South Llano River State Park International Dark Sky Park Application

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Section 1. Executive Summary and Eligibility

South Llano River State Park, (the "Park") is pleased to submit this Application for designation as a Dark Sky Park by the International Dark-Sky Association (IDA).

South Llano River State Park requests designation as a Dark Sky Park at the Gold Tier sky quality level.

South Llano River State Park is a Texas State park and provides the opportunity for public night-time access, including overnight camping. The park is open daily 365 days per year and provides night-time access to the public. Visitors can obtain a day use permit that allows access to the Park until 10:00 p.m., however, if special events are scheduled at night, such as star parties and night sky education programs, the day use permits are extended to later in the evening to allow attendance at such events. The Park also accommodates overnight camping that allows the public to stay at the park all night long. The park meets the eligibility requirements for designation as a Dark Sky Park specified in the IDA's Dark Sky Park Designation Guidelines.

In addition, the Park meets or exceeds the minimum requirements for designation as a Dark Sky Park specified in the IDA's Dark Sky Park Designation Guidelines.

A brief overview of the Application is summarized below:

Section 2 includes the required IDA nomination letter as well as a number of other letters in support of designating the Park as a Dark Sky Park.

Section 3 describes the history and location of the Park, including detail about the Park's geology, wildlife and dark skies.

Section 4 describes the location of the park and the map of the area to be designated as a Dark Sky Park.

Section 5 describes the dark sky quality at the Park and describes the Park's permanently installed dark sky monitoring station.

Section 6 details a number of efforts and initiatives undertaken by the Park that demonstrate the Park's commitment to dark sky preservation and education.

Section 7 describes the Park's dark sky interpretive programs and education and includes a copy of the park's dark sky education curriculum.

Section 8 includes South Llano River State Park's Guidelines for Outdoor Lighting, a set of general principles and prescriptions for outdoor lighting in the Park.

Section 9 details the lighting inventory and improvement plan undertaken by the Park, demonstrating compliance with the Park's Guidelines for Outdoor Lighting.

Finally, Section 10 acknowledges the people and organizations that have given support to the Park in making this Application.

Contact Information:

Joshua Dean
Assistant Superintendent
South Llano River State Park
1927 Park Road 73
Junction, Texas 76849

Phone: (325) 446-3994

Email: Joshua.dean@tpwd.texas.gov

Section 2. International Dark Sky Park Nomination and Support Letters

This section includes copies of the nomination and support letters regarding the Park's Application as summarized below:

- Letter of Support from Joshua Dean, Assistant Park Superintendent South Llano River State Park
- IDA Nomination Letter, Ken Kattner, Putman Mountain Observatory
- Support Letter from Texas State Representative Andrew S. Murr
- Support Letter from Brent Leisure, Director Texas Parks and Wildlife
- Support Letter from Nol Dear, President of Friends of South Llano River State Park
- Support Letter from Constance E. Booth, Executive Director, Kimble County Chamber of Commerce
- Support Letter from Robert Stubblefield, Director, Texas Tech University Center at Junction
- Support Letter from Bill Neiman, Director, Hill Country Alliance

TEXAS PARKS & WILDLIFE

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September 12th, 2016

IDA Board of Directors
International Dark Sky Association
3223 North First Avenue
Tucson, Arizona 85719-2103

Dear IDA Board Members,

I would like to express my sincere support for the nomination of South Llano River State Park to receive the International Dark Sky Park designation. As the Assistant Superintendent of South Llano River State Park I have had the opportunity to observe fantastic astronomical displays here at the park. South Llano River State Park is located in Kimble County, Texas, which is a very rural county with a population of about 4,600 people (2010 Census). Junction, Texas, which is the county seat, is located just four miles from the park. South Llano River State Park is within close proximity to Interstate Highway 10, making the park easily accessible from major metropolitan areas such as San Antonio and Austin, which are approximately two and two and a half hours drive from the park (respectively). South Llano River State Park offers both day use facilities and overnight camping facilities which allow for star-gazing opportunities.

The Hill Country Alliance, in conjunction with the City of Junction, have taken steps to install Dark Sky friendly lighting within the City of Junction. Furthermore, Ken Kattner has installed a sky quality meter at South Llano River State Park to allow the public to monitor sky conditions via the internet.

A light assessment was performed at South Llano River State Park in August of 2013, at which time the park ranked "2" on the Bortle Scale. Earlier this year, with the support from the Friends of South Llano River State Park, the park retrofitted its light fixtures to make them Dark Sky compliant. The park conducts several night sky interpretive programs for the public, to showcase the truly dark skies featured at the park and to educate about the importance of protecting the night sky.

Again, I would like to emphasize the commitment on part of the Park Staff and Volunteers, as well as the Hill Country Alliance and the City of Junction to maintain and preserve the night sky at South Llano River State Park. Thus, I believe South Llano River State Park is a prime candidate for the International Dark Sky Park designation. I respectfully request that you give this nomination your utmost consideration.

Sincerely,

Assistant Superintendent
South Llano River State Park

4200 SMITH SCHOOL ROAD
AUSTIN, TEXAS 78744-3291
512.389.4800
www.tpwd.state.tx.us

Putman Mountain Observatory
12217 RR 2323
Fredericksburg, Texas 78624

November 15, 2016

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

Dear IDA Board of Directors:

It is with great enthusiasm as a member of the International Dark Sky Association, that I submit this nomination letter in support of South Llano River State Park being designated a Dark Sky Park.

Along with a number of other interested people and organizations, I have worked with the staff at South Llano River State Park over the last year and have seen their efforts first hand to become a Dark Sky Park, including the inventory and retrofit of existing fixtures, installation of a sky quality monitoring station and education and outreach efforts to the public. The park staff have undertaken a substantial and sincere effort in this regard.

Now, the park routinely offers programming and events to promote public awareness and education about preserving the dark skies above the park and elsewhere. These programs are often given in collaboration with local astronomy groups and the Texas Tech University at Junction Outdoor School.

The park is leading by example in continuing the local effort to preserve the dark night skies over Texas. The nearby town of Junction has recently adopted a dark sky preservation resolution and has replaced older style mercury vapor fixtures with shielded fixtures. South Llano River State Park becoming a Dark Sky Park is an important addition to the region's efforts to protect the dark skies and raise public awareness.

On behalf of South Llano River State Park, I fully endorse the designation of the park as an International Dark Sky park.

Best regards

Ken Kattner

Bandera County
Crockett County
Edwards County
Kimble County
Kerr County
Llano County

Mason County
Medina County
Menard County
Real County
Schleicher County
Sutton County

TEXAS HOUSE OF REPRESENTATIVES
ANDREW S. MURR
District 53

November 28, 2016

International Dark Sky Association
Board of Directors
3223 North First Avenue
Tucson, Arizona 85719-2103

Dear Board of Directors,

I have the privilege of representing Kimble County – home to South Llano River State Park – in the Texas House of Representatives. In addition, I reside on our family ranch approximately 10 miles from this park, and I drive by its entrance every day on my way to work. I wish to join in with my support for the Park's application to become an International Dark Sky Park with your organization.

Understanding the benefits and challenges associated with growth and development, many Texans and other visitors travel to South Llano River State Park to enjoy its secluded and natural beauty. Park employees and volunteers have gone to great lengths to foster local dark skies, providing a unique opportunity to view the heavens that attracts so many stargazers. These efforts also have a positive economic impact locally and inherently lead to the education of individuals in how they can save money with their utility bills and maintain a view of the night sky.

I am proud that South Llano River State Park is working to provide visitors with a fantastic destination (day and night), and I believe that the Park will benefit greatly with the reward of a formal designation from the International Dark Sky Association. On behalf of so many Texans, I respectfully ask that you give the Park's application every serious consideration.

Very sincerely,

Andrew Murr

Andrew S. Murr
State Representative

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TEXAS PARKS & WILDLIFE

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May 5, 2016

IDA Board of Directors
International Dark-Sky Association
1225 North First Avenue
Tucson, Arizona 85719-2103

Dear IDA Board of Directors,

On behalf of the Texas Parks and Wildlife Department, I am pleased to offer our support of South Llano River State Park's nomination as a "Dark Sky Park." The unique outdoor experiences that Texas and out-of-state visitors enjoy in state parks and natural areas are becoming increasingly important as these are often the only publicly accessible places to do so. To experience a magnificent dark sky is most definitely part of the wonderment and discovery we hope all visitors will experience in their parks.

The leadership within Texas State Parks is working in concert with many partners to assess light conditions in our parks and to make the necessary adjustments in our lighting systems to protect the dark sky values we all enjoy. Modeling night sky protection is essential for us in these unique settings. South Llano River State Park is enjoyed by thousands of visitors every year and its designation as a "Dark Sky Park" will help us to emphasize the value we place on night sky preservation and incorporate stewardship messages into the programming provided to visitors.

We applaud the International Dark Sky Association for your tremendous work to preserve our night skies. Thank you for your consideration of South Llano River State Park as a Dark Sky Park.

Sincerely,

Brent Leisure, Director
Texas Parks and Wildlife

4200 SMITH SCHOOL ROAD
AUSTIN, TEXAS 78744-3291
512.389.4800
www.tpwd.texas.gov

April 28, 2016

Board of Directors
International Dark Sky Association
3223 North First Avenue
Tucson, Arizona 85719-2103

Dear IDA Board Members,

On behalf of the Friends of South Llano River State Park, I would like to offer our support for the nomination of South Llano River State Park as an International Dark Sky Park.

South Llano River State Park (SLRSP) is one of the finest state parks in Texas, and it offers a family oriented respite in the Texas Hill Country where thousands of visitors per year come to experience a rural atmosphere and escape the hustle and bustle of large cities all over Texas, the United States, and other countries. Since 1996, the Friends of South Llano River State Park have worked diligently and tirelessly to promote and preserve the park's natural resources through public awareness and appreciation programs. Specifically, the Friends of South Llano River State Park have helped develop SLRSP into one of the premier birding destinations in all of Texas, and the United States. Additionally, we stand in full support of SLRSP staff in educating the public about the importance of preserving the night skies at SLRSP and in Kimble County as a whole. We are currently working with SLRSP management to procure and install outdoor lighting to protect the night sky viewing opportunities.

SLRSP offers a families a chance to gaze into the heavens and see the phenomenon of the night sky that few other places can offer. We believe that an International Dark Sky Park designation will allow SLRSP to reach even more visitors that are particularly interested in star-gazing opportunities; and how they can do more where they live to protect the night sky.

Thank you for all that you do to educate, inform, and promote dark skies around the world. The information you make available to the public on your website is invaluable to organizations such as ours.

Sincerely,

Nol Dear
President
Friends of South Llano River State Park
325-446-3154

KIMBLE COUNTY CHAMBER OF COMMERCE

"Land of Living Waters"

402 Main, Junction, TX 76849

325/446-3190 Fax: 325/446-2871

www.junctiontexas.net e-mail: junctiontx@cebridge.net

May 3, 2016

IDA Board of Directors, International Dark Sky Association

3223 North First Avenue

Tucson, Arizona 85719-2103

Dear Board of Directors Members,

As a representative of the local business community, the Kimble County Chamber of Commerce & Junction Visitor Information heartily encourages the approval of the South Llano River State Park's Dark Sky Application.

The South Llano River State Park is definitely an asset to our community, and we feel we are expressing the sentiments of our membership, as well as our citizens, when we endorse their application for Dark Skies. The preservation of our Dark Sky is an issue of much importance and concern for our community and our Chamber's Membership. We were the first in our community to bring this issue to the attention of our Junction City Council, and have adopted it as one of our major focal points when promoting our community.

We also feel this will be a great incentive for other businesses to follow suit and improve their downtown properties as well, thereby helping our entire City and county.

We congratulate the South Llano River State Park in this important endeavor and are hoping the approval of this application is forthcoming.

If we can be of further assistance, please do not hesitate to contact us.

Yours truly,
Constance E. Booth
Constance E. Booth, Executive Director

TEXAS TECH UNIVERSITY
Center at Junction

TTU LLANO RIVER FIELD STATION

June 30, 2016

IDA Board of Directors
International Dark Sky Association
3223 North First Avenue
Tucson, Arizona 85719-2103

Dear Board of Directors,

As a resident of Junction, Texas, in Kimble County, and the Director of the Texas Tech University's Llano River Field Station, I support the nomination of the South Llano River State Park as an International Dark Sky Park.

The South Llano River State Park is unique among state parks in Texas not only by its location along the pristine South Llano River, but because it has retained its dark night skies initiative. It is located adjacent to the Texas Tech University Center at Junction which is home to the internationally recognized Outdoor School program. The Outdoor School in conjunction with the state park, offers programs to educate the public about the wonders of the universe through the starry skies above the park. With over 50,000 visitors a year, the park is beloved by local citizens and residents across Texas. Many visitors, especially children, have come to the park, and have looked up at the starry sky, only to have seen the Milky Way for the very first time. The park is a popular destination for nature walks, primitive camping, bird watching, kayaking and star gazing. It is located just outside Junction, Texas and is supported by residents serious about preserving the cultural heritage, the natural beauty, and the night skies of the Texas Hill Country.

The dark skies above the South Llano River State Park, in Junction, Texas, are worthy of our attention and our protection. Designation as an International Dark Sky Park would assist us in these efforts. Thank you for your consideration.

Sincerely,

Robert Stubblefield, Director
Texas Tech University Center at Junction
Llano River Field Station

P.O. Box 186/254 Red Raider Lane | Junction, Texas 76849 | T: 325-446-2301 | F: 325-446-4011

education
conservation
cooperation

hill country alliance

July 23, 2016

IDA Board of Directors
International Dark Sky Association
3223 North First Avenue
Tucson, Arizona 85719-2103

Dear IDA Board Members,

Please accept this Letter of Recommendation. HCA fully supports the South Llano River State Park for nomination as a "Dark Sky Park". Citizens of the Texas Hill Country are increasingly identifying with the eastward march of sky-glow up into the hills from the Austin-San Antonio I-35 corridor. Numerous local Hill Country counties, towns and regional utility providers have recently enacted resolutions to preserve the night sky. Several more progressive municipalities have recently passed local Outdoor Lighting Ordinances. The Hill Country Alliance serves as a strong advocate to provide support to these communities and others throughout our 17 county region of Central Texas.

HCA has placed a high priority on pursuing an official Hill Country 'Night Sky Reserve' in the near future. But today, we are engaged and working with every State Park in the region to expand public awareness and outreach needed to enlarge night sky conservation programs. The farther west we go across the Hill Country, we find communities that are in need of greater support for implementing conservation policies and practices. The emphasis on conservation is sometimes taken for granted. But it is successful programs and validation from organizations such as IDA that gives an extra boost needed to achieve lasting results.

Beyond that, we believe every single conservation effort made to protecting and preserving our night skies gives ever-lasting benefits to all local landowners and visitors alike.

HCA is very excited about the conservation concepts being implemented at the South Llano River State Park. We've seen amazing things happen when local citizens, landowners, local officials share passion and a vision. We want you to know that HCA will engage our resources and expertise to help guide additional conservation of the night sky and other efforts to reduce light pollution all across the Texas Hill Country. We are happy to assist and support community driven projects like these.

Ready to collaborate,

Bill Neiman, Board of Directors
Hill Country Alliance
210-414-1718

Hill Country Alliance | 15315 Highway 71 West, Bee Cave, Texas 78738 | Phone 512.263.9147 | Fax 512.263.3471 | info@hillcountryalliance.org

Section 3. History and Description of South Llano River State Park

The land that is now the South Llano River State Park and adjoining Walter Buck Wildlife Management Area was donated to the Texas Parks and Wildlife Department (TPWD) by Mr. Walter W. Buck, Jr. He had lived and ranched on this land since 1910. Never married, he was fond of saying, "this land was his one great love." He wanted this acreage to remain intact, in a natural state and open to the public. In 1977, he conditionally gave the entire ranch to the TPWD for only wildlife conservation and/or park purposes. Following the construction of facilities the Park was opened to the public on July 4, 1990.

Native Peoples

There is evidence that the earliest human presence in the park was approximately 8000 years ago. Places in the river bottomlands where hearthstones, charcoal, and flint flakes have been found together indicate the locations of semi-permanent camps. Artifact and carbon dating indicate periodic occupation at these sites for over 4000 years. The record is silent for the next 3800 years. In 1767, a Spanish expedition traveling north down the river encountered a band of Indians about 10 miles upstream from the park. They named this group the Los Chanes; the only recorded mention of this band. The Spaniards never occupied any territory in the vicinity of the park, although they traveled through this region to reach the San Saba de La Santa Cruz' mission for the Lipan Apaches in the vicinity of present Menard. Unfortunately for the Lipans, the Spanish and the later settlers, this area lay at the edge of the expanding range of the Comanche Indians. The Comanches considered all the area over which they hunted to be theirs alone, not to be trespassed by any other people. Although their presence in this area of Texas is well established, they left no trace of being within the Park boundary. The Comanches, holding their hunting lands inviolate, not only destroyed the Spanish missionary efforts near Menard, but also proved to be a significant deterrent to Spanish, then Mexican and later Anglo settlement of this region.

Anglo Settlement

In the late 1860's, campaigns by the Texas Rangers and U.S. Army soldiers reduced the threat of Comanche Indian attacks. Anglo settlers arrived in the area surrounding the junction of the North Llano and South Llano rivers in the 1870's.

In 1976, a wagon train arrived at Junction from Missouri led by Benjamin F. Pepper. The train contained his extended family and a number of others. Included were his married daughters, Mary Ann and Susan, daughter Effa, and son Charles W. Pepper. The elder Pepper purchased property about 5 miles upstream from Junction on the north (west) side of the South Llano River. Mary and her husband Sid Thomas established their 500 acre homestead on the south (east) side of the river. Susan with her husband W. R. McKee located near the Thomas place. James Armstrong who had accompanied the Pepper wagon train from Missouri, purchased the land immediately west of the Thomas place, which also fronts on the river.

In the years between 1880 and 1910, Sid Thomas gradually purchased additions to his property until it totaled nearly 2000 acres. This former Thomas property became the core of the Buck Ranch and the South Llano River State Park. While the Thomases lived here, they made a small family cemetery on the property. It is in the Headquarters area, east of the goat shed. It contains two marked graves, that of Charles W. Pepper and Francis M. Thomas, son of Sid Thomas. Among the several unmarked graves, is that of Stephen Baldwin. Stephen, who died from a rattle-snake bite, was the three year old son of Effa Pepper. In 1889, Sid and Mary Thomas moved to Junction where they purchased and successfully operated the City Hotel. In 1903, a water company built the "Four Mile Dam". It was located where the river bends sharply to the left looking upstream from the present Park tube take-out location. A ditch from this dam carried irrigation water to Junction until it was abandoned about 1925. In 1910, Sid and Mary retired from the hotel business and moved to San Antonio. At that time, they sold their land on the South Llano to Walter White Buck, Sr.

The Buck Ranch

Mr. Buck, a successful retired jeweler from Hillsboro, Texas, bought the Thomas property in hopes of finding a drier climate for his oldest son, Stroud who had tuberculosis. In 1910, Mr. Buck, his wife Corrie, his 18 year old son Walter, Jr., and his daughter Elsie moved to their new ranch. The family traveled the 275 miles in a hack, while the furniture followed in a covered wagon pulled by two mules. Stroud, died at the ranch about a year after the move. Mr. Buck nevertheless decided to remain and make a living by ranching. Over the next ten years, Mr. Buck became a successful rancher and acquired pieces of adjoining property from the McKees and Armstrongs. These additions expanded the ranch from approximately 2000 acres to over 2500 acres. The Armstrong addition is the property over which the current Park entry road passes.

The Bucks moved into the Thomas house and began enlarging the building. The Thomas house consisted of a hand-hewn log structure (now the west corner of the Park Headquarters building). The logs had been moved from a previous site in the river bottomland. To this building the Thomases also added lean-to structures for a kitchen and dining room. Walter Buck, Sr. added the living room (present visitors registration area), bedrooms, kitchen, and porches. The living room contained a large, wood burning stove for heat. The house had a hand-dug well on the north side. Most of the living was done in the screened porch area at the southeast corner. They ate on the porch in summer and in the kitchen in winter. Thanksgiving and Christmas dinners were served in the living room at a large table with 12 chairs.

Soon after the house remodeling, the Bucks also built the large goat shed and other outbuildings. The goat house was used for shelter in bad weather, and as a place for the goats to have their kids. When the Thomases sold the property, there was no stock on the land. Mr. Buck, Sr. stocked the land with about 450 goats, 450 sheep, and 20 head of cattle. The shearing of the goats and sheep was done in the old log crib barn (in the vicinity of the windmill on the current Park entry road). Here the initials of some of the shearers can still be seen on the white oak logs.

After his father died in 1933, operation of the ranch fell to Walter, Jr. He sold all the sheep, running only goats and cattle. Several years later, he also sold all the goats, and increased the number of cattle to 125 head.

He made many improvements to the ranch, adding the bathroom to the east side of the house, a tack storage and milkhouse west of the goatshed and a small house just south of the milkhouse. This house was built for a couple hired to care for Walter's elderly mother, who lived until 1940. In the 1950's, Mr. Buck leased the mineral rights to Phillips Petroleum Co. They drilled an exploratory well (now on the Fawn Trail) about one mile south of Park Headquarters. Neither oil nor gas was found in commercial quantities. It was completed as a gas well and sold to Mr. Buck for $550 for his needs. This well continues to provide gas for all Park uses. Mr. Buck was an early advocate of conservation. He gradually reduced the stock on his land to about 25 head of cattle. He also cared for the pecan trees, which produced harvests of 75,000 pounds in the 1970's. He began to lease hunting rights and provide facilities for wildlife. To accommodate hunters, Mr. Buck moved and remodeled the old Armstrong house from the vicinity of the log barn on the entry road. He relocated it about 100 yards to the south of the Park Headquarters. In 1965, immediately south of (behind) Headquarters, he built and moved into a modern house. It is now used as a residence for Park staff.

