (free of aerosols and water vapor that reduce visibility), land with high elevation relative to its surroundings, and a sparse human population in the immediate vicinity of the park results in a view of the night sky that is vulnerable as well as pristine. Photometric measurements taken within the park show that zenith sky condition is virtually unaltered, attaining the theoretical natural darkness of 21.90 magnitudes per square arc-second and even going beyond that in one dataset to 22.19 magnitudes per square arc-second. Three artificial light domes are humanly visible from mountain summits within the park from Las Vegas (311km), Salt Lake City (290km), and the Ely area (62km). The Ely light dome itself is resolvable into three sources, presumed to be Ely, Ruth, and McGill. The visibility of these light domes is remarkable given their distance and a testament to the transparency of the air, but they are minor impacts to an otherwise natural sky. A baseline brightness of these light pollution sources has been established, and these can be monitored over time. A photometric report from the park and images are included below.

The night skies of Great Basin are sought by park visitors and are one of the key interpretive themes provided by the park. Amateur astronomers travel to observe in the park and the night sky quality there is considered a nationally significant resource.

Regional Sky Brightness

Sky glow from the regional location does not significantly affect night sky at Great Basin National Park. From mountain summits, light domes are photometrically visible from regional cities. The very few residential lights in Baker, NV do not create a visible light dome at any location within the park and are minimal in nature. The Local Baker Advisory Board established an agreement with Mt. Wheeler Power (the local power coop) that all outdoor residential security lighting be changed to full cutoff fixtures as residents request or as any new security lighting is installed.

City	Distance (mi)	Azimuth (D)
Baker, NV	5	98
Ely, NV	46	306
Delta, UT	93	71
Cedar City, UT	106	144
St. George, UT	131	165
Salt Lake City, UT	174	44
Las Vegas, NV	199	15

Figure 14. Distance and Direction to Regional Cities

Figure 15. Night Sky Image from Buck Mtn. Showing Local Light Domes (Photo by D. Duriscoe)

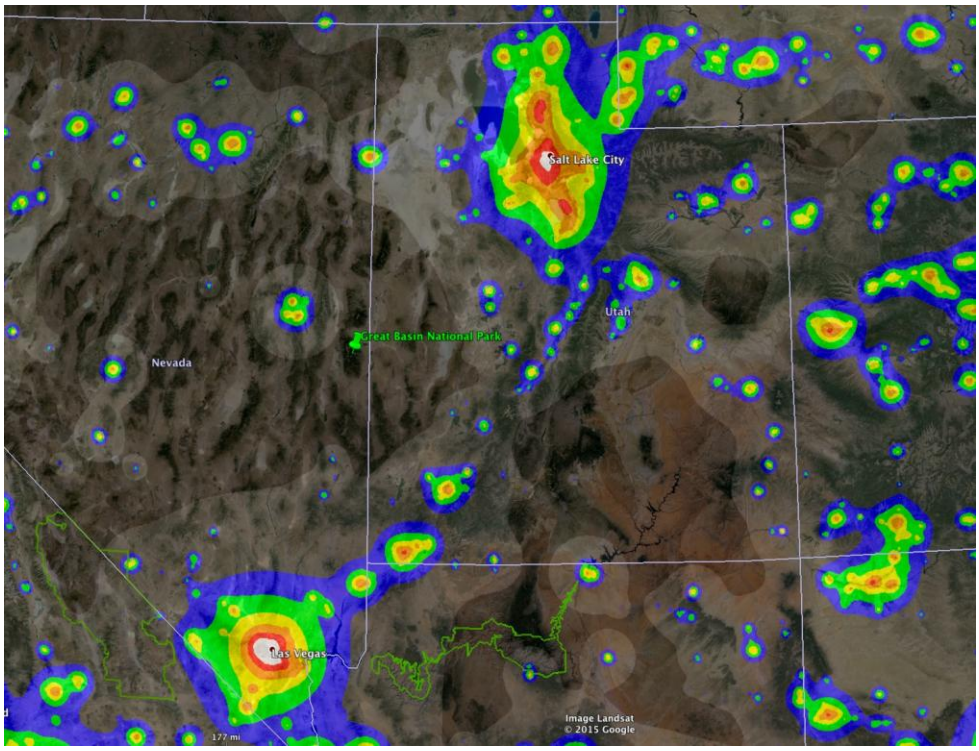


Figure 16. Regional Sky Brightness (Source Google Earth)

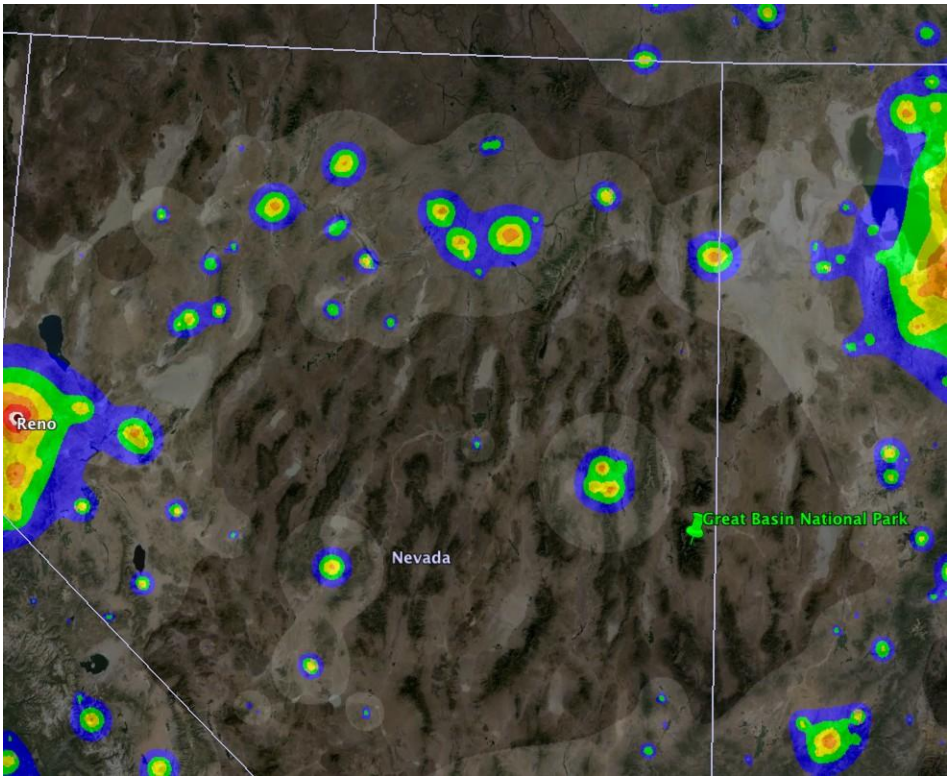
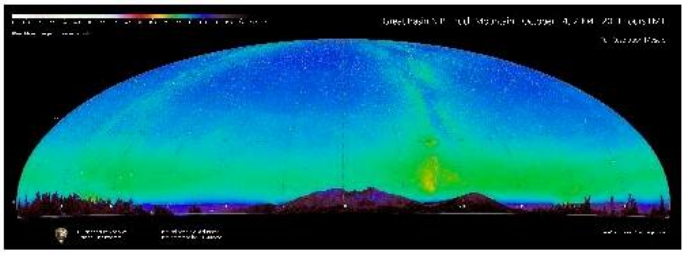
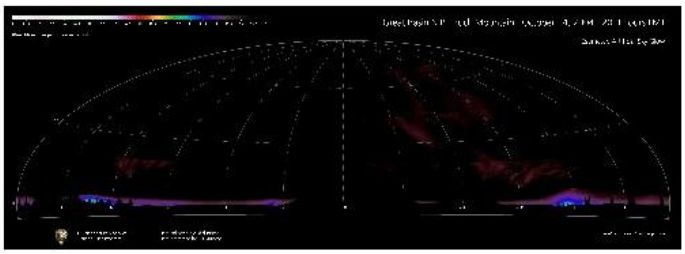


Figure 17. Regional Sky Brightness in the Great Basin Hydrological Province (Source Google Earth)

Night Sky Quality Survey

In 2004, 2005, and 2006 the NPS Natural Sounds and Night Sky Division conducted photometric surveys creating night sky monitoring quality reports on Buck Mountain and Mt Washington inside the park. Below are the data collected in both surveys. A photometric report from the park and images are included below.

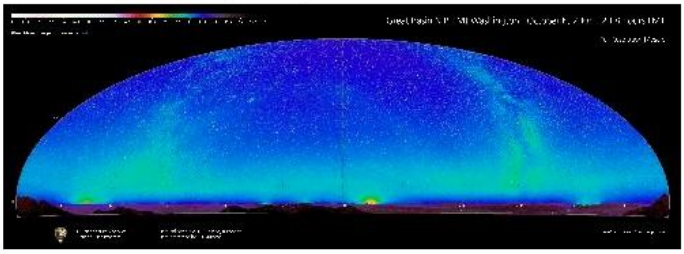
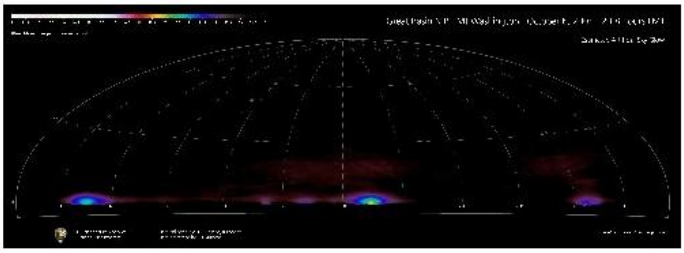
Category	Details	Observed and Estimated Artificial Sky Brightness Mosaics
Park:	Great Basin NP	Click on either image for a high resolution view --THESE ARE LARGE FILES
Site Name:	Buck Mtn.	
Longitude:	-114.30	
Latitude:	39.03	
Elevation (m):	3356	
Date (LMT):	14-Oct-2004	
Time (LMT Hours):	20.02	
Camera:	SBIG1	
Lens:	Nikon 1.8	
Observers:	D Duriscoe	
Air temp. (°C):	3.3	
R. H. (%):		
Wind Speed (mph):	2	
Extinction Coeff. (mag/airmass):	0.11	
NELM:	6.8	
Bortle Class:	2	
Synthetic SQM:	21.11	
SQI All- sky:	**97.6**	
SQI to Z.A. 70°:	**98.7**	
Number of stars visible:	**3400**	

NARRATIVE: Site on summit of Blue Ridge (Buck Mountain) just east of saddle to Bald Mountain, in a jumble of rocks. Cross country travel from Wheeler Pk. Trailhead parking, not good for public or telescopes. Sky pretty bright, apparently from airglow, but still reveals considerable detail in Milky Way. Light domes from cities insignificant, would not be noticed from in the canyon. As near pristine from light pollution as any site yet visited. Very clear air, some hint of layered haze, seeing fair.

