Integrating Technology Into Glacier National Park's Common Loon Citizen Science Project

An Interactive Qualifying Project
submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfilment of the requirements for the
degree of Bachelor of Science

by
Seth Chaves
Kyle Lang
Danielle Lavigne
Molly Youngs

Date:
11 October 2019

Report Submitted to:

Professor Frederick Bianchi
Worcester Polytechnic Institute

Abstract

The Common Loon Citizen Science Project in Glacier National Park is currently dealing with an uneven distribution of citizen scientists and the over involvement of staff. In order to mitigate this uneven distribution of citizen scientists, our group was asked to develop a tool that would allow citizen scientists to redirect their focus based on the number of surveys at different lakes. Our group developed a mapping application that displays basic information about the different lakes in the park so that citizen scientists can efficiently plan out their survey sites, decreasing the involvement of the staff and promoting a more even distribution of data points throughout the park's lakes.

Acknowledgements

This project was made possible due to the assistance from numerous groups and people. We have thoroughly enjoyed our past seven weeks in Glacier National Park. We are thankful for the opportunity that WPI's IQP program provides for all students to gain real-world experience in exciting places across the globe. Thank you to the National Park Service for hosting us and doing spectacular work preserving our country's natural landscape.

We would like to thank the staff of the Crown of the Continent Research Learning Center. Nathanael Wold was invaluable to our project. He provided constant guidance during the development process and was very responsive to the many questions we had. In addition, he was kind enough to take us out into the park and conduct a loon survey with our team. Jami Belt and Anya Tyson both gave valuable insight into the program and constructive criticism on the map. They also helped to plan out the team's loon survey. Tara Carolin was instrumental in bringing not only our team, but the entire IQP group to the park. Without her, this IQP would not have been possible. Ginger Rigdon assisted the team with logistics and basic park information.

Thank you to Professor Bakermans for providing valuable insight during our interview. Finally, thank you to Professor Bianchi and Doctor Balistrieri. Doctor Balistrieri provided valuable feedback and criticism during the creation of our proposal, which built a solid foundation for the construction of the paper and the project. Professor Bianchi guided us throughout the entire project. He was always willing to meet and was very responsive. His useful feedback and wisdom helped to mold the project. In addition, he worked with Tara Carolin to set up the IQP projects.

Authorship

	Writer	Editor
Abstract	**KRL**	**SJC**
Acknowledgements	**MWY**	**SJC**
Authorship	**KRL**	**ALL**
Table of Contents	**MWY**	**MWY**
Table of Figures	**MWY**	**SJC**
Executive Summary	**KRL**	**SJC**
1. Introduction	**SJC**	**ALL**
2. Background		
2.1 National Parks Service	KRL	ALL
2.2 Glacier National Park	DEL	ALL
2.3 Climate Change	MWY	ALL
2.4 Citizen Science	DEL	ALL
2.5 Common Loon	MWY	ALL
2.6 Liaison	MWY	ALL
2.7 Esri Products	MWY	ALL
3. Methodology		
3.1 On-Site Research	KRL	ALL
3.2 Experimentation	KRL	ALL
3.3 Development	SJC	ALL
3.4 Testing	KRL	ALL
4. Results and Analysis		
4.1 Basemaps	SJC	ALL
4.2 WebApp	KRL	ALL
4.3 Elevation Profile	SJC	ALL
4.4 Employee Map	KRL	ALL
4.5 Benefits	SJC	ALL
5. Recommendations and Conclusion	**MWY**	**ALL**
Bibliography	**SJC**	**ALL**
Appendices		

Appendix A	MWY	ALL
Appendix B	MWY	ALL
Appendix C	SJC&KRL	ALL
Appendix D	ALL	ALL
Appendix E	SJC&KRL	MWY
Appendix F	ALL	ALL

Table of Contents

Table of Figures

Executive Summary

The Common Loon Citizen Science Project in Glacier National Park faced extensive processing times and an uneven distribution of citizen scientists within their program. The Crown of the Continent Research Learning Center (CCRLC) runs the Common Loon Citizen Science Project and organizes the citizen scientists within the park. They currently utilize pen and paper collection to conduct surveys on the breeding common loon population in Glacier National Park. The paper surveys are then collected and manually entered into an online database, which leads to extensive processing times of the information. Citizen scientists are also given a large file of paper documents to help them plan where in the park they should conduct a loon survey. The file is bulky and the information within is spread amongst numerous pages. This large file of documents contains no information on how many surveys have been conducted at each lake or when the last survey was conducted. As a result, citizen scientists are left to choose survey sites solely based on priority and hike type, which leads to an uneven distribution of citizen scientists across the forty-five priority lakes in the park.

To help combat the issues the Common Loon Citizen Science Project faced, three web applications were developed. These applications were developed to consolidate important information into one platform to assist citizen scientists in choosing survey sites. The first web application is a public map that includes information on hike difficulties, lake priorities, number of surveys, the last date a survey was conducted, and additional information about the priority lakes in the park. The second web application is a tool that provides the elevation profile for a variety of trails that lead to different survey locations within the park. The elevation profile gives citizen scientists a sense of the terrain leading out to the survey sites and allows them to gauge their ability to get to a specific lake. The third web application is an employee map that provides employees the same information as the public mapping application, except it contains more sensitive information. This information includes the total number of birds, the number of chicks, nest status, etc. These three mapping applications were given to the CCRLC to improve the efficiency of the Common Loon Citizen Science Project and to mitigate the uneven distribution of citizen scientists in the park.

We developed these applications by completing the following steps:

1. Explore citizen science programs
2. Research ArcGIS Online
3. Develop maps that plot the data points collected by the Common Loon Citizen Project utilizing the standard ArcGIS Online map-building platform
4. Provide recommendations for future consideration

Displayed below is the public web application.
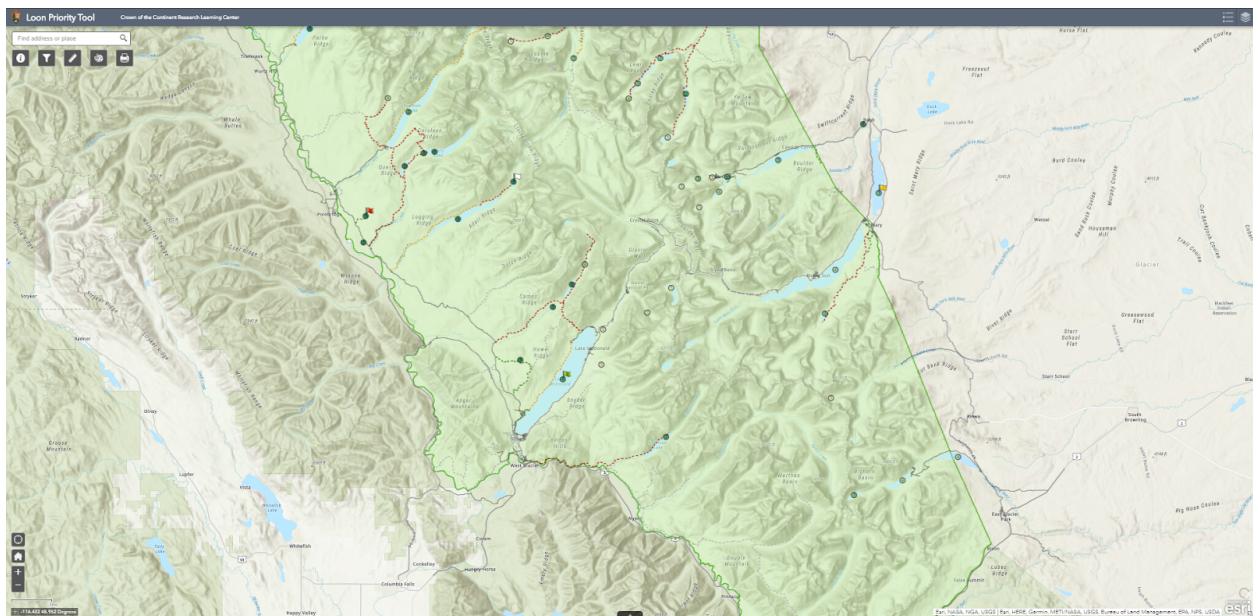
Figure 1: Public Mapping Application

Taken from (Lang, 2019a)

This is the public mapping application as viewed on a laptop.

After the development of the three applications, a list of recommendations was created to help guide the program in the future. The applications could be updated with a variety of live layers that give information on weather alerts, trail status, and road closures. This would consolidate more information in one location, increasing the ease of use for citizen scientists. The elevation profile could also be added to the public mapping application in the future. Currently, this is only possible if the application is hosted on a custom server which is not the

case in Glacier. Citizen scientists with little technological experience may have difficulty navigating the public mapping application. An information session could be included in the existing training session to help familiarize users with the tool. The program still uses a variety of documents to help guide and spread necessary information to citizen scientists. Having these documents easily accessible from the mapping application would reduce paper usage and increase convenience for the citizen scientists. The CCRLC also runs the High Country Citizen Science Project. Developing a new application for this project could help in the volunteer distribution process. Moving more of the common loon training session online could get more volunteers involved in the program. Citizen scientists who are planning a day trip could participate in the program instead of spending the day in a training session. The future integration of technology will help the Common Loon Citizen Science Project become more efficient, which will help the CCRLC better monitor the species.

1. Introduction

The National Park Service helps to preserve historically important monuments and grounds in the United States. Currently, the organization is struggling to modernize due to an increasing maintenance backlog, decreasing budget, and reduction of staff. As of the 2017 fiscal year, the National Park Service's estimated maintenance backlog amounts to $11.6 billion (National Park Service, 2018b). The 2020 budget proposal shows an overall funding of $2.7 billion and a call to cut over 400 staff members (Repanshek, 2019). The effect of the National Park Service's current financial situation limits the programs and research opportunities available in the parks. As a result, the National Park Service is searching for new and efficient methods to improve their programs without further dividing their budget.

Glacier National Park offers a variety of educational and research-based programs in order to understand the changes occurring in their ecosystems. Budget and staff cuts can greatly affect the scope and continuation of these programs. With over one million acres of land to monitor, staff cuts have a significant impact on where and what can be feasibly investigated (National Geographic, 2019). One of the ways Glacier has combated this issue is to involve visitors in their citizen science programs. Citizen scientists help to survey the variety of

ecosystems and report their findings back to the park's research and learning center, saving the park time and money. Due to its importance, Glacier is always looking for ways to improve and optimize this program.

While Glacier's citizen science program continues to provide researchers with vital information, some of the program's practices have become dated. Sorting through the piles of collected data is time consuming and results in significant processing times before the data can be published. Additionally, some survey sites are receiving an overabundance of participants while others could benefit from increased participation. The uneven distribution of participants and downtime in data dissemination shows that the current methods in place have reached their practical limits. The transition from paper and pencil to technology will allow those in charge of the program to analyze their environment more efficiently.

Technological advancements have greatly improved the efficiency at which data can be processed. Ideally, all of Glacier's citizen science programs would utilize a platform that would record participant's observations, sort the data, and then display the results in a variety of infographics with minimal downtime. This platform could be accessed from a variety of devices including personal computers, laptops, and cell phones. Researchers would be able to spend more time using the data and participants could see the fruits of their labor in near real-time. Additionally, potential participants could view locations that are lacking in observations and choose to explore those areas instead. Glacier has shown interest in utilizing a platform known as Survey123 to help achieve these goals.

The purpose of our project is to provide an efficient and effective means of organizing citizen science data collection for the Common Loon Citizen Science Project and to include a specific set of recommendations. A map available to program participants would provide easy access for participants to view available survey sites, as well as the data collected at each site. The first objective is to explore citizen science programs. The second objective is to research ArcGIS Online. The third objective is to develop a map that plots the data points collected by the Common Loon Citizen Project utilizing the standard ArcGIS Online map-building platform. The fourth objective is to provide a set of recommendations for future consideration.

2. Background

2.1 National Parks Service

The United States of America is home to many national parks that foster and protect a collection of natural beauty from coast to coast. A national park is defined as a scenic or historically important area of countryside protected by the federal government for the enjoyment of the general public or the preservation of wildlife (National Park Service, n.d.b). Ronald F. Lee, a past National Park Service Chief Historian, described some of the national parks and monuments as "crown jewels" (Lee, 1972). In order to be deemed a national park, a piece of land must meet certain qualifications.

The first qualification to become a national park is to possess nationally significant natural, cultural, or recreational resources (Jones and Jones, 2001). In order to become a national park, a piece of land must hold some sort of value or aspect that demands conservation or protection. For example, Acadia National Park in Maine protects the natural beauty of the highest rocky headlands along the Atlantic coastline of the United States (National Park Service, 2019a). Another example is the Everglades National Park in Florida which protects an unparalleled landscape that provides important habitat for numerous rare and endangered species like the manatee, American crocodile, and the elusive Florida panther (National Park Service, 2019c). These examples of specific values and aspects constitute the necessity of national park protection and conservation. The protection and conservation of designating a piece of land as a national park ensures the existence of these specific pieces of land for future generations to experience and enjoy.

The second qualification to become a national park is to be a suitable and feasible addition to the National Park System (Jones and Jones, 2001). The National Park System is composed of 419 units, commonly referred to as parks, more than 150 related areas, and numerous programs that assist in conserving the nation's natural and cultural heritage for the benefit of current and future generations (National Park Service, 2019f). The qualifications to become a unit of the National Park System and the qualifications to become a national park in the National Park System differ. In fact, the National Park System "units" have at least nineteen

naming designations (National Park Service, 2019f). These units include national parks, national battlefields, national monuments, national reserves, national seashores, etc. (National Park Service, 2019f). These related areas include affiliated areas, national trail systems, national wild and scenic rivers system, etc. (National Park Service, 2019f). Collectively, the National Park System, excluding related areas, covers more than 85 million acres in all 50 states, the District of Columbia, and U.S. Territories (National Park Service, 2019f). This 85 million acres is managed by the National Park Service, therefore an addition to the National Park System includes the ability of the National Park Service to manage the piece of land under investigation to become a national park (National Park Service, 2019h).

The third qualification is that a national park is required to be directly managed by the National Park Service instead of protection by some other government agency or by the private sector. The National Park Service is a federal bureau in the Department of the Interior responsible for maintaining national parks and monuments (National Park Service, 2019h). The National Park Service was created on August 25, 1916 by the "Organic Act" signed by President Woodrow Wilson (National Park Service, 2019f). Before the establishment of the National Park Service, national parks, monuments, and other related areas were the responsibility of the Department of the Interior, the War Department, and the U.S. Forestry Service (National Park Service, 2018). Therefore, the purpose of the Organic Act was to place the management of the national park system under one agency instead of multiple.

The mission of the National Park Service is to preserve the natural and cultural resources and values of the National Park System for the enjoyment, education and inspiration of this and future generations (National Park Service, 2019h). As a governmental agency, the National Park Service receives government funding to pay its 20,000 employees along with the costs associated with managing and maintaining the units of the National Park System (National Park Service, 2019f). The service is headed by a director who is appointed by the President of the United States and then approved by the Senate (National Park Service, 2019h). The National Park Service also consists of seven Regional Directors that are directly responsible for national park management and program implementation in their respective regions, which can be seen in

Figure 1 (National Park Service, n.d.c). The National Park Service is the backbone of the National Park System that serves nearly 330 million visitors annually.

Fig. 2: Map of National Park Service Regions

Taken and adapted from (National Park Service, n.d.c.)

This map displays the National Park Service regional breakdown. Different parks are represented by the green dots on the map.

The National Park Service's official emblem reflects the values and qualities of national parks across the country. The emblem consists of a Sequoia tree, a bison, mountains and water, all encased in an arrowhead. The emblem in Figure 2 was made the official emblem of the National Park Service in 1951 (National Park Service, 2019h). Each part of the National Park Service's emblem has a specific meaning. The Sequoia tree and bison represent the vegetation and wildlife (National Park Service, 2019h). The mountains and water represent the scenic and recreational values (National Park Service, 2019h). The arrowhead represents the historical and archeological values protected by the U.S. national Park service (National Park Service, 2019h). The emblem can be seen at the entrance of any of the 61 national parks that the National Park Service is responsible for and is meant to remind visitors of the importance of the protection and conservation of the national parks and the natural beauty of the United States of America.

Fig. 3: National Park Service Emblem

Taken and adapted from (United States Geological Survey, n.d.a)

This is the official National Park Service Emblem as of 1951.

Since the establishment of Yellowstone National Park in 1872, the United States and the world has seen significant development and technological advancements that the National Park System needed to adapt. With the turn of the century, the National Park Service held a symposium in Vail, Colorado to establish recommendations in order to ensure the success of the National Park System (National Park Service, 2016c). These recommendations were organized into the Vail Agenda which set multiple different tasks for the National Park Service to complete (National Park Service, 2016c). These tasks were broken into six different groups: Resource Stewardship and Protection, Access and Enjoyment, Education and Interpretation, Proactive Leadership, Science and Research, and Professionalism. The agenda suggested that the National Park Service focus on forging state and local level partnerships to help maintain and further develop the parks. For example, the symposium led to the creation of National Heritage Areas, federally designated historic regions that are owned and maintained at a state or local level but still receive funding from the National Park Service (National Park Service, 2016c). The agenda also established the Recreational Fee Demonstration Program which allowed certain sites to test fee increases for admissions and different facilities/activities (National Park Service, 2016c). The Vail Agenda established multiple tasks and goals for the National Park Service that would help

them succeed in the 21st century, however one of the goals, important specifically to our project, was to expand upon the research and learning that is happening in the national parks.