A rural real estate boom hit Texas in the 1970's. Many ranches were subdivided to satisfy urban dwellers seeking weekend homes. Mr. Buck wanted his ranch to remain intact and to be managed for wildlife and open to the public. Unfortunately, his desire to see others enjoy the land as he had, did not happen during his lifetime. Walter W. Buck Jr. died in 1982 at the age of 90. The Park was opened to the public in 1990.

Geology

South Llano River State Park elevations vary significantly between the river-bottom (about 1700 feet above sea level) to the tops of hills that establish the Edwards Plateau (about 2150 feet above sea level). This means that there are essentially three types of habitats, those being the Alluvial Flats (River-bottom), Colluvial Bench (the flat areas above river-bottom but below the rising hills of the uplands), and the Upland Area (hilltops). Each area offers distinct habitat for wildlife and is explained further below.

The higher elevations of the Park are underlain by Edwards limestone. Below this basal layer lies the Glen Rose which consists of alternating layers of limestone and marl. A broad colluvial bench exists between the upland and bottomland portions of this area. The northern part of the Park (river bottom area) is underlain by Quarternary alluvial deposits. Calcareous rocks (possibly gravel deposits) exist close to the surface in parts of this area.

Plant and Animal Life

Plant Life

Biological communities at the Park form three major units – bottomland, colluvial bench, upland – each of which can be further subdivided.

River Bottom Area

Areas of the river which are characterized by rapidly-moving water are devoid of higher plants. Gravel bars which are only slightly above the present level of the river are characterized by sycamore, switchgrass, and mullein. Alluvial flat areas near the river support sycamore, muhlenberg oak, American elm, and mountain grape. A large part of the bottomland acreage is covered by pecan (both native and grafted). Cedar Elm becomes more common as the elevation increases, and the presence of plateau live oak indicates that gravels exist close to the surface. Other species indicating rocky soil areas are agarita and Ashe juniper.

Two bottomland pools (Buck Lake and Green Lake) support both aquatic and wetland plants. Sunny areas of the pool have extensive growths of bladderpad while shady areas support duckweed. Sawgrass is most common around the edge of these pools.

Colluvial Flat (Area above the river bottom but below uplands and sloping hills)

A broad colluvial flat between the upland and bottomland portions of the Park supports a medium to tall scrub vegetation. Dominant plant species are scrub oak, netleaf hackberry, prairie yucca, and Texas persimmon. Taller plateau oaks also occur in this area. Invasion of mesquite, ashe juniper, and prickly pear cactus has occurred. Of significant occurrence in this area is the Texas peach bush, a rare plant restricted to suitable areas of the Texas Hill Country.

Uplands (Including sloping hillsides)

Intermediate slopes above the Colluvial Bench support a scrub woodland of ashe juniper, scrub oak, twisted-leaf yucca, prickly pear, and evergreen sumac. Most abundant grasses are Texas winter grass and side-oats grama. The rounded hilltops support a scrub oak savannah. Significant amounts of ashe juniper are present. Plants represented here are generally those which are present on the intermediate slopes with the addition of little leaf lead tree. Areas of bare or near-bare rock support the blue-green alga Nostoc and resurrection plant.

Upland areas have been dissected by a number of intermittent creek drainages which support a relatively heavily-wooded community. Dominant trees in the canyon woodland are Lacey oak, Texas oak, ashe juniper, little black walnut, and mountain grape. Little bluestem is locally abundant, as is frostweed. Isolated mesic areas around and below seeps also support sycamore and buttonbush.

Limestone cliffs above these dry drainages support agarita, Texas persimmon, scrub oak, evergreen sumac, Mexican buckeye, and twisted-leaf yucca.

Wildlife

Wildlife resources at South Llano River State Park are diverse and abundant. Most commonly seen are two game animals – Rio Grande turkey and white tailed deer. The bottomland (alluvial) portion of the Park has supported a winter roost of Rio Grande turkeys for as long as observations of this area are known (seventy years). The roost area encompasses essentially all wooded bottomland areas within the Park in addition to neighboring landowner holdings on both east and west boundaries. Census counts have varied between 200 and 600 birds during winter roosting periods. Variations in bird numbers indicates fluctuations rather than periodic utilization of alternate roost areas. Birds which occupy this roost during the winter disperse southward during early spring for distances up to seven miles.

Dispersed birds begin to reappear at the roost site in October. They remain in this area until sometime in March. During this period daily daylight feeding forays occur out of the bottomland into the colluvial flats and slopes to the south (still remaining within the boundaries of the Park site). Late afternoon and night periods are spent in the wooded bottomland. Limited nesting occurs in this bottomland area in addition to colluvial flats and slope areas of the Park.

This roost area has been observed by residents of the area since the first decade of the twentieth century. Turkey roosts are very habitual; this roost has probably existed for at least several hundred years. Roost areas often appear no different from adjacent tracts of land which contain few or no turkeys. Significant factors in utilization of the Park by turkeys are likely to be natural funneling by major side canyons and the existence of broad wooded bottomland area.

White-tailed deer are common to South Llano River State Park. Deer numbers are generally higher than optimum levels desired for this area. Other exotic ungulate species such as axis deer, fallow deer, and sika deer also inhabit the Park. Other wildlife species present in the Park include fox squirrels which frequent the bottomland while rock squirrels are seen along various rocky outcrops. Black-tailed jackrabbits are commonly seen in the old pasture areas of the bottomland. Armadillos and eastern cottontail rabbits are also in abundance.

South Llano River State Park is known across the state and country as one of the best places to birdwatch, both during the spring migration and non-migration periods. The endangered Golden- cheeked Warbler and Black-capped Vireo nest in the Park during the spring and summer months. Other popular bird species found in the Park include the painted bunting, green kingfisher, indigo bunting, vermilion flycatcher, and a host of other species can be found in the Park. Many species of bird are observed at one of four bird blinds located throughout the Park.

Thousands of monarch butterflies utilize the bottomland during their fall migration. The monarchs nectar and seek shelter in the frostweed plants. In the spring, monarchs utilize the Colluvial Bench and upland areas of the Park to lay their eggs.

Light Pollution Can Negatively Impact Wildlife

Light pollution is defined by the International Dark Sky Association (IDA) as "the inappropriate or excessive use of artificial light." It is well known that light pollution seems to be greater near large cities and metropolitan areas. One only need look at a satellite image of earth at night to realize how much artificial light is present across the United States. Unfortunately, all of this extra light at night has unintended consequences for wildlife and ecosystems.

Most migratory songbirds migrate at night, using the moon and stars for navigation, as well as other cues such as the earth's magnetic field. Artificial light can interfere with their navigation. In addition, birds die from collisions with towers and buildings at night that are lit (www.darksky.org). Here at South Llano River State Park, we are privileged to host two endangered migratory bird species, the Golden-cheeked Warbler and the Black-capped Vireo. It is important that we preserve the night skies here at the Park to protect these species and their habitats.

Light pollution also affects insect patterns. This affects the animals that feed on insects, as well as plants pollinated by insects, thereby impacting the ecosystem as a whole (www.darksky.org). Two well-known insect species at South Llano River State Park are the monarch butterfly and the firefly. Both of these insects take advantage of the protected river bottom—the monarchs pass through during their fall migration, and fireflies breed there during the spring and summer. Preserving the Park's dark skies will help ensure that the Park continues to provide habitat for both of these iconic insect species, as well as many others.

Frogs are another group of animals affected by artificial light. Studies have shown that exposure to artificial light affects frog behavior (Baker and Richardson 2006, Hall 2016)[1] which could in turn affect their population dynamics (Baker and Richardson 2006). Various species of frog live and breed at South Llano River State Park. Preserving the dark skies at our Park will help protect frogs and other amphibians, a group already sensitive to environmental changes.[2]

[1] Baker, B.J. and J.M.L. Richardson. 2006. The effect of artificial light on male breeding-season behaviour in green frogs, *Rana clamitans melanota. Canadian Journal of Zoology*., 84:1528-1532 NRC Research Press

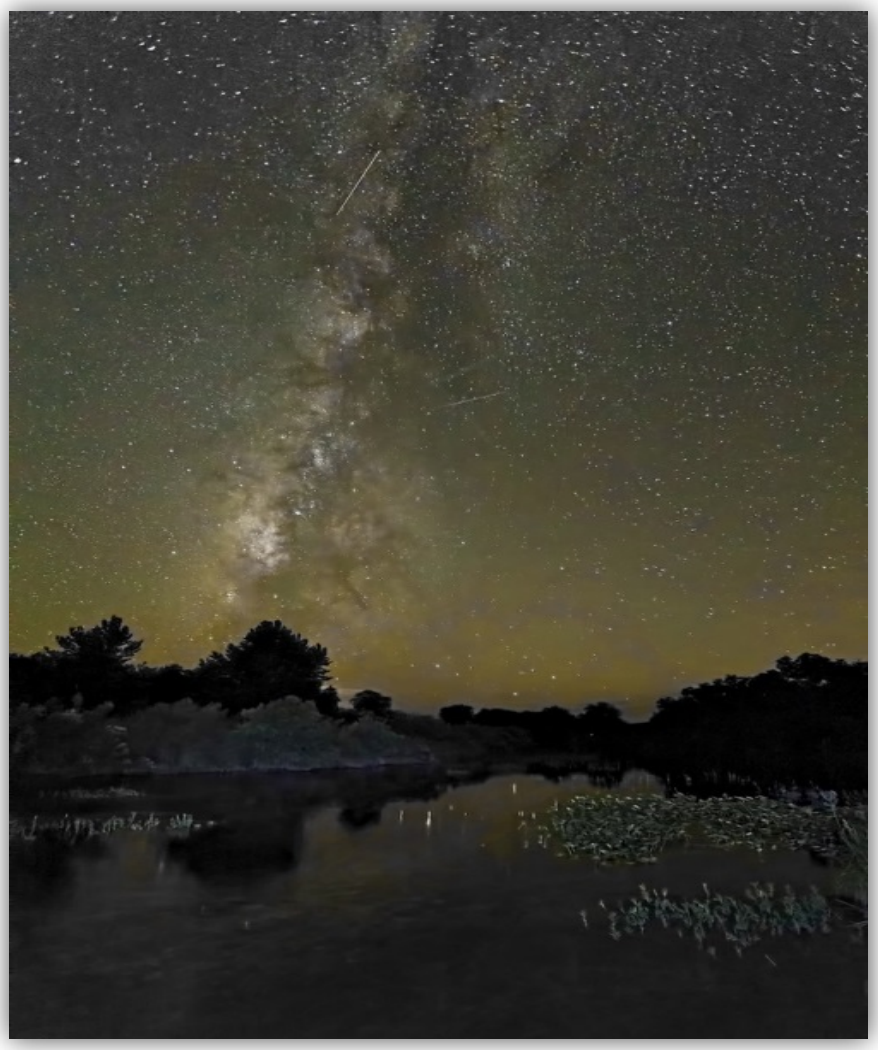
[2] Hall, Alexander S. 2016. Acute Artificial Light Diminishes Central Texas Anuran Calling Behavior, *The American Midland Naturalist*., 175: 183-193 BioOne. Web. 24 June 2016.

Dark Skies

The Park is open daily 365 days per year and provides night-time access to the public. Visitors can obtain a day use permit that allows access to the Park until 10:00 p.m., however, if special events are scheduled at night, such as star parties and night sky education programs, the day use permits are extended to later in the evening to allow attendance at such events. The Park also accommodates overnight camping that allows the public to stay at the Park all night long.

The skies above the Park are exceptionally dark and are enjoyed by multitudes of visitors. Over 50,000 visitors come to the Park each year for a day trip and hike, a weekend camping trip, maybe a first backpack trip, for birding, and for many other activities.

One of those activities is watching the stars, Milky Way and constellations in the inky black skies over the Park.

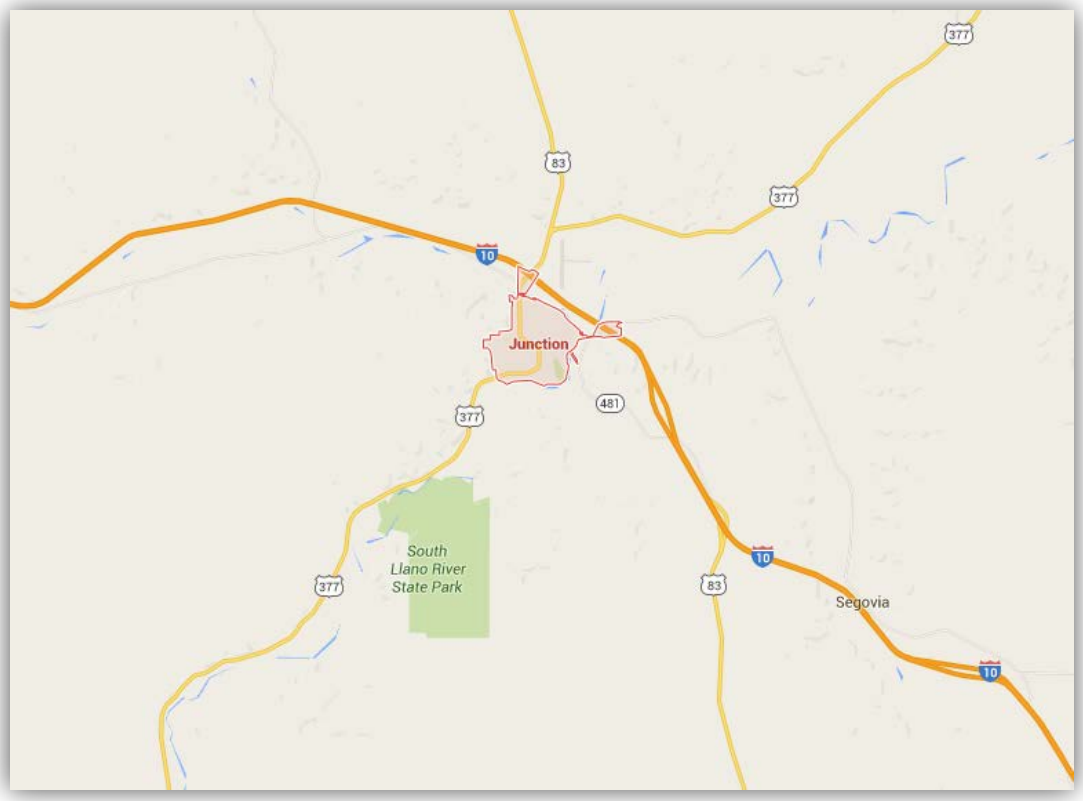


Section 4. Location of South Llano River State Park and Map of Area to be designated

The Location

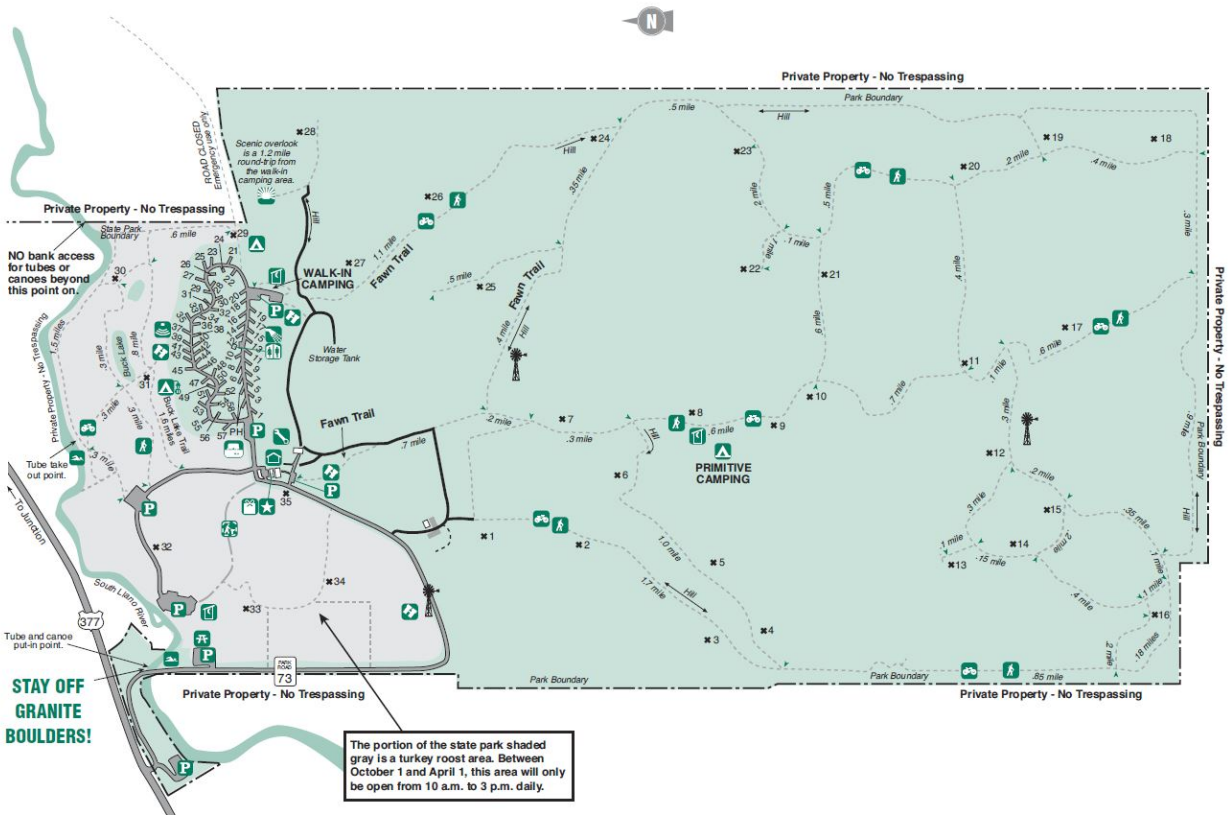
South Llano River State Park is located south of the city of Junction in Kimble County, Texas. The Park is a 2,600 acre site adjacent to the Llano River. The nearest city is Junction (population 2,498) located approximately 3 to 4 miles north of the Park. The Park is significantly west of San Antonio (over 100 miles) and Austin (over 120 miles).

The Park is located within the Edwards Plateau, a broad geologically uplifted area starting at the Balcones Escarpment running through Austin to the east and continuing to the Pecos River well to the west of the Park.



A Google map indicating the location of South Llano River State Park is shown above. The Google map shows general location, however, Park boundaries to the west are more truncated than displayed. For an accurate depiction of Park boundaries, see the Park map of area to be designated on the next page.

The entire Park is designated to be a Dark Sky Park as shown below.



TEXAS PARKS & WILDLIFE

South Llano River

State Park

Section 5. Sky Quality at South Llano River State Park

The sky quality at the Park is 21.75 Mag/Sq Arcsec (MPSAS) or better on nights with no moon and good transparency. To monitor sky quality over time, the Park has installed a permanent sky quality monitoring station that uploads live information to the Park's web page each night. Details concerning the sky quality monitoring station are described below.

IDA Lighting Assessment

In August 2013, Lou Zyla, an IDA representative conducted an IDA Lighting Assessment at the Park and the findings are excerpted from the report:

Lighting evaluation:
The lighting situation in South Llano River is excellent due mainly to the fact that it is a fairly small park and there are not that many lights. The park is roughly 5 miles south of Junction and the skies at night are excellent. The park ranks number 2 on the Bortle scale which is classified as a truly dark sight with shadows cast by the milky way and the milky way itself is highly structured. There is a tiny light dome from Junction but that is very minor.

All lighting changes recommended in the assessment have been implemented. A copy of the full assessment report is included in Appendix 1.

City of Junction Lighting Retrofit

In 2013, the City of Junction initiated a city lighting retrofit project based on a $10,000 grant received from the Hill Country Alliance. The city was using 300 watt mercury vapor fixtures prior to the retrofit project. Every city-owned light fixture was inventoried and examined. Mr. Bill Wren from McDonald Observatory made several night time visits to Junction to assess the outdoor lighting and to formulate a recommendation on fixture type and wattage.

Based on the assessment and recommendation, a total of 110 outdated 300 watt mercury vapor fixtures were replaced with full cut-off, 70 watt sodium vapor fixtures. This retrofit installed better fixtures that included full-cutoff shielding at a much lower wattage and eliminated poor mercury vapor lighting.

There were funds remaining after the retrofit which were used by the Junction Independent School District for numerous upgrades to their on campus outdoor lighting fixtures. Also, the Texas Tech University at Junction campus was provided shields from McDonald Observatory to reduce their campus lighting footprint on the night sky.

Finally, based on the increased public awareness resulting from the lighting retrofit, the Kimble County Commissioners Court, as well as the Junction City Council both passed night sky resolutions to protect the night sky.

Installation of Permanent Dark Sky Monitoring Station

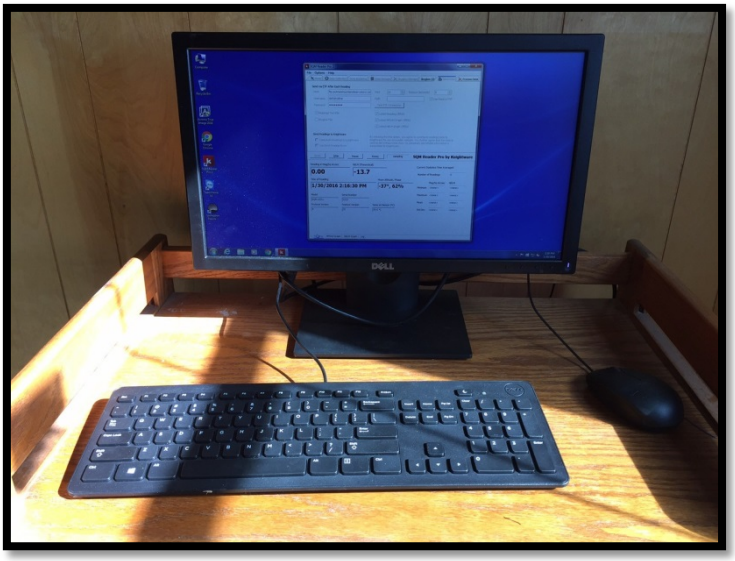
Preserving the pristine darkness of the night skies is important to the Park so that visitors can enjoy the wonder of the night sky. The skies over the Park are dark enough to view the Milky Way, but they need to be protected from encroaching city lights.

