Tourist-Centric Citizen Science in Denali National Park and Preserve

by

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ABSTRACT

Citizen Science programs create a bi-directional flow of knowledge between scientists and citizen volunteers; this flow democratizes science in order to create an informed public (Bonney et al. 2014; Brown, Kelly, and Whitall 2014). This democratization is a fundamental part of creating a science that can address today's pressing environmental, economic, and social justice problems (Lubchenco 1998). While citizen science programs create an avenue for sharing knowledge between the public and scientists, the exact program details and dynamics leading to different outcomes have not been studied in detail. The current shortcomings in the literature fall into three categories. First, the concept of 'volunteer' is used as a catch-all without considering how different demographics (e.g. young, old, wealthy, poor, differently abled, local inhabitants, and visitors) affect both volunteer and scientific outcomes of citizen science. The second shortcoming: there are no standards to assess the quality of citizen science datasets. The third shortcoming: the volunteer and scientific outcomes of these programs are not routinely, or strategically, measured, or integrated into policy and planning (Brossard, Lewenstein, and Bonney 2005). This research advances the understanding of tourist volunteers in citizen science by examining these three short-comings through a case-study in Denali National Park and Preserve. This case study included the development of the Map of Life-Denali citizen science program is a "tourist-friendly" program. Volunteers of the program use the Map of Life- Denali mobile application to record wildlife observations in the park. Research conducted on this program shows that tourists can be successful citizen science volunteers, and when compared to resident volunteers produce similar data, and have positive volunteer outcomes. The development of a fitness for use assessment, called STAAq is also a part of this research. This assessment is shown to be an effective method for assessing citizen science data quality. Throughout the development and launch of the program, stakeholders (the Park Service, and Aramark) were consulted. The Map of Life-Denali program will be integrated into the park's shuttle and tour bus systems as an educational tool, however the scientific merits of the program are still disputed.

DEDICATION

This dissertation is dedicated to my parents,

Steve and Debby Fischer, thank you for your (presumed) love and support.

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CHAPTER 1 INTRODUCTION

Citizen Science programs create a bi-directional flow of knowledge between scientists and citizen volunteers, this flow democratizes science in order to create an informed public (Bonney et al. 2014; Brown, Kelly, and Whitall 2014). This democratization is a fundamental part of creating a science that can address today's pressing environmental, economic, and social justice problems (Lubchenco 1998). Both government and non-governmental organizations, from global to local levels, are increasingly using citizen science programs to address a litany of important topics such as: climate change, pollution, traffic congestion, public safety, and biodiversity (Follett and Strezov 2015). This broader use and acceptance of citizen science creates a wealth of research opportunities on the best ways to leverage citizen science, and integrate these programs into scientific research.

In the broadest sense, citizen science programs actively engage the public in scientific research. This engagement is done primarily through data collection, although some citizen science programs have also sought to involve the public in research project design and data analysis (Allen and Cooper 2006; Bonney et al. 2014; Bonney et al. 2009a; Brossard, Lewenstein, and Bonney 2005; Brown, Kelly, and Whitall 2014; Conrad and Hilchey 2011; Couvet et al. 2008; Gouveia et al. 2004; Newman et al. 2011; Tulloch et al. 2013). Scientists provide the opportunities and structure for citizens to engage in science and to become more scientifically literate. At the same time, the public contributes data in a cost effective and timely manner (Abdulkarim, Kamberov, and Hay 2014; Bonney et al. 2009b; Couvet et al. 2008; Gouveia et al. 2004; Tulloch et al. 2013).

This bi-directional flow of knowledge leads to two main outcomes of citizen science projects (Dickinson, Zuckerberg, and Bonter 2010).

These two main outcomes of citizen science are: volunteer outcomes and scientific outcomes. Volunteer outcomes refers to the benefits the volunteers receive through their participation. Specific volunteer outcomes include; increase in scientific literacy, gain in place attachment, and educational benefits. Scientific outcomes refer to the benefits the researcher receive from the citizen science program and the volunteers. These outcomes include gaining relevant data from the volunteers, or usable data analysis (Dickinson, Zuckerberg, and Bonter 2010).

While citizen science programs generally result in positive volunteer and scientific outcomes, there are three current short-comings in the literature. First, the concept of 'volunteer' is used as a catch-all without considering how different demographics (e.g., young, old, wealthy, poor, differently abled, local residents, and visitors) affect both educational and scientific outcomes of citizen science. The second short-coming is that there are no standards to assess the quality of citizen science datasets, resulting in questions surrounding the data validity, accuracy, and therefore utility (Bonney et al. 2014). The third short-coming is that the volunteer and scientific outcomes of these programs are not routinely, or strategically, measured, or integrated into policy and planning (Brossard, Lewenstein, and Bonney 2005).

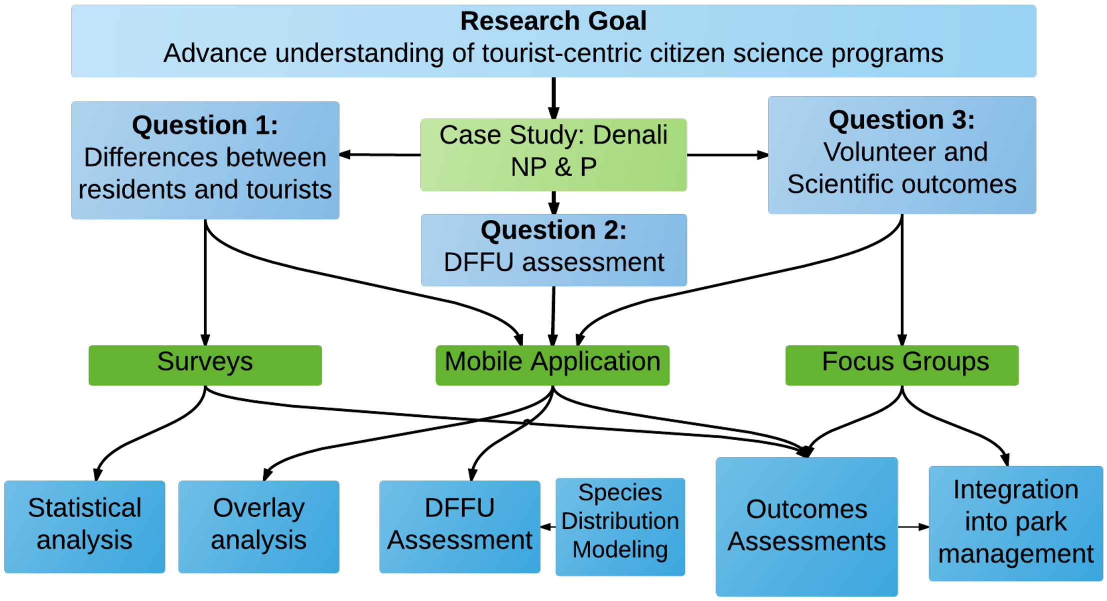

Figure 1.1 Research Framework; This figure depicts how each mode of data collection and method addresses the three research questions and ultimately the overall research goal. The Surveys, mobile application, and focus groups with park officials, each provide data to address the research questions.

The primary objective of this research is to advance understanding of tourist-centric citizen science programs (Figure 1.1 Research Framework; This figure depicts how each mode of data collection and method addresses the three research questions and ultimately the overall research goal. The Surveys, mobile application, and focus groups with park officials, each provide data to address the research questions. To address this objective this dissertation addresses three short-comings of citizen science through the analysis of the results of the Map of Life-Denali citizen science program. First, this dissertation addresses the lack of understanding about how volunteer demographics affect citizen science outcomes, giving specific attention to tourists versus residents of a location. Second, it addresses the quality of data collected by citizen science programs. And third, it addresses the lack of integration between volunteer and scientific outcomes with scientific research and policy making.

Focusing on a comparison between tourists and residents is motivated by a tendency for citizen science programs to use volunteers who can attend one or more training sessions, or commit to long-term involvement (Delaney et al. 2008). To agree to such commitments, volunteers are often local residents, or long-term/frequent visitors, who have the ability to make this type of time commitment. In some geographic settings, however, tourists also represent a large pool of potential volunteers, such as National Parks, protected areas, historical sites, and even popular urban centers. (Cousins, Evans, and Sadler 2009). These tourist volunteers can assist in a variety of citizen science projects, including: ecological projects, either in the wilderness or urban areas, meteorological or climate monitoring, archaeological site monitoring and excavation. Tourists are typically eager to learn more about the area they are visiting (Lück 2003), and if proven to collect quality data, tourists have the potential to produce successful volunteer and scientific outcomes for a citizen science program. While recent research has begun to address factors such as age and gender, the differences between local residents, and tourists, is overlooked.

1.1 Problem Statement

The goal of this research is to better understand tourist-centric citizen science. This goal is addressed by tackling the three aforementioned short-comings of citizen science. To that end, the following specific research questions emerge:

1. What is the difference between residents and tourists, in terms of data quality and volunteer outcomes (i.e. place attachment and educational outcomes) in citizen science?

2. How can a Data Fitness for Use (DFFU) assessment be used to measure data quality and utility in tourist-driven citizen science?
3. How can the volunteer and scientific outcomes of citizen science be measured, and ultimately integrated into park management and planning?

This research surveyed both resident and tourist participants of the citizen science program, and compared the survey results to address these research questions and gain a better understanding of differences between residents, and tourist volunteers. This includes: the differences in the ability of evoking place attachment to affect participation, the differences in quality of data collection, and the differences in the ability to use outcomes. It is hypothesized that a volunteer's place attachment, the emotional bond between a person and place, may affect their motivation to participate in the project (Budruk and White 2008; Ellis and Waterton 2004; Nov, Arazy, and Anderson 2014; Rotman et al. 2012). However, it is not known if a volunteer's residency status, either local resident or tourist's place attachment, impacts the data quality, and ultimately volunteer and scientific outcomes of a project. This project hypothesizes that tourists, after participating in a citizen science project, can evoke place attachment at a level equal to, or better, than residents. Incorporating technology, such as mobile phone-based applications, in a tourist-centric citizen science program will produce high quality educational and scientific outcomes that are similar, or better, than resident-participants in the same program.

Many methods can be used to assess data quality, including positional and attribute accuracy, completeness, and lineage (Guptill and Morrison 2013), however with citizen science data these methods to not include an assessment of fitness for use. Data Fitness For Use (DFFU) does not provide a blanket assessment of data quality, however, assesses whether these data could be used for a specific application, within a given area (Devillers and Bédard 2007). A DFFU assessment tailored to citizen science data will increase the utility of the collected data (Dickinson, Zuckerberg, and Bonter 2010). This DFFU assessment explicitly focuses on Volunteered Geographic Information (VGI), which refers to geographic data that is collected by the public (Bimonte et al. 2014; Goodchild 2007). Whether, or not, a project recognizes the use of geographic data, many data points collected within a citizen science project are spatially explicit, and thus considered VGI. The geographic aspects of VGI give it properties with respect to data quality, that is not often encountered in other types of volunteer-collected data (Elwood, Goodchild, and Sui 2012; Goodchild 2009). There is little discussion in the literature regarding how a citizen science program should properly collect, and manage, spatial information. This research developed a DFFU assessment, designed specifically with VGI in mind.

The success, or the outcomes, of citizens science projects are not often measured, or not measured systematically, in turn the success of the volunteer outcomes are questioned (Brossard, Lewenstein, and Bonney 2005). Additionally, datasets produced by citizen science programs are not being widely used in peer –reviewed literature, or in decision making (Conrad and Hilchey 2011). As such, citizen science programs are not being incorporated into long-term educational initiatives, or planning and management. Through a mixed methods approach (qualitative and quantitative research methods) this research assesses the educational and scientific outcomes of the citizen science project through analyzing the knowledge gained by the volunteers, and quality of the data collected. These assessments reveal if the educational and scientific goals were met, and the overall usability of the project. The results of these assessment were presented to the project stakeholders, Denali National Park and Preserve (Denali NP&P) and Aramark officials (the park's main concessionaire).