Since the National Park Service is a federal bureau in the Department of the Interior, it receives a new budget each year from the federal government. The budget proposal for the 2020 fiscal year (FY) cuts funding to the Department of the Interior's by fourteen percent (Repanshek, 2019). This would result the overall funding for the National Park Service to be roughly 2.7 billion dollars (Repanshek, 2019). While this is an increase to the budget when compared to the 2018 FY, it is a net decrease over the 2016 FY budget which reached 2.85 billion dollars (National Park Service, n.d.d.). Overall, the proposed 2020 FY budget has a net cut of 460.4 million dollars to various programs within the bureau (Repanshek, 2019). A decreasing budget is not the only issue that the National Park Service faces. During the 2017 FY, the National Park Service estimated that they had an 11.6 billion dollar maintenance backlog (National Park Service, 2018). This backlog includes repairs to the roads, bridges, buildings, and trails that are used by park visitors and employees daily (National Park Service, 2018b). While the National Park Service used over 650 million dollars to address the backlog in 2017 alone, the backlog has remained between 11 billion and 12 billion dollars since 2010 (National Park Service, 2018b). This is due to an increase in the number of yearly visitors, an aging infrastructure, and an overall decreasing budget (National Park Service, 2018b). Despite these financial constraints, the National Park Service has continued to try to improve upon its current programs with new technology.

The National Park Service has many programs in place that integrate new technology into the national parks. For example, the National Park Service has deployed webcams that overlook Brooks Falls in Katmai National Park in Alaska where brown bears can be seen catching salmon in the falls (National Park Service, n.d.a). Integration of technology such as "bear cams" increases society's interest in national parks because people who do have direct access to the park can now realize the importance of conservation and protection of the United States national park system. The National Park Service also employs multiple different social media platforms, such as Instagram, Facebook, and Twitter, to post pictures, updates, and news of the park for the public to view and keep up with as seen in Figure 3. The integration of current technology into

the National Park System allows for the National Park Service to stay up to date with society and continue to display to the public the importance of the national parks and the purpose they serve.

Fig. 4: National Park Service Social Media

Taken and created from Piktochart

This graphic displays the various social media platforms that the National Park Service can be found on.

2.2 Glacier National Park

Human habitation dates back over 10,000 years, when several different Native American tribes inhabited the area (National Park Service, n.d.e). These tribes traveled over the mountains to hunt the great herds of buffalo on the eastern plains (National Park Service, n.d.e). The Blackfeet Tribe controlled vast prairies east of the mountains, and the Salish and Kootenai Tribes lived in the western valleys (National Park Service, n.d.e). Today, the Blackfeet tribe still controls the land east of the park.

In the early 1800s, Europeans arrived in search of pelts. Exploration of the area soon opened up the region to a variety of trading activities between the indigenous and European settlers (National Park Service, n.d.e).

In 1806, the Lewis and Clark Expedition came within 50 miles of what is present-day Glacier National Park (National Park Service, 2016a). By the mid-1800s, most of the land had been explored by the European settlers (National Park Service, 2016a). Glacier National Park hosted a multitude of resources that attracted early settlers, such as pelts, home sites, coal, metals, oil, and beautiful scenery (National Park Service, 2016a). Even though there was a European presence, the Blackfeet Tribe maintained control of the area. This continued up until the 1870s, when the number of settlers rapidly increased due to the realization of the potential of the land (National Park Service, 2016a).

Around the end of the 1800s, people started to realize that the area that would become Glacier National Park was an area of unique scenic beauty. It was at this point that this area attracted the attention of the Great Northern Railway executives who were seeking a route to the west coast (National Parks Traveler, n.d.). The President of the railway, John Stevens, saw the potential for tourism in the park. With the help of Coonsah, a Flathead Tribe guide, they determined Marias Pass was the most appropriate path for the rail (National Parks Traveler, n.d.). By 1891, the Great Northern Railway allowed a greater number of people to enter the heart of northwest Montana, and by extension, the future park (National Parks Traveler, n.d.).

Homesteaders began settling in the valleys west of Marias Pass, and soon some small towns began to develop (National Park Service, n.d.e). These homesteaders eventually became the park's first rangers (National Park Service, 2016b). The landscape of Glacier caught the attention of tourists and influential leaders alike. One of these leaders was George Bird Grinnell, the man who pushed for the creation of Glacier National Park (Park History). He participated in the negotiations with the Blackfeet tribe that led to the purchase of land that now makes up the east side of Glacier (Graetz & Graetz, n.d.). In 1910, Grinnell and his associates were rewarded for their efforts when President Taft created Glacier National Park (National Park Service, n.d.e).

In 1932, Canada and the U.S. united Waterton Lakes National Park, a Canadian national park, and Glacier National Park to create the world's first International Peace Park (National Geographic, 2019). Through this unification, both parks would work together towards wildlife preservation, scientific research, and visitor services (International Designation). In addition to

being a Peace Park, Glacier National Park is a biosphere reserve, a world heritage site, and a prime destination for its historical significance (International Designations).

There are 375 historic properties in Glacier National Park, six of which are National Historic Landmarks (National Park Service, 2017c). The most popular of these landmarks is Going-to-the-Sun Road, which stretches 50 miles between West Glacier and St. Mary (National Park Service, 2017c). The construction of this road began in 1919 and was finished in a little over 10 years (National Park Service, 2017c). There was a very prominent debate over where the road would run; some people wanted the road to continue all the way up into Waterton Lakes, while others wanted it to run by Gunsight Pass (National Parks Traveler, n.d.). The U.S. Bureau of Public Roads, however, decided on the route seen today, as seen in Figure 4, climbing up and over the continental divide at Logan Pass (National Parks Traveler, n.d.).
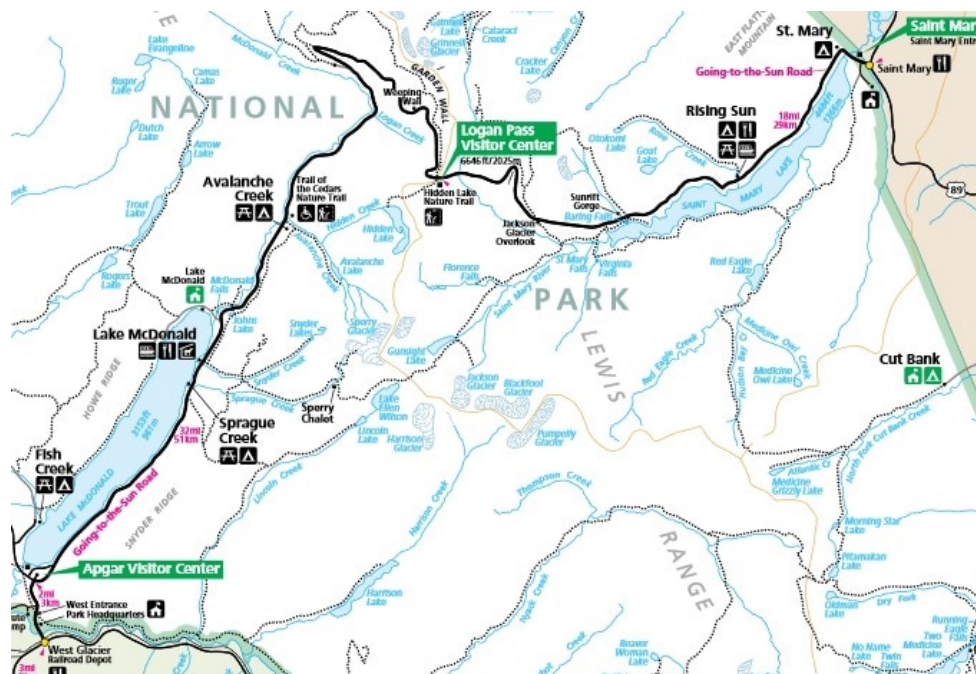

Fig. 5: Going-to-the-Sun Road
Taken and adapted from (Shetler, 2019)

This map depicts the Going-to-the-Sun Road in a black outline. This is the only road that runs through the park. It passes the Apgar Visitor Center, the Logan Pass Visitor Center, and the Saint Mary Entrance.

Glacier National Park has a landscape that gives both desired resources and inspiration to those persistent enough to venture through it. There are over 2,000 plant species in the park, including trees over 200 years old, about 260 species of birds, and around 60 species of mammals (National Geographic, 2019). Gray wolves returned to Glacier in the 1980s for the first time since the 1950s (National Geographic, 2019). The park is a habitat to many forms of wildlife that must adapt to its severe weather conditions.

The weather in Glacier is highly variable, so much so that the conditions can be extreme. It currently holds a world record for the fastest temperature drop, going from 46°F to -56°F in just 24 hours (National Park Service, 2016d). The drier areas of the park average 23 inches of rain a year, while wet areas receive 30 inches of rain a year (National Park Service, 2016d). Glacier also receives a significant amount of snow per year, averaging around 16 feet (National Park Service, 2016d). The wind speeds can also get very high, some reaching 100 mph, which is stronger than a Category 1 hurricane (National Hurricane Center, n.d.).

The park is considered the headwater of the continent. The water from Triple Divide Peak eventually flows to the Pacific Ocean, Gulf of Mexico, and Hudson Bay (National Geographic, 2019). The park is home to many glaciers. A glacier is a slowly moving mass or river of ice (National Park Service, 2019d). They are created by years of snowpack accumulation compacting the bottom layers into a sheet of ice (National Park Service, 2019d). The size of a glacier is affected by ice flow dynamics, variations in ice thickness, and avalanches (National Park Service, 2019e). Once the ice layer gets to be bigger than 100 feet, the ice at the base of the glacier becomes viscous due to the pressure, and the glacier will slide downhill (National Park Service, 2019d). This movement, in addition to the size of a glacier, will result in it being designated as an active glacier. The minimum size criteria for an active glacier is 0.1km² (25 acres), and glaciers smaller than this are stationary (National Park Service, 2019d). There were over 100 active glaciers in the park in 1910 (National Park Service, 2019e). By 2015, only 26 glaciers remained that met the size criteria to be considered active (National Park Service, 2019e). This decrease is caused by Earth's heating climate. The park has developed multiple projects to track the receding glaciers.

The United States Geological Survey started the Repeat Photography Project in 1997 (United States Geological Survey, n.d.b). The project focuses on recreating historic photos of glaciers to help track their retreat (United States Geological Survey, n.d.b). Some of the photos cannot be recreated because the pictures were taken from atop the now-disappeared glaciers. For example, Jackson Glacier was once a part of Blackfoot Glacier, which split during its retreat as pictured in Figure 5. The project has illustrated the receding glaciers and displays how different areas of the park look drastically different today than the areas did historically.
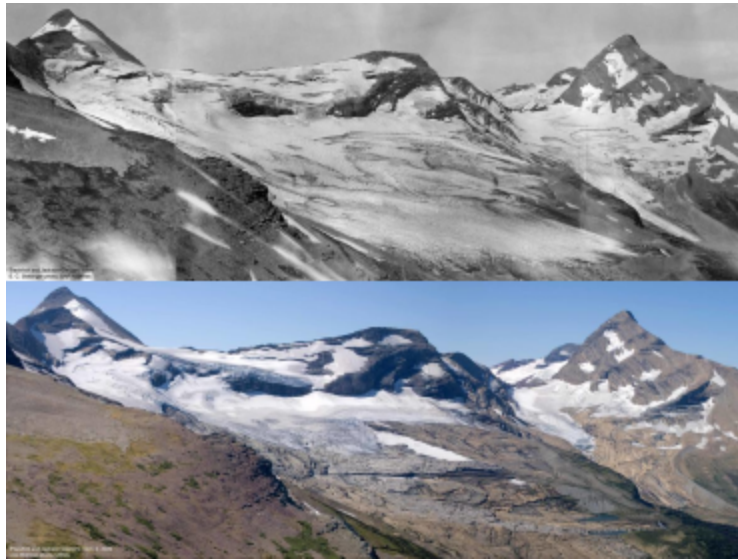
Fig. 6: Jackson Glacier and Blackfoot Glacier

Taken and adapted from (National Park Service, 2019b)

This image depicts Jackson and Blackfoot Glacier in 1914 and 2009.

2.3 Climate Change

One of the largest problems facing humanity today is that of our changing climate. The temperature of Earth's atmosphere has increased more than 1.6°F since the 1850s (Shaftel, Callery, & Jackson, 2019). A majority of this increase in temperature is due to human activity releasing heat-trapping greenhouse gases (Nunez, 2019). The concentration of these greenhouse gases is the highest they have been in the past 800,000 years (Nunez, 2019). These greenhouse gases are causing an increase in global temperature known as global warming. Global warming

is a type of climate change (Nunez, 2019). The two are often used as synonyms, but climate change describes a very complex change in the climate of an area. It includes not only increasing temperature, but extreme weather events, changes in precipitation levels, and a multitude of other factors (Nunez, 2019). The effects of a continuously changing climate would be disastrous for humans and the rest of Earth's inhabitants.

There are many greenhouse gases that trap heat in Earth's atmosphere (Nunez, 2019). These include carbon dioxide (CO_2), water vapor, and methane (Shaftel, Jackson, & Callery, 2019a). The levels of greenhouse gases have always fluctuated, but over the past few thousand years, they have been relatively constant (Nunez, 2019). In the past 150 years, however, there has been a great increase in the amount of CO_2 in the atmosphere (Shaftel et al., 2019a). Our modern lifestyles depend on a multitude of activities that release these dangerous greenhouses gases (Shaftel et al., 2019a). The most prevalent of these is the burning of fossil fuels such as coal and oil (Shaftel et al., 2019a). The United Nations tasked the Intergovernmental Panel on Climate Change (IPCC) with investigating climate change. The IPCC determined that Earth's temperature will continue to increase by 2.5°F to 10°F over the course of the next century if changes are not made (Shaftel, Jackson, & Callery, 2019b).

There are many ways that the climate all over the Earth is changing. The warmer temperatures are causing glaciers and polar ice sheets to melt (Shaftel et al., 2019). Greenland, for example, lost an average of 286 billion tons of ice per year between 1993 and 2016 (Shaftel et al., 2019). Some scientists have discussed the possibility of the Arctic becoming ice-free if no changes are made (Shaftel et al., 2019b). This massive amount of melting ice eventually becomes a part of the ocean, where sea levels are rapidly rising (Shaftel et al., 2019). In the last century, sea levels rose about eight inches (Shaftel et al., 2019). In the last two decades, this number has nearly doubled, and keeps accelerating (Shaftel et al., 2019). Scientists have predicted that the sea level will increase between 1 and 4 feet by 2100 (Shaftel et al., 2019b) In addition to that, the oceans are becoming more acidic, which could be catastrophic for marine species (Shaftel et al., 2019). The temperature increase has also affected precipitation in many parts of the world. Wetter areas of the world will become wetter, and drier areas will become drier (Shaftel et al., 2019b). There will be an increase in heavy precipitation events, even in more

arid areas (Shaftel et al., 2019b). Additionally, there will be an increase in extreme weather events such as, stronger and more intense hurricanes (Shaftel et al., 2019b). It's been predicted that by the end of the century, extreme heat days will be occurring every two or three years instead of happening once every twenty or more years (Shaftel et al., 2019b).

Climate change could have many devastating effects in Glacier National Park. Warmer and drier weather conditions, coupled with poor forest management, has caused an increase in frequency and severity of wildfires in the park (National Parks Service, 2019b). While forest fires can be a natural part of how an ecosystem replenishes nutrients, it can be dangerous for ecosystems and humans alike if these wildfires are too severe or get out of hand. It can, of course, threaten people and property too close the fire (National Parks Service, 2019b). However, forest fires can cause a significant decrease in the air quality of an entire region, causing many public health problems (National Parks Service, 2019b). Perhaps even more alarming, warmer weather is causing the retreat of glaciers in Glacier National Park (National Parks Service, 2019b). With fewer glaciers, there is less overall water in the park in the warmer seasons. The glacial loss—and reduced snow in winters—will lower water levels in the many water systems in the park (National Parks Service, 2019b). This can have many negative effects, as the water flowing from Glacier is used as agricultural irrigation and to generate electricity in hydroelectric dams in the Columbia River Watershed (National Parks Service, 2019b). There are also many aquatic species in the park that are very sensitive to temperature. Warmer waters could cause these species to become endangered, or potentially wipe out the populations in Glacier if there are already low numbers (National Parks Service, 2019b). These changes can cause alterations throughout the food chain. For example, monitoring loon populations can help scientists determine the health of aquatic invertebrate populations, which are much more difficult to monitor (Editors of Encyclopaedia Britannica, 2014).