The Park has undertaken significant efforts to minimize artificial illumination at night to allow visitors to enjoy the dark skies. Further, the Park has installed a dark sky monitoring station to measure in real-time the relative darkness of the skies above the Park each night.

The monitoring station includes a sky quality meter mounted at a storage and work building and pointed at the zenith along with a computer system that logs readings each night.

The Sky Quality Meter is manufactured by Unihedron and recommended by the International Dark Sky Association. The Sky Quality Meter is a SQM-LE model and the full width half maximum of the angular sensitivity is twenty degrees. The monitoring software is SQM Reader Pro made by Knightware Software. The software keeps a detailed historical data base that will assist in long term monitoring of the sky quality over the Park. The software is also capable of storing sky quality readings in Skyglow Standard format, a new standard recommended by the IDA that was officially adopted at the 12th European Symposium for the Protection of the Night Sky.

The computer system posts readings every 15 minutes to a web page for monitoring and public



access. The meter is not active during day time.

Sky Quality Monitoring Station Data

As described above, the Park has installed a permanent sky quality monitoring station. On a recent night, the sky quality monitoring station recorded sky quality readings above 21.80 MPSAS at the zenith. The chart below illustrates the actual readings recorded by the sky quality monitoring station and the darker readings 21.75 MPSAS and greater are shown.

Date	Time	MPSAS	NELM	Temp(C)	SolarAlt	LunarAlt	LunarPhase
2/29/2016	18:46:48	8.32	(5.30)	34.10	(2.80)	(71.80)	0.59
2/29/2016	19:01:48	11.83	(1.80)	33.10	(6.00)	(69.70)	0.59
2/29/2016	19:16:48	16.09	2.30	32.50	(9.20)	(67.30)	0.59
2/29/2016	19:31:48	19.10	4.80	31.90	(12.40)	(64.80)	0.59
2/29/2016	19:46:48	20.90	6.10	31.50	(15.70)	(62.10)	0.59
2/29/2016	20:01:48	21.03	6.10	31.20	(18.90)	(59.20)	0.59
2/29/2016	20:16:48	21.15	6.20	31.20	(22.10)	(56.30)	0.59
2/29/2016	20:31:49	21.33	6.30	30.90	(25.30)	(53.40)	0.58
2/29/2016	20:46:49	21.41	6.30	30.20	(28.50)	(50.40)	0.58
2/29/2016	21:01:49	21.46	6.40	29.90	(31.70)	(47.40)	0.58
2/29/2016	21:16:49	21.50	6.40	29.60	(34.90)	(44.30)	0.58
2/29/2016	21:31:49	21.55	6.40	29.30	(38.00)	(41.30)	0.58
2/29/2016	21:46:49	21.62	6.40	29.00	(41.10)	(38.20)	0.58
2/29/2016	22:01:49	21.67	6.50	28.60	(44.20)	(35.10)	0.58
2/29/2016	22:16:49	21.72	6.50	28.30	(47.10)	(32.00)	0.58
2/29/2016	22:31:49	21.76	6.50	28.00	(50.00)	(28.90)	0.58
2/29/2016	22:46:49	21.78	6.50	27.70	(52.80)	(25.80)	0.58
2/29/2016	23:01:49	21.82	6.50	27.30	(55.50)	(22.70)	0.57
2/29/2016	23:16:49	21.83	6.50	27.30	(58.00)	(19.60)	0.57
2/29/2016	23:31:49	21.84	6.60	27.30	(60.40)	(16.60)	0.57
2/29/2016	23:46:49	21.84	6.60	27.30	(62.40)	(13.50)	0.57
3/1/2016	0:01:49	21.84	6.60	27.30	(64.20)	(10.50)	0.57
3/1/2016	0:16:49	21.85	6.60	27.00	(65.60)	(7.40)	0.57
3/1/2016	0:31:49	21.83	6.50	27.00	(66.50)	(4.40)	0.57
3/1/2016	0:46:49	21.77	6.50	27.00	(66.90)	(1.50)	0.57
3/1/2016	1:01:49	21.53	6.40	27.00	(66.80)	1.50	0.57
3/1/2016	1:16:49	21.19	6.20	27.30	(66.20)	4.40	0.57
3/1/2016	1:31:49	20.79	6.00	28.00	(65.10)	7.30	0.56

The Park's Dark Sky Monitoring web page can be accessed at:

http://tpwd.texas.gov/state-parks/south-llano-river/dark-skies

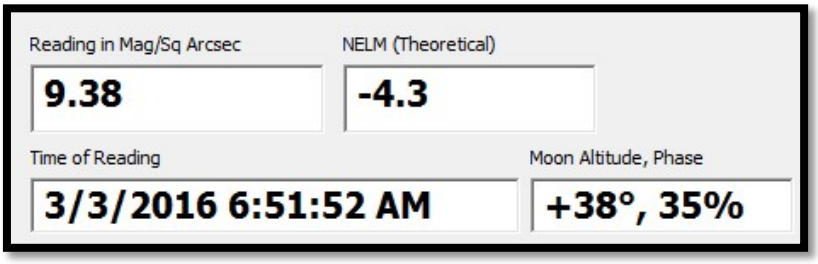
A description of the information on the web page is described in the next section.

Real-Time Sky Darkness Monitoring

The sky quality monitoring station records measurements in a number of ways, but the two most common are:

- Magnitudes per Square Arc Second (Mag/Sq Arcsec or MPAS)
- Naked Eye Limiting Magnitude (NELM).

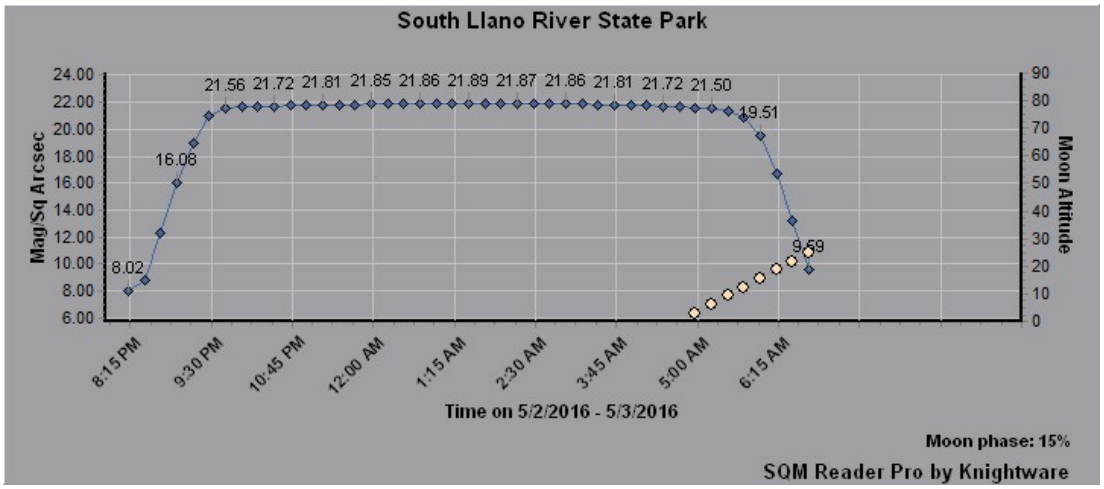
The Park's dark sky monitoring web page gives sky quality readings in both formats. The chart below from the web page indicates the current sky darkness readings in Mag/Sq Arcsec (magnitudes per square arcsecond) and NELM (naked eye limiting magnitude). The higher the number in Mag/Sq Arcsec and NELM, the darker it is. These measurements are explained in more detail below. A reading greater than 21.5 Mag/Sq Arcsec or 6.0 NELM is considered a dark sky. An example of the information provided by the web page is shown below.

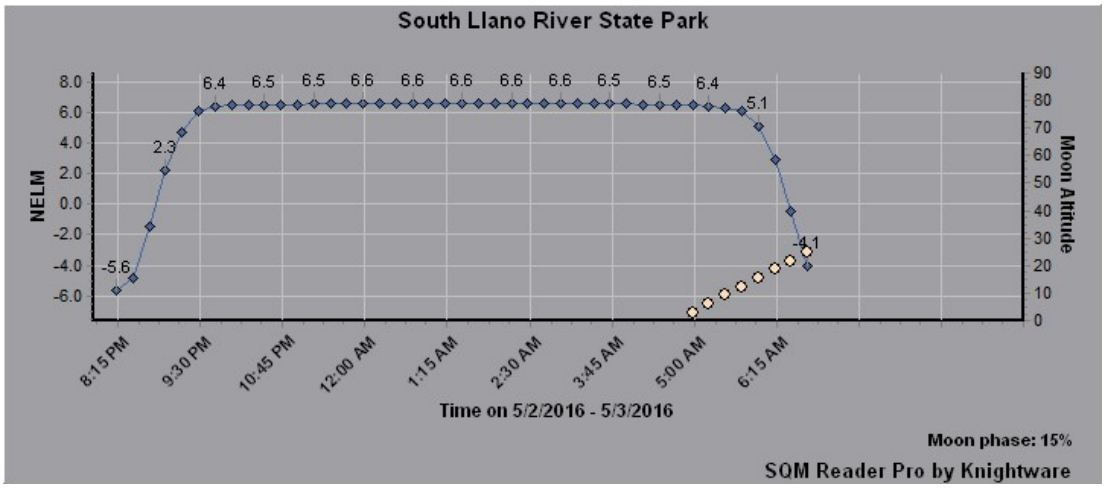


SQM Current Readings

The graphs below show the sky darkness fluctuations over time. One chart is based on NELM measurements and the other is based on Mag/Sq Arcsec. Measurements are taken every 15 minutes and posted to the graph in real time. Measurements are taken starting at sunset and continue through the night until sunrise the next morning.

In the graphs below, the blue line represents the current sky quality meter reading. The line with white circles represents the altitude of the moon in the sky. The current phase of the moon, as a percentage, is indicated in the lower right portion of the graph. Over time the blue line decreases as the moon rises - which means as the moon climbs higher in the sky, the darkness of the sky decreases. Conversely, the blue line increase as the moon sets – which means the sky gets darker as the moon sets lower in the sky.





Fluctuations in sky darkness are caused by the rising and setting of the moon, the Milky Way passing directly overhead and man-made sources. Readings greater than 22.5 Mag/Sq Arcsec typically indicate the sky is clouded over which makes the environment very dark because there is no star light or any other light coming from the sky.

A number of factors contribute to how dark the night sky is, including the moon, milky-way, airglow from gases in the atmosphere, and the largest contributor – light pollution from man-made sources of illumination.

Explanation of Magnitude

Both measurements use the term "magnitude" which comes from the term "apparent magnitude" that astronomers use to describe how bright an object appears in the night sky. Apparent magnitude was originally based on a scale from 1 to 6, with 1 representing the magnitude of a particular reference star and 6 representing the faintest object that can be seen by the naked eye.

Going from one magnitude to another represents a change in brightness of 2.5 times. This means an object of magnitude 3 is 2.5 times brighter than on object of magnitude 4. The important point to remember is that brighter objects have smaller magnitudes and fainter objects have larger magnitudes. The magnitude scale can even have negative numbers which means the object is very bright. For example, the brightest star in the sky is Sirius and has an apparent magnitude of -1.6. Sirius is near the constellation Orion in the winter sky.

Therefore, Naked Eye Limiting Magnitude or NELM simply represents the faintest magnitude that your naked eye can perceive under the particular sky being measured. A NELM of 6.0 means you will be able to see objects as faint as magnitude 6.0 which is about as faint as the human eye can see. A NELM of 2.0 on the other hand, means the sky is relatively bright due to the presence of the moon in the sky or you could be in an urban location with a lot of light pollution. Some of the darkest locations on planet Earth have a NELM of around 7.0 to 7.5.

Some examples of objects with varying magnitudes are listed below.

Apparent Magnitude	Celestial Object
-26.7	Sun
-12.6	Full Moon
-4.4	Venus (at brightest)
-3.0	Mars (at brightest)
-1.6	Sirius (brightest star)
+3.0	Naked eye limit in an urban neighborhood
+5.5	Uranus (at brightest)
+6.0	Naked eye limit
+9.5	Faintest objects visible with binoculars

Explanation of Mag/Sq Arcsec

Astronomers also use Mag/Sq Arcsec to measure relative sky darkness. There is even a formula to convert from NELM to Mag/Sq Arcsec. Mag/Sq Arcsec is simply the apparent magnitude (discussed above) for a certain square area of the sky represented in arc seconds. A square arc second is a square area of the sky that is one arc second on each side. An arc second is a very small measurement. For example, Jupiter looks very small in the sky, but through binoculars it does have a disk-like shape and a small diameter. Jupiter's angular diameter ranges from 30 to 50 arc seconds. Therefore, Mag/Sq Arcsec means the brightness (expressed in apparent magnitude) of a one arc second square area of the sky. This is very small and almost a single point in the sky.

The Bortle Scale

The Bortle Dark-Sky Scale is a numeric scale that measures the night sky's naked eye brightness and stellar limiting magnitude at a particular location. It quantifies the ability to observe celestial objects and the interference caused by light pollution and sky glow.

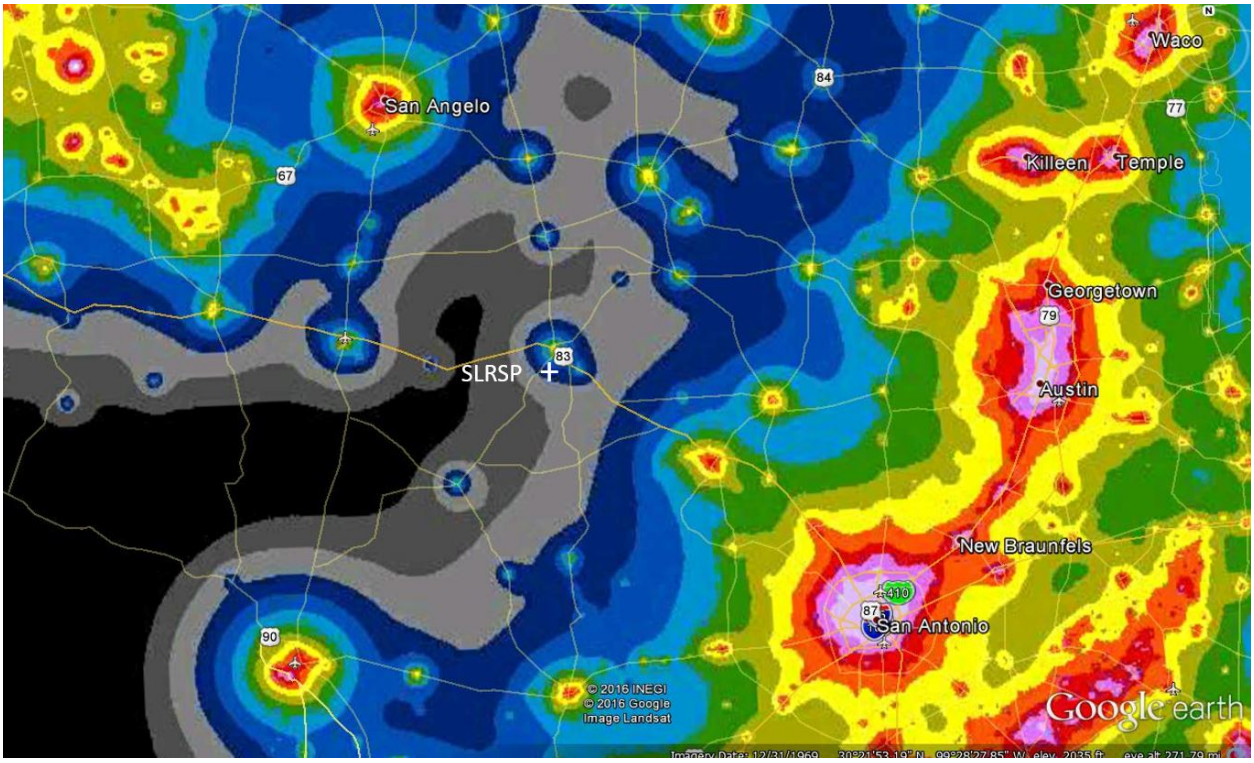
John E. Bortle created the scale and published it in the February 2001 edition of Sky & Telescope magazine to help observers compare the darkness of observing sites. The scale ranges from Class 1, the darkest skies available on Earth, through Class 9, inner-city skies. In the chart below, the Bortle scale is depicted with a color coding scheme along with Naked Eye Limiting Magnitude (NELM) and Mag/Sq Arcsec so you can compare the different measurements.

Bortle Scale	Title	NELM	Mag/Arcsecond	Description
1	Excellent Dark Sky Site	7.6 – 8.0	22.00 – 21.99	Zodiacal light visible; M33 direct vision naked eye object; Regions of the Milky Way cast obvious shadows on the ground; surroundings basically invisible.
2	Typical True Dark Sky Site	7.1 – 7.5	21.99 – 21.89	Highly structured summer Milky Way; distinctly yellowish zodiacal light bright enough to cast shadows at dusk and dawn.
3	Rural Sky	6.6 – 7.0	21.89 – 21.69	Low light domes (10 to 15 degrees) on horizon. M33 easy with averted vision. Milky way shows bulge.
4	Rural / Suburban Transition	6.2 – 6.5	21.69 – 21.25	Zodiacal light seen on best nights. Milky way shows much dark lane structure with beginnings of faint bulge. M33 difficult even when above 50 degrees.
4.5	Suburban Sky	5.9 – 6.2	21.25 – 20.49	Some dark lanes in Milky Way but no bulge. Washed out Milky Way visible near horizon. Zodiacal light very rare. Light domes up to 45 degrees.
5	Bright Suburban Sky	5.6 – 5.9	20.49 – 19.50	Milky Way washed out at zenith and invisible at horizon. Many light domes. Clouds are brighter than sky.
6 – 7	Suburban / Urban Transition or Full Moon	5.0 – 5.5	19.50 – 18.38	Milky Way at best very faint at zenith. M31 difficult and indistinct. Sky is grey up to 35 degrees.
8 - 9	City Sky	3.0 – 4.0	< 18.38	Entire sky is grayish or brighter. Familiar constellations are missing stars. Most people don't look up.

Location of Sky Quality Monitoring Station

The sky quality monitoring station is located at the Park. The map below shows the sky glow around the Park with colors that match the Bortle scale.

The Park is designated at the SLRSP crosshairs. The cities of Junction, Austin and San Antonio are indicated. The Bortle scale map is based on the latest data from the New World Atlas of Artificial Night Sky Brightness.[3]

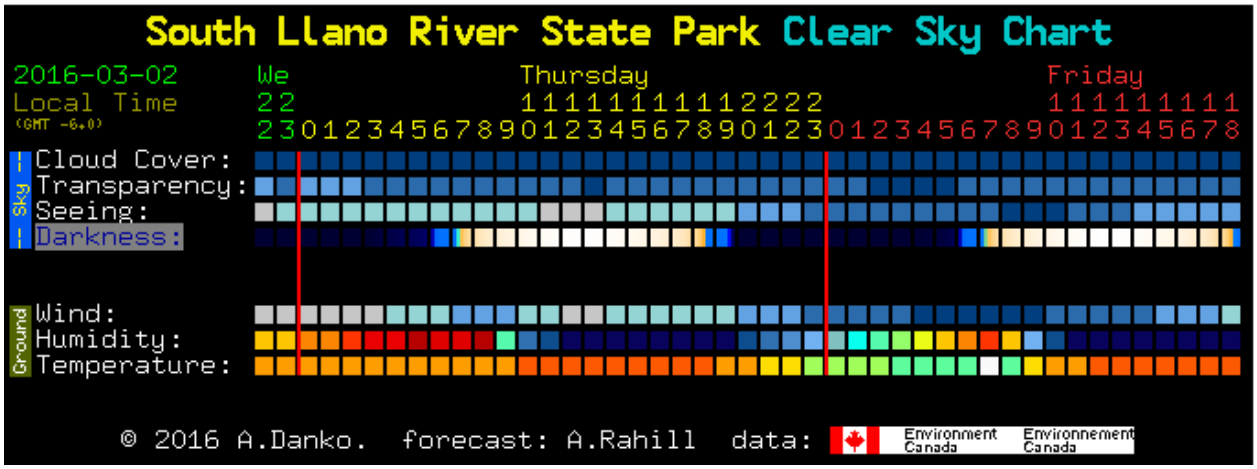


In 2013, the city of Junction undertook a city-owned lighting retrofit to replace old mercury vapor street lights with newer, full cutoff sodium lights with a much lower wattage. See section 5 of this Application for a more detailed discussion.

[3] Falchi, Fabio; Cinzano, Pierantonio; Duriscoe, Dan; Kyba, Christopher C. M.; Elvidge, Christopher D.; Baugh, Kimberly; Portnov, Boris; Rybnikova, Nataliya A.; Furgoni, Riccardo (2016): Supplement to: The New World Atlas of Artificial Night Sky Brightness. GFZ Data Services. http://doi.org/10.5880/GFZ.1.4.2016.001

Clear Sky Chart

The Park also has a Clear Sky Chart. A Clear Sky Chart is an astronomer's forecast about sky conditions, including, darkness, cloudiness, transparency and the seeing quality.