1.2 Case Study Area

This study, comparing tourists and residents in citizen science, is based in Denali National Park and Preserve. Denali NP&P is in south-central Alaska (Figure 1.2 Denali National Park and Preserve, the singular park road meanders through prime habitat for much of Denali's wildlife, and it is only accessible for visitors via bus.). The park's scenery and wildlife attract ~500,000 visitors each year, many of whom experience the park in buses along the only road through the park (Manni et al. 2012). On average, 90% of the visitors are tourists (i.e., not from Alaska) (Manni et al. 2012). This large number of tourist visitors provides a large potential pool of volunteers for this research. The park

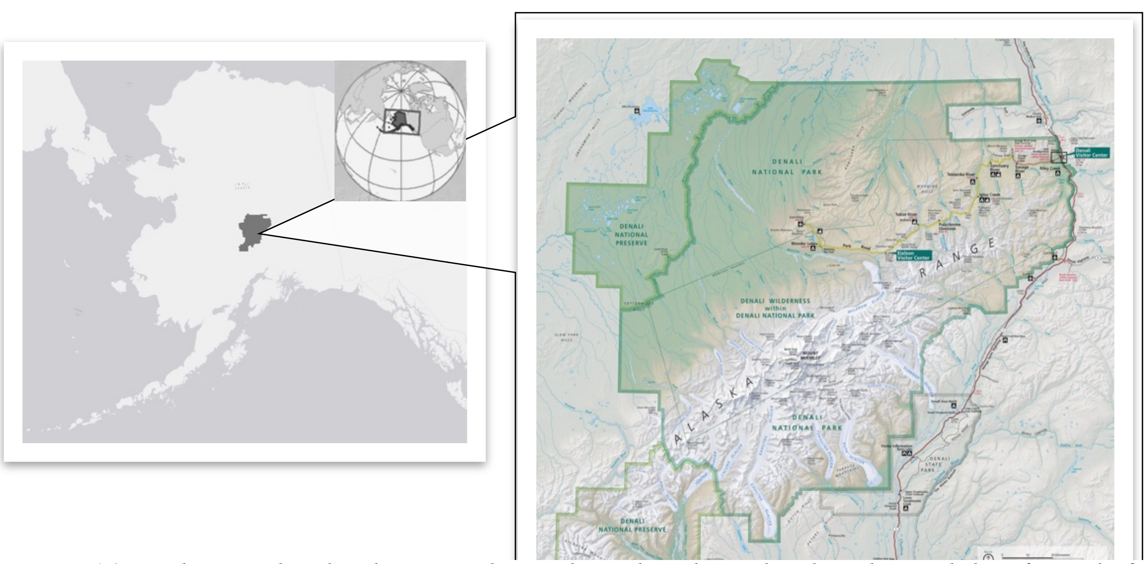

Figure 1.2 Denali National Park and Preserve, the singular park road meanders through prime habitat for much of Denali's wildlife, and it is only accessible for visitors via bus.

covers a total of 6-million acres, and is home to North America's highest peak, Denali. Denali was chosen because of two key factors: the recent NPS centennial initiatives and celebrations, and the existence of the Road Ecology Program, which is interested in incorporating citizen science programs.

The first key reason for selecting Denali is the recent Centennial for both the National Park Service and Denali NP&P. Because of this event, park managers are actively considering how the park engages younger visitors and National Park System supporters. This focus lends itself to developing new visitor-centric citizen science programs geared toward using familiar technology, such as mobile phone-based applications. Denali NP&P is currently welcoming projects that directly engage the public in park research initiatives. This project's use of mobile phone-based technology aligns well with the park's Centennial initiative to engage younger generations to cultivate a renewed enthusiasm for the National Park System. The results of a pilot study conducted in the Summer of 2015, show support from the park service, and from park visitors, for a mobile phone-based application citizen science program (Appendix A).

The second key reason that Denali NP&P was chosen for this project is the Road Ecology Program (REP). The REP is actively monitoring how the ecology along the park road is impacted by the transportation system (Kilkus et al. 2011). Data from Ride Observation and Record (ROAR) program are currently used to inform monitoring and research done by the REP. The ROAR program is an existing program where park employees ride the busses and record wildlife sightings, this program is used to direct the development of the tourist-centric citizen science efforts. The ROAR participants are paid part-time workers, who are local residents, ranging from youths to retired adults. ROAR provides a means to compare the Map of Life-Denali to another authoritative data source. This project was designed to complement the existing REP and ROAR in the park. The overall educational goal of this project is to provide an interpretive and educational experience for park visitors, through the use of the mobile phone-based application.

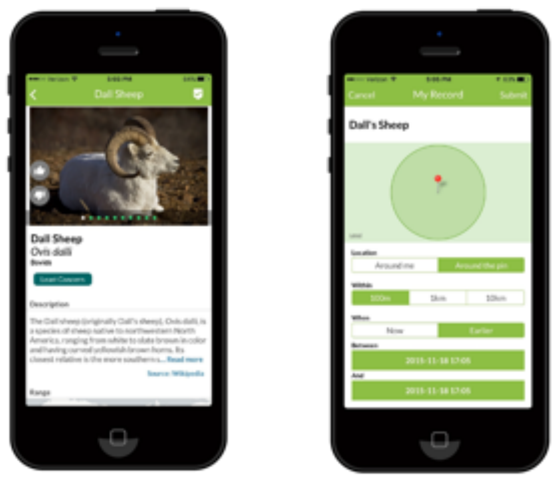

Figure 1.3 Map of Life- Denali Mobile Application

The Map of Life-Denali mobile phone-based application was used for data collection for this dissertation citizen science program (Figure 1.3 Map of Life- Denali Mobile Application). The Map of Life application was developed at Yale University, with a customized Map of Life – Denali Application created for this research. The Map of Life - Denali is downloadable through the Map of Life application. The two key differences are that Map of Life – Denali can be used without a Wi-Fi, or cellular data connection (both park limitations) and the customized application includes links to the surveys used in this dissertation. The application allows volunteers to record the precise location of their wildlife observations while touring the park. The participants initially downloaded the application while at the park entrance, then used it offline, relying on their phone's internal GPS to capture spatial data. An information page with park specific information, such as animal safety warnings, and a description of the citizen science project is featured in the Map of Life-Denali application. Identifying species photos and detailed species information appear in the application, when a volunteer searches for a specific animal.

1.3 Dissertation Roadmap

The remainder of this document describes the research in detail. Chapter 2 describes the relevant literature including the volunteers, data, and outcomes of citizen science. Chapter 3 describes the research methods, including rationale for the case study, data collection methods, and the analytical approach. Chapter 4 presents the results of the research, including a summary of the volunteers and data they collected, and the results of the analysis for the three research questions for all research questions. This is followed by a discussion in Chapter 5, which interprets the results relative to the three research questions. The final chapter of the dissertation is Chapter 6, the conclusion, in which the major findings are summarized, the project significance is described, and future directions are identified.

CHAPTER 2 LITERATURE REVIEW

The relevant literature on citizen science focuses on the volunteers, data collection methods, and implementation and program success, in terms of biodiversity and conservation management. This section is divided into three sub-sections, each focusing on a major component of citizen science: volunteers, data, and volunteer and scientific outcomes (Figure 2.1 The process of citizen science, and the layout of the literature review.). Volunteers are the defining piece of citizen science, and the volunteers have a direct impact on data produced by the program, and the outcomes of the program (Cohn 2008). Data quality is a familiar concern in the citizen science literature, and many projects have developed novel approaches to analyze and improve data quality (Cohn 2008; Toogood 2013). Volunteer and scientific outcomes are not routinely measured, nor integrated into policies and planning (Delaney et al. 2008).

Figure 2.1 The process of citizen science, and the layout of the literature review.

2.1 Volunteers

Citizen science programs provide scientists with a team of excited volunteers willing to work for little or no cost (Nov, Arazy, and Anderson 2014; Richter and Winter 2011; Toomey and Domroese 2013). With a team of volunteers, large-scale projects that span large geographies, or timeframes, are possible (Crall et al. 2015; Roy et al. 2012). Understanding the demographics (age, education, and residency) of the volunteers helps shape an understanding of how to train and use the volunteers to their full potential (Allen and Cooper 2006; Delaney et al. 2008; Mccaffrey 2005). Volunteers in citizen science programs range in age from school children, to adults (Muise et al. 2007), and the volunteers can also be local residents of the study area, or visitors (tourists). Each of these traits (age, educational levels, residency) along with volunteer training, have implications for volunteer and scientific outcomes of citizen science. However, the impact of different groups on scientific outcomes of citizen science has not been widely studied

Age, education, and level of project-specific training are correlated with scientific outcomes (data collection and data quality) (Delaney et al. 2008). Education levels of the volunteers can affect data quality (Delaney et al. 2008). According to Delaney et al. (2008), when different groups of volunteers were asked to identify different species of crab, the third graders had 80% accuracy, while university students were 95% accurate. Therefore, highly educated, and older, volunteers unsurprisingly produce more accurate data.

Like age and educational level, the training that volunteers receive is also connected to the success of the volunteer and scientific outcomes of a citizen science project (Starr et al. 2014). The amount and intensity of the training varies widely, since it mainly depends on the volunteers' level of participation in the project (Starr et al. 2014). Some projects have extensive training for their volunteers and have them work independently (Assis et al. 2009). Other projects have little initial training, and rely on volunteers interacting with the project long-term to improve their performance during the project. When the volunteers are provided incentives for participating in the project over the long term, the volunteers produced better quality data, the longer they were involved in the project (Wood et al. 2011). A simpler project with volunteers only collecting data may require less training than a project asking volunteers to perform data analysis, or collect more intricate samples. The amount of training needed depends on the level of participation of the volunteer (Haklay 2013). However, when volunteers are not residents of the study area of the citizen science project, they may not have the capacity to participate in training, or maintain engagement in the project long-term.

What is less known about citizen science volunteers is the effect of location (or residency) on participation levels, and data collection capabilities. Volunteers are often local residents of the study area (Cooper et al. 2007; Lee, Quinn, and Duke 2006), however, some projects are web-based, so their participants can be located anywhere (Reed, Rodriguez, and Rickhoff 2012), while very few citizen science projects are based on tourist participants (Cousins, Evans, and Sadler 2009).

A tourist is a person who travels to, and stays in, a place outside of his or her usual environment for not more than one consecutive year for business, leisure, or other purposes (Nelson 2013). This definition is bit sterile, since there are many different typologies of tourism, from classifying people as drifters, explorers, or tourists to spring breakers (Nelson 2013). Tourists may not have a "sense of place" like that of local residents, but there is potential for tourists to gain insight into the place they are visiting, as long as they are willing to be open-minded. People experience unfamiliar places differently than familiar places, and may have a heightened awareness in a new place. It is rare to visit a place with no preconceived notions or expectations, however, over the course of a trip you might create more meaningful notions of this place and meaning, and a sense of place (Nelson 2013).

> "Experiences in new places often cause us to reflect on our experiences in those places most familiar to us… experiences in other places may cause us to refine our sense of place." Nelson (2013: 268)

It is assumed that tourists have little connection to the places they visit, and given the short-term nature of their experiences in these environments, they may not see the consequences of their behavior. There is potential for tourists to learn about the places they visit and to understand the consequences of their actions in that place. Nelson (2013).