2.4 Citizen Science

Citizen science is a system where participants help researchers and institutions conduct field work and analyze data (Oxford University Press, 2019). There are a variety of citizen science platforms and programs to choose from. Sometimes, citizen science is conducted through

the use of data collection apps such as iNaturalist or BirdLog (Klemick, 2015). Once a volunteer uploads data to these apps, professionals can access the data to use in studies (Klemick, 2015). Many citizen science programs utilize collection events, such as BioBlitzes, to have participants spend a short amount of time collecting as much data as possible (National Geographic, n.d.). The data collected can then be sorted by a professional scientist or researcher. Other citizen science programs utilize pen-and-paper surveys to obtain the results they need. This is the main type of data collection currently used in Glacier National Park.

In Glacier National Park, citizen science is used to address the need for research and monitoring, despite funding and personnel constraints (National Park Service, 2017a). These citizen science programs provide baseline data that can improve understanding of wildlife species (National Park Service, 2017a). The Crown of the Continent Research Learning Center (CCRLC) runs Glacier's citizen science programs and promotes science and stewardship in Glacier National Park (National Park Service, 2017a). The CCRLC is one of 18 National Park Research Learning Centers that are part of a national effort to improve scientific literacy in National Parks (National Park Service, 2017a). The CCRLC puts a lot of focus on hands-on learning activities (National Park Service, 2017a). The park collects data in a variety of ways. The park has held BioBlitzes, where participants use the iNaturalist app to upload pictures of various types of wildlife they see in the park (iNaturalist, 2016). This allows the park to gather a large mass of data that can then be used for multiple other projects. Another way that Glacier's citizen science programs collect data is through surveys. Participants in these programs go through training with park officials (NPT Staff, 2017). After the training, these participants can go out in the park and fill out a survey on a specific species of plant or animal, which is then used by park biologists to monitor populations (NPT Staff, 2017).

The three most well-known citizen science programs at Glacier are the BioBlitz program, the Common Loon Citizen Science Project, and the High Country Citizen Science Project. The BioBlitz program, as mentioned before, is used to collect a large amount of basic data (NPT Staff, 2017). There is no training required for this program, participants need only take a picture of a species and upload it to the iNaturalist app (NPT Staff, 2017). The Common Loon Citizen Science Project was the park's first citizen science program, and was established in 2005

(National Park Service, 2017b). Participants must complete a day of training where they learn to accurately identify common loons, as well as identify the sex, age, and behaviors of a loon (National Park Service, 2017b). The High Country Citizen Science Project was established in 2008, and monitors populations of mountain goats and pikas in the park (National Park Service, 2019g). Similar to the Common Loon Project, participants must go through a day of training to be able to identify species, sex, and age of mountain goats and pikas in the park (National Park Service, 2019g). These programs, along with many other programs in the park, are focused on monitoring the populations of species that are affected by changes in habitat and human disturbances (NPT Staff, 2017). The park can use changes in population numbers to monitor the health of these species, which allows biologists to monitor the extent and severity of the effects of habitat changes and human disturbances in Glacier National Park.

2.5 Common Loon

The common loon is a Montana Species of Special Concern (National Park Service, 2017b). This classification means that the common loon is a native animal that is breeding in the state and is "at risk" due to declining population trends, threats to their habitats, and/or restricted distribution (Montana Fish, Wildlife, and Park, n.d.). Common loons are known for being excellent divers. They primarily prey on small fish, which necessitates proficiency in diving. Characteristics such as dense bones, heavy bodies, and comparatively small wings for their body size make them adept at diving (National Park Service, 2018a). Common loons live in crystal-clear lakes making hunting for prey much easier (The Cornell Lab of Ornithology, n.d.). Common loons can be found in wooded lakes, tundra ponds, and coastal waters (Audubon, n.d.). Their specific habitat allows common loons to be indicators of water quality (The Cornell of Ornithology, n.d.). The common loon's specific needs for survival make them more vulnerable to human intervention.

Fig. 7: Common Loon

Taken from (Wege, 2009)

An image of two adult common loons swimming.

The common loon is considered a "symbol of wilderness" and its rich yodeling can be heard in forests throughout the early summer (Audubon, n.d.). The loons that provide these beautiful sounds that once filled the north woods have been impacted by many different factors. Human disturbance on lakes in the summer have led loons to disappear from former nesting areas (Audubon, n.d.). The increase in acid rain could lead to reduced food supplies in the loon's breeding range pictured in Figure 6 (Audubon, n.d.). Changing temperatures associated with climate change could also impact the populations of small fish that the loon feeds on. Glacier National Park hosts about twenty percent of Montana's breeding loon population, however, the park only produces five to six loon chicks a year (National Park Service, 2017b). Climate change

will inevitably affect the populations of common loons in Montana, exemplifying the necessity of the Common Loon Citizen Science Project.

Contaminants in the air and water can have an adverse effect on the health and behavior of many animals. Increased mercury levels in bodies of water has been observed to significantly impact common loons (Evers et al., 2007). Loons who were exposed to a higher level of mercury became more lethargic and spent less time foraging (Evers et al., 2007). Prolonged high exposure decreased a loon's chance of successfully reproducing (Evers et al., 2007). Breeding loons spent less time incubating their eggs in mercury rich environments (Evers et al., 2007). Unattended eggs can experience large fluctuations in temperature, potentially killing the developing chicks (Evers et al., 2007). When the parents are away from the nest, it also provides an opportunity for predators to steal eggs (Evers et al., 2007). The cumulation of these effects result in a decrease in chick survival rate and a decrease in the overall common loon population (Evers et al., 2007).

Fig. 8: Common Loon Breeding Range

Taken and adapted from (Audubon, n.d.).

This image depicts the breeding range of the Common Loon in North America. The dark pink represents where breeding is common. The light pink represents where breeding is uncommon. The blue represents where the Common Loon spends the winter.

2.6 Liaison

Tara Carolin is the Director of the Crown of the Continent Research Learning Center (Germann, 2013). Since becoming director in 2009, she has worked to grow and improve the Center in many ways. She has created and fostered partnerships with other organizations, helped to disperse research results to people in the scientific field and to the public, and has become a leader in climate change research and adaptation planning (Germann, 2013). She also leads Glacier National Park's citizen science programs (Germann, 2013).

Jami Belt is a biologist at the Crown of the Continent Research Learning Center (Jami Belt, n.d.). She has worked on many projects monitoring populations of different species in the park, some of which involve the citizen science programs at the park (Jami Belt, n.d.). A few of the papers she has published are *Predictors of Current and Longer-Term Patterns of Abundance of American Pikas (Ochotona princeps) across a Leading-Edge Protected Area, Citizen Science and Observer Variability During American Pika Surveys, and Evaluating Population Estimates of Mountain Goats Based on Citizen Science* (Jami Belt, n.d.). She is currently a big part of the High Country Citizen Science Project, which monitors populations of Pikas and Mountain Goats in the park (Jami Belt, n.d.).

Nathanael Wold is a Geoscientist working at the Crown of the Continent Research Learning Center. Nate has a BS in Geology from Kansas State University, and an MS in Geology from the University of Montana. He specializes in Water Resources and Geographic Information Systems (Nathanael Wold, n.d.). He is currently working with the CCRLC to integrate technology into Glacier National Park's citizen science programs.

2.7 Esri Products

Esri is a geographic information systems (GIS) company that develops geospatial software. They have a wide variety of ArcGIS products, which deal with mapping and spatial analysis (About Esri, n.d.).

ArcGIS Online is a cloud-based mapping program developed by Esri (ArcGIS Online, n.d.). The program allows high-quality interactive maps to be created for a multitude of purposes, such as field operations, city planning, and public health (ArcGIS Online, n.d.). ArcGIS Online has a large collection of basemaps (Make Maps with ArcGIS Online, n.d.). It allows users to upload and utilize a large variety of file types, such as spreadsheets and geospatial files (Make Maps with ArcGIS Online, n.d.). Once uploaded to ArcGIS Online, data is easy to update and edit from the software (Work with Your Data in a Powerful System, n.d.). After a map is created, ArcGIS Online offers many tools to analyze patterns and relationships in displayed data (Analyze Data in the Context of Location, n.d.). It can also apply various boundaries, parameters, and filters to assist in data analysis (Work with Your Data in a Powerful System, n.d.). A published map can be turned into a web application, which provides many ways to share both the map and the data it contains (Share Maps & Collaborate with Colleagues to Solve Problems, n.d.). Web applications can be created using a template or can be custom-made (ArcGIS for Developers, n.d.). A completed web application can be embedded in websites or social media (Share Maps & Collaborate with Colleagues to Solve Problems, n.d.). However, Esri provides multiple other programs that can be used in conjunction with ArcGIS Online to help disperse data gathered (Field Operations, n.d.).

Survey123 is a survey application developed by Esri. It allows users to easily create complex surveys and analyze the responses. When creating a survey, Survey123 offers a variety of customization options including embedded audio, images, and a multitude of languages. The created survey can be accessed via desktop or mobile device, and does not require an internet connection after the initial download. Once a survey is completed, the information is stored locally on the device and is uploaded once the device regains connectivity. Collected data can then be shown in a summary analysis, or can be sent to other ArcGIS products for a more in-depth analysis (Survey123 for ArcGIS, n.d.).

3. Methodology

The purpose of our project was to provide an efficient and effective means of organizing citizen science data collection for the Common Loon Citizen Science Project through the incorporation of technology and to include a specific set of recommendations. In order to fulfill the purpose of our project, we completed the following four objectives:

1. Explore citizen science programs
2. Research ArcGIS Online
3. Develop maps that plot the data points collected by the Common Loon Citizen Project utilizing the standard ArcGIS Online map-building platform
4. Provide recommendations for future consideration

In this section, we describe the methods that were used to complete these four objectives.

3.1 On-Site Research

We had limited access to information on how Glacier National Park's Common Loon Citizen Science Project is operated. On-site research was utilized to collect more specific information on the citizen science program, focusing on how the data of the program is collected and how citizen scientists are being organized throughout the park. We contacted park researchers, utilized the research tools the park offers, as well as participated in the Common Loon Citizen Science Project. The on-site research allowed us to better formulate potential solutions to the problems the program faces by targeting its current weaknesses.

3.2 Experimentation

We utilized ArcGIS Online to develop an application to assist the Common Loon Citizen Science Project. Before doing so, it was necessary to learn the capabilities of ArcGIS Online. Initially, we read the documentation for the software and explored their lesson gallery. The lesson gallery contained step-by-step walkthroughs on how to perform different functions within the program and showed a variety of different use cases. After, we created a variety of custom

maps to gain some experience and practice some skills. These steps allowed us to better understand the program and its limits before diving into the development process.

3.3 Development

Before creating the mapping application, we needed to develop a basemap in the software. The basemap contains a variety of layers which control what data the map holds and what information can be seen on the map. This involved modifying existing layers owned by the park, as well as creating new layers as they were needed. After the completion of the basemap, the mapping application was created. This application took the information from Survey123 and organized the information in a pop-up that is unique to each of the priority lakes in the park. The information that each pop-up displayed helped to provide citizen scientists with a better understanding of the survey needs of each lake. Additionally, region, hiking, and survey information were listed to aid the citizen scientists in their decision making process. The pop-up was constantly refined to ensure that the most pertinent information was easily spotted. An additional application was developed specifically for employees. This required the creation of a separate basemap with a few unique layers. The employee mapping application displayed more sensitive information to help them better understand the condition of the loons surveyed at each site. They were able to easily access the last survey conducted, as well as the citizen scientist's contact information in case more details were needed or a discrepancy was located. Throughout this process, we met weekly with the workers at the CCRLC to receive feedback and ensure that expectations were being met.

3.4 Testing

To ensure that our map was functioning properly, we needed to submit a few survey points and check to see if the map updated automatically. The application was used to pick a survey site in order to gauge the feasibility and ease of use of the map's features. Multiple survey points were marked and submitted along our observation route in regions with and without cell service. After the field test, the application was refined and any issues that arose were resolved. Through this testing and further development of our application, a list of recommendations were created for the NPS.

4. Results and Analysis

4.1 Basemaps

      The first step in providing the National Park Service an alternative solution to their current problem was to develop a basemap with ArcGIS Online that included basic information about the park and the Common Loon Citizen Science Project. This basic information was conveyed through multiple feature layers displayed in Figure 9. These included a park boundary layer, lake layer, trail layer, road layer, subdistricts layer, lake priority layer, survey point layer, and a priority points layer. Additionally, an analysis layer named the Survey Needs layer was created. A more detailed basemap was created and customized for employee use. A step-by-step creation guide can be found in Appendix E. These two basemaps provided the CCRLC with the necessary tools to increase the efficiency of the Common Loon Citizen Science Project.
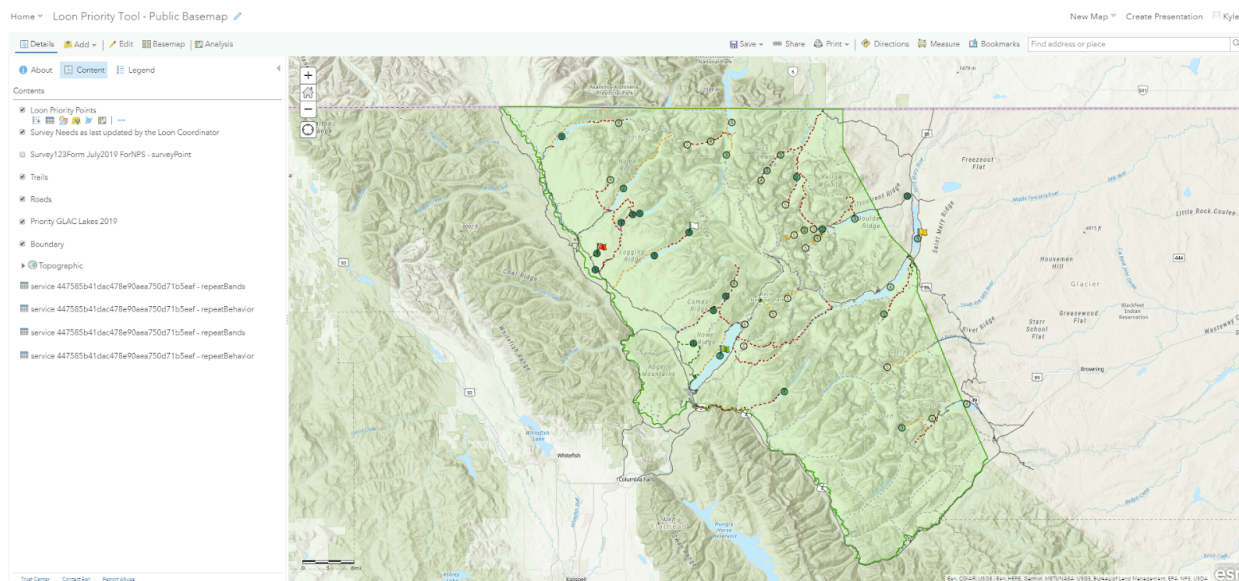
Fig. 9: Public Basemap

Taken from (Lang, 2019e)

This basemap is utilized by the public mapping application and includes basic information about Glacier National Park and the Common Loon Citizen Science Project.

The two basemaps are made up of nine different layers. The park boundary displayed the park's limits with an outline and filled the interior of the park with a solid color. Its default visual options obscured some of the other information on the map, so this layer was modified to appear more subtle. The lake layer included all of the lakes within the park. This layer was also toned down, as it made the map appeared cluttered. The trail layer included all of the trails that the park has documented and provided basic information of each of the trails including distance, elevation change, and trail rating. The information listed in these attributes lacked consistency, therefore an attribute to categorize the trails. The trails were categorized as less challenging, challenging, and very challenging. The trail difficulties were provided to us by the CCRLC upon request. The road layer included all of the roads that are in the park. These were visually modified since they were initially confused with the trails. The subdistricts layer included the seven regions that the park is segmented into. This layer was only used in the employee basemap. We removed the fill color in this layer and kept the regional outlines to reduce visual clutter. The lake priority layer included an outline of each lake that the CCRLC had categorized as being a potential habitat for the common loon. The lakes are assigned a priority number ranging from one to five, which represent varying levels of loon activity in the area. A breakdown of the different priorities can be found in Appendix B.

In order for the map to update with the survey information, it was necessary to create a layer that displayed all of the survey points from the Common Loon Citizen Science Project. We published the Survey123 form that would be used by the participants and exported the information to our ArcGIS Online accounts. Next, a priority points layer was created. This layer contained a single point located at the center of each lake. This was done to keep the pop-up concise. This layer also contained a manual override option. The coordinator of the Common Loon Citizen Science Project can open the table and modify the override value to flag a lake on the map. The included flags are spring loon day, summer loon day, post summer loon day, confirmation needed, and not flagged. Finally, the survey needs layer was created by merging the priority point and survey point layers. Since the survey needs layer is the result of a merge, it contains all of the information of the other two layers, which allows us to concisely display the necessary information in the pop-up.

