



WPI

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Dark Sky 2014
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Worcester Polytechnic Institute in partial fulfillment of the requirements
for the Degree of Bachelor of Science

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Abstract

The night skies of Acadia National Park, and the nocturnal ecosystems that depend on them, are threatened by light pollution. This project seeks to actualize Acadia's Night Sky Initiative; to measure, promote, and protect the natural night sky. The team measured and analyzed the brightness of the sky throughout Acadia and surrounding communities. The team enhanced the park's ability to promote the night sky by consolidating and expanding existing information regarding the night sky for park officials and the general public. The team also analyzed the feasibility of Acadia becoming an International Dark Sky Park.

Executive Summary

The United States government recognized the need to protect the natural wonders of this land and created the Organic Act of 1916. The National Park Service was thus created to conserve and protect the natural and historic lands while also making them accessible for the public to enjoy. Since 1916 over fifty national parks were created; one being Acadia National Park.

The Call to Action Plan was created for the centennial celebration of the National Park Service Call to connect, education, preserve, and organization. The points that relate to the Dark Sky Project are point 27 Starry Starry Night and 28 Park Pulse. These points work together to preserve the night sky through management, cultivation, achievement and collaboration.

There have been several sky quality analyses of Acadia. The College of the Atlantic completed a sky quality analysis in 2007 that used a wide angle sky quality meter. In 2008, the Island Astronomy Institute used a CCD Camera. In 2013 WPI conducted study similar to that of CoA but with a narrow angle sky quality meter.

The goal of this project was to address light pollution in and around Acadia National Park by collecting vital sky quality data and increasing awareness. In order to do this the team divided up this mission into one deliverable with three sections to better address light pollution in and around acadia. The team followed Acadia's Night Sky Initiative.

The team managed to collect over 10,000 points by using our innovative Android app. This data was grouped into about 600 locations. These groups were then transformed into a map of the entire island by using GIS software and inverse distance weighted. Multiple effects, such as the Milky Way and improper calibration of equipment.

In order to preserve the night sky, Acadia must promote the importance of it and what harm is being done. As part of the Night Sky Initiative, Acadia stresses to measure, promote, and protect the night sky. When it comes to promoting the night sky, Acadia offers a few programs. These programs include Stars Over Sand Beach, stargazing parties, and the Acadia Night Sky Festival. All of these programs are very effective ways of promoting the night sky. The team wanted to raise further awareness by creating content for there to be an Acadia specific Night Sky webpage. This webpage will be on the Acadia website, and it will provide information on light pollution and other aspects regarding the night sky. The website will also display a promotional video concerning Acadia's night sky that the team also created.

Light Pollution is harmful, but it is also fixable. The dark night sky is 100% recoverable.

Protecting the night sky is vital to keeping this natural resource. There are many different ways the night sky can be protected. This section is broken down into how the night sky can be protected on an International, National, and Local level.

Acadia can involve global organizations, such as the International Dark Sky Association (IDA), to help protect its night sky. The IDA helps preserve night skies all over the world. They give Dark Sky Park designations to parks that meet the necessary requirements. The team investigated the requirements, and determined Acadia meets almost all of them. Acadia does not have the required percentage of fully shielded light fixtures. Acadia could apply for a Dark Sky Park Provisional Status as they work towards installing night sky friendly light fixtures. The team provided Acadia with an overview of all the requirements and also a synopsis of the application process.

The National Parks Service created the Call to Action Plan for all National Parks to follow. The two points that relate to this project are Point 27, Starry Starry Night, and Point 28 Park Pulse. These points focus on protecting the night sky and connecting the park to the community. Acadia's Night Sky Initiative goes along with Point 27, Starry Starry Night. Acadia should archive all data and collections that relate to the Night Sky Initiative and make it available to the public.

On a local level, Acadia can protect its night sky by continuing to correctly shield lights in and around Acadia, working with local towns on creating night sky friendly ordinances, and creating a lighting inventory. The most effective way of doing so is by changing light fixtures to be fully shielded. This will set a good example for communities to follow. The team provided Acadia with a skeleton of how a light management plan should look, and what it should encompass. The Acadia Astronomical Society (AAS) is an organization consisting of MDI residents, Acadia Park Rangers and it is also open to the public. This organization focuses on the beauty of Acadia's night sky, and how it is a valuable resource that the park has. The president of the AAS contacted the team to give a presentation at one of their meetings. The presentation was given on the team's research, as well as the importance of enacting night sky ordinances. The presentation was a success as it reached out to the community.

The team made several recommendations to the park to improve its sky quality and increase awareness. These recommendations were made inline with the Night Sky Initiative. The team recommends for the sky quality measurements of the night sky in and around Acadia to be continued. Year by year comparison of the sky quality analyses serves to document any progress made toward eliminating light pollution in the park as well as highlighting areas that are still polluting the night sky. In addition to continuing the use of sky quality meters to measure the brightness of the sky, other methods such as the use of CCD cameras should be investigated.

The team recommends that Acadia continues to promote its night sky. In order to do this, the team has recommended other programs to add to the park. These programs include creating a second Stars Over Sand Beach program that is more advanced and directed towards an older crowd, implementing the IDA's Save Our Stars program into the park, and turning the abandoned Fire Tower on Beech Hill into an Astronomy Observatory. The team believes all of the mentioned programs would make a great impact on promoting the night sky. In order to preserve the night sky, the team recommends that Acadia furthers its Night Sky Initiative by applying for the IDA Dark Sky Park Provisional Status and continue working with surrounding towns to pass more expensive light ordinances.

In conclusion, the Dark Sky project was a success. The team created the most detailed and accurate sky quality map of Mount Desert Island and Schoodic Peninsula up-to-date. The team also created content for a night sky webpage to be added to Acadia's website. This webpage will also consist of a night sky promotional video on the web page that the team created. Overall, the mission of the project to address light pollution in and around Acadia was achieved.

Authorship

All sections were edited by all. Below are the major editors and first draft creators.

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Chapter 1: Introduction

Almost a century ago, the United States government recognized the imminent threat to the natural wonders of this land. The Organic Act of 1916 created regulations to conserve and protect the natural and historic lands, while also making them accessible for the public to enjoy (*National Park Service Organic Act*, 1916). Acadia National Park was created three years later to preserve the land on Mount Desert Island in Maine. Acadia's current mission statement aligns with the Organic Act and pledges to "protect and conserve outstanding scenic, natural, and cultural resources for present and future generations" (National Park Service, 2000; "Pks in Chron order," 2005).

One of Acadia's most scenic and overlooked natural resource is the nocturnal ecosystem. The wildlife of the park heavily depends on the delicate natural balance of the entire ecosystem of Acadia. The natural behavior patterns of nocturnal creatures are dictated by the lunar cycle and the subsequent ebb and flow of the brightness of the night. Any disturbance of the natural brightness to the night – the dark sky – can catastrophically disrupt the equilibrium of Acadia and all its creatures.

Technological progress and urbanization have caused an exponential increase in artificial light. This invasive light, or light pollution, is polluting the night; not just the sky, or the animals, but also the people. Light pollution has "obliterated the stars for much of the world's population" (International Dark-Sky Association, 2014). For almost all of our history on this planet, the clear skies have been a source of wonder and inspiration. Now that most of the world's population resides in cities, where skyglow obliterates all but the brightest of stars, clear skies are the exception rather than the rule. Growing up in the Bronx, Neil deGrasse Tyson thought the Hayden Planetarium was "a nice hoax. It [couldn't] be real ... they think there's that many stars up there" until a few years later, when he stumbled into rural Pennsylvania and embarrassingly thought "It reminds me of the Hayden Planetarium" (*Stephen Colbert Interview - Montclair Kimberley Academy*, 2010). Astronomy depends on these waning clear skies, and we are in danger of extinguishing this spark of creativity.

Despite the secluded nature of Acadia, it is not immune to the encroachment of urban build up and the associated superfluous lighting. In 2008, Acadia created a Night Sky Initiative to address the threat posed by light pollution. Acadia's Night Sky Initiative set forth guidelines to help measure, promote, and protect the night sky in Acadia National Park and surrounding communities (National Park Service, 2008). To track the impact of the initiative and other sky friendly programs, there must be sky quality readings to document the changing light pollution in Acadia.

There have been two comprehensive sky quality studies of Acadia to date. The study

conducted in March, 2007 by the College of the Atlantic (CoA) was a cursory overview of the sky quality in Acadia (Bacon & Gehlot, 2007). Worcester Polytechnic Institute's (WPI) study in 2013 primarily retraced and improved upon the 2007 study (S. A. S. author--B. Roth, Rolon, Morse, Larsen, & Bianchi, 2013). While these studies are important, further research is warranted. In order to make a difference, it is vital to promote awareness in conjunction with continued research.

Government and local organizations have taken interest in educating the public on lighting. The education allows the public to reduce energy usage and minimize light pollution. Towns across the United States have implemented lighting regulations through their zoning ordinances. The International Dark Sky Association has researched and regulated light pollution internationally with the help of parks, reserves and communities. It has also created guidelines for these regulations and education programs.

This project aimed to address light pollution in and around Acadia by collecting vital data and increasing awareness. The team measured, analyzed and mapped the pollution across the park and surrounding areas. The project called for the evaluation of preexisting community and park programs concerning the dark sky. The team expanded the sky quality research to Schoodic Peninsula, where Acadia plans to open a new campground in the near future.

The team developed an action plan to reduce light pollution in the area around Acadia through educational programs with citizens and government officials of Mount Desert Island. With the improved sky quality data and active education plans, the team assisted Acadia National Park in beginning the application process to be recognized as an International Dark Sky Park. Our efforts coincided with the National Park Service's Call to Action Plan "Starry Starry Night" and worked towards the centennial celebration for the future of the National Parks Services ("A Call to Action," 2013).

Chapter 2: Literature Review

The impetus of the Dark Sky project was to aid Acadia National Park in its mission to maintain a clear night sky. This chapter covers the basic information needed to understand the National Park Service's role in protecting the natural environment (while still allowing public access), the negative consequences of light pollution, the origin of that light light pollution, and the methods for measuring and reducing it through education of the general public.

2.1 National Park Service

The American commitment to preserve and protect nature is clearly evident as early as March 1, 1872, when President Ulysses S. Grant signed the Act of Dedication creating the first national park in the world. National Parks were designed to be “pleasure ground[s] for the benefit and enjoyment of the people” (United States, 1872). By the summer of 1916, eleven other federally-owned lands had become recognized as national parks (“Pks in Chron order,” 2005). On August 25, 1916, President Woodrow Wilson created the National Park Service through the Organic Act to properly manage the growing number of national parks. (*National Park Service Organic Act*, 1916)

The National Park Service's mission – to “conserve the scenery and the natural and historic objects and the [wildlife] therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations” – exemplifies the continued commitment to the preservation of federal lands. (National Park Service, 2000) To ensure that the national parks remain unimpaired for those future generations, the general public must be aware of what resources are to be conserved and why, in order to best serve the dual purpose of the national parks; to protect the natural environment, while at the same time educating the general public. Consequently, sections of the park that are fully open to the public are not conserved in the same manner as the rest of the park. (“Closure Area,” 2014) These sections enable the general public to learn about and enjoy the park, and by extension, to educate them about the need for national parks.

2.2 Acadia National Park

Acadia National Park, created on February 26, 1919, is located on Mount Desert Island in Maine and encompasses nearly 48,000 acres. (“Park Statistics - Acadia National Park,” 2013) Acadia National Park's many major natural features and ecosystems are home to a wide variety of animals. The nocturnal ecosystem of Acadia is unique due to its wide variety of creatures and its coastal

location. Many people travel to Acadia for its often overlooked national treasure: one of the darkest skies on the east coast (“About Us | Acadia Night Sky Festival,” 2014).

2.3 Dark Sky

A dark sky is an integral part of a thriving natural ecosystem. The dark sky allows for nocturnal ecosystems to flourish. Animals depend on the dark sky for mating, hunting and other habits at night. Porcupines, raccoons, and bats are some of the nocturnal creatures that live in Acadia. These animals need the natural darkness to forage and hunt (Kaiser, 2010). The dark sky can be easily compromised: either naturally by clouds and weather, or artificially by humans. Both indoor and outdoor lighting, as well as smog, affect the dark sky. When excessive artificial light is introduced, the natural balance of the ecosystem deteriorates. Animals that have found their way to mating grounds for thousands of generations can no longer navigate to those grounds. Predators that rely on the dark of the night to hunt their prey undetected will starve when the night is bright enough for their prey to see them. When the night sky is artificially brightened, animals can become disoriented enough to perform daytime activities at night. Further, when the night sky is too bright, rodents such as deer mice cannot forage for food because their predator, the short eared owl, can detect and catch them more easily (Navara & Nelson, 2007).

2.4 Light Pollution

A dark sky does not need to be a sky devoid of all artificial light. In this modern age, any sky near a hub of civilization will be altered by the artificial glow intrinsic to our society. The most direct way to darken the night, removing any and all artificial lighting, fails to accommodate some of the needs of our culture. In fact, not all artificial light is wasteful. While traffic lights, car headlights, and streetlights add to sky glow, they are vital to the safety of our society (Riegel, 1973).

Solving the problem of light pollution will have to balance two seemingly irreconcilable tasks: maintaining the safety and convenience of lighting while simultaneously preserving and restoring the dark sky. Sky quality, and by extension light pollution, is measured in magnitudes per square arcsecond (mpsas). This unit represents the astronomical brightness of a section of the sky. Sky quality meters, or SQM's, are used to average the brightness of a section of the sky and return the value in mpsas (“Sky Quality Meter,” 2014). See Appendix A: Magnitudes per square arcsecond: mpsas.

There are various ways to reduce light pollution. In addition to educating the public on the impact and prevention of light pollution, regulations can be made at the state and town levels. These regulations identify types of lights that are shielded to prevent light from going upward to the sky (International Dark-Sky Association, 2014a). See Figure 1 for an illustration of the effects of shielding.

2.5 International Dark-Sky Association

Light pollution is a problem not only in the United States, but in all developed countries. Actions have been taken worldwide to reduce light pollution. These efforts have been designed to control unwanted nighttime light to preserve the natural dark sky. The International Dark-Sky Association (IDA), created in 1988, was the “first organization to call attention to the hazards of light pollution”, and has developed a way to recognize dark sky places (“About Us | Acadia Night Sky Festival,” 2014).

The IDA allows parks, reserves, and communities to become International Dark Sky Places (IDSP). Any park that meets its requirements can become a Dark Sky Park (International Dark-Sky Association, 2014b). The IDA offers various educational programs that focus on the dark sky. One of the programs, Save Our Stars, educates local clubs and organizations (“Save Our Stars (SOS),” 2014).

Acadia National Park has the potential for some of the darkest skies in the country. Astronomers have flocked to Acadia’s secluded skies each year for the annual Acadia Night Sky Festival, now entering its 6th year (“About Us | Acadia Night Sky Festival,” 2014). The National Park Service is in communication with the IDA to establish Dark Sky Parks. This joint effort has given rise to three Dark Sky National Parks in the United States: Big Bend National Park in Texas, Death Valley National Park, in California, and Chaco Culture National Historical Park in New Mexico (International Dark-Sky Association, 2014b). Currently the closest dark sky park is Cherry Springs State Park, in Pennsylvania. By becoming an International Dark Sky Park, Acadia would be the first national park to receive IDA status this side of the Mississippi. There is tremendous support for Acadia to become a Dark Sky Park and to preserve the night sky.

2.6 Call To Action Plan

In its efforts to protect the natural dark sky and to provide more night time access to the

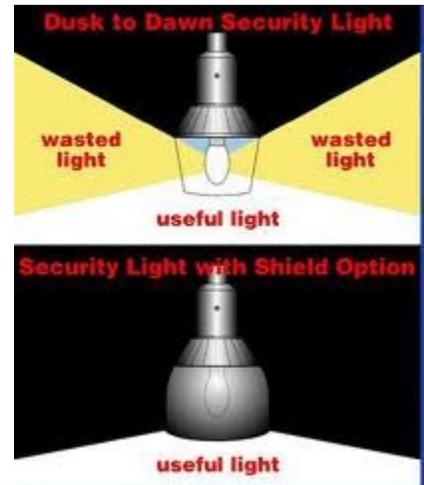


Figure 1: Impact of shielding on light pollution

public, Acadia plans to focus on implementing points 27 and 28 of the Call to Action Plan (CtA). The CtA has a broad agenda for improving the management of the National Park Service and “Preserving America’s Special Places”. Point 27 of the CtA, *Starry Starry Night*, emphasizes the need to “lead the way in protecting natural darkness” by creating a “model for dark sky protection” while working “in collaboration with other federal agencies, partners, and local communities.” Point 28 of the CtA, *Park Pulse*, outlines the National Park Service’s desire to use information on the “overall status of park resources... to improve park priority setting and communicate complex park condition information to the public in a clear and simple way.” Acadia intends to combine *Starry Starry Night* with *Park Pulse* in an effort to uphold the overarching goal of the CtA – to “actively ensure conservation of national parks, public lands, wilderness, and historic places for the enjoyment of future generations.” (“A Call to Action,” 2013).

2.7 Policy

The Dark Sky Movement in Acadia has many available resources, including light pollution regulations at the town and state level. Maine has studied light pollution through the Municipal Planning Group and the Maine Department of Agriculture, Conservation and Forestry. The Municipal Planning Assistance Program has created a report “to encourage the preservation of Dark Skies” to the business, research and economic development committee. Maine has called for the “preservation of this natural resource” through the review of “outdoor lighting standards for commercial development.” Maine’s legislature also mandates that this report must be given to the commercial developers to give them “options and recommendations for this promotion” (State of Maine, 2010).

Local authorities can also help reduce light pollution. Legal actions such as police power give “states and their legislatures” the ability to “enact regulations over persons and property to prohibit all things inimical to their citizen’s health, safety, morals and general welfare” (Burke, 2013). The towns surrounding Acadia can protect its sky quality through zoning ordinances. Acadia deserves the same level of legal protection as all United States landmarks. “Aesthetics” are considered to be a “legitimate purpose of zoning if it has substantial relationship to other, more traditional purposes ... such as the preservation of property values or the local economy.” (Burke, 2013). The park’s night sky is brightened by light trespass from outside sources. This diminished sky quality, along with the subsequent disruption of the nocturnal ecosystem, reduces the appeal of the park for astronomers and other scientists. If fewer astronomers visit Acadia, Mount Desert Island’s economy could be negatively impacted. Properly regulating lighting will ensure the increase in sky quality and decrease areas affected by light pollution, thereby preserving Acadia.

2.8 Previous research

Vested interest from all levels of government and other organizations have led to several surveys throughout Acadia. These surveys include: Worcester Polytechnic Institute from Summer 2013 (WPI 2013), College of the Atlantic from Winter 2007 (CoA 2007), and the Island Astronomy Institute from Spring 2008 (IAI 2008). There have been other surveys, but those surveys present their findings with aggregate data for the entire park. However, presenting sky quality data in this format loses valuable information such as how light pollution impacts different areas of the park. Data collection, especially in areas that are slated for development or where the light fixtures are scheduled to be modified, is vital to the success of any plan to reduce light pollution.

The IAI survey was conducted with CCD cameras and created a high-quality full-sky map for each location. In contrast, both of the other studies used Unihedron Sky Quality Meters. These take the average brightness of a section of the sky, and report it as a single number in magnitudes per square arcseconds. The WPI study used a superset of the CoA study's locations. There are too many discrepancies between these studies to make more than a few meaningful analyses. These show that Acadia has relatively dark skies, but that light pollution is present. This conclusion is based on all the raw numbers from these studies averaging 21 mpsas. These readings are about one magnitude brighter than the darkest skies measured on earth (Astronomy Institute of Maine, 2008; Bacon & Gehlot, 2007; Garstang, 1991; S. A. S. author--B. Roth et al., 2013). For details on mpsas, see Appendix A: Magnitudes per square arcsecond: mpsas.

2.9 Education

Many of the Mount Desert Island residents are unaware of the dangers of light pollution (S. Roth & Morse, 2014). In order to properly inform the public and to address light pollution and the dark sky, there need to be education programs. Such programs must consider all education activities that Acadia has offered to date, and examine light pollution programs of dark sky parks. These programs could include guided night tours, informational pamphlets, and hands-on demonstrations. Informing the public about the harms of light pollution can gather the necessary public support to implement lighting regulations. This will involve the entire community in the night sky protection effort.

2.10 Project Objectives

This review of the night sky and its threatened status at Acadia National Park lead the team to model our project on Acadia's Night Sky Initiative. We helped formalize the initiative in all three areas: measure, promote, and protect. The first section was to measure the sky quality over Mount

Desert Island. We did so by expanding upon the 2013 WPI analysis and focusing on acquiring readings Schoodic Peninsula. We used the same equipment as the 2013 WPI study to allow for direct comparisons. The second was to evaluate and enhance the promotional programs of the night sky at Acadia. Since education is a vital component in improving sky quality, we ensured that there was sufficient educational material about the importance of dark skies. The third was to initiate the application process for Acadia to be recognized as an International Dark Sky Park, as well as to initiate other forms of protection.

Chapter 3: Methodology

The primary goal of this project was to help protect the night sky in and around Acadia National Park by collecting vital data and promoting awareness. To achieve this, we formalized Acadia's Night Sky Initiative. For the measure aspect, we created a sky quality survey and analysis. The data was mapped to determine the areas most affected by light pollution. For the promote aspect, we helped to enhance educational programs concerning Acadia's dark sky and nocturnal ecosystems. This promoted public awareness of the danger of light pollution and the small actions that can be taken to help reduce it. The final aspect was protection, and we investigated the feasibility of an application to the International Dark-Sky Association.

3.1 Project Timeline

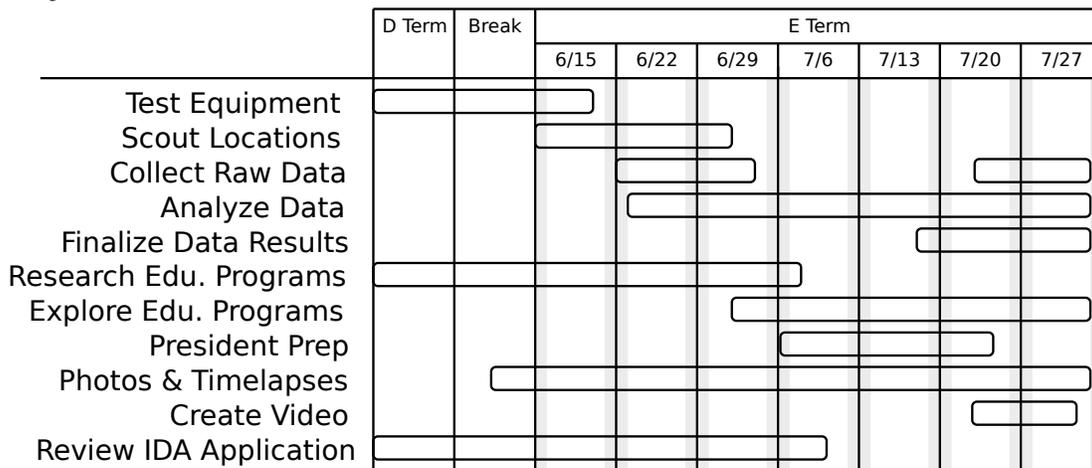


Figure 2: Project timeline by section

3.2 Sky Quality Analysis

The first section of Acadia National Park's Night Sky Initiative called for a sky quality map and analysis of the light pollution over Acadia. In addition to obtaining data in the areas covered in the WPI 2013 and CoA 2007 studies, the team also focused on Schoodic Peninsula. This required measuring the brightness of the sky at various points across Acadia. Optimal times to collect the data to avoid natural error sources, such as the sun and the moon, were considered.

3.2.1 Time

To accurately measure the brightness of the sky, readings were taken after astronomical twilight. Figure 3 (produced using the US Naval Observatory's twilight and moon tables) shows

optimal times for measurements were between 10:50pm and 2:20am EDT from June 22, 2014 to July 2, 2014, with smaller dark windows on the surrounding nights. This provided 3.5 hours of observation time each night, and gave the team a total of over 40 hours for optimal data collection.