Examples of tourist-based citizen science come from hopeful tourism, or ecotourism programs, which focus on tourists who intend to spend their entire holiday participating in a research project, such as Earthwatch trips, gap year trips for students, etc. (Brightsmith, Stronza, and Holle 2008; Crabbe 2012). Hopeful tourism and ecotourism trips are characterized by knowledge production, ethics, volunteerism etc. (Brosnan, Filep, and Rock 2015; Cousins, Evans, and Sadler 2009). These holidays, though impactful, can be costly, time-consuming, and not accessible by a more general tourist population. To reach a wider tourist audience who may not be seeking out these opportunities, or may not have the money or time to dedicate to a singular project, these potential volunteers can become involved in citizen science. Instead of planning a trip around a citizen science initiative, citizen science can be integrated into existing tourist attractions, such as recreation and wilderness areas (e.g., the U.S. National Park system). This type of tourism is called nature tourism, people visit an area specifically for the appreciation of natural attractions, such as national parks, activities may include hiking, camping. bird watching etc. (Nelson 2013:58). While citizen science projects exist in these locations, the volunteers are typically local volunteers rather than tourists.

Tourists are good candidates for citizen science projects because tourism is increasing world-wide, and tourists are often eager to learn more about the location they are visiting (Burger 2000; Lück 2003). In the US , the National Park Service alone expects to see an 8-23% increase in visits in the next few years (Fisichelli et al. 2015). Lück (2003) found that a majority of toursits they surveyed really wanted to know more about the area they were visiting, therefore, interpretation and an educatiotnal experience are important.

Although tourists seem like good citizen science volunteers, their potential for different spatial and temporal biases, while collecting citizen science data has not been explored. There may be unique spatial and temporal biases because some tourist destinations have a time of year that is more popular for tourism, and tourists may not venture away from popular areas. The potential biases in data collected by tourists means that questions arise when considering volunteers who may be unfamiliar with the study area, and as a result may not possess local knowledge. It is unknown how tourist volunteers may affect citizen science outcomes, both the volunteer and scientific outcomes of citizen science. Using tourists raises questions about the relative quality of data, and whether the tourists themselves gain as much knowledge as local residents.

2.2 Data

Data collection is the main activity performed by citizen scientists and thus for many projects is the main contribution of the volunteers to science (Lepczyk 2005). Citizen science volunteers collect different types of data in a variety of ways, regardless, the quality of these datasets is often scrutinized. Data are collected either actively, or passively, by the participants, depending on the purpose of the citizen science project. Technologies such as mobile phones are familiar for many of the volunteers and have become widely used for data collection in citizen science (Devisch and Veestraeten 2013). The type of data that is collected also depends on the purpose of the program. A popular type of data is Volunteered Geographic Information (VGI) (Tulloch et al. 2013). Data quality is a reoccurring concern in the citizen science literature, and many different methods and frameworks have been developed to analyze and improve data quality (Cohn 2008; Toogood 2013).

Citizens are collecting data actively and passively (Haklay 2013). Active data collection involves the citizens being in the field and actively recording data during the project. Many ecology-based projects ask citizens to actively collect species data, such as identification of the species and their geographic location. Passive data collection uses "volunteers-as-sensors", and does not require direct recording, but instead uses technology such as mobile phones, or GPS devices, to log data automatically. For example, Doherty, Lemieux, and Canally (2014) had volunteers use their smart phones equipped with an accelerometer to track physical activity. Some believe that "volunteers-as-sensors" is the future of citizen science because volunteers can participate with little more than their personal smartphone, or wearable device (Catlin-Groves 2011). One critique, however, is that the educational component of citizen science can get lost with more passive volunteer activities (Haklay 2013).

Easily accessible technology, such as mobile phone-based applications, are increasing the interest in both active and passive citizen science participation, as these technologies are advancing what scientists can achieve, and are opening programs to a larger pool of volunteers (Bonney et al. 2014; Boulos et al. 2011; Connors, Lei, and Kelly 2012; Hart et al. 2012; Kim, Mankoff, and Paulos 2013; Pocock et al. 2015; Roy et al. 2012; Starr et al. 2014). Even potential volunteers who do not express interest in mobile application-based citizen science programs are often eager to participate, for example, farmers surveyed in the UK were enthusiastic to participate in a citizen science program (Dehnen-Schmutz et al. 2016)

The use of mobile technology in citizen science has led to the development of mobile device-based applications, such as eBird, iNaturalist, and Map of Life (Newman et al. 2012). Creating these types of applications is made easier through initiatives such as the "Sensor" website, that allow citizen science program developers to create citizen science mobile applications with minimal knowledge of the underlying coding/programming (Kim, Mankoff, and Paulos 2013). While many of these applications use internal mobile technology, such as the phone's GPS or internal clock, to capture data, other projects use mobile technology and applications with add-on devices to collect data, such as collecting measurements of aerosols in the air (Land-Zandstra et al. 2016). These applications are changing how people interact with nature (Jepson and Ladle 2015).

Using familiar technology like mobile phone-based applications, allows the volunteers to become more independent of scientists and researchers (Devisch and Veestraeten 2013) and other volunteers (Land-Zandstra et al. 2016). This potentially limits the amount of training needed to become effective participants in a citizen science program (Devisch and Veestraeten 2013).

This technology also allows for easier, more efficient, and more cost-effective data collection for citizen science programs, and this is especially true when volunteers collect spatial data (Bruce et al. 2014; Kim et al. 2011). Whether, or not, a project recognizes the use of geographic data (e.g. Assis et al. 2009), much of the data collected in a citizen science project is spatially explicit, meaning it contains geographic information in the form of coordinates.

When geographic information is collected by the public it is referred to as: Volunteered Geographic Information, or VGI, however, VGI is not always a product of citizen science. (Bimonte et al. 2014; Goodchild 2007). The geographic aspects of VGI give it properties with respect to data quality that are not often encountered in other types of user generated content (UGC), specifically spatial context (Elwood, Goodchild, and Sui 2012; Goodchild 2009). There is little discussion in the literature of how citizen science programs can properly collect and manage spatial information, even though they need data management systems which can deal with geospatial data storage, analysis, and display (Mehdipoor et al. 2015; Newman et al. 2011).

A specific type of VGI that is commonly collected in citizen science programs is species occurrence data (Dickinson et al. 2012; Tulloch et al. 2013). These types of data often include: taxonomic information, spatial information about where the observation took place, and sometimes includes species absences (Jordan et al. 2011; Lukyanenko, Parsons, and Wiersma 2011). These citizen science data are being collected and used by projects like the Cornell Ornithology Lab. People collect these data via mobile applications (Map of Life, iNaturalist), or GPS submissions via the web (Portland Coyote Watch Project, Denali Plant Finder), so this data can be used for species population and distribution modeling and conservation biology efforts. These data, however can be prone to observer error, as collecting presence-absence data may include false-negatives (Ward et al. 2015).

Despite potential data quality issues, a growing number of researchers are using these data for different models such as species distribution models (Foody 2008). Species Distribution Modeling (SDM) is a specific type of ecological modeling, where species data collected by citizen science volunteers are being used. SDM are a type of ecological model that can predict the distribution of a particular species, throughout a landscape. Franklin (2013) notes that new developments in SDM allow researchers to forecast impacts of climate change, land use change, and global change. Citizen science data collected through mobile applications like Map of Life, eBird etc. or data collected from volunteers performing surveys (Ward et al. 2015) can be used for SDM.

Citizen science data have been compared to authoritative datasets in terms of their performance in species distribution modeling. Crall et al. (2015) used citizen science data for invasive plant distribution modeling and model performance for both the authoritative data and the citizen science data. The volunteer data did not greatly change model performance, but did change the suitability-surface generated by the model by actually making them more realistic. This can be good, or bad, depending on how robust your model should be (Crall et al. 2015).

Sometimes authoritative data is not available, thus citizen science data can fill in gaps left by authoritative species data, and other data (Bruce et al. 2014; Ward et al. 2015). For example, the widely used citizen science dataset eBird (based out of Cornell University), provides researchers with data on various bird species, which otherwise are not found in authoritative datasets (Hurlbert and Liang 2012; Sullivan, Aycrigg, and Barry 2014; Wood et al. 2011).

eBird data, collected through the eBird mobile application and website, have been used for many projects to study distributions, populations, and migration patterns (Hurlbert and Liang 2012; Kelling et al. 2015; Sullivan, Aycrigg, and Barry 2014; Wood et al. 2011). Hurlbert and Liang (2012) used eBird data to characterize the migrations of birds, specifically the arrival date of birds, to look at how climate change affects migrations. The citizen science gathered data are therefore an excellent fit for this project, because it covered many decades, and a wide spatial scale. Data that are normally used are from banded birds being tracked in reserves, or protected areas.

The accuracy and quality of VGI data is a reoccurring concern commonly cited in the literature (Delaney et al. 2008). There are myriad methods and techniques aimed at measuring and improving data quality, including increasing the number of participants contributing data such as Linus' Law, hybrid or mash-up data sets, where citizen science data is combined with authoritative datasets, and data quality assessment based on data quality indicators (Comber et al. 2013; Haklay 2010; Senaratne et al. 2016).

Linus' Law, originated in open-source software development, and refers to the process of measuring the quality of the VGI by considering the number of peers who have reviewed, or edited, its content (Elwood, Goodchild, and Sui 2012). In the case of crowd-sourced/VGI data, Linus' Law refers to the notion that with a large number of data contributors, the biases or inaccuracies made by a few of those contributors will be quieted.

Hybrid/ mash-up datasets are another method to assess and improve VGI data quality. Hybrid datasets involve integrating the citizen science data with traditionally collected data (Elwood, Goodchild, and Sui 2012; Parker, May, and Mitchell 2012; Upton et al. 2015). Combined datasets (e.g. data mash-ups, hybrid datasets, or cross validation) allow researchers to test out accuracy, or combine the datasets to fill in gaps (Abdulkarim, Kamberov, and Hay 2014; Batty and Hudson-Smith 2010; Bruce et al. 2014; Connors, Lei, and Kelly 2012; Parker, May, and Mitchell 2012; Upton et al. 2015).

Thorough assessment of VGI data, based on quality indicators, is also used to improve and examine VGI data quality. Senaratne et al. (2016) identified 17 quality measures and indicators, and their associated method for assessing VGI. Including standard measures of quality; position accuracy, topological consistency, thematic accuracy, completeness, and temporal accuracy among others, they found that these standard measures of data quality alone are not enough to assess VGI quality, thus additional indicators like reputation, trust, credibility, vagueness, experience, local knowledge, are also used in the VGI literature (Senaratne et al. 2016).

While these techniques have been used to assess and improve VGI data quality, concerns about VGI data quality are still present in the literature. An analysis of data fitness for use may address these on-going concerns (Crall et al. 2015; Dickinson, Zuckerberg, and Bonter 2010; Parker, May, and Mitchell 2012). Data fitness for use (DFFU) is a methodology that can be used to evaluate the level of fitness between citizen science data characteristics and a user’s needs (Chrisman 1983; Devillers and Bédard 2007; Juran et al. 1974; Veregin 1999). Senaratne et al. (2016) concluded that a systematic framework needed to be developed that provides methods and measures to evaluate the fitness for use of VGI. While a specific dataset may be considered low quality for one project, it may be adequate for another. The biggest issue with data analysis of citizen science data is making sure the raw data that has been collected, are analyzed with the appropriate techniques. When performing data analysis on citizen science data, the researchers must consider data fitness for use (DFFU), and make sure these data that are collected can be used to answer the scientific questions posed (Haklay 2013).

By using DFFU as a metric for data quality, it is an obvious way to reduce the uncertainty of using a dataset. Data quality is then not necessarily the issue, but in-truth labeling, and ‘what are these data good for? is the issue (Veregin 1999). These data are not only judged on what it can be fit for, but also the limitations and uncertainty (Veregin 1999).