A pop-up was configured to show up on our map which shows some basic information about each of the priority lakes such as number of surveys done at that lake, last date a survey was conducted, hike distance to get to the lake, etc. We developed two scripts using ArcGIS Online's unique programming language called Arcade. The first script counted the number of survey points and the second automatically updated the flagged notes whenever the survey status is changed. A refresh interval of 30 minutes was set on the layer to rerun the scripts so that they would update with new survey information. The scripts can be found in Appendix E. A key feature to point out is the difference between the public and employee pop-ups. The employee pop-up includes a subsection labeled "Employee Information" which included sensitive information about the common loon breeding population. This information was hidden from the public map to prevent any harm to the common loons in the park. For example, if the public map displayed nesting information or chick numbers, there may be an unwanted increase in citizen scientists to the area who want to see a chick. The increase in human foot traffic could cause the common loons to abandon their nests. The pop-up also includes a link to the current trail conditions of the park.
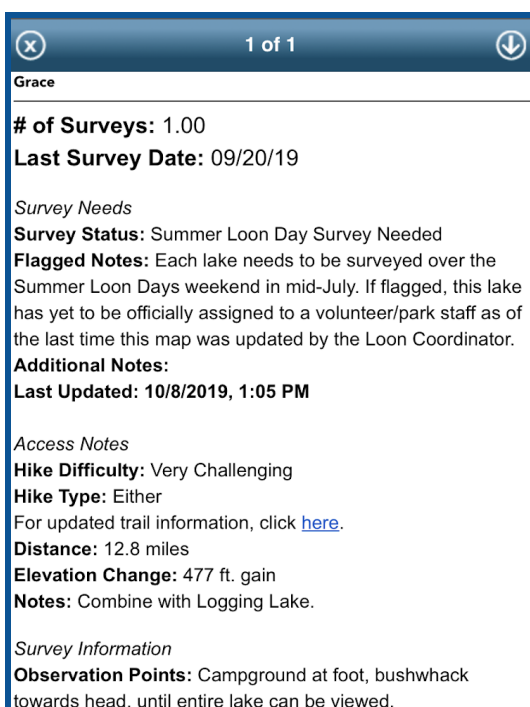
Public Pop-Up   Employee Pop-Up
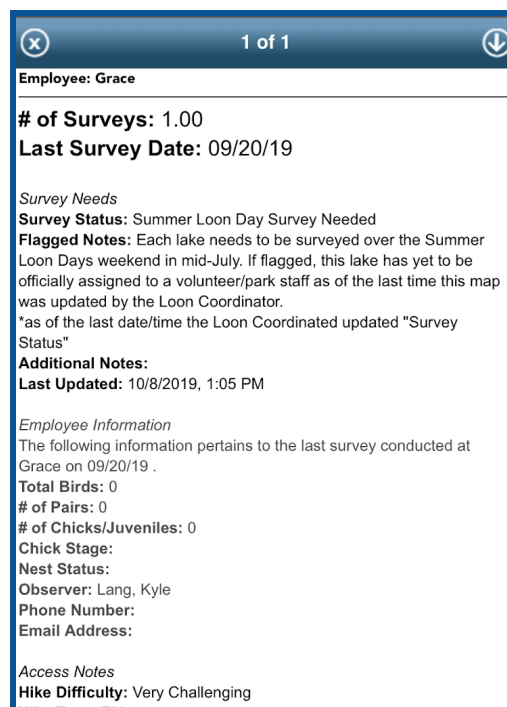
Fig. 10: Public Pop-Up and Employee Pop-Up

Taken from (Lang, 2019e) and (Lang, 2019d)

An image of the pop-up for the public map next to an image of the pop-up for the employee map.

When a user clicks on either map, a pop-up will appear and display important information

pertaining to survey needs, access notes, survey information, and additional information.

4.2 WebApp

In order to make our basemap useable by the public, we developed a browser-based

application that can be accessed from a computer or mobile device. In addition to the information

found within the basemap, this application includes multiple widgets and features that allow

users to better plan their observation days.

The about widget provided a basic description of the map, an overview of how to operate

the map, and a link to a pdf containing images of all of the loon priority lakes. This widget will

also include a link to a guide containing in-depth details on how to use the map. In the future, the

National Park Service will add a survey to obtain feedback about the various widgets and

features included in the map. A sample survey can be found in Appendix B. This will help the map to grow and adapt to the changing needs of the citizen science team.

The measure widget can be used to ascertain the distance between two or more different points on the map. The tool can measure lengths, areas, and provide measurements in various units. This is useful when a citizen scientist needs to travel off-trail to an observation point. Participants can then amend this information to their trail distance to get a more accurate depiction of their hike.

The draw widget can be used to make marks on the map. Points, lines, and polygons of various size, shape, and color can be placed on the map by volunteers. These can be used to mark different areas, such as observation points. Once a volunteer has drawn on the map, these marks will stay on the map when using the print widget. The draw widget can also be used to measure the perimeter and area of a polygon that is drawn on the map.

The filter widget can be used to highlight specific lakes and trails. Lakes can be filtered based off of priority, letting volunteers only see the lakes of their desired priority on the map. Hiking trails can be filtered based on difficulty, showing only lakes that are accessible by trails of the desired difficulty. An additional filter for Survey Needs is in place, allowing volunteers to view only lakes that have been flagged with a specific need from the Common Loon Citizen Science Coordinator. These filters work together to allow citizen scientists to quickly find what trails and lakes match their interest level and hiking capabilities.

The print widget can be used to save a copy of the map. The saved copy can be used on a phone or can be printed out onto paper. This allows participants to utilize the map inside the park, where there is no cell service. Additionally, marks made with the draw widget and filters applied with the filter widget will also be saved onto the map.

This public application will be utilized to increase efficiency of the Common Loon Citizen Science Project as well as to create a more even distribution of citizen scientists across Glacier National Park. The application will be published by the CCRLC and be available to all participants in the program.
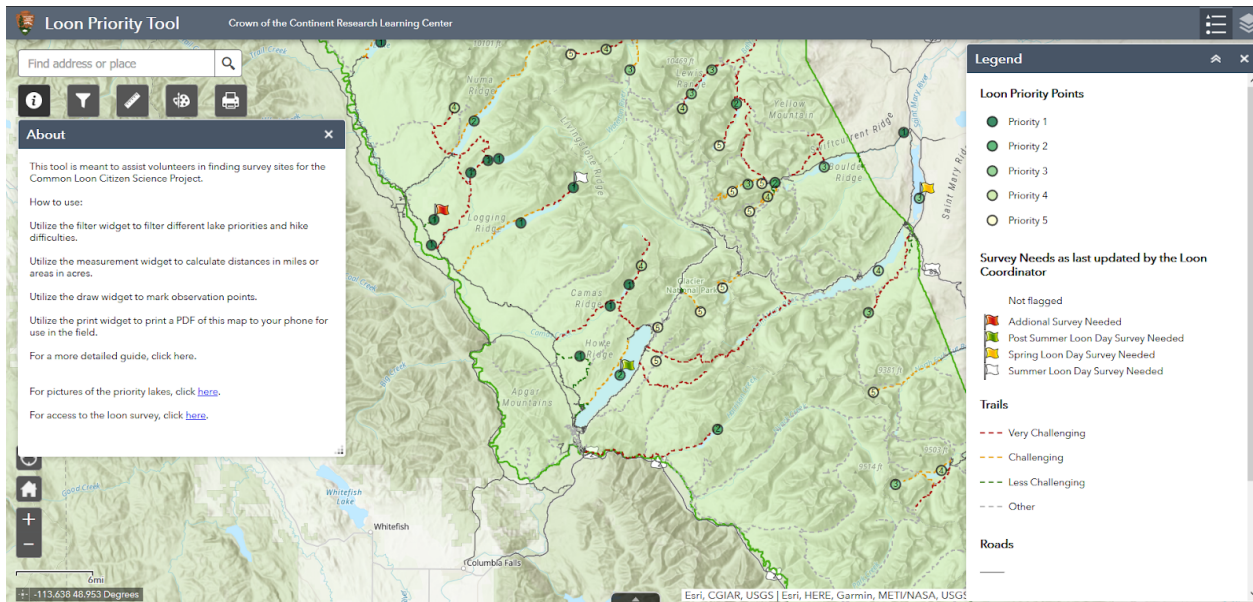
Fig. 11: Public Web Application

Taken from (Lang, 2019a)

This is the view of the mapping application when viewed from a laptop. To the right is the legend which explains the symbology located on the map. On the left, the About tab is open and displaying information. To the right of the about tab are the filter, measure, draw, and print widgets.

4.3 Elevation Profile

We developed an additional application to use in conjunction with the web application to allow participants to see the elevation profile of a trail. Participants also have the ability to add individual points on the map to receive the elevation change between those points. This will allow participants to better determine if a trail suits their hiking capabilities. Citizen Scientists will be able to understand where the most challenging part of their hike will be and plan accordingly for those segments.

The elevation profile had to be made into a separate application. The original intent was to include this as a widget in the public application, but there was no elevation profile widget available in the collection of widgets present in the ArcGIS Online WebApp Builder. A custom elevation profile widget was created by a member of the ArcGIS Online community. This custom widget can only be applied if the application owner decides to host the app on their own

server instead of the provided ArcGIS Online server. The CCRLC was uninterested in hosting their own server, so a seperate application was created with the elevation profile theme instead.
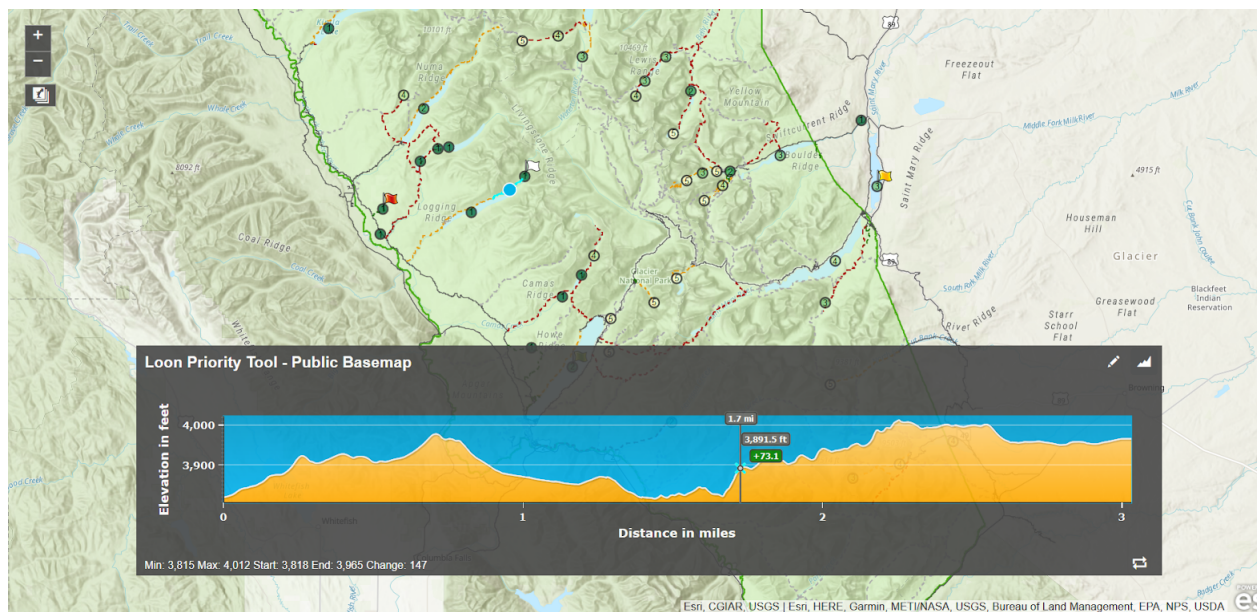
Fig. 12: Elevation Profile

Taken from (Lang, 2019b)

Here is the view of the elevation profile tool as viewed from a laptop. This map is currently displaying the elevation profile for the very challenging trail leading to Grace lake. When the mouse is hovering over the chart, more detailed information on distance and height are displayed.

4.4 Employee Map

A third application utilized only by employees of the National Park Service was developed. This application includes more sensitive information about the state of the breeding loon population in the park that could be harmful to the loons if shared publicly. This layer includes information about the number of chicks in a specific region of the park, information about the last observers at a lake, as well as information about nests.
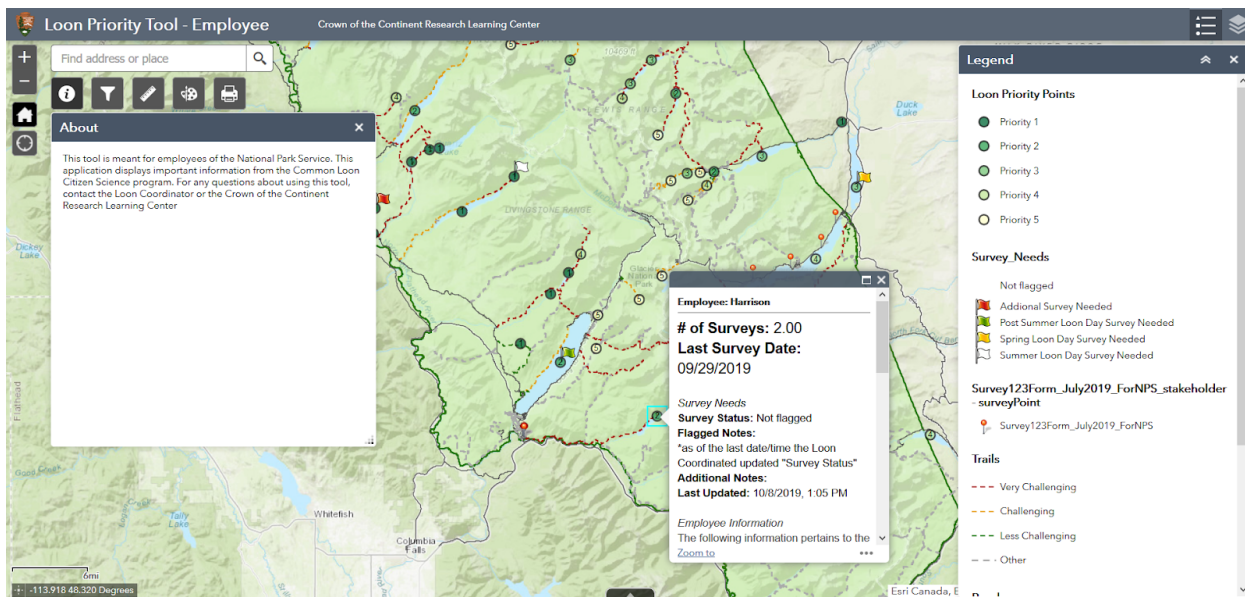
Fig. 13: Employee Web Application

Taken from (Lang, 2019c)

An image of the employee web application. The basemap is pictured with the about widget and legend open, and a lake is displaying the pop-up shown in Fig. 8.

This map will allow the employees to better understand the breeding population of loons in the park by utilizing a variety of analysis layers. These analysis layers provide critical information regarding common loons which helps the coordinator to redirect citizen scientists to areas that have more chicks than others to keep an updated list of nest status and chick stages.

A key feature of the employee basemap is the survey needs attribute. The survey needs attribute will allow the loon coordinator to redirect citizen scientists to lakes that are in need of surveys. For example, in the event that a citizen scientist reports that chicks have hatched at Bowman Lake, the loon coordinator can go into the employee application and edit the survey needs status of Bowman Lake to "additional survey needed." This will create a red dot that will redirect citizen scientists to Bowman Lake, allowing the loon coordinator to get a confirmation that there are indeed hatched chicks. Whenever a status is changed, the date of the change is listed under "last updated." The loon coordinator is able to update the survey needs of a lake from the employee application. Another option is for the loon coordinator to edit either basemap

with the updated information or to just edit the layer. These key features will be very helpful for the CCRLC in managing the breeding loon population in the park.

      With the utilization of both the public and employee application, the CCRLC will have two very beneficial tools that will help further the program. The integration of technology into the program will decrease processing times of loon data, reduce paper usage, and allow staff more time to focus on analyzing and studying the loon population in the park.

4.5 Benefits

      We developed a map for the Crown of the Continent Research Learning Center to assist them in their Common Loon Citizen Science Project. The program is currently facing issues related to an uneven distribution of citizen scientists as well as the over involvement of CCRLC staff members.

      To solve the uneven distribution of citizen scientists, the mapping application shows a large amount of information in one location. Previously, some of this information was provided in a large file of documents. Instead of sifting through the various papers, citizen scientists will be able to filter for the information they desire. This will reduce paper usage and allow the citizen scientists to easily identify lakes that need surveys based on lake priority, number of surveys, hike difficulty, and other information. The most important factors are the survey query and the survey needs feature on the map. This will redirect citizen scientists to lakes that have less surveys and lakes that have been flagged as needing surveys by the Common Loon Project Coordinator.

      To combat the over involvement of NPS staff, this mapping application will allow citizen scientists to plan their own survey days with less direct influence from the staff. Currently, a citizen scientist will send the staff a list of locations they would like to survey. This list is then evaluated by the staff to determine which locations are most in need of surveys, and then sent back to the citizen scientist. This process is inefficient and time consuming. By giving the citizen scientists information such as survey needs and lake priority, they can evaluate their selected lakes on their own. This will allow the staff to focus more on monitoring the breeding loon population in the park and analyzing the patterns and distribution of the population.