Figure 18. Photometric Survey 2004

Indicator	Observed		Estimated Artificial		Light Pollution Ratio (Artificial/Natural)
Sky Luminance Measures					
	mag/ arscec^2	µcd/ m^2	mag/ arscec^2	µcd/ m^2	
Zenith	21.21	354	> 24.5	< 17	< 0.10
Mean all-sky	20.84	501	25.38	8	< 0.04
Brightest	19.87	1,207	20.52	665	3.89
Darkest	21.32	318	> 24.5	< 17	< 0.10
Median	20.89	473	> 25.1	< 10	< 0.03
Illuminance Measures					
	mags	milli-lux	mags	milli-lux	
Horizontal	-6.85	1.39	-2.71	0.03	0.04
Max Vertical	-6.36	0.89	-2.61	0.03	0.07

Figure 19. Photometric Survey 2004

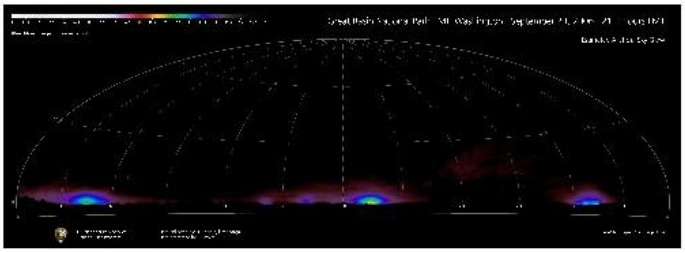
Category	Details	Observed and Estimated Artificial Sky Brightness Mosaics
Park:	Great Basin NP	Click on either image for a high resolution view --**THESE ARE LARGE FILES**
Site Name:	Mt Washington	
Longitude:	-114.31	
Latitude:	38.91	
Elevation (m):	3558	
Date (LMT):	06-Oct-2005	
Time (LMT Hours):	23.83	
Camera:	SBIG1	
Lens:	Nikon 1.8	
Observers:	D Duriscoe B Roberts	
Air temp. (°C):	4.3	
R. H. (%):	5.0	
Wind Speed (mph):	10	
Extinction Coeff. (mag/airmass):	0.12	
NELM:	7.2	
Bortle Class:	1	
Synthetic SQM:	21.38	
SQI All- sky:	**97.6**	
SQI to Z.A. 70°:	**99.6**	
Number of stars visible:	**3990**	

NARRATIVE: Summit of Mt. Washington, 1/4 mile walk from end of road. Spectacular site but very exposed, cold, windy. Excellent sites for public or telescope near end of road but difficult 4WD access. Very transparent, seeing fair, breezy, exceptionally dry at 5% R.H. Airglow has distinct blue green color, gegenschein easily seen but not the entire zodiacal band. Detail in the Milky Way in Cassiopeia substantial, M33 easy naked eye object, seen with direct vision. Light domes of Las Vegas and Salt Lake City are apparent but not brighter than Mars, brighter areas below the level horizon. Lack of oxygen may be a handicap for visual observing.

Figure 20. Photometric Survey 2005

Indicator	Observed		Estimated Artificial		Light Pollution Ratio (Artificial/Natural)
Sky Luminance Measures					
	mag/ arscec^2	µcd/ m^2	mag/ arscec^2	µcd/ m^2	
Zenith	21.60	249	> 24.5	< 17	< 0.10
Mean all-sky	21.15	375	24.75	13	0.05
Brightest	19.58	1,574	19.81	1,278	7.47
Darkest	21.59	247	> 24.5	< 17	< 0.10
Median	21.19	356	> 25.1	< 10	< 0.03
Illuminance Measures					
	mags	milli-lux	mags	milli-lux	
Horizontal	-6.54	1.05	-1.98	0.02	0.02
Max Vertical	-6.04	0.66	-3.03	0.04	0.10

Figure 21. Photometric Survey 2005

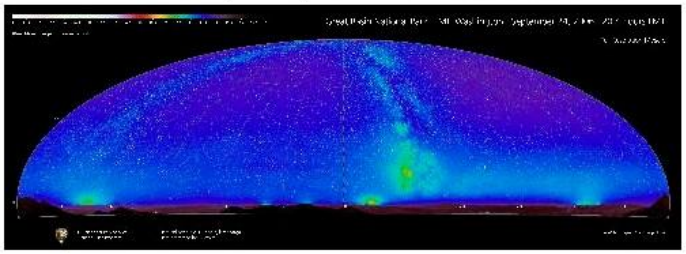
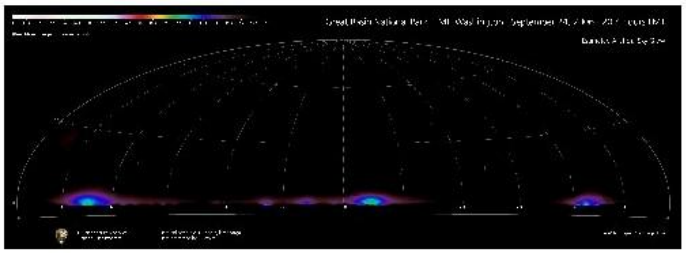
Category	Details	Observed and Estimated Artificial Sky Brightness Mosaics
Park:	Great Basin NP	Click on either image for a high resolution view --**THESE ARE LARGE FILES**
Site Name:	Mt. Washington	
Longitude:	-114.31	
Latitude:	38.91	
Elevation (m):	3560	
Date (LMT):	23-Sep-2006	
Time (LMT Hours):	21.32	
Camera:	IMG 1	
Lens:	Nikon 1.8	
Observers:	C Moore K Magargal	
Air temp. (°C):	-6.7	
R. H. (%):	78.0	
Wind Speed (mph):	2	
Extinction Coeff. (mag/airmass):	0.14	
NELM:		
Bortle Class:		
Synthetic SQM:	21.79	
SQI All- sky:	**97.2**	
SQI to Z.A. 70°:	**99.6**	
Number of stars visible:	**5140**	

NARRATIVE: Light domes of Las Vegas, Salt Lake City, St. George, Mequite, and Cedar City.Layered haze towards east. Haze was lower or smoother to west. M13 easy target. M 15 difficult direct vision target. Air was steady. Multiple ranch lights visible to both E and W. Garrison was visible. Frost accumulated but none noted on camera lens. Humidity was higher than expected.

Figure 22. Photometric Survey 2006

Indicator	Observed		Estimated Artificial		Light Pollution Ratio (Artificial/Natural)
Sky Luminance Measures					
	mag/ arscec^2	µcd/ m^2	mag/ arscec^2	µcd/ m^2	
Zenith	21.83	200	> 24.5	< 17	< 0.10
Mean all-sky	21.63	241	24.68	14	0.06
Brightest	19.58	1,578	19.71	1,399	8.18
Darkest	22.11	154	> 24.5	< 17	< 0.10
Median	21.68	228	> 25.1	< 10	< 0.03
Illuminance Measures					
	mags	milli-lux	mags	milli-lux	
Horizontal	-6.07	0.68	> -1.0	< 0.01	< 0.01
Max Vertical	-5.66	0.46	-3.07	0.04	0.11

Figure 23. Photometric Survey 2006

Category	Details	Observed and Estimated Artificial Sky Brightness Mosaics
Park:	Great Basin NP	Click on either image for a high resolution view --**THESE ARE LARGE FILES**
Site Name:	Mt. Washington	
Longitude:	-114.31	
Latitude:	38.91	
Elevation (m):	3560	
Date (LMT):	24-Sep-2006	
Time (LMT Hours):	20.39	
Camera:	IMG 1	
Lens:	Nikon 1.8	
Observers:	C Moore K Magargal	
Air temp. (°C):	-2.2	
R. H. (%):	60.0	
Wind Speed (mph):	5	
Extinction Coeff. (mag/airmass):	0.14	
NELM:		
Bortle Class:	3	
Synthetic SQM:	21.59	
SQI All- sky:	**98.4**	
SQI to Z.A. 70°:	**99.7**	
Number of stars visible:	**4510**	

NARRATIVE: Slightly higher extinction than previos night (9/24). M13 medium difficulty averted vision. Light domes seem distictly dimmer than last night excepy Ely which was closest. Seeing good, steady.

Figure 24. Photometric Survey 2006

Indicator	Observed		Estimated Artificial		Light Pollution Ratio (Artificial/Natural)
Sky Luminance Measures					
	mag/ arscec^2	µcd/ m^2	mag/ arscec^2	µcd/ m^2	
Zenith	21.46	283	> 24.5	< 17	< 0.10
Mean all-sky	21.42	293	24.85	12	0.05
Brightest	19.98	1,095	20.20	890	5.20
Darkest	21.91	184	> 24.5	< 17	< 0.10
Median	21.43	286	> 25.1	< 10	< 0.03
Illuminance Measures					
	mags	milli-lux	mags	milli-lux	
Horizontal	-6.30	0.84	-2.37	0.02	0.03
Max Vertical	-5.85	0.55	-2.64	0.03	0.07

Figure 25. Photometric Survey 2006

Unihedron Night Sky Quality Survey

Two night sky quality surveys were conducted in November 2013 (19 data points) and October 2015 (26 data points). Both night sky surveys were conducted at the same locations (October 2015 contains more data points because of no snow). The studies were conducted using a Unihedron "Sky Quality Meter - L" measuring the brightness of the night sky in magnitudes per square arcsecond (mags/arcsecond^2). Methodology used during the surveys were, (1) surveys were begun one hour passed astronomical sunset; (2) data was acquired on moonless nights with little to no cloud cover; (3) the sky quality meter was allowed five minutes to equilibrate to the outside ambient temperature at each data location and was transported between locations outside of the vehicle; and (4) all measurements were obtained with meter directed toward the zenith.

Figure 26. Unihedron Sky Quality Meter - L (Photo by Unihedron)

The average measurements for all points in November 2013 were 21.32 mags/arcsecond^2. The average measurements for all points in October 2015 were 21.48 mags/arcsecond^2.

The October 2015 Night Sky Survey was conducted on a clear, moonless night. Sky transparency was observed to be average, and sky stability was observed to be below average. The November 2013 Night Sky Survey was conducted on a clear, moonless night. Sky transparency was observed to be average, and sky stability was observed to be average. In both surveys, the Unihedron Sky Quality Meter was kept as close to outside ambient temperature as possible. Individual data measurements are located in Appendix A. Future surveys will be conducted by National Park Service staff along with volunteers and partners.