Section 6. South Llano River State Park Dark Sky Commitment

The Park is dedicated to dark sky preservation and proper outdoor lighting management by recognizing dark skies as an important natural, cultural and even scientific resource. One of the Park's outreach goals is to preserve the beauty of the Park area night skies by fostering public appreciation and understanding of the importance of the night sky as a significant natural resource.

The Park's commitment to dark skies, outdoor lighting management and public education and awareness is demonstrated by a number of initiatives:

- Support from TPWD's Dark Skies Program;
- IDA Sponsored Lighting Assessment;
- Adoption of Guidelines for Outdoor Lighting;
- Implementation of Outdoor Lighting Improvement Program;
- Installation of permanent dark sky monitoring station;
- Collaboration with external organizations in dark sky restoration efforts;
- Adopting Dark Sky Preservation Interpretive Program Curriculum; and
- Promoting educational and interpretive programs.

Texas Parks and Wildlife Department's Commitment to Dark Skies

The Park's commitment to dark sky preservation and education is supported by the Texas Parks and Wildlife Department's initiative to preserve night skies in the Texas State Parks. The Texas Parks and Wildlife Department has established a new statewide initiative called the *Dark Skies Program* that interprets and celebrates night skies in state parks with regular evening programs. This will involve establishing new "partnerships" with local astronomy groups as well as a commitment to train Park staff to lead night sky programs.

According to Texas Parks and Wildlife Department Director, Brent Leisure:

> "Preserving night skies is an important component of our overall conservation goal in state parks. Reducing light pollution in parks and educating visitors about the loss of dark skies is an important initiative. As with most things, resources are required to adapt antiquated lighting fixtures and deliver programs to enhance public awareness. We are fortunate to have the support of advocacy groups that share this concern."

In addition, Brent Leisure has authored a support letter as part of this Application. See section 2 of this Application. In Brent Leisure's support letter he notes:

> "The leadership within the Texas State Parks is working in concert with many partners to assess light conditions in our parks and to make the necessary adjustments in our lighting systems to protect the dark sky values we all enjoy. Modeling night sky protection is essential for us in these unique settings. South Llano River State Park is enjoyed by thousands of visitors every year and its designation as a 'Dark Sky Park' will help us to emphasize the value we place on night sky preservation and incorporate stewardship messages into the programming provided to visitors.

The Texas Parks and Wildlife Department has established a web page dedicated to the Dark Skies Program. The web page can be viewed at the following link:

https://tpwd.texas.gov/spdest/programs/dark_skies/

The Dark Skies Program provides information about star gazing and the various state parks that have achieved International Dark Sky Park status. Also, in partnership with McDonald Observatory, the Texas Parks and Wildlife Department has produced public information videos about preserving darkskies in Texas. SLRSP plans to use these video in the Park's outreach efforts. A link to the video is below.

https://www.youtube.com/watch?v=2XkF5OmPZ74

IDA Sponsored Lighting Assessment

The Park requested a lighting and dark sky assessment to begin the process of improving outdoor lighting in the Park. In August 2013, an IDA Lighting Assessment was conducted at the Park. All lighting changes recommended in the assessment have been adopted and are either completed or in the process of being implemented. A copy of the full assessment report is included in Appendix 1 to this Application.

Adoption of Guidelines for Outdoor Lighting

The Park has adopted the Guidelines for Outdoor Lighting that are included in Section 9 of this Application. These guidelines have been implemented throughout the Park as the reference for changing and improving the outdoor lighting in the Park. These guidelines also serve to direct any future additions to outdoor lighting in the Park. The Park will also comply with any future state-wide guidelines for outdoor lighting adopted by the Texas Parks and Wildlife Department.

Outdoor Lighting Improvement Program

In response to the Outdoor Lighting Assessment and the Guidelines for Outdoor Lighting, Park management has examined every lighting fixture in the Park to ensure compliance with the guidelines. Where needed, existing lighting was removed and replaced, shielding was implemented and timers and switches were installed.

Presently, all outdoor lighting in the Park complies with the Guidelines for Outdoor Lighting. The Lighting Inventory for the Park is included in Section 10 of this Application and shows that each fixture in the Park complies with the guidelines.

The Outdoor Lighting Improvement Program will also serve as part of the Park's interpretive and educational programs. When teaching the public about the importance of preserving dark skies, the efforts undertaken to improve the Park's outdoor lighting will be used as an example to show how better lighting is easy to implement and install.

Permanent Dark Sky Monitoring Station

Section 5 of this Application describes the installation of the permanent dark sky monitoring station. The dark sky monitoring station keeps a database of sky quality readings to monitor and assess light pollution and sky quality over time. Sky quality monitoring information will be used by the Park in its outreach and interpretive programs to educate the public about night sky preservation.

The Park has implemented a revised web page that features dark sky information, including "live" posting of current sky quality readings from the Park's dark sky monitoring station. The public is able to see current sky quality readings as they occur each night along with an explanation of the readings.

Collaboration with External Organizations on Dark Sky Awareness

The Park is working with a number of external organizations to raise awareness about dark sky preservation, including Hill Country Alliance, Texas Tech University at Junction, astronomy clubs and local astronomers, and nearby schools. The Park is also reaching out to city officials, including the Mayor's office in Junction Texas to begin a dialogue about dark sky awareness. Recently, a number of concerned citizens met with city officials to discuss Junction applying for Dark Sky Community status with the IDA. The Park hopes to set an example and standard for dark sky awareness for the communities surrounding the Park.

Leadership Example in Restoration of Dark Skies

As noted, the Park is dedicated to dark sky preservation and proper outdoor lighting management by recognizing dark skies as an important natural, cultural and even scientific resource. The

Park has set a leadership example in the restoration of dark skies through its Sky Quality Monitoring Station and the *Starlight on Country Nights* program which is presented to the public. This program is exhibited in part at the acorn blind where there is a permanently installed power point screen for the presentations. On either side of the screen are retrofitted light fixtures that have been "boxed" and shielded to demonstrate to the public how shielding works. Before and after photos are also shown (*See* Lighting Inventory Photos AB-1 and AB-2). This night sky friendly lighting project is publically visible and interpreted. In addition, the *Starlight on Country Nights* program also teaches the public about inventorying and monitoring night sky quality with the Park's Sky Quality Monitoring Station. Moreover, the Park's website has live data posted from the Park's Sky Quality Monitoring Station with explanation to educate the public about this important monitoring effort.

Section 7. Dark Sky Interpretive Programs and Education

Dark Sky Interpretive Program Curriculum

The Park has developed a curriculum for teaching the general public about dark sky preservation efforts. This curriculum is based in part on information and teaching materials provided by the IDA. Topics include, defining the problem of light pollution, harm to wildlife, harm to humans, safe and better lighting and energy waste.

The curriculum will be used in the Park's outreach, educational and interpretive programs that are described in more detail below. A copy of the curriculum is attached at the end of this section.

Outreach, Educational and Interpretive Programs

Based on the Dark Sky Interpretive Program Curriculum, the Park has developed an outreach program called *Starlight on Country Nights* to educate the public about dark sky preservation and better outdoor lighting. Two important aspects of this program are to demonstrate a night time friendly lighting project to the public and also to explain the Dark Sky Monitoring Station in order to educate the public about dark sky preservation efforts at the Park. This dark sky preservation program is part of the Park's Family Park Program series. A public program is scheduled at the Park approximately once every other month. Upcoming programs are listed on the Park's *Facebook* page, website and posted at the Park's administrative building.

The Park has held a number of *Starlight on Country Night* programs and star parties over the past several months to teach about the Park's dark skies, preservation efforts, light pollution and the Park's IDA Dark Sky Park application process:

- July 22, 2016
- August 6, 2016

- September 3, 2016
- September 24, 2016 (canceled due to weather)
- October 20, 2016 (shorter presentation to Junction Rotary Club).
- November 19, 2016

Copies of the flyers for these events are included at the end of this section under *Starlight on Country Nights Brochure and Face Book Promotions*. At the September 3 presentation of Starlight on Country Nights, 22 adults and 14 children attended. Park Interpreter Holly Platz presented information and photos about light pollution and how it affects wildlife, the Park's recent efforts to protect dark skies and how the public can help by using proper lighting and advocating proper lighting to their neighbors and community members. Before and after photos of the Park's retrofitted light fixtures were shown and the Sky Quality Monitoring Station was explained. The Park's efforts to become an IDA Dark Sky Park were also presented.

At the November 19 presentation, Texas Tech University at Junction Outdoor School, Mason Star Gazers and local amateur astronomer, Greg Beers partnered with the Park in making the presentation and putting on a star party for visitors. A total of 58 people attended (48 adults and 13 children).

In addition, on the Park's Facebook page, the Park is adding promotional posts about dark sky awareness issues. Copies of these promotional materials are included at the end of this section under *Starlight on Country Nights Brochure and Face Book Promotions*. The Park's *Facebook* page is located at the link below.

https://www.facebook.com/SouthLlanoRiver/

The Park also plans to show *Dark Skies: The Night Watch*, a production from the Texas Parks & Wildlife Department that explains the importance of keeping our skies dark, featuring Bill Wren from McDonald Observatory. The production can be seen at the link below.

https://www.youtube.com/watch?v=2XkF5OmPZ74

The Park has reached out to local astronomy groups (Mason Star Gazers and Hill Country Astronomers) to hold public star parties, introduce the public to the night sky and preservation efforts and assist with the *Starlight on Country Nights* programming. The star parties include general astronomy but also interpretive education on dark sky preservation. To further these efforts, the Park has posted on the TPWD volunteer page for interpretive volunteers to assist the Park in star-gazing opportunities. Also, the Park has contacted the local chapter of the Texas Master Naturalist program for their assistance in locating volunteers interested in helping with star parties and dark sky awareness programs.

In addition, Park Interpreter, Holly Platz makes star party presentations and during night hikes and other evening events, she points out constellations and planets to program attendees. She also points out the changes the Park has made to existing fixtures as an IDA Dark Sky Park.

The Texas Parks and Wildlife Department maintains a dedicated website for each state park. The website for the Park has being updated to include a star gazing tab that provides information about the Park's permanent sky quality monitoring station. Live readings from the sky quality monitoring station are posted to this web page each night for the public to monitor the sky quality at the Park. In the future, this web page will provide additional information to the public about dark sky preservation efforts. The link for the new web page is shown below:

http://tpwd.texas.gov/state-parks/south-llano-river/dark-skies

Future Efforts and Planning

One key to dark sky preservation is to teach the wonders of the night sky to children. Park Interpreter, Holly Platz plans to partner with local Middle School teachers on an interpretive project which features the Park's dark sky preservation. Future outreach efforts will continue to target area schools.

The Park is working on an interpretive display for one of the Park's bulletin boards to explain dark sky preservation efforts, overview the Park's permanent sky quality monitoring station and indicate what celestial events take place each month.

The Park also plans to collaborate with the Texas Tech University Center at Junction and their Outdoor School Program to coordinate efforts to teach the public about the importance of preserving night skies. Robert Stubblefield, Director of the Texas Tech University Center at Junction is supportive of the Park's application to become a Dark Sky Park and to work on future outreach efforts with the Park.

Finally, the Park plans to continue updating dark sky interpretive materials and programs with lessons learned from implementing the Park's Guidelines for Outdoor Lighting.

South Llano River State Park

Dark Sky Interpretive Program Curriculum

I. Introduction

A. Introductory Concepts

1. What is Light Pollution?

2. Light Pollution Terminology

a) Glare
b) Urban sky glow
c) Light trespass
d) Clutter
e) Shielded
f) Full cut-off

3. The problem of light pollution

4. Harm to wildlife

5. Lighting for Safety

6. Harm to Human Health

7. Energy Waste

II. Light Pollution – What's the problem?

A. Four Components of light pollution

1. Skyglow

a) What is it?
b) Disrupts astronomy
c) Disrupts Circadian rhythms

2. Light Trespass - streetlights or a neighbor's security light directs unwanted lighting onto our property or into our homes, contributes to a loss of natural darkness.

3. Glare - a nighttime environment that is over-lit results in lowered visibility: direct glare from improperly shielded fixtures is often blinding.

4. Clutter - The redundant lighting found in many urban centers results in a clutter of lights that contribute to sky glow, trespass, and glare while destroying the ambiance of our nighttime environment.

III. Harm to wildlife

A. From newly hatched sea turtles to migrating birds, fish, frogs, salamanders, and lighting bugs, artificial night lighting disrupts the cycles of nocturnal creatures in potentially devastating ways**.** Research is ongoing but it is becoming apparent that both bright days and dark nights are necessary to maintain healthy hormone production, cell function, and brain activity, as well as normal feeding, mating, and migratory behavior for many species, including humans.

B. Mammals

a) Bright lights from cities and towns cause nocturnal mammals across the globe to experience a loss of their night ecosystem. Examples of these affected mammals are bats, raccoons, coyotes, deer and moose. These species can experience a decline in reproduction, leading to a shrinking population, difficulty foraging for food due to too much light and exposure to predators that would otherwise be unable to see them and increased mortality caused by impairment of their night vision.

C. Birds

1. Many species of birds migrate or hunt at night. This dependence on darkness makes them extremely vulnerable to bright lights in areas that are naturally dark.

2. Birds can be drawn to light sources and become fixated on the beam. This confusion causes a variety of negative effects, such as:

a) 100 million birds a year throughout North America die in collisions with lighted buildings and towers.

b) Not wanting to fly back into the dark, they continue to fly in the light's beam until they are exhausted, fall or become prey.

c) Artificial lights can also cause migrating birds to wander off course and never reach their natural destination.

d) Marine birds have been known to collide with lighthouses, wind turbines and drilling platforms at sea.

D. Amphibians

1. The haze from sky glow extends far beyond the borders of an urban city, impacting the environment for miles, including wetlands, the natural habitat of amphibians. It causes amphibians, and other creatures of the marshes, to become confused and disoriented, causing:

a) a decrease in reproduction, resulting in lower populations,

b) reduced foraging for food and lower body weight, and

c) confusion of natural instincts that protect against predators and the elements.

E. Reptiles

1. Reptiles are greatly affected by light pollution. For example, female sea turtles like to nest on remote and very dark beaches. Coastal lights interfere with their ability to find a safe nesting area for their eggs. Sea turtle hatchlings crawl instinctively toward the relative safety of the ocean because of its reflection of the moon and stars. For centuries, this reflection was the brightest point of light on a beach. Artificial lights can confuse the hatchlings and cause them to crawl away from the ocean and onto roads or into communities. If they do not find their way back to the ocean, they could become fatally exhausted or dehydrated.

2. Nocturnal reptiles can also become disoriented by the artificial light invading their homes and experience a change in natural behaviors. These behaviors might include: appetite problems resulting in decreased weight, decrease in mating, resulting in diminished populations; and increased vulnerability to natural predators.

F. Insects

1. Moths and other insects are attracted to artificial lights and may stay near that light all night. This activity around the light expends too much energy and interferes with mating and migration, causing population reduction, makes them easy prey for bats and other nocturnal predators, further reducing their numbers, and impacts all species who rely on insects for food or pollination.

IV. Harm to Humans

A. Glare on the eyes

B. Circadian Rhythms and Melatonin

C. Sleep Disorders

V. Energy Waste

A. Light pollution wastes money and energy. Billions of dollars are spent on unnecessary lighting every year in the United States alone, with over $2.2 billion going directly into the nighttime sky via unshielded outdoor lights.

B. Unshielded outdoor lights are directly responsible for 14.7 million tons of carbon dioxide waste. Simply reducing and removing unnecessary lighting saves money and energy, often at minimal expense. Over-lighting the night neither improves visibility nor increases nighttime safety, utility, security, or ambiance.

C. Wasted outdoor lighting, that shines directly upward, is estimated at 17,400 gigawatt-hours a year. At an average of $.10 per kilo watt-hour the cost of that wasted energy is $1.74 billion a year.

VI. Safety

A. Brighter does not mean safer

B. Good visibility is the goal

C. See where you're driving

D. See where you're walking

VII. Practical Actions

A. Use light only when and where it's needed. Turn off lights when they are not needed and create a curfew for lights-out. Minimize interim light use with timers and motion detectors.

B. Use only as much light as needed. Over lighting reduces the eye's ability to see outside of the lit area. In addition, excess light can produce glare, which also reduces visibility.

C. Selecting the correct lamp wattage for your needs increases safety and reduces costs.

D. Shine lights down, not up. A well-designed fixture will direct the light where it's needed most - at the ground.

E. Select new fixtures that are fully shielded; retrofit or replace poor quality fixtures.

F. Use efficient light sources for outdoor lighting around homes and businesses. Consider a low wattage compact fluorescent for good, energy efficient, economical lighting.

VIII. Examples of Acceptable Fixtures

IX. Outdoor Lighting Improvement Plan

A. Overview of Guidelines for Outdoor Lighting

B. Explanation of shielding

C. Lumens discussion

D. Tour of fixtures in the Park and explanation of improvements in fixtures

E. What does a Dark Sky Park designation mean?

X. Permanent Sky Quality Measuring Station

A. Tour of measuring station

B. Explanation of measurement system

C. Explanation of magnitude

D. Explanation of sky glow

Starlight on Country Nights
Program Brochure

and

Facebook Promotions

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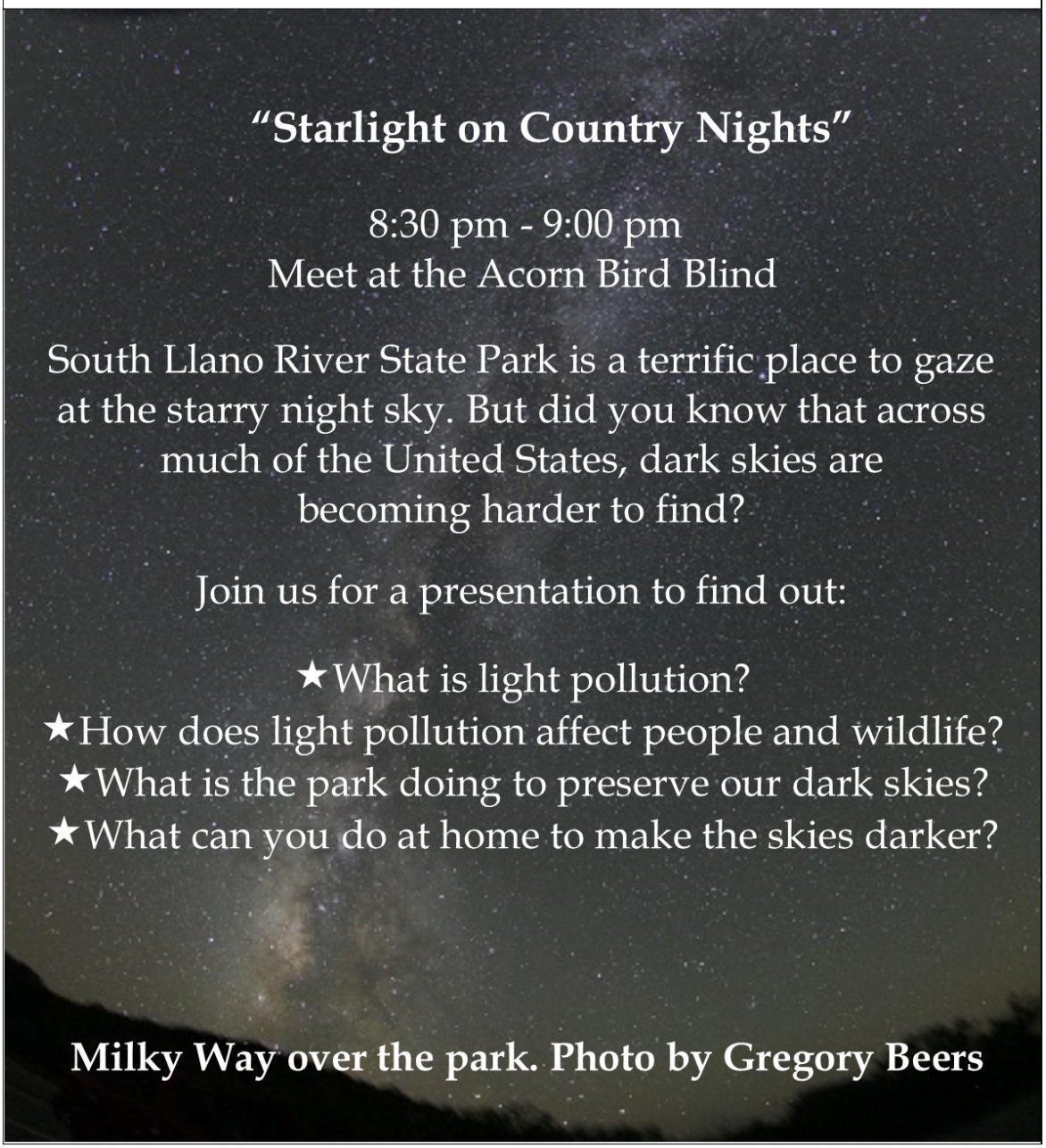
Family Park Program
South Llano River State Park
Phone: (325) 446-3994