5. Recommendations and Conclusion

The goal of the mapping application was to increase the efficiency of the Common Loon Citizen Science Project and develop a solution for the uneven distribution of citizen scientists in the park. The program must continue to adapt and be open to the integration of technology. The following recommendations are offered to potentially further the state of the program and help protect Montana's breeding loon population.

A future feature that CCRLC volunteers may find useful is the inclusion of a hosted feature layer that updates with weather alerts, trail status, and road closure information. This would allow citizen scientists to easily identify regions of the park that are not accessible instead of having to open up the Glacier National Park website for that information. The pop-up for this layer could then include more detailed information for the closings as well as links to any other relevant articles that apply. This would allow citizen scientists to efficiently decide which lake to survey and easily plan out their day based on current conditions.

If the park did decide to host the Loon Priority Application on their own server, they could add the elevation profile widget. This would replace the measure widget since the elevation profile provides an x-scale containing the distance of the selected segment. It also would consolidate the two separate maps into one, simplifying the process further for the volunteers. Hosting the application on their own server would allow for greater control over various features of the application and provide more customization options in the future, including the further development of other custom widgets.

Some participants may prefer the pencil and paper methods that had previously been implemented due to difficulties understanding the new technology. Before implementing a wide-scale solution, a research study should be conducted to better understand the number of participants that have difficulty using the map. If the results of this investigation signify that a wide-scale solution should be implemented, a simple solution would be to integrate the map into the existing common loon training session. A short info session demonstrating the uses of the map could be added using the How to Use Guides in Appendix D as a base for how the session could be structured. A more complex solution may be to create a simplified map for use by those

with less technological experience. This simplified map would still contain the essential information, but the use of widgets would be reduced, along with forgoing the Elevation Profile. A training session and a version of the map that is more simplified would allow for more participants to find the map useful.

In the future, the CCRLC could add more documentation to the map. The about section could contain links to PDFs of the paper documents contained in the folder given at the end of the training session. This would allow volunteers to download the papers to a mobile device for easy access while in the field. It could also contain additional links to reference sheets for loons, other types of wildlife, and different types of watercraft. Additional links to safety sheets and information could also be included. This would further consolidate the information into one location and further reduce paper usage.

The Loon Priority Application can be adapted to other Citizen Science projects the CCRLC offers. The map could be applied to the High Country Citizen Science Project, which monitors the population of mountain goats and pikas in the park. Most importantly, the lake priority layer would need to be replaced with a layer that indicates the various priorities of mountain goat and pika habitats. In addition, the hiking trail layer would need to be updated to guide volunteers to these habitats instead of lakes. The current survey layer would be replaced with the survey layer from the High Country survey. The terminology in the pop-ups would also need to be updated. With little customization, the mapping application could be applied to the High Country Citizen Science Project, increase the efficiency of the project, and give the staff more time to analyze the populations of mountain goats and pikas in the park.

The CCRLC may find it beneficial to put some or all of the citizen science program's training online. Online training would allow park visitors only in the area for a short amount of time to participate in the program. Instead of spending a day in the park going through the training session, the training could be completed before arrival. This training could be as simple as having online videos that substitute for part of or all of the in-class training. The training could also be more complex and involve the creation of an interactive web page. This page could include quizzes and surveys to help participants practice the content they have learned, along with helping the CCRLC staff ensure that the participants are collecting high-quality data. The

webpage could also include a way of tracking the time a citizen scientist spends learning, to ensure that the volunteer is a reliable source of data. Converting part or all of the Common Loon Citizen Science Project's training online could increase the amount of participants in the program, thus the amount of surveys collected in the park.

In conclusion, the mapping application that we developed will increase the efficiency of the Common Loon Citizen Science Project, solve the uneven distribution of citizen scientists, and provide the biologists of the CCRLC with more time to analyze the breeding loon population in Glacier National Park. Through the integration of technology, the program will continue to modernize for the betterment of the park's loon population.

Bibliography

About Esri. (n.d.). Retrieved Oct 8, 2019 from
https://www.esri.com/en-us/about/about-esri/overview.

Analyze Data in the Context of Location. (n.d.). Retrieved September 17, 2019, from
https://www.esri.com/en-us/arcgis/products/arcgis-online/capabilities/analyze-data.

ArcGIS Online. (n.d.). Retrieved September 17, 2019, from
https://www.esri.com/en-us/arcgis/products/arcgis-online/overview.

ArcGIS for Developers. (n.d.). Retrieved September 17, 2019, from
https://www.esri.com/en-us/arcgis/products/arcgis-for-developers/overview.

Audubon. (n.d.). Common loon. Retrieved from
https://www.audubon.org/field-guide/bird/common-loon

Belt, J. (n.d.). Jami J. Belt | National Park Service, Washington, D.C. | NPS. Retrieved from
https://www.researchgate.net/profile/Jami_Belt

Editors of Encyclopaedia Britannica. (2014). Common loon. Retrieved from
https://www.britannica.com/animal/common-loon

Evers, D. C., Savoy, L. J., Desorbo, C. R., Yates, D. E., Hanson, W., Taylor, K. M., … Fair,
J. (2007). Adverse effects from environmental mercury loads on breeding common
loons. *Ecotoxicology*, *17*(2), 69–81. doi: 10.1007/s10646-007-0168-7 Retrieved from
https://link.springer.com/article/10.1007%2Fs10646-007-0168-7

Field Operations. (n.d.). Retrieved September 17, 2019, from
https://www.esri.com/en-us/arcgis/products/field-operations/overview.

Germann, D. (2013). Research learning center director receives regional award - Glacier
National Park (U.S. national park service). Retrieved from

https://www.nps.gov/glac/learn/news/research-learning-center-director-receives-regional-award.htm

Graetz, R., & Graetz, S. (n.d.). Events reveal crown of the continent timeline. Retrieved from http://www.umt.edu/this-is-montana/columns/stories/crown-timeline.php

iNaturalist. (2016). *2016 National Parks BioBlitz - Glacier wildlife observations.* Retrieved Apr 12, 2019, from https://www.inaturalist.org/projects/2016-national-parks-bioblitz-glacier-wildlife-observations

Jones and Jones. (2001). Criteria for designation. Retrieved from https://www.nps.gov/iceagefloods/pdf/f.pdf

Klemick, E. (2015). *Mobile apps for citizen science.* Retrieved Apr 12, 2019, from https://ssec.si.edu/stemvisions-blog/mobile-apps-citizen-science

Lang, Kyle. (2019a). *Loon Priority Tool - Application.* Retrieved Oct 9, 2019, from https://w-p-i.maps.arcgis.com/apps/webappviewer/index.html?id=4bd3deb54eab41108cf95e92c36b6cf8

Lang, Kyle. (2019b). *Loon Priority Tool - Elevation Profile.* Retrieved Oct 9, 2019, from https://w-p-i.maps.arcgis.com/apps/Profile/index.html?appid=a26a24aea44c484a9a2b9cb7ed97c139

Lang, Kyle. (2019c). *Loon Priority Tool - Employee.* Retrieved Oct 9, 2019, from https://w-p-i.maps.arcgis.com/apps/webappviewer/index.html?id=b537ddfdfb334166ab8a01cbd23d64b5

Lang, Kyle. (2019d). *Loon Priority Tool - Employee Basemap.* Retrieved Oct 9, 2019, from https://w-p-i.maps.arcgis.com/home/webmap/viewer.html?webmap=52c33a55db24479280db17bd6049b88f

Lang, Kyle. (2019e). *Loon Priority Tool - Public Basemap.* Retrieved Oct 9, 2019, from
https://w-p-i.maps.arcgis.com/home/webmap/viewer.html?webmap=50c4a4f1effd49b5
87e0dca1d86d9673

Lee, R. F. (1972). *Family tree of the national park system*. Philadelphia, Pennsylvania:
Eastern National Parks.

Make Maps with ArcGIS Online. (n.d.). Retrieved September 17, 2019, from
https://www.esri.com/en-us/arcgis/products/arcgis-online/capabilities/make-maps.

Montana Fish, Wildlife, and Parks. (n.d.). Montana's species of concern. Retrieved from
http://fwp.mt.gov/fishAndWildlife/species/speciesOfConcern/

https://www.nationalgeographic.com/travel/national-parks/glacier-national-park/

Nathaneal Wold. (n.d.). Retrieved September 18,2019, from
https://www.linkedin.com/in/nate-wold-6b835860/.

National Geographic (n.d.). *BioBlitz program.* Retrieved Apr 12, 2019, from
http://www.nationalgeographic.org/projects/bioblitz/

National Geographic. (2019). A guide to Glacier National Park. Retrieved from
https://www.nationalgeographic.com/travel/national-parks/glacier-national-park/

National Hurricane Center. (n.d.). Saffir-simpson hurricane wind scale. Retrieved from
https://www.nhc.noaa.gov/aboutsshws.php

National Park Service. (n.d.a). Bear cam - live from brooks falls in katmai national park.
Retrieved from
https://explore.org/livecams/brown-bears/brown-bear-salmon-cam-brooks-falls

National Park Service. (n.d.b). Can you outrun the Wright flyer. Retrieved from
https://www.nps.gov/teachers/classrooms/can-you-outrun-the-wright-flyer.htm

National Park Service. (n.d.c). Contact us. Retrieved from
  https://www.nps.gov/orgs/1557/contactus.htm?fullweb=1

National Park Service. (n.d.d). *Fiscal year 2018 NPS funding*. National Park Service.
  Retrieved from https://www.doi.gov/sites/doi.gov/files/uploads/fy2018_bib_bh069.pdf

National Park Service. (n.d.e). History & culture. Retrieved from
  https://www.nps.gov/glac/learn/historyculture/index.htm

National Park Service. (n.d.f). Organizational structure of the national park service.
  Retrieved from https://www.nps.gov/aboutus/organizational-structure.htm

National Park Service. (2016a). Early settlers. Retrieved from
  https://www.nps.gov/glac/learn/historyculture/early-settlers.htm

National Park Service. (2016b). National Park Service personnel. Retrieved from
  https://www.nps.gov/glac/learn/historyculture/nps-personnel.htm

National Park Service. (2016c). NPS entering the 21st century. Retrieved from
  https://www.nps.gov/articles/npshistory-entering-21st-century.htm

National Park Service. (2016d). Weather. Retrieved from
  https://www.nps.gov/glac/learn/nature/weather.htm

National Park Service. (2017a). Citizen science - Crown of the Continent Research Learning
  Center (U.S. national park service). Retrieved from
  https://www.nps.gov/rlc/crown/citizen-science.htm

National Park Service. (2017b). Common loon citizen science project. Retrieved from
  https://www.nps.gov/rlc/crown/common-loon-citizen-science-project.htm

National Park Service. (2017c). Places. Retrieved from
  https://www.nps.gov/glac/learn/historyculture/places.htm

National Park Service. (2018a). Common loons resource brief. Retrieved from
https://www.nps.gov/articles/common-loons-brief.htm

National Park Service. (2018b). President's proposed $2.7 billion budget for NPS includes
legislation to address $11.6 billion in deferred maintenance. Retrieved from
https://www.nps.gov/orgs/1207/02-12-2017-budget-proposal.htm

National Park Service. (2019a). Acadia National Park. Retrieved from
https://www.nps.gov/acad/index.htm

National Park Service. (2019b). Climate change. Retrieved from
https://www.nps.gov/glac/learn/nature/climate-change.htm

National Park Service. (2019c). Everglades National Park. Retrieved from
https://www.nps.gov/ever/index.htm

National Park Service. (2019d). Glacial geology. Retrieved from
https://www.nps.gov/glac/learn/nature/glacial-geology.htm

National Park Service. (2019e). Glaciers. Retrieved from
https://www.nps.gov/glac/learn/nature/glaciersoverview.htm

National Park Service. (2019f). National Park system. Retrieved from
https://www.nps.gov/aboutus/national-park-system.htm

National Park Service. (2019g). Pikas at Rocky - Rocky Mountain National Park (U.S.
National Park Service). Retrieved from
https://www.nps.gov/romo/learn/nature/pikas.htm

National Park Service. (2019h). What we do. Retrieved from
https://www.nps.gov/aboutus/index.htm

National Parks Traveler (n.d.). Park history: Glacier national park. Retrieved from
https://www.nationalparkstraveler.org/parks/glacier-national-park/park-history-glacier-national-park

NPT Staff. (2017). *Citizen science opportunities at Glacier National Park;* Retrieved April 12, 2019, from https://www.nationalparkstraveler.org/2017/05/citizen-science-opportunities-glacier-national-park

Nunez, C. (2019). *What is global warming?* Retrieved Apr 21, 2019, from https://www.nationalgeographic.com/environment/global-warming/global-warming-overview/

Oxford University Press. (2019). *Citizen science.* Retrieved Apr 12, 2019, from https://en.oxforddictionaries.com/definition/citizen_science

Repanshek, K. (2019). UPDATED | President's FY20 budget proposal cuts interior by 14 percent. Retrieved from https://www.nationalparkstraveler.org/2019/03/updated-presidents-fy20-budget-proposal-cuts-interior-14-percent

Shaftel, H., Callery, S. & Jackson, R. (2019). *Climate change evidence: How do we know?* Retrieved Apr 21, 2019, from https://climate.nasa.gov/evidence

Shaftel, H., Jackson, R. & Callery, S. (2019a). *The causes of climate change.* Retrieved Apr 21, 2019, from https://climate.nasa.gov/causes

Shaftel, H., Jackson, R. & Callery, S. (2019b). *The effects of climate change.* Retrieved Apr 21, 2019, from https://climate.nasa.gov/effects

Share Maps & Collaborate with Colleagues to Solve Problems. (n.d.). Retrieved September 17, 2019, from https://www.esri.com/en-us/arcgis/products/arcgis-online/capabilities/share-collaborate.

Shetler, S. (2019). Mile by mile: Here's what you'll see on Going-to-the-Sun road in Glacier National Park. Retrieved from https://quirkytravelguy.com/mile-guide-going-to-sun-road-glacier-park/

Survey123 for ArcGIS. (n.d.). Retrieved October 7, 2019, from

    https://www.esri.com/en-us/arcgis/products/survey123/overview.

The Cornell Lab of Ornithology. (n.d.). Common loon life history. Retrieved from

    https://www.allaboutbirds.org/guide/Common_Loon/lifehistory

United States Geological Survey. (n.d.a). Logo - National Park Service. Retrieved from

    https://www.usgs.gov/media/images/logo-national-park-service-cuyahoga-valley-national-park

United States Geological Survey. (n.d.b). Repeat photography project. Retrieved from

    https://www.usgs.gov/centers/norock/science/repeat-photography-project?qt-science_center_objects=0#qt-science_center_objects

Usability.gov. (2013). Online surveys. Retrieved from

    https://www.usability.gov/how-to-and-tools/methods/online-surveys.html

Wege, G. J. (2009). *Common Loons*. Photograph. Retrieved from

    https://www.flickr.com/photos/usfwsmidwest/4514433523

Work with Your Data in a Powerful System. (n.d.). Retrieved September 17, 2019, from

    https://www.esri.com/en-us/arcgis/products/arcgis-online/capabilities/data.

WPI. (n.d.) Marja bakermans. Retrieved from

    https://www.wpi.edu/people/faculty/mbakermans

Appendices

Appendix A

Interview with Local Expert

  Marja Bakermans is an Associate Teaching Professor at WPI. She received her PhD from Ohio State University in 2008 (WPI, n.d.). Bakermans studies various species of warblers and the migratory habits of whip-poor-wills to monitor the influence of forest management, urbanization, and agriculture on wildlife (WPI, n.d.). She conducts an extensive amount of field research on a variety of bird species. Bakermans can provide insight into field survey methods, specifically how they are conducted and what information they can provide. She can also provide recommendations about how data collected from field surveys can be displayed in different manners.

Protocol

  Kyle and Seth were assigned with asking the questions during the interview. Molly recorded minutes. Danielle was tasked with timing each question to ensure that no question went over seven minutes. At her discretion, a question could extend past this limit if time allowed.

Question 1 (5 mins)

Context: Last time we met, you expressed a difference between amateur and professional data collection. Knowing this, what can be done to shorten this gap? Regarding birds, what can amateurs reasonably be expected to collect?

Question: What is the limit to the type of data collections amateurs can collect?

Answer:
- She asked how many loon species there are, we answered that there are only common loons in the park
- Presence / absence is the easiest type of data to collect and the easiest type of data to trust
    - As data increases in complexity, amateur data collection becomes less reliable

- She discussed that it's best to have standardized protocol
    - Have basic requirements, and ensure that they can be met
    - She said that the model the park has, where volunteers are trained and then must collect a certain amount of data per year, is a good model, because people who collect more data may receive more extensive training
- Training is needed for the depth of the park's survey
    - For minimal training, only presence / absence and maybe count could be trusted

Question 2 (2 mins)

Context: One goal of this project is to present data collected by citizen scientists in the park. With the new data collection method being tested, participants of different skill levels will be sending back field observations. *

Question: Is it feasible to have data from people with different training levels to be integrated into one visualization? How would this affect the reliability and validity of data presented?

Answer:
- Analyses can account for training level
    - Data can be analyzed in different ways, and then checked for differences in the analyses
    - If there are differences, the data should be differentiated
    - If there are no differences, the data can be shown together

Question 3 (2 mins)

Context: As previously stated, people participating in this program have varying amounts of experience.