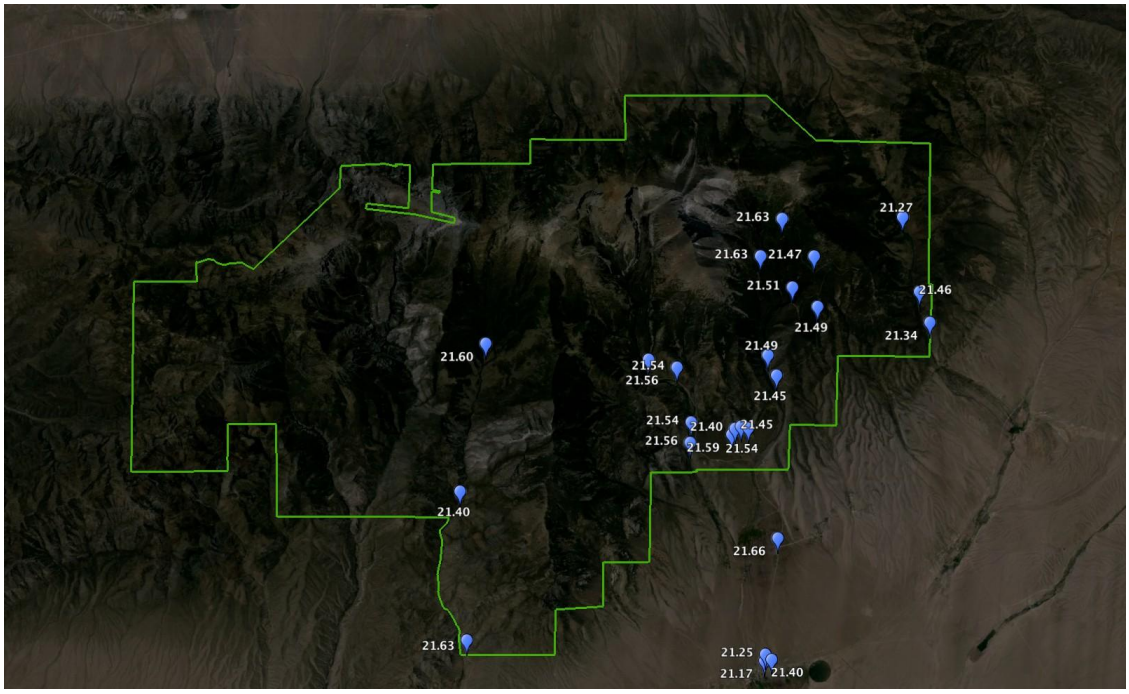


Figure 27. Night Sky Quality Measurements - October 2015

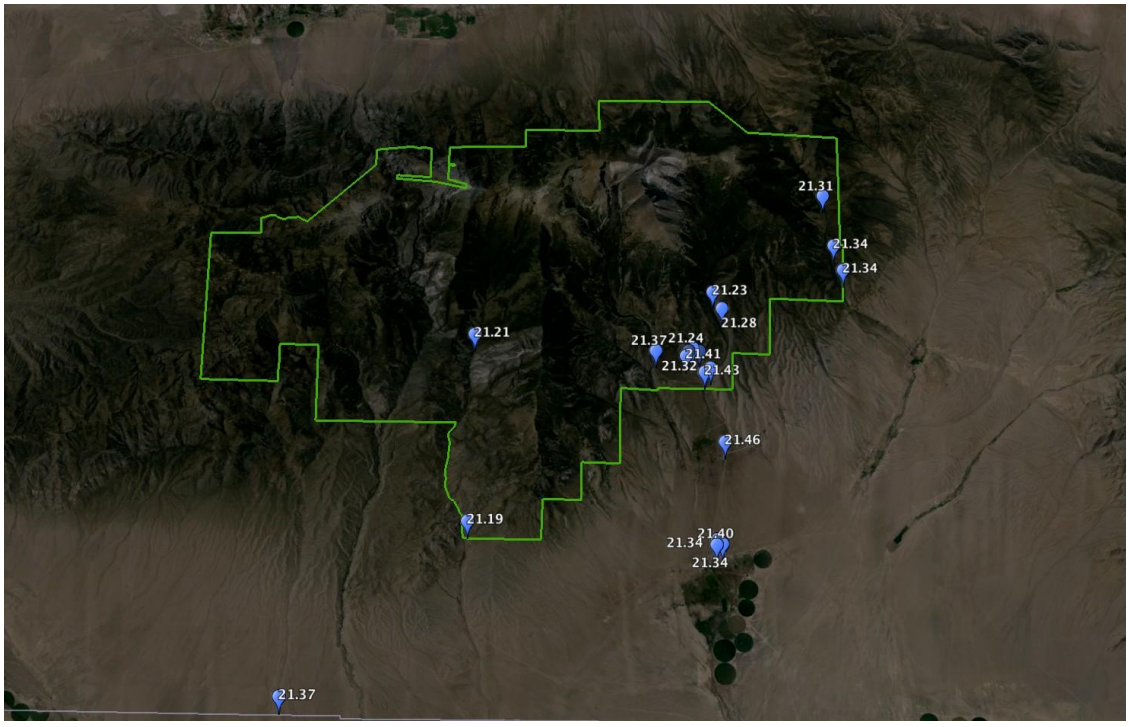


Figure 28. Night Sky Quality Measurements - November 2013

7. NPS Agency Policy and Legislative Protection

NPS Organic Act of 1916

The Organic Act of 1916 formally established the National Park Service. Congress directed the NPS to manage parks and monuments

"to conserve the scenery and the natural and historic objects and wild life therein and to provide for the enjoyment of the same manner and by such means as will leave them unimpaired for the enjoyment of future generations" (The NPS Organic Act of 1916-PL 64-235)

NPS Management Policies 2006

Section 4.10 Lightscape Management (excerpt):

The Service will preserve, to the greatest extent possible, the natural lightscape of parks, which are natural resources and values that exist in the absence of human caused light……The stars, planets, and earth's moon that are visible during clear nights influence humans and many other species of animals, such as birds that navigate by the stars or prey animals that reduce their activities during moonlit nights

Improper outdoor lighting can impede the view and visitor enjoyment of a natural dark sky. Recognizing the roles that light and dark periods and darkness play in natural resource processes and the evolution of species, the Service will protect natural darkness and other components of the natural lightscape in parks. To prevent the loss of dark conditions and of natural night skies, the Service will minimize light that emanates from park facilities, and also seek the cooperation of park visitors, neighbors, and local government agencies to prevent or minimize the intrusion of artificial light into the night scene of the ecosystems of parks…

The service will

- *Restrict the use of artificial lighting in parks to those areas where security, basic human safety, and specific cultural resources requirements must be met;*
- *Use minimal impact lighting techniques;*
- *Shield the use of artificial lighting where necessary to prevent the disruption of the night sky, natural cave process, physiological processes of living organisms, and similar natural processes.*

The decision about whether or not to install artificial lighting in particular circumstances is left to the discretion of the superintendent and is made through the planning process.

Great Basin National Park General Management Plan (1992)
This plan includes management for the preservation of the park's vistas with a focus on air quality.

Proposed Action: Natural Resource Management

> Other natural resource management actions will include…cooperating in regional efforts to maintain pristine air quality and reduce existing and potential air pollution effects.

Great Basin National Park Foundation Document
The purpose of a foundation document is to provide basic guidance for planning and management decisions. Great Basin National Park has included Dark Night Skies.

Fundamental Resource Values
Scenic Views and Dark Night Skies. The clean air and unique lack of artificial lighting and development inside and outside of the park enhances the color and contrast of landscape features, allows visitors to see great distances and provides panoramic views of the naturally dark night skies.
Interpretive Themes
Great Basin National Park offers an increasingly rare opportunity to view a natural dark night sky, provoking contemplation, inspiration and wonder.
Other Important Issues
Viewsheds. Scenic views are threatened by the potential for energy development in Snake and Spring and Hamilin Valleys. Light pollution threatens dark night skies. Dust from dirt roads may cause air quality issues.

Appendix B: Analysis of Fundamental Resources and Values

Fundamental Resource or Value	Scenic Views and Dark Night Skies
Current Condition and Trends	**Conditions** • Although the park is one of the cleanest air quality areas in the country, views are sometimes obscured by pollution-caused haze. Visibility is rated a moderate concern based on NPS Air Resources Division benchmarks. Ozone concentrations from 2008-2012 are at 71.7 parts per billion, which falls within the moderate concern category. • There is little to no light pollution, giving this park some of the best conditions in the National Park System. • The park has an anthropogenic light ratio of .05. Compared to other nonurban NPS units, this is an extremely good condition.

	Trends • The trend in visibility on the 20% clearest days improved and remained relatively unchanged on the 20% haziest days. Ozone concentrations have remained relatively unchanged. • Baker is actively working to reduce light pollution. • The park is seeking International Dark Sky Certification, and will improve lighting fixtures in the park. • The park is considering construction of an observatory.
Threats and Opportunities	**Threats** • If dewatering occurs, plants will decrease while dust will increase • Energy development and mining on adjacent public lands • Regional and local sources of air, noise and light pollution such as power plants, oil and gas developments, industrial facilities, agriculture and urban developments. **Opportunities** • The Park could provide more astronomy programs. • Work with counties to encourage a zoning plan and a lighting ordinance or guidelines. • Pave Baker Creek road to reduce dust • There are ongoing opportunities through federal air quality programs

8. Great Basin Dark Sky Park Light Management Plan (LMP)

Purpose and Goals

Great Basin National Park's unique location enables it to have some of the darkest night skies in the continental United States. Due to its distance from major urban centers, and unique geographical placement, it also maintains some of the clearest and steadiest atmosphere conditions. These conditions create superb transparency and stability in its skies. This combination produces the world-class night skies that make Great Basin an international destination for park visitors seeking a pure, primeval night sky experience. As part of the park's mission, Great Basin recognizes this as an important resource for preservation and protection.

Not only is the park's true dark sky an invaluable natural resource which park visitor come to experience, but the skies also provide one of the best locations to conduct astronomical and astrophysical research. In the 1970's Arizona State University considered Wheeler Peak of Great Basin National Park to be the last best-undeveloped site for an astronomical observatory in the United States (oral communication with Dr. David Bennum, University of Nevada, Reno). Great Basin is in the planning process of developing the first research-class astronomical observatory in the national park system. The Great Basin Observatory (www.greatbasinobservatory.org) plans to be a fully automated and autonomous observatory utilizing a 0.7-meter Planewave telescope and research class charge coupling devices (CCD) for imaging. This addition to the park will not only increase its visibility as a world-class night sky destination but will mark Great Basin National Park a world-class location to conduct research.

The Light Management Plan provides a foundation and blueprint for preserving the natural dark skies over Great Basin National Park. The guide outlined in this management plan will help guide park management in future lighting decisions and the modification of existing light in the park with the goal of having the lowest output while creating a safe environment for visitors and employees.

The park has had verbal conversations with White Pine County, NV Department of Public Works about the County’s policies on public and private outdoor lighting and none are available at this time. Great Basin will meet the local codes (Storey County Codes Sections 8.02.010 through 8.02.090) and ordinances of other rural counties in Nevada such as Storey County in western Nevada where dark night skies are prevalent and important to local residents.