There are various models of DFFU assessment, and many depend on metadata to assess data fitness. Pôças et al. (2014) created a DFFU assessment called EQDaM, external quality of spatial data from metadata. The metadata for each dataset was used to compare different quality indicators, where these indicators are chosen by the users. The indicators include: spatial, temporal, topology, lineage, precision, accessibility, and legitimacy. All of these quality indicators can be assessed through these data's metadata, however, accurate metadata may be difficult to acquire, especially for VGI (Grira, Bédard, and Roche 2010). Metadata, however, are not a reliable source of information about most citizen science and VGI data, because in most cases metadata does not exist. Volunteered collected data may show more errors and bias, however, the metadata or provenance can document this, and provenance can be a substitute for missing, or incorrect metadata (Fonte et al. 2015; Frew 2008). There are some examples of the inclusion of metadata with volunteered collected data, Sheppard, Wiggins, and Terveen (2014) included metadata and provenance into their database. They use an entity attribute model to track metadata, and how these data may change over time.

Comparing fitness for use based on quality indicators is also represented in Shimizu (2014) with the AAAq. This assessment compares fitness based on accuracy, agreement and aptness of the datasets. Instead of relying on metadata like Pôças et al. (2014), Shimizu (2014) performed spatial analysis of the Raster datasets. While metadata should be improved, performing a DFFU assessment on these data instead of the metadata, is a more promising avenue for assessment of VGI. Shimizu (2014) AAAq assessment is robust, and can easily be modified and added upon. The assessment is applicable to any modeling with a statistical performance output. The addition of other assessment components, like spatial and temporal scale, can be added to the AAAq to make it applicable to more scenarios.

2.3 Volunteer and Scientific Outcomes of Citizen Science

Currently, few if any standards exist to measure the bi-directional flow of knowledge in citizen science and the outcomes of that flow of knowledge, which impact volunteer and scientific outcomes of a citizen science program (Freitag and Pfeffer 2013). This bi-direction flow consists of scientists providing opportunities and structure for citizens to engage in scientific research and to become more scientifically literate. At the same time, the public contributes data in a cost effective and timely manner (Abdulkarim, Kamberov, and Hay 2014; Bonney et al. 2009a; Couvet et al. 2008; Gouveia et al. 2004; Tulloch et al. 2013). Volunteer outcomes - also referred to as participant outcomes, or internal outcomes (Lawrence 2006) - includes scientific literacy (e.g., education) and sense of place (e.g., place attachment) (Haywood 2014). Scientific outcomes - also referred to as research outcomes, or external outcomes (Lawrence 2006) - includes data collected, or analyzed, within the citizen science program.

Citizen science proponents hope that as a result of volunteers participating in a project, it will both contribute to science, and result in a gain in knowledge for the volunteers. This will change their behavior, and create a better global citizen, (Haywood, Parrish, and Dolliver 2016). However, the lack of standards in measuring citizen science program outcomes is a barrier to understanding the kind and amount of knowledge that volunteers are learning (Toogood 2013), their attachment to place, and propensity for conservation stewardship. Volunteers may not be gaining as much knowledge from these programs as we think (Toogood 2013). While citizen science programs generally aim for volunteers to gain knowledge about the subject matter of the program, some projects also aim for participants to learn big-picture ideas and become more scientifically literate.

Toomey and Domroese (2013) found that participants may not be learning about big-picture ideas, such as conservation and ecosystem issues. Similarly, Jordan, Gray, and Howe (2011) found that volunteers were able to identify specific plants, but this did not translate into a change in their behavior. Some projects encourage their volunteers to think scientifically, and emphasize the scientific "process"; and Trumbull et al. (2000) found evidence that some projects do achieve this goal. However, Jordan, Gray, and Howe (2011) found that simply participating in a program was not enough to increase understanding of the scientific process. They assert that programs are often too narrowly focused on their immediate data collection goals, and need to consider how to convey big-picture ideas to their volunteers. New methods to measure the educational success of citizen science will help citizen science programs improve their educational outcomes.

In addition to scientific literacy, place attachment is a targeted outcome in citizen science programs. Tuan (1977) describes place attachment, sometimes called sense of place, as "what begins as undifferentiated spaces becomes place when we endow it with value" (Tuan 1977). Place attachment has three components; place identity, place dependence, and place affect (Halpenny 2006). Place identity is a deeper connection with a place, an individual may define themselves through this connection to a certain place (Halpenny 2006). Place dependence is a functional need for the space (Budruk and White 2008; Halpenny 2006; Haywood 2014). Place affect refers to the emotions and feelings that a person exhibits towards a place (Halpenny 2006). Each of these components of place attachment play a role in a volunteer's participation in citizen science, and can affect the educational and scientific outcomes of a project.

Despite its importance, place attachment is often overlooked in citizen science programs, but it is important to creating a well-rounded volunteer (Haywood, Parrish, and Dolliver 2016; Haywood 2014; Vining, Merrick, and Price 2008). Place based learning programs like citizen science, create personal meaning for people by providing an educational and interpretive experience about the area they are helping to study. This increases place attachment, which can then lead to advocacy for conservation (Halpenny 2010). High levels of place attachment are connected to greater motivation to participate in citizen science (Haywood 2014).

It is known that people often feel attachment to natural places (e.g., places untouched by humans) (Haywood 2014; Vining, Merrick, and Price 2008). Furthermore, many tourists and regular visitors exhibit strong attachments to places, even before they visit (Williams and Stewart 1998). One study that did examine how citizen science can increase a participant's sense of place defined as: knowledge, awareness, skills, disposition to care (Evans et al. 2005) In addition to increasing scientific literacy, results show that volunteers also increased place attachment by changing behaviors and caring more about the area and project. Place attachment exists in recreational areas, as the visitor develops a bond to the place they are visiting (White, Virden, and Riper 2008). Therefore, it is possible for tourist volunteers to evoke place attachment.

This project extends our understanding of place attachment's influence on citizen science, by comparing participation levels and data collection quality between resident and tourists, who have different levels of place attachment to the case study area. Thus, the idea of place attachment and difference in the sense of place, between local residents and tourists participating in citizen science, requires further examination.

Another concern about volunteer outcomes is that citizen science programs are rarely incorporated into existing educational programs, such as school curricula and interpretive programs in protected areas (Calabrese-Barton 2012). While not accomplished in practice, the potential to incorporate citizen science into classroom curricula is frequently discussed (Calabrese-Barton 2012). Alternatively, there is little discussion of aligning the educational outcomes of citizen science projects with the educational and interpretive goals of protected areas such as the U.S. National Park System (e.g., Muise et al. 2007). Further integration of the educational components and outcomes into educational initiatives may provide a sound basis for citizen science programs to last long-term.

While much remains to be studied about the volunteer outcomes, including educational outcomes, of citizen science programs, an equally large research gap exists concerning the study of scientific outcomes. Scientific outcomes refer to data collected, or analyzed, within the citizen science program and these data usability for research and policy making. Scientific outcomes are hardly ever measured, and it is not clear if these data collected by volunteers, or volunteer contributions to analysis, are actually aiding scientific research (Silvertown 2009). In order to make citizen science datasets and scientific outcomes more reputable, there needs to be methods to measure and assess scientific outcomes (Ottinger 2009).

Problems asserting the scientific merit of citizen science programs are exacerbated by the fact that citizen science data and analysis are rarely used by scientists, or policy makers. The results of citizen science programs and the datasets are rarely used in peer-reviewed publications- Theobald et al. (2015) found that only 12% of citizen science projects they reviewed provided data to peer-reviewed articles.

An exception, however, seems to be the acceptance of citizen bird science i.e., the eBird program and other projects from the Cornell Ornithology Lab (Conrad and Hilchey 2011; Delaney et al. 2008; Theobald et al. 2015). Data collected through the Cornell Ornithology lab citizen science program have been used for various projects, including urban bird studies (Mccaffrey 2005), examining wild bird prevalence (Caruana and Elhawary 2006), and measuring spatial-temporal variations in bird migration (Hurlbert and Liang 2012)

This exception notwithstanding, hesitations to use citizen science datasets and uncertainty about its validity may lead to a viscous cycle. Scientists may prematurely reject citizen science data because they question its validity, thus reducing the incentive of anyone in the scientific community to vet citizen science datasets, because it is considered to be poor quality. Ultimately, a cultural shift will be needed in the scientific community in order to truly accept datasets collected by citizen scientists (Haklay 2013).

Integration of citizen science into policy making is not often written about in peer reviewed literature. A common-sense avenue for citizen science to influence policy is through the National Park Service (NPS). Although examples of citizen science programs supported by, or partnered with, NPS exists, these programs are rarely written about in the literature. One example is the “Team Odonata” project in Great Smoky Mountain National Park –one of the few NPS citizen science projects that is published. The “Team

Odonata" project provided educational experiences to the volunteers, and added to the Park species list (Muise et al. 2007).

Examples of projects in the grey literature, or posted online, include bio-blitzes where volunteers use an application like iNaturalist to record observations of a specific species, or family. More specific programs include Glacier National Park's Common Loon project, where volunteers survey lakes in the park and document population and size of the loons. These projects, however, and data from these projects, are not disseminated outside of the park, and there is no measurement of how much these projects are influencing policy and management in the parks.

The integration of citizen science and NPS is a logical contribution to park management. Examples of international parks using citizen science programs exist in the peer-review literature (e.g. Bourgeois et al. (2016) and Fischer and Young (2007)). For example, Bourgeois et al. (2016), used data collected by citizen scientists to study invasive plants in Kruger National Park and South Africa. Additionally, (Fischer and Young 2007) used citizen science data for biodiversity management in Cairngorms National Park in central Scotland. It is unclear why the U.S. National Park Service has not produced literature, or partnered with scientists and researchers to produce literature. The principles of citizen science on engagement and scientific literacy, mirror the principles laid out in the Park Service's mission:

> "The National Park Service preserves unimpaired the natural and cultural resources and values of the National Park System for the enjoyment, education, and inspiration of this and future generations."

There is room for the NPS to create their own citizen science programs, or partner with an existing program. These partnerships allow scientists to connect with potential volunteers through environmental education initiatives with the park service, or other agencies (Wals et al. 2014). Citizen science can have a strong impact on the younger generation's understanding of the natural world and scientific thinking (Wals et al. 2014).

2.4 Concluding Remarks

This literature review exposed three main short-comings of citizen science. First, the concept of volunteer is often used to characterize all citizen science participants without considering how different demographics (e.g., young, old, wealthy, poor, differently abled, local inhabitants, and visitors) affect both educational and scientific outcomes of citizen science. Second, an assessment technique for datasets to identify their fitness for use in a specific application is needed. Third, an approach is needed to measure the volunteer and scientific outcomes of citizen science projects and integrate the collected data and analysis into scientific research and management policies. This dissertation addresses these shortcoming by examining the bi-directional flow of knowledge and the volunteer and scientific outcomes through survey methods (surveying the volunteer before and after they participate in the project) collaboration with stakeholders (through focus groups and meetings), and analyzing data for its fitness for use.

CHAPTER 3 METHODS

The goal of this chapter is to describe the research methods used to compare resident and tourist volunteers in citizen science. This chapter is divided into two main sections. The first section describes the data collection. Data collection for my study aimed to access a broad range of information including tourists' and residents' viewpoints, animal sightings from both volunteers and official data collectors, and meetings and focus groups with park officials. The second section of this chapter describes the data analysis, which includes three components. First, the analysis of the survey data to address research question one. Second, the development of a Data Fitness for Use assessment for data collected with the mobile phone-based application which addresses the second research question. Third, the analysis of the results of the focus groups addresses the third research question.