Park programs are open to the public and free with park entrance fee

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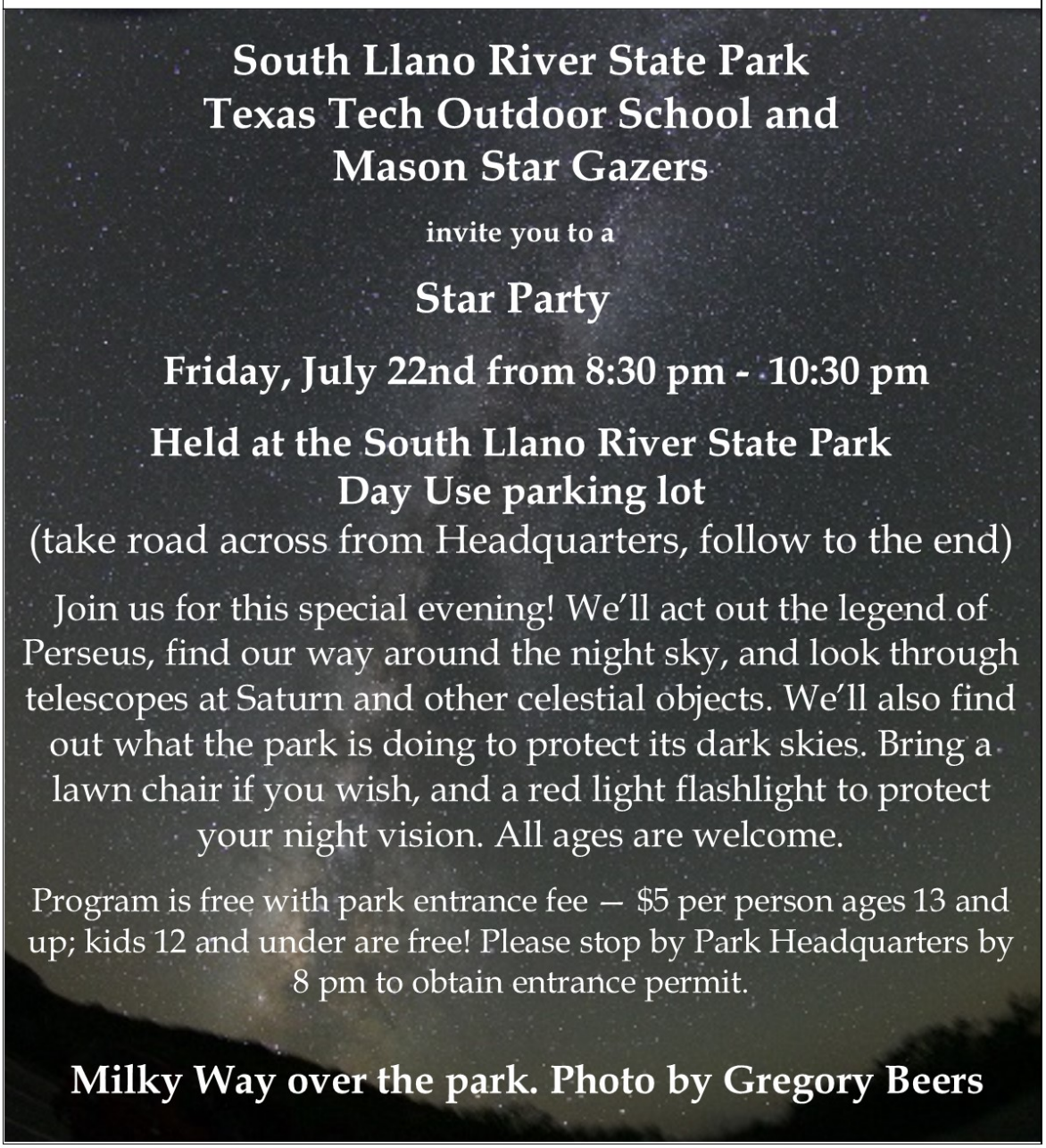

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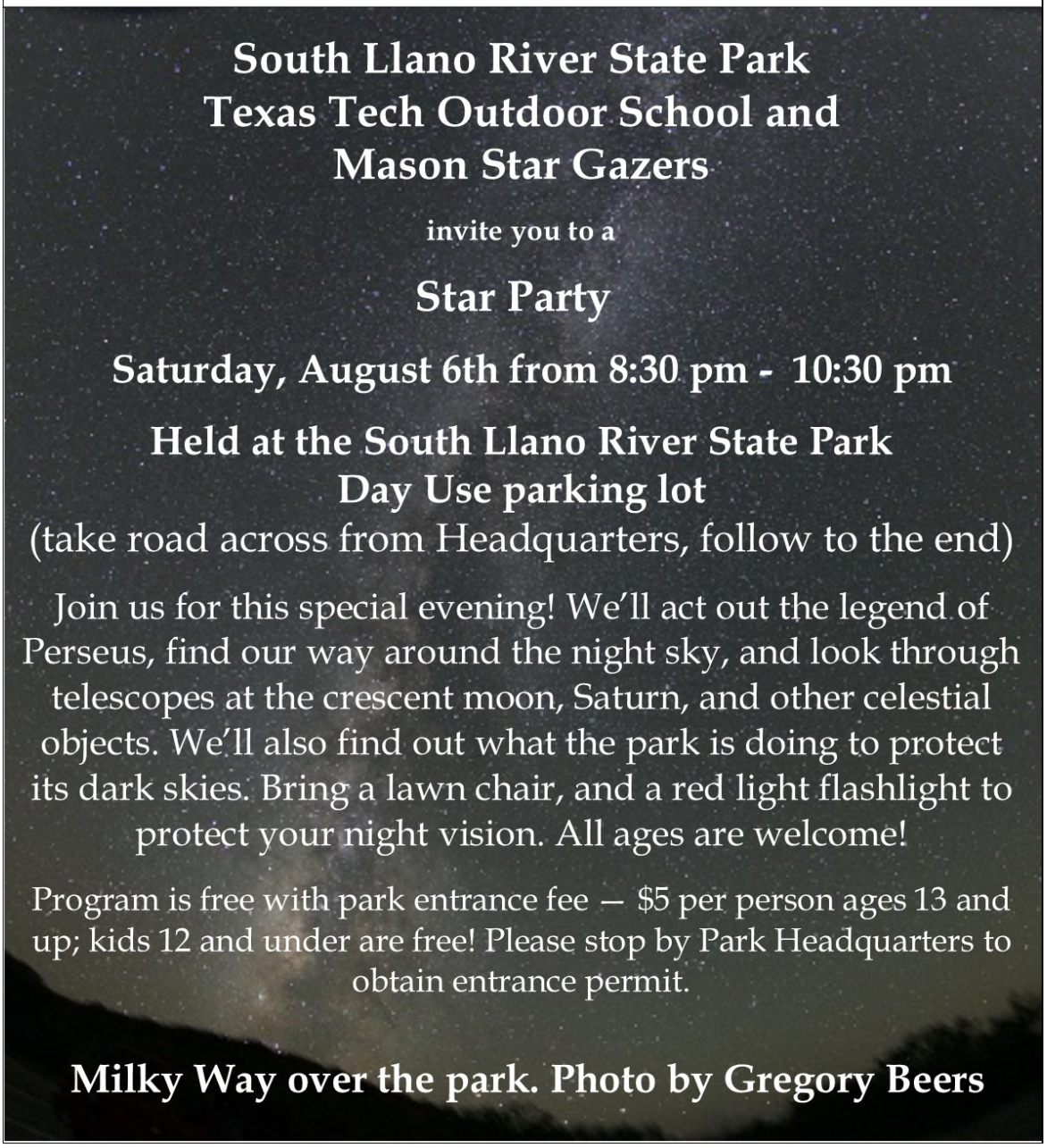

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Geocaching 101

Friday, September 2nd, 3:00 pm - 4:00 pm
Meet at the Acorn Blind
(down the path from the restrooms, between campsites 39 and 41)

Experience the fun of Geocaching, a high-tech treasure hunt you can do anywhere in the world using a GPS unit or your smartphone! Hand-held GPS units will be provided for this activity. Good walking shoes, sun protection, drinking water, and bug spray are recommended. All ages welcome!

Skins, Skulls, and More!

Saturday, September 3rd,
Drop-in between 3:00 pm and 4:00 pm
Held at the Acorn Blind
(down the path from the restrooms, between campsites 39 and 41)

Stop by the Acorn Blind this afternoon to see and touch animal furs and skulls, and find out what a skull can tell us about how an animal lives! All ages welcome.

"Starlight on Country Nights"

Saturday, September 3rd, 8:30 pm - 9:00 pm
Held at the Acorn Blind
(down the path from the restrooms, between campsites 39 and 41)

South Llano River State Park is a terrific place to gaze at the starry night sky. But did you know that across much of the United States, dark skies are becoming harder to find? Bring the whole family for a presentation to find out:

- ★ What is light pollution, and how does it affect people and wildlife?
- ★ What is the park doing to protect its dark skies?
- ★ What can you do at home to make the skies darker?

Shielded light fixture at the park

Park programs are open to the public and free with park entrance fee

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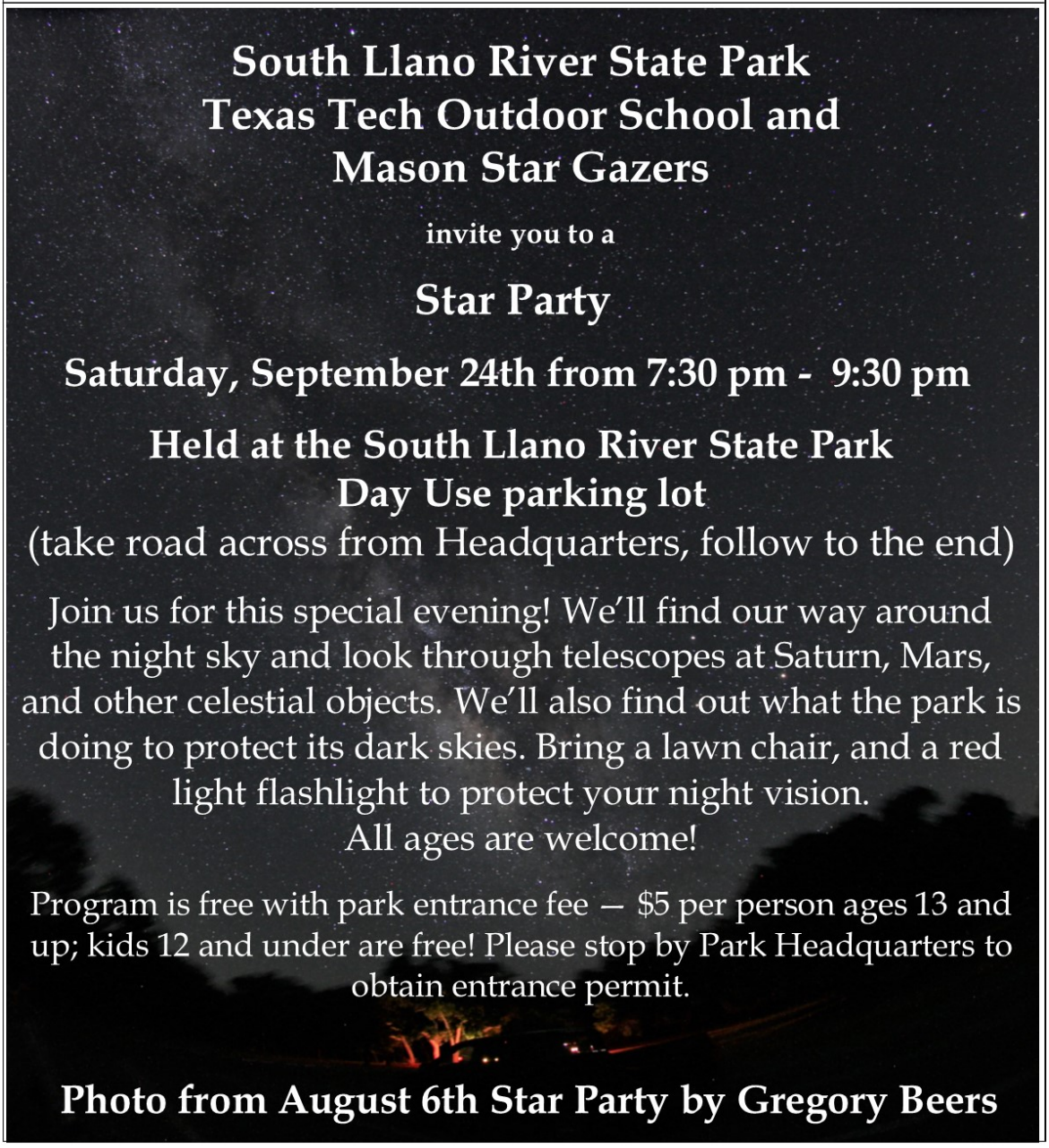

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South Llano River State Park - Texas Parks and Wildlife
added 3 new photos.
Published by Ranger Holly [?] · Yesterday at 20:08 ·

Photographer Gregory Beers took these photos of the Milky Way last October here at the park! The skies at South Llano River State Park are very dark, ranking 3 on the Bortle Scale (this scale ranks sky darkness from 1 to 10, with lower numbers indicating darker skies).
http://tpwd.texas.gov/…/things-to…/stargazing/bortle-ratings

2,411 people reached

Boost post


© John Windsor Photographer 2016
John Windsor ▸ South Llano River State Park - Texas Parks and Wildlife
11 May
I went to SLRSP hunting for the Milky Way, and it did not disappoint. This was shot at about 4am, but as the summer goes along, it will be rising in the Southern sky earlier and earlier. Photos like this are possible because of the wonderfully dark skies. Thanks to Matt and Holly and all the others I have not had the pleasure of meeting for their hard work on the Dark Sky Initiative. If you have not heard of it, ask the next time you visit the park.
Like
Comment
Share
Message
8
Top comments
2 shares
2 comments
Nancy Castillo Mary Castillo Gerlach, remind me to bring my tripod on our trip.
Like · Reply · 2 · 18 May at 20:16
Yesica Brianna Parrales Teresa Culbertson look!! That is awesome. Hope we can see you guys soon
Like · Reply · 1 · 18 May at 20:50
Write a comment...

South Llano River State Park - Texas Parks and Wildlife
shared John Windsor's photo.
Published by Ranger Holly [?] · 18 May ·

Thanks so much for sharing this amazing photo, Mr. Windsor! We are in the process of applying to become an International Dark Sky Park. Check out our Stargazing tab on our website, and stay tuned for updates!
http://tpwd.texas.gov/state-pa…/south-llano-river/dark-skies

John Windsor ▶ **South Llano River State Park - Texas Parks and Wildlife**
11 May ·

I went to SLRSP hunting for the Milky Way, and it did not disappoint. This was shot at about 4am, but as the summer goes along, it will be rising in the Southern sky earlier and earlier. Photos like this are possible because of the wonderfully dark skies. Thanks to Matt and Holly and all the others I have not had the pleasure of meeting for their hard work on the Dark Sky Initiative. If you have not heard of it, ask the next time you visit the park.

682 people reached

Boost post

Like Comment Share

South Llano River State Park

Dark Sky Education Webpage

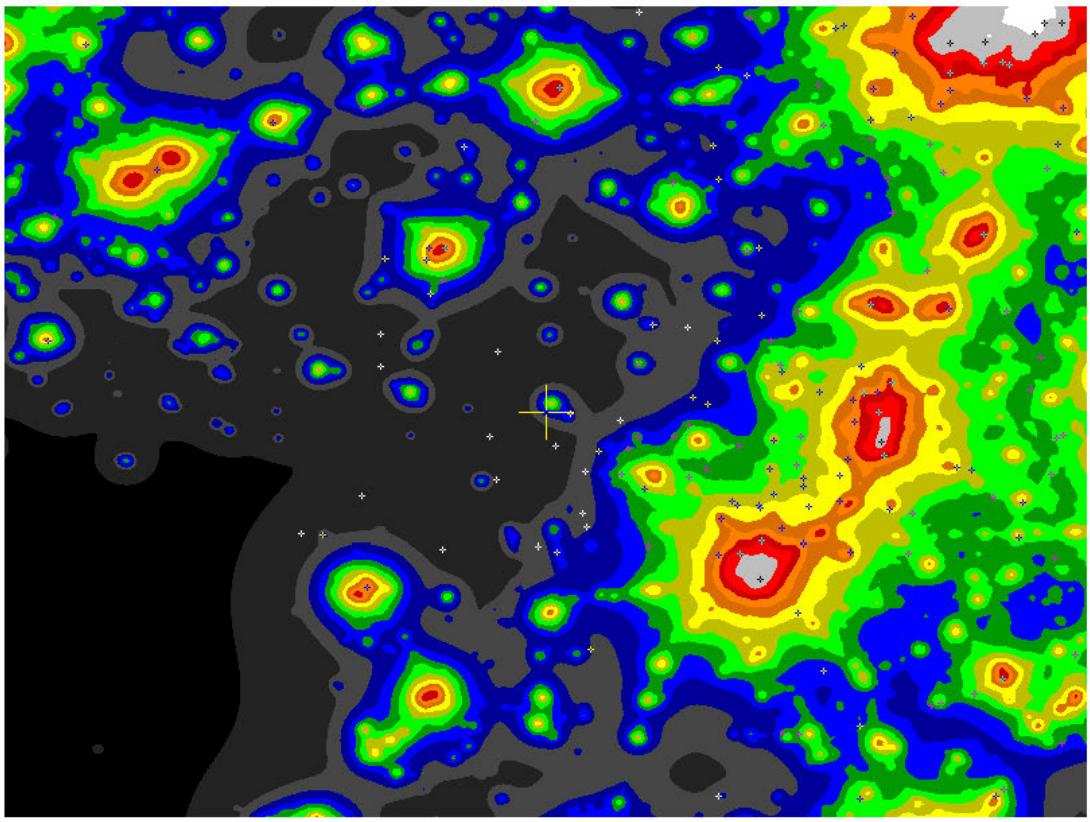
South Llano River State Park Stargazing — Texas Parks & Wildlife Department

How Dark Is It?

The Bortle Dark-Sky Scale measures how well you can see objects in the sky at night. Light pollution and sky glow can interfere with your ability to see "celestial objects."

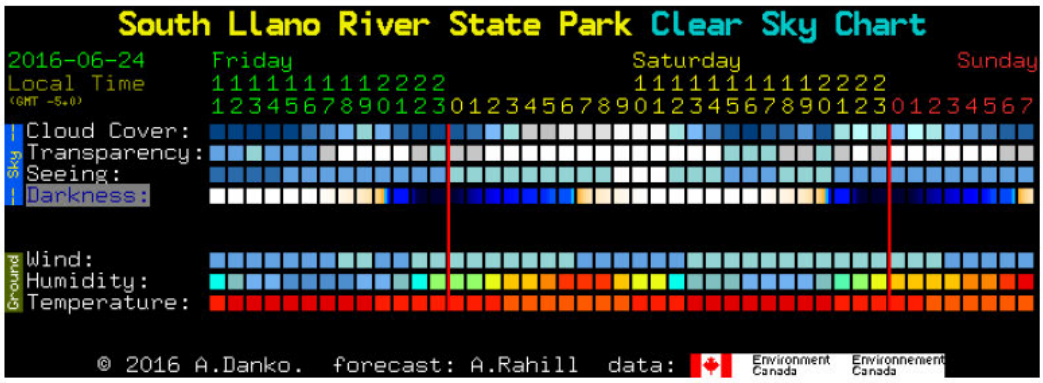
The scale ranges from Class 1, the darkest sides available on Earth, through Class 9, inner-city skies. South Llano's Bortle Scale rating is 3. (Visit Bortle Scale Ratings page to see ratings for all state parks.)

The map below shows the sky glow around the park with colors that match the Bortle scale.



Clear Sky Chart

A Clear Sky Chart is an astronomer's forecast about sky conditions, including, darkness, cloudiness, transparency and the seeing quality. More information about the Clear Sky Chart can be found here.



Real-Time Dark Sky Monitoring

We have installed a dark sky monitor to measure the relative darkness of the sky above the park. The monitoring station posts readings to this page every 15 minutes during the night. The meter is not active during daylight.

Current Reading

Below you will see the real time sky darkness measurements at South Llano River State Park. Remember, the meter does not take readings during the day.

The chart shows the current sky darkness readings in Mag/Sq Arcsec (magnitudes per square arc second) and NELM (naked eye limiting magnitude). The higher the number in Mag/Sq Arcsec and NELM, the darker it is.

A reading greater than 21.5 Mag/Sq Arcsec or 6.0 NELM indicates a very dark sky. Readings greater than 22.5 Mag/Sq Arcsec typically mean that the sky is cloudy.

Learn more about these terms on our Astronomy Definitions page.