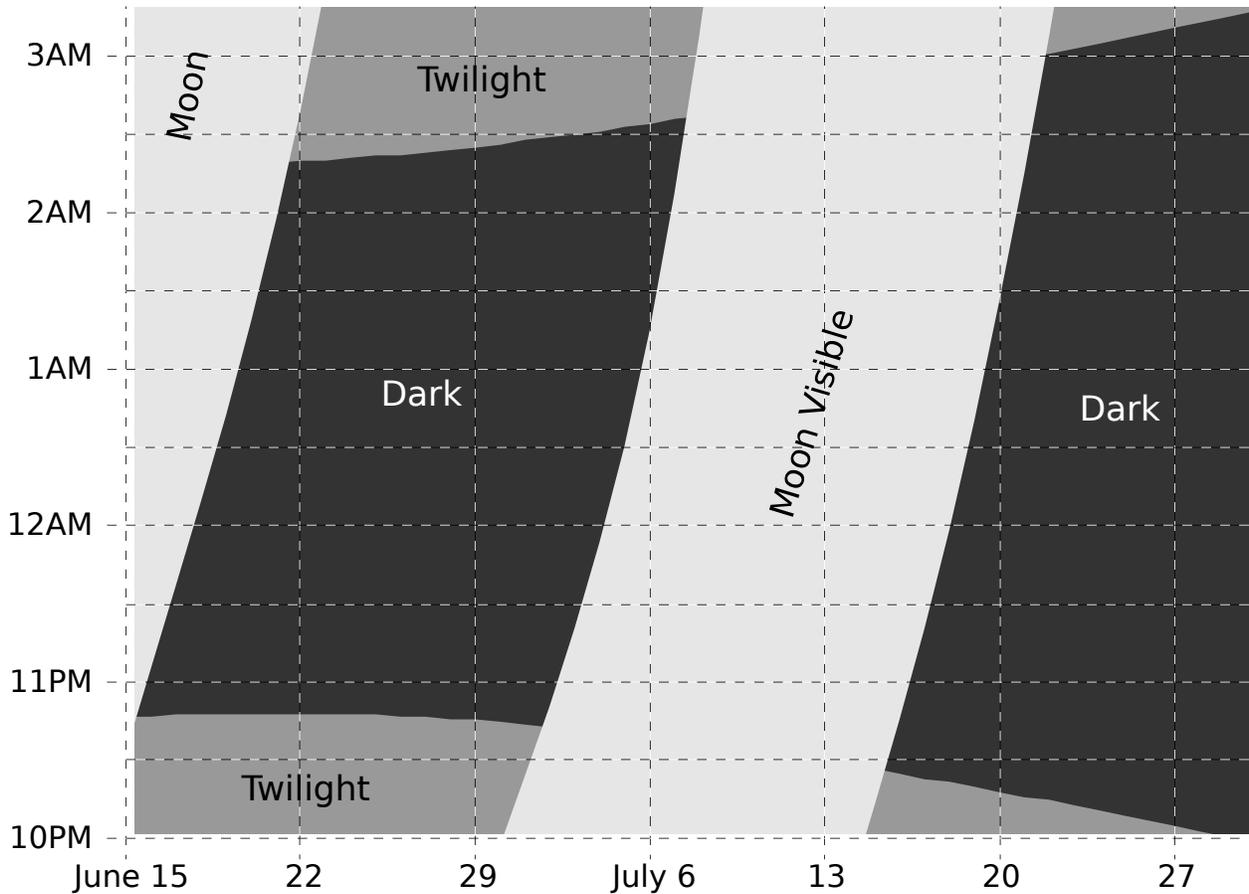


Figure 3: Optimal times for data collection

Historically, an average June day in Bar Harbor has had a 50% chance of being cloudy. (“Average Weather for Bar Harbor, Maine,” 2012) Thus, the team closely monitored the weather and planned our routes with the assumption that only half of the nights in our time window would be viable. The team worked with park planners to rank areas in order of importance as follows:

1. Schoodic Peninsula, specifically in and around SERC and Acadia's new campsites on the peninsula (currently under construction)
2. Sand Beach
3. Roads around Mt. Desert Island where the WPI 2013 and CoA 2007 studies took readings
4. Surrounding towns
5. Seawall & Blackwoods Campground

The team used this ranking to help budget available time and to prioritize areas of greatest

importance to Acadia National Park.

3.2.2 Map Points

To cover a given area, we determined all the nearby roads with minimal tree cover via the Satellite view in Google Maps. We then drove along these roads until we came to a location that was not surrounded by trees and with no bright lights directly overhead. We turned off the headlights (or, in some cases, the entire car) to avoid polluting the skies with reflected headlight glare. For small clearings, we took several readings before moving on. For larger clearings, we collected readings while walking down the road. This allowed us to collect a statistically significant number of datapoints in these areas. The resulting map at these locations was therefore especially smooth, continuous, and accurate.

3.2.3 Acquiring Data

Data was collected using Unihedron SQM-LU-DL meters. These devices support taking individual readings via USB, so we are able to plug these meters into Android devices with GPS and USB-OTG support. This removed the need for manual data logging and separate GPS devices. By using the USB interface to computerize collection, the team recorded and analyzed about fifty times as many data points as the 2013 WPI study in a comparable amount of time. The team created an Android application, *Androidmedae*, to log all important and potentially relevant information at the touch of a button, or automatically after the SQM had traveled a specified distance in arcseconds (See Technical Report 1: *Androidmedae*). After the information was collected on the Android devices, it was uploaded into a single PostgreSQL database with PostGIS extensions that stored the geographical data alongside the non-geographical data. *Androidmedae* allowed for the collected data to be uploaded in a single batch once the Android device had an internet connection. Once it was uploaded into the database, we used GNU R and QGIS to analyze the data.

3.3 Promote

The night sky is often overlooked and under-appreciated. Measuring the night sky, though important, is not sufficient to fix the light pollution problem in Acadia. The sky quality maps and analysis and other illuminating light pollution studies are meaningless if they never brought to the attention of the public “in a clear and simple way” (“A Call to Action,” 2013). Advocating for night sky protection through awareness is vital for promoting appreciation for this natural wonder. The team researched what promotional programs Acadia offers concerning the night sky. This research will include park programs, community outreach and other forms of spreading information.

3.4 Protect

Protecting the night sky is important as it is vital to the nocturnal ecosystem and to human health. In order to preserve natural resources such as the night sky, action can be taken at all levels: local, national and international.

3.4.1 Local

At the local level, towns can have dark sky ordinances enacted that regulate lights as well as education outreach organizations. The team researched established ordinances and investigated other community outreach programs. The team researched lighting policies in local zoning ordinances and integrated them into a form of educational program in order to raise public awareness. Enhancing Acadia's educational programs can build a stronger connection to the community. The program worked to raise public awareness of the harms of light pollution as well as educate the public on existing regulations in the areas around Acadia.

3.4.2 National

Acadia's Night Sky Initiative exemplifies the essence of point 27 of the Call to Action Plan, Starry Starry Night. It sets a precedent of collaborating with outside organizations and the community to spread appreciation for the night sky. This initiative and its success in the community, through the Annual Night Sky Festival, sets a high standard of excellence for other parks to follow. The Night Sky Initiative measures, promotes and protects the night sky and can archive what has been done. The team plans to make recommendations on how this can be done.

3.4.3 International

The International Dark-Sky Association is another invaluable resource available to Acadia. The IDA helps fund projects concerning the night sky or light pollution. It provides information in forms of educational programs and supports groups that formalize protection of the night sky. The signature program of the IDA is the International Dark Sky Places Program. This program designates communities, reserves, or parks who have exceptional night skies.

The IDA has established various educational programs to help places focus on the dark sky. One such program is the Save Our Stars (SOS) program that began early in Spring 2014. SOS focuses on enhancing and improving clubs and organizations. The SOS program could be used to supplement educational programs in Acadia and at the College of the Atlantic.

The International Dark Sky Places program offers various designations to places seeking to be formally recognized for their night sky protection efforts. One such designation, that of a Dark Sky Park, is defined as:

“a public land possessing an exceptional or distinguished quality of starry nights and a nocturnal environment that is specifically protected for its scientific, natural, educational, cultural heritage, and/or public enjoyment.” (International Dark-Sky Association)

Acadia National Park has the potential to become a Dark Sky Park as it is home to some of the darkest locations on the east coast. The team investigated the application requirements and determined that the team’s sky quality measurements and analysis could be used in the application process. The team also investigated the many other components of the IDA application.

3.5 Summary

This was the second year for a group of WPI students to conduct a sky quality analysis project in Acadia National Park. As long as WPI and Acadia National Park continue to work together, the data analysis portion of the Dark Sky Park requirement will be fulfilled. The team analyzed and enhanced the educational programs in Acadia to continue the fulfillment of the Dark Sky Park application requirements (See section 3.3). The team also planned to initiate the application process with Acadia to be recognized as an International Dark Sky Park.

Chapter 4: Results

In this chapter, the results and findings of our research are expanded and discussed. The deliverable is the formalization of Acadia's Night Sky Initiative to organize the team's and previous works in an easily accessible manner.

4.1 Measure: Sky Quality Analysis

While reviewing our data (all of which is posted in Appendix H: Raw Data), it became apparent that our readings were $\approx 30\%$ brighter while walking to the west as opposed to waking east, as can be seen in Figure 4, which was computed using Appendix C: Screen Normal Calculations. After this was noticed, the team started taking readings in multiple directions at each spot. Plotting orientation vs magnitude vs time revealed that the east was brighter than the west, growing then shrinking as the night progressed. The team also noticed that it got brighter part way through the dark-sky time window, as can be seen in Figure 5.

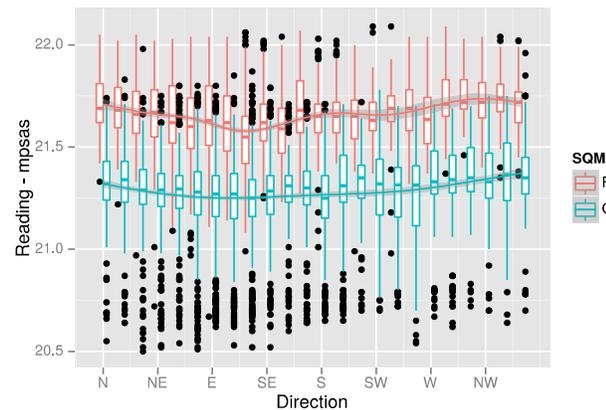


Figure 4: ESE is the brightest, and WNW is the darkest from the Milky Way

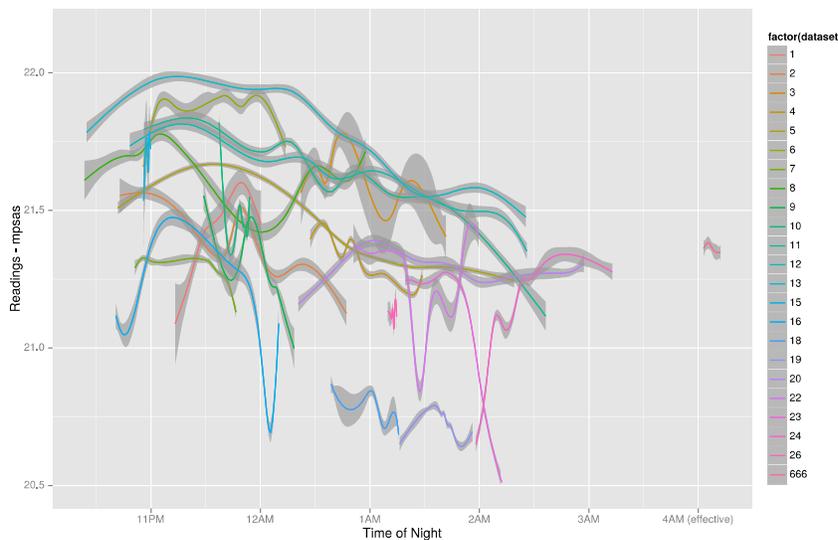


Figure 5: Effect of the Milky Way moving into the meter's field of view (downward trend)

can be seen in Figure 5. This, along with visual observation, served to demonstrate the significance of the effect of the Milky Way on dark skies.

Careful analysis of the data also revealed that the SQM's were not identical; one focused behind, and one focused in front of the zenith. Another discrepancy was that one of

our two SQM's (F) was reporting values 0.27 magnitudes per square arcsecond darker than the other (G). These observations were confirmed by leaving the SQM's in 45 second datalogging mode while hooked up to a battery overnight at Eagle Lake and Beach Mountain. To fix the linear offset of the readings between the two SQM's, the team mailed one SQM (F) back to Unihedron for calibration. After F's return, the team used the newly calibrated F to both retroactively adjust all of our data and to calibrate our other meter (G).

The following effects were also all corrected for in our final data:

1. All July readings were corrected for the 2 hours difference in the position of the night sky as it moves about 4 minutes each day from the difference between the sidereal day and mean solar day.
2. Correcting calibration of the SQM's (all data collected by F prior to the calibration was reduced by 0.18, and all of the data collected by G was increased by 0.09).
3. A piecewise function to approximately remove the milky way difference between the start of readings and end of readings.
4. A linear offset to add the milky way back in as a constant glow.

The datasets in Table 1 were taken along the paths in Figure 6.

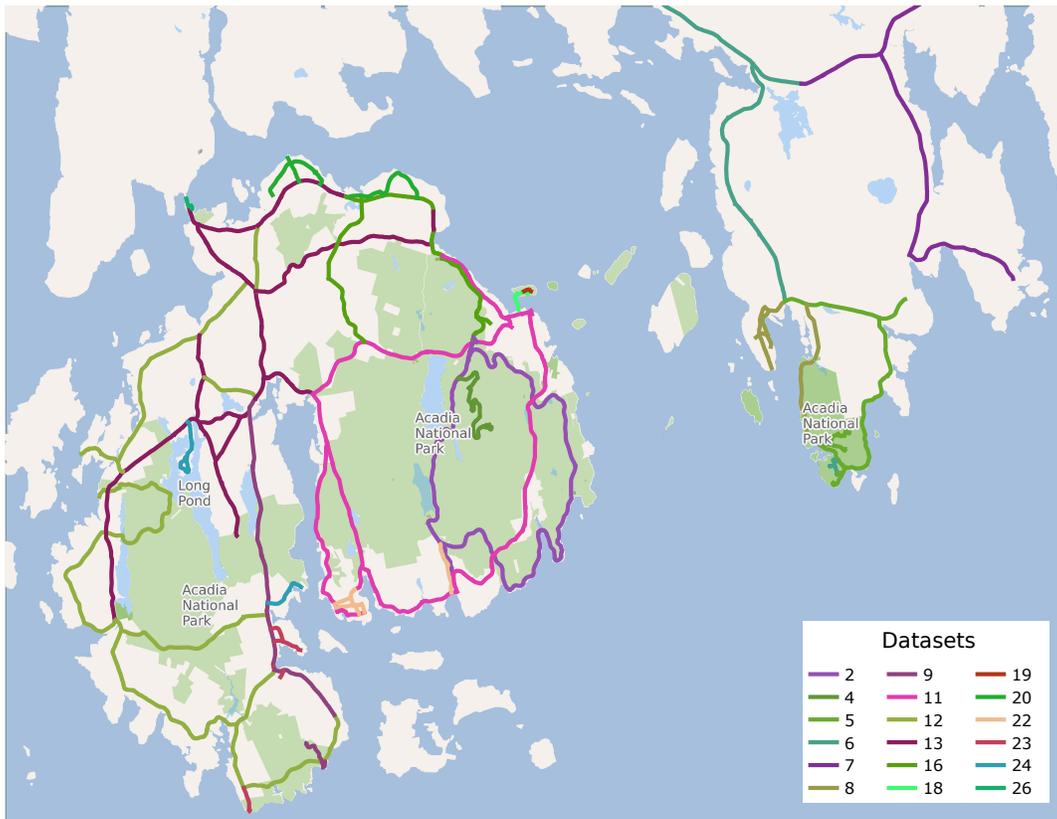


Figure 6: Routes taken in various datasets (ignoring duplicates)

Set	Date	Meter	Weather	Count	Description
1	6/18	G,F	Partly Clouds	159	Sand Beach
2	6/19	G,F	Clear	1143	Park Loop Road (few trees)
2.1	6/19	G,F	Clear	523	Park Loop Road (Some trees)
3	6/21	F	Partly Clear	95	S PLR & Golf Course in Northeast Harbor
4	6/21	G	Partly Clear	403	Cadillac Mountain (Road)
4.1	6/21	G	Partly Clear	178	Cadillac Mountain (Trail)
5	6/22	G	Clear	1564	Schoodic Head
5.1	6/22	G	Clear	52	S Schoodic
6	6/22	F	Clear	205	NW Schoodic
7	6/23	G	Hazy	217	NE Schoodic
8	6/23	F	Hazy	533	Winter Harbor & new campgrounds
9	6/26	G	Partly Clear	186	Southwest Harbor & Seawall
10	6/24	F	Partly Clouds	63	Northeast Harbor & Seargent
11	6/26	F	Partly Clear	574	Northeast Harbor & Seargent
12	6/27	F	Clear	549	Western MDI
13	6/28	F	Clear	657	North-Western MDI
15	6/30	F	Clear	78	Cadillac Mtn
16	6/30	G	Clear	407	Park Entrance & Norway
18	7/18	G	Clear	43	Bar Island
19	7/18	G	Mostly Clear	253	Bar Island & The Bar
20	7/21	G	Clear	548	North detail & 233
22	7/22	G	Clear	225	Northeast Harbor
23	7/23	G	Clear	134	Seawall & Bass Harbor
24	7/23	G	Clear	146	Southwest Harbor
26	7/29	G	Clear	62	Thompson Island
666	7/22	G	Clear	77	CoA @ Power Outage
	6/29	G	Clear	839+	Time Lapse @ Eagle Lake
	7/6	G,F	Partly Cloudy	496	Time Lapse @ Beech Mountain

Table 1: Dataset metadata

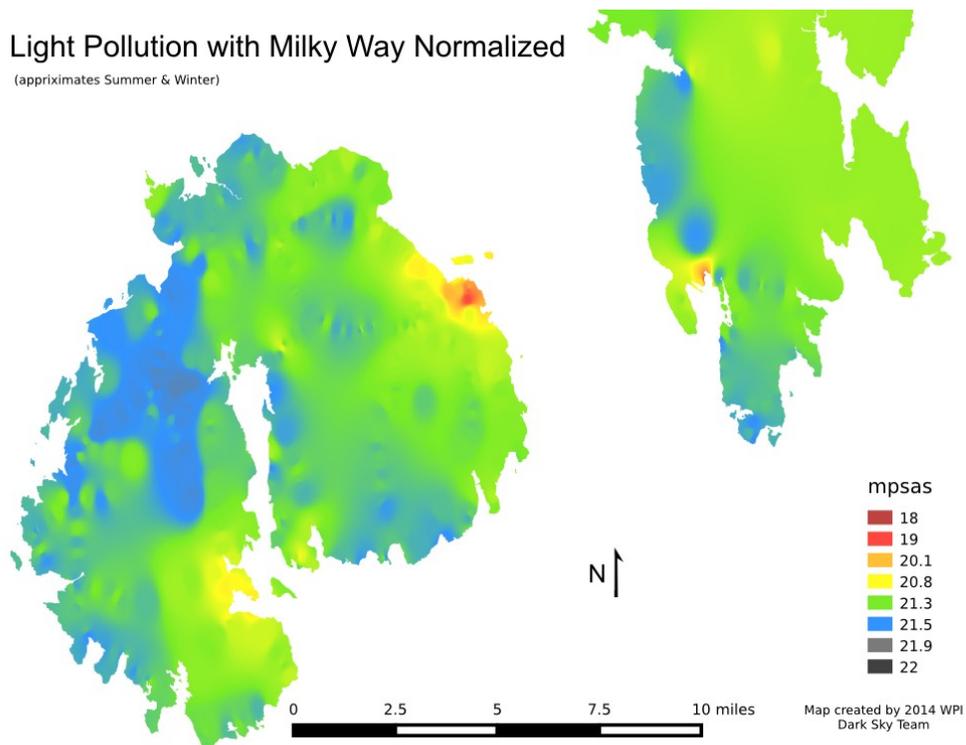


Figure 7: Milky Way Normalized Map

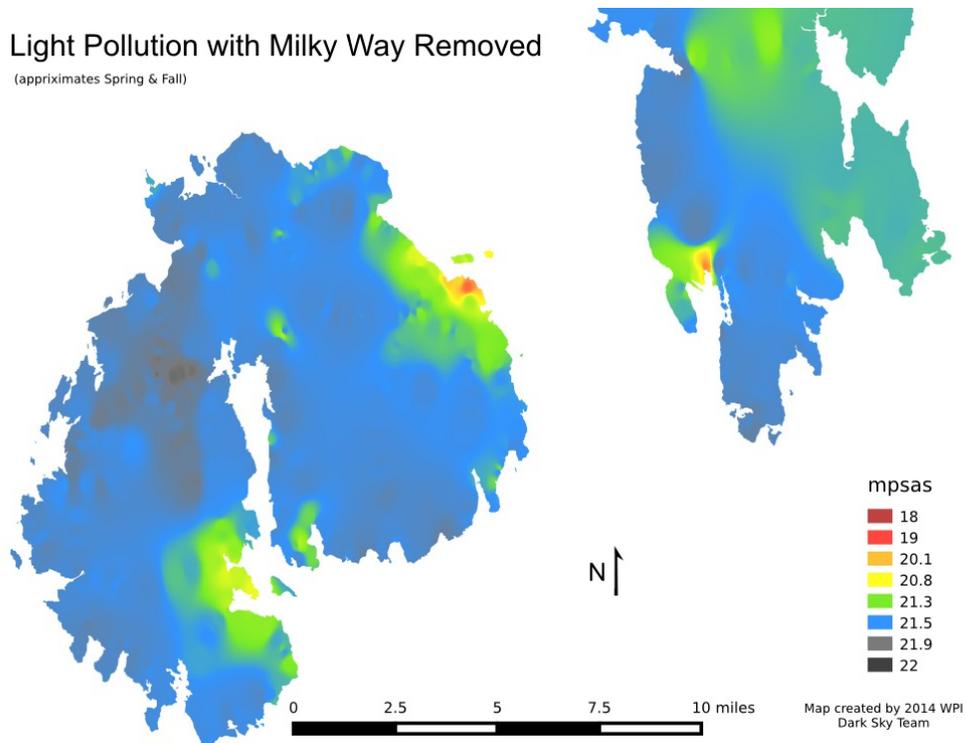


Figure 8: Mount Desert Island & Schoodic with Milky Way mathematically removed

4.1.1 Analysis

GIS software interpolated the data using Inverse Distance Weighted (IDW) with a power of $P=4.0$ on a scale of 250x200 feet per pixel that created a smooth map of darkness over the entire area of Acadia. Because this is the same interpolation method as the 2007 CoA and 2013 WPI studies, we were able to make some direct comparisons. The map we generated from our sky quality data closely resembles 2007 CoA study with the western “quiet side” of the island darker than the east side. The western side is clearly darker, and contains some of the darkest raw readings near 22.00, taken when the Milky Way was nearly out of view of the SQM.



Figure 9: Automatic point groups

Individual points (10k+) were combined into 583 groupings to correct the data for outliers & statistical anomalies. These points were grouped into location groups by a Ruby script (see Appendix B: Spanning Tree Grouper (code listing) for the code) that created spanning trees of nearby points and merged them together into groups. While this failed to break apart high density areas like the top of Cadillac Mountain, it worked well enough for our purposes. Since most of the groups contained about 5-10 points, we took the median of each group to ignore outliers. This median was then located in the centroid of the group for the IDW interpolation. See Figure 9 for the groups.

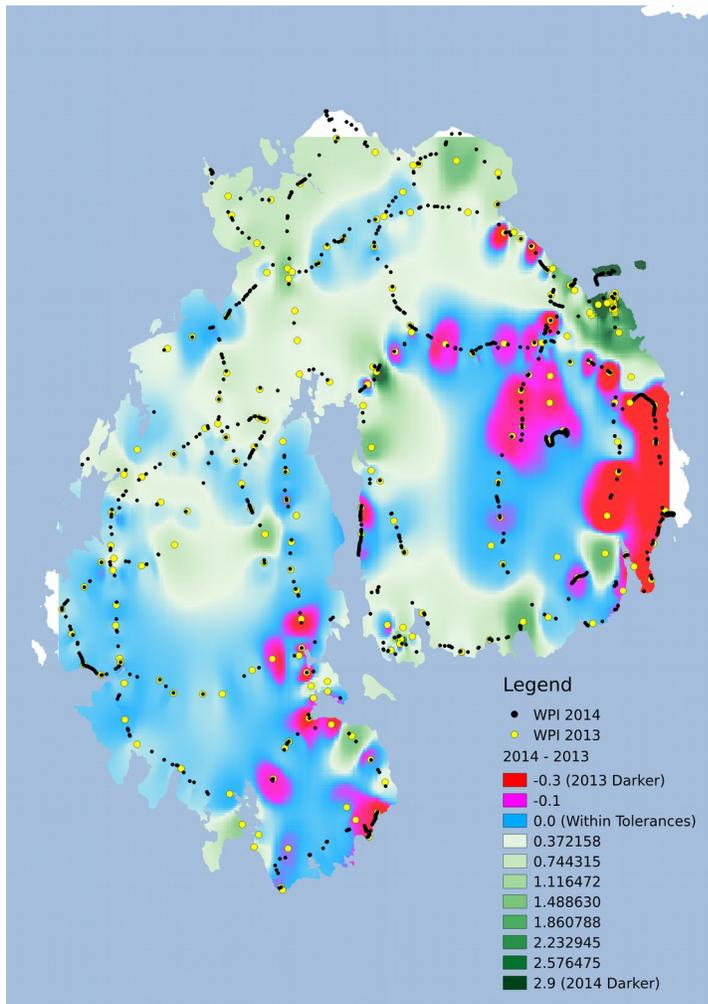


Figure 10: Difference between 2013 and 2014 maps

constraining the high school's glow to a better approximation of its actual spill.