Question: How do you incorporate field data from less experienced participants in a meaningful way?
- Incorporate data into your research
- Do you set up a special rubric for the day?

- What's realistic for people to learn in a day regarding birds? In half a day? In an hour?

Answer:
- The most reliable data is for management regulations and policies
    - One-day visitor data can't be used for this purpose
    - This data is often shared with the government, and thus must be reliable
- Summary information can use all data and be shared with the public
- It's important to have participant data shown somehow, so that people can see their contribution and feel more motivated to continue participating
    - Less accurate and precise data can be used in summaries

Question 4 (14 mins)

Context: This program collects various data such as population numbers, chick development stages, predators, behaviors, and nesting locations. The visualization method we are creating will most likely incorporate some of this data to display to the general public.

Question: How do you display various types of data? What are the most impactful results to display?

Answer:
- It's important to show data over time, but collecting data like this can be hard for individual biologists
- Any data that can provide information towards popular trends is important
    - Offspring amount / survival
    - Population numbers
    - Anything that relates to survival and reproductive success - this may include certain behaviors
    - Which lakes have the highest population numbers for adults and chicks
- If you have a successful lake, investigate what can be done at other lakes to improve their data

- It's important to think about all information / factors that are relevant to this

    - Including things such as lake depth and temperature

- **In MA there's a loon reintroduction project**

    - Can look into this for various info about loon necessities

    - In western part of the state

    - Big collaboration between organizations, including BRI (biodiversity research institute, nonprofit research), mass wildlife, a lot of different partners

        - Look into potential volunteer opportunities

- She asks if the citizen science program is for reintroduction or for population monitoring, we answer that we believe it's population monitoring, but would need to verify

    - She recommends that we find out if it's to increase baseline data for population size

        - If above is true then behavioral data is not *necessary*, but could be used to infer population size based on territorial / protective behaviors

        - If it's *just* population size, then potentially more data can be collected by focusing on more basic population data

    - She recommends we look at eBird to see some common loon data

Question 5 (2 mins)

Context: There are a variety of trails in the park that cover a range of different difficulty levels. Citizen scientists come from all sorts of different backgrounds and age groups. We are hoping to get an idea of the difficulties of data collection in order to better distribute participants.

Question: How would you describe the difficulty of data collection both mentally and physically?

Answer:

- People want to contribute because it's fun and exciting

- Having a space for people to show / view data collected helps improve participation
- Mass Audubon has a board they can record what species they see where
- As a professional it's more stressful
- It's important to involve kids when possible to help them love nature and understand science

Notes

- She will try and get us information on the reintroduction program
- *Frontiers in Ecology and the Environment* is a highly reputable scientific journal
    - They've been publishing a lot on citizen science lately
    - The journal looks a lot at the "big picture"
    - She gives a couple articles we can look at: "Assessing data quality in citizen science" and "Data validation in citizen science: a case study from Project FeederWatch"

Appendix B

Lake Priorities

Priority 1: Nesting occured or attempted in the last five years

Priority 2: Nesting records exist and lake occupied by resident pair in the previous five years

Priority 3: Lake has been occupied during the nesting season sometime in the previous five years by a pair

Priority 4: Additional lakes with potential breeding habitat (over ten acres in size and at elevations less than 5200 feet)

Priority 5: Additional lakes under ten acres and/or elevations over 5200 feet

Appendix C

       A survey is a list of questions intended for a target audience that is generally completed through the completion and submission of a form (Usability.gov, 2013). Modern surveys have been moving towards online submission methods as many online survey platforms include a variety of data analysis tools (Usability.gov, 2013). Online surveys can also be accessed by users who may no longer be onsite allowing for a potential increase in user responses received (Usability.gov, 2013). A survey should consist of a clearly defined purpose, detailed plan, and a list of well-developed questions.

1.) On a scale from 1 to 5, how easy was the map to use?

       1 = difficult, 3 = neutral, 5 = very easy

2.) On a scale from 1 to 5, how likely would it be that you would use the map again?

       1 = very unlikely, 3 = neutral, 5 = very likely

3.) What feature on this map was the most useful? Why?

       Open-ended, 'Why' is optional

4.) What feature on this map was the least useful? Why?

       Open-ended, 'Why?' is optional

5.) What feature would you like to see added to the map?

       Open-ended

6.) What would you change about the map?

       Open-ended

Appendix D
How-to-Use Guide
Loon Priority Tool

When first opened, the application displays a map of Glacier National Park with lakes, lake priorities, hiking trails, and roads. There are many tools in this application to help effectively utilize this map.

Legend:
- Located in the top right-hand corner - the icon is three lines
- When clicked on, it opens a panel that describes the symbology the map utilizes

Layers List:
- Located to the right of the Legend icon - icon is three stacked squares
- When clicked on, it indicates which layers are included in the current viewing of the map

Widgets: (in order)

About
- Located below the search bar, all the way to the left - the icon is a gray square with a white circle containing an "i"
- When clicked on, it displays basic information about the program and the map, including a feedback survey and a link to a document containing pictures of all the lakes

Filter
- Located on the left side of the map, next to the About widget - the icon is a gray square with a white funnel
- When clicked on, it allows the user to filter out different lake priorities and hiking trails
To Use:
- Click the switch at the top right in the filter pop-up to turn the Priority Points Filter on/off
- Select the Lake Priority filter dropdown to filter which priority lake you want to survey:
  - Priority 1 - Nesting occurred or attempted in the last five years
  - Priority 2 - Nesting records exist and lake occupied by resident pair in the previous 5 years
  - Priority 3 - Lake has been occupied during the nesting season sometime in the previous 5 years by a pair

○ Priority 4 - Additional lakes with potential breeding habitat (over 10 acres in size and at elevations less than 5200 feet)
○ Priority 5 - Additional lakes under 10 acres and/or at elevations over 5200 feet
● Select the Hike Difficulty filter dropdown to filter by hike difficulty:
○ Road Access
○ Less Challenging
○ Challenging
○ Very Challenging
● Select the Survey Needs filter dropdown to filter by survey needs:
○ Not Flagged
○ Additional Survey Needed
○ Post Summer Loon Day Survey Needed
○ Spring Loon Day Survey Needed
○ Summer Loon Day Survey Needed

Measure

● Located on the top left, next to the Filter widget - the icon is a gray square with a white ruler inside
● When clicked on, the measure tool can be used to calculate distances in miles or areas in acres

To Use:
● Select area, distance, or location using the icons in the top left of the widget, then select unit of measurement to the right of these icons
● Area:
○ Click on the map to create corners of perimeter of desired area
○ Double click at last point to finish the area
○ Click clear to clear the selection
● Distance:
○ Click on the map to create points along distance
○ Click once on a map to create the beginning of a line, double click on the map to finish the line between the two points
○ Click clear to clear the selection
● Location:
○ Hover over with mouse to view latitude and longitude within the area
○ Click to select desired location
○ Click clear to clear the selection

Draw

- Located on the top left, next to the Measure widget - the icon is a gray square with a white paintbrush and palette inside
- When clicked on, it allows you to mark observation points

To Use:
- Select draw mode by clicking on one of the displayed icons
  - Point:
    - Click the dropdown and select a category
    - Select the graphic you want to use
    - Select Size, Color, Transparency, Outline Color, and Outline Width
    - You can turn Show Location Measurement on/off
      - Select Unit, Font Color, Font Size
    - Click to select point
  - Line:
    - Select line type
    - Select Color, Size, Transparency, and Width
    - You can turn Show Location Measurement on/off
      - Select Unit, Font Color, Font Size
    - Press down to start and let go to finish
  - Polyline:
    - Select line type
    - Select Color, Size, Transparency, and Width
    - You can turn Show Location Measurement on/off
      - Select Unit, Font Color, Font Size
    - Click to start drawing
    - Click at points along path
    - Double click to finish
  - Freehand Polyline:
    - Select line type
    - Select Color, Size, Transparency, and Width
    - You can turn Show Location Measurement on/off
      - Select Unit, Font Color, Font Size
    - Press down to start and let go to finish
  - Arrow:
    - Select shape type
    - Select Color, Width, Transparency, Outline Color, and Outline Width
    - You can turn Show Location Measurement on/off
      - Select Unit, Font Color, Font Size
    - Press down to start and let go to finish
  - Triangle:

- ■ Select shape type
- ■ Select Color, Transparency, Outline Color, and Outline Width
- ■ You can turn Show Location Measurement on/off
  - ● Select Unit, Font Color, Font Size
- ■ Press down to start and let go to finish
- ○ Extent:
  - ■ Select shape type
  - ■ Select Color, Transparency, Outline Color, and Outline Width
  - ■ You can turn Show Location Measurement on/off
    - ● Select Unit, Font Color, Font Size
  - ■ Press down to start and let go to finish
- ○ Circle:
  - ■ Select shape type
  - ■ Select Color, Transparency, Outline Color, and Outline Width
  - ■ You can turn Show Location Measurement on/off
    - ● Select Unit, Font Color, Font Size
  - ■ Press down to start and let go to finish
- ○ Ellipse:
  - ■ Select shape type
  - ■ Select Color, Transparency, Outline Color, and Outline Width
  - ■ You can turn Show Location Measurement on/off
    - ● Select Unit, Font Color, Font Size
  - ■ Press down to start and let go to finish
- ○ Polygon:
  - ■ Select shape type
  - ■ Select Color, Transparency, Outline Color, and Outline Width
  - ■ You can turn Show Location Measurement on/off
    - ● Select Unit, Font Color, Font Size
  - ■ Press down to start and let go to finish
- ○ Freehand Polygon:
  - ■ Select shape type
  - ■ Select Color, Transparency, Outline Color, and Outline Width
  - ■ You can turn Show Location Measurement on/off
    - ● Select Unit, Font Color, Font Size
  - ■ Press down to start and let go to finish
- ○ Text:
  - ■ Select Text, Font Color, Font Size
  - ■ Click where you want this text to go

Print 🖶

- ● Located on the top left, next to the Draw widget - the icon is a gray square with a white printer inside
- ● When clicked on, it can create a PDF of the map that can then be saved and printed either on paper or to the files onto a phone

To Use:

- ● 'Layout' and 'Format' both have dropdown options, but these most likely will not need to be changed
- ● Clicking 'advanced' will allow you to add more specific features to your map
- ● When desired settings are in place, click 'Print' - a PDF will then appear in the widget, and once clicked on, the pdf can be saved and printed

Pop-Up:

Additional information about each lake can be accessed by clicking on the circle in the center of the lake.

- ● *Survey Needs* gives information about the recent surveys conducted and the survey status of the lake
- ● *Access Notes* gives hiking information, such as difficulty and type, along with additional notes about the lake
- ● *Survey Information* gives information on observation points for the lake
- ● *Additional Information* gives more detailed location information on the lake

To Use:

- ● Click the circle in the middle of the lake to view the pop up
- ● Desktop Version:
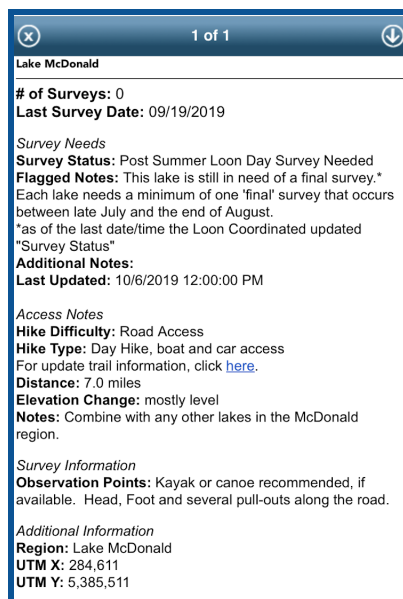
- Mobile Version:
  - Click the arrow on the right in the pop-up to view the additional information for that lake

Elevation Profile Tool

Zoom:
- The plus (+) and minus (-) buttons located at the top left of the screen change the level of zoom on the map.

Legend:
- Clicking on the legend brings up a list of all of the layers that are on the map.
- By checking or unchecking the boxes, the layers can be shown or hidden

- Clicking the arrow to the right of the layer name will open a drop down menu that will display the labels for the symbology found on the map for that layer. Clicking the arrow again will re-collapse the menu.
- Clicking the X in the top right corner will close the legend.

Elevation Profile Chart:

- Clicking the mountain icon ( ) will open or collapse the profile chart.
- Clicking a trail on the map will display its elevation profile in the chart.
  - Clicking on another trail will only display the elevation chart for that segment, even though all previously clicked on segments will remain highlighted.
  - To clear all of the highlighted segments on the map click the draw tool ( ) twice
- Clicking the draw tool ( ) will allow you to place a point by clicking on the map. When you are about to be done drawing points, double-click to place your last point. The elevation profile will then be generated.
  - If you want to draw more points, clicking on the map again will remove the previous points and start a new selection.
  - Click on the drawing tool again to remove all points on the map and turn off the drawing tool.
- Clicking on the profile flip tool ( ) will flip the chart to display in the opposite direction.
- Dragging your mouse cursor over the elevation profile chart will provide information on the distance, height, and change in height at that point on the trail.
  - A dot will appear on the map in relation to where the cursor is on the chart.

Loon Priority Tool - Employee

The differences between the Employee Map and the Public Map are as follows:

Pop-Up
The Pop-Up shows the information shown in the Public Map, but includes an additional
Employee Information section, which includes information such as:
- Some basic survey information from the most recent survey, such as total number of birds, # of pairs, # of chicks/juveniles, Chick Size, Nest Status, and Significant Observer Notes
- Information on the observer who took the last survey, including observer's name, phone number, and eMail address

Ability to Edit
        In order to edit the different survey needs, priority, etc. of a lake open the item's details of the priority points layer. On the layer item's details, click on the data tab. In order to edit, make sure you are logged into ArcGIS Online. Scroll to the desired lake you wish to change the information for and then scroll over to the appropriate column. Double click the box with the appropriate information and then editing will be enabled.
        The majority of the edits to the pop up can be made in the "Loon Priority Points" layer. All edits must be made to either the "Loon Priority Points" layer or the survey point layer in order for information to change in the pop up.
        Provided below is an example of how to edit the survey status of a lake.

1. To begin editing the survey status of a lake, open the "Loon Priority Tool - Public Basemap". Make sure to open the actual basemap and not the public application. Survey status cannot be edited from the application.
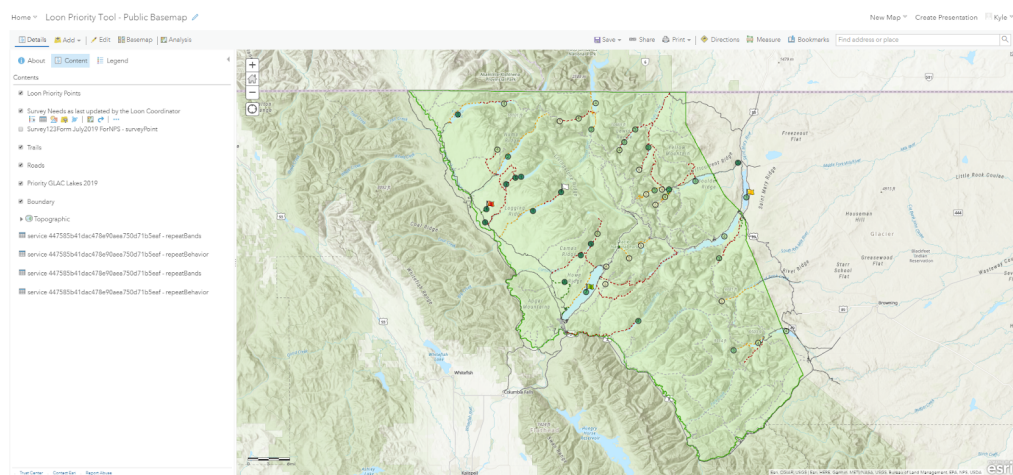
2. Find the "Loon Priority Points" layer and hover your mouse over the layer. Click on the "Show Table" button, which is the second button from the left.
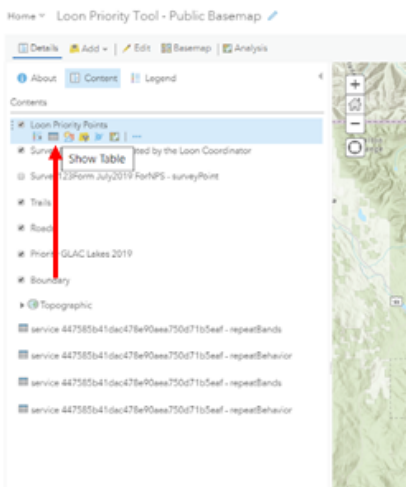
3. Once the table opens, it displays the multiple attributes in the "Loon Priority Points" layer. Scroll over to the "Survey Needs" attribute. The titles of the attributes can be found in a light gray strip across the top of the table.

4. The "Survey Needs" column shows the status of each of the 45 priority lakes in the park. The four types of statuses are 'Not flagged', 'Spring Loon Day Survey Needed', 'Summer Loon Day Survey Needed', 'Post Summer Loon Day Survey Needed', and 'Additional Survey Needed'. In order to change the status of a lake, these phrases must be typed into the "Survey Needs" column with the corresponding row of the lake whose status is being changed.