Reading in Mag/Sq Arcsec	NELM (Theoretical)
8.24	-5.4

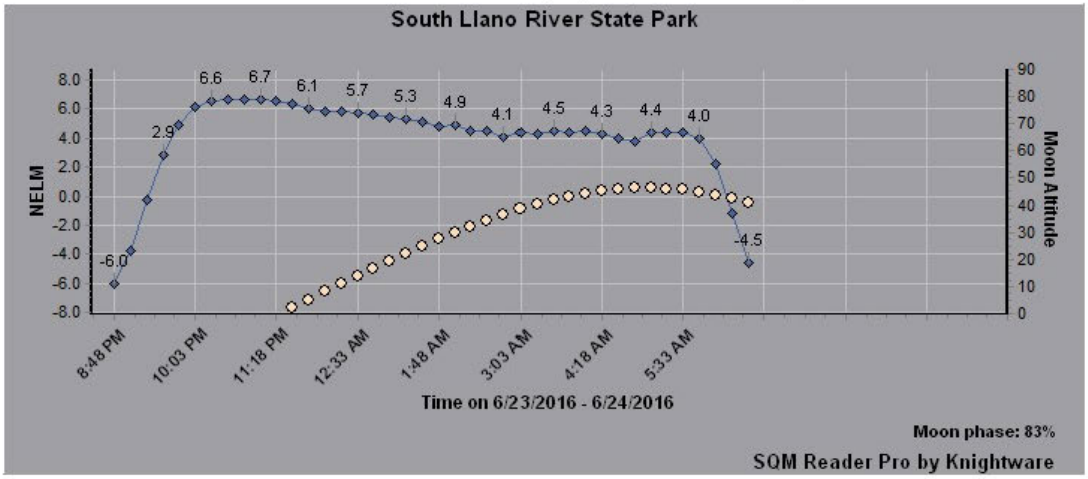
Time of Reading	Moon Altitude, Phase
6/24/2016 6:33:12 AM	+41°, 83%

SQM Current Readings

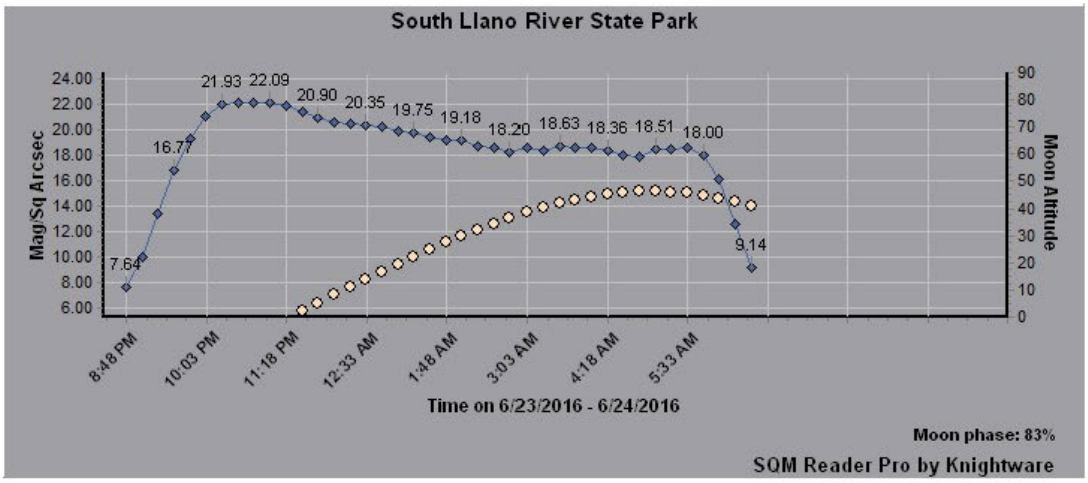
Current Night's Readings

The graphs below show fluctuations in sky darkness over time. One chart shows NELM measurements and the other shows Mag/Sq Arcsec. Again, the monitoring station takes readings every 15 minutes throughout the night and posts in real time.

In these graphs, the blue line represents the sky quality meter reading. The line with white circles shows the altitude of the moon. Look for the current phase of the moon, as a percentage, in the lower right corner of the graph. The blue line will decrease as the moon rises, because as the moon climbs higher in the sky, the sky brightens. Conversely, the blue line will increase as the moon sets: as the moon gets lower in the sky, the sky darkens.



Naked Eye Limiting Magnitude



Magnitudes per Square Arcsecond

The rising and setting of the moon, the Milky Way passing directly overhead, and man-made light can cause fluctuations in sky darkness.

Section 8. South Llano River State Park Guidelines for Outdoor Lighting

The Park (like most Texas State Parks) does not have a general management plan specific to the Park, however, by adopting the Guidelines for Outdoor Lighting (the "Guidelines"), the Park recognizes dark skies as an important natural, cultural and scientific resource. The Guidelines adopted by the Park serve the purpose of recognizing dark skies as an important natural, cultural and scientific resource.

The Guidelines will be maintained by the Park as the reference source and authority governing outdoor lighting in the Park.

The Guidelines are patterned after *Guidelines for Outdoor Lighting in RASC Dark-sky Preserves and IDA Dark Sky Places* adopted by the Royal Astronomical Society of Canada March 2008 and revised spring 2016.

The Texas State Parks leadership is also supportive of dark sky preservation and education of the public at a state-wide level. See section 6, *Texas Parks and Wildlife Department's Commitment to Dark Skies*.

The Park intends to comply with any state-wide outdoor lighting guidelines adopted in the future by the Texas Parks and Wildlife Department. A copy of the current guidelines for outdoor lighting follows.

South Llano River State Park
Guidelines for Outdoor Lighting

September 2016

1.0 SCOPE

This document presents Guidelines for Outdoor Lighting (GOL) in South Llano River State Park (SLRSP). The Guidelines are patterned after *Guidelines for Outdoor Lighting in RASC Dark-sky Preserves and IDA Dark Sky Places* adopted by the Royal Astronomical Society of Canada March 2008 and updated spring 2016. The GOL is in support of the SLRSP application to be designated a Dark Sky Park by the International Dark-Sky Association (IDA). It is also the intention of SLRSP to comply with any state-wide outdoor lighting guidelines adopted by the Texas Parks and Wildlife Department in the future.

The goals of the GOL are to promote the reduction in light pollution, demonstrate good night-time lighting practices, improve the nocturnal environment of wildlife, protect and expand dark observing sites for astronomy, and provide accessible locations for the general public to experience the naturally dark night sky.

The GOL has two primary objectives: to limit glare and the adverse ecological impact of artificial lighting throughout SLRSP and to provide technical specifications for acceptable illumination levels required for navigation within SLRSP.

General guidelines for outdoor lighting are discussed in Section 2. Specific guidelines for outdoor lighting in SLRSP are presented in Section 3. Definitions for certain terms used in the GOL are provided in section 4.

2.0 GUIDELINES FOR OUTDOOR LIGHTING

2.1 Basic Principles

This section provides basic tenants and principles that were considered in developing the GOL.

SLRSP is divided into two basic lighting zones. Zone 1 includes all of the buildings, facilities, roadways and parking areas for visitors. Generally, Zone 1 is in a contiguous area along the park entrance and roadway that connects the camping areas. The remainder of the park is Zone 2, which includes the primitive camping areas and trails. Presently, there is no artificial lighting in Zone 2 and it is intended for Zone 2 to remain completely free from artificial lighting.

Zone 1 has pedestrian and vehicular traffic, and therefore, outdoor lighting is necessary for basic safety and navigation. To balance safety with respecting and protecting the natural environment a number of guiding principles have been developed as follows:

- Illumination should be to the minimum practical level,

- The affected area of illumination should be as small as practical,

- The duration of the illumination should be as short as practical, and

- Illumination should minimize the amount of short wavelength spectral content including UV and blue light (avoid cool or wide spectrum white light).

What is "practical" depends upon the specific facilities in the area and the technology available at that time.

Park managers have the discretion to assess what levels are most appropriate for each facility in Zone 1 and within the limits outlined in Section 3 of this GOL. Lighting is limited to provide only what is required for basic safety and navigation in Zone 1. The artificial lighting is restricted to Zone 1 and for the periods of human activity unless otherwise noted.

The following tenets have been used in developing these specifications.

- Buildings require illumination only when open or available to people. After the office is closed to the public, all lighting visible from the outside should be turned off or covered unless access to the building is required after hours.

- To save energy and minimize the duration and extent of light pollution, lighted pathways should be illuminated only when pedestrians are in transit. All reasonable effort should be made to turn off lighting when pedestrian traffic is low or is no longer expected.

- To minimize the impact of artificial lighting on the ecosystem, the areas covered by this specification should only provide a safe transition between lighted structures and the surrounding unlighted area and to assist in navigation.

- To minimize the extent of light pollution, the area of illumination should be strictly limited.

- To limit the duration of light exposure on the ecosystem and to save energy, light activated timing circuits should turn off outdoor lighting. The time delay should begin at sunset and should extend to an appropriate time into the evening to permit scheduled activity to end.

- Where vehicle and pedestrian traffic is at a low speed or infrequent, retro-reflective signage should be used instead of installed lighting fixtures.

2.2 General Outdoor Lighting Guidelines

This section identifies certain types of structures that may require illumination within Zone 1. In all cases, fully shielded luminaires should be used and illumination should be controlled to prevent light scattering beyond the immediate area of the light fixture. A fixture located under a porch or roof overhang is considered a shielded fixture.

The definition for a Fully Shielded fixture is provided below:

> *Fully Shielded* means fixtures, as installed, that are designed or shielded in such a manner that all light rays emitted by the fixture, either directly from the luminaires or indirectly from the fixture, are not permitted to project above a horizontal plane running through the lowest point on the fixture where light is emitted.

See GOL Section 4.

Further, the color of this light should have minimal UV and blue (short wavelength) content. A color temperature of 3000 or less is required. Finally, "Dark Time" lighting curfews should apply.

"Dark Time" is a term used to identify the end of significant activity within an area. This term is used in the GOL to identify when light should be discouraged. Dark Time is assumed to begin two hours after sunset.

Interior and exterior lighting that remains on for extended periods after operating hours not only wastes energy but can also be a nuisance. Insects are attracted to exterior building lights and interior lighting that shines through windows. In addition to the need for cleaning up dead flies before the building opens in the morning for the public, the light distracts insects from their normal activity. Outdoor illumination from indoor lighting is approximately equivalent to the natural illumination 30-minutes after sunset. After this time, effort should be made to shield indoor lighting with shutters or screens.

2.2.1 Buildings

Types of buildings in Zone 1 that need outdoor lighting are described below. These descriptions are designed to be flexible in order to accommodate additional structures added to Zone 1 in the future.

- Administration Buildings,
- Public Buildings,
- Retail Outlets,
- Vending Machine Enclosures,
- Toilet and Washroom Facilities, and
- Cooler/Check Station

2.2.1.1 Administration Buildings

Park Administration Buildings are generally defined as those with private offices, living quarters, maintenance and utilities and specifically include the Headquarters Building, Headquarters Barn, Headquarters parking lot area, Maintenance Shop, Water Treatment Plant and Superintendent

Residence and Assistant Manager Residence.

Park Administrative Buildings will generally be closed after dark. Illumination of the main doorway and especially any steps leading to the main door may be required after sunset in the early spring, late autumn and winter.

- After hours, either all interior lighting should be turned off, or window and door blinds should be used to prevent interior light from shining outside.

- All outdoor lighting should be turned off within 30 minutes of the Administrative Building being closed. Manual reset switches may be used to extend this period for late-working staff. Certain fixtures may remain on all night in order to accommodate ingress and egress, restroom access and guests arriving after hours.

- Outdoor lighting should be limited to the main access door areas and steps (if any).

- Light activated timing circuits may be used to turn the lighting on after sunset and off after a period of time specified by park managers and subject to the building use. Manual reset switches or motion detectors may be used to extend this period by a pre-programmed duration. To the extent light activated timing circuits are not used, any fixtures that remain on all night should be fully shielded.

2.2.1.2 Public Buildings

Public buildings are generally defined as those open to the public during business hours and may also contain private offices or parts of Administrative Buildings such as the Headquarters Building and parking lot. The Headquarters, Building, state parks store and interpretive center are all located in the same building, and therefore, the lighting guidelines for Public Buildings can be applied to these buildings as well. Due to the public nature of these buildings with high pedestrian traffic, exterior illumination may be higher than otherwise for Administration Buildings. In addition, the Bird Blind is an area where the public is able to watch birds and other animals. It is also an interpretive/teaching area used for slide shows and to demonstrate different lighting fixtures and the difference between good and bad lighting.

- After hours, either all interior lighting should be turned off, or window and door blinds should be used to prevent interior light from shining outside.

- All outdoor lighting should be turned off within 30 minutes of the Public Building being closed. Manual reset switches may be used to extend this period for late-working staff. Certain fixtures may remain on all night in order to accommodate ingress and egress, restroom access and guests arriving after hours.

- Outdoor lighting should be limited to the main access door areas and steps (if any).

- Light activated timing circuits may be used to turn the lighting on after sunset and off after a period of time specified by park managers and subject to the building use.

Manual reset switches or motion detectors may be used to extend this period by a pre-programmed duration. To the extent light activated timing circuits are not used, any fixtures that remain on all night should be fully shielded.

2.2.1.3 Retail Outlets

Retail Outlets are generally defined as stores open to the public during business hours. The Headquarters Building, state parks store and interpretive center are all located in the same building, and therefore, the lighting guidelines for Retail Outlets can be applied to these buildings as well. It is assumed Retail Outlets will have higher pedestrian traffic than most other areas to the extent they remain open for business after dark.

- During hours of operation, window and door blinds should be used to prevent interior light from shining outside 30 minutes after sunset.
- After hours, either all interior lighting should be turned off, or window and door blinds should be used to prevent interior light from shining outside.
- All exterior lighting should be turned off within 30 minutes after business hours.
- Outdoor lighting is permitted, and restricted to, the area around the access doors using fully shielded fixtures.
- All exterior lighting should be turned off within 30 minutes after business hours.

2.2.1.4 Vending Machines

Vending machines should be located in an enclosed space and their lights should not shine directly outside through doorways or windows. Where practical, these machines should be enclosed in existing public buildings. Figure 1 shows an example of a dedicated vending machine enclosure. Only fully shielded fixtures should be used to illuminate the area outside the entrances. The extent of this outside illuminated ground area is restricted to less than 20 feet from the entrance.

Light from vending machines is usually from a number of fluorescent tubes behind the translucent display and may emit significant amounts of UV and blue light. This light undermines dark adaptation and attracts flying insects. Therefore, the illumination levels outside these enclosures may be higher than for other buildings to allow the transition for visitors from the bright interior to the dark surroundings.

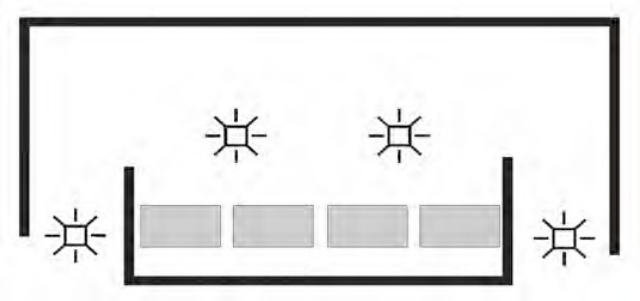


Figure 1 – Sample Vending Machine

Doorway lighting should be turned off within two hours after sunset. Interior lighting may remain on at the park manager's discretion. Currently, the Park has no vending machines.

2.2.1.5 Toilet and Washroom Facilities

Toilet and washroom facilities should be available throughout the night. If illuminated, fully shielded fixtures should be used to illuminate the entrance and any steps leading to the doorway. If deemed necessary by park managers, these structures may have a non-cut-off marker light by the door. This marker light should be the lowest practical wattage. For example, a small 15-watt incandescent lamp can be easily seen for 600 feet. Alternatively, an LED fixture less than 3000K may be used.

Interior lighting in these facilities must also be considered. Excessive interior lighting levels can produce serious glare that impairs exterior visibility if windows are present. Interior lighting should use bug light or yellow color whenever possible and should not exceed 25 watts per incandescent fixture.

2.2.1.6 Cooler/Check Station

The Park offers to the public scheduled deer hunts approximately seven times per year. The hunts are necessary in order to control the deer population. Each hunt is three days long with hunters spending up to two nights at the Park. This means there are approximately 12 to 16 nights per year when the Cooler/Check Station is utilized. The Cooler/Check Station is a small metal building used to check in the hunters as they arrive. It is also used for field dressing the deer and storage in the cooler. In order to accommodate this process there are pairs of unshielded flood lights on the building and in a nearby tree. These lights are switched and typically only used up to 10 p.m. on the 12 to 16 nights per year when necessary to field dress deer.

- Existing unshielded flood lights may be used, but only as necessary to accommodate field dressing deer up to midnight during the nights the Park is conducting public hunts.

- The existing lights must be switched and on timers (to prevent them from being

inadvertently left on) with access to the timers only available to Park personnel to activate the lights during scheduled hunts conducted by the Park.

- As the existing unshielded fixtures wear out, they will be replaced with fully shielded fixtures.

2.2.2 Parking Lots

Generally, parking lots have less traffic at night than during the day. Parking lots may require lighting due to scheduled, after-dusk activities. This lighting will be necessary until gate closure, Dark Time, or when the scheduled activity ends. The lighting may also be necessary for guests arriving at the park after-hours in order to navigate to parking and camping areas.

Where required, pole mounted fully shielded luminaires should be placed one pole- height from the extreme corners of the parking lot and distributed evenly along the perimeter with an approximate pole spacing of no less than 4-times the luminaire height. See Figure 2 below. Their light distribution pattern should be "full forward" and aimed into the lot. If necessary, poles may be located within the parking lot area.

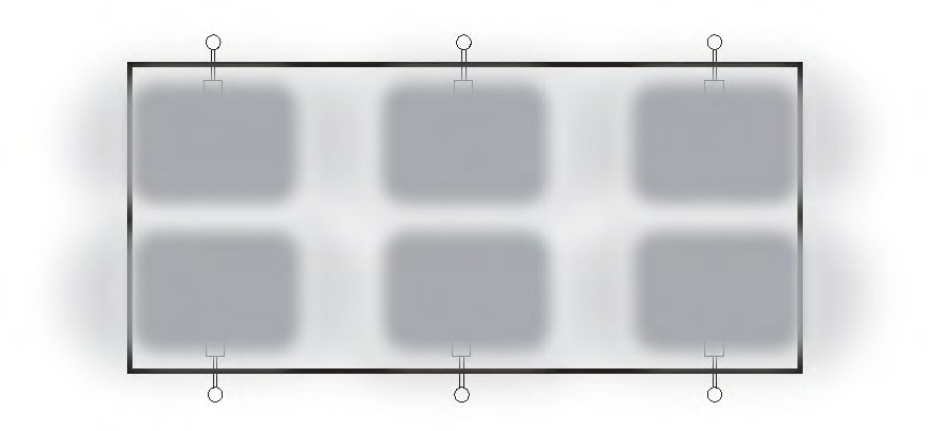


Figure 2 Parking Lot

2.2.2.1 Administration Parking Lots

Administrative personnel will generally leave when offices close. Luminaires in administration parking lots should be turned off within 30 minutes of the office closure unless the park manager determines illumination is necessary for safety reasons or guests arriving after hours. However, illumination levels should not exceed the limits listed in Table 1 below. A timing circuit should control the lights with a manual reset for employees working late.

2.2.2.2 Visitor Parking Lots (Small)

Generally small lots (less than 10 cars) experience little traffic and should not be illuminated unless the park manager determines illumination is necessary for safety reasons or guests arriving after hours. Illumination levels should not exceed the limits listed in Table 1 below.

2.2.2.3 Visitor Parking Lots (Large)

Larger parking lots (spaces for approximately more than 10 cars) may require better visibility than smaller lots. These lots may be illuminated at the discretion of the Park manager. However illumination levels should not exceed the limits listed in Table 1 below.

Table 1 Parking Lot Illumination Guidelines (Maximum Values)

Parking Area	Type	Lamp	Illumination Level	Height m (ft)	Curfew
Administration Lot	Fully Shielded	LPS, HPS or LED < 3000K	7000 lumens	6 (20)	Yes
Visitor Lot < 10 cars	Fully Shielded	LPS, HPS or LED < 3000K	7000 lumens	6 (20)	N/A
Visitor Lot > 10 cars	Fully Shielded	LPS, HPS or LED < 3000K	7000 lumens	6 (20)	Yes

2.2.3 Roadways

Intersections are some of the most dangerous areas for drivers. Therefore, they should be marked with reflective signage and/or reflective markers. If there are any roads within a park that have high speed limits and/or incur a high volume of traffic after dark then, marker lighting may be required to alert drivers to an intersection. Illumination should be a last resort and illumination of adjacent areas should be minimized.

To further minimize the impact of these luminaires on the environment, the luminaire should be mounted no higher than 20 feet and the fixture should use Low Pressure Sodium (LPS) or LED less than 3000K to minimize the exposure to the environment of UV and blue light.

Most park roads have low traffic volumes after dark. Recognizing the infrequent use of these roads and the potential impact lighting may have on the surroundings; these intersections should not be illuminated.

Except for the enhance sign and stop light and signage at the host station, illuminated signage should not be permitted on any road within the park and non-intersections should not be illuminated.

Where applicable, federal and state highway standards may take precedence when safety or security can be shown to be compromised.

2.2.4 Pathways

Pathways and sidewalks provide a relatively level surface for pedestrian traffic, and aid in site navigation. Visibility is necessary for navigation but excessive illumination will prevent pedestrians from seeing off the path. Although visitors use flashlights, additional pathway lighting may be required to guide visitors to public facilities.

Paths are also used by wildlife. Therefore, pathway lighting should be restricted to only those paths near buildings and parking lots and then only those paths that the Park Superintendent or Manager considers it essential to illuminate.

Since overhead fully shielded luminaires will illuminate areas much wider than the path, low output bollard lighting or other low mounted path lighting should be used such that the lights are directed down and along the path. The fixture must be shielded and neither the lens nor a reflector should be visible to someone walking on the path. The illumination pattern is approximately limited to the path width and the illumination level should be the lowest possible to do the job.

Pathways should use white or light colored stone (gravel or limestone) instead of asphalt or other dark colored surfaces to help reflect ambient light. Retro reflective or passive fluorescent markers are encouraged instead of illumination to mark the pathway. These may be mounted on bollards or in the pathway surface.

Generally, individuals walking along a pathway will have left the area after a minute or so unless they remain for an activity. To minimize unnecessary light exposure, switches with timing circuits may be used to activate the lighting and to automatically turn them off after a few minutes. Proximity detectors should be installed at the entrances to pathways.

The closeness of the luminaires to the ground necessitates very low intensity lights or passive fluorescent markers. This limits the current products available to low wattage incandescent lamps and LEDs. These guidelines for pathway lighting can be reduced to four points.

- Whenever possible pathways in the park should not be illuminated. If deemed absolutely necessary by the park superintendent or manager, specific pathways may be illuminated or lined with fluorescent markers.

- Illuminated pathways should have fully shielded low mounted lighting fixtures and the illumination is to be less than 0.1 lumens per square foot.

- Pathway lighting should be turned off at the Dark Time lighting curfew. Retro-

reflective markers or passive fluorescent markers may assist pedestrians after Dark Time.