In the 2006 NPS Management Policies document, lightscape management is defined as: "the effective use of good design to appropriately light areas and minimize or eliminate clutter, the spill-over of light into areas where light is not wanted, and light pollution, all of which wastes energy and impacts park visitors, neighbors and resources."

The goal of the Light Management Plan is to continue to ensure that night skies above the park remain uninfluenced by any anthropogenic lighting. This will preserve the idea that the many visitors seeking a dark sky refuge can enjoy almost any location within the park.

Lighting Guidelines

Lighting Zones

Lighting zones (LZ) reflect the base (or ambient) light levels that are desired. The use of lighting zones was initially developed by the International Commission on Illumination (CIE) and appeared first in the United States in IES Recommended Practice for Exterior Environmental Lighting, RP-33-99. Following the IES guidance, two LZs were chosen for Great Basin National Park, LZ-0, and LZ-1. The following two lighting zones are applied to the Great Basin National Park:

LZ-0: No ambient lighting

Areas where the natural environment will be severely and adversely affected by lighting. Impacts include disturbing the biological cycles of flora and fauna and detracting from the human enjoyment and appreciation of the natural environment. Human activity is subordinate in importance to nature. The vision of human residents and users is adapted to the darkness, and they expect to see little or no lighting. When not needed, lighting should be extinguished. Approximately 99.8% (77,089 acres[2]) of the area of Great Basin National Park falls within lighting zone zero (LZ0) (Figure 30).

LZ-1: Low ambient lighting

Areas where lighting might adversely affect flora and fauna or disturb the character of the area. The vision of human residents and users is adapted to low light levels. Lighting may be used for safety and convenience, but it is not necessarily uniform or continuous. After curfew, most lighting should be extinguished or reduced as activity levels decline. Approximately 0.2% (91 acres) of the park is located within light zone one (LZ1). This includes the Lehman Caves Visitor Center (1 acre), maintenance and residential area (10 acres), and the Baker Administrative Site (including the Great Basin Visitor Center, Resource Center, and Baker Residential Area) (80 acres) (Figure 30).

Park Management Commitments

Great Basin National Park commits to replacing or removing 50% of these non-compliant fixtures by the end of calendar year 2016 to full cutoff fixtures. The park also commits to replacing or removing 100% of non-compliant fixtures by the end of calendar year 2017. This night sky friendly lighting project will be highlighted in a public display in the park's main visitor center for the public to see the changes the park is making and serve as an example that visitors can do at home and work. The following requirements will be used in making future lighting decisions:

- Light fixtures will only be used for specific purposes and specific tasks.
- Lights will only be operated when necessary.
- Lights should work on switches or motion sensors only, excluding the full cutoff lights on the exteriors of the Lehman Caves Visitor Center and the Great Basin Visitor Center. Both visitor center light systems are on time-operated systems that will be programmed to illuminate for only a few hours after sunset.
- Light fixtures will be full cutoff and pointed downward.
- Light out will not exceed 600 lumens unless necessary for safety or emergencies.
- The light color temperature will be <2500 kelvin amber or warm white.
- Energy efficiency should be considered when making lighting decisions; compact fluorescent (CFL) or light emitting diode (LED) should be used.

Conclusion

Great Basin National Park recognizes its location in non-light polluted skies is one of the last remaining dark-sky sanctuaries in the United States. The true dark skies over the park have become a desired destination for thousands of visitors per year, and the park is committed to maintaining this special dark space. At this moment, Great Basin National Park has no plans to add any additional lighting within the park.

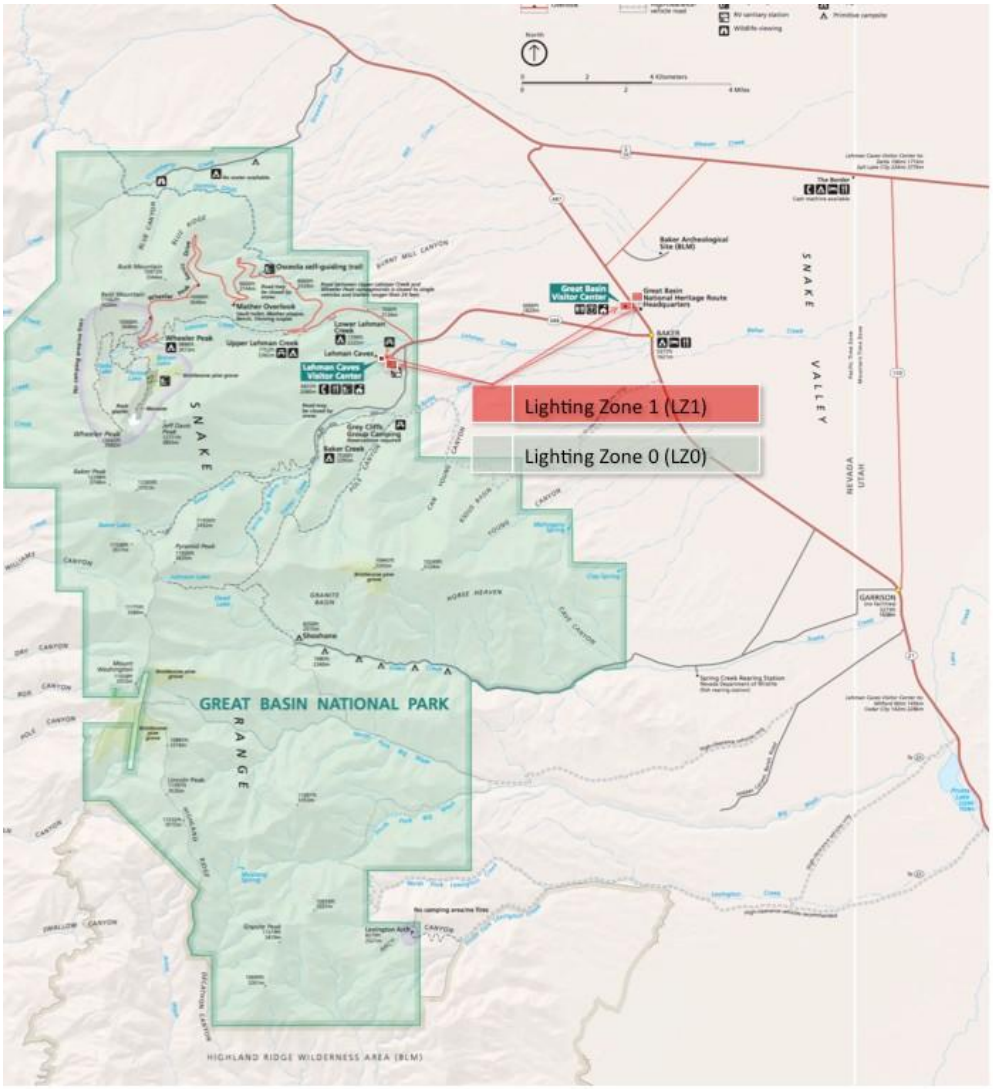
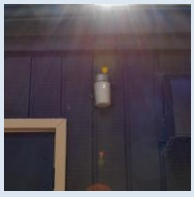


Figure 29. Great Basin Lighting Zones

9. Park Lighting Inventory

Site	Location	Number of Fixtures and Fixture Type	Photo	Use	Fully Shielded	Special Purpose <1000 Lumens	Conformity with Lighting Guidelines	Notes or Usage Information
Lehman Caves Visitor Center	Front Porch	11- Full Cutoff Hood		Visitor Center Safety	YES	NO	YES	One Red CFL (13W-800 lumen) to promote night sky friendly environment and safety. On timer for 4-6 hours after sunset.
Lehman Caves Visitor Center	Front Porch	5 - Recessed Square Downlight		Visitor Center Safety	NO	NO	YES	Two Red CFL (13W-800 lumen) to promote night sky friendly environment and safety. Shielded by roof overhang.
Lehman Caves Visitor Center	North End	1 - Frosted Globe		Visitor Center Safety	NO	YES	YES	One Red CFL (13W-800 lumen), to promote night sky friendly environment and safety.
Lehman Caves Visitor Center	Lehman Cave Entrance	3 - Frosted Globe		Night emergency light	NO	YES	YES	One CFL (13W-800 lumen), used for cave emergency. **Not used in normal operation.**
Lehman Caves Visitor Center	Lehman Cave Entrance	1 - Partially Shielded PAR floodlight		Night emergency light	NO	YES	YES	One 75W incandescent (900 lumen). NON-OPERABLE.

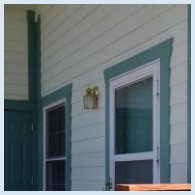
1

Site	Location	Number of Fixtures and Fixture Type	Photo	Use	Fully Shielded	Special Purpose <1000 Lumens	Conformity with Lighting Guidelines	Notes or Usage Information
Lehman Caves Visitor Center	Back Patio	1 - Unshielded Barn Light		Visitor Center Safety	NO	YES	YES	One mercury vapor bulb (unk W). NON-OPERABLE. To be removed.
Lehman Caves Visitor Center	Back Porch	3 - Frosted Globe		Visitor Center Safety	NO	YES	YES	One CFL (13W-800 lumen) for emergency use. Not used in normal operations.
Lehman Caves Visitor Center	Back Café Porch	2 - Square Downlight		Visitor Center Safety	NO	YES	YES	Two CFL (13W-800 lumen). Not used in normal operations.
Lehman Caves Visitor Center	Front Café	1 - Unshielded Barn Light		Visitor Center Safety	NO	YES	YES	One mercury vapor bulb (unk W). NON-OPERABLE. To be removed.
Lehman Caves Visitor Center	Frontline Stairway	16 - Fully Shielded Walkway Downlight		Stairway Safety	YES	NO	YES	4-pin PLC CFL (7W-400 lumen), covered with red filter. On timer for 4-6 hours after sunset.

1

Site	Location	Number of Fixtures and Fixture Type	Photo	Use	Fully Shielded	Special Purpose <1000 Lumens	Conformity with Lighting Guidelines	Notes or Usage Information
Great Basin Visitor Center	Parking Lot Walkway	16 - Fully Shielded Bollard		Visitor Safety	YES	NO	YES	4-pin PLC CFL (7W-400 lumen).
Great Basin Visitor Center	Bulletin Board	4 - Fully Shielded Recessed Downlight		Visitor Convenience	YES	YES	YES	4-pin PLC CFL (7W-400 lumen). On 5 minute motion detector.
Great Basin Visitor Center and Resource Center	Main Entrance Pathways	7 - Fully Shielded Recessed Downlight		Visitor Safety	YES	NO	YES	4-pin PLC CFL (7W-400 lumen).
Great Basin Visitor Center	Outside Theater	8 - Drop Lens		Visitor Convenience	NO	YES	YES	One CFL (13W-900 lumen). NON-OPERABLE.
Great Basin Resource Center	Rear Entrance	1 - Partially Shielded Wall Mount		Employee Safety	NO	NO	NO	One 4-pin PLC CFL (42W-3200 lumen). On motion detector.