From our comparison, it appears that light pollution levels have remained relatively constant or within tolerances (blue on the map in Figure 10). Note that the blue zone is not centered around zero, as a comparison of last year's data in open tree-free areas in 30 different locations shows a 0.17-0.19 offset. That offset was the reported offset of one of our SQMs. Further conclusions cannot realistically be drawn due to the lack of any corrective factors in the 2013 study.

As part of our analysis, we compared our map to the map produced by the WPI 2013 study. It was readily apparent that there were discrepancies between the two data sets (see Figure 10). Notably, our readings for Sand Beach, although in line with the surrounding areas, were significantly brighter than the previous study indicated. Nearby, the towns of Bar Harbor, Otter Cove, and Seal Harbor were all not nearly as pronounced as previous studies. Otter Cove was not visible on our map because we did not collect points in its highly dense areas of streetlights. Seal Harbor and Bar Harbor also appear darker in our map because we had fewer readings in their most built-up streets. The Mt. Desert Island High School, while still excessively lit with unshielded parking lot lighting, shows up less on our map. This is because of our high point density,

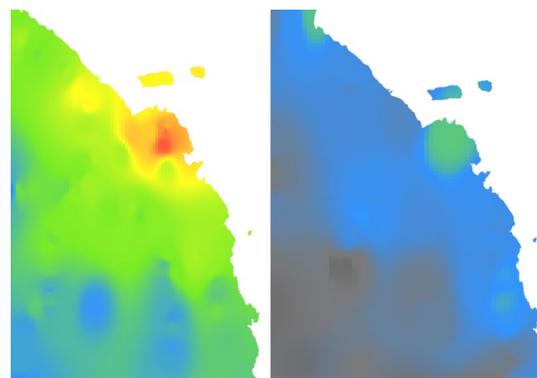


Figure 11: Bar Harbor simulation of lights turned off (right) vs normal (left)

There were multiple power outages in Bar Harbor during July, but only one of them occurred during our dark sky window. By using this data, we were able to extrapolate what would happen if Bar Harbor turned off all of its lights in Figure 11.

While not useful for creating the map, it was interesting to observe the effect of the moon on the brightness of the night sky, as can easily be seen in Figure 12, which used the same camera settings, and was taken about 2 hours apart. The College of the Atlantic campus dropped from about 20.8 to 18.7, over 200% brighter. The Moon completely washed out the Milky Way almost everywhere, including Sand Beach.



Figure 12: The same location with the moon up (right) and down (left)

4.2 Promote: Educational Evaluation and Community Outreach

Promoting the night sky is vital for its preservation. The team researched the preexisting programs by contacting park officials John Kelly, Kirk Lurvey and Michael Marion. The team found that Acadia offered one interpretive program hosted multiple nights per week in the summer months, and monthly star gazing parties held throughout the park.

4.2.1 Interpretive Programs

Educational and interpretive programs serve to promote appreciation and knowledge of the night sky. Acadia offers many different ranger led programs for people of all ages. In spite of this, only a few of the available programs deal directly with the night sky. These night sky programs are Stars Over Sand Beach, and star-gazing parties. The team attended several of those



Figure 13: Ranger Kirk pointing out Saturn at Stars over Sand Beach

4.2.1.1 Stars Over Sand Beach

Stars Over Sand Beach (SOSB) is a family friendly introduction to the beautiful skies of Acadia. This program is held a few times in June and twice weekly in the months of July and August. From 9 to 10 pm, young and old alike “sit back and learn about Acadia’s night sky” (National Park Service, 2014). The dark rangers point out constellations and enthrall the audience as they take them back through space and time with epic tales from Greek mythology.

The team attended four SOSB Programs. The first was to experience the program as tourists. At the second program, the team took a timelapse and individual photographs of the event and initiated contact with Kirk Lurvey, the ranger in charge that night.

The team met with Ranger Kirk twice to discuss the program and its potential to educate the public about the dangers of light pollution.

The team returned twice more, again as visitors, to enjoy the guided journey through the night sky. At the fourth SOSB program, the team was delighted to discover that Ranger Kirk had already begun to implement our suggestions. The short segment enhanced the experience and educational value to visitors and was very well received.

4.2.1.2 Stargazing Parties

Acadia National Park host star gazing parties throughout the park every few weeks. The team learned that these are co-hosted by an outside organization, the Acadia Astronomical Society (AAS). This organizations works to promote and protect Acadia’s night sky. Many of the rangers on the Acadia Night Sky Initiative Team are also active members of the AAS. One such person is Ranger Michael Marion; VP of AAS and Chief Ranger in charge of SOSB. These dedicated individuals strengthen the



Figure 14: Telescopes at a stargazing party near Seawall

community's connection to Acadia and its beautiful dark skies.

The team attended two of these stargazing parties. These events each featured three to five high powered telescopes. These telescopes allowed attendees to glimpse planets, stars, and even distant galaxies. Visitors left these star parties with renewed awe of the vastness of space and a deeper appreciation for the night sky. These experiences can serve to solidify the reality of what is being lost every time someone flicks on an unshielded light.

4.2.2 Community Outreach

These interpretive programs, though wonderfully informative and inspiring, are unable to educate most of the public surrounding Acadia. Engaging visitors in the community requires advertising events to the public in accessible and enticing way. Community outreach can include events such as Stars Over Sand Beach or large scaled festivals such as the Acadia Night Sky Festival. Other forms of outreach can include creating an internet presence for Acadia's night sky.

The Acadia website's night sky link redirects directly to the National Park's night sky page. None of Acadia's many wonderful dark sky programs are featured on the park's website. The team addressed this problem by creating content for an Acadia specific night sky webpage. The webpage consolidates the information on Acadia's night sky programs into one easy to find location, and combines it with breathtaking dark sky images, an educational video, and facts about Acadia and its skies.

4.2.2.1 Acadia Night Sky Festival

In 2008, Acadia created its Night Sky Initiative. Acadia, in conjunction with the Bar Harbor Chamber of Commerce, Friends of Acadia, Acadia Astronomical Society, Jackson Laboratory, and other key community businesses and organizations, created the Acadia Night Sky Festival. This festival attracts people from all over the world to celebrate the night sky on the darkest spot on the east coast of United States.

People come to to the Night Sky Festival for the many night sky based activities such as famous keynote speakers, informative seminars, space related movies, solar observations and various workshops. The highlight of the festival are the two very large star gazing parties held at Seawall Picnic Area and Cadillac Mountain. For that night the park closes Cadillac Mountain roadway and the public is bussed up. There were 1,000 visitors and had 35 telescopes. This year it is expected to have 50 telescopes and they expect over 1,000 visitors. The goal of the festival is to encourage the public to understand the importance of the night sky and to make them aware of how it can be preserved.

As previously mentioned, the Night Sky Festival is held only in the fall. Therefore the team was unable to experience the event first hand. However, the team met with various chairmen of the Acadia Night Sky Festival committee to discuss the events and programs and how the festival has grown over the past six years.

4.2.2.2 Website

Acadia can further promote its night sky through online resources. In being a National Park, it is very important for Acadia to have a website so that potential visitors of the park can access it and learn more about what the park has to offer. Currently Acadia does not have a night sky page on its website, the park only has a link to the NPS night sky page. The team determined that an Acadia specific page concerning the night sky is vital for its promotion. The NPS restricts the features and formats that can be used on Acadia's website. Therefore, the team was unable to completely design the format of the page. However, the team created Acadia specific content for the park to develop their night sky webpage. (see website content on Appendix E: Website Content)

This website will feature pictures of the night sky taken by the team, as well as content on the different aspects regarding the night sky. This content includes information on the different night sky programs that Acadia offers such as any stargazing parties, Stars Over Sand Beach, and the Night Sky Festival. The website will also touch on what light pollution is and how it can be fixed and/or prevented. The team also created an Acadia specific night sky promotional video that will be displayed on the website. (for storyboard, see Appendix D: Final Storyboard) The goal of the website is to provide helpful information relating to the night sky for the public to view. Although the video, pictures, and content were given to the National Park, the web page has yet to go live.

4.3 Protect

One of Acadia's most breathtaking view is of the starry night sky and that is why protecting it is vital. "Unlike many resource management challenges at Acadia National Park, light pollution is a relatively easy problem to fix, and the natural dark sky is 100% recoverable." The loss of this beauty would truly be tragic as the Milky Way, Earth's home galaxy, can be seen by visitors. Two-thirds of Americans are unable to see the Milky Way. The team researched and made recommendations for the numerous ways Acadia might protect the starry night sky. This section is broken down into international, national and local.

4.3.1 International

To improve the dark night sky in Acadia and prevent further impacts of light pollution, Acadia can become recognized as an International Dark Sky Park. The team conducted a feasibility

study through researching the guidelines and requirements of becoming an International Dark Sky Park. The team provided Acadia with an overview of what requirements there are and what Acadia would need to achieve them or what Acadia has already achieved. The requirements included light management plan, educational programs, sky quality analysis and other little requirements. This document can be found in Appendix F: Acadia IDA Overview. The team also provided a synopsis of the application process along with an alternative for the park to apply for a provisional status that would give the park more time to reach some requirements before obtaining a full time status. This would allow the park to receive recognition as an International Dark Sky Park sooner.

4.3.2 National

The team collected information from the Acadia Night Sky Initiative and articles that have been written on the Acadia Night Sky. Acadia's Night Sky Initiative should be followed as an excellent model of point 28 Starry Starry Night. The Night Sky Initiative shows the park's collaboration with communities surrounding the park and other agencies and organizations. Acadia needs to consolidate all of the information pertaining to the initiative into an organized and easily accessible archive. Such an archive would allow for public access to see the sky quality analyses from College of the Atlantic 2007, Island Astronomy Institute 2008, and WPI 2013 and 2014. This archival data base can be hosted on the park's server or in hard copies in park offices.

4.3.3 Local

At the local level Acadia can protect its night sky through inventorying lights, continuing to change light fixtures, develop plans for managing the lights and working with surrounding towns to implement dark sky ordinances and educate the public on the harms of light pollution. The biggest steps Acadia can take in protecting the night sky is by changing its light fixtures and set examples for communities to follow. The team concluded that there should be a more current lighting inventory and a light management plan created. The lighting inventory must be done thoroughly throughout the park and include SERC, the campground installments and to park take out any broken unused light fixtures. Examples of a lighting inventory and light management plan can be found in the IDA overview.

Another way to protect the night sky is through enacting dark sky or outdoor lighting ordinances into the town's land use ordinance. The team researched various town ordinances that have enacted light specific restraints and found ones for Bar Harbor, Southwest Harbor and Town of Mount Desert. These can be viewed in Appendix G: Ordinances. It is important to document such ordinances and ensure they are being abided by.

The team meet with the president of the Acadia Astronomical Society to brainstorm how to go about re-engaging the public in protecting the night sky and why the lighting ordinance is so important. The team created a presentation on our research and analyzed the importance of night sky ordinances and how to keep the public of Bar Harbor engaged with the night sky (the preparation notes can be seen in Appendix J: AAS Preperation). The presentation was given Wednesday July, 9th in the Jesup Memorial Library in Bar Harbor to the AAS President, Secretary, IDA member, several Mount Desert Island residents, park official and visitors to Acadia (the presentation can be found in Appendix I: AAS Presentation). The feedback of this presentation was positive by having open discussion and questions from the audience. From the meeting came recommendations for how to keep the public engaged and how best to protect the night sky.

Chapter 5: Recommendations

We recommend that future groups continue monitoring the light pollution across the island and Schoodic, especially at Blackwoods, Seawall, and the new campgrounds on Schoodic. A full survey should be done at a minimum of every 3 years, and less comprehensive surveys can be done in the intervening years. This would enable high-quality year-by-year comparison to see where sky quality is improving, deteriorating, or remaining at relatively constant levels. Ideally, the teams conducting the sky quality analysis would obtain a small sample of readings at quarter mile or half mile intervals along the major roads on Mt. Desert Island and Schoodic (adjusting the intervals to ensure that no readings are taken under or near tree cover). The less rigorous sky quality analyses conducted in the off years could also focus on one or two specific regions for more detailed study. Here are some examples of focus areas for future studies:

- Including Isle Au Haut and other outlying islands that are part of Acadia
- Taking readings on Eagle Lake or Jordan Pond from a canoe or kayak
- Including several peaks or other clearings that are not accessible by road

We also suggest that future groups investigate the feasibility of using other equipment such as CCD cameras or DSLR's to determine where the light pollution is coming from, similar to the IAI's 2008 study. It would also be interesting to embed several SQM-LU-DL's or SQM-LE's (in protective coverings) in various locations across the park for year-round data collection. This would provide a low maintenance supplement to the more detailed summer maps produced by WPI teams.

Future studies should have their equipment calibrated a month or so prior to Acadia's annual sky quality analysis, with a possible re-calibration after all the data has been collected. Future studies should also calculate and correct for the actual formula of the milky way passing over the lognormal sensor in the SQMs (instead of a piecewise approximation) for more accurate data analysis.

We recommend that the park expands the scope of the Stars Over Sand Beach program. We believe it is important to continue to discuss light pollution, its harmful effects, and what can be done about it. Another recommendation is to develop a companion program to SOSB that delves into more advanced topics. This could attract a different selection of people and also provide a way for people who enjoyed SOSB to learn more in an equally interactive and engaging manner.

We also suggest for Acadia and the 2015 Dark Sky team to investigate the IDA's SOS program. Implementing the SOS program could provide a wonderful supplement to Acadia's existing educational programs while bolstering Acadia's bid to become an International Dark Sky Park.

We also encourage Acadia to consider converting the abandoned Fire Tower (Figure 15) on top of Beech Mountain into an astronomy observation tower. An observation tower in Acadia would provide a dedicated place, for astronomers and the general public, to view the night sky.

Our final recommendation is for Acadia to initiate the IDA application process as soon as possible. Even though Acadia does not yet have the required percentage of dark sky compliant lighting or a specific lighting reform plan, Acadia should open the channels of communication with the IDA. The IDA has the resources to guide Acadia through the application process. With their help, Acadia should be able to become an International Dark Sky Park within the next few years



Figure 15: Beech Mountain fire tower

Chapter 6: Conclusion

The team not only expanded the 2013 WPI Study, but also made it our mission to address the entire Night Sky Initiative. The team focused on measuring, promoting, and protecting the night sky of Acadia. Our map of Mount Desert Island and Schoodic Peninsula is the most accurate sky quality map of Acadia to date. The team also created content for an Acadia specific night sky webpage including our night sky promotional video. This will be used to further promote Acadia's Night Sky. The team reviewed the IDA guidelines and requirements for becoming an International Dark Sky Park and found it feasible for the park to become an IDSP with provisional status now, or a full park in two to three years time. The fundamental goals, to address light pollution by collecting vital data and increasing awareness, were achieved. Our project actually made a tangible difference to Acadia's night sky protection & promotion efforts by helping shape education reform.

Technical Report 1: Androidmedae

Abstract

This document shows how to use Androidmedae, our data collection app, and how it works internally.

Requirements

Androidmedae requires a device running Android 4.3 (API 18) or later. It must be able to act as a USB host (either with a USB-A female or micro USB female that supports OTG). Positioning requires an actual GPS on the device, as well as magnetic and accelerometer sensors. Most Android 4.0+ phones have all 3 built in. Building the app from source requires Android Studio (currently using the release from around May 2014), or enough know-how to do it manually.

Using

Androidmedae is relatively simple to operate. Plug in the SQM via a USB-OTG cable to the Android device. On most systems, this should identify Androidmedae as able to handle the device. If not, open Androidmedae manually. The FTDI Android serial driver contains a bug that can cause Androidmedae to crash if it is already open when the SQM is attached; simply re-open the app. If the Lat/Lon text at the top is red, GPS is disabled. Make sure the GPS is enabled, and it is recommended to put the device in airplane mode to disable wifi and cell reception in order to conserve battery power. Once the app recognizes the SQM, it will display the device ID above the large button, and start displaying the sensor's readings every second. Note that in dark locations, the time to acquire about 3-5 seconds. See the 3rd line of the app for the time to acquire. Affix the device to the SQM so the sensor is pointing out the

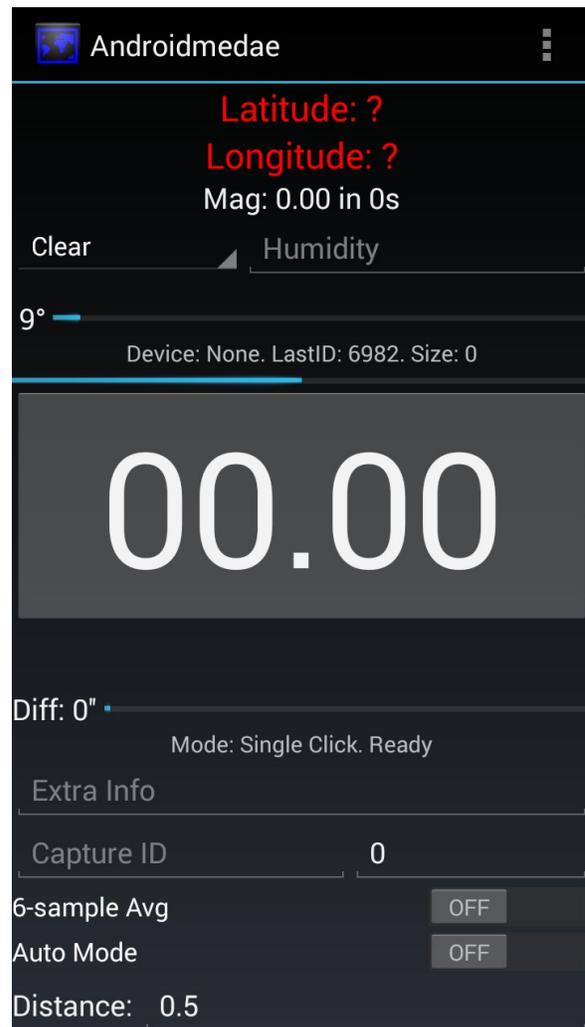


Figure 16: Screenshot of Androidmedae

top while still enabling the tripod to be mounted to the back of the SQM. Point the SQM/device combo up at the zenith, and the face of the large button should turn black from red. The button turns red when the top of the Android device is more than 10 degrees off the zenith to assist in pointing the device straight up. Weather (Defaulting to clear) and humidity are also logged after manual input. The default mode is single reading. Tap the button to take a reading. It will increase the size and LastID fields above the big button. LastID is a ID that is specific to the android device and the current capture ID. It is randomized to minimize collisions, but collisions will happen in the LastID field. LastID is meant to be an easy way to record accidental bad data points, although we didn't use it very much. The Diff meter below the big button shows the difference in arcseconds traveled across the surface of the earth between the last recorded location, and the current location. Extra info is an arbitrary text field for notes. Data can be partitioned into arbitrary datasets with the capture ID and subset fields. The 6 sample average is broken and we determined that it was not worth it to fix; averaging was done post-recording. Do not use the 6 sample average mode, unless you feel like fixing it yourself. Auto mode works, and records values when the diff gets above the specified distance, also in arcseconds. All data is saved to /sdcard/test.csv, and can be uploaded to pre-determined servers by going to menu > Upload. The dialog box shows the output of that web page.

Using the upload-csv.php script on bottle.cs.wpi.edu, the dialog shows the upload ID, upload filename, and how many records were processed. Any errors are also shown, the most common being missing capture ID's. This enables manually fixing the CSV file by the upload filename.

Code

The code is relatively simple data-logging application. It is clocked off of multiple sources: GPS status, touches/UI, orientation sensor updates, and SQM responses. Data points are only logged via the GPS clock in auto mode, or on touches in single mode. The orientation sensor and SQM updates are saved in variables for the logging to access. The SQM thread is timed to request "ux" every second, but the reading thread is only synchronized by the responses. The first response is always a query of the SQM ID.

Listing: Collector.java

```
package edu.wpi.iqp.androidmedae;

import android.app.Activity;
import android.app.AlertDialog;
import android.content.BroadcastReceiver;
import android.content.Context;
import android.content.DialogInterface;
import android.content.Intent;
```

```

import android.content.IntentFilter;
import android.graphics.Color;
import android.graphics.drawable.Drawable;
import android.hardware.Sensor;
import android.hardware.SensorEvent;
import android.hardware.SensorEventListener;
import android.hardware.SensorManager;
import android.hardware.usb.UsbManager;
import android.location.Location;
import android.location.LocationListener;
import android.location.LocationManager;
import android.os.Bundle;
import android.os.Environment;
import android.os.Handler;
import android.provider.Settings;
import android.util.Log;
import android.view.Menu;
import android.view.MenuItem;
import android.view.View;
import android.widget.Button;
import android.widget.EditText;
import android.widget.ProgressBar;
import android.widget.Spinner;
import android.widget.Switch;
import android.widget.TextView;
import android.widget.Toast;

import com.physicaloid.lib.Physicaloid;
import com.physicaloid.lib.usb.driver.uart.UartConfig;

import java.io.File;
import java.io.FileNotFoundException;
import java.io.FileOutputStream;
import java.io.FileReader;
import java.io.IOException;
import java.io.LineNumberReader;
import java.io.OutputStreamWriter;

public class Collector extends Activity implements SensorEventListener
{
    private static final String tag = "Androidmedat";
    BroadcastReceiver usbReceiver = new BroadcastReceiver()
    {
        @Override
        public void onReceive(Context context, Intent intent)
        {
            String action = intent.getAction();

            if (UsbManager.ACTION_USB_DEVICE_ATTACHED.equals(action))
            {
                if (!serial.isOpened())
                    tryOpenSerial();
            }
            else if (UsbManager.ACTION_USB_DEVICE_DETACHED.equals(action))
            {
                disconnect();
            }
            else
                Log.d(tag, action);
        }
    };
    private static final int MODE_SINGLE = 0;
    private int mode = MODE_SINGLE;
    private static final int MODE_AUTO = 1;
    private static final int MODE_30 = 3;
    File f;
    int numSats = 0;
    String devID;
    int mode_id = 0;
    String connectedTo = "None";
    boolean connectedToID = false;
    Thread txThread = null;
    boolean gotRXID = false;
    int comIdd = 0;
    private LocationManager locationManager;
    private double lat = 0, longi = 0, altitude = 0, latLast = 0, lonLast = 0;
    private Physicaloid serial;
    private boolean serialStop = false;
    private boolean runningTxRxLoop = false, thirty_running = false;

```

```

private Runnable txLoop = new Runnable()
{
    private final byte[] ux = new byte[]{117, 120};
    private final byte[] L0 = new byte[]{105, 120};

    @Override
    public void run()
    {
        serial.write(L0);
        try
        {
            Thread.sleep(5000); //TODO: use semaphores & locks
            if (!gotRXID)
                serial.write(L0);
            Thread.sleep(1000);
        }
        catch (InterruptedException e)
        {
            e.printStackTrace();
        }
        while (runningTxRxLoop && !serialStop)
        {
            serial.write(ux);
            try
            {
                Thread.sleep(1000);
            }
            catch (InterruptedException e)
            {
                e.printStackTrace();
            }
        }
        runningTxRxLoop = false;
    }
};
private Runnable rxLoop = new Runnable()
{
    private StringBuffer buf = new StringBuffer();

    @Override
    public void run()
    {
        while (true)
        {
            byte[] rbuf = new byte[8196];
            int len = serial.read(rbuf);
            rbuf[len] = 0;
            if (len > 0)
            {
                String res = new String(rbuf).substring(0, len);
                buf.append(res);
                if ((len = buf.indexOf("\r\n")) != -1)
                {
                    if (!gotRXID)
                    {
                        if (len == 37 && buf.substring(0, 2).equals("i,"))
                        {
                            if (!gotRXID)
                                txThread.interrupt();
                            gotRXID = true;
                            connectedTo = buf.substring(29, 37);
                            connectedToID = true;
                            buf.delete(0, len + 2);
                            handler.post(new Runnable()
                            {
                                @Override
                                public void run()
                                {
                                    updateConnIDStatus();
                                }
                            });
                        }
                    }
                    else
                    {
                        if (len != 55)
                            Log.d(tag, "length is " + len + " for: " + res);
                        updateMagValue(buf.substring(0, len));
                    }
                }
            }
        }
    }
};