- Main pathways leading to night facilities may be illuminated during activities at the discretion of the Park manager. Passive fluorescent markers are preferred.

2.2.5 Signage

Signs within a park are essential to the efficient navigation of the site. They may display: names for sites or buildings (usually mounted in proximity to buildings or other structures), directions (located along roadways or pathways and their intersections) and other information (located to the side of roadways and pathways).

Illuminated signs should be prohibited unless illuminated from above and fully shielded. Internally illuminated signs, signs illuminated from below and in front of the sign should be prohibited. To improve the visibility of signs after dark, their location, color scheme, and material should permit reading the sign with flashlights or existing lighting.

Retro-reflective signage should be used to ensure signs are visible only when necessary. Signs may be mounted on or near buildings such that exterior building lighting may provide some illumination, and they should use colors consistent with retro-reflective materials and illumination with flashlights.

Signs should be located so pedestrians can easily see them. Elevated signs are less likely to be illuminated by fully shielded luminaires. Pathway and information signs should be located less than one meter above the grade of the path so that they may be found and read by pedestrians with flashlights after dark. Signs mounted at a higher elevation may be missed as flashlights are aimed at the ground. All bollards should be marked with retro- reflective material so they may be visible to pedestrians after Dark Time. Roadway signs should be mounted in accordance with standard roadway practice.

3.0 Site Specific Guidelines for SLRSP

Site specific guidelines for SLRSP were adapted from Big Bend National Park and Enchanted Rock State Natural Area and modified to comply with the guidelines outlined in Section 2 above. These site specific guidelines are prescriptive in nature which means they describe the type, size, lamp and illumination level of the light in Zone 1 of SLRSP.

3.1 Lighting Zones

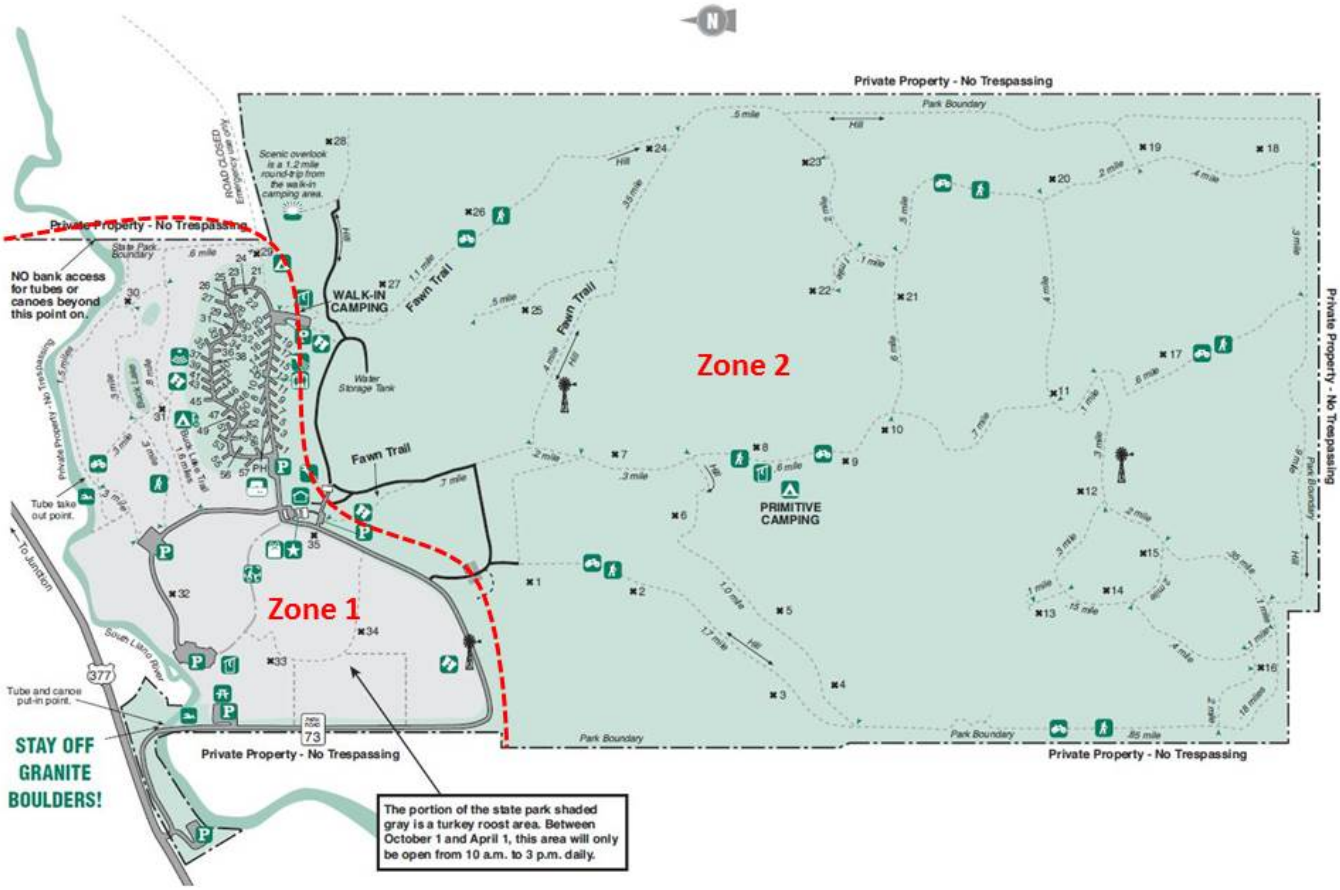
SLRSP has two basic outdoor lighting zones defined as follows:

Zone 1: Facilities and buildings, roadways and parking areas located at the park entrance and along the paved road connecting the facilities and camping areas, specifically including:

- Headquarters Building
- Headquarters Parking Lot
- Headquarters Barn
- Public showers and restrooms
- Cooler/Check Station
- Dump Station
- Bird Blind
- Hunter's Cabin
- Maintenance Shop
- Water Treatment Plant
- Superintendent and Assistant Manager Residences

Zone 2: All other areas of the park that are not in Zone 1. There is no outdoor lighting in Zone 2. Zone 2 areas are all "undeveloped" property in their natural state. The use of red or amber flashlights should be encouraged but high power flashlights (> 300 lumens) should not be allowed. As with permanent lighting, amber and red light flashlights will reduce glare and help maintain dark adaptation. The use of white flashlights should be discouraged or used sparingly. Installation and extended use of portable outdoor lighting is strictly prohibited. In order to develop additional facilities in the future, park managers may designate additional areas of Zone 2 to be included in Zone 1, however, such areas should comply with the lighting requirements for Zone 1.

A map depicting areas designated as Zones 1 and 2 is shown below.



3.2 Lighting Prescriptions for Zone 1

7000 lumens is the maximum allowable lamp output (except for emergency lighting). In most cases 500 – 1600 lumens will be sufficient.

Residential Surrounds (Superintendent's House and Assistant Manager's House)	
Maximum Lamp Lumens	1600 lumens/300 watts for security light
Recommended Light Type	Fully shielded/under eave or porch
Recommended Illumination Area	Light dispersal limited to residential boundary
Recommended Duty Cycle	Mix of switches for (for occasional use) and motion sensors. Not on all night.

Public Showers and Restrooms	
Maximum Lamp Lumens (watts)	1600 lumens
Recommended Light Type	Fully shielded/under eave or porch
Recommended Illumination Area	Light dispersal limited to entrance of restroom facility and doorways.
Recommended Duty Cycle	On from dusk to dawn to accommodate overnight camping.

Composting Toilets	
Maximum Lamp Lumens (watts)	1600 lumens
Recommended Light Type	Fully shielded/under eave or porch
Recommended Illumination Area	Light dispersal limited to entrance of restroom facility and doorways.
Recommended Duty Cycle	On from dusk to dawn to accommodate overnight camping, or on motion sensor.

Headquarters (Administration, Barn, State Parks Store and Interpretive Center)	
Maximum Lamp Lumens (watts)	1600 lumens
Recommended Light Type	Fully shielded/under eave or porch
Recommended Illumination Area	Light dispersal limited to entrances, walkways around building, outdoor restroom facilities and information bulletin board for after-hours arrivals for camping.
Recommended Duty Cycle	On from dusk to dawn to accommodate overnight camping and after-hour arrivals.

Hunter's Cabin	
Maximum Lamp Lumens (watts)	1600 lumens
Recommended Light Type	Fully shielded/under eave or porch
Recommended Illumination Area	Light dispersal limited to residential boundary and for ingress/egress.
Recommended Duty Cycle	Switched, only used for ingress/egress. Not on all night.

Maintenance Shop	
Maximum Lamp Lumens (watts)	7000 lumens for LPS 1600 lumens for incandescent/LED
Recommended Light Type	LPS and incandescent fully shielded/under eave or porch. Emergency pump indicator lights may be unshielded, but illuminate only to indicate a mechanical or electrical emergency.
Recommended Illumination Area	Light dispersal limited to building surround area and for ingress and egress.
Recommended Duty Cycle	Switched, only used for ingress/egress. Not on all night. Emergency pump indicator lights illuminate only when mechanical/electrical emergency arises.

Cooler/Check Station	
Maximum Lamp Lumens (watts)	1600 lumens
Recommended Light Type	Not shielded, but will be replaced with shielded fixtures when they wear out.
Recommended Illumination Area	Light dispersal limited to check station building boundary
Recommended Duty Cycle	Switched and on timers only by Park personnel to accommodate field dressing deer at night. 12 to 16 nights per year up to midnight.

Dump Station	
Maximum Lamp Lumens (watts)	7000 lumens, 175 watt LPS
Recommended Light Type	LPS and Fully shielded
Recommended Illumination Area	Light dispersal limited to area surrounding Dump Station
Recommended Duty Cycle	Sunset to Sunrise using photo cell.

Entrance Signage	
Maximum Lamp Lumens (watts)	1600 lumens
Recommended Light Type	Fully shielded
Recommended Illumination Area	Park entrance sign.
Recommended Duty Cycle	On from sunset to sunrise (photocell or timer) for illumination of Park entrance sign.

Host Station and Wood Shed Lighting	
Maximum Lamp Lumens (watts)	1600 lumens
Recommended Light Type	Fully shielded
Recommended Illumination Area	Entrance and stop sign at host station. Also illumination for covered wood storage shed.
Recommended Duty Cycle	Switched, on until 10:00 p.m. each night.

Acorn Bird Blind	
Maximum Lamp Lumens (watts)	1600 lumens
Recommended Light Type	Fully shielded, however some can be unshielded to be used for presentations to compare good lighting with poor lighting fixtures.
Recommended Illumination Area	Ingress and egress and building surrounds and for short periods after presentations.
Recommended Duty Cycle	Switched, only on for periodic activities, but rarely used.

Defined Terms

CFL means compact fluorescent lamps.

Fully Shielded means fixtures, as installed, that are designed or shielded in such a manner that all light rays emitted by the fixture, either directly from the luminaires or indirectly from the fixture, are not permitted to project above a horizontal plane running through the lowest point on the fixture where light is emitted.

GOL means these Guidelines for Outdoor Lighting.

HID means High Intensity Discharge lamps (LPS, HPS, MH lamps).

HPS means High Pressure Sodium lamps ("yellow" colored lamps).

LEDs means Light Emitting Diodes.

LPS means Low Pressure Sodium lamps (monochromatic, single color lamps).

Lumen means a unit of measurement used to quantify the amount of light produced by a bulb or emitted from a fixture (as distinct from "watt," a measure of power consumption). The lumen rating associated with a given lamp is generally indicated on its packaging or may be obtained from the manufacturer (abbreviated lm).

Luminaire, or Luminous elements (of a light fixture) means individually or collectively: the lamp (light bulb), any diffusing elements and surfaces intended to reflect or refract light emitted from the lamp.

Section 9. South Llano River State Park Lighting Inventory

The Park has undertaken an inventory of existing lighting and review with the Lighting Assessment. Based on that inventory and review, the Park has implemented an outdoor lighting improvement plan to make sure all outdoor lighting in the Park complies with the Park's Guidelines for Outdoor Lighting. A copy of the Park's Lighting Inventory follows.

South Llano River State Park

Lighting Inventory

Location	Light Ref. #	Fixture	Application	FCO/ Shielded	Special Purpose <600 Lumens	Conforms with LMP
Superintendent House by HQ	SH-1 Back steps	1 fixture – 2 bulbs, 60 watt incandescent ceiling mounted	Security, house egress/ ingress, switched, not on all night	Yes, under front porch ceiling	No	Yes
	SH-2 East	1 fixture - Flood light, 300 watt, wall-mounted and pointed down	Security, house egress/ ingress, switched, not on all night	Yes, under eave	No	Yes
	SH-3 Inside porch	3 fixtures – each with 2 CFL bulbs, 60 watt, in ceiling mounted fixture	Security, house egress/ingress, switched, not on all night	Yes, inside screened/ enclosed porch	No	Yes
	SH-4 Back porch	1 fixture – with 43 watt incandescent bulb, under roof eave	Security, house egress/ingress, switched, not on all night	Yes, under roof eave	No	Yes
Assistant Manager House by Park entrance	AM-1 Shed/ Pumphouse	2 fixtures, each with 2 floodlights	Security, egress/ingress, switched, not on all night	No	No	Yes
	AM-2 Carport	1 fixture, with 2 fluorescent bulbs	Security, ingress/egress, switched, not on all night	Yes, under carport roof	No	Yes
	AM-3 Front Porch	1 fixture, with 1 incandescent bulb	Security, ingress/egress, switched, not on all night	Yes, under porch roof	No	Yes
	AM-4 Front Steps	1 fixture, with 2 floodlights	Security, ingress/egress, switched, not on all night	Yes, under eave	No	Yes
	RR-1 Chase, North side, back	1 fixture mounted inside yellow translucent box -1 CFL bulb – 60 watt incandescent, Yellow bug light	Area security, ingress/egress sunset to sunrise, on a timer	Yes, under eave. Fixture has been box shielded.	No	Yes

Location	Light Ref. #	Fixture	Application	FCO/ Shielded	Special Purpose <600 Lumens	Conforms with LMP
Restrooms	RR-2 East	1 fixture mounted inside yellow translucent box -1 CFL bulb – 60 watt Incandescent, Yellow bug light	Area security ingress/egress sunset to sunrise, on a timer	Yes, under eave	No	Yes
	RR-3West	1 fixture mounted inside yellow translucent box -1 CFL bulb – 60 watt Incandescent, Yellow bug light	Area security ingress/egress sunset to sunrise, on a timer	Yes, under eave	No	Yes
	RR-4 Front/South	1 fixture mounted inside yellow translucent box -1 CFL bulb – 60 watt Incandescent, Yellow bug light	Area security ingress/egress sunset to sunrise, on a timer	Yes, under eave	No	Yes
Composting toilets	CT-1 Interior	Solar powered LED fixture	Restroom lighting, motion-activated by door, stays on for an increment of time	Inside compost toilet building	Yes	Yes
	CT-2 Exterior	Solar powered LED fixture	Restroom lighting, motion-activated by door, stays on for an increment of time	Yes, under eave, outside compost toilet building door	Yes	Yes
Park Headquarters	HQ-1 Screened in porch	1 fixture - 60 Watt Incandescent Yellow, Bug Light	Security, ingress/egress, switched, not on all night	Yes, shielded by porch ceiling	No	Yes
	HQ-2 Parking lot	1 fixture – unshielded street light	Security	No, but non-functional. Will be removed or replaced with shielded fixture	No	Yes

Location	Light Ref. #	Fixture	Application	FCO/ Shielded	Special Purpose <600 Lumens	Conforms with LMP
Park Headquarters	HQ-3 Self-registration	1 fixture- fluorescent tube light, 32 Watt	Security, work light, sunrise – sunset, on photocell.	Yes, shielded under kiosk eave	No	Yes
	HQ-4 and HQ-5 Barn	3 fixtures – incandescent bulbs, 100, 150, and 200 watts	Work light, ingress/egress, switched, not on all night	Yes, sheltered under long, open barn	No	Yes
	HQ-6 Front porch	2 fixtures – 1 incandescent bulb per fixture, 52 watts	Egress / ingress switched, not on all night. Only on when office is open, 7:45 am to 8:45 pm (summer)	Yes, sheltered under front porch	No	Yes
Hunter's Cabin	HC-1 Cabin Steps	1 fixture – incandescent bulb, 52 watts	Security, ingress/egress, switched, not on all night	Yes, under eave	No	Yes
	HC-2 Cabin North	1 fixture, two floodlights, 75 watts each	Security, ingress/egress, switched, not on all night	Yes, under eave. Will be removed, not needed.	No	Yes
	HC-3 Cabin South	1 fixture, spot for 2 flood-lights (only one bulb (currently), current bulb is 75 watts	Security, ingress/egress, switched, not on all night	Yes, under eave. Will be removed, not needed.	No	Yes
	HC-4 Porch	2 fixtures, each with incandescent bulb, 52 watts.	Security, ingress/egress, switched, not on all night. Only used appx. 10 nights/year	Yes, shielded under porch roof	No	Yes
	HC-5 Field by hunters cabin	1 fixture, street light, LPS	Security	Not functional, not on at night, will be removed.	No	Yes

Location	Light Ref. #	Fixture	Application	FCO/ Shielded	Special Purpose <600 Lumens	Conforms with LMP
Maintenance Shop	M-1 South	1 Fixture – Low pressure sodium, 175 watt, wall-mounted inside yellow translucent box	Safety, work light, ingress/egress, switched, not on all night.	Yes, under eave, but will be shielded to prevent glare	No	Yes
	M-2 East	1 Fixture – Incandescent bulb, 100 watt, wall-mounted	Safety, work light, ingress/egress, switched, not on all night.	Yes, under eave, shielded	No	Yes
	M-3 Open Bay	4 Fixtures – 2 are 60 Watt CFL bulbs, 2 are incandescent bulbs, 60 and 100 watts	Safety, Work light, ingress/egress, switched, not on all night.	Yes, shielded, in open bay under roof	No	Yes
	M-4 Water Treatment Plant Entrance Emergency Lights	2 wall-mounted incandescent bulbs: 1 yellow 60 watt, 1 clear 100 watt and 1 wall-mounted box fixture – incandescent 60 watt bulb	Emergency lights only activate in case of water emergency; wall-mounted box is for WTP egress/ingress, switched, not on all night	Not shielded	No	Yes
	M-5 Carport	2 fixtures – 2 fluorescent tube 8-foot lights, T-12	Safety, parking light, switched, not on all night,	Yes, under carport	No	Yes
Cooler/Check Station (only used during public hunts, appx. 12 – 16 nights total each year)	CS-1 Office SW	1 fixtures – 2 floodlights	Work light/deer field dressing, on timer, not on all night (only 12-16 nights per year)	No	No	Yes
	CS-2 Office West	1 Fixture – 2 floodlights	Work light/deer field dressing, on timer, not on all night (only 12-16 nights per year)	No	No	Yes
	CS-3 Tree	1 fixture - 2 floodlights	This fixture has been completely removed	N/A	N/A	N/A
	CS-4 Cooler 1	1 fixture - 2 floodlights	Work light/deer field dressing, on timer, not on all night (only 12-16 nights per year)	Yes, under eave	No	Yes

Location	Light Ref. #	Fixture	Application	FCO/ Shielded	Special Purpose <600 Lumens	Conforms with LMP
Cooler/Check Station (only used during public hunts, appx. 12 – 16 nights total each year)	CS-5 Cooler 2	1 fixture - 2 floodlights	Work light, non-functional.	Yes, under eave	No	Yes
	CS-6 Cooler 3	1 fixture - 2 floodlights	Work light/deer field dressing, on timer, not on all night (only 12-16 nights per year)	Yes, under eave	No	Yes
	CS-7 Garage North 1	1 fixture - 2 floodlights	Work light/deer field dressing, on timer, not on all night (only 12-16 nights per year, on motion sensor)	No	No	Yes
	CS-8 Garage North 2	1 fixture – 75 watt incandescent.	Work light/deer field dressing, on timer, not on all night (only 12-16 nights per year)	Yes, shielded	No	Yes
	CS-9 Garage South	1 fixture - 2 floodlights	Work light/deer field dressing, on timer, not on all night (only 12-16 nights per year)	No	No	Yes
	CS-10 Garage West	1 fixture - 1 floodlight	Work light/deer field dressing, on timer, not on all night (only 12-16 nights per year)	No	No	Yes
Dump station	DS-1	175 watt LPS	Sunset to sunrise, on a photocell	Shielded Luminaire (painted black)	No	Yes
Entrance sign	E-1	2 LED fixtures, solar-powered	Illumination of Park entrance sign, only on from sunset to sunrise, on a photocell	Yes, Pointed down	Yes	Yes
Campground Host Station	HS-1	1 fixture, CFL bulb	Work light, illuminates sign, switched, off at 10:00 p.m.	Yes, shielded, pointed down	No	Yes
Campground Host Station	HS-2	1 fixture, CFL bulb	Illuminates stop sign, switched, off at 10:00 p.m.	Yes, shielded, pointed down	No	Yes

Location	Light Ref. #	Fixture	Application	FCO/ Shielded	Special Purpose <600 Lumens	Conforms with LMP
Wood shed by campsite 1	WS-1	1 fixture, CFL bulb	Work light, switched, off at 10:00 p.m.	Yes, under corner of tin roof	No	Yes
Acorn bird blind, down path between campsites 39 and 41	AB-1 Before and After	1 fixture, 2 floodlights	Security, ingress/egress, switched, not on all night. Only used to demonstrate poor lighting fixtures for interpretive talks	Yes, under roof eave. Box shielded.	No	Yes
	AB-2 Before and After	1 fixture, 2 floodlights	Security, ingress/egress, switched, not on all night. Only used to demonstrate poor lighting fixtures for interpretive talks	Yes, under roof eave. Box shielded.	No	Yes