1

Site	Location	Number of Fixtures and Fixture Type	Photo	Use	Fully Shielded	Special Purpose <1000 Lumens	Conformity with Lighting Guidelines	Notes or Usage Information
Great Basin Resource Center	Rear Entrance	2 - Surface Mounted Fluorescent Wraparound		Employee Safety and Convenience	NO	YES	NO	Two linear T4 (10W-475 lumen) fluorescent tube. Under roof cover.
Baker Historic Ranger Station	Fire Cache	1 - Full Cutoff Barn Light		Fire Cache Emergency	YES	NO	YES	One sodium vapor (unkW) outside security light.
Baker Historic Ranger Station	Fire Cache - Rear	1- Unshielded Downlight		Fire Cache Security	NO	YES	NO	One incandescent (75W-900 lumen). Manually operated. Not used in normal operations.
Baker Residential Area	Residence 15,16,17	3 - Unshielded Decorative Porch Light		Residential Porch Light	NO	YES	NO	One incandescent (75W-900 lumen). Used by resident preference.
Baker Residential Area	Dormitory and Utility Room	7 - Unshielded Decorative Light		Utility/Residential Light	NO	YES	NO	One CFL (13W-400 lumen). Manually switched. Utility building not used in normal operation. Used by resident preference.

1

Site	Location	Number of Fixtures and Fixture Type	Photo	Use	Fully Shielded	Special Purpose <1000 Lumens	Conformity with Lighting Guidelines	Notes or Usage Information
Baker Residential Area	Apartment and Dormitory	2 - Wall mounted Emergency Indicator		Alarm Indicator	NO	YES	YES	One red incandescent alarm indicator (75W-900 lumen). Used on when alarm emergency is present.
Upper Maintenance Area	Resource Management Building	2 - Partially Shielded Floodlight		Employee Safety and Convenience	NO	NO	NO	Two incandescent (60W-800 lumen) floodlights. On a motion detector.
Upper Maintenance Area	Main Maintenance Shop	1 - Partially Shielded (opaque) Barn Light		Employee Safety and Convenience	NO	NO	NO	One LED (unkW) bulb. On a motion detector.
Upper Maintenance Area	Parking Lot	2 - Unshielded Pole Mounted Floodlights		Employee Safety and Convenience	NO	YES	YES	No bulbs present. NON-OPERABLE.
Upper Maintenance Area	Fire Cache	1 - Unshielded Floodlight		Fire Emergency	NO	YES	NO	PAR 38 incandescent (75W-900 lumen) floodlight.

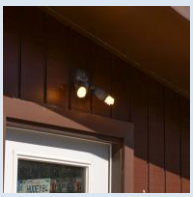
1

Site	Location	Number of Fixtures and Fixture Type	Photo	Use	Fully Shielded	Special Purpose <1000 Lumens	Conformity with Lighting Guidelines	Notes or Usage Information
Upper Maintenance Area	Park Ranger Fitness Room	1 - Unshielded Clear Globe		Employee Safety and Convenience	NO	YES	NO	One CFL (13W-800 lumen). Manually switched. Not used in normal operations.
Park Ranger Station	Ranger Station - Rear	1- Unshielded Bare Bulb		Law Enforcement Employee Safety and Convenience	NO	NO	NO	One R30 LED (17W-1100 lumen).
Park Ranger Station	Ranger Station - Front	1 - Partially Shielded Floodlight		Law Enforcement Employee Safety and Convenience	NO	NO	NO	One BR38 outdoor incandescent flood (75W-765 lumen). On a motion detector.
Upper Residential Area	Laundry Area	1 - Unshielded Decorative Fixture		Residential	NO	YES	NO	One incandescent (75W-900 lumen). Manually operated. Used at user convenience.
Upper Residential Area	Residence 1	1 - Partially Shielded Floodlight		Residential	NO	YES	NO	One BR38 outdoor incandescent flood (75W-765 lumen). Manually operated. Used at resident convenience.

1

Site	Location	Number of Fixtures and Fixture Type	Photo	Use	Fully Shielded	Special Purpose <1000 Lumens	Conformity with Lighting Guidelines	Notes or Usage Information
Upper Residential Area	Residence 1	1 - Unshielded Square Downlight		Residential	NO	YES	NO	One incandescent (75W-900 lumen). Manually operated. Used at resident preference.
Upper Residential Area	Residence 1	1 - Unshielded Decorative Fixture		Residential	NO	YES	NO	One incandescent (75W-900 lumen). Manually operated and on a motion detector. Used at resident preference.
Upper Residential Area	Residence 2	1 - Partially Recessed Square Downlight		Residential	NO	YES	NO	One incandescent (75W-900 lumen). Manually operated and on a motion detector. Used at resident preference.
Upper Residential Area	Residence 2	1 - Unshielded Decorative Fixture		Residential	NO	YES	NO	One incandescent (75W-900 lumen). Manually operated. Used at resident preference.
Upper Residential Area	Residence 2	1 - Unshielded Decorative Fixture		Residential	NO	YES	NO	One incandescent (75W-900 lumen). Manually operated. Used at resident preference.

1

Site	Location	Number of Fixtures and Fixture Type	Photo	Use	Fully Shielded	Special Purpose <1000 Lumens	Conformity with Lighting Guidelines	Notes or Usage Information
Upper Residential Area	Residence 2	1 - Unshielded Decorative Fixture		Residential	NO	YES	NO	One CFL (13W-400 lumen). Manually operated. Used at resident preference.
Upper Residential Area	Residence 3	1 - Unshielded Frosted Globe		Residential	NO	YES	NO	One CFL (13W-400 lumen). Manually operated. Used at resident preference.
Upper Residential Area	Residence 4	1 - Unshielded Frosted Globe		Residential	NO	YES	NO	One CFL (13W-400 lumen). Manually operated. Used at resident preference.
Upper Residential Area	Residence 7	1 - Unshielded Frosted Globe		Residential	NO	YES	NO	One CFL (13W-400 lumen). Manually operated. Used at resident preference.
Upper Residential Area	Residence 7	1 - Unshielded Floodlight		Residential	NO	YES	NO	Two CFL (13W-400 lumen). Manually operated. On a motion detector. Used at resident preference.

1

Site	Location	Number of Fixtures and Fixture Type	Photo	Use	Fully Shielded	Special Purpose <1000 Lumens	Conformity with Lighting Guidelines	Notes or Usage Information
Upper Residential Area	Residence 7	1 - Unshielded Frosted Globe		Residential	NO	YES	NO	One CFL (13W-400 lumen). Manually operated. Used at resident preference.
Upper Residential Area	Residence 8	1 - Unshielded Bulb Only		Residential	NO	NO	NO	One incandescent (100W-1600 lumen). Manually operated. Operation by resident preference.
Upper Residential Area	Residence 8	1 - Unshielded Frosted Globe		Residential	NO	YES	NO	One incandescent (75W-900 lumen). Manually operated. Used at resident preference.
Upper Residential Area	Residence 9	1 - Unshielded Floodlight		Residential	NO	YES	NO	Two PAR38 incandescent floodlight (75W-765lumen). On a motion detector. Manually operated. Used at resident preference.
Upper Residential Area	Residence 9	1 - Unshielded Frosted Globe		Residential	NO	YES	NO	One incandescent (60W-800 lumen). Manually operated. Used at resident preference.

1

Site	Location	Number of Fixtures and Fixture Type	Photo	Use	Fully Shielded	Special Purpose <1000 Lumens	Conformity with Lighting Guidelines	Notes or Usage Information
Upper Residential Area	Residence 9	1 -Unshielded Floodlight		Residential	NO	YES	NO	One CFL floodlight (16W-750 lumen). Manually operated. Used by resident preference.
Upper Residential Area	Residence 10	1 - Unshielded Frosted Globe		Residential	NO	YES	NO	One incandescent (75W-900 lumen). Manually operated. Used at resident preference.
Upper Residential Area	Residence 10	1 - Unshielded Frosted Globe		Residential	NO	YES	NO	One CFL (13W-400 lumen). Manually operated. Used at resident preference.
Upper Residential Area	Residence 11	1 - Unshielded Bulb Only		Residential	NO	YES	NO	One LED (9.5W-800 lumen). Manually operated. Used at resident preference.
Upper Residential Area	Residence 11	1 - Unshielded Bulb Only		Residential	NO	YES	NO	One incandescent (60W-800 lumen). Manually operated. Used at resident preference.

1

Site	Location	Number of Fixtures and Fixture Type	Photo	Use	Fully Shielded	Special Purpose <1000 Lumens	Conformity with Lighting Guidelines	Notes or Usage Information
Upper Residential Area	Residence 11	1 - Unshielded Frosted Globe		Residential	NO	YES	NO	Unknown bulb type. Manually operated. Used at resident preference.
Upper Residential Area	Residence 12	1 - Partially Shielded Droplight		Residential	NO	YES	NO	No bulb present. Manually operated. Used at resident preference.
Upper Residential Area	Residence 12	1 - Unshielded Clear Globe		Residential	NO	YES	NO	One incandescent (60W-800 lumen). Manually operated. Used at resident preference.
Upper Residential Area	Residence 12	1 - Unshielded Clear Globe		Residential	NO	YES	NO	One incandescent (60W-800 lumen). Manually operated. Used at resident preference.
Upper Residential Area	Residence 12	1 - Unshielded Frosted Globe		Residential	NO	YES	NO	One CFL (13W-400 lumen). Manually operated. Used at resident preference.

1

10. Lighting Retrofits and Night Sky Enhancing Projects

Great Basin National Park recognizes that dark night skies are becoming a primary reason for many visitors to travel to the park. As light pollution creeps outward from our cities, the areas in which people can travel to enjoy true dark skies are diminishing. Great Basin National Park wants to remain a sanctuary in which visitors may travel to experience and enjoy dark primeval skies. To accomplish this, the park has dedicated major effort with interpretive programs (over 100 events in 2015), the construction of a permanent star gazing location and amphitheater (2016), and the construction of a research-class astronomical observatory (2016).

Great Basin National Park recognizes that in its commitment to the protection and preservation of dark night sky resources, physical changes to lighting have to occur. The park has completed one light retrofit project and has plans to remove unneeded lighting fixtures or replace with full cutoff fixtures.