```

```

        buf.delete(0, len + 2);
    }
}
}
if (serialStop || !runningTxRxLoop)
{
    runningTxRxLoop = false;
    buf = new StringBuffer();
    return;
}
}
};
private Handler handler = new Handler();
private TextView latText;
private TextView longText;
private TextView magText;
private SensorManager mSensorManager;
private float[] grav = null, accel = null;
private float lastAccuracy;
private float[] ORvalues;
private int rid = 0, sizeFF;
private Drawable drw;
private Button buttonn;
private ProgressBar diffValue;
private TextView distanceLast;
private EditText autoDistanceEdit;
private ProgressBar saveProgress;
private TextView txv;
private ProgressBar zenithOf;
private Switch sw, E0;
private TextView ModeStatus;
private TextView zenithOffText;
private double thirty_totals;
private int thirty_count;
private String magString = "X, 00.00m,0000000000Hz,0000000000c,0000000.000s, 000.00C";

@Override
protected void onCreate(Bundle savedInstanceState)
{
    super.onCreate(savedInstanceState);
    setContentView(R.layout.fragment_collector);
    this.buttonn = (Button) findViewById(R.id.buttonn);
    drw = buttonn.getBackground();
    latText = ((TextView) findViewById(R.id.latitude));
    longText = ((TextView) findViewById(R.id.longitude));
    diffValue = ((ProgressBar) findViewById(R.id.diffValue));
    distanceLast = ((TextView) findViewById(R.id.distanceLast));
    autoDistanceEdit = ((EditText) findViewById(R.id.autoDistanceEdit));
    saveProgress = ((ProgressBar) findViewById(R.id.saveProgress));
    txv = ((TextView) findViewById(R.id.DeviceStatus));
    magText = (TextView) findViewById(R.id.mags);
    zenithOf = ((ProgressBar) findViewById(R.id.zenithOf));
    ModeStatus = ((TextView) findViewById(R.id.ModeStatus));
    sw = ((Switch) findViewById(R.id.autoMode));
    E0 = ((Switch) findViewById(R.id.avg30));
    zenithOffText = ((TextView) findViewById(R.id.zenithOff));

    rid = (int) Math.round(Math.random() * 10000);
    devID = Settings.Secure.getString(getContentResolver(), Settings.Secure.ANDROID_ID);
    f = new File(Environment.getExternalStorageDirectory().getAbsolutePath(), "test.csv");
    LineNumberReader lnr;
    try
    {
        lnr = new LineNumberReader(new FileReader(f));
        try
        {
            lnr.skip(Long.MAX_VALUE);
            sizeFF = lnr.getLineNumber() + 1;
        }
        catch (IOException e)
        {
            e.printStackTrace();
        }
        try
        {
            lnr.close();
        }
        catch (IOException e)
        {
            e.printStackTrace();
        }
    }
}

```

```

    }
}
catch (FileNotFoundException e)
{
    sizeFF = 0;
}

magText = ((TextView) findViewById(R.id.mags));
locationManager = (LocationManager) getSystemService(Context.LOCATION_SERVICE);
locationManager.requestLocationUpdates(LocationManager.GPS_PROVIDER, 2000, 1, new LocationListener()
{
    @Override
    public void onLocationChanged(Location location)
    {
        boolean changed = false;
        if (lat != location.getLatitude())
        {
            lat = location.getLatitude();
            if (latLast == 0)
                latLast = lat;
            int h = (int) lat;
            int m = Math.abs((int) ((lat - h) * 60));
            double s = Math.abs(((Math.abs(lat - h) - m / 60.0) * 60) * 60);
            latText.setText(String.format("Lat: %d° %d' %.2f\"", h, m, s));
            changed = true;
        }
        if (longi != location.getLongitude())
        {
            longi = location.getLongitude();
            if (lonLast == 0)
                lonLast = longi;
            int h = (int) longi;
            int m = Math.abs((int) ((longi - h) * 60));
            double s = Math.abs(((Math.abs(longi - h) - m / 60.0) * 60) * 60);
            longText.setText(String.format("Long: %d° %d' %.2f\"", h, m, s));
            changed = true;
        }
        altiitude = location.getAltitude();
        lastAccuracy = location.getAccuracy();
        numSats = location.getExtras().getInt("satellites");
        if (changed)
        {
            gpsChanged();
        }
    }
});

@Override
public void onStatusChanged(String s, int i, Bundle bundle)
{
    //no-op
}

@Override
public void onProviderEnabled(String s)
{
    latText.setTextColor(Color.WHITE);
    longText.setTextColor(Color.WHITE);
}

@Override
public void onProviderDisabled(String s)
{
    latText.setTextColor(Color.RED);
    longText.setTextColor(Color.RED);
}
});

mSensorManager = (SensorManager) getSystemService(SENSOR_SERVICE);

serial = new Physicaloid(this);
IntentFilter filter = new IntentFilter();
filter.addAction(UsbManager.ACTION_USB_DEVICE_ATTACHED);
filter.addAction(UsbManager.ACTION_USB_DEVICE_DETACHED);
registerReceiver(usbReciever, filter);
tryOpenSerial();
}

private void gpsChanged()
{
    double dist = Math.hypot(latLast - lat, longi - lonLast) * 360000.0;
}

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diffValue.setProgress((int) Math.round(dist));
distanceLast.setText("Diff: " + Math.round(dist) / 100.0 + " " );

if (mode == MODE_AUTO)
{
    double off = Double.parseDouble(autoDistanceEdit.getText().toString());

    if ((dist / 100.0) > off)
    {
        logdata();
        mode_id++;
    }
}

private void thirtyCollect(String latest)
{
    thirty_count++;
    thirty_totals += Double.parseDouble(latest);
    if (thirty_totals >= 6)
    {
        String backup = magString;

        String mss = String.format("u, %.2f%s", thirty_totals / 6.0, magString.substring(10));
        magString = mss;
        logdata();
        magString = backup;
        thirty_totals = 0;
        thirty_count = 0;
        thirty_running = false;
    }
    saveProgress.setProgress(thirty_count * 16);
    buttonn.setEnabled(true);
}

protected void onResume()
{
    super.onResume();
    mSensorManager.registerListener(this, mSensorManager.getDefaultSensor(Sensor.TYPE_ACCELEROMETER),
    SensorManager.SENSOR_DELAY_NORMAL);
    mSensorManager.registerListener(this, mSensorManager.getDefaultSensor(Sensor.TYPE_MAGNETIC_FIELD),
    SensorManager.SENSOR_DELAY_NORMAL);
}

protected void onPause()
{
    super.onPause();
    mSensorManager.unregisterListener(this);
}

private void tryOpenSerial()
{
    if (!serial.isOpened())
    {
        if (!serial.open())
        {
            Toast.makeText(this, "Can't open device", Toast.LENGTH_SHORT).show();
            connectedTo = "None";
            connectedToID = false;
            updateConnIDStatus();
            return;
        }
        else
        {
            serial.setConfig(new UartConfig(115200, UartConfig.DATA_BITS8, UartConfig.STOP_BITS1,
            UartConfig.PARITY_NONE, false, false));
            Toast.makeText(this, "Connected", Toast.LENGTH_SHORT).show();
            connectedTo = "Querying...";
            connectedToID = false;
            updateConnIDStatus();
        }
    }
    if (!runningTxRxLoop)
        startTxRxLoop();
}

private void updateConnIDStatus()
{
    if (txv != null)
        txv.setText("Device: " + connectedTo + ". LastID: " + Integer.toString(rid) + ". Size: " +

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sizeFF);
}

private void startTxRxLoop()
{
    if (runningTxRxLoop)
        return;
    serialStop = false;
    runningTxRxLoop = true;
    gotRXID = false;
    new Thread(rxLoop).start();
    txThread = new Thread(txLoop);
    txThread.start();
}

private void updateMagValue(final String full)
{
    handler.post(new Runnable()
    {
        @Override
        public void run()
        {
            if (magString != full)
            {
                magString = full;
                String mss = magString.substring(2, 8);
                magText.setText("Mag:" + mss + " in " + magString.substring(40, 46) + "s");
                buttonn.setText(mss);
                if (mode == MODE_SINGLE)
                    buttonn.setEnabled(true);
                else if (mode == MODE_30 && thirty_running)
                    thirtyCollect(mss);
            }
        }
    });
}

@Override
protected void onNewIntent(Intent intent)
{
    tryOpenSerial();
}

private void disconnect()
{
    serialStop = true;
    serial.close();
    updateMagValue("x, 00.00m,0000000000Hz,0000000000c,0000000.000s, 000.00C");
    connectedTo = "None";
    connectedToID = false;
    updateConnIDStatus();
    Toast.makeText(this, "Disconnected from USB", Toast.LENGTH_SHORT).show();
}

@Override
protected void onDestroy()
{
    serialStop = true;
    serial.close();
    serial = new Physicaloid(this);
    unregisterReceiver(usbReceiver);
    super.onDestroy();
}

public void autoSwap(View view)
{
    int tmp = (sw.isChecked() ? 1 : 0);
    tmp += E0.isChecked() ? 2 : 0;
    switch (tmp)
    {
        case 0:
            mode = MODE_SINGLE;
            break;
        case 1:
            mode = MODE_AUTO;
            break;
        case 2:
            mode = MODE_30;
            break;
        default:
            if (view == sw)
    }
}

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        {
            mode = MODE_AUTO;
            E0.setChecked(false);
        }
        else
        {
            mode = MODE_30;
            sw.setChecked(false);
        }
    }
    mode_id = 0;
    thirty_running = false;
    thirty_count = 0;
    thirty_totals = 0;
    if (mode == MODE_SINGLE)
    {
        saveProgress.setProgress(0);
        ModeStatus.setText("Single Mode. Ready");
        buttonn.setEnabled(true);
    }
    else if (mode == MODE_AUTO)
    {
        saveProgress.setProgress(100);
        ModeStatus.setText("GPS Radius mode. Ready");
        buttonn.setEnabled(false);
    }
    else if (mode == MODE_30)
    {
        saveProgress.setProgress(0);
        ModeStatus.setText("Average mode. Ready");
        buttonn.setEnabled(true);
    }
}

public void onClickz(View view)
{
    if (mode == MODE_30)
    {
        thirty_running = false;
        thirty_count = 0;
        thirty_totals = 0;
        buttonn.setEnabled(false);
    }
    else if (mode == MODE_SINGLE)
    {
        logdata();
        saveProgress.setProgress(0);
    }
}

public void logdata()
{
    try
    {
        FileOutputStream fo = new FileOutputStream(f, true);
        OutputStreamWriter osw = new OutputStreamWriter(fo);
        //milis time, lat, long, altitude, accuracy, #satellites, [ur, magnitude, hz, count, time, temp],
        [azimuth[0], zenithOffset[1], tilt[2]], weather, capture set, subset, microset, notes, SQM_id, localID,
        phoneID, mode, mode_id, auto_density/last_distance, 2,3(dataversion.app version)
        osw.write(String.format("%d,%s,%s,%s,%f,%d,%s,%s,%s,%s,%s,%s,%s,%s,%d,%s,%d,%d,%s,%s,3,4\n",
            System.currentTimeMillis(),
            Double.toString(latLast = lat),
            Double.toString(lonLast = longi),
            Double.toString(altiotude),
            lastAccuracy,
            numSats,
            magString,
            valuate(ORvalues),
            ((Spinner) findViewById(R.id.weather)).getSelectedItem().toString(),
            ((EditText) findViewById(R.id.captureSet)).getText(),
            ((EditText) findViewById(R.id.subsectionID)).getText(),
            "0", //microset
            ((EditText) findViewById(R.id.notes)).getText(),
            (connectedToID ? connectedTo : "None"),
            rid++,
            devID,
            mode,
            mode_id,
            ((EditText) findViewById(R.id.autoDistanceEdit)).getText(),
            ((EditText) findViewById(R.id.humid)).getText()
        ));
    }
}

```

```

        sizeFF++;
        updateConnIDStatus();
        osw.close();
        fo.close();
        buttonn.setEnabled(false);
        latLast = lat;
        lonLast = longi;
        gpsChanged();
    }
    catch (IOException e)
    {
        e.printStackTrace();
        Toast.makeText(Collector.this, e.toString(), Toast.LENGTH_LONG).show();
    }
}

public String valuate(float[] s)
{
    int k = s.length;
    if (k == 0)
    {
        return "";
    }
    StringBuilder out = new StringBuilder();
    out.append(Double.toString(s[0]));
    for (int x = 1; x < k; ++x)
    {
        out.append(",").append(Double.toString(s[x]));
    }
    return out.toString();
}

@Override
public boolean onCreateOptionsMenu(Menu menu)
{
    // Inflate the menu; this adds items to the action bar if it is present.
    getMenuInflater().inflate(R.menu.collector, menu);
    return true;
}

@Override
public boolean onOptionsItemSelected(MenuItem item)
{
    // Handle action bar item clicks here. The action bar will
    // automatically handle clicks on the Home/Up button, so long
    // as you specify a parent activity in AndroidManifest.xml.
    int id = item.getItemId();
    if (id == R.id.action_delete)
    {
        AlertDialog.Builder builder = new AlertDialog.Builder(this);

        builder.setMessage("All data not uploaded will be lost");

        builder.setPositiveButton("Delete", new DialogInterface.OnClickListener()
        {
            @Override
            public void onClick(DialogInterface dialogInterface, int i)
            {
                dialogInterface.dismiss();
                f.delete();
                sizeFF = 0;
                updateConnIDStatus();
            }
        });

        builder.setNegativeButton("Cancel", new DialogInterface.OnClickListener()
        {
            @Override
            public void onClick(DialogInterface dialogInterface, int i)
            {
                dialogInterface.dismiss();
            }
        });

        AlertDialog dialog = builder.create();
        dialog.show();
        return true;
    }
    else if (id == R.id.action_upload)
    {

```

```

        new Uploader(this).execute(f);
        LineNumberReader lnr;
        try
        {
            lnr = new LineNumberReader(new FileReader(f));
            try
            {
                lnr.skip(Long.MAX_VALUE);
                sizeFF = lnr.getLineNumber() + 1;
            }
            catch (IOException e)
            {
                e.printStackTrace();
            }
            try
            {
                lnr.close();
            }
            catch (IOException e)
            {
                e.printStackTrace();
            }
        }
        catch (FileNotFoundException e)
        {
            sizeFF = 0;
        }
        updateConnIDStatus();
        return true;
    }
    return super.onOptionsItemSelected(item);
}

@Override
public void onSensorChanged(SensorEvent sensorEvent)
{
    if (sensorEvent.sensor.getType() == Sensor.TYPE_MAGNETIC_FIELD)
        grav = sensorEvent.values;
    else if (sensorEvent.sensor.getType() == Sensor.TYPE_ACCELEROMETER)
        accel = sensorEvent.values;
    if (grav != null && accel != null)
    {
        float[] Rr = new float[9];
        float[] values = new float[3];
        SensorManager.getRotationMatrix(Rr, null, accel, grav);
        SensorManager.getOrientation(Rr, values);
        zenithOf.setProgress((int) Math.round(values[1] * 180 / Math.PI) + 90);
        zenithOf.setText(" " + zenithOf.getProgress() + "° ");
        zenithOf.setBackgroundColor((Math.abs(zenithOf.getProgress()) < 10) ?
getResources().getColor(android.R.color.transparent) :
getResources().getColor(android.R.color.holo_orange_dark));
        if (Math.abs(zenithOf.getProgress()) < 10)
            buttonn.setBackground(drw);
        else
            buttonn.setBackgroundResource(android.R.color.holo_red_dark);
        ORvalues = values;
        Log.d("AndroidmedaeTagCSV", String.format("%f,%f,%f", values[0], values[1], values[2]));
    }
}

@Override
public void onAccuracyChanged(Sensor sensor, int i)
{
    Log.d(tag, "Sensor changed accuracy!" + i + sensor.toString());
}
}

```

Listing: Uploader.java

```

package edu.wpi.iqp.androidmedae;

import android.app.AlertDialog;
import android.app.ProgressDialog;
import android.content.Context;
import android.content.DialogInterface;
import android.os.AsyncTask;

import java.io.DataInputStream;
import java.io.DataOutputStream;

```

```

import java.io.File;
import java.io.FileInputStream;
import java.io.FileNotFoundException;
import java.io.InputStream;
import java.net.HttpURLConnection;
import java.net.URL;
import java.util.Scanner;

/**
 * Created by patrick on 6/11/14.
 */
public class Uploader extends AsyncTask<File, Integer, String>
{
    private final Context parent;
    ProgressDialog pd;
    boolean fnf = false;

    public Uploader(Context parent)
    {
        this.parent = parent;
    }

    static String convertStreamToString(InputStream is)
    {
        Scanner s = new Scanner(is).useDelimiter("\\A");
        return s.hasNext() ? s.next() : "";
    }

    public static void alert(Context ctx, String message)
    {
        AlertDialog.Builder builder = new AlertDialog.Builder(ctx);

        builder.setMessage(message);

        builder.setPositiveButton("OK", new DialogInterface.OnClickListener()
        {
            @Override
            public void onClick(DialogInterface dialogInterface, int i)
            {
                dialogInterface.dismiss();
            }
        });

        AlertDialog dialog = builder.create();
        dialog.show();
    }

    @Override
    protected void onPreExecute()
    {
        super.onPreExecute();
        pd = ProgressDialog.show(parent, "Uploading Data", "Connecting to bortle...", false);
    }

    @Override
    protected void onProgressUpdate(Integer... values)
    {
        super.onProgressUpdate(values);

        pd.setMessage("Collected data is now being uploaded...");
        pd.setMax(values[0]);
    }

    @Override
    protected String doInBackground(File... objects)
    {
        File f = objects[0];

        HttpURLConnection connection = null;
        DataOutputStream outputStream = null;
        DataInputStream inputStream = null;
        String urlServer = "https://bortle.cs.wpi.edu/upload-csv.php";
        String lineEnd = "\r\n";
        String twoHyphens = "--";
        String boundary = "e9ec721c24f6d8ff7167af7fd129db7d0e6cb4c6";

        int bytesRead, bytesAvailable, bufferSize;
        byte[] buffer;
        int maxBufferSize = 1 * 1024 * 1024;
    }
}

```

```

try
{
    FileInputStream fileInputStream = new FileInputStream(f);

    URL url = new URL(urlServer);
    connection = (URLConnection) url.openConnection();

    // Allow Inputs & Outputs.
    connection.setDoInput(true);
    connection.setDoOutput(true);
    connection.setUseCaches(false);

    // Set HTTP method to POST.
    connection.setRequestMethod("POST");

    connection.setRequestProperty("Content-Type", "multipart/form-data;boundary=" + boundary);

    outputStream = new DataOutputStream(connection.getOutputStream());
    outputStream.writeBytes(twoHyphens + boundary + lineEnd);
    outputStream.writeBytes("Content-Disposition: form-data; name=\"upload\";filename=\"data.csv\" " +
lineEnd);
    outputStream.writeBytes(lineEnd);

    bytesAvailable = fileInputStream.available();
    bufferSize = Math.min(bytesAvailable, maxBufferSize);
    buffer = new byte[bufferSize];
    publishProgress(bufferSize);
    int written = 0;
    // Read file
    bytesRead = fileInputStream.read(buffer, 0, bufferSize);

    while (bytesRead > 0)
    {
        outputStream.write(buffer, 0, bufferSize);
        publishProgress(written += bufferSize);
        bytesAvailable = fileInputStream.available();
        bufferSize = Math.min(bytesAvailable, maxBufferSize);
        bytesRead = fileInputStream.read(buffer, 0, bufferSize);
    }

    outputStream.writeBytes(lineEnd);
    outputStream.writeBytes(twoHyphens + boundary + twoHyphens + lineEnd);

    // Responses from the server (code and message)
    int serverResponseCode = connection.getResponseCode();
    String serverResponseMessage = connection.getResponseMessage();
    String dataRes = convertStreamToString(connection.getInputStream());
    fileInputStream.close();
    outputStream.flush();
    outputStream.close();
    if (serverResponseCode == 200 && dataRes.indexOf("Uploaded to ") != -1)
        f.delete();
    return "HTTP " + serverResponseCode + serverResponseMessage + "\n" + dataRes;
}
catch (FileNotFoundException ex)
{
    fnf = true;
}
catch (Exception ex)
{
    //Exception handling
    ex.printStackTrace();
}

return null;
}

@Override
protected void onPostExecute(String data)
{
    pd.dismiss();
    if (fnf)
        alert(parent, "No data exists to upload. Collect some data first.");
    else if (data != null)
        alert(parent, data);
}
}

```

```
}
```

Listing: fragment_collector.xml

```
<ScrollView
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:id="@+id/scrollView"
    xmlns:tools="http://schemas.android.com/tools"

    tools:context="edu.wpi.iqp.androidmedae.Collector"

    xmlns:android="http://schemas.android.com/apk/res/android">
    <LinearLayout
        android:orientation="vertical"
        android:layout_width="fill_parent"
        android:layout_height="fill_parent"
        >

        <TextView
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:textAppearance="@android:style/TextAppearance.Large"
            android:text="Latitude: ?"
            android:id="@+id/latitude"
            android:layout_gravity="center_horizontal"
            android:focusable="true"
            android:enabled="true"
            android:focusableInTouchMode="true" />

        <TextView
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:textAppearance="@android:style/TextAppearance.Large"
            android:text="Longitude: ?"
            android:id="@+id/longitude"
            android:layout_gravity="center_horizontal"
            android:focusable="true"
            android:focusableInTouchMode="true"
            android:enabled="true" />

            <TextView
                android:layout_width="wrap_content"
                android:layout_height="wrap_content"
                android:textAppearance="@android:style/TextAppearance.Medium"
                android:text="Mag: 0.00 in 0s"
                android:id="@+id/mags"
                android:layout_gravity="center_horizontal"
                android:focusable="true"
                android:enabled="true"
                android:focusableInTouchMode="true" />

            <LinearLayout
                android:orientation="horizontal"
                android:layout_width="match_parent"
                android:layout_height="wrap_content"
                android:layout_marginBottom="12dp">

                <Spinner
                    android:layout_width="wrap_content"
                    android:layout_height="wrap_content"
                    android:id="@+id/weather"
                    android:spinnerMode="dialog"
                    android:entries="@array/weather_array"
                    android:dropDownSelector="@android:style/Widget.Spinner.DropDown"
                    android:layout_weight="1"
                    />

                <EditText
                    android:layout_width="wrap_content"
                    android:layout_height="wrap_content"
                    android:inputType="number"
                    android:ems="10"
                    android:id="@+id/humid"
                    android:layout_weight="1"
                    android:layout_gravity="center_vertical"
                    android:hint="Humidity"/>
            </LinearLayout>

        </LinearLayout>
    </ScrollView>
```

```

        android:orientation="horizontal"
        android:layout_width="fill_parent"
        android:layout_height="wrap_content">

        <TextView
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:textAppearance="?android:attr/textAppearanceMedium"
            android:text="90°"
            android:id="@+id/zenithOff" />

        <ProgressBar
            style="@android:style/Widget.Holo.ProgressBar.Horizontal"
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:id="@+id/zenithOf"
            android:max="180"
            android:progress="90"
            android:indeterminate="false"
            android:indeterminateOnly="false"
            android:background="@android:color/holo_red_dark"
            android:clickable="true"
            android:layout_weight="1"
            android:layout_gravity="center_vertical" />

    </LinearLayout>

    <TextView
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:text="Device: Not Connected. Last ID: ?. Size: ?"
        android:id="@+id/DeviceStatus"
        android:layout_gravity="center_horizontal" />

    <ProgressBar
        style="?android:attr/progressBarStyleHorizontal"
        android:layout_width="fill_parent"
        android:layout_height="wrap_content"
        android:id="@+id/saveProgress"
        android:layout_gravity="center_horizontal"
        android:layout_marginBottom="-5dp"
        android:progress="50"
        android:indeterminate="false" />

    <Button
        android:layout_width="fill_parent"
        android:layout_height="wrap_content"
        android:text="00.00"
        android:id="@+id/buttonn"
        android:onClick="onClickz"
        android:focusable="false"
        android:layout_marginBottom="40dp"
        android:textSize="100dp"
    />

    <LinearLayout
        android:orientation="horizontal"
        android:layout_width="match_parent"
        android:layout_height="wrap_content"
        android:layout_gravity="center_horizontal">

        <TextView
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:textAppearance="?android:attr/textAppearanceMedium"
            android:text="Diff: 0' ' "
            android:id="@+id/distanceLast" />

        <ProgressBar
            style="?android:attr/progressBarStyleHorizontal"
            android:layout_width="fill_parent"
            android:layout_height="wrap_content"
            android:id="@+id/diffValue"
            android:layout_gravity="center_vertical"
            android:indeterminate="false"
            android:max="100"
            android:progress="1" />

    </LinearLayout>

    <TextView
        android:layout_width="wrap_content"

```

```

        android:layout_height="wrap_content"
        android:textAppearance="?android:attr/textAppearanceSmall"
        android:text="Mode: Single Click. Ready"
        android:id="@+id/ModeStatus"
        android:layout_gravity="center_horizontal" />

<EditText
    android:layout_width="match_parent"
    android:layout_height="wrap_content"
    android:id="@+id/notes"
    android:hint="Extra Info" />

<LinearLayout
    android:orientation="horizontal"
    android:layout_width="match_parent"
    android:layout_height="wrap_content"
    android:layout_gravity="center_horizontal">

    <EditText
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:inputType="number"
        android:ems="10"
        android:id="@+id/captureSet"
        android:hint="Capture ID" />

        <EditText
            android:layout_width="fill_parent"
            android:layout_height="wrap_content"
            android:inputType="number"
            android:ems="10"
            android:id="@+id/subsectionID"
            android:hint="Subsection"
            android:text="0"/>
</LinearLayout>

<Switch
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    android:text="6-sample Avg"
    android:id="@+id/avg30"
    android:checked="false"
    android:enabled="true"
    android:focusable="true"
    android:onClick="autoSwap" />

<Switch
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    android:text="Auto Mode"
    android:id="@+id/autoMode"
    android:layout_gravity="center_horizontal"
    android:checked="false"
    android:onClick="autoSwap" />

<LinearLayout
    android:orientation="horizontal"
    android:layout_width="match_parent"
    android:layout_height="wrap_content"
    android:layout_gravity="center_horizontal">

    <TextView
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:textAppearance="?android:attr/textAppearanceMedium"
        android:text="Distance: "
        android:id="@+id/autoDistance" />

    <EditText
        android:layout_width="match_parent"
        android:layout_height="wrap_content"
        android:inputType="number|numberDecimal"
        android:ems="10"
        android:id="@+id/autoDistanceEdit"
        android:numeric="decimal"
        android:text="0.5"/>
</LinearLayout>

</LinearLayout>

```

```
</ScrollView>
```

Full Code can be found at <https://bitbucket.org/byteit101/androidmedae> or by searching for 6f25b979a6c04707432159341497269f913b45f39bbf573d37459b067b24b9c0

Technical Report 2: Server Setup

Abstract

This document shows how we set up a virtual machine for storing and visualizing our relatively large dataset, and the format we stored our data in.