Lighting Inventory Photographs

Superintendent House by HQ

Outside Light Back Steps
Photograph Reference: SH-1

Outside Light East
Photograph Reference SH-2

Inside Porch
Photograph Reference: SH-3

Back Porch
Photograph Reference SH-4

Lighting Inventory Photographs

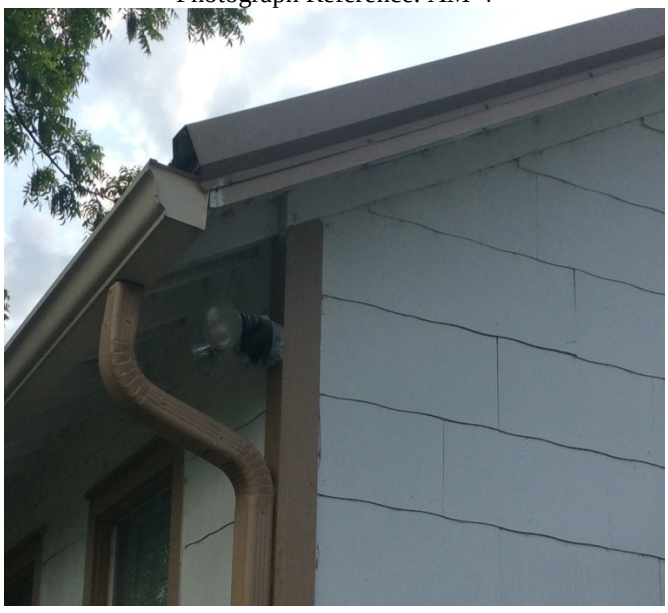
Assistant Manager's House

Shed
Reference AM-1

Carport
Photograph Reference: AM-2

Front Porch
Photograph Reference: AM-3

Front Steps
Photograph Reference: AM-4



Lighting Inventory Photographs

Restrooms

Restrooms Chase/North/Back
Photograph Reference:RR-1

Restrooms Female/East
Photograph Reference: RR-2

Restrooms Male/West
Photograph Reference: RR-3

Restroom Front/South
Photograph Reference: RR-4

Lighting Inventory Photographs

Composting Toilet

Interior
CT-1

Exterior
CT-2

Lighting Inventory Photographs

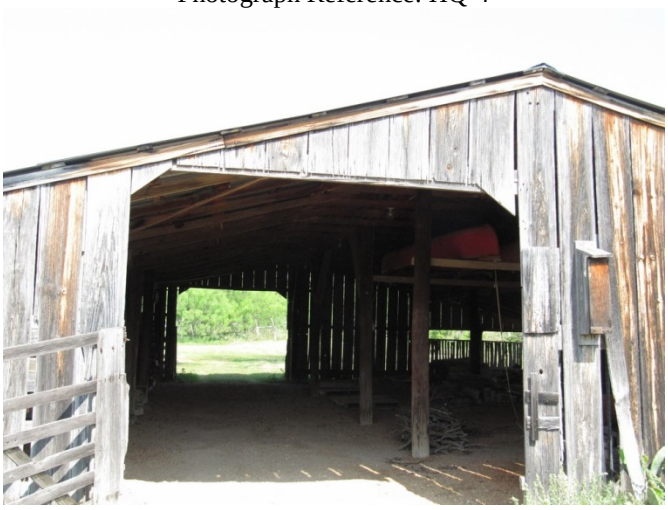
Park Headquarters

Screened in porch
Photograph Reference: HQ-1

Parking Lot (non-functional)
Photograph Reference: HQ-2

Self-registration
Photograph Reference: HQ-3

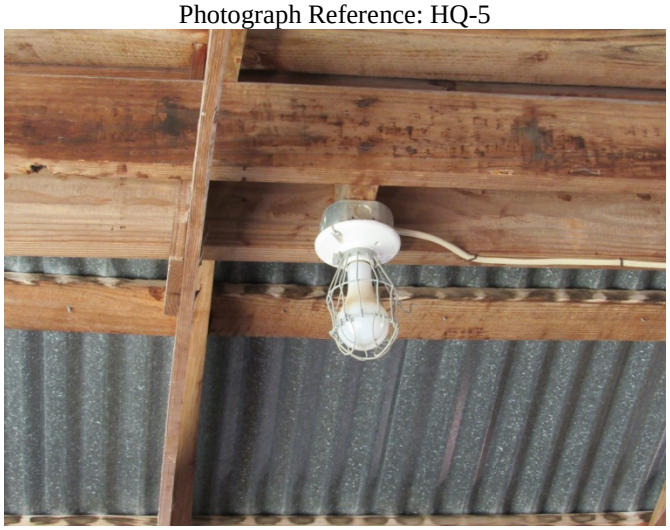
Barn
Photograph Reference: HQ-4



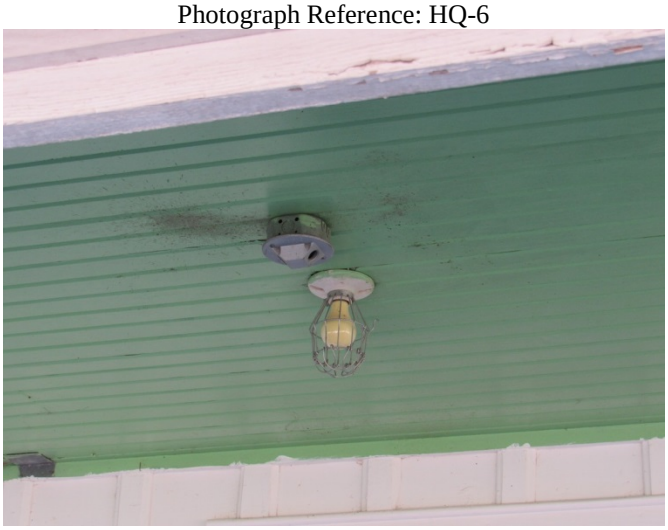
Lighting Inventory Photographs

Park Headquarters

Inside Barn Ceiling Lighting
Photograph Reference: HQ-5



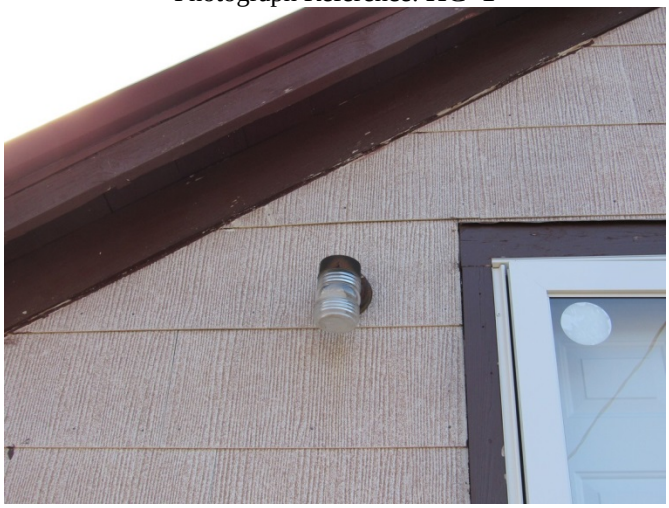
Front Porch
Photograph Reference: HQ-6



Lighting Inventory Photographs

Hunter's Cabin

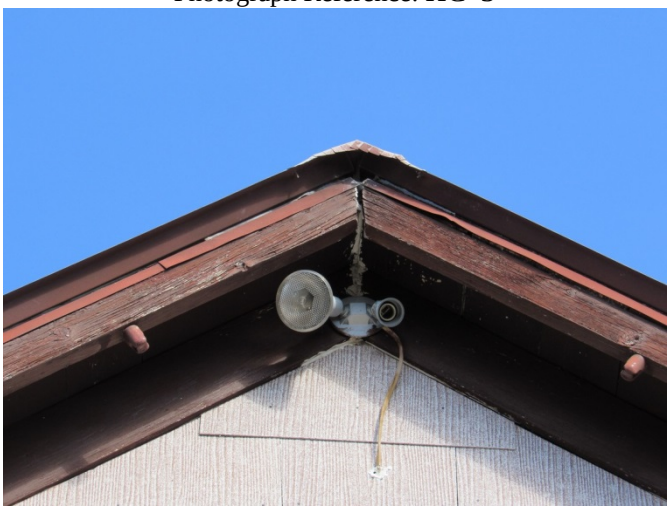
Cabin Steps
Photograph Reference: HC–1



Cabin North (Before)
Photograph Reference: HC-2

Cabin North (After Removal)
Photograph Reference: HC-2

Cabin South (Before)
Photograph Reference: HC–3



Lighting Inventory Photographs

Hunter's Cabin

Cabin South (After Removal)
Photograph Reference: HC–3

Porch
Photograph Reference: HC–4

Field by Hunters Cabin (Non-functional)
Photograph Reference: HC–5

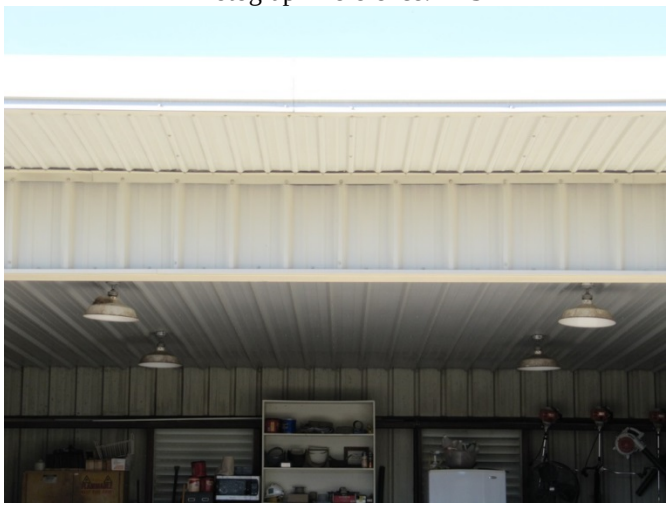
Lighting Inventory Photographs

Maintenance Shop

South
Photograph Reference: M-1

East
Photograph Reference: M-2

Open Bay
Photograph Reference: M-3



Water Treatment Plant Entrance Emergency Lights (Before)
Photograph Reference: M-4

Lighting Inventory Photographs

Maintenance Shop

Water Treatment Plant Entrance Emergency Lights (After)
Photograph Reference: M-4

Water Treatment Plant Entrance Emergency Lights (After)
Photograph Reference: M-4

Lighting Inventory Photographs

Maintenance Shop

Carport
Photograph Reference: M-5

Lighting Inventory Photographs

Cooler/Check Station

Office SW
Photograph Reference: CS-1

Office West
Photograph Reference: CS-2

Tree (This fixture has been completely removed)
Photograph Reference: CS-3

Cooler 1
Photograph Reference: CS-4

Lighting Inventory Photographs

Cooler/Check Station

Cooler 2
Photograph Reference: CS-5

Cooler 3
Photograph Reference: CS-6

Garage North 1
Photograph Reference: CS-7

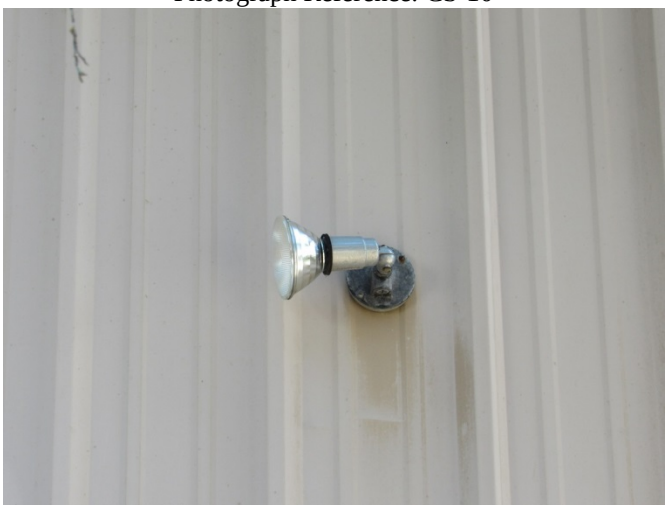
Garage North 2
Photograph Reference: CS-8

Lighting Inventory Photographs

Cooler/Check Station

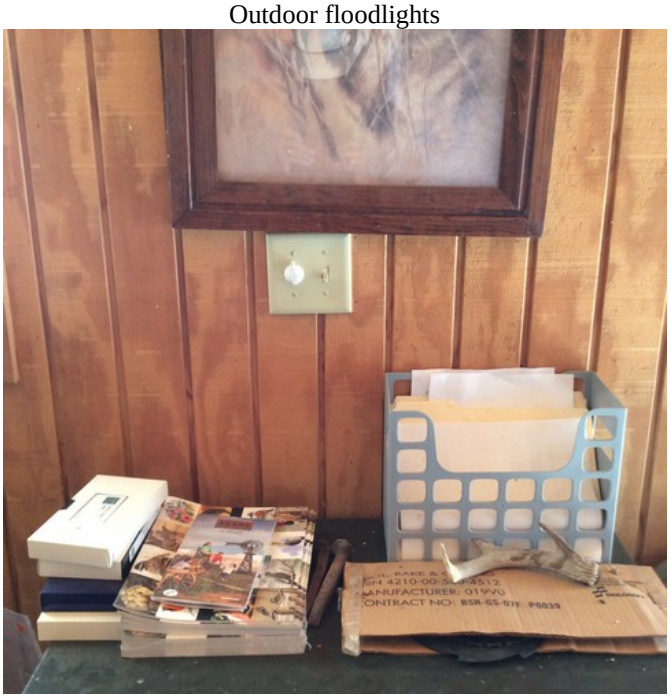
Garage South
Photograph Reference: CS-9

Garage West
Photograph Reference: CS-10



Timer Switches
Outdoor floodlights

Timer Switches
Outdoor floodlights



Lighting Inventory Photographs

Dump Station

Maintenance Light
Photograph Reference: DS – 1

Lighting Inventory Photographs

Entrance Sign

Photograph Reference: E – 1

Lighting Inventory Photographs

Campground Host Station

Sign Light
Photograph Reference: HS-1

Stop Light Sign
Photograph reference HS-2

Lighting Inventory Photographs

Wood Shed by Campsite 1

Photograph Reference: WS – 1

Lighting Inventory Photographs

Acorn bird blind, path between Campsites 39 and 41

Photograph Reference: AB-1
Before

Photograph Reference: AB-1
After

Photograph Reference: AB-2
Before

Photograph Reference: AB-2
After

Section 10. Contributions and Acknowledgements

The staff of South Llano River State Park wish to thank the following groups and individuals who helped make submission of this Application possible:

- Ken Kattner for giving his knowledge, time, and expertise in developing the Dark Sky application, for donating the Sky Quality Meter, and for his constant support and technical assistance.

- Friends of South Llano River State Park for supporting the Park financially, as well as their continued support of the Park's dark sky and other educational programs.

- Texas Parks and Wildlife Department for their technical assistance and advice, their support of dark sky preservation at South Llano River State Park, and for their leadership in night sky preservation.

- Bill Neiman for his assistance installing the Sky Quality Meter at the Park.

- Carolyn Whiteside for allowing the Park to use her stunning night time star photos in this Application.

- Bill Wren and Cindy Luongo Cassidy, for their development of dark sky education materials.

- Lou Zyla for performing the initial lighting inventory and assessment at South Llano.

- Mason Stargazers, Texas Tech University Outdoor School and amateur astronomer Greg Beers for partnering with us in past and future night sky education, and allowing the public to enjoy the Park's dark skies through their telescopes.

- Ky Harkey, Director of Interpretive Services for State Parks, for supporting and promoting Stargazing opportunities in Texas State Parks.

- Phillip Plata, Web Administrator for Texas Parks and Wildlife Department, for adding the Stargazing tab on South Llano River State Park's home page to help educate and inform our visitors about the wonders of the stars.

- Brent Leisure, Director of State Parks, for his leadership in ensuring the night skies are preserved in state parks for all Texans.

- Todd McClanahan, Region 3 Director, for supporting night sky preservation.

- The staff and volunteers at South Llano River State Park, for their efforts in preparing this Application, and for supporting the Park's dark sky efforts.

- City of Junction, Texas, for making dark skies a priority, and for supporting the Park's efforts in the same.

- Those who wrote support letters for this Application, including Texas State Representative Andrew S. Murr, Brent Leisure, Director of Texas State Parks; Nol Dear, President, Friends of South Llano River State Park; Constance E. Booth, Executive Director, Kimble County Chamber of Commerce; Robert Stubblefield, Director, Texas Tech University's Llano River Field Station; Bill Neiman, Board of Directors, Hill Country Alliance and Ken Kattner, Putman Mountain Observatory.

Appendix 1.

August 2013 Lighting Assessment

South Llano River State Park
Lighting Assessment & Retrofit Project
Date of Assessment: 8-28-2013
By Lou Zyla, IDA representative

To Fred Gregg , Park Superintendent:

Thank you for allowing me to assess the lighting in South Llano River State Park. This assessment was undertaken as part of a project to assist TPWD to protect the night skies, reduce glare, reduce operating expenses, allow TPWD to be an example of good lighting practices, reduce the intrusion of artificial lighting in the habitat of wildlife, and identify parks that have the potential to be designated as International Dark-Sky Association (IDA) Dark Sky Parks. Following best practices of night time lighting would provide a true dark sky experience for the public and help educate the public about lighting practices that control the spread of light pollution. South Llano River State Park could, once retrofitted, be an ideal venue for ranger-led nighttime interpretive programs. Amateur astronomers would be eager volunteers to share their knowledge of the night sky, knowing that lighting in the park would not interfere with observations.

Lighting evaluation:
The lighting situation in South Llano River is excellent due mainly to the fact that it is a fairly small park and there are not that many lights. The park is roughly 5 miles south of Junction and the skies at night are excellent. The park ranks number 2 on the Bortle scale which is classified as a truly dark sight with shadows cast by the milky way and the milky way itself is highly structured. There is a tiny light dome from Junction but that is very minor.

There were only 12 light fixtures in the entire park. During our visit 2 of these fixtures were not working. The light at the entrance to the headquarters building was on during the day (due to a dim entryway) but off at night. The cobra light at the park headquarters parking lot and the barn light at the trailer dump station in the campground should be replaced with full cutoff or fully shielded lighting found in many modern parking lots. One of the ways that parking lots may be illuminated with a fully shielded fixture is by using one as shown in the picture below:

This allows you to keep the source of the light shielded while allowing the light to spread to the area where light is needed. To improve vision, the eye must be protected from directly viewing the light source. So, even full cut-off lights may need additional shielding to be installed in a manner that hides the source of the light from most normal viewing points. Shielding the light concentrates it where it's needed and usually allows you to reduce the wattage to get the same or more light where you need it. The amount of light needed for the fixture to produce when this practice is followed is usually about half that of a fixture without shielding. The savings to your electric bill are made, not by reducing light where it is needed, but by eliminating light that is wasted into the sky.

The dump station light was sodium vapor which is a better light source than mercury vapor. The headquarters parking lot light was not working while we were there so we were not able to photograph that light at night. The park director assured us this was temporary, they were awaiting parts to fix the photocell.

The campground had lights at the restroom and the camp host greeting station. The camp host greeting station is a mobile temporary light, which we believe is only on up to 10:00 PM when the camp host is on duty.

This a mobile light on wheels. The glare from this light was bad and made greeting the camp host difficult. We highly recommend that this light be pointed downwards and shielded so incoming motorists have a better lighting experience. Since it is a mobile light it may require some custom work by the park maintenance staff..

The restroom facility at the campground had 4 unshielded wall packs, one of which was not working. The wall pack on the north wall was not working during our visit. The wall packs by the restroom doors (east and west) were under significant eaves so they were not causing any light pollution. Furthermore the lighting was dim from

these wall packs so even though they were not shielded they really didn't produce any glare. The north side wall pack was not working and also located under a significant eave. The south side wall pack was under a smaller eave and also seemed a little brighter. We recommend that this wall pack be replaced with a shielded one.

South side restroom wallpack

Example of a shielded wall pack

Bird Blind Interpretive Area

The bird blind closest to the camping area has an area where rangers and other persons do interpretive programs. One side of the bird blind is painted white for use by a portable projector. There were 2 eave-mounted floodlights in this area, which are only used during interpretive programs on weekends. The floodlights illuminate the outdoor seating area. We recommend these bird blind floodlights be equipped with Parshield Glare Visors.

Summary of Lighting recommendations:

1. Replace headquarters parking lot and dump station parking lot lights with fully shielded parking lot lights.

2. Retrofit campground greeters mobile light with a shield and point the light downwards.

3. Replace south side restroom wall pack with a shielded wall pack.

4. Shield floodlights in the bird blind interpretive area.

Complete Exterior Lighting Inventory

Lighting Assessment Evaluation Chart

South Llano River State Park - August 2013

Location	#	Photo	Description	Purpose of Light	Fully Shielded Y/N	Retrofit Notes
Dump Station	#1		Barn Light	Illuminate Dump Station	N	20 ft high LPS. Recommend motion detection & shielded light
Park Headquarters	#1		Cobra Light (non recessed)	Illuminate Parking Lot	N	Change to full cutoff light
	#2		Plain bulb under porch	Illuminates porch & entrance	N	Ok - under overhang Not on at night
Restroom/Showers	#1		Wall Light	Illuminates entrance from street	N	Not on at night

	#2		Wall Light	Illuminates Men's restroom door	N	Ok - under eave
	#3		Wall Light	Illuminates women's entrance door	N	Ok - under eave
	#4		Wall Light	Illuminates back entrance	N	Needs shield (no overhang)
Camp Hosts			Portable Light	Greeting campers after dark	N	