In 2014, the park changed all normally used outdoor lighting at the Lehman Caves Visitor Center to red (~1000K) full cutoff lights. This location serves as the primary location for all evening astronomy programs, and the red light conversion not only increases safety at the programs by providing low wattage red wavelength for dark eye vision adaption but also is a visual commitment to night sky protection. These red lights are illuminated seven nights a week, but for only a minimal amount of time. The park realizes that after dark visitation to the Lehman Caves Visitor Center occurs mainly in the few hours after sunset, so to enhance visitor safety the lights are timed to come on at sunset and remain illuminated only for the first hours after sunset. After this period, the lights are extinguished.

To enhance the park's dark sky resource protection message, increase visitor safety, and meet the growing demand for visitor interest in dark sky interpretive programs and personal night sky viewing, the park has funded a major capital project to design and build a permanent astronomy program amphitheater and stargazing site. With funding from the Southern Nevada Public Land Management Act (SNPLMA), the park plans to construct this site in 2016. When completed, this site will accommodate up to 200 visitors for interpretive astronomy programs, have complete audio and visual delivery systems for ranger-led night sky talks, and have a location where visitors will be able to observe astronomical objects through the park's multiple telescopes. In addition to using this site for formal night sky interpretive programs, the site will also be utilized by visitors at times when formal programs are not occurring as a safe location to observe the incredible night skies above the park by themselves.

This star gazing location will have low-wattage, full cutoff lighting to promote safe movement while not interfering with sky quality. The site will conform to green-operation, as it will be powered completely using solar power.

For future commitments, the park recognizes it must continue to promote dark night skies. It also recognizes that some faculties in the park have legacy non-compliant lighting fixtures. The vast majorities are either non-operable or not used in normal operations. Some fixtures determined to be unneeded will be removed. For lighting fixtures that are determined to be required for safety or convenience, a list of priorities will be developed, and a retrofit schedule will be produced. The park commits to having 50% of all lighting futures determined to removed or replace by the end of 2016, and to complete the remaining 50% lighting projects by the end of 2017. ***In summary, Great Basin National Park commits to be in 100% compliance with IDA-DSP-GOL lighting standards by the end of 2017.***

Figure 30. Astronomy Interpretive Program Showing Lehman Caves Visitor Center Red Light Retrofit (Photo by T. Auchter)

11. Interpretive Programs on Night Skies

Introduction

Great Basin National Park's isolation from major urban areas and travel corridors help to create some of the darkest night skies of any national park in the continental United States and is becoming the primary reason a substantial amount of visitors choose Great Basin as their destination. In 2010 members of the park's night sky team created a goal of making Great Basin National Park a premiere international destination for people looking for experiences after dark; a major switch in interpretive programming needed to be made. In the years since, the park has grown the night sky/astronomy based interpretive programs from 300 visitors in 2009 to over 13,000 in 2015.

To plan, direct, and conduct these interpretation programs many park personnel are involved. Beginning in 2012 the park committed a full-time, supervisory level park ranger to oversee and plan the astronomy based interpretive plan. The park also hires two seasonal Park Guides (Dark Rangers) to develop and conduct the astronomy based interpretive programs. The park has maintained a close relationship with the NPS Master Astronomy VIP program. This program provides NPS trained amateur astronomy volunteers to reside at the park to assist with the parks astronomy programs. Currently the park records over 1000 volunteer hours in astronomy interpretation. Beginning in 2015, the interpretive division hired a Student Conservation Association internship to work exclusively on the astronomy based interpretation programs.

Partnerships greatly enhanced this focus on astronomy interpretation. A partnership with the Great Basin National Park Foundation has provided approximately $20,000 in donated funds to purchase five telescopes, solar telescopes, audio and visual equipment, financial support for astronomy volunteer housing, and a host of ancillary equipment. This tremendous support allowed the interpretive offerings to grow each and every year.

Great Basin's interpretive plan continues to make night sky/astronomy interpretive programs one of the highest priority interpretive missions the park offers. This commitment allows us to expand each year to help meet visitor demand for these programs.

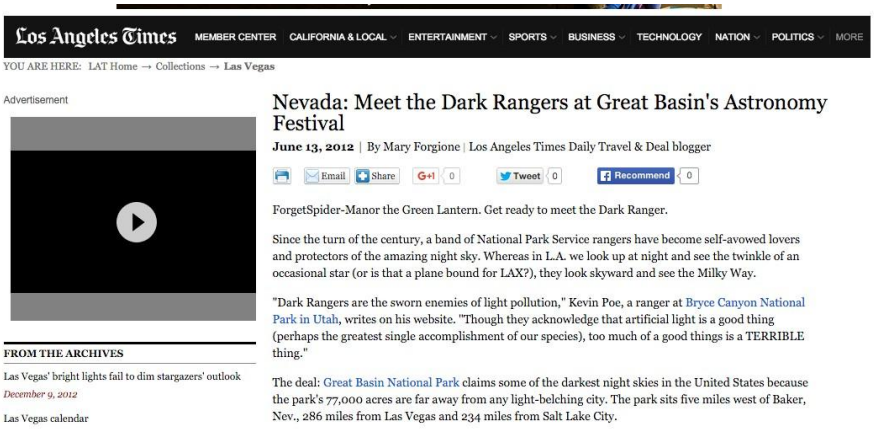
Formal Astronomy Interpretive Programs

The interpretive division currently conducts over 100 astronomy related programs per year. The foundation of our interpretive plan is our formal astronomy programs. These programs are conducted, as mentioned, seven months out of the year, and have quickly become one of the most demanded programs by park visitors. The average formal astronomy program is conducted by a lead Dark Ranger, who will present a visual based interpretive program. Program topics can cover such topics as stellar evolution, archaeoastronomy, biological impacts from light pollution, and the night skies influence on human culture. Also, each program always has a night sky perseveration and safety message. After each Dark Ranger presentation, viewing astronomical objects through the park's multiple telescopes occurs. From the beginning, the park did not want to use a "star party" format and decided that its formal programs would be interpretive from beginning to end. The interpretive arch developed during the initial presentation is continued through informal interpretation when the public is viewing through the

telescopes. This was incorporated because when the context is preserved throughout the entire program a physical and emotional connection to the night sky can be successful.

Astronomy Festival

To compliment the various astronomy-based interpretive programs, the park celebrates its night skies during a three-day astronomy festival each September. In 2015, the park had its sixth annual astronomy festival that included over 30 daytime and nighttime events. Daytime events offered ranged from afternoon lectures on scientific and light pollution topics, afternoon hands-on programs geared toward kids, solar telescope viewing at multiple locations in the park, a sunrise archaeoastronomy event at the Baker Archeological Site, a Fremont Indian historical site, Astronomy 101 lectures, to night photography workshops. Nighttime events included a keynote speaker presentation, a telescope star party, a chance for kids to earn their "deep-space observation certificate", and one of the most attended events, the Park Ranger Talent Show, where employees of Great Basin National Park preform talents that have a night sky connection.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FROM THE ARCHIVES

Las Vegas' bright lights fail to dim stargazers' outlook

December 9, 2012

Las Vegas calendar

Nevada: Meet the Dark Rangers at Great Basin's Astronomy Festival

June 13, 2012 | By Mary Forgione | Los Angeles Times Daily Travel & Deal blogger

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ForgetSpider-Manor the Green Lantern. Get ready to meet the Dark Ranger.

Since the turn of the century, a band of National Park Service rangers have become self-avowed lovers and protectors of the amazing night sky. Whereas in L.A. we look up at night and see the twinkle of an occasional star (or is that a plane bound for LAX?), they look skyward and see the Milky Way.

"Dark Rangers are the sworn enemies of light pollution," Kevin Poe, a ranger at Bryce Canyon National Park in Utah, writes on his website. "Though they acknowledge that artificial light is a good thing (perhaps the greatest single accomplishment of our species), too much of a good things is a TERRIBLE thing."

The deal: Great Basin National Park claims some of the darkest night skies in the United States because the park's 77,000 acres are far away from any light-belching city. The park sits five miles west of Baker, Nev., 286 miles from Las Vegas and 234 miles from Salt Lake City.

Figure 31. LA Times article about the Great Basin Astronomy Festival

The Great Basin Astronomy Festival has grown each year and set an attendance record in 2015 with over 2600 park visitors attending astronomy events and has garnered international press.

Special Events

In addition to the normal program schedule, the interpretive division conducts many specialized astronomy based interpretive programs throughout the year. Some offerings include the Full Moon Guided Hikes, which take visitors on a guided hike on summer full moon nights, special holiday weekend programming, observation of the NASA's International Observe the Moon Night, meteor shower watching parties. The park was also asked by Senator Harry Reid to be the official representative of the state of Nevada for the White House Astronomy night in October 2015.

Web/Social Media

Great Basin National Park wants to offer extensive astronomy based interpretive programs not only within its boundaries, but also wants to meet the visitor "where they are". Using the park's social media websites thousands of visitors get to interact with the park's programs electronically. Since a large percentage of visitors are coming to Great Basin for its dark skies or being a part of interpretive astronomy programs an extensive webpage (www.nps.gov/grba/planyourvisit/great-basin-night-sky) has been designed to inform and help in planning.

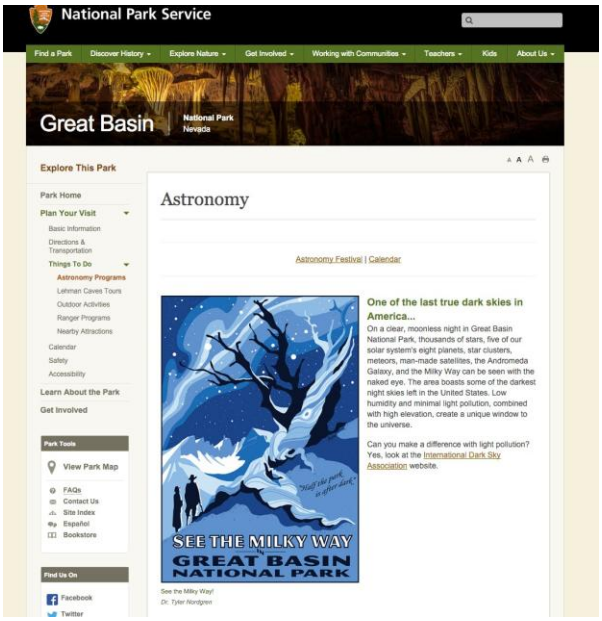

Figure 32. Excerpt from Great Basin's astronomy webpage

Interpretive Media

Continuing the astronomy interpretation's online presence, in 2013 the park saw the release of one of its Ranger Minutes entitled *Astronomy*. Ranger Minutes is a video series of 2-3 minute video vignettes telling the stories of Great Basin National Park. This thought-provoking, professional quality video series is presented online and plays in the park's two visitor centers theaters to 100,000s of visitors per year. The astronomy ranger minute is consistently claimed to be the most popular, indicating the visitors' interest in dark night skies.