Rational

For this IQP, we needed to store and analyze relatively large amounts of data. It was impractical to attempt to manually manage the GIS data, as this is often in the gigabyte range. Last year's team used spreadsheets; specifically Microsoft Excel. While this allows simple analysis to be done easily, it is a poor storage and analysis platform for larger data sets or complex analyses. As we had multiple people taking multiple readings at multiple locations this year, manually merging this data would be needlessly tedious and time consuming. To avoid this, we needed a proper database that was capable of supporting multi-user access with correct read-write synchronization.

PostgreSQL, or Postgres, is the industry standard database for open source object-relational databases (ORDBMS). Postgres is capable of scaling to terabytes of data and is also one of the most flexible relational and object-relational database systems via its custom type system. PostGIS is one such extension, providing geometric and geographic types for GIS systems, like line, point, and geography. Throughout this paper, any reference to PostgreSQL will assume that the PostGIS types are installed unless explicitly mentioned. The PostgreSQL + PostGIS system is used not only because of its high quality and high usage, but also because it is free and open source software.

Setup

The WPI CS department lets students host servers for classes on virtual machines. Being a CS student, I was able to acquire `bortle.cs.wpi.edu` for the purposes of this IQP (contact Michael Voorhis). Bortle runs 64 bit Linux (Ubuntu 14.04 LTS specifically) and contains the following extra software:

- Servers
 - PostgreSQL 9.3 (with PostGIS 2.1 extensions installed)
 - Apache 2.4 + mod_python 3.3 + Python 2.7 + PHP 5.5
- Services
 - TileStache
 - Mapnik
 - Polymaps-based slippy map
 - Custom upload service for Android App

- Data
 - OpenStreetMap baselayers for Southington, Worcester, and Bar Harbor
 - OpenStreetMap styles
 - Continents (land_polygon)
 - WPI 2013 study data points

Database

Postgres is the main and most important service on bortle. It holds all the data in a indexed, easily searchable, standardized machine readable form. Any GIS software that supports PostGIS or ODBC can connect to Postgres to import and analyze data. Non-GIS specific database software (such as GNU R) can also connect to analyze data as Postgres is a standard SQL server. The following layout was present inside the darksky database:

- planet_osm_*
 - OpenStreetMap baselayers and data from osm2pgsql import utilities
 - read-only
- wpi13
 - data from 2013 WPI study
 - read-only
- ghosts
 - contained test data from early development of Androidmedae
 - read-write
- land_polygon
 - Base continent shapes
 - read-only
- layer_styles
 - QGIS style mappings (QGIS specific)
 - Saved the styles associated with each layer from QGIS to enable seamless working on multiple computers
 - read-write
- wpi14
 - Our data
 - read-write
- devices
 - Mapping for multiple android devices
- sqms
 - Mapping for multiple SQM devices
- uploads
 - Information regarding who uploaded the data
- groups14
 - Automatic Spanning tree-based groups of data
 - read-write

- groupboxes (view)
 - Area of groups14
- groupboxpoints (view)
 - centroids of groupboxes
- wpi14_corrected (view)
 - wpi14 + corrective factors

The full schemas are available at the end of this document

Web server

Apache is the industry standard web server, powering over half of all websites in the entire world. Apache is used here to expose the slippy map and Mapnik tiles, as well as to allow the Android apps to upload data into the Postgres database. The following paths are important:

- / - redirect to our website via PHP
- /13 - redirect to 2013 website via PHP
- /view.html - slippy map
- /tiles - the tilestache/mapnik section, all via mod_python
 - /tiles/render.gis/ - tile section
 - /tiles/render.gis/allPoints/ - OSM base layer png tiles
 - /tiles/render.gis/ghosts/ - GeoJSON vector tiles for ghosts table
 - /tiles/render.gis/wpi13/ - GeoJSON tiles for wpi13 table
 - /tiles/render.gis/wpi14/ - GeoJSON tiles for wpi14 table
- /upload-csv.php?id={csv-name}

TileStache is a caching wrapper around Mapnik & Postgres to save tiles that have not changed by avoiding re-rendering the entire map on each hit. It is unimportant from a big picture overview however, so simply know that it saves CPU resources on the server.

Mapnik is used to render sections of a map in 256x256 pixel chunks, called tiles. By breaking the map into tiles, we can avoid re-rendering the map for each user, and scrolling only involves fetching the tiles that have just scrolled into view. All commercial online mapping tools use map tiles in nearly the same way. OpenStreetMaps itself uses Mapnik, which is where the Mapnik style comes from. Any similarities are intentional.

The slippy map, found at view.html, is in the same style as Google Maps, Bing Maps, OpenStreetMap, etc. It provides an interactive tile viewer for browser-based users to scroll and zoom about though the GIS data without requiring dedicated GIS software. Also due to TileStache, it is often significantly faster. The slippy map at view.html uses Polymaps, a javascript library that utilizes modern browser's built-in SVG abilities to enable vector-based graphics and styling of GeoJSON data. Polymaps uses the /tiles/render.gis layers to fetch and display the correct map tiles from all

given layers, and to style them for easy consumption.

Upload Script

```
<?php
header("Content-type: text/plain");
if (!(isset($_GET['id']) || strpos($_GET['id'], "/") !== FALSE || !file_exists("csv/".$_GET['id'] . ".csv")))
&& !isset($_FILES['upload']))
{
    echo "Missing/invalid arguments";
    exit;
}
function randString($length, $charset='0123456789abcdef')
{
    $str = '';
    $count = strlen($charset);
    while ($length-- > 0) {
        $str .= $charset[mt_rand(0, $count-1)];
    }
    return $str;
}

$id = "csv/".$randString(10);
if (isset($_FILES['upload']))
{
    if (move_uploaded_file($_FILES['upload']['tmp_name'], "$id.csv"))
    {
        echo "Uploaded to $id\n";
    }
    else
    {
        echo "Error moving file";
        exit;
    }
}
else
    $id = "csv/".$_GET['id'];

$row = 1;
$rows = 0;
$spitzer = array();
if (($handle = fopen("$id.csv", "r")) !== FALSE) {
    while (($data = fgetcsv($handle, 2048, ",")) !== FALSE) {
        $num = count($data);
        $row++;
        if ($num != 29)
        {
            echo "$num fields in line $row!\n";
            exit;
        }
        else
        {
            $named = array(
                "timestamp" => $data[0] / 1000.0,
                "lat" => $data[1],
                "lon" => $data[2],
                "altitude" => $data[3],
                "accuracy" => $data[4],
                "satellites" => $data[5],
                "status" => $data[6],
                "magnitude" => substr($data[7], 0, -1),
                "duration" => substr($data[10], 0, -1),
                "temp" => substr($data[11], 0, -1),
                "orientationZ" => $data[12],
                "orientationX" => $data[13],
                "orientationY" => $data[14],
                "weather" => $data[15],
                "dataset" => $data[16],
                "dataset_minor" => $data[17],
                "dataset_section" => $data[18],
                "notes" => $data[19],
                "sqm_id" => $data[20],
                "record_id" => $data[21],
                "device_id" => $data[22],
                "mode" => $data[23],
                "mode_id" => $data[24],
                "mode_arg" => $data[25],
                "humidity" => $data[26],
                "datafver" => $data[27],
            );
        }
    }
}
```

```

        "appver" => $data[28],
    );
    if ($named["status"] != "u")
    {
        echo "warning, not importing partial dataset:\n";
        print_r($named);
    }
    else
    {
        $rows++;
        $spitzer[] = $named;
    }
}
fclose($handle);
echo "read $rows ok\n";
}
else
    echo "unable to open file";
if (isset($_GET['debug'])) print_r($spitzer);
//exit;
$db = new PDO("pgsql:user=www-data dbname=darksky password=www-data");
$db->beginTransaction();
$res = $db->prepare("insert into uploads (upload_time, who, person) values (NOW(), :who, :person) returning
upload_id");
if (!$res->execute(array("who" => $_SERVER['REMOTE_ADDR'], "person" => $id)))
{
    print_r($db->errorInfo());
    $db->rollBack();
    exit;
}
list($upload_id) = $res->fetch();
echo "Upload ID: $upload_id\n";
$prep = $db->prepare("INSERT INTO `wpi14` (acquired, geom, altitude, accuracy, satellites, magnitude,
duration, temperature, orientation_altitude, orientation_compass, orientation_twist, weather, dataset,
dataset_minor, dataset_section, notes, sqm_id, record_id, device_id, collection_mode, mode_id, mode_arg,
appver, upload_id, humidity) VALUES (to_timestamp(:timestamp), ST_SetSRID(ST_Point(:lon, :lat), 4326),
:altitude, :accuracy, :satellites, :magnitude, :duration, :temp, :orientationX, :orientationY, :orientationZ,
:weather, :dataset, :dataset_minor, :dataset_section, :notes, :sqm_id, :record_id, :device_id, :mode,
:mode_id, :mode_arg, :appver, :upload_id, :humidity)");

foreach ($spitzer as $args)
{
    unset($args['status']);
    unset($args['datafver']);
    $args['duration'] .= " seconds";
    $args['upload_id'] = $upload_id;
    if ($args['humidity'] == "")
        $args['humidity'] = null;
    if ($args['dataset'] == "" && isset($_GET['dataset']))
        $args['dataset'] = $_GET['dataset'];
    if (!$prep->execute($args))
    {
        print_r($db->errorInfo());
        $db->rollBack();
        exit;
    }
}
$db->commit();
rename($id.".csv", $id."-db.csv");
echo "ok, imported $rows";
?>

```

Viewer Source

```

<!doctype HTML>
<html>
<head>
<title>Dark Sky Interactive Map</title>
<meta http-equiv="X-UA-Compatible" content="IE=edge,chrome=1" />
<meta charset="UTF-8" />
<meta name="viewport" content="width=device-width, initial-scale=1.0, maximum-scale=1.0, user-scalable=no" />
<script src="polymaps.js"></script>
<script>
var cv = document.createElement("canvas");
cv.width=2500;
cv.height = 1;
var img = new Image();
img.src="gradient.png";
var po = org.polymaps;

```

```

if (cv.getContext)
{
var cx = cv.getContext("2d");
var LocationMaps = {
  "Acadia": [{"lon": -68.43661221801757, "lat": 44.2118600993757},
{"lon": -68.02943143188476, "lat": 44.44713486551291}],
  "Schoodic": [{"lon": -68.08590802490234, "lat": 44.326883160151795},
{"lon": -68.02968892395019, "lat": 44.37898882326917}],
  "Blackwoods": [{"lon": -68.21660670578002, "lat": 44.30319322538429},
{"lon": -68.18849715530395, "lat": 44.31501635846175}],
  "Seawall": [{"lon": -68.32183512985229, "lat": 44.23761610305428},
{"lon": -68.29372557937621, "lat": 44.24945243659093}],
  "Worcester": [{"lon": -71.82387742340087, "lat": 42.26879395433491},
{"lon": -71.78409489929199, "lat": 42.286892987258966}],
};
function centerMap()
{
  map.extent(LocationMaps[this.id]);
  map.zoom(Math.floor(map.zoom()));
  showHide.click();
}
window.onload = function(){
  cx.drawImage(img, 0,0);
  window.grads = cx.getImageData(0,0,2500,1).data;
  window.layers = {};
  window.map = org.polymaps.map()
    .container(document.body.appendChild(po.svg("svg")))
    .add(window.layers.osml = po.image().url("//bortle.cs.wpi.edu/tiles/render.gis/allPoints/{Z}/{X}/
{Y}.png"))
    .add((window.layers.osms = po.image().url(po.url("/{S}.tile.openstreetmap.org/{Z}/{X}/
{Y}.png").hosts(["a", "b", "c"]))).visible(false)
    .add((window.layers.googst =
po.image().url("//mt1.google.com/vt/lyrs=m&x={X}&y={Y}&z={Z}")).visible(false))
    .add((window.layers.googtr =
po.image().url("//mt1.google.com/vt/lyrs=p&x={X}&y={Y}&z={Z}")).visible(false))
    .add((window.layers.nokia =
po.image().url("http://maptile.maps.svc.ovi.com/maptiler/maptile/newest/satellite.day/{Z}/{X}/
{Y}/256/png8")).visible(false))
    .add(window.wpighosts = po.geoJson().url("//bortle.cs.wpi.edu/tiles/render.gis/ghosts/{Z}/{X}/
{Y}.geojson").on("load", load).on("show", load).clip(false).visible(false))
    .add(window.wpil = po.geoJson().url("//bortle.cs.wpi.edu/tiles/render.gis/wpi13/{Z}/{X}/
{Y}.geojson").on("load", load).on("show", load).clip(false).visible(false))
    .add(window.wpil4 = po.geoJson().url("//bortle.cs.wpi.edu/tiles/render.gis/wpi14/{Z}/{X}/
{Y}.geojson").on("load", load).on("show", load).clip(false))
    .center({lon: -68.2330, lat: 44.3296})
    .add(po.drag())
    .add(po.wheel().smooth(false))
    .add(po.dblclick())
    .add(po.arrow())
    .add(po.touch())
    .add(po.hash())
    .add(po.compass());

  // make info button
  (function()
  {
    var compass = document.querySelector(".compass");
    var i = po.svg("path");
    attr(i, {d: "m 1.516113,94.5542 c 0.314448,1e-5 0.580235,0.10858 0.797364,0.32568 0.217116,0.21714
0.325677,0.48293 0.325683,0.79737 -6e-6,0.30698 -0.112311,0.57276 -0.336914,0.79736 -0.217128,0.21713
-0.479172,0.3257 -0.786133,0.32568 -0.306971,2e-5 -0.572758,-0.10855 -0.797363,-0.32568 -0.217127,-0.2246
-0.325688,-0.49038 -0.325684,-0.79736 -4e-6,-0.31444 0.108557,-0.58023 0.325684,-0.79737 0.217118,-0.2171
0.482905,-0.32567 0.797363,-0.32568 m 0.145996,4.4585 -2.223632,7.87255 c -0.149743,0.53158 -0.224613,0.84978
-0.22461,0.95459 -3e-6,0.1198 0.03369,0.21713 0.101074,0.292 0.07487,0.0749 0.160967,0.1123 0.258301,0.1123
0.112302,0 0.247067,-0.0599 0.404297,-0.17969 0.426754,-0.33691 0.857255,-0.81608 1.291504,-1.4375 l
0.393066,0.2583 c -0.509119,0.77865 -1.108077,1.43376 -1.796875,1.96534 -0.509117,0.39681 -0.99577,0.59521
-1.459961,0.59521 -0.306967,0 -0.557781,-0.0898 -0.752441,-0.26953 -0.194663,-0.18717 -0.291993,-0.41927
-0.291992,-0.69629 -1e-6,-0.27702 0.09359,-0.73747 0.280762,-1.38135 l 1.45996,-5.03125 c 0.239581,-0.82356
0.359372,-1.34016 0.359376,-1.5498 -4e-6,-0.16471 -0.0599,-0.29947 -0.179688,-0.4043 -0.112308,-0.10481
-0.269534,-0.15722 -0.47168,-0.15722 -0.164716,0 -0.505373,0.0412 -1.021972,0.12353 l 0,-0.43799
3.874511,-0.6289", "class": "chevron"});
    var circleBack = po.svg("circle");
    attr(circleBack, {cx: 0, cy: 103, r: 12, "class": "fore back"});
    var gg = po.svg("g");
    attr(gg, {"class": "info"})
    gg.appendChild(circleBack);
    gg.appendChild(i);
    var oReq = new XMLHttpRequest();
    oReq.addEventListener("load", function(x)
    {
      var parser = new DOMParser();

```

```

        var doc = parser.parseFromString(this.responseText, "image/svg+xml");
        gg.appendChild(doc.getElementById("layerBits"));
        gg.appendChild(doc.getElementById("defs3358"));
    });
oReq.open("get", "GradientBit.svg", true);
oReq.send();
var toggle = false;
    gg.addEventListener("click", function(){if (toggle != toggle)gg.setAttribute("class", "info");else
gg.setAttribute("class", "info active"), false);
//gg.addEventListener("mouseover", function(){gg.setAttribute("class", "info active"), false);
//gg.addEventListener("mouseout", function(){gg.setAttribute("class", "info"), false);
compass.appendChild(gg);
})();

var callback = function()
{
    map.container().setAttribute("width", window.innerWidth);
    map.container().setAttribute("height", window.innerHeight);
    map.resize();
};
window.onresize = callback;
callback();

var layout = document.getElementById("layout");
window.showHide = document.getElementById("showhide");
showHide.addEventListener("change", function() {
    if (showHide.checked)
        layout.className = "";
    else
        layout.className = ("hidden");
});

btns = document.querySelectorAll("#layout >.scroller> button");
for (var i = 0; i < btns.length; i++)
{
    btns[i].addEventListener("click", centerMap);
}
bases = document.getElementsByName("basel")
for (var i = 0; i < bases.length; i++)
{
    bases[i].addEventListener("change", function()
    {
        for (var j in window.layers)
            layers[j].visible(false);
        layers[this.value].visible(this.checked);
        showHide.click();
    });
}
bases = document.getElementsByName("mode")
for (var i = 0; i < bases.length; i++)
{
    bases[i].addEventListener("change", function()
    {
        window.justDots = this.value;
        if (document.getElementById("wpi13")) wpi13.reshape();
        if (document.getElementById("wpi14")) wpi14.reshape();
        if (document.getElementById("ghosts")) wpighosts.reshape();
        showHide.click();
    });
}
document.getElementById("wpi13").addEventListener("change", function()
{
    wpi13.visible(this.checked);
    showHide.click();
});
document.getElementById("wpi14").addEventListener("change", function()
{
    wpi14.visible(this.checked);
    showHide.click();
});
document.getElementById("ghosts").addEventListener("change", function()
{
    wpighosts.visible(this.checked);
    showHide.click();
});
});
window.justDots = "posts";
window.rGnext = 0;
function drawData(prop, transform)
{
    var sets = Math.round(prop.magnitude * 100);

```

```

var rgpM = "rgb(" + grads[4*sets] + ", " + grads[4*sets + 1] + ", " + grads[4*sets+2] + ")";
switch (window.justDots)
{
  case "small":
  {
    var circle = attr(po.svg("circle"), {r: 4.5, fill: rgpM});
circle.appendChild(po.svg("title").appendChild(document.createTextNode(prop.magnitude)).parentNode);
return circle;
  }
  case "large":
  {
    var circle = attr(po.svg("circle"), {r: 9, fill: "url(#dataRG" + rGnext + ")"});
circle.appendChild(po.svg("title").appendChild(document.createTextNode(prop.magnitude)).parentNode);
var defs = po.svg("defs");
var rg = po.svg("radialGradient");
defs.appendChild(rg);
rg.setAttribute("id", "dataRG" + rGnext++);
rg.appendChild(attr(po.svg("stop"), {offset: "0%", "stop-color": rgpM, "stop-opacity": 1}));
rg.appendChild(attr(po.svg("stop"), {offset: "100%", "stop-color": rgpM, "stop-opacity": 0}));
var gg = po.svg("g");
gg.appendChild(circle);
gg.appendChild(defs);
defs.setAttribute("transform", transform)
return gg;
  }
  case "posts":
  default:
  {
    var np = po.svg("g");
    pathp = po.svg("path");
    np.appendChild(pathp);
    attr(pathp, {d: "m -15,-21.987185 c -2.77,0 -5,2.23 -5,5 l 0,7.0000005 c 0,2.77 2.23,5 5,5 l 10,0
5,4.99999998 5,-4.99999998 10,0 c 2.77,0 5,-2.23 5,-5 l 0,-7.0000005 c 0,-2.77 -2.23,-5 -5,-5 l -30,0 z M
-4.34375,-3.3309345 C -6.53824,-2.6199845 -8,-1.3888945 -8,0.01281548 -8,2.2148855 -4.41828,4.0128155
0,4.0128155 c 4.41828,0 8,-1.79793 8,-4.00000002 C 8,-1.3888945 6.53824,-2.6199845 4.34375,-3.3309345 l
-1.8125,1.8125 C 3.42787,-1.1528445 4,-0.60959452 4,0.01281548 4,1.1138455 2.20914,2.0128155 0,2.0128155 c
-2.20914,0 -4,-0.89897 -4,-2.00000002 0,-0.62241 0.57213,-1.16565998 1.46875,-1.53124998 l -1.8125,-1.8125 z",
fill: rgpM});
    var textp = po.svg("text");
    attr(textp, {x: 0, y: -8.9871855, style:
"font-size:12px;font-style:normal;font-weight:normal;text-align:center;line-height:125%;letter-spacing:0px;word-spacing:0px;text-anchor:middle;fill:#ffffff;fill-opacity:1;stroke:none;font-family:Sans"});
    var tspanp = po.svg("tspan");
    attr(tspanp, {x: 0, y: -8.9871855});
    tspanp.appendChild(document.createTextNode(prop.magnitude));
    textp.appendChild(tspanp);
    np.appendChild(textp);

pathp.appendChild(po.svg("title").appendChild(document.createTextNode(prop.magnitude)).parentNode);
return np;
  }
}
}

function attr(node, keys)
{
  for (var key in keys)
  {
    node.setAttribute(key, keys[key]);
  }
  return node;
}

function load(e)
{
  var po = org.polymaps;
  for (var i = 0; i < e.features.length; i++)
  {
    var feature = e.features[i];
    var pathp = feature.element;
    window.pathp = pathp;
    var parent = pathp.parentNode;
    parent.removeChild(pathp);
    var transform = pathp.getAttribute("transform");
    var prev = pathp;
    pathp = drawData(feature.data.properties, transform);
    parent.appendChild(pathp);
    pathp.setAttribute("transform", transform);
    feature.element = pathp;
  }
}

```

```

    }
  }
}

</script>
<style>
html, body {
width: 100%;
height: 100%;
padding: 0;
margin: 0;
overflow: hidden;
}

body {
margin: 0;
background: #E5E0D9;
}

svg {
display: block;
overflow: hidden;
width: 100%;
height: 100%;
}

#copy {
position: absolute;
left: 0;
bottom: 4px;
padding-left: 5px;
font: 9px sans-serif;
color: #fff;
cursor: default;
}

#copy a {
color: #fff;
}

.compass .back {
fill: #eee;
fill-opacity: .8;
}

.compass .fore {
stroke: #999;
stroke-width: 1.5px;
}

.compass rect.back.fore {
fill: #999;
fill-opacity: .3;
stroke: #eee;
stroke-width: 1px;
shape-rendering: crispEdges;
}

.compass .direction {
fill: none;
}

.compass .chevron {
fill: none;
stroke: #999;
stroke-width: 2px;
}

.compass .active .chevron, .compass .chevron.active {
stroke: #fff;
}

.compass .info .chevron {
stroke: none;
fill: #999;
}

.compass .active.info .chevron, .compass .info .chevron.active {
fill: #fff;
stroke: none;
}

.compass.active .active .direction {