5. To edit the survey needs of a lake, double click on the cell you wish to change. Type out what status you wish to change the lake to. Press enter. The survey status of the lake has now changed and the corresponding flag, or no flag, will update to the map.

6. Finally, in order for the map to update across all three applications, the layer and map must be saved. In order to save the layer, hover your mouse over the "Loon Priority Points" layer. The last button on the layer is three dots labeled "More options", click on it. A drop down list appears and at the bottom of the list is a "Save Layer" button. Save the layer. After the layer has been saved, save the map at the top of the map towards the middle of the screen.
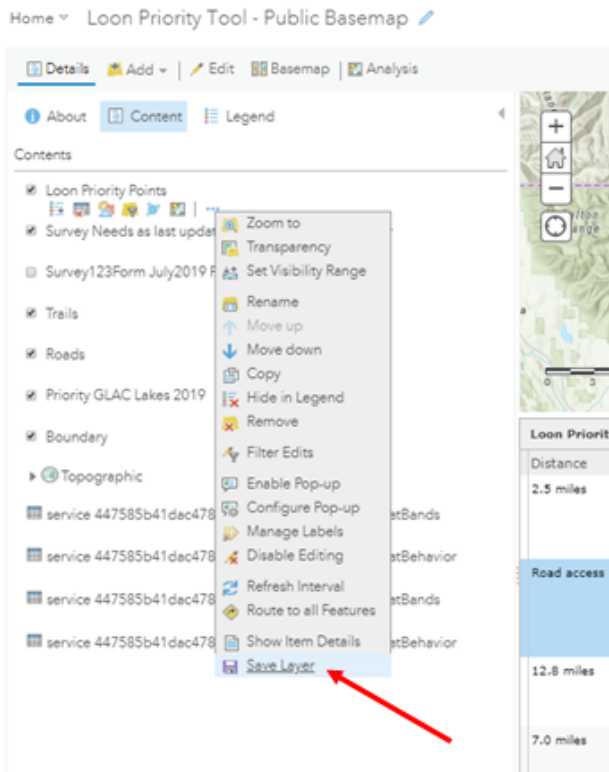
Also, if the above form of editing is not ideal, there is another way to edit the survey status of a lake. Below are detailed steps for that form of editing.

1. To begin editing the survey status of a lake, open the "Loon Priority Tool - Public Basemap". Make sure to open the actual basemap and not the public application. Survey status cannot be edited from the application.
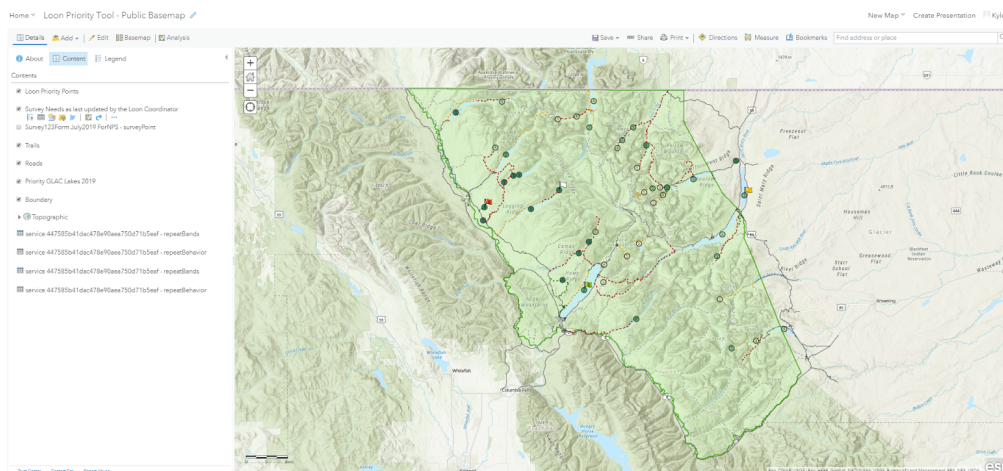
2. Find the "Loon Priority Points" layer and hover your mouse over the layer. Click on the "More options" button, which is the last button on the right. In the "More options" drop down list is a button labeled "Show Item Details", click on the button.
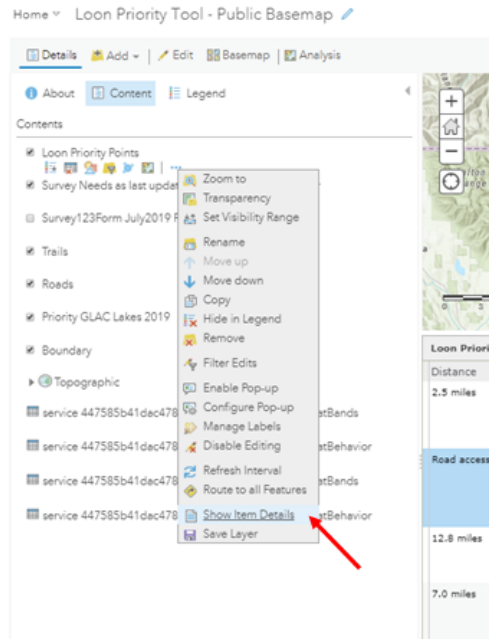
3. The "Show Item Details" button will open a new page with information on the "Loon Priority Points" layer. A button labeled "Data" appears in the top right of the screen. This button opens the same attribute table accessible from the map.

4. Scroll over to the "Survey Needs" column. The "Survey Needs" column shows the status of each of the 45 priority lakes in the park. The four types of statuses are 'Not flagged', 'Spring Loon Day Survey Needed', 'Summer Loon Day Survey Needed', 'Post Summer Loon Day Survey Needed', and 'Additional Survey Needed'. In order to change the status of a lake, these phrases must be typed into the "Survey Needs" column with the corresponding row of the lake whose status is being changed.

5. To edit the survey needs of a lake, double click on the cell you wish to change. Type out what status you wish to change the lake to. Press enter. The survey status of the lake has now changed and the corresponding flag, or no flag, will update to the map. The layer will now save and update across the three applications.

Home   Gallery   Map   Scene   Groups   Content   Organization

Kyle Lang
krlang_wpi

Loon Priority Points

Overview   **Data**   Visualization   Usage   Settings

Table   Fields

Double-click a value in the table to change it.   Data Last Updated: Oct 8, 2019, 1:22:58 PM

Loon_Priority_Lake_Obs_Pts__0 (Features: 45, Selected: 1)   ≡

Observation_Po...	Notes	Priority_Notes	Territory	Hike Difficulty	Survey Needs	Last Updated	Additional Notes	x	y
Trail around lake, near hotel and near road.	Combine with Josephine and Grinnel, or Sherburne or Fishercap, et al.	Priority 2: Nesting records exist and lake occupied by resident pair in the previous 5 years.	300	Less Challenging	Not flagged	10/5/2016, 6:00 PM		-113.66	48.80
Various access point along lakeshore. Canoe or kayak recommended if available.		Priority 3: Lake has been occupied during the nesting season sometime in the previous 5 years by a pair.	198	Road Access	ey Survey Needed	10/5/2019, 6:00 PM		-113.42	48.78
Campground at foot, bushwhack towards head, until entire lake can be viewed.	Combine with Logging Lake.	Priority 1: Nesting occurred or attempted in the last five years.	110	Very Challenging	Summer Loon Day Survey Needed	10/5/2019, 6:00 PM		-114.00	48.79
Kayak or canoe recommended, if available. Head, Foot and several pull-outs along the road.	Combine with any other lakes in the McDonald region.	Priority 1: Nesting occurred or attempted in the last five years.	163	Road Access	Post Summer Loon Day Survey Needed	10/5/2016, 6:00 PM		-113.92	48.59
Large Douglas Fir is a good observation spot.	Can be combined with Winona.	Priority 1: Nesting occurred or attempted in the last five years.	125	Less Challenging	Addional Survey Needed	10/5/2019, 6:00 PM		-114.23	48.76
Head of lake: from road or on hill across road.	Can be combined with Hidden Meadow or on the	Priority 1: Nesting occurred or attempted in the	349	Road Access	Not flagged	10/5/2019, 6:00 PM		-114.24	48.73

Appendix E

How-to-Create Guide
Loon Priority Tool

This guide will contain the steps on how to create the public and employee basemap, application, and elevation profile.

Lakes and Territories

Akokala	3	Grinnell	113	Lake McDonald	163	Rogers	268
Arrow	6	Harrison	121	Lake Sherburne	275	St Mary	289
Avalanche	11	Helen	122	Logging	178	Swiftcurrent	300
Babb Beaver	12	Hidden	123	Lower Quartz	197	Trout	314
Bowman	27	Hidden Meadow	125	Lower St Mary	198	Two Medicine	316
Bullhead	33	Howe	130	Lower Two Medicine	203	Upper Kintla	329
Cosley	53	Johns	136	Medicine Grizzly	215	Upper Two Medicine	338
Elizabeth	76	Kintla	143	Middle Quartz	217	Waterton	343
Fish	83	Kootenai	150	Mokowanis	224	Winona	349
Fishercap	86	Lake Frances	156	Quartz	255		
Glenns	108	Lake Janet	159	Red Eagle	262		
Grace	110	Lake Josephine	138	Red Rock	264		

List of Layers
The list of layers below are how the layers should be ordered in the basemap from top to bottom.

Public Basemap
- Survey Needs (Analysis Layer)
- Priority Points Layer
- Survey Point Layer from Survey123
- Trails
- Roads
- Priority Lakes (used to display the 45 priority lakes, do not use in analysis)
- Boundary

Employee Basemap
- Survey Needs (Analysis Layer), rename to "Employee Survey Needs"
- Survey Point Layer from Survey123
- Location Repeat Layer from Survey123
- Priority Points Layer
- Trails
- Roads
- Priority Lakes (used to display the 45 priority lakes, do not use in analysis)
- Boundary
- Subdistricts

Boundary
- Click "Add" at the top of the page
- Select "Search for layers"
    - Change "My Content" to "My Group" or My Organization" depending on where the boundary file is accessible.
- Click the + in the bottom right of the layer to add it to the basemap.

    If the layer is saved as a file on your computer, when you click "Add" choose "Add layer by file" instead, select your file, and import the layer.

- Click "Change Style"
- Choose an attribute to show
    - Show location only
- Select a drawing style
    - Click "Options"
- Click to the left of "Symbols" to change how the symbol is displayed
    - Change the fill to #D3FFBE (Light Green)
        - Set the transparency to ~60%

- Change the outline to #38A800 (Dark Green)
    - Set the transparency to 0%
    - Set the line width to 2 px
- Click "OK" to save the changes
- Set the Overall transparency to ~12.5%
- Click "DONE" to save the changes

Priority Lakes
- Click "Add" at the top of the page
- Select "Search for layers"
    - Change "My Content" to "My Group" or My Organization" depending on where the boundary file is accessible.
- Click the + in the bottom right of the layer to add it to the basemap.

    If the layer is saved as a file on your computer, when you click "Add" choose "Add layer by file" instead, select your file, and import the layer.

- Click "Change Style"
- Choose an attribute to show
    - Show location only
- Select a drawing style
    - Click "Options"
- Click to the left of "Symbols" to change how the symbol is displayed
    - Change the fill to #4F81BD (Blue)
        - Set the transparency to 0%
    - Change the outline to #365D8D (Dark Blue)
        - Set the transparency to 0%
        - Set the line width to 2 px
    - Click "OK" to save the changes
- Set the Overall transparency to 75%
- Click "DONE" to save the changes

Roads
- Click "Add" at the top of the page
- Select "Search for layers"
    - Change "My Content" to "My Group" or My Organization" depending on where the boundary file is accessible.
- Click the + in the bottom right of the layer to add it to the basemap.

If the layer is saved as a file on your computer, when you click "Add" choose "Add layer by file" instead, select your file, and import the layer.

- Click "Change Style"
- Choose an attribute to show
    - Show location only
- Select a drawing style
    - Click "Options"
- Click to the left of "Symbols" to change how the symbol is displayed
    - Change the color to #4D4D4D (dark grey)
        - Set the transparency to 0%
        - Set the line width to 1 px
        - Pattern and arrow are a straight, unbroken line (first option)
    - Click "OK" to save the changes
- Set the Overall transparency to 0%
- Click "DONE" to save the changes

Trails
- Click "Add" at the top of the page
- Select "Search for layers"
    - Change "My Content" to "My Group" or My Organization" depending on where the boundary file is accessible.
- Click the + in the bottom right of the layer to add it to the basemap.

If the layer is saved as a file on your computer, when you click "Add" choose "Add layer by file" instead, select your file, and import the layer.

- Click "Change Style"
- Choose an attribute to show
    - trailRatin
- Select a drawing style
    - Click "Options"
- Click Very Challenging
    - Change the color to #A80000 (Dark Red)
        - Set the transparency to 0%
        - Set the line width to 1.5 px
        - Pattern is a dashed line (third option)
        - Arrow is a straight, unbroken line (first option)

- Click "OK" to save the changes
- Click Challenging
    - Change the color to #E69800 (Orange)
        - Set the transparency to 0%
        - Set the line width to 1.5 px
        - Pattern is a dashed line (third option)
        - Arrow is a straight, unbroken line (first option)
    - Click "OK" to save the changes
- Click Less Challenging
    - Change the color to #267300 (Dark Green)
        - Set the transparency to 0%
        - Set the line width to 1.5 px
        - Pattern is a dashed line (third option)
        - Arrow is a straight, unbroken line (first option)
    - Click "OK" to save the changes
- Click Other
    - Change the color to #AAAAAA (Light Grey)
        - Set the transparency to 0%
        - Set the line width to 1.5 px
        - Pattern is a dashed line (third option)
        - Arrow is a straight, unbroken line (first option)
    - Click "OK" to save the changes
- Set the Overall transparency to 0%
- Click "DONE" to save the changes

Subdistricts
- Click "Add" at the top of the page
- Select "Search for layers"
    - Change "My Content" to "My Group" or My Organization" depending on where the boundary file is accessible.
- Click the + in the bottom right of the layer to add it to the basemap.

If the layer is saved as a file on your computer, when you click "Add" choose "Add layer by file" instead, select your file, and import the layer. Uncheck the layer in the Contents tab so it does not appear on the map visually.

Survey Point Layer from Survey123
- Click "Add" at the top of the page

- Select "Search for layers"
- Click the + in the bottom right of the layer to add it to the basemap.
    - The Survey123 layer should appear in "My Content" if it was published by you on Survey123

Uncheck the layer in the Contents tab so it does not appear on the map visually.

Survey Point Layer from Survey123 (Employee)
- Click "Add" at the top of the page
- Select "Search for layers"
- Click the + in the bottom right of the layer to add it to the basemap.
    - The Survey123 layer should appear in "My Content" if it was published by you on Survey123

Symbology Configuration
- Click "Change Style"
- Choose an attribute to show
    - Show location only
- Select a drawing style
    - Click "Options"
- Click to the left of "Symbols" to change how the symbol is displayed
    - Under shapes select "Basic" from the drop down menu
        - We chose the red pin
        - Symbol Size set to 20 px
    - Click "OK" to save the changes
- Set the Overall transparency to 0%
- Click "DONE" to save the changes

Location Repeat Layer from Survey123
    Added automatically when the Survey Point Layer from Survey123 is added. Delete the layer from the Public Basemap. Uncheck the layer on the Employee basemap.
    If the location repeat is checked on, custom symbols will appear for the following repeats: Observation Point, Loon, Nesting Area, Nursery Area, Other Type, Watercraft, Other. The default options were left, but they can be further customized.

- Click "Change Style"

- Choose an attribute to show
    - Location Type
- Select a drawing style
    - Click "Options"
- Click to edit the symbol or label
    - Click "OK" to save the changes
- Set the Overall transparency to 0%
- Click "DONE" to save the changes

Priority Points Layer

This layer will include all 45 of the priority lakes as points in the center of each of the lakes

- Export priority points layer from WPI Citizen Science Group. All necessary information is in the excel sheet. Caution: may need updating for some attributes such as hike type and observation points.

Legend for Priority Points
- In order to configure the labels for the priority lakes, click on "change style" under the priority lakes layer
- Under "choose attribute to show", choose "Priority"
- For each of the priorities, the lake will be represented by a basic circle that is size 15.
- Each basic circle will have a black outline with a line thickness of 2.
- The hex codes for the fill of each of the priorities are listed below
    - Priority 1: #006837
    - Priority 2: #31A354
    - Priority 3: #78C679
    - Priority 4: #C2E699
    - Priority 5: #FFFFCC

Refresh Interval
- Click "More Options"
    - Click "Refresh Interval"
- Check the box to turn on the refresh interval
    - Enter 30 minutes into the box

This will cause the layer to refresh every 30 minutes.