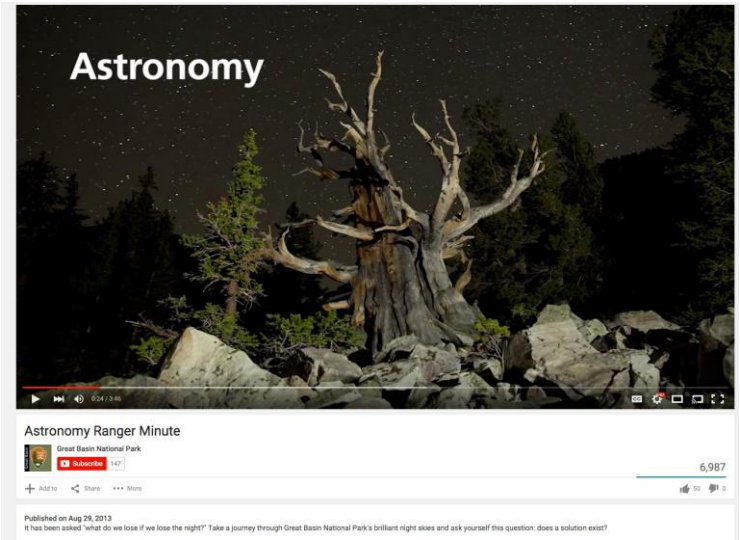

Figure 33. Astronomy Ranger Minutes on the Park's YouTube Webpage

Outreach

As the park has developed its in park and electronic interpretive presence, the interpretive division began to concentrate on presenting various astronomy programs on location. Programs have been performed on location at regional elementary schools, summer camps, and various clubs and gatherings.

One of the most popular outreach events is the creation of a partnership between the park, the Great Basin National Heritage Area, and the Nevada Northern Railway to create the "Star Train". The Star Train is located onboard the Nevada Northern Railway's historical diesel train out of Ely, NV. Multiple times each summer the park's dark rangers present an astronomical program onboard the train. The program consists of astronomical information, trivia contest with prizes, and is capped by viewing through the park's telescopes. When the train leaves the Ely area the train stops at a dark sky location, passengers disembark, and the dark rangers have the telescopes available for public viewing. This is quickly becoming one of the most popular themed train rides the Nevada Northern Railway offers.

Figure 34. The Star Train with the Nevada Northern Railway

Great Basin Astronomical Observatory

The air quality and lack of development make Nevada's only national park, Great Basin National Park, one of the last dark sky sanctuaries in the contiguous United States. A look at modern light pollution maps show the encroachment of light pollution into the deepest parts of the American Southwest leaving the few remaining areas under threat. One way to protect our night skies is to invest in and create a need for continued vigilance. One idea to accomplish this is to place a tangible value on true dark skies when it comes to scientific and public needs: build a permanent research-grade astronomical observatory. The building of this observatory, the investment it requires, create an absolute necessity to be engaged in the protection of this often overlooked and diminishing resource: the night sky.

The dark skies at Great Basin National Park are world-class and famous. In the 1970's Arizona State University considered Wheeler Peak to be the last best-undeveloped site for an astronomical observatory in the United States (oral communication with Dr. David Bennum). The night skies at Great Basin National Park measure to a Bortle Dark Sky Scale Class I/II (titled: Typical True Dark Sky Site). However, for astronomy, darkness is only one of three critical measurements.

Two additional critical measurements are seeing (stability of the atmosphere), and transparency (quality of the atmosphere), and Great Basin skies excel in both categories. Although there are larger observatories in the United States, none of them are located in true dark skies like at Great Basin National Park.

The primary goal of the observatory will be to conduct astronomical and astrophysical research with a secondary goal of interpretation, outreach, and education.

Areas of research that could be conducted inside the proposed Great Basin Observatory:

- Galaxy Detection
- Extra-solar Planet Discovery and Measurement
- Variable Star Measurements
- Asteroid Detection
- Comet Detection
- Supernova Studies and Detection
- Gamma Ray Burst Measurement
- Other Rapid Transit Events

Although scientific research would be the primary goal for the observatory, it would also fulfill a large and new addition of interpretive, educational, outreach, and resource protection messages to many different visitors to Great Basin National Park. The park and its partners have designed each piece of equipment to perform dual roles: research and outreach – which allows a lot of versatility and avenues for interpretive outreach growth. Our interpretive outreach goals have three identified target audiences: (1) school groups on field trips with interpretive and educational programs inside the visitor center, (2) on-site park visitors on ranger-led interpretive programs, and (3) visitors to Great Basin National Park's website. Although these are initial ideas for outreach and education, this is by no means an exhaustive list to the extent in which this observatory can be used. This observatory will be a destination piece for the visitor either in person or via The Internet.

Great Basin has identified a site within the park which suits the needs of construction, isolation, all year access, darkness, and low angle obstructions. This site has been previously disturbed and has a dirt road leading to the area. The site would contain a 16-foot diameter modular clam-shell observatory and an approximately 16 foot by 24 foot modular, single story control room.

The costs for construction and site preparation, purchasing of all equipment, installation of equipment, and five years of operating cost would be donated by the Great Basin National Park Foundation. The National Park Service would own the observatory, control room, and all of the equipment.

Operations will be overseen by a cooperative of partners, which now consists of the University of Nevada Reno, Western Nevada College in Carson City, NV, Concordia University in Irvine, CA, and Southern Utah University. This Great Basin Observatory Cooperative will be in charge of scheduling research teams and transferring data once complete.

This project envisions the novel data required to ask and answer fundamental questions in physics. It can be used to educate and inspire scientists, students, and visitors into the wonders that our National Parks provide. As the National Park Service approaches its 100th anniversary in 2016, there is no better time to expand our definition of parks, the resources, and opportunities for research and recreation they protect. The leadership of the National Park Service is asking us to innovate our thinking, and this project is a wonderful gateway into our public relevance as we enter our second century.

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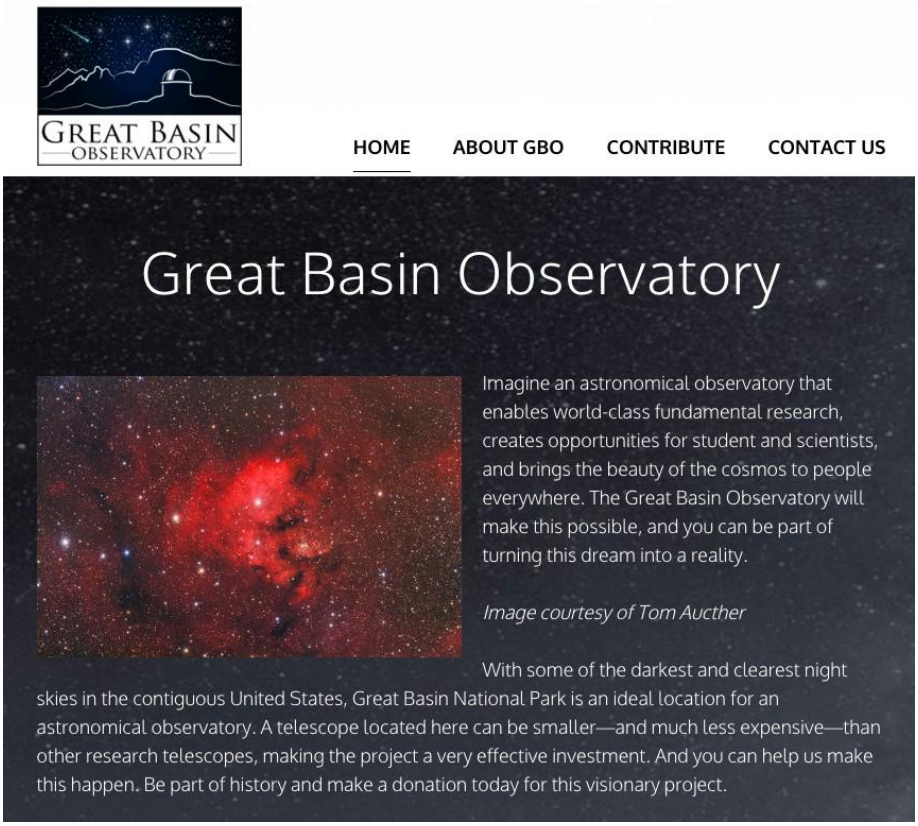

Figure 35. Great Basin Observatory Webpage (www.greatbasinobservatory.org)

Future Plans

In addition to the permanent star gazing/amphitheater site and the Great Basin Observatory, the park has plans to install a museum designed, interactive installation at the Lehman Caves Visitor Center entitled, "Darkness". This interpretive exhibit will focus on the importance of darkness to Great Basin National Park with a concentration of darkness in its cave systems and night skies.