```

```

    fill: #999;
}

#layout {
    background: none repeat scroll 0 0 rgba(238, 238, 238, 0.8);
    box-shadow: 0 0 5px;
    display: block;
    height: 100%;
    position: absolute;
    transition: all 0.8s ease 0s;
    width: 11em;
}
#layout > .scroller > button {
    display: block;
    width: 100%;
}
#layout > .scroller > h1 {
    font-family: sans-serif;
    font-size: 16pt;
    font-style: italic;
    font-weight: normal;
    margin: 0.3em 0;
    padding: 0;
    text-align: center;
}
#layout > .scroller > label:not(.horiz) {
    display: block;
}
.scroller {
    overflow-y: auto;
    height: 100%;
}
#showhidebox {
    background-color: rgba(238, 238, 238, 0.8);
    border-color: #999999;
    border-style: solid solid none none;
    border-top-right-radius: 12px;
    border-width: 2px;
    bottom: 0;
    display: block;
    height: 34pt;
    left: 11em;
    position: absolute;
    width: 27pt;
    overflow: hidden;
}
#showhidebox > label:after {
    color: #999999;
    content: '»';
    font-size: 28pt;
    padding: 0 5px;
}
#showhidebox > input {
    cursor: pointer;
    height: 100%;
    margin: 0;
    opacity: 0;
    position: absolute;
    width: 100%;
    z-index: 99;
}
#showhide:checked ~ label:after {
    content: '«';
}
#layout.hidden {
    box-shadow: 0 0 0;
    -webkit-transform: translate(-11em);
    -ms-transform: translate(-11em);
    transform: translate(-11em);
}
#pd ~ input:checked + label > img {
    background-color: highlight;
    box-shadow: 0 0 5px highlight;
    border-radius: 5px;
}
.scroller > #pd ~ input {
    display: none;
}
#pd ~ input + label > img {
    border: 1px solid rgba(0, 0, 0, 0);
}

```

```

}
#pd ~ label {
  display: inline-block;
  padding-left: 0.6em;
}
.info:not(.active) > #layerBits {
  display: none;
}
.info.active > path, .info.active > circle {
  display: none;
}
</style>
</head>
<body>You need to enable Javascript to view this interactive map<div id="layout" class="hidden"><div
class="back" id="showhidebox"><input type="checkbox" id="showhide"><label for="showhide"></label></div><div
class="scroller"><h1>Jump To</h1>
<button id="Acadia">Acadia</button>
<button id="Schoodic">Schoodic</button>
<button id="Seawall">Seawall</button>
<button id="Blackwoods">Blackwoods</button>
<button id="Worcester">Worcester</button><h1>Base Layer</h1>
<label><input type="radio" name="basel" value="osml" checked>Local</label>
<label><input type="radio" name="basel" value="osms">OpenStreetMaps</label>
<label><input type="radio" name="basel" value="googst">Google Maps</label>
<label><input type="radio" name="basel" value="googtr">Terrain</label>
<label><input type="radio" name="basel" value="nokia">Satellite, insecure</label>
<h1>GIS Layers</h1>
<label><input type="checkbox" id="wpi13">WPI '13</label>
<label><input type="checkbox" id="ghosts">Institute Park</label>
<label><input type="checkbox" id="wpi14" checked>WPI '14</label>
<h1 id="pd">Point Display</h1>
<input type="radio" name="mode" id="modeFuzz" value="large"><label class="horiz" for="modeFuzz"></label>
<input type="radio" name="mode" id="modePoint" value="small"><label class="horiz" for="modePoint"></label>
<input type="radio" name="mode" id="modeMarker" value="posts" checked><label class="horiz"
for="modeMarker"></label>
</div></div><script>if (!!document.createElementNS && !!document.createElementNS('http://www.w3.org/2000/svg',
"svg").createSVGRect)
{document.body.removeChild(document.body.firstChild);}else{document.body.innerHTML="<br><br><div
style='text-align:center;font-weight:bold'>Your browser does not seem to support SVG, which is required for
this map to display properly. Internet Explorer 9, Firefox, and Chrome all support
SVG.</div>"}</script></body>
</html>

```

Data Schemas

```

CREATE TABLE wpi14 (
  gid serial,
  altitude real NOT NULL,
  accuracy real,
  satellites integer,
  acquired timestamp with time zone NOT NULL,
  magnitude real NOT NULL,
  duration interval,
  temperature real,
  orientation_altitude real NOT NULL,
  orientation_compass real DEFAULT 0 NOT NULL,
  orientation_twist real DEFAULT 0 NOT NULL,
  weather character varying(100) NOT NULL,
  dataset integer NOT NULL,
  dataset_minor smallint DEFAULT 0 NOT NULL,
  dataset_section smallint DEFAULT 0 NOT NULL,
  notes character varying(150),
  sqm_id integer NOT NULL,
  record_id integer NOT NULL,
  device_id character(16) NOT NULL,
  collection_mode smallint NOT NULL,
  mode_id integer NOT NULL,
  mode_arg real DEFAULT 0,
  appver integer NOT NULL,
  geom geometry(Point,4326),
  upload_id integer NOT NULL,
  humidity smallint
);
CREATE TABLE devices (
  device_id character(16) NOT NULL,
  "desc" character varying(50) NOT NULL,
  android_version character varying(15) NOT NULL
);

```

```
CREATE TABLE sqms (  
  sqm_id integer NOT NULL,  
  name "char" NOT NULL,  
  "offset" real NOT NULL  
);  
CREATE TABLE group14 (  
  groupid integer NOT NULL,  
  gid integer NOT NULL  
);  
CREATE TABLE uploads (  
  upload_id serial,  
  who inet NOT NULL,  
  upload_time timestamp with time zone NOT NULL,  
  person character varying(200)  
);
```

Full Schema setup & data can be found by searching for
6f25b979a6c04707432159341497269f913b45f39bbf573d37459b067b24b9c0

Appendix A: Magnitudes per square arcsecond: mpsas

Mpsas, or Magnitudes per square arcsecond uses the astronomical definition of apparent magnitude: 0 is Vega, and dimmer stars are higher numbers. The apparent magnitude scale is an inverse logarithmic scale developed by the Greek astronomer Hipparchus. The dimmest stars that can be seen with the naked eye (assuming a true dark sky and no cloud cover) are magnitude 6 stars. If one star is 100 times as bright as another star, the brighter star is 5 magnitudes brighter which corresponds to an apparent magnitude of 5 less than the dimmer star. The apparent magnitude of the bright star Sirius is -1.5 while the dimmer Proxima Centauri is 10.7. The brightest object in our sky, the Sun, has a magnitude of -26.75. (Barbara Ryden, Bradley M. Peterson, 2010)

A second, or arcsecond, is 1/3600th of a degree, and a square arcsecond is a one arcsecond by one arcsecond square area of sky. Thus a sky that is, eg, 18 mpsas has the brightness of a magnitude 18 star over the entire collection area, which is averaged to a square arcsecond.

Appendix B: Spanning Tree Grouper (code listing)

```
require 'pg'
# This script attempts to create large spanning trees of nearby points and merge the spanning trees to one
group.
# It fails on large groups of data in straight lines (one huge group is created), but works fine for discrete
points
db = PG.connect(:dbname => 'darksky', :user=>"viewer", :password=>"viewer", :host=> "bortle.cs.wpi.edu")

ht = {}
groups = []
visited = []
# PostGIS groups them within some distance, here 0.0005 arcseconds
db.exec("select
  s1.gid, s2.gid as sgid, s1.magnitude, s1.geom, st_astext(s1.geom), ST_Distance(s1.geom, s2.geom)
from wpi14 as s1
join wpi14 as s2 on ST_DWithin(s1.geom, s2.geom, 0.0005)
where s2.gid != s1.gid and s1.dataset > 1 and s1.dataset < 600 and s2.dataset < 600 and s2.dataset > 1
order by s1.gid;") do |result|
  result.each do |res|
    # dump each row into a hashtable of (base gid) => [nearby points, ...]
    local = (ht[res["gid"].to_i] ||= {data: res, keys: []})
    local[:keys] << res["sgid"].to_i #save keys to make it easier
  end
end
# keep track of unvisited nodes so we are sure we visit everything
unvisited = ht.keys

# this is the merging lambda. lambda because it preserves scope so I can modify unvisited and ht within the
function. no encapsulation :-D
fnc = lambda do |st, grp_id=nil|
  visited << st
  unvisited.delete st
  grp = [st]
  if grp_id == nil
    grp_id = groups.length
    groups << grp
  else
    grp = groups[grp_id]
    grp << st
  end
  keys = ht[st][:keys]
  keys.each do |ky|
    fnc[ky, grp_id] if unvisited.include? ky
  end
  # the above Merge the spanning trees into a new group or an existing group
  # so that groups[grp_id] = [All, the, points, in, a, spanning, tree, plus, all, the, points's, spanning
points, uniq'ed]
end

while unvisited.length > 0
  fnc[unvisited[0]]
end

if visited.length != ht.keys.length || visited.length != groups.flatten.length
  puts "!!!!" # something went horribly wrong, abort
  exit
end

# print our results in csv style of "groupid", "gid"
groups.each_with_index do |x, i|
  x.each do |xx|
    puts "#{i}, #{xx}"
  end
end
end
```

Appendix C: Screen Normal Calculations

The following math is used to compute the normal of the screen for determining the direction the SQM was facing for Milky way calculations based on directions.:

$$\vec{u} = \text{Vector along the direction the top of the SQM is facing} \quad \vec{u} = \begin{bmatrix} \cos(\theta) \\ \sin(\theta) \\ \sin(\varphi) \end{bmatrix}$$

\vec{N} = Vector normal to the plane of the face of the untilted SQM

$$\vec{N} = \begin{bmatrix} \cos(\theta) \\ \sin(\theta) \\ 0 \end{bmatrix} \times \begin{bmatrix} \cos(\theta) \\ \sin(\theta) \\ \sin(\varphi) \end{bmatrix} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \cos(\theta) & \sin(\theta) & 0 \\ \cos(\theta) & \sin(\theta) & \sin(\varphi) \end{vmatrix}$$

$$\vec{N} = \hat{i}(\sin(\theta)\sin(\varphi)) - \hat{j}(\cos(\theta)\sin(\varphi)) + \hat{k}(\cos(\theta)\sin(\varphi) - \cos(\theta)\sin(\theta)) = \begin{bmatrix} \sin(\theta)\sin(\varphi) \\ -\cos(\theta)\sin(\varphi) \\ \cos(\theta)(\sin(\varphi) - \sin(\theta)) \end{bmatrix}$$

$$P = \text{Projection Matrix that projects onto the xy plane} \quad P = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

R = Rotation matrix to rotate \vec{N} around \vec{u} by t

$$R = \begin{bmatrix} \cos(t) + \cos^2(\theta)(1 - \cos(t)) & \cos(\theta)\sin(\theta)(1 - \cos(t)) - \sin(\varphi)\sin(t) & \cos(\theta)\sin(\varphi)(1 - \cos(t)) + \sin(\theta)\sin(t) \\ \cos(\theta)\sin(\theta)(1 - \cos(t)) + \sin(\varphi)\sin(t) & \cos(t) + \sin^2(\theta)(1 - \cos(t)) & \sin(\theta)\sin(\theta)(1 - \cos(t)) - \cos(\theta)\sin(t) \\ \cos(\theta)\sin(\varphi)(1 - \cos(t)) - \sin(\theta)\sin(t) & \sin(\theta)\sin(\varphi)(1 - \cos(t)) + \cos(\theta)\sin(t) & \cos(t) + \sin^2(\varphi)(1 - \cos(t)) \end{bmatrix}$$

$$PR = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \cos(t) + \cos^2(\theta)(1 - \cos(t)) & \cos(\theta)\sin(\theta)(1 - \cos(t)) - \sin(\varphi)\sin(t) & \cos(\theta)\sin(\varphi)(1 - \cos(t)) + \sin(\theta)\sin(t) \\ \cos(\theta)\sin(\theta)(1 - \cos(t)) + \sin(\varphi)\sin(t) & \cos(t) + \sin^2(\theta)(1 - \cos(t)) & \sin(\theta)\sin(\theta)(1 - \cos(t)) - \cos(\theta)\sin(t) \\ \cos(\theta)\sin(\varphi)(1 - \cos(t)) - \sin(\theta)\sin(t) & \sin(\theta)\sin(\varphi)(1 - \cos(t)) + \cos(\theta)\sin(t) & \cos(t) + \sin^2(\varphi)(1 - \cos(t)) \end{bmatrix}$$

$$PR = \begin{bmatrix} \cos(t) + \cos^2(\theta)(1 - \cos(t)) & \cos(\theta)\sin(\theta)(1 - \cos(t)) - \sin(\varphi)\sin(t) & \cos(\theta)\sin(\varphi)(1 - \cos(t)) + \sin(\theta)\sin(t) \\ \cos(\theta)\sin(\theta)(1 - \cos(t)) + \sin(\varphi)\sin(t) & \cos(t) + \sin^2(\theta)(1 - \cos(t)) & \sin(\theta)\sin(\theta)(1 - \cos(t)) - \cos(\theta)\sin(t) \\ 0 & 0 & 0 \end{bmatrix}$$

$$PR\vec{N} = \begin{bmatrix} \cos(t) + \cos^2(\theta)(1 - \cos(t)) & \cos(\theta)\sin(\theta)(1 - \cos(t)) - \sin(\varphi)\sin(t) & \cos(\theta)\sin(\varphi)(1 - \cos(t)) + \sin(\theta)\sin(t) \\ \cos(\theta)\sin(\theta)(1 - \cos(t)) + \sin(\varphi)\sin(t) & \cos(t) + \sin^2(\theta)(1 - \cos(t)) & \sin(\theta)\sin(\theta)(1 - \cos(t)) - \cos(\theta)\sin(t) \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \sin(\theta)\sin(\varphi) \\ -\cos(\theta)\sin(\varphi) \\ \cos(\theta)(\sin(\varphi) - \sin(\theta)) \end{bmatrix}$$

\vec{N}' = xy projection of the vector normal to the face of the tilted SQM = $PR\vec{N}$

$$\vec{N}' = \begin{bmatrix} ((\cos(t) + \cos^2(\theta)(1 - \cos(t)))\sin(\theta)\sin(\varphi)) - ((\cos(\theta)\sin(\theta)(1 - \cos(t)) - \sin(\varphi)\sin(t))\cos(\theta)\sin(\varphi) + (\cos(\theta)\sin(\varphi)(1 - \cos(t)) + \sin(\theta)\sin(t))\cos(\theta)(\sin(\varphi) - \sin(\theta))) \\ ((\cos(\theta)\sin(\theta)(1 - \cos(t)) + \sin(\varphi)\sin(t))\sin(\theta)\sin(\varphi)) - ((\cos(t) + \sin^2(\theta)(1 - \cos(t)))\cos(\theta)\sin(\varphi)) + ((\sin(\theta)\sin(\theta)(1 - \cos(t)) - \cos(\theta)\sin(t))\cos(\theta)(\sin(\varphi) - \sin(\theta))) \\ 0 \end{bmatrix}$$

$$\tan^{-1} \left[\frac{\hat{i} \text{ of } \vec{N}'}{\hat{j} \text{ of } \vec{N}'} \right] = \text{Compass direction (in radians) of the face of the SQM}$$

$$\tan^{-1} \left[\frac{\hat{i} \text{ of } \vec{N}'}{\hat{j} \text{ of } \vec{N}'} \right] = \tan^{-1} \left[\frac{((\cos(t) + \cos^2(\theta)(1 - \cos(t)))\sin(\theta)\sin(\varphi)) - ((\cos(\theta)\sin(\theta)(1 - \cos(t)) - \sin(\varphi)\sin(t))\cos(\theta)\sin(\varphi) + (\cos(\theta)\sin(\varphi)(1 - \cos(t)) + \sin(\theta)\sin(t))\cos(\theta)(\sin(\varphi) - \sin(\theta)))}{((\cos(\theta)\sin(\theta)(1 - \cos(t)) + \sin(\varphi)\sin(t))\sin(\theta)\sin(\varphi)) - ((\cos(t) + \sin^2(\theta)(1 - \cos(t)))\cos(\theta)\sin(\varphi)) + ((\sin(\theta)\sin(\theta)(1 - \cos(t)) - \cos(\theta)\sin(t))\cos(\theta)(\sin(\varphi) - \sin(\theta)))} \right]$$

Which gives us the expression:

$$\text{Math.atan2}(((\cos(t) + (\cos(\theta))^2 * (1 - \cos(t))) * (\sin(\theta) * \sin(\varphi))) - (((\cos(\theta) * \sin(\theta)) * (1 - \cos(t))) - (\sin(\varphi)) * \sin(t)) * (\cos(\theta) * \sin(\varphi))) + ((\cos(\theta) * \sin(\varphi)) * (1 - \cos(t)) + (\sin(\theta) * \sin(t)) * (\cos(\theta) * \sin(\varphi)) - (\cos(\theta) * \sin(\theta)) * \sin(\varphi))), (((\cos(\theta) * \sin(\theta)) * (1 - \cos(t)) + (\sin(\theta) * \sin(t)) * (\cos(\theta) * \sin(\varphi)) - (\cos(\theta) * \sin(\theta)) * \sin(\varphi))) - ((\cos(t) + (\sin(\theta))^2 * (1 - \cos(t))) * (\cos(\theta) * \sin(\varphi))) + ((\sin(\theta) * \sin(\theta)) * (1 - \cos(t)) - (\cos(\theta) * \sin(t)) * \cos(\theta) * (\sin(\varphi) - \sin(\theta))))$$

Appendix D: Final Storyboard

Final Draft of Storyboard for Acadia Dark Sky Video

Time	Description	Audio (Music/Speaker)	Images To Insert
0:00	Fade in	Music Speaker: Acadia National Park.	Time lapse of sunrise in Acadia
0:07	(figure out transition if needed)	Music fades to background Speaker: ryan add something	Video Pano from Cadillac MT, blue hill overlook (full 360)
0:12	Pop up over the paused video pano	Music still faded Speaker: Located in downeast maine, the nearly 48,000 acres [forest and mountain and beach...] are the expanding legacy of the first national park east of the Mississippi river	Map of Maine Zoom into downeast with acadia national park highlighted (MDI, Schoodic and islands)
0:15	Pop in	Music still faded begin to crescendo Speaker: Acadia's [natural beauty and blablahablh] has made it one of the most-visited national park in the United States	Time lapse of park entrance gate
0:18	Pop in	Music	Kayaking
0:20	Pop	music	Biking
0:21	Pop	music	Hiking
0:23	Pop	music	Whale watch video?
0:25	Pop	music	Horse carriage s
0:26	pop	music	Park loop road sign, drive by sand beach and rocks
0:29	Slowly fades	Music softens or changes	Sunset time lapse into the night

		slightly Speaker: Acadia after dark is not silent. Making the top 10 great places to star gaze by USA Today 2012... (work on this phrase)	sky
0:37	Pop	Music	Time lapse of night sky
0:43	pop	Music	Time lapse of night sky or just images or a video pano?
0:50	Fade into	Music change or soften at the end of time lapse Speaker: but acadia is threatened by the least expected pollutant... light. (work on this phrase)	Time lapse from Cadillac Then stops zooms in on light pollution from bar harbor
0:56	Pop into	Music soft Light pollution fact Speaker: Two thirds of Americans can no longer see the stars where they live due to light pollution.	Time lapse of bar harbor (with the moose on... cut it before it goes out)
1:04	Fade into	Music soft Speaker: Acadia has recognized this threat and began its Night Sky Initiative	Night sky time lapse with acadia sign
1:06		--- Music soft or off – Interview with John Kelly or S.O.S.B (Scripted?)	John Kelly interview --- discuss the night sky initiative measuring promoting and protecting Acadia's night sky Corresponding images while voice over.
		Speaker (John Kelly or S.O.S.B) It is important to measure the night sky.	Measuring WPI Dark Sky Astronomers

		<p>Speaker (John Kellyor S.O.S.B) Acadia promotes the night sky through example as it has interpretative night sky programs</p>	<p>Promoting Visitor center time lapse Stars over sand beach video pictures (find out what knowing the night is) Night sky festival images?</p>
		<p>Speaker(John Kellyor S.O.S.B): -aas and ida mention here- Ways to protect the night sky are changing light fixtures to be fully shielded and enact dark sky ordinances.</p>	<p>Protecting - Aas + ida symbol- Lighting fixture diagram or actual fixture Bar Harbor going to sleep, no cars... moose out. (Fade out)</p>
1:30	Fade all the way Black background	<p>music Speaker: To learn more about the night sky or to plan your trip to Acadia visit nps.gov/acad</p>	<p>End credit type black background website NPS logo</p>

Appendix E: Website Content

Monday 7/21/2014

2nd Level Paragraphs

Night Sky & Astronomy Programs

The night sky above Acadia gives visitors the sight of a lifetime with breathtaking views of the Milky Way among thousands of stars visible to the naked eye. With only minimal impact from light pollution, the night sky at Acadia is considered one of the great places to stargaze in the northeast United States. Two-thirds of Americans can no longer see the stars due to misdirected artificial light, or light pollution. Acadia has created the Night Sky Initiative to address light pollution in and around the park.

(On the left)

Acadia National Park prizes the natural beauty of the night sky and recognized the threat posed by development in and outside of the park. The increase in lighting from municipal streetlights, and commercial and residential sources surrounding Acadia produce light pollution that degrades the quality of the natural night sky.

(On the right)

Mission: The goal of the Night Sky Initiative is to improve and protect the quality of the night sky in Acadia National Park and surrounding communities.

Possible Quote: “No sight is more provocative of awe than is the night sky scattered thick with stars.”
-Llewelyn Powys

(in middle)

Night Sky Initiative

The National Park Service (NPS) has shown its commitment to protecting the night sky through the Night Sky Initiative, which is a partnership project to “measure, promote, and protect the night sky at Acadia”. To prevent further degradation and to improve the dark sky of Acadia, the NPS is cooperating with local governments, residents, businesses, schools, and other organizations to prevent or minimize light pollution in the surrounding communities.

Measure

There are various ways to accurately measure light pollution (possible link to <http://www.nature.nps.gov/night/measure.cfm?>) Several research teams have measured the quality of Acadia National Park's night sky. The National Park Service partnered with the Island Astronomy Institute to measure light pollution in several strategic locations across the park using CCD cameras (link to <http://astroinstitute.org/NPS%20Surveys/npsystem.html>). Additionally, the College of the Atlantic and Worcester Polytechnic Institute have conducted comprehensive whole-park studies in 2007 (CoA) and 2013 & 2014 (WPI). All of these studies have shown that while there is some light pollution from the nearby towns Acadia National Park hosts nearly pristine skies on the west side of Mount Desert island and in southern Schoodic.

Promote

Acadia is widely recognized for its excellent night skies and natural lightscape. In 2012, USA Today heralded it as one of the 10 great places to stargaze in the world. Acadia National Park has partnered with multiple outside organizations to promote the annual Acadia Night Sky Festival every September. This event alone brings thousands of visitors to enjoy the natural lightscape that Acadia National Park protects. Throughout the summer months, the regularly scheduled Stars over Sand Beach and Knowing the Night programs gives families the opportunity to explore Acadia after dark and the night sky first hand with the guidance of engaging storytelling of knowledgeable park rangers.

Interpretive Programs

Stars Over Sand Beach (photo from sosb)

Stargazing Parties (photo from anp and aas)

Protect

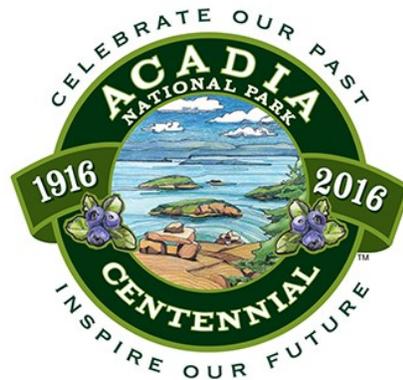
Light pollution is among the easiest types of pollution to fix and one of the only types of pollution that is 100% recoverable from. Acadia National Park has worked with the nearby towns of Bar Harbor and other towns on Mt. Desert Island and around Frenchman's Bay to help reduce light pollution by mandating fully shielded lighting in new development in lighting ordinances or Dark Sky Ordinance. [link to [Lighting Manual - SPO Technical Assistance Bulletin.pdf](#)]

Appendix F: Acadia IDA Overview

Acadia National Park

Preparation Process
for
International Dark-Sky Association's
Dark Sky Park Application

Prepared by 2014 WPI Dark Sky IQP



WPI

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Introduction (WPI)

The WPI Dark Sky Team strongly encourages Acadia National Park to apply to become recognized as an International Dark Sky Park (IDSP) by the International Dark-Sky Association (IDA). Being recognized as International Dark Sky Park would set Acadia apart from any other parks. Acadia's dedication to the night sky can be seen through the Acadia Night Sky Initiative, which started in 2008 to measure, promote and protect the night sky.