The three research questions in this dissertation are:

1. What is the difference between residents and tourists, data quality and volunteer outcomes (i.e. place attachment and educational outcomes) in citizen science?
2. How can a Data Fitness for Use (DFFU) assessment be used to measure data quality and utility in tourist-driven citizen science?
3. How can the volunteer and scientific outcomes of citizen science be measured, and ultimately integrated into park management and planning?

3.1 Data Collection

This dissertation utilizes five primary and two secondary data sources (Table 3.1 Data Sources). Primary data were collected through the Map of Life - Denali mobile application, or through focus groups with volunteers and park officials. These data include the species observations by volunteers, pre- and post-surveys administered to the volunteers, focus group interviews with volunteers, and focus group interviews with Denali National Park Service officials. Data collection methods were reviewed and exempted by the ASU IRB, STUDY00003874, and reviewed and approved by the National Park Service, DENA-2016-SCI-0002 (Appendix J). Secondary data included authoritative data collected from Denali's Ride Observe and Record (ROAR) program, and expertly collected data obtained from the National Park Service. Data collection is discussed in detail below.

Table 3.1 Data Sources

	Data Source	Description
Primary Data	MOL Species Observation Data	Spatial point data collected from the Map of Life-Denali mobile application. These data include: time and location, and species information for each observation point. Includes data for plants, birds, mammals, and amphibians within the park
	Pre- Survey	Included sections to examine volunteer place attachment and knowledge
	Post- Survey	Included sections to examine volunteer place attachment and knowledge, and an opportunity for volunteers to provide feedback for the program
	Volunteer Focus Group Questionnaire	Provide feedback for the program and the mobile application.
	Park Official Focus Group Interviews	Provide feedback about the program and plans for integration of the program into park educational programs and scientific research.
Secondary Data	ROAR Species Observation Data	Spatial point observation data collected through the Ride Observe and Record (ROAR) program in Denali. These data include: location, time, species identification, and behavior for each point observation. Includes data for birds and mammals within the park
	NPS Species Observation Data	Spatial point data collected through radio and GPS collar "ping". Some data are also collected through aerial surveys. Includes data for the "Big 5": Grizzly bear, Caribou, Moose, Dall sheep, and Wolf.

3.1.1 Primary Data Collection

The Map of Life- Denali mobile application collected the volunteered geographic information (VGI) used in the three dissertation research questions. The VGI consists of geo-tagged wildlife observations made by volunteers using the application during the Summer of 2016. The VGI includes geographic coordinates of the wildlife observation, taxonomic information for the species, a time stamp, and a unique observer ID. These data were retrieved from the Map of Life server on September 30th 2016.

To address the first and third research questions a longitudinal survey and multiple small focus group interviews with the volunteers were conducted (see Appendix B & C). The longitudinal survey was conducted with a pre-visit survey before they begin collecting data, and second, a post-visit survey, after they have completed data collection. The pre-visit survey is divided into three parts: demographic information: age, state/country of residence, quiz questions, and a place attachment question. The post-visit survey is also divided into three parts. First, is a repeat of the quiz questions from the first survey, followed by additional place attachment questions, and lastly, asking for feedback about the mobile application. The focus group interviews were conducted using a short presentation about the project, questionnaires, and open discussion. The questionnaires asked volunteers about their satisfaction with the citizen science program, the mobile application, and thoughts and opinions on citizen science programs in general (Appendix D).

Links to the pre- and post-visit surveys are in the Map of Life-Denali mobile application. The goals of the pre and post-visit surveys are to understand differences in volunteer outcome (including place attachment and educational outcomes) between tourist and resident volunteers, before and after they participated in the program. The post-visit survey has a secondary goal to record feedback and opinions from the volunteers on the usability of the application, and satisfaction with their participation in the program. Influenced by the quizzes given to volunteers in the Portland Urban Coyote Project, the pre- and post-visit surveys included a quiz, which tests volunteers on their knowledge of the park before and after data collection.

In total, the typical visitor spent approximately 5 minutes setting up the application and filling out the pre-visit survey. The volunteers were instructed to take the post-visit survey after their visit to the park. After 2 weeks, an email was sent to volunteers who had not completed the post-visit survey. This survey took approximately 5 minutes to complete. Volunteers who participated in the focus groups were given a questionnaire during the focus groups, and were not instructed to fill out either the pre or post- visit surveys.

The pre-visit survey captured demographic information, pre-visit knowledge about the park, and pre-visit place attachment. The first section of the survey captured a volunteer's basic demographic information: age, and state/country of residence, and the volunteers were also asked to indicate how many times they have visited Denali before, and which bus they are taking into the park that day. If the volunteer is from Alaska, or a local seasonal worker in Alaska, they are considered 'local' or 'residents'; while volunteers from outside of Alaska are considered a 'tourist'. The second section included quiz type multiple-choice and true/false questions, to determine how much the visitor knows about the park. These questions cover basic wildlife facts, wildlife safety, and conservation issues. Each of these questions also included an 'I don't know' option. The third and final section of the pre-visit survey asks volunteers about their place attachment to the park. This question is word choice style, where volunteers can choose multiple words to describe their place attachment to the park.

The word choice section of the surveys included words and phrases from three categories- tangible, intangible, negative (Table 3.2 Word Categories). Tangible words included: wilderness, nature, wildlife, camping. Intangible words were connected to place attachment/sense of place and included: connected, home, attachment, being a part of nature. Negative words included: boring, and cold. The responses to the word choice question were analyzed using descriptive statistics and Chi-square statistics to examine any difference in place attachment between the two groups (residents and tourists) and in and between these groups before and after participation in the program.

Table 3.2 Word Categories

Tangible	Intangible	Negative
Camping	Attachment	Boring
Hiking	Home	Cold
Wilderness	Belonging	
Nature	Being a part of nature	
Sightseeing	Connected	
Mountains	Defines Me	
Wildlife	Conservation	
	Happiness	
	Means a lot	
	Sense of place	
	Unique	

The post-visit survey included the same quiz questions from the pre-visit survey, but added more detailed questions about place attachment, and included a section to capture end-user feedback about the mobile application. By having the volunteers retake the quiz, changes in their knowledge were measured and compared, before and after they used the mobile application, and their visit to the park. The third section of questions in the Post-visit survey more deeply examined place attachment, and explored how the mobile application and citizen science program influences place attachment to the park. These place attachment questions include a 5 point Likert scale, which ranges from strongly disagree, to strongly agree. These questions addressed place attachment overall, then explored the three components of place attachment; place dependence, place identity, and place affect. The last section of the survey included two questions asking the participants about their use of the Map of Life-Denali application.

Multiple focus group interviews were conducted with volunteers during the Summer of 2016. The focus group interviews took place at Denali Backcountry Lodge (DBL - a private facility) and at the park's Murie Science and Learning Center (MSLC). In total, eight focus groups were conducted (five at DBL and three at the MSLC). Focus group were open to any park visitor, as these focus groups were advertised throughout the park, and the focus group participants did not need to have used the Map of Life-Denali application, or have filled out the pre- and post- visit surveys. During each focus group interview, the researcher gave a presentation about this citizen science program and explained how the Map of Life-Denali application worked. Focus group participants were encouraged to ask questions throughout the presentation and then were given a short questionnaire at the end of the presentation– some presentation attendees did not complete the questionnaire. While completing the questionnaire, participants were encouraged to openly discuss the Map of Life-Denali citizen science program and mobile application, and citizen science in general. Some participants had experience with this program and the mobile application, while others did not.

Three focus group interviews were conducted with park officials and concession representatives (Appendix E). The attendees of these focus groups were invited by the project researcher, and the park's Chief Social Scientist. Focus group participants were chosen based on their interest in the program, park education, and park wildlife. The results of these focus group interviews were used to specifically address the third research question on how to measure and integrate the educational and scientific outcomes of citizen science into park management and planning. The focus groups involved park officials, including; the park's Research and Science Team Lead, Wildlife Biologists, Social Scientist, and Interpretation Rangers. These focus groups were moderated by the researcher. Small group meetings with some park officials were held in addition to the focus groups, if the official was unable to attend the scheduled focus group, or wanted to speak individually with the researcher. Meetings were also held with the Director of Operations of Aramark- Denali, as Aramark is the main concessionaire at Denali and operates the shuttle bus system and conducts bus tours in the park. Aramark is interested in incorporating the mobile application into their bus tour itinerary, and is contractually obligated by Denali National Park and Preserve to support the use of a wildlife sighting mobile application.

The first focus group interview was held in June 2016. The goals of this first focus group were to introduce the mobile application, discuss the overall educational and scientific goals of the project, create more specific goals for the project, review the development of the educational and scientific assessments, and discuss the potential for integrating the educational and scientific outcomes into long-term educational programs in the park, and park planning and management. In attendance were the Research and Science Team Lead and Chief Social Scientist for the park. Additional follow-up meetings (held one-on-one) were held with two wildlife biologists, three representatives from the Murie Science and Learning Center, and the Director of Operations at Aramark. The goal of these follow-up meetings was to gain more detailed feedback from particular park officials about the launch of the citizen science program.

The second focus group interview was held in September 2016 with the goal to discuss the future of the citizen science program. The interview included a presentation of preliminary results of the project, including the results of the surveys, and preliminary analysis of the species data. This focus group interview was attended by 8 park officials including 4 Wildlife Biologists, an Interpretation Ranger, the Chief of Commercial Services, the Chief Social Scientist, and the Research and Science Team Lead. Individual meetings were held with 4 representatives from the Murie Science and Learning Center and with the Director of Operations at Aramark.

The third and final focus group interview was intended to further discuss the future of the citizen science program. The interview included a presentation to park officials showing program results of the educational and scientific outcomes, and examples of the integration of the project into park education programming, and park planning and management. This focus group was held in March 2017 with 14 park officials attending the meeting, including 6 Wildlife Biologists, 3 Interpretation Rangers, the Chief of Commercial Services, the Chief Social Scientist, 2 representatives from the Murie Science and Learning Center, and a Cultural Resources Ranger. Following the focus group interview, individual meetings were held with the Director of Operations at Aramark and one wildlife biologist.

3.1.2 Secondary Data Collection

Secondary data includes authoritative data collected from Denali's Ride Observe and Record (ROAR) program, and expertly collected data obtained from the National Park Service. The ROAR data are species occurrence data for all species found in the park, collected daily during the summer months by part-time park employees, who ride the park shuttle busses throughout the summer season. They record the species they observe, time, location, and animal behavior through tablet devices equipped with GPS equipment. The NPS data include species observation data for: Grizzly Bear, Caribou, Moose, Dall Sheep and Wolf. These data are collected through radio collar, GPS collars, and aerial survey methods. These data were originally complied for the park's Natural Resource Condition Assessment in 2012.

3.2 Data Analysis

These data collected via the mobile application, surveys, and focus groups were analyzed to address the three dissertation research questions. This section is divided into the three sections based on the analysis used for each research question.

3.2.1 Research Question 1

The first dissertation research question is:

> What are the differences between resident and tourist volunteers with respect to data quality and volunteer outcomes (place attachment and educational outcomes), in citizen science programs?

To address the first research question, statistical analysis was performed on the survey data, and spatial analysis was performed on data collected through the Map of Life-Denali application. The goal of this analysis is to examine differences between resident and tourist volunteers. The species data collected by the two volunteer groups, as well was place attachment and educational outcomes, are compared to gain insight into the potential for tourist volunteers in citizen science. Analysis of this research question is divided into three parts: data quality, place attachment, and education.