Survey Needs Layer

- Prerequisites:
    - Layer that includes all priority lakes as points
    - Layer that includes the survey points (from Survey123)
    - Need ownership of both layers
    - Need to have at least one survey point at every single priority lake entered into Survey123. These survey points should contain no information beyond lake name, survey day, date and time, and observer name
    - Ability to perform analysis within ArcGIS Online
    - Lakes points layer has territory number used in Survey123 application associated with each lake
- Click Analysis. Under summarize data click Join Features
- Choose Target Layer:
    - Priority Lakes Points layer
- Choose Layer to join to target layer:
    - Survey Point Layer
- Choose the fields to match:
    - Choose select territory for both layers
- Choose join operation:
    - Set to join one-to-one
- Define which record is kept:
    - Choose order by
    - Field:
        - Survey date (auto-populated)
    - Sort by:
        - Oldest
- Result layer name:
    - Rename to Survey Point Query
    - Select "create result as hosted feature layer view"
- Click "Run Analysis"

Refresh Interval
- Click "More Options"
    - Click "Refresh Interval"
- Check the box to turn on the refresh interval
    - Enter 30 minutes into the box

This will cause the layer to refresh every 30 minutes, allowing it to update with new survey information and rerun the scripts.

Pop-Up
The pop-up that is displayed to the user is created in this layer.
- Click "More Options" on the Survey Needs layer

- Select "Configure Pop-Up"
- Pop-up Title
    - {Name}
        - This formats the title of the pop-up to become the name of the selected lake
- Pop-Up Contents
    - Select "A custom attribute display" from the Display drop down menu

Before visually customizing the pop-ups further, custom expressions need to be entered to count the number of survey points and to automatically update notes based on a points flag status.

# of Surveys
- Under attribute expressions click the "Add" button
- Rename the expression to "# of Surveys" in the top left corner of the screen
- Enter the following code:
- *Make sure the layer is named the same in the legend as in the following code

```
var sql = "selectTerritory = '" + $feature.selectTerritory + "'";
var tbl = Filter(FeatureSetByName($map,"Survey123Form July2019 ForNPS -
surveyPoint"), sql);

var tblCnt = count(tbl)

return tblCnt - 1
```

- Click "OK"

Flagged Notes
- Under attribute expressions click the "Add" button
- Rename the expression to "# of Surveys" in the top left corner of the screen
- Enter the following code:

```
var flg = ""

if ($feature.Survey_Needs == "Not flagged") {
     flg = ""
}
else if ($feature.Survey_Needs == "Spring Loon Day Survey Needed") {
     flg = "Each priority lake needs to be surveyed at least once between
early May to early July. Ideally, this survey occurs during the mid-May Spring
Loon Days weekend, but in some cases, survey access may not be possible till
June or early July."
}
else if ($feature.Survey_Needs == "Summer Loon Day Survey Needed") {
     flg = "Each lake needs to be surveyed over the Summer Loon Days weekend
in mid-July. If flagged, this lake has yet to be officially assigned to a
```

```
volunteer/park staff as of the last time this map was updated by the Loon
Coordinator."
}
else if ($feature.Survey_Needs == "Post Summer Loon Day Survey Needed") {
      flg = "Each lake needs a minimum of one 'final' survey that occurs
between late July and the end of August."
}
else if ($feature.Survey_Needs == "Additional Survey Needed") {
      flg = "This need may be related to loon breeding activity, unusual
conditions, or a variety of other reasons."
}
else {
      flg = "Please update statement information and check for spelling
errors."
}

return flg
```

- Click "OK"

This code may need to be modified as flags and flag notes change, so a brief description of how to modify the code and how it works will be included.

- The first statement `var flg = ""` creates a variable called flg. Do NOT edit this line.
- The statement: `if ($feature.Survey_Needs == "Not flagged")` creates the condition to be tested. `$feature.Survey_Needs` is the attribute in the map that has the flag information. The text in red should match the name of the flags in the override layer. The red text in between the quotation marks need to be updated if the name of the flags are changed in the override layer.
- Under each `if` and `else if` statement is a line with `flg = ""`
    - The words within the red parenthesis are the flag notes. If one of the flag descriptions needs to be updated, the text between the red quotation marks can be replaced with the new description.
    - This section takes the flg variable we made in line one and makes it "store" the descriptions we entered *if* the flag the lake has on the map matches the flag associated with each description.
- The `else` statement that finishes off that block of code is an error message. If the text "Please update statement information and check for spelling errors." appears in the pop-up instead of the flag description, then there has been some type of spelling error, formatting error, or a new flag has been added and it does not have a description yet.
- The `return flg` line takes the flg variable that now is storing the flag description we want and turns it into an output that can be displayed. Do NOT edit this line
- If more flags are added to the override layer in the future, the code will need to be updated to automatically add the flag descriptions. In that case, the code format below can be copied into the new line. The new flag would be entered into the first set of red quotation marks, the description would be entered in between the second set of red quotation marks.

```
else if ($feature.Survey_Needs == "") {
      flg = ""
}
```

Now that the custom expressions have been created, we can configure the custom pop-up.
- Click the "Configure" button under Pop-up Contents
- The formatting we used will be pasted below, however the employee information section should not be pasted into the public application pop up and only into the employee pop up:

# of Surveys: {expression/expr0}
Last Survey Date: {surveyDateText}

Survey Needs
Survey Status: {Survey_Needs}
Flagged Notes: {expression/expr1}
*as of the last date/time the Loon Coordinated updated "Survey Status"
Additional Notes: {Additional_Notes}
Last Updated: {EditDate}

Employee Information
The following information pertains to the last survey conducted at {NAME} on {surveyDateText} .
Total Birds: {birdsTotal}
# of Pairs: {birdsPairsAdults}
# of Chicks/Juveniles: {birdsChicksJuv}
Chick Stage: {birdsChickStage}
Nest Status: {nestStatus}
Observer: {observerName}
Phone Number: {observerPhone}
Email Address: {observerAddress}

Access Notes
Hike Difficulty: {Hike_Difficulty}
Hike Type: {Hike_Type}
For updated trail information, click here.
Distance: {Distance}
Elevation Change: {Elevation_Change}
Notes: {Notes}

Survey Information
Observation Points: {Observation_Points}

Additional Information
Region: {Region}
UTM X: {UTM_X}
UTM Y: {UTM_Y}

A brief description of how to edit this text will be provided. The title of each attribute that will be displayed was typed on the left in bold. Following it in brackets { } is the actual attribute. They can be entered manually or the + to the right of the text size menu can be clicked and the attribute can be selected.

Legend Survey Needs
- Click "Change Style"
- Choose an attribute to show
    - Survey Needs
- Select a drawing style
    - Click "Options"
- Click to edit how the symbol is displayed
    - Under shapes select "Basic" from the drop down menu
        - Circle
        - Symbol Size set to 15 px
        - Fill for each label
            - The flags can be found under "Basic Shapes"
            - Additional Survey Needed: red flag
            - Post Summer Loon Day: green flag
            - Summer Loon Day: white flag
            - Spring Loon Day: yellow flag
        - Outline
            - Transparency 0%
            - Line width 2 px
    - Click "OK" to save the changes
- Set the Overall transparency to 0%
- Click "DONE" to save the changes

Public Application
Use the public basemap for the public application.

To create a web app from the public application, under the item details of the public basemap, follow these steps.

Under widgets, choose the following widgets for the five widgets to show
1. About
2. Filter
3. Measurement
4. Draw
5. Print

This is what the widget main screen should look like:

Header

Set the widgets in this controller >

Attribute T...   Coordinate   Extent Navi...   Full Screen

Home   My Location   Overview ...   Scalebar

Search   Splash   Zoom Slider

About   Filter   Measurem...   Draw

Print
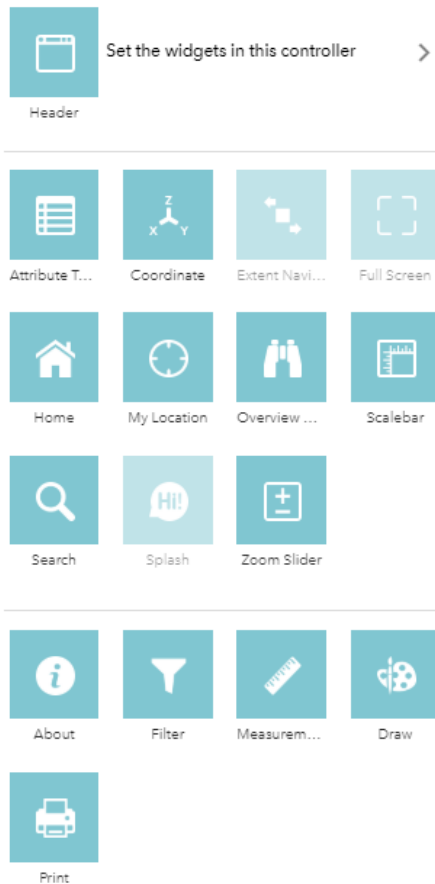
Configuration of each widget
1. About
    a. Under this widget, display information about the program, a link to the "How to Use" guide, a link to the PDF that has pictures of all the priority lakes, and a link to a feedback form
2. Filter
    a. Under this widget, create a widget for the "Priority Points" layer
    b. Create three expressions for this filter
    c. First expression
        i. Under "predefine multiple values"
        ii. Click "Add" to create the first item in the drop down list
        iii. Double click the value and click the drop down to pick the first value
        iv. Continue to do this until all of the items in the drop down are in the desired order
        v. Click apply

| Survey Needs (Strin ▾ | is any of ▾ | Predefine multiple values … | ⚙ ✕ |

☑ Ask for values   ☐ Case sensitive

Prompt   Survey Needs is any of

Hint

List values: All unique values of this field ▾

    d. Second expression:
        i.   Under "predefine multiple values"
        ii.   Click "Add" to create the first item in the drop down list
        iii.   Double click the value and click the drop down to pick the first value
        iv.   Continue to do this until all of the items in the drop down are in the desired order
        v.   Click apply

| Hike Difficulty (Strin ▾ | is any of ▾ | Predefine multiple values … | ⚙ ✕ |

☑ Ask for values   ☐ Case sensitive

Prompt   Hike Difficulty is any of

Hint

List values: All unique values of this field ▾

    e. Third expression:

| Priority (Number) ▾ | is any of ▾ | 0 selected ▾ | ⚙ ✕ |

☑ Ask for values

Prompt   Priority is any of

Hint

List values: Values filtered by all other expressions ▾

    f. Under options, check "apply this filter when the widget is open".
3. Measurement
    a. Default area unit - Acres
    b. Default length unit - Miles
    c. Show measurement tools, check off area, distance, and location
4. Draw
    a. No customizing needs to be done to the draw tool

5. Print
    a. No customizing needs to be done to the print tool
*Under the header section in the widget, the legend and layer list will show up.

Edit legend to only show legends for the Survey needs layer, priority points layer, trails layer, roads layer, lakes layer, and boundary layer.

Edit layer list to only show the survey needs layer, priority points layer, trails layer, roads layer, lakes layer, and boundary layer.

Employee Application
        Same as the public application, except created from the employee basemap. To create a web app from the employee application, under the item details of the employee basemap, follow these steps.
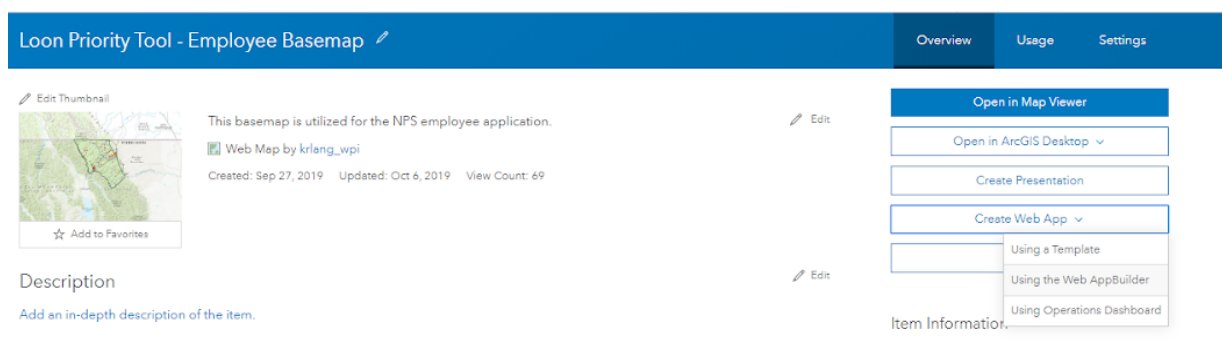
Elevation Profile

- Prerequisites:
    - Complete Loon Priority Public Basemap

- Open the Public basemap and click the "Share" option
- Under "Embed this map" click "Create a Web App"
- Under the Configurable Apps tab, choose the "Elevation Profile" option
    - Click "Create Web App" to continue
- Enter your desired names, tags, and summary then save to a folder by clicking "Done"

        The Elevation profile should begin to load. The following section will focus on the customization options for the Web App.

- General Tab:

- The title and description can be changed here.
    - We left the description blank and kept named the map "Loon Priority Tool - Elevation Profile"
- An optional splash screen can be added.
    - The splash screen has its own title and description. The splash screen only appears when the application is first opened. We chose not to add one.
- Theme Tab:
    - Change the colors and opacity of the elevation profile UI.
    - Here are the selections we had for our color options by section. The hexadecimal color value will be listed next to some options in order to match our color choices exactly. These can be modified to match whatever aesthetic you desire.
        - Background Color: #666666 (Dark Grey)
        - Background Opacity: 0.9
        - Text Color: #FFFFFF (White)
        - Axis font color: #FFFFFF (White)
        - Axis major tick color: #FFFFFF (White)
        - Elevation bottom color: #FFAA00 (Orange)
        - Elevation top color: #FFD37F (Light Orange)
        - Sky bottom color: #00B2EE (Sky Blue)
        - Sky top color: #009ACD (Dark Sky Blue)
    - Elevation profile location
        - Bottom center
    - Custom Layout
        - Default
- Options
    - Turn on "Enable legend"
    - Share Dialog allows map users to share the map with others on various social media platforms and through email. We left this option disabled.
- Elevation Profile
    - Set units to Miles
    - Turn on "Display draw tool"
        - This allows users to create an elevation profile by placing custom points on the map. Useful for knowing terrain in off-trail segments.
- Search
    - No options were turned on here

If you have any questions or need clarification on anything in this guide, contact citizenscience.glacier.a19@gmail.com.

Appendix F

Gantt Chart

GANTT CHART

PROJECT TITLE	Integrating Technology Into Citizen Science	COMPANY NAME	Glacier National Park Citizen Science Team
PROJECT GROUP MEMBERS	Seth Chaves, Kyle Lang, Danielle Lavigne, Molly Youngs	DATE	4/23/19

WBS NUMBER	TASK TITLE	START DATE	DUE DATE	DURATION (Days)	% OF TASK COMPLETE
1	**Benchmarking**				
1.1	Identify possible benchmarks	5/1/19	8/27/19	116	0%
1.2	Assign benchmarks to each group member	5/1/19	8/27/19	116	0%
1.2	Carry out benchmarking	5/1/19	8/27/19	116	0%
1.3	Analyze results	5/1/19	8/27/19	116	0%
1.4	Apply results to Glacier National Park	5/1/19	8/27/19	116	0%
2	**On-Site Research**				
2.1	Identify reseach tools in park	8/28/19	8/29/19	1	0%
2.2	Gain access to research tools	8/29/19	8/30/19	1	0%
2.3	Research	8/30/19	9/4/19	4	0%
2.4	Analyze research	9/4/19	9/6/19	2	0%
3	**Brainstorming**				
3.1	Identify problems	9/9/19	9/11/19	2	0%
3.2	Plan meeting place	9/11/19	9/11/19	0	0%
3.3	Assign roles	9/11/19	9/11/19	0	0%
3.4	Formulate solutions	9/12/19	9/13/19	1	0%
4	**Map Development**				
4.1	Identify platform	8/28/19	9/4/19	6	0%
4.2	Development	9/4/19	9/18/19	14	0%
4.3	Testing	9/18/19	9/25/19	7	0%
4.4	Final Revisions	10/4/19	10/9/19	5	0%
5	**Surveys**				
5.1	Identify target sample	9/16/19	9/17/19	1	0%
5.2	Develop potential questions	9/17/19	9/18/19	1	0%
5.3	Carry out surveys	9/18/19	9/25/19	7	0%
5.4	Analyze results	9/25/19	9/27/19	2	0%
6	**Focus Groups**				
6.1	Identify target participants	9/30/19	9/30/19	0	0%
6.2	Plan meeting place	9/30/19	9/30/19	0	0%
6.3	Contact target participants	9/30/19	10/1/19	1	0%
6.4	Plan focus group discussion	10/1/19	10/2/19	1	0%
6.5	Carry out focus group	10/2/19	10/3/19	1	0%
6.6	Analyze results	10/4/19	10/4/19	0	0%
7	**Paper**				
7.1	Paper Writing (Every Friday)	-	-	-	-
7.7	Paper Editing	9/30/19	10/10/19	10	0%
8	**Presentation**				
8.1	Presentation Editing (Every Friday)	-	-	-	-
8.7	Presentation Practicing	9/30/19	10/10/19	10	0%

Timeline columns: WEEK 1 | RESEARCH WEEK 2 | WEEK 3 | ANALYSIS WEEK 4 | WEEK 5 | WEEK 6 | FINAL Week 7 (each divided into M T W R F)