In this document the team has reviewed the IDSP Guidelines and highlights areas that will need to be addressed. We strongly believe that Acadia would fall under the Gold or Silver Tier but may need to first be given a Provisional Status to allow for improvements to be made in park's lighting. Under the Provisional Status the park will be able to advocate for itself stronger to receive funding for the installation of shielded lighting and stronger the light regulations in surrounding towns.

International Dark Sky Park Information

(Information gathered from IDSP Guidelines Final-May13-BP)

Definition:

An IDA Dark Sky Park (DSP) is a public land possessing an exceptional or distinguished quality of starry nights and a nocturnal environment that is specifically protected for its scientific, natural, educational, cultural heritage, and/or public enjoyment.

Goals for IDA Dark Sky Park Creation

- To identify, restore, and protect public lands (national, state, provincial, and other parks and notable public lands) with exceptional commitment to, and success in implementing, the ideals of dark sky preservation and outstanding night skies.
- To promote ecotourism
- To promote protection of nocturnal habitat and human health, public enjoyment of the night sky and its heritage, and/or areas ideal for professional and amateur astronomy;
- To encourage park administrators to recognize dark skies as a valuable resource in need of proactive protection;
- To provide international recognition for such parks;
- To encourage parks and similar public entities to become environmental leaders on dark sky issues by communication the importance of dark skies to the general public and surrounding communities, and by providing an example of what is possible with proper stewardship.

WPI Comment

These goals align with Acadia's current mission and programs. An IDA status will greatly improve the awareness of Acadia's Dark Sky to the residents in the area, visitors and park rangers.

Benefits

Achieving this designation brings recognition of the efforts a park has made towards protecting dark skies. It will raise the awareness of the park, staff, visitors, and the surrounding community. Designation as an IDA DSP (Dark Sky Park) entitles the park to display the ID DSP logo in official park publications and promotions, and use of this logo by commercial or other groups within community when identifying the park area itself. (e.g. an organization can say "located in Cherry Springs State Park, an IDA DSP" or other words to the same effect). IDA will maintain a web page identifying and describing all IDA DSPs. The park agency may also identify IDA as a park partner and erect a public sign in the park announcing the dark sky park status.

Eligibility (ALL MUST BE MET)

- All protected public lands, whether managed by national, state, provincial, or local agencies, are eligible. There may include parks, refuges, forests, wilderness areas, monuments, protected rivers, or other categories of protected lands. For this document, they are generically referred to as a "park;"
- The park must provide the opportunity for public nighttime access, with or without supervision. Regular visitation by the public is essential to meet the goals of the IDSP program. A portion of designated land may meet this requirement, or access must be available for a portion the night.
- The park must provide an exceptional dark sky resource, relative to the communities and cities that surround it. Core night sky quality must fit in one of the three tier qualifications Gold, Silver, or Bronze. (See below section H Sky Quality Tiers)

WPI Comment

Acadia reaches all three of these eligibility requirements. It is expected Acadia will be in the Gold or Silver tier based on the sky quality measurements from WPI 2014 night sky survey.

Minimum Requirements for All Parks

- A. A quality comprehensive Lightscape Management Plan (LMP) with the following minimum standards:

- a. New, current, and retrofitted lighting must meet the park's LMP (which must meet the "Lightscape Management Plan Guidelines" see below). The RASC/IDA Guidelines for Outdoor Lighting (GOL) should be used while creating the park's LMP. These guidelines may be found on IDA's website at www.darksky.org/RASCGOL or attached.
- b. Included policy for determining whether an area should or should not be lighted, and appropriate illumination levels, AND
- c. Fully shielded fixtures are standard throughout the park. Any lighting fixtures above 600 lumens are required to use fully shielded fixtures emitting no light at or above the horizontal. An exception to this may be when lighting fixtures contain lamps emitting less than 600 lumens. When such unshielded fixtures are used, impacts to the lightscape must be minimized with the use of timers and or curfews, And,
- d. Methods for determining the appropriate type of lamp (color, efficiency, technology) and fixture that should be used with goals to maximize energy efficiency and minimize impact to human vision dark adaptation/recovery time, wildlife, and the nocturnal ecology. It is recommended that only lighting under 3100K correlated color temperature (CCT) be used as this will minimize the impact on most wildlife, AND
- e. LMP should conform to or surpass agency or departmental policy on lighting and dark sky protection as well as other applicable guidance and laws (e.g. environmental leadership programs, agency orders, wilderness act, energy management guidelines).

Lightscape Management Plan Guidelines

The LMP should embody good lighting ethics such as:

- a. Meet or exceed agency or departmental policies regarding outdoor lighting
- b. Only use light when it is needed, where it is needed, and in the appropriate amount
- c. Outdoor lighting fixtures should be fully-shielded and have appropriate use of timers and motion sensors.
 - a. Lighting less than 600lumens may be unshielded lights for special purposes, such as historical preservation. The approved special uses should be stated in the LMP. IDA will scrutinize these uses to ensure that park lighting is suitable example of good lighting for the public and protects the nighttime environment to the maximum practical extent. IDA may request additional descriptions, photographs, or drawings of these lights. These lights are not exempt from the lighting guidelines, and must still be designed to minimize impact to the lightscape.
- d. IDA has collaborated with the Royal Astronomical Society of Canada to develop the RASC/IDA Guidelines for Outdoor Lighting (GOL) see

www.darksky.org/RASCGOL or attached. These guidelines should be adopted as part of the LMP for the park. If there are provisions of the GOL that are not appropriate for the park, the GOL may be amended or substituted and determine on a case-by-case basis if the changes are acceptable for the individual park.

WPI Comment

Acadia should create a Light Management Plan if there is not one already created. This can be completed in the summer of 2015 through a WPI IQP, a park official or an outside resource such as Friends of Acadia or another student project/internship.

- B. The park's commitment to dark skies and lightscape management, as shown by:
- a. The park recognizes dark skies as an important natural, cultural, and/or scientific resource value as demonstrated by inclusion in approval management documents (e.g General Management Plan, Resource Management Plan, Facility Development Plan), AND
 - b. At least two-thirds (67% of existing outdoor lighting fixtures within park boundaries conform to the park's LMP at the time of IDA DSP (or an alternative fraction approved by the IDA Dark Sky Places Committee (DSPC) AND;
 - c. A schedule defining a five-year plan for when 90% of all outdoor lighting on park land will conform with the park's LMP, and written commitment that 100% of the lighting will conform in the future, AND;
 - d. A measurement program must be maintained either by the park or by another public or private organization (university, research center, IDA chapter, astronomy club, ect) to follow the evolution of light pollution in the IDA DSP and assert that the night sky quality does not degrade. **Installation of at least one permanently mounted, approved, night sky brightness meter (NSBM)** and participation in the IDA Global Sky Monitory website is recommended, AND;
 - e. The park has set a leadership example in the restoration of dark skies by implementing at least one of the following:
 - i. Producing at least one "night sky friendly" lighting project that is publicly visible and interpreted, OR
 - ii. Involving at least two external partners in dark sky restoration efforts (e.g chamber of commerce, power utility, university research, tribal nations, environmental groups, natural history association), OR
 - iii. Cooperation with at least two nearby municipalities that results in adoption of lighting codes that improve sky conditions in the park, OR
 - iv. Inventorying and monitoring night sky quality and using results to educate the public, OR
 - v. A commination of the above or an alternative restoration project may be suggested

Lighting Inventory

- A) When there are numerous outdoor lights it is acceptable to group lights by facility or area. Whether the fixtures are fully-shielded, are special purpose fixtures under 600 lumens, and what the lighting application is should be noted for each fixture or group of fixtures.
- B) Lighting Inventory should also include a plan or stated commitment to bring all outdoor lights into compliance with the Lightscape Management Plan (LMP).
- C) Daytime photographs or manufacturer diagrams of each fixture type may also accompany the inventory

Sample table below from a portion of a lighting inventory:

Location	Fixture	Fully-Shielded	Special Purpose <600 lumens	Application	Conformity with LMP
Visitor Center	12 fixtures on 14' pole, 70 W HPS	YES	NO	Parking lot, timer off at 10pm	YES
	2 door lights, 100 W MH	YES	NO	Building egress	YES
	6 bollard (post) lights, 32 W CFL	NO	NO	Walkway	NO – see plan
Historic Cabin	2 carriage style lights at doorways, 40 W incandescent	NO	YES	Historic Preservation, egress	YES
Maintenance Yard	6 wall packs, 250 W MH	NO	NO	Occasional night operations	NO – see plan
	8 Glarebusters, 11 W CFL	YES	NO	Egress, security	YES

Lamps of 600 lumens output and less include: 40 watt incandescent and less; 35 watt tungsten (quartz) halogen and less; 8 watt linear fluorescent and less; 11 watt compact fluorescent and less.

WPI Comment

While there was a lighting inventory completed in 2011, Acadia should redo or revamp with a more up to date inventory. An inventory can be completed during the summer of 2015 and the information gathered shape a LMP in areas that are giving off the most unwanted light. The park can address Light Management Plans within communities and work towards the towns surrounding Acadia follow suit in changing light fixtures over.

- C. The park's commitment to public education.
 - a. The importance of dark skies/natural darkness and the benefits of good lighting should be part of park interpretation/ outreach programs. (Dark skies education refers not only to astronomy education but also education about wildlife, energy efficiency, safety, and human health.) If park typically provides interpretive programs, then dark skies must be one of the central themes communicated through on-site interpretation. If interpretive programs are not typically offered, then extensive

publications, flyers, press releases, media, social media, or other outreach are appropriate substitutes, AND

- b. Dedicated programming must occur at least four times per year, however, more events are preferable. These events may highlight the dark sky in any appropriate way (e.g. cultural or historic value, importance to wildlife, astronomical or stargazing events, and a portion of the event must include dark sky awareness or preservation specifically including reference to the IDA and what it means to be an IDA DSP.

WPI Comment

Acadia National Park

- D. IDA reserves the right to request stronger or alternative requirements if deemed appropriate and deny IDA DSP status if these requirements are not met. Any requests by IDA will be made through direct contact and communication with the park.
- E. Once established the park must erect and maintain signs indicating the IDA Dark Sky Park designation along a roadway entrance, along a footpath entrance or if no roadway exists, or a visitor contact center. Sign must include IDA DSP text and logo. With Dark Sky Places Committee (DSPC) approval, an alternative wording may be used, such as Dark Sky Wilderness, Night Sky Refuge, or similar. The park may include the awarded tier if desired. Once the sign is erected a picture documenting this sign must be taken and sent to IDA for records along with a description of its location.

WPI Comment

Acadia can include a sign at areas where signs already exist entering the park from various roads. Depending on what power Acadia has in changing or adding signs.

- F. Designation is permanent, but is subject to regular review by IDA and possible revocation if minimum requirements are not maintained. More details may be found in the “reassessment of IDA DSP designation” section.
- G. The Park will submit an annual report to IDA by October 1st detailing activities and progress towards fulfilling IDA DSP goals during the previous year. The Park should include dates and brief descriptions of interpretive events, lighting retrofit projects, community outreach, ect. Samples of printed materials and press articles should also be included. The annual report should not require a lot of time to produce, as it should be a compilation of information generated during the previous year. A form will be provided to aid in the compilation of these details. Electronic submission of these documents is required in MSWord or PDF format. If the annual report is not sent in a timely fashion, IDA may suspend the IDA DSP’s status until the annual reporting requirements have been met.

WPI Comment

Please see the final page containing “Reassessment of IDA DSP Designations” for more information.

H. Sky Quality Tiers

- a. Once the minimum requirements have been met, an IDA DSP is designated by IDA at one of three levels – Gold, Silver, or Bronze indicating the estimated sky quality of the site
- b. Gold corresponds to natural, non-polluted or near-natural night
- c. Silver corresponds to nighttime environments that have minor impacts from light pollution and other artificial light disturbance, yet still display good quality night skies and has exemplary nighttime lightscapes
- d. Bronze corresponds to areas not meeting the requirements of Silver, yet still offering people, plants, and animals a respite from a degraded nocturnal environment.
- e. The determination of whether the minimum sky quality standard has been met and what tier will be awarded will be decided by IDA based on submitted information.
- f. For breakdown of requirements for each tier designation, see the table below:

Sky Quality Tiers Overview

GOLD, SILVER, AND BRONZE TIER DESIGNATION

Indicator	Gold	Silver	Bronze
Philosophy	Nighttime environments that have negligible to minor impacts from light pollution and other artificial light disturbance, yet still display outstanding quality night skies and have superior nighttime lightscapes.	Nighttime environments that have minor impacts from light pollution and other artificial light disturbance, yet still display good quality night skies and have exemplary nighttime lightscapes.	Areas not meeting the requirements of <i>Silver</i> , yet still offering people, plants, and animals a respite from a degraded nocturnal environment and suitable for communicating the issue of light pollution and connecting people with the many aspects of the night sky.
Artificial Light and Skyglow	Typical observer is not distracted by glaring light sources. Light domes are only dim and restricted to sky close to horizon.	Point light sources and glaring lights do not dominate nighttime scene. Light domes present around horizon but do not stretch to zenith.	Areas with greater artificial light and skyglow than <i>Silver</i> , but where aspects of the natural sky are still visible.
Observable Sky Phenomena	The full array of visible sky phenomena can be viewed—e.g. aurora, airglow, Milky Way, zodiacal light, and faint meteors.	Brighter sky phenomena can be regularly viewed, with fainter ones sometimes visible. Milky Way is visible in summer and winter.	Many sky phenomena cannot be seen. Milky Way is seen when pointed out to the average person, as is the Andromeda Galaxy.
Nocturnal Environment	Area is devoid of obvious lights that can cause wildlife disorientation. Artificial light levels are thought to be below the threshold for plant and animal impact. Ecological processes related to nocturnality are unaltered. No lighting atop towers or buildings within park boundary.	Areas that have minor to moderate ground illumination from artificial skyglow. Lights that may cause disorientation to wildlife are distant. Disruption of ecological processes is minor with no impairment to plants or wildlife.	Areas with greater nocturnal impact than <i>Silver</i> , but where ecosystems are still functional.
Visual Limiting Magnitude	Equal or greater than 6.8 under clear skies and good seeing conditions	6.0 to 6.7 under clear skies and good conditions	5.0 to 5.9 under clear skies and good seeing conditions
Bortle Sky Class	1-3	3-5	5-6
Unihedron Sky Quality Meter	> 21.75	21.74-21.00	20.99-20.00

WPI Comment

Acadia falls solidly under silver with some gold readings from the 2014 WPI Dark Sky, Sky Quality Analysis. The team has provided photo proof of observable sky phenomena.

Guidelines on IDA DSP Process

Provisional status

- In some cases, a park interested in being designated may lack the resources to do so. IF minimum sky quality criteria and appropriate outreach requirements have been met, a park may apply for and be granted Provisional status. Provisional Status recognizes the park's outgoing work to become an IDA DSP and is intended to be used as a leverage point to enable the necessary lighting upgrades or retrofits and policy changes.
- Provisional status expires after three years. At any time before the end of its provisional status, a park may reapply for full status. Material submitted for the removal or provisional status may be an addendum to the initial application as long as the material includes a current assessment of night sky quality, goals, outreach, and programs listed in the original application.
- To be considered for a provisional status, send a nomination package to support the following needed information:
 - Initial sky Quality measurements;
 - The minimum quality night sky described under "Eligibility" must be met in order to attain Bronze IDA DSP Designation
 - Documented intent to create and support an IDA DSP;
 - An action plan describing how the aspiring Park will meet minimum requirements;

Nomination

The nomination may be initiated by an IDA qualified nominator who has personally reviewed a park's outdoor lighting and commitment to natural lightscapes, or by a member of the park staff who maintains an IDA membership. TO become an IDA qualified nominator you must be an IDA member and be approved by the IDA Dark Sky Places manager. The nomination may be a joint effort between park administration and the qualified nominator. Nominators are encouraged to correspond with IDA staff and the park throughout this process – from first consideration of IDA DSP through the final submission package.

IDA DSP Application Process

Steps for Applicant

- A. Initial contact with IDA by phone or email to discuss the process and make recommendations followed by regular contact to consult with IDA staff and to review progress;
- B. A formal point of contact (POC) person is designated and their phone address and email information is forwarded to IDA staff. Before an after designation, any changes to this POC, or their information, must be communicated to IDA in order to ensure accurate communication at all times;

- C. Upon completion the park sends the application to IDA staff for review of the document. IDA staff confirms that the application is complete and ready for submission;
- D. Completed application packet in .pdf and/or MS Word.doc format sent electronically to DSPC by IDA staff for review.
- E. Submit in plenty of time for IDA staff to review and prepare your application to make the bimonthly deadline that you prefer, as found on www.darksky.org/idsp or see attached. Requests to rush applications will NOT be accepted; meaning that planning ahead is essential if the park is planning to meet a deadline.

WPI Comment

- 1) Dark-Sky Association Contact Info:
(<http://darksky.org/who-we-are/staff>)

Emails-

Scott Kardel

Acting Executive Director

e-mail: "wskardel@darksky.org"

Susan Ciarniello

Membership Director

e-mail: "susan@darksky.org"

- 2) POC- John Kelly (Park Planner)
(207) 288-8703 phone
john_t_kelly@nps.gov

- 3) Below are the deadlines for 2014
July 28th 2014
September 22 2014
Sky festival September 25-29th
November 24 2014

To Be Included in an IDA DSP Submission

- A. Map(s) of area to be designated. (For larger parks with a minimum total size of 1,000 km² a smaller portion of the park may be designated with special permission. A description explaining why this subset of the larger park was chosen must be approved in advance by IDA's Dark Sky Places program manager.)
- B. Letter of nomination in support from appropriate park administrator.
- C. Any management documents supporting dark skies and/or natural lightscapes as a valued resource.
- D. If it exist, agency or departmental policy on outdoor lighting and dark sky protection.

- E. Documentation of sky quality, light pollution measures, satellite pictures, maps, photographs, or other evidence that demonstrates the noteworthiness of the resource. Measurements of night sky brightness using an approved night sky brightness meter (NSBM), such as the Unihedron Sky Quality Meter or the IDA Night Sky Brightness Monitor showing at least 12 locations within the park. Measurements should document the approximate darkest and brightest areas of the park. Data included in the application must contain an updated survey of the park completed no more than two years before the application's submission along with any other relevant surveys. Learn more about creating a night sky quality survey on IDA's website www.darksky.org/nightsurvey. Or see attached.
- F. Lightscape Management Plan
- G. Documentation signed by park administrator showing a Lighting Inventory of the Park and plan to bring 90% of outdoor lighting into compliance with the IDA-DSP-GOL within five years.
- H. Description of restoration project (e.g lighting project, community outreach, ect.)
- I. Description of interpretive program or interpretive products related to dark skies/natural darkness. Any related examples of successful education (photos, documentation of student projects, ect)
- J. Future plans
- K. Proposed alternative wording for IDA DSP (eg Dark Sky Wilderness, Dark Sky Refuge, ect.) if desired.
- L. An outline of an application is available and may be used upon request.

IDA Review Process

- A. Applications are sent to the committee on a bi-monthly basis.
- B. Before the park's final application is submitted it is highly recommended that the park be in regular conversation with IDA staff to perfect the application before the deadline. Applications not ready for submission by the current deadline for committee consideration will be considered at the next committee meeting.
- C. IDA staff forwards application to Dark Sky Places committee for review at the deadline;
- D. Approval of application by DSPC is by a 2/3 majority vote, or denial with reasons and recommendations. The DSPC committee may consider the application for up to two months before releasing a decision;
- E. Determination of sky quality tier – Gold Silver or Bronze;
- F. If approved the location will be notified and the program manager will organize a press release with the location during a 10-day waiting period during which the Board of Directors will have the formal right to veto should they perceive a problem with the application. The park

- has the right to choose when the press release is made public but must be organized the announcement to be made at the same time as IDA's release unless otherwise discussed and decided upon by both parties;
- G. If approved, the park is awarded the IDA DSP designation and listed along with their application on the IDA website. By submitting the application the park agrees to have their application posted to IDA's website unless otherwise stated;
 - H. IF denied, a letter is sent to applicant outlining elements of the application that need improvement and specific recommendations for ways to remedy them. Applications can be resubmitted for future consideration after remediation is complete.
 - I. Periodic checks, through the submission of the annual report, will be performed to ensure that minimum standards and objectives of the program are being upheld and adequate progress is being made.

Reassessment of IDA DSP Designations

To ensure that parks continue to be exemplary in their protection and restoration of natural lightscapes, IDA will periodically reevaluate DSPs. Annual reports are due October 1st. This is done to confirm that parks continue to meet the minimum requirements, are sustaining partnership and interpretation efforts, and are making adequate progress toward 90% compliance with Lightscape Management Plans. IF the annual report is not sent in a timely fashion or questions or concerns cannot be resolved after the review, it may be necessary for IDA to suspend/revoke the IDA DSP's status until resolution can be achieved.

A form for the annual report maybe be found on IDA's website at www.darksky.org/parks or see attached.

WPI Comment

If the park is to gain IDA DSP status, WPI could continue work on Dark Sky project and help Acadia with the annual report sky quality readings and ways to work toward the 90% compliance.

Appendix G: Ordinances

Southwest Harbor

E. EXTERIOR LIGHTING STANDARDS

1. Exterior lighting shall be designed to minimize the adverse impact on neighboring properties and the traveling public.
2. Exterior lights shall be appropriately shielded to prevent direct light from being visible outside the property line. Luminance will not exceed 0.1 foot candles at the property line.
3. Parking area lighting, display lighting, and spotlight type fixtures attached to buildings shall be shielded, and located and maintained so as not to create or constitute a hazard or nuisance.

Town of Mount Desert Island

6A.6 Lighting - Outdoor

1. **Purpose.** To establish minimum requirements for outdoor lighting that enhance visibility and public safety by preventing uncontrolled intrusion into adjacent properties and the natural environment. Voluntary best practices are recommended to promote energy conservation and preserve the Town's night sky which is an important part of the Town's character.
2. **Requirements**
 1. **Full cutoff.** All lights greater than *1800 lumens (a 100 watt incandescent light produces 1800 lumens) shall be shielded to direct all light towards the ground. Page 6 - 3
 2. **Light trespass.** All light shall be directed away from adjacent properties. The light sources in flood and spot lights shall not be directly visible from adjacent properties. High intensity light sources shall not be directly visible to motorists on public roads.
 3. **Excessive Lighting** may not be used to direct attention away from existing business and community lighting.
 1. The lighting of structural canopies such as gas station canopies shall not be used to attract attention to the business. Areas under structural canopies shall be illuminated so that the uniformity ratio (ratio of average to minimum illumination) shall be no greater than 5:1 with an average illumination level of not more than 30 footcandles.
 2. Light fixtures located on structural canopies shall be mounted so that the lens cover is recessed or flush with the ceiling of the canopy.
3. **Recommended Best Practices:**
 1. **Motion sensors.** Use motion sensors to control flood and spot lights.
 2. **HPS lights.** Use high pressure sodium (HPS) lights to minimize sky glow where color recognition is not needed.
 3. **Non-security parking lights.** Turn off non-security parking lot lights after business hours to save energy and protect the night sky.
 4. **Minimum amount of lighting.** Provide the minimum amount of light needed to achieve safe uniform lighting with lights that consume the lowest amount of power possible.

5. **Shield or flush mount lights.** Fully shield or horizontally flush mount all lights.
 6. **Signs and flags.** Illuminate signs and flags from above and shield all sports lighting.
 7. **Guidelines for professional design.** Request that professionals follow Illuminating Engineering Society guidelines for intensity and uniformity and not to exceed the minimum recommended values.
4. **Definitions**
- Lumen: Approximately the amount of light measured one foot from a candle. 1 lumen is approximately 1 foot candle.
- *A 100 watt incandescent light produces 1800 lumens.
5. **Grandfathering.** These requirements apply only to new construction and lighting installations.

Bar Harbor

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access. If the proposed development contains any areas identified in the Comprehensive Plan or by the Maine Critical Areas Program as rare and irreplaceable natural areas, these areas shall be included as open space and suitably protected by appropriate covenants and management plans.

- Y. Heat.** No radiant heat shall be perceptible beyond the lines of the lot on which it originates.
- Z. Light and glare.** All site plans shall demonstrate that the proposed development shall comply with the following requirements with respect to exterior lighting. In addition, activities located within the Design Review Overlay District that require a certificate of appropriateness pursuant to Article XIII, Design Review, are subject to additional requirements set forth in the standards of Article XIII.