Appendix A – Night Sky Quality Survey

Site #	Location	Date	Time	Latitude (DODD)	Longitude (D.DD)	Msmt 1	Msmt 2	Msmt 3	Msmt 4	Msmt 5	Avg Measurement (mages/arcsecond^2)	Temp (Cel)	Elevation (ft)
1	Lehman Caves Visitor Center	10/10/2015	3:00 AM	39.005853	-114.219102	21.52	21.43	21.40	21.44	21.44	21.45	14	6796
2	Picnic Area	10/10/2015	2:55 AM	39.008131	-114.218466	21.60	21.51	21.57	21.48	21.53	21.54	15	6755
3	Maintenance Area	10/10/2015	2:42 AM	39.003981	-114.218217	21.40	21.41	21.39	21.37	21.43	21.40	17	6820
4	Astronomical Observatory Site	10/10/2015	2:45 AM	39.002984	-114.215813	21.67	21.60	21.59	21.55	21.56	21.59	17	6781
5	Pole Canyon Trailhead	10/10/2015	2:32 AM	38.989938	-114.212569	21.56	21.54	21.55	21.55	21.60	21.56	16	6862
6	Gray Cliffs Campground	10/10/2015	2:27 AM	38.990247	-114.220722	21.57	21.55	21.53	21.53	21.52	21.54	14	7100
7	Baker Creek Campground	10/10/2015	2:20 AM	38.985534	-114.242664	21.60	21.53	21.51	21.51	21.53	21.54	15	7658
8	Baker Creek Trailhead	10/10/2015	2:15 AM	38.976642	-114.245784	21.68	21.51	21.53	21.54	21.53	21.56	14	7952
9	Lower Lehman Creek Campground	10/10/2015	12:51 AM	39.016568	-114.239654	21.47	21.45	21.44	21.44	21.44	21.45	13	7311
10	Upper Lehman Creek Campground	10/10/2015	12:58 AM	39.013632	-114.247707	21.48	21.47	21.49	21.50	21.49	21.49	12	7572
11	Osceola Ditch Trailhead	10/10/2015	1:05 AM	39.028564	-114.266986	21.53	21.53	21.47	21.45	21.49	21.49	12	8332
12	Mather Overlook	10/10/2015	1:13 AM	39.020523	-114.274504	21.60	21.49	21.46	21.49	21.50	21.51	11	9155
13	Wheeler Peak Scenic Overlook	10/10/2015	1:24 AM	39.026675	-114.286594	21.53	21.46	21.45	21.48	21.45	21.47	11	9890
14	Bristlecone Trailhead	10/10/2015	1:32 AM	39.010421	-114.286594	21.73	21.63	21.62	21.59	21.59	21.63	10	9937
15	Wheeler Peak Campground	10/10/2015	1:39 AM	39.016829	-114.301184	21.67	21.60	21.64	21.60	21.62	21.63	9	9812
16	Ranching Exhibit	10/10/2015	12:38 AM	39.017919	-114.173868	21.90	21.62	21.60	21.61	21.56	21.66	16	5985
17	Great Basin Visitor Center	10/9/2015	8:50 PM	39.014472	-114.126338	21.39	21.25	21.11	21.25	21.26	21.25	21	5307
18	Baker Fire Cache	10/9/2015	9:02 PM	39.014234	-114.123708	21.22	21.15	21.16	21.16	21.18	21.17	20	5307
19	Baker Housing Unit	10/9/2015	8:57 PM	39.016476	-114.124203	21.46	21.40	21.38	21.38	21.37	21.40	20	5307
20	Strawberry Creek - Park Boundary	10/9/2015	9:27 PM	39.064578	-114.261059	21.38	21.36	21.33	21.33	21.32	21.34	18	6921
21	Strawberry Creek - End Road	10/9/2015	9:44 PM	39.055197	-114.302885	21.30	21.28	21.27	21.25	21.26	21.27	14	7840
22	Snake Creek - Park Boundary	10/10/2015	12:08 AM	38.920398	-114.132575	21.65	21.62	21.63	21.63	21.61	21.63	13	6240
23	Snake Creek - End Road	10/9/2015	11:15 PM	38.926359	-114.251822	21.62	21.63	21.62	21.59	21.55	21.60	7	8187
24	Strawberry Creek Campground	10/9/2015	9:33 PM	39.061002	-114.273298	21.55	21.41	21.38	21.47	21.48	21.46	18	7200
25	Tilford Cabin	10/9/2015	11:50 PM	38.918375	-114.192838	21.41	21.38	21.44	21.37	21.39	21.40	13	7138
26	Main Entrance – Hwy 488	10/10/2015	12:45 AM	39.010293	-114.208073	21.50	21.47	21.46	21.46	21.45	21.47	14	6544
	Sky Quality Average										**21.48**		

Figure 36. Night Sky Quality Survey - October 2015

Site #	Location	Date	Time	Latitude (DODD)	Longitude (D.DD)	Msmt 1	Msmt 2	Msmt 3	Msmt 4	Msmt 5	Avg Measurement (mages/arcsecond^2)	Elevation (ft)
1	Lehman Caves Visitor Center	11/1/2013	8:18 PM	39.005650	-114.219682	21.29	21.25	21.24	21.21	21.22	21.24	6816
2	Picnic Area	11/1/2013	8:24 PM	39.008168	-114.218245	21.49	21.32	21.23	21.23	21.23	21.30	6765
3	Maintenance Area	11/1/2013	8:34 PM	39.003947	-114.218252	21.24	21.24	21.22	21.23	21.22	21.23	6810
4	Astronomical Observatory Site	11/1/2013	8:38 PM	39.002987	-114.215817	21.46	21.39	21.40	21.40	21.40	21.41	6784
5	Gray Cliffs Campground	11/1/2013	8:48 PM	38.991392	-114.218162	21.40	21.37	21.38	21.32	21.36	21.37	7030
6	Boneyard	11/1/2013	9:02 PM	39.012465	-114.210028	21.40	21.19	21.36	21.29	21.34	21.32	6625
7	Lower Lehman Creek Campground	11/1/2013	9:10 PM	39.016810	-114.239715	21.29	21.26	21.33	21.26	21.26	21.28	7347
8	Upper Lehman Creek Campground	11/1/2013	8:18 PM	39.013180	-114.247652	21.32	21.24	21.15	21.22	21.22	21.23	7600
9	Main Entrance – Hwy 488	11/1/2013	9:26 PM	39.010183	-114.207963	21.50	21.43	21.43	21.38	21.40	21.43	6560
10	Ranching Exhibit	11/1/2013	9:33 PM	39.017855	-114.173758	21.58	21.45	21.42	21.44	21.42	21.46	5970
11	Baker Fire Cache	11/1/2013	9:48 PM	39.014287	-114.123808	21.39	21.35	21.34	21.33	21.31	21.34	5319
12	Baker Housing Unit	11/1/2013	9:52 PM	39.016533	-114.124223	21.46	21.45	21.36	21.38	21.33	21.40	5276
13	Great Basin Visitor Center	11/1/2013	9:59 PM	39.014490	-114.126238	21.40	21.33	21.30	21.30	21.38	21.34	5341
14	Strawberry Creek - Park Boundary	11/1/2013	10:24 PM	39.064568	-114.261058	21.44	21.37	21.32	21.31	21.27	21.34	6910
15	Strawberry Creek Campground	11/1/2013	10:31 PM	39.060950	-114.273285	21.45	21.40	21.32	21.26	21.26	21.34	7186
16	Strawberry Creek Trailer Turn	11/1/2013	10:45 PM	39.057047	-114.298837	21.41	21.28	21.28	21.25	21.32	21.31	7782
17	State Line Lexington Arch Rd	11/2/2013	12:08 AM	38.852250	-114.049433	21.46	21.34	21.35	21.34	21.37	21.37	5676
18	Snake Creek - Park Boundary	11/2/2013	12:45 AM	38.920208	-114.132958	21.24	21.18	21.18	21.15	21.19	21.19	6245
19	Snake Creek Cattle Guard	11/2/2013	1:13 AM	38.921665	-114.224112	21.29	21.18	21.22	21.15	21.22	21.21	7617
	Sky Quality Average										**21.32**	

Figure 37. Night Sky Quality Survey - November 2013

Appendix B – Great Basin Foundation Document - Fundamental Resources and Values

Fundamental resources and values (FRVs) are those features, systems, processes, experiences, stories, scenes, sounds, smells, or other attributes determined to warrant primary consideration during planning and management processes because they are essential to achieving the purpose of the park and maintaining its significance. Fundamental resources and values are closely related to a park's legislative purpose and are more specific than significance statements. Fundamental resources and values help focus planning and management efforts on what is truly significant about the park. One of the most important responsibilities of NPS managers is to ensure the conservation and public enjoyment of those qualities that are essential (fundamental) to achieving the purpose of the park and maintaining its significance. If fundamental resources and values are allowed to deteriorate, the park purpose and/or significance could be jeopardized.

The following fundamental resources and values have been identified for Great Basin National Park:

Caves, Karst, and Cave-Forming Processes, Including Lehman Caves. Great Basin National Park contains the longest, deepest, and highest elevation caves in Nevada and one of the highest concentration of caves in the Great Basin. Because roughly half of the park consists of karst topography, there is a high potential for many additional cave discoveries. Likewise, the geologic and hydrological cave-forming processes are ongoing and protected in the park, yielding a continual development and evolution of caves and cave formations. Lexington Arch is an outstanding example of a remnant cave system.

These cave systems support many endemic species such as the Model Cave amphipod and the Lehman Caves pseudoscorpion, as well as several species of bats, including the Townsend's big-eared bat. Caves are also a repository of paleontological resources for study of regional faunal change. Caves used as shelter by people over the last 13,000 years may contain important archeological information. The park's signature cave, Lehman Caves, was originally protected as Lehman Caves National Monument prior to the establishment of the national park and contains more than 300 shield formations.

Water Resources. Great Basin National Park protects 10 perennial streams in an arid desert environment, 6 sub-alpine lakes, and 425 perennial springs, as well as the interaction of groundwater and surface water in its many caves. The cave-forming processes and endemic cave biota are dependent on these natural hydrological processes. Water resources provide habitat for many aquatic species, including the native Bonneville cutthroat trout, springsnails, and other native aquatic species. Stream corridors and periodic flooding also provide essential conditions for the survival of riparian plant and animal communities in a desert environment. Four of the park's natural springs serve as public water supplies for visitors and staff and the park serves as a watershed for public water supplies in the surrounding valleys.

Evidence of Past and Current Climate Change. Great Basin National Park preserves important resources that document the surrounding climate conditions over the past million years. These resources include: cave formations (speleothems), lake sediment cores, packrat middens, cirques and other glacial features, bristlecone pines, fossils, and evidence of human response to change in archeological sites. These resources provide unique periods of reference from multiple lines of evidence that can help inform projections of future climate patterns and changes.

Intact Great Basin Ecosystems. Great Basin National Park protects a wide range of biological diversity and ecological systems representative of the Great Basin. Due to the almost 8,000-foot vertical gradient in the park, the ecosystems range from desert scrub to montane forests to alpine

tundra. Healthy populations of native plants and animals are found throughout the park, including species endemic to the park or the nearby area.

Ancient Bristlecone Pines. Found on windswept ridges and moraines, ancient bristlecone pines are the iconic species of Great Basin National Park. Great Basin National Park protects some of the oldest and most expansive groves of bristlecone pines, the oldest trees on earth, which can survive more than 5,000 years. Their twisted and gnarled forms connect us to an ancient past. As an iconic species, bristlecones are a major draw for visitors, who can access ancient groves via a moderate hike. By cross- dating with dead downed trees, a complete climate record of more than 7,000 years has been compiled. In addition to the famous ancient groves, the park also contains mesic groves at lower elevations, where bristlecones have shorter lifespans, but still may live a thousand years.

Solitude. Visitors to Great Basin National Park have opportunities to experience solitude because of the park's remoteness and limited park development. Abundant trails provide opportunities to experience areas where natural sounds predominate.

Scenic Views and Dark Night Skies. The clean air and unique lack of artificial lighting and development inside and outside of the park enhances the color and contrast of landscape features, allows visitors to see great distances, and provides panoramic views of the naturally dark night skies.

Representative Resources of the Great Basin's 13,000 Years of Human History. Unique and important archeological sites, historic structures, cultural landscapes, and ethnographic resources offer insight into 13,000 years of human interaction with the desert, providing opportunity to understand our place in this Great Basin environment. Over the millennia, native cultures experienced environmental change from Paleo period post glacial landscapes to Archaic adaptions for increasing desert conditions. Fremont farming and foraging and the continuing life of Paiute and Shoshone people are evident in archeological sites, rock art, and traditional cultural places of the park. Historic structures and sites and cultural landscapes reflect the growing economy of the Western United States from the late 1800s through modern times, preserving an intangible link to generational history and connection with larger regional, American, and world history.

Credits and Acknowledgements Bibliography

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