3.2.1.1 Data Quality

Difference in data quality between the volunteer groups was examined to assess if tourists and residents produce comparable data for citizen science. Species observation data collected from the Map of Life-Denali mobile application was analyzed to compare the spatial data collected by the local residents to the spatial data collected by the tourists. The hypothesis is the majority (>50%) of these species observations from the tourists and residents were collected in similar areas. Map-based overlay analysis was performed with the species occurrence points. This analysis indicates if data from the two samples are located in similar geographic locations.

To compare these two point datasets, heat maps were created for both resident and tourist data for four of the five “Big Five” species (Moose, Caribou, Grizzly Bear, and Dall Sheep). Wolf data were analyzed here because only four wolves were recorded by volunteers. To account for difference in sample size between the residents and tourists, a random sample was taken from the tourist data to match the sample size of the resident data. The random sample was derived from the sampling tool, in the Biogeography add-on in Esri’s ArcMap Version 10.3, which selects a random sample from the existing point data. Maps showing the complete tourist dataset for each species is found in Appendix G.

The species occurrence point data was converted to raster format through using the Kernel Density tools in ESRI’s ArcMap. A raster consists of rows and columns of cells where each cell contains a value, in this case the cell values represent the number species observations made within that cell. This Kernel Density tool calculates the density of points around each output raster cell, thus a smooth surface is created. The chosen cell size was 1000 meters because this is the level of error in the Map of Life-Denali application (volunteers can choose how far they are away from the animals, 1,000 is the farthest option). The cells with the highest values contain the points, cell values decrease farther away from the point, and cells with zero value are at the limit of search radius distance from the point. The values of each cell in the two raster layers are added together via ESRI's ArcMap Overlay tool to create a new raster layer which reflects where these raster layers correspond.

The area of this resulting overlay raster was calculated to determine how much the tourist's species observations coincide with the resident's species observations. This area is determined by counting the number of cells whose value does not equal zero (if the cell equals zero these underlying raster layers do not overlap at all in that cell). To calculate how much the tourist's species observations, coincide with the resident's species observations, the total area of tourist raster layers was divided by the overlap raster.

The results of this analysis show how the resident's and tourist's species observations are in similar geographic locations. It helps determine if species observations collected by the tourists are comparable to the resident collected data. The results of this analysis also determine if the tourists are misidentifying species. For example, if a tourist consistently misidentifies a Caribou as a Dall sheep, this sighting may be an outlier in the Dall sheep overlay analysis. This overlay analysis shows if the two volunteer groups are recording wildlife in similar areas.

3.2.1.2 Place Attachment

To address the place attachment portion of the first research question two hypotheses were developed:

1. Residents will have a greater place attachment to the park at the beginning of their visit to the park.
2. Visitors will have a greater increase of place attachment as shown in the post-visit survey.

These hypotheses were analyzed using the responses to the pre- and post-visit surveys. Specifically, the responses to the word choice section of the pre- and post-visit survey, and the Likert scale section in the post-visit survey.

For descriptive statistics, the percentage for each word was calculated based on how many times that word was chosen by the total number of people (e.g., 47% of people chose the word wilderness). For the Chi-square statistics, the raw counts from the pre and post- visit survey quizzes were then calculated for each category and each sample. Equal sample size is not an assumption of the chi-square test (Field, Miles, and Field 2012). Specifically, the Pearson's chi-square and Fisher's Exact test were used. This assesses whether two categorical variables are associated. In some cases, the counts were considered too small for an accurate chi-square test, so a Fisher's Exact test was used. If the counts are below 5, the sample distribution of the test is too deviant from a chi-square distribution. However, the Fisher's Exact test can be used to calculate the probability of the significance statistic that is accurate, even when sample sizes are small.

Two of the questions from the Likert scale section of the post-visit survey were analyzed to address the first research question (#2 covering attachment to the park and #3 attachment to nature and the use of the application, Appendix C). All Likert scale data was examined using descriptive statistics and chi-square (Pearson's and Fisher's Exact tests). Also, the raw counts of each category in each question were calculated for tourists and residents, then the counts of the two groups were compared with the chi-square for each question. (Responses to the other Likert scale questions are used to address other questions in this research).

3.2.1.3 Education

To address the education portion of the first research question two hypotheses were developed:

1. Residents will have a greater pre-application-use knowledge of the park.
2. Tourists will have a greater increase in knowledge of the park

These hypotheses were addressed by analyzing the quiz section of the pre and post-visit surveys, and the Likert scale section of the post-visit survey. Specifically, the second question from the Likert scale section was used to address education (#2 "Did the app enhance your educational experience"). This question was also analyzed using descriptive statistics and chi-square (same as described above).

The quiz section of the pre- and post-visit surveys was analyzed using descriptive statistics (i.e. mean) and a non-parametric version of the t-test, the Wilcoxon Signed-Rank Test. The raw scores from the quizzes were converted into percentages for analysis.

The Wilcoxon sum and signed rank tests were done to compare the changes between the pre and post-visit quizzes for each group (residents or tourists), and the difference between the groups for the pre and post-visit surveys. The Wilcoxon Signed-Rank test, was used because these data are non-parametric and is an accepted alternative to t-tests, yet is more conservative than t-tests (Field, Miles, and Field 2012). This test looks at the difference between two samples, and tests whether the populations from which the samples are drawn are from the same location. This test was used to compare the differences between the two groups, and their pre and post-visit quiz scores. The Wilcoxon Single Rank Test was used to look at the pre and post-visit quiz scores of each group individually. The effect size was calculated with the Cohen's effect size statistic for the Wilcoxon sum ranked tests. Effect size looks at the measure of the magnitudes of an observed effect. By running the Wilcoxon tests in the R programming language, the value of the test statistic is corrected by the small sample size (Field, Miles, and Field 2012).

3.2.2 Research Question 2

The second research question for the dissertation is:

How can a Data Fitness for Use (DFFU) assessment be used to measure data quality and utility in tourist-driven citizen science?

A DFFU assessment was developed then tested. This assessment, called STAAq (Spatial, Temporal, Aptness, and Application Assessment), compares the combination of the tourist species observations and resident species observations collected through the Map of Life-Denali application to the ROAR program data from the park service, and to the expertly collected datasets from NPS (Table 3.3 Datasets for the DFFU assessment).

This assessment is an application of the AAA_Q (Accuracy, Aptness, and Agreement from Shimizu (2014). The STAAq assessment- like other DFFU assessments- determines the degree to which a dataset is suitable for a particular application. Since many citizen science projects are applied to conservation biology, and environmental assessments, these datasets were tested for fitness for use in species distribution modeling.

Table 3.3 Datasets for the DFFU assessment

Dataset	Description
Map of Life -Denali VGI (Primary Data) Includes Tourist and Resident Volunteer Datasets	Data collected from the Map of Life- Denali Application, Summer 2016.
ROAR Data (Secondary Data)	Expert Data collected through the ROAR program in Denali
National Park Service- Natural Resource Condition Assessment Data (Secondary Data)	Expert gathered data through radio collars, GPS collars, and ground and aerial surveys.

Species Distribution Models (SDM), are ecological models used to predict the distribution of species throughout a landscape. Species presence data and environmental variables are used in the model to predict species distribution (Franklin 2013). These environmental variables can include: climate data, geological data, or land cover data. Using the Maxent software package with the maximum entropy models, the distribution for each of the species. Maxent estimates the species distribution by finding the probability of distribution of maximum entropy, which is the most spread out distribution and the most uniform distribution (Phillips et al. 2006).

The STAAq assessment was used to determine which of the three datasets in Table 3.3, is most fit for use to answer the following hypothetical research questions (1) What is the distribution of Grizzly Bears in the Summer in Denali? (2) What is the historical year-round distribution of Caribou in Denali? Although these datasets are comprised of species identification and observation location information for multiple species in Denali, only Grizzly Bear and Caribou data are used for this analysis (The results from SDM for other "Big-5" species are found in Appendix H. $STAA_q$ is used to assess the datasets (listed in Table 3.3) for use in species distribution modeling. The species occurrence points are subject to a set of constraints based on the environmental variables (Phillips et al. 2006). Environmental variables include: climate, land/ground cover, and elevation. The available data drove this project to use Maxent, which only requires presence data and environmental data for the study area (Franklin 2010, Philips et al. 2009).

This assessment was adapted from the original AAA_Q assessment developed by Shimizu (2014), which has three components: accuracy, agreement, and aptness. Accuracy refers to how accurate these data are geographically, and categorically. Accuracy can be examined through how well these data address different accuracy components. Agreement looks at the consistency of datasets being compared. Too many differences between the datasets indicates poor agreement, while better accuracy means that the datasets overlap to a greater extent. Aptness refers to the context in which these data are used. Aptness in the ranking order depends on what level of errors the decision makers are willing to accept (Shimizu 2014).

This project applies Shimizu's AAA_Q assessment and focuses on spatial (Shimizu refers to spatial scale as positional) and temporal scale referenced in the description of the Accuracy component of the AAA_Q assessment. These added assessments are important in evaluating spatial data including VGI. Accuracy, agreement, aptness, and temporal and spatial scale are all described as elements of spatial data quality (Guptill and Morrison 2013), thus the addition of temporal and spatial scale to the existing DFFU assessment provides a more complete examination of data quality. VGI increases temporal and spatial extent of data collection (Dickinson, Zuckerberg, and Bonter 2010), but these components of data are not often evaluated. The temporal scale component assesses the following elements: observation time, temporal resolution, and temporal extent. The spatial scale components assess the datasets spatial resolution and extent. The agreement component is not included in this DFFU assessment.

Each dataset is ranked according to how they perform with each of the four components. These rankings are then averaged to create an overall ranking of the datasets. Table 3.4 shows each of the four components in the STAAq assessment. Weight (w) can be applied to any of the components. The number of elements (j) that is assessed by the particular component. The same “Big-Five” species (Grizzly Bear, Caribou, Moose, Dall Sheep, Wolf) were chosen to represent each dataset. These sub-datasets are assessed through the DFFU then these rankings are averaged to give the overall ranking for each dataset in each component.

Table 3.4 STAAq Components

Component	Formula	Description
Spatial Scale	$S_q = w_1 \frac{s_1 + s_2 + s_j}{j}$	Spatial Scale= S_q S_j = rank of elements, j= number of elements
Temporal Scale	$T_q = w_2 \frac{t_1 + t_2 + t_j}{j}$	Temporal Scale = T_q t_j= rank of elements
Aptness	$A_{1q} = w_3 \bullet a_{1q}$	Aptness= A_{1q} a = the uniqueness of the dataset.
Application	$A_{2q} = w_4 \frac{a2_1 + a2_2 + a2_j}{j}$	Application = A_{2q} a_{1j}= rank of elements for the datasets
$STAA_Q$	$\text{STAAq} = w_1 \sum X_{iQ}$	Average of all the ranks of all components (X) for each data set. Rank of 1 is considered best.

The spatial scale component (S) (*Figure 3.1 Spatial Scale (S) Component applied from Shimizu, M. 2014.*) assesses two elements: spatial resolution and spatial extent. Spatial resolution refers to the minimum cell size of the raster data, or in the case of point data, a measurement of error (Goodchild 2011). Spatial extent refers to the spatial scope of these data, or the size of the area represented in these data (Goodchild 2011). Spatial scale is assessed like the accuracy component, while resolution and extent are elements (j) which are assessed to determine the rank of each data set. The datasets are assessed on how well they perform at different standards of the spatial scale elements. For example, the resolution element can be used to assess these data per a specific cell size, or measurement of error.

The desired spatial scale for this case study is high resolution data for Denali National Park and Preserve. The spatial extent is the extent of the park's boundary. The spatial resolution in this case is the measurement error of the point data. These were collected with various techniques: GPS collar, Radio collar, and phone GPS systems. The resulting points have some error associated with them. The amount of this error is considered the spatial resolution. The desired spatial resolution is 5 meters.