[Amended 11-2-1999; 11-4-2008

- (1) Purpose:** to establish minimum requirements for outdoor lighting that increase visibility and public safety by controlling glare and preventing intrusion into adjacent properties and the natural environment. Voluntary best practices are recommended to promote energy conservation and preserve the Town's night sky, which is a natural resource and valuable component of the Town's character.
- (2) Exemptions (with exception to lights that cause disability glare as noted herein):**
- (a)** All lighting less than 1,800 lumens.
 - (b)** Lighting of places of worship and flags, emergency, as well as approved sports lighting.
 - (c)** The temporary use of low-wattage or low-voltage lighting for public festivals, celebrations, and the observance of holidays is exempt from regulation, except where these lights may create a hazard or nuisance from glare. Light trespass requirements remain in effect; and, where possible, lighting should be full cutoff.
 - (d)** Lighting of signs in Appendix A listed as historic.
- (3) Requirements.**
- (a)** Use of full-cutoff fixtures. All lights greater than 1,800 lumens shall be shielded to direct all light towards the ground so that the lighting elements are not exposed to normal view and do not create or constitute a hazard or nuisance to motorists, pedestrians or neighboring residents.
 - [1]** Fixtures shall conform with the Illumination Engineering Society (IES) Specification for Full Cutoff to ensure lighting elements are not exposed to normal view (see the Guidelines for Lighting document provided by the Planning Department, which contains illustrations of currently available fixtures conforming with the IES specifications).
 - [2]** Disability glare. Full-cutoff fixtures shall be used so as not to create or constitute a hazard or nuisance to motorists, pedestrians or neighboring residents in the opinion of the Police

Department. High-intensity discharge (HID) light sources causing disability glare shall not be directly visible to drivers.

(b) Avoidance of light trespass. All light shall be directed away from adjacent properties. The light sources in flood- and spotlights shall not be directly visible from adjacent properties. For purposes of this subsection, abutting properties shall include properties that are separated from the lot being developed by a street, road or right-of-way.

[1] The maximum illumination of an adjacent parcel from light emitted from an artificial light source is 0.1 horizontal footcandles and 0.1 vertical footcandles when measured:

[a] At five feet inside an adjacent residential parcel.

[b] At 10 feet inside an adjacent commercial or industrial parcel.

[2] No line of sight to a light source is permitted five feet or more beyond the edge of the public right-of-way or property line in a residential district by an observer viewing from a position that is level with or higher than the ground below the fixture.

[3] Compliance is achieved with fixture shielding, directional control designed into the fixture, fixture location, fixture height, fixture aim, or a combination of these factors.

(4) Additional requirements for commercial and multifamily applications:

(a) Signs and advertising.

[1] All externally illuminated signs shall be lighted by top-mounted lights pointed downward. No sign may be illuminated with fixtures not shielded from upward transmission of light.

[2] Signs may be illuminated internally only by nonflashing lights. Any lights that flash, pulse, rotate, move, or simulate motion are not permitted.

[Amended 6-8-2010]

[3] All lights shall be shielded to ensure that light sources are not directly visible to drivers or from neighboring properties.

(b) White string mini-lights meeting the requirements of holiday lighting are allowed as part of interior window displays, in trees, bushes, and shrubs as part of the landscaping, or under canopies as part of the regular lighting if they are compatible with the building.

(c) Lighting reviewed by the Planning Board or the Design Review Board shall ensure that the style of the light and light standard is consistent with the architectural style of the principal building.

(d) The maximum height of freestanding lights shall be the same as the principal building or be no higher than 25 feet, whichever is less.

(5) Recommended best practices. Recommended practices can be found in a guidebook provided at the Planning Department.

(6) Nonconformance.

(a) All site plans and subdivisions filed after December 4, 2008, shall be in compliance with this section.

(b) Any luminaires that direct light toward streets, parking lots or the water, that cause disability glare to motorists, cyclists, pedestrians or boaters, shall either be shielded or redirected as per enforcement action under Article X and shall not be subject to any nonconforming protections.

(c) Any luminaire that replaces a nonconforming luminaire or any nonconforming luminaire that is moved must meet the standards of this chapter.

AA. Noise. All site plans shall demonstrate that the proposed development will comply in all applicable respects with the Bar Harbor Noise Ordinance, Chapter 139, Noise, of the Bar Harbor Code.

BB. Signs and advertising. All site plans shall demonstrate that all signs related to the proposed development will comply with the following standards, to which all signs located within the Town of Bar Harbor are subject, regardless of the need for site plan approval. In addition, activities located within the Design Review Overlay District that require a certificate of appropriateness pursuant to Article XIII, Design Review, are subject to additional requirements set forth in the standards of Article XIII.

[Amended 11-5-1991; 11-2-1999; 11-4-2003; 6-13-2006; 11-7-2006; 11-6-2007; 6-9-2009]

(1) Purpose and intent. To establish clear direction on regulating and reviewing signage by applying specific criteria standards that will prescribe fair and consistent standards in order to:

(a) Allow description of goods and services.

(b) Enhance character of the area.

(c) Enhance architectural elements of a building.

(d) Use minimum wording and sign size to avoid cluttered appearance.

(e) Encourage compatible materials, color, scale and design to provide consistency with the existing building and its environs.

(f) Improve traffic, pedestrian and public safety; reduce distractions and obstructions.

(g) Protect and enhance property values.

(h) Respect the historical elements of a building, property and district.

Appendix H: Raw Data

Starting on the next page, all the data is in CSV form. Full SQL queries and more representations can be found at <https://bitbucket.org/byteit101/androidmedae> or by searching for 6f25b979a6c04707432159341497269f913b45f39bbf573d37459b067b24b9c0

X,Y,gid,altitude,acquisition,satellites,acquired,magnitude,temperature,orientation,altitude,orientation,compass,orientation,timestamp,weather,dataset_minor,dataset_section,notes,sgm_id,record_id,device_id,collection_mode,mode_id,mode_arg,appver,upload_id,humidity

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##-18810290000004, 44.3888111, 2412, 53, 3, 2014-06-19 23:51:29.949-04.21.68, 14.8., -1.51087, -0.23947, 2.04021, Clear, 2.0, 0., 2337.8910, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2413, 53, 3, 2014-06-19 23:51:29.251-04.21.68, 14.8., -1.47198, -1.68382, -1.31094, Clear, 2.0, 0., 2337.8911, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2414, 53, 3, 2014-06-19 23:51:31.251-04.21.68, 14.8., -1.41851, -0.21025, -0.4, Clear, 2.0, 0., 2337.8912, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2415, 53, 3, 2014-06-19 23:51:33.251-04.21.68, 14.8., -1.51299, -0.31805, -1.9721, Clear, 2.0, 0., 2337.8913, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2416, 53, 3, 2014-06-19 23:51:35.251-04.21.68, 14.8., -1.52849, -0.58026, -0.30417, Clear, 2.0, 0., 2337.8914, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2417, 53, 3, 2014-06-19 23:51:37.251-04.21.68, 14.8., -1.47887, -0.791, -0.2091, Clear, 2.0, 0., 2337.8915, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2418, 53, 3, 2014-06-19 23:51:39.251-04.21.68, 14.8., -1.46875, -0.74073, -0.54728, Clear, 2.0, 0., 2337.8916, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2419, 53, 3, 2014-06-19 23:51:41.251-04.21.68, 14.8., -1.37962, -0.72771, -1.56301, Clear, 2.0, 0., 2337.8917, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2420, 53, 3, 2014-06-19 23:51:43.251-04.21.68, 14.8., -1.46427, -0.544, -1.53105, Clear, 2.0, 0., 2337.8918, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2421, 53, 3, 2014-06-19 23:51:45.251-04.21.68, 14.8., -1.51557, -0.74047, -0.41446, Clear, 2.0, 0., 2337.8919, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2422, 53, 3, 2014-06-19 23:51:47.251-04.21.68, 14.8., -1.5392, -0.09598, 2.18874, Clear, 2.0, 0., 2337.8920, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2423, 53, 3, 2014-06-19 23:51:49.251-04.21.68, 14.8., -1.38953, -0.27316, -0.73147, Clear, 2.0, 0., 2337.8921, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2424, 53, 3, 2014-06-19 23:51:51.251-04.21.68, 14.8., -1.5362, 2.70982, -1.28445, Clear, 2.0, 0., 2337.8922, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2425, 53, 3, 2014-06-19 23:51:53.251-04.21.68, 14.8., -1.51046, -0.5162, -0.21364, Clear, 2.0, 0., 2337.8923, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2426, 53, 3, 2014-06-19 23:51:55.251-04.21.68, 14.8., -1.39915, -1.36849, -0.61481, Clear, 2.0, 0., 2337.8924, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2427, 53, 3, 2014-06-19 23:51:57.251-04.21.68, 14.8., -1.49268, 0.04393, -0.95706, Clear, 2.0, 0., 2337.8925, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2428, 52, 3, 2014-06-19 23:51:59.251-04.21.68, 14.8., -1.45901, -0.62286, -1.45779, Clear, 2.0, 0., 2337.8926, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2429, 52, 3, 2014-06-19 23:52:01.251-04.21.68, 14.8., -1.49798, -0.97873, -1.42447, Clear, 2.0, 0., 2337.8927, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2430, 52, 3, 2014-06-19 23:52:03.251-04.21.68, 14.8., -1.55488, -1.09568, -1.84818, Clear, 2.0, 0., 2337.8928, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2431, 52, 3, 2014-06-19 23:52:05.251-04.21.68, 14.8., -1.49408, -0.22525, 0.02852, Clear, 2.0, 0., 2337.8929, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2432, 52, 3, 2014-06-19 23:52:07.251-04.21.68, 14.8., -1.47446, -1.27592, 0.99705, Clear, 2.0, 0., 2337.893, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2433, 52, 3, 2014-06-19 23:52:09.251-04.21.68, 14.8., -1.47446, -1.27592, 0.99705, Clear, 2.0, 0., 2337.893, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2434, 51, 3, 2014-06-19 23:52:11.251-04.21.68, 14.8., -1.19272, -1.31593, 0.96868, Clear, 2.0, 0., 2337.893, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2435, 51, 3, 2014-06-19 23:52:13.251-04.21.68, 14.8., -1.51111, -1.4896, -0.52048, Clear, 2.0, 0., 2337.893, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2436, 51, 3, 2014-06-19 23:52:15.251-04.21.68, 14.8., -1.42329, -1.9167, -0.36193, Clear, 2.0, 0., 2337.893, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2437, 51, 3, 2014-06-19 23:52:17.251-04.21.68, 14.8., -1.45834, 0.78287, -0.0359, Clear, 2.0, 0., 2337.893, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2438, 51, 3, 2014-06-19 23:52:19.251-04.21.68, 14.8., -1.4414, -0.1608, -0.21028, Clear, 2.0, 0., 2337.893, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2439, 51, 3, 2014-06-19 23:52:21.251-04.21.68, 14.8., -1.4692, -0.4124, -1.16976, Clear, 2.0, 0., 2337.893, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2440, 51, 3, 2014-06-19 23:52:23.251-04.21.68, 14.8., -1.4192, 0.8882, -0.0969, Clear, 2.0, 0., 2337.893, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2441, 51, 3, 2014-06-19 23:52:25.251-04.21.68, 14.8., -1.48807, -0.0202, 0.2034, Clear, 2.0, 0., 2337.893, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2442, 51, 3, 2014-06-19 23:52:27.251-04.21.68, 14.8., -1.48807, -0.0202, 0.2034, Clear, 2.0, 0., 2337.893, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2443, 51, 3, 2014-06-19 23:52:29.251-04.21.68, 14.8., -1.42027, -1.7703, 0.52397, Clear, 2.0, 0., 2337.894, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2444, 51, 3, 2014-06-19 23:52:31.251-04.21.68, 14.8., -1.52361, -1.7949, -1.4476, Clear, 2.0, 0., 2337.894, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2445, 50, 3, 2014-06-19 23:52:33.251-04.21.68, 14.8., -1.44754, -1.25896, -2.1707, Clear, 2.0, 0., 2337.894, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2446, 50, 3, 2014-06-19 23:52:35.251-04.21.68, 14.8., -1.39232, -0.8714, -0.57079, Clear, 2.0, 0., 2337.894, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2447, 50, 3, 2014-06-19 23:52:37.251-04.21.68, 14.8., -1.43242, -0.568, -1.4937, Clear, 2.0, 0., 2337.894, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2448, 50, 3, 2014-06-19 23:52:39.251-04.21.68, 14.8., -1.50478, 0.27141, -1.30433, Clear, 2.0, 0., 2337.894, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2449, 50, 3, 2014-06-19 23:52:41.251-04.21.68, 14.8., -1.50651, -0.0270, 0.27489, Clear, 2.0, 0., 2337.894, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2450, 50, 3, 2014-06-19 23:52:43.251-04.21.68, 14.8., -1.42329, -1.9167, -0.36193, Clear, 2.0, 0., 2337.894, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2451, 50, 3, 2014-06-19 23:52:45.251-04.21.68, 14.8., -1.48979, -1.2670, -1.0158, Clear, 2.0, 0., 2337.894, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2452, 50, 3, 2014-06-19 23:52:47.251-04.21.68, 14.8., -1.50645, -0.0772, -0.9137, Clear, 2.0, 0., 2337.895, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2453, 50, 3, 2014-06-19 23:52:49.251-04.21.68, 14.8., -1.5268, -0.7462, -0.21028, Clear, 2.0, 0., 2337.895, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2454, 50, 3, 2014-06-19 23:52:51.251-04.21.68, 14.8., -1.467, 2.67424, -1.31694, Clear, 2.0, 0., 2337.895, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2455, 49, 3, 2014-06-19 23:52:53.251-04.21.68, 14.8., -1.49493, -0.8109, -0.54965, Clear, 2.0, 0., 2337.895, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2456, 49, 3, 2014-06-19 23:52:55.251-04.21.68, 14.8., -1.48979, -1.2670, -1.0158, Clear, 2.0, 0., 2337.895, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2457, 49, 3, 2014-06-19 23:52:57.251-04.21.68, 14.8., -1.47343, 1.04747, -0.90218, Clear, 2.0, 0., 2337.895, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2458, 49, 3, 2014-06-19 23:52:59.251-04.21.68, 14.8., -1.48511, -0.20929, 0.0676, Clear, 2.0, 0., 2337.895, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2459, 49, 3, 2014-06-19 23:53:01.251-04.21.68, 14.8., -1.46327, -0.10078, 0.8996, Clear, 2.0, 0., 2337.895, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2460, 49, 3, 2014-06-19 23:53:03.251-04.21.68, 14.8., -1.43289, 0.96709, -1.04399, Clear, 2.0, 0., 2337.895, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2461, 49, 3, 2014-06-19 23:53:05.251-04.21.68, 14.8., -1.38808, -0.63181, -1.6296, Clear, 2.0, 0., 2337.895, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2462, 49, 3, 2014-06-19 23:53:07.251-04.21.68, 14.8., -1.40849, -0.26815, -1.9213, Clear, 2.0, 0., 2337.895, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2463, 49, 3, 2014-06-19 23:53:09.251-04.21.68, 14.8., -1.4724, 0.1035, 2.3654, Clear, 2.0, 0., 2337.896, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2464, 49, 3, 2014-06-19 23:53:11.251-04.21.68, 14.8., -1.4239, -1.08792, 0.2268, Clear, 2.0, 0., 2337.896, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2465, 49, 3, 2014-06-19 23:53:13.251-04.21.68, 14.8., -1.4239, -1.08792, 0.2268, Clear, 2.0, 0., 2337.896, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2466, 49, 3, 2014-06-19 23:53:15.251-04.21.68, 14.8., -1.4749, -0.90765, -1.36011, Clear, 2.0, 0., 2337.896, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2467, 49, 3, 2014-06-19 23:53:17.251-04.21.68, 14.8., -1.39643, 0.19029, -0.4524, Clear, 2.0, 0., 2337.896, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2468, 49, 3, 2014-06-19 23:53:19.251-04.21.68, 14.8., -1.4608, 0.7926, -0.49309, Clear, 2.0, 0., 2337.896, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2469, 49, 3, 2014-06-19 23:53:21.251-04.21.68, 14.8., -1.4328, 0.68151, -1.57349, Clear, 2.0, 0., 2337.897, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2470, 49, 3, 2014-06-19 23:53:23.251-04.21.68, 14.8., -1.3079, -0.20975, -2.0399, Clear, 2.0, 0., 2337.898, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2471, 49, 3, 2014-06-19 23:53:25.251-04.21.68, 14.8., -1.4827, -0.4446, -1.82049, Clear, 2.0, 0., 2337.898, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2472, 49, 3, 2014-06-19 23:53:27.251-04.21.68, 14.8., -1.52917, -1.17294, -1.30038, Clear, 2.0, 0., 2337.898, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2473, 49, 3, 2014-06-19 23:53:29.251-04.21.68, 14.8., -1.4657, -1.4451, -0.83691, Clear, 2.0, 0., 2337.897, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2474, 49, 3, 2014-06-19 23:53:31.251-04.21.68, 14.8., -1.4511, -0.6137, -1.1857, Clear, 2.0, 0., 2337.897, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2475, 49, 3, 2014-06-19 23:53:33.251-04.21.68, 14.8., -1.4227, -1.8671, 0.41525, Clear, 2.0, 0., 2337.897, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2476, 50, 3, 2014-06-19 23:53:35.251-04.21.68, 14.8., -1.3921, -0.0439, 0.2468, Clear, 2.0, 0., 2337.897, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2477, 50, 3, 2014-06-19 23:53:37.251-04.21.68, 14.8., -1.4854, 0.9626, -0.32703, Clear, 2.0, 0., 2337.897, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2478, 50, 3, 2014-06-19 23:53:39.251-04.21.68, 14.8., -1.44347, -1.01674, -1.24915, Clear, 2.0, 0., 2337.897, Zefc3173056a05ab, 0, 0, 0, 5, 4, 11, 67

##-1881029199999994, 44.3888069, 2479, 49, 3, 2014-06-19 23:53:41.251-04.21.68, 14.8., -1.3421, -1.3431, -0.94466, Clear, 2.0, 0., 2337.898, Zefc3173056

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Appendix I: AAS Presentation

The Bar Harbor Dark Sky

Acadia Astronomical Society

MEETING WEDNESDAY JULY 9TH

WPI 2014 Dark Sky IQP Team

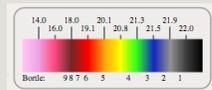
To address light pollution in and around Acadia by collecting vital data and increasing awareness.

Sky Quality Analysis
Educational Evaluation
International Dark-Sky Association Application

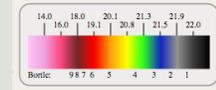
www.bortle.cs.wpi.edu

Sky Quality MDI and Schoodic

<https://bortle.cs.wpi.edu/view.html#12,0026,3296/-68,7330>



Sky Quality Bar Harbor



The City Dark (2011)

16:02



From Schoodic Facing Bar Harbor

Photo: Patrick Plenefsch



Schoodic Facing Bar Harbor

Photo: Patrick Plenefisch



From Schoodic Facing Bar Harbor and Winter Harbor

Photo: Patrick Plenefisch



Cad Mt facing Serc, Winter and Prospect Harbor

Photo: Patrick Plenefisch

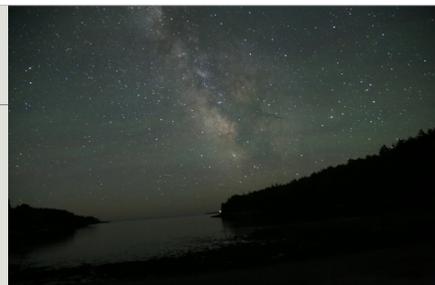


From Cad Mt facing Northeast Harbor



Past Otter Cove from Park Loop Road

Photo: Patrick Plenefisch



Otter Cove w/Lighthouse

Photo: Patrick Plenefisch



Moonrise from Park Loop Road

Photo: Patrick Plenefisch



Eagle Lake Viewing Stars and Saturn

Photo: Patrick Plenefisch



Geddy's Moose

Photo: Patrick Plenefisch



Facing Winter Harbor on from Schoodic

Photo: Patrick Plenefisch



Milky Way over Cadillac Mountain & Eagle Lake

Photo: Patrick Plenefisch

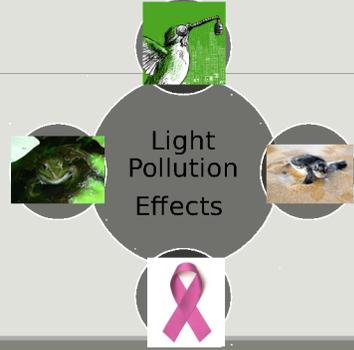
Discussions



Why Should We Preserve the Dark Sky?



Schoodic Looking to Bar Harbor
Photo: Patrick Plenefisch



How Should We Preserve the Dark Sky?



<http://www.skylandsastronomy.com/neighborsnew.gif>



Winter Harbor Lights

Photo: Patrick Plenefisch



Winter Harbor Lights

Photo: Patrick Plenefisch

Preserving the Dark Sky

Z. Light and glare. All site plans shall demonstrate that the proposed development shall comply with the following requirements with respect to exterior lighting. In addition, activities located within the Design Review Overlay District that require a certificate of appropriateness pursuant to Article XIII, Design Review, are subject to additional requirements set forth in the standards of Article XIIE.

[Amended 11-2-1999; 11-4-2008]

- (1) Purpose: to establish minimum requirements for outdoor lighting that increase visibility and public safety by controlling glare and preventing intrusion into adjacent properties and the natural environment. Voluntary best practices are recommended to promote energy conservation and preserve the Town's night sky, which is a natural resource and valuable component of the Town's character.
- (2) Exemptions (with exception to lights that cause disability glare as noted herein):
 - (a) All lighting less than 1,800 lumens.
 - (b) Lighting of places of worship and flags, emergency, as well as approved sports lighting.
 - (c) The temporary use of low-voltage or low-voltage lighting for public festivals, celebrations, and the observance of holidays is exempt from regulation, except where these lights may create a hazard or nuisance from glare. Light trespass requirements remain in effect; and, where possible, lighting should be full cutoff.
 - (d) Lighting of signs in Appendix A listed as historic.

What Are Lumens?

Lumen is standard unit of light measure by how it is perceived by the human eye

- 40 watt incandescent = 380 - 460 Lumens
- 60 watt incandescent = 750 - 850 lumens
- 75 watt incandescent = 1100 - 1300 lumens
- 100 watt incandescent = 1700 - 1800 lumens**
- Direct sunlight = 100,000 lumens.



Building Lights

Area Lights

Shoreline and Dock Lights

Use Timers
- on at sunset
- off 2-hours later

Use Motion Sensors
- lights on only when needed

Use "Warm Light"
- not blue white light

Shield & Set Back

Outdoor Lighting Protocol

RASC and IDA GOL, Autumn, 2012 pg36
http://www.earth.org/files/118001_118001_118001/118001/350px-HELP2_MERIS.jpg



Promoting Dark Sky Friendly Lighting

<http://www.standassociates.com/wp-content/uploads/2013/02/green-lighting-solution-vn09.jpg>



**San Francisco
Oakland Bay Bridge**

Darkened Cities

Photo Credit to Thierry Cohen and Danziger Gallery



**New York
Empire State Building**

Darkened Cities

Photo Credit to Thierry Cohen and Danziger Gallery



**France
Notre Dame**

Darkened Cities

Photo Credit to Thierry Cohen and Danziger Gallery



**Brazil
Rio de Janeiro**

Darkened Cities

Photo Credit to Thierry Cohen and Danziger Gallery



**Japan
Tokyo**

Darkened Cities

Photo Credit to Thierry Cohen and Danziger Gallery

Appendix J: AAS Preparation

Acadia Astronomy Society
Meeting Wednesday July 9th

Preparation:

Watch "the City Dark"

Read 'Ecological Consequences of Artificial Light At Night'
'End of Night'

Review Ordinance

Discussion Points:

1. Why should we preserve the dark sky?

astronomy (aesthetic, research, getting people interested in science)

ecology (altering species balance, predator prey availability and distribution)

health (cancer, SAD, sleep/wake, mental health)

tourism (Bar Harbor/Acadia)

spiritual/cultural

economic development (other dark sky opportunities)

safety (explain why HID security lights are a myth-illustrate? maybe goes in topic 2.)

2. How should we preserve the dark sky?

Lighting technologies (illustrate)

Lighting reduction

3. How do we promote dark sky friendly lighting? (roles - actions)

individual actions - changing lighting, monitoring violations

homeowners - changing lighting

businesses - changing lighting, marketing lighting products

town - enforcement and education, streetlights, etc

policy - amendments to the ordinance, enforcement

advocates - letters to the editor, organize 'lights out bar harbor/maine'

educators - mention preservation at the scope, lighting demo on display at events, in town hall,

informational mailing, illustrating the ordinance, town specific information at festival, other area towns,

Park-become dark sky preserve

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