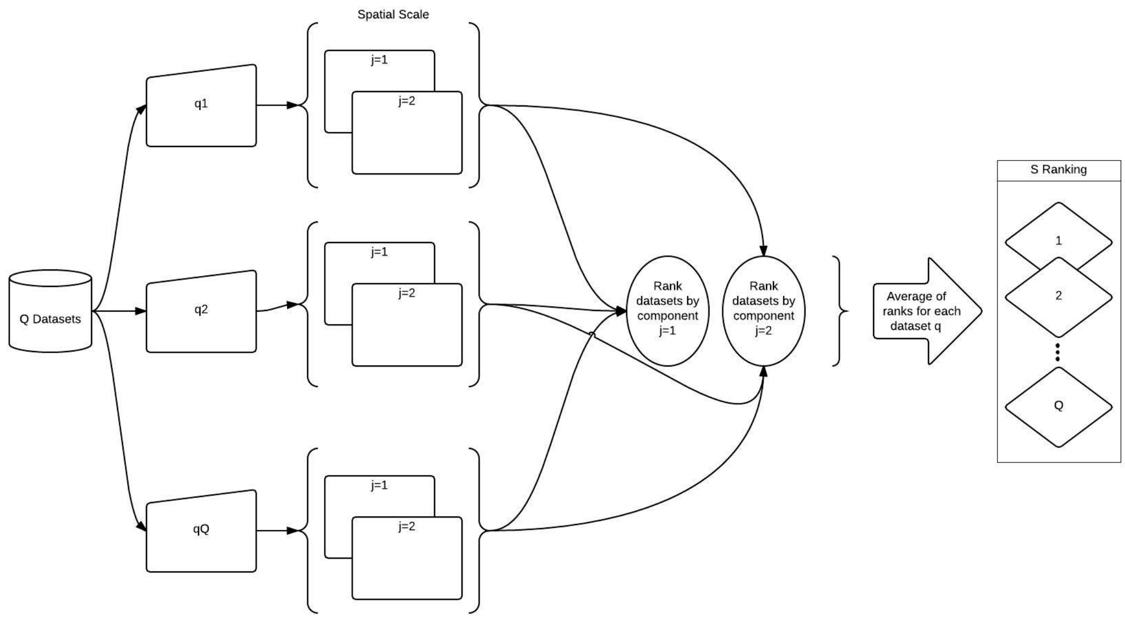

Figure 3.1 Spatial Scale (S) Component applied from Shimizu, M. 2014. The Development and Assessment of A Spatial Decision Support System for Watershed Management in the Niantic River Watershed: A Geodesign Approach (Doctoral dissertation). Arizona State University.

Temporal scale (T) (*Figure 3.2 Temporal Scale (T) Component applied from Shimizu, M. 2014.)* is determined by assessing the performance of each dataset with three different elements (j) of temporal scale; observation time, temporal resolution, and temporal extent. Observation time refers to the time at which the event was observed (Guptill and Morrison 2013). Temporal resolution, also referred to as temporal consistency, is defined as the frequency at which the dataset is collected (Guptill and Morrison 2013). Temporal extent, or temporal transaction, refers to the length of the data collection, or how much of a time span the dataset covers (Guptill and Morrison 2013). The datasets are ranked based on how they perform with each of the elements. For example, if a dataset that spans multiple years is desired, the dataset with a larger temporal extent is ranked higher.

In this case study, the desired temporal scale is data collected daily in the Summer season (June –September) during the last five years (2012 thru 2016). Thus, the desired observation time is any time of day during the months of June through September. The desired temporal resolution is daily collection. The desired temporal extent is the last 5 years: June 2012 to September 2016.

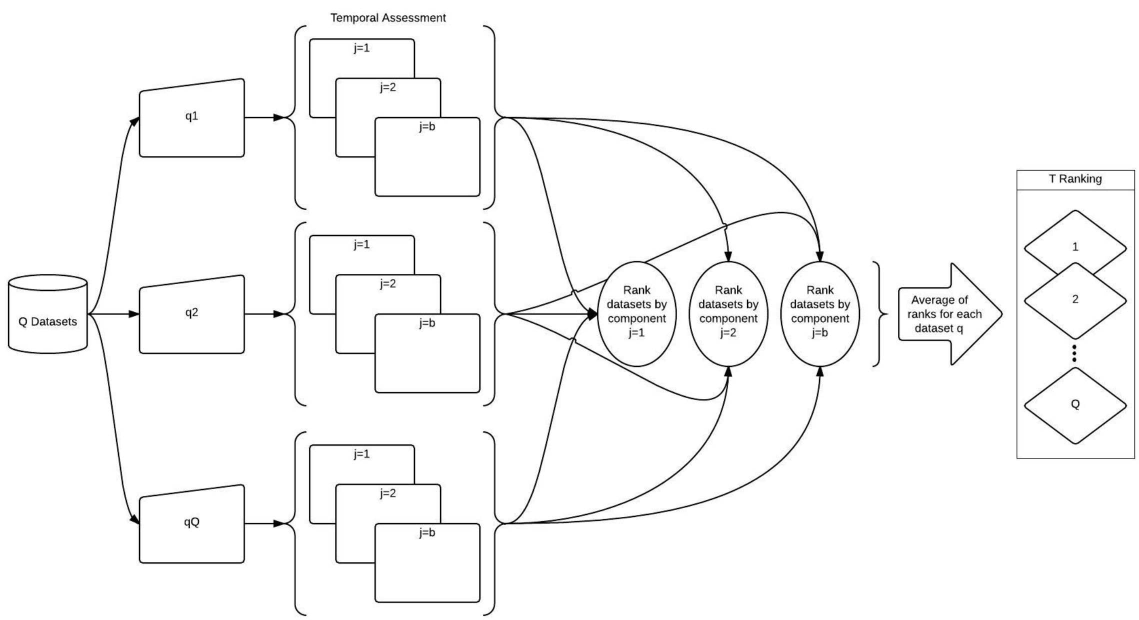

Figure 3.2 Temporal Scale (T) Component applied from Shimizu, M. 2014. The Development and Assessment of A Spatial Decision Support System for Watershed Management in the Niantic River Watershed: A Geodesign Approach (Doctoral dissertation). Arizona State University.

Aptness (determines the uniqueness (U) of the datasets. In order to determine aptness, these data must be in raster format. Aptness is calculated cell by cell, to determine how unique each dataset is. In some cases, uniqueness is a desired quality in the datasets, while in other cases it is not. Figure 3.1 Aptness (A1) Component applied from Shimizu (2014) shows the process of determining aptness. R1, R2, and RQ represent sample raster data for each of the datasets (Q). Each cell in the raster is given a value. The raster layers are then added together to create R. The original raster layers for each dataset are then multiplied by R to create R1R, R2R, and RQR. Then cell by cell agreement, c, is determined between the datasets.

c= 0 none of the datasets have an attribute assigned to that cell

c= 1 one dataset assigned an attribute to that cell

c= 2 two datasets assigned an attribute to that cell

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.

.

c=Q all datasets assigned an attribute to that cell

In the case of aptness c=1 shows which dataset is unique. The process of “cell by cell” agreement results in a new raster layer (RQA2), the layer RQR is divided by this new layer to calculate the percent of uniqueness (U) of the dataset. Then it must be determined if omission, or commission, is preferred. Is uniqueness of a dataset a desired quality, or not? In this case study uniqueness is not desired.

e= 1 when error of commission is preferred

e= 0 when error of omission is preferred.

Finally, the datasets are ranked in either ascending or descending order, depending on the value of e.

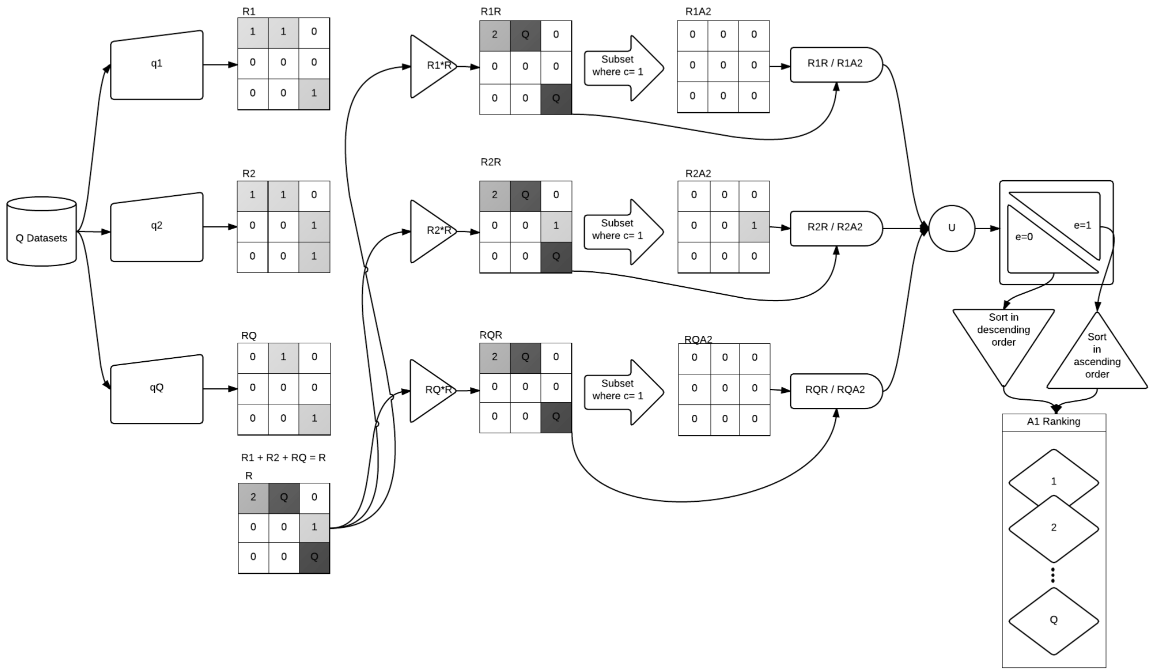

Figure 3.2 Aptness (A1) Component applied from Shimizu, M. 2014 The Development and Assessment of A Spatial Decision Support System for Watershed Management in the Niantic River Watershed: A Geodesign Approach (Doctoral dissertation). Arizona State University.

The Application component (Figure 3.3 Application (A2) Component applied from Shimizu, M. 2014.) is concerned with the product of the model, which in this case is SDM. The elements of the application component vary with the models being assessed, for example Shimizu (2014), uses the application component (called Accuracy component in Shimizu 2014) to assess how accurately a model calculated the total nitrogen removal and nitrogen load in a water shed. This research uses the accuracy component to examine how well the SDM predict species distribution based on three environmental variables: climate (precipitation and temperature), land cover, and elevation. In Figure 3.4 Application (A2) Component applied from Shimizu (2014), the datasets are represented by q1, q2, qQ. The elements of the components (in the case of this study the environmental variables used in the SDM) are represented by j. The datasets are ranked based on how well they perform with each of the elements (Area Under the Curve (AUC) statistic was used). Then these rankings are averaged to produce a final A_1 ranking.

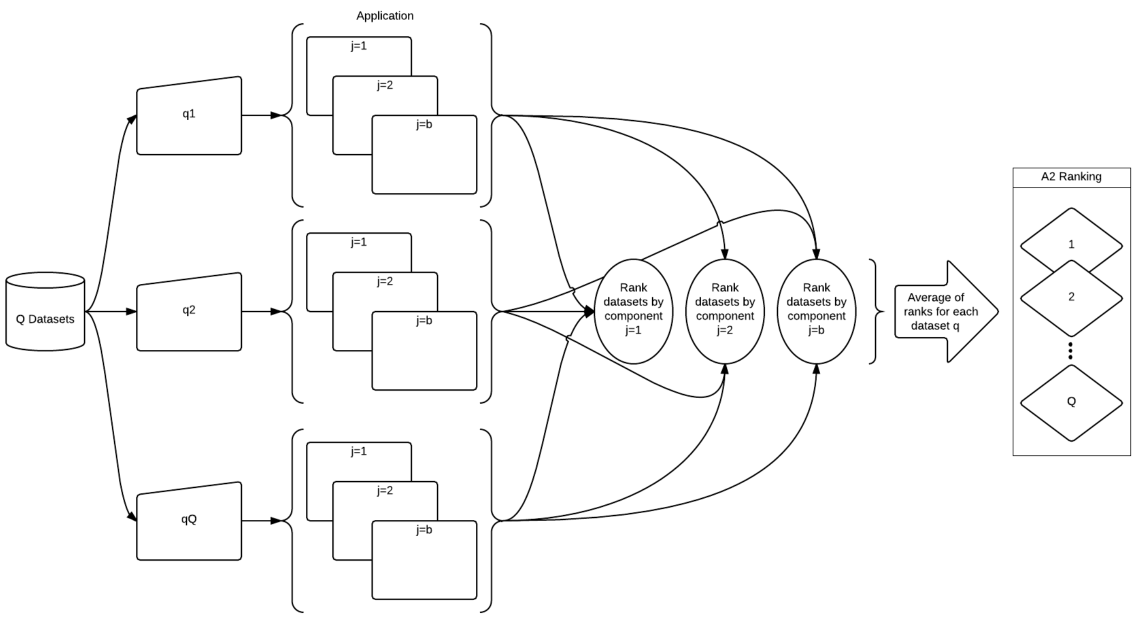

Figure 3.5 Application (A2) Component applied from Shimizu, M. 2014. The Development and Assessment of A Spatial Decision Support System for Watershed Management in the Niantic River Watershed: A Geodesign Approach (Doctoral dissertation). Arizona State University.

The overall ranking of the datasets was determined by averaging the rankings of each component (Roszkowska 2013). The resulting fractional ranks are then ranked to provide a final ranking of the datasets. A weight can be applied to each component prior to averaging the ranks, if desired. This average ranking shows how the datasets compare to each other in terms of fitness for use.

3.2.3 Research Question 3

The third question in this dissertation is:

How can the volunteer and scientific outcomes of citizen science be measured and ultimately integrated into park management and planning?

This portion of the research measures the volunteer scientific outcomes of the citizen science program and assesses the integration of these outcomes into park management and planning. This includes the development of an outcomes assessment to evaluate and measure the success of volunteers and scientific outcomes, in tourist-driven citizen science– for this research the measurement of volunteer outcomes focuses on the volunteer's educational outcomes. The results from the focus groups with both the volunteers, and park officials, are analyzed to address this research question.

An outcomes assessment was developed and used to separately assess the educational and scientific outcomes of the Map of Life- Denali citizen science program (Figure 3.6 Outcomes Assessment). The first step in the outcomes assessment is to establish general goals for the citizen science project. Next, an agreed upon method of measurement was established. The third step refines the goal specifying something specific and measurable. The fourth step measured the outcomes using survey responses. Then lastly, these measured outcomes are compared to the specific goal.

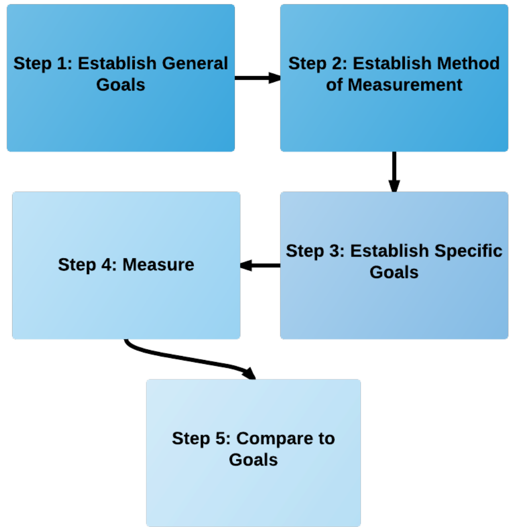

Figure 3.6 Outcomes Assessment

This outcomes assessment was used to measure the educational and scientific outcomes of the citizen science project. The goals and methods of measurement for evaluating both the educational and scientific outcomes were discussed with park officials in the first focus groups and set of meetings with park officials in June 2016. For the educational assessment, the general goal for volunteers to learn about wildlife safety was established. Next, an agreed upon method of measurement was established, so in the case of this study, wildlife safety knowledge is measured, through the survey question responses. The third step refined the goal specifying something specific and measurable. We set an objective of achieving 70%, or better, in correct responses to the survey questions related to wildlife safety. The fourth step measured the outcomes using post-visit survey responses. Then lastly, we compared these measured outcomes to the specific goal. These are presented in the Results chapter. Preliminary results of the assessment were presented at the second focus group meetings in September 2016, and Final results were presented at the third focus group in March 2017. The results of this assessment can be used by the park staff to assess the overall educational and interpretive experience in the park.

The outcomes assessment was then applied to the scientific outcomes of the program. The scientific outcomes of the project were assessed based on its ability to be used in the Road Ecology Program (REP), which is the general goal. The methods of measurement for this case study are two sightings indices, the Annual Sighting Index, which is a measure of how often a participant saw a member of a species in that year, and the Road Sightings Index, which provides a probability of seeing a particular species along the park road. Comparative data for the scientific outcomes assessment were obtained from the ROAR program in Denali NP&P. These observations are made by paid part-time workers who are well trained, and have been involved in the ROAR program long-term, thus, this dataset is ideal for the comparative assessment. The specific goal for this assessment is to have a less than 5% average difference between the two datasets in each of the sightings indices. The results of the scientific assessment were provided to the park service at the third focus group.

The notes from the focus groups were coded and categorized based on themes. Some individual meetings were held with officials who did not attend the focus groups. Content analysis was performed to examine the park officials' opinions of the citizen science project, including their perceptions of the success of the project, and potential to integrate the project into park management. Descriptive statistics and frequency counts were used to describe the outcomes of the content analysis.

During the first focus group and first set of meetings, park officials and Aramark representatives provided feedback on the surveys and mobile application used in the citizen science program. The park officials also shared their opinions on the educational and scientific goals of the program, which informed the outcomes assessment. The results from the initial focus group with park officials were analyzed and guided the development of the educational and scientific outcome assessment, as well as the integration of educational and scientific outcomes into park planning and management. The second focus group and second set of meetings presented some preliminary results to the park service officials and Aramark representatives. During this focus group the park officials assessed the examples presented, and discussed a pragmatic approach to integrating the Map of Life – Denali application into park educational and research programs.

A third focus group and third set of meetings with park officials and Aramark representatives were held in March 2017. The goal for this set of meetings was to present final results of this research, including results of the educational and scientific outcomes assessments to park officials and Aramark. Additionally, examples of how the scientific outcomes can be integrated into the park planning and management were presented, and examples of how the educational aspects of the project can be integrated into existing interpretive initiatives. The results of the focus groups were analyzed to determine the two measures of success of the program: 1) Did the citizen science program meet the goals set by the park service? 2) Can and will this program be integrated into existing park educational initiatives and management?

3.3 Concluding Remarks

This chapter detailed the methods used in this dissertation research organized around the three research questions. The two sections on data covered the sources of primary and secondary data to address each of the three research questions. These data are analyzed using both qualitative and quantitative methods including statistical methods, and spatial analysis methods. The next chapter discusses the results of these analyses.

CHAPTER 4 RESULTS

This research utilizes a mixed-methods approach to understand tourist citizen science, specifically: the volunteers, the data fitness, and the outcomes. As detailed in the Methods chapter multiple methods of data collection were employed for this research: surveys, focus groups, and mobile technology. This chapter analyzes these data to answer the three specific research questions, and ultimately the main objective of this research, understanding tourist-centric citizen science.

This chapter is divided into four sections. The first section of this chapter provides a description of the volunteers and VGI they collected. The subsequent sections address each of the three research questions. Results from each of the surveys, focus groups, and the mobile application are presented as they pertain to each of the survey questions. For example, questions from the post-visit survey pertain to either the first and third research question, thus the analysis and results from questions are discussed in the section of the research question they address.

4.1 The Volunteers

This section describes the sample sizes from the surveys and questionnaire as well as demographics and descriptive information about the volunteers. In total, 139 people participated in the pre and post-visit surveys, 21 Residents and 118 Tourists. A questionnaire was conducted in focus group settings, where 32 volunteers (1 resident, and 31 tourists) completed the questionnaire. Some of the focus group participants did not complete the questionnaire. Volunteers who participated in the focus group surveys did not participate in the pre and post-visit surveys. Of the volunteers who participated in the surveys, 136 volunteers produced usable VGI- 22 residents and 114 tourists.

Additionally, a non-response survey was conducted to record volunteers who did not want to, or could not, participate in the program (Appendix F). This non-response survey is discussed in detail in the fourth section of this chapter.

Volunteers were asked to provide basic demographic information in the pre-visit survey, including age, and where they were from. Volunteers ranged from ages 18 to over 75 years (Figure 4.1 Age Range of the volunteers, the common age range is for all the volunteers is 41-55. The median age for Tourist volunteers is 41-55, the common age for residents is under 25 (this may be because local seasonal employees volunteered) n=129.). The average age of visitors to Denali is 57, most of the volunteers were 41 years or older. Many of the volunteers, 80%, were visiting Denali for the first time. Others were returning visitors or residents who live and/or work in or near the park, either year-round or seasonally. The volunteers were from all over the United States and abroad. Volunteers from the United States most frequently came from Alaska, California, and Texas. International volunteers included people from India, Spain, Germany, and the United Kingdom. Volunteers from Alaska, or who work in the park seasonally, are considered Residents in this study.

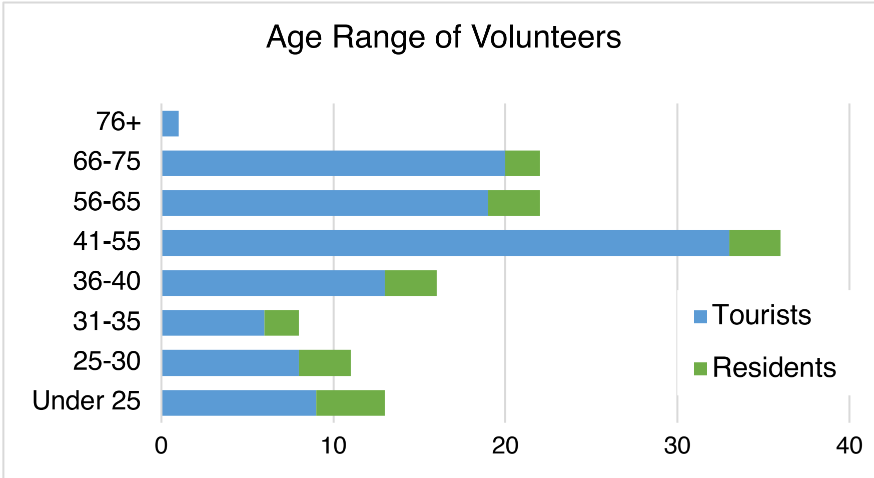

Figure 4.1 Age Range of the volunteers, the common age range is for all the volunteers is 41-55. The median age for Tourist volunteers is 41-55, the common age for residents is under 25 (this may be because local seasonal employees volunteered) n=129.

In the questionnaire from the focus groups, volunteers were asked why they wanted to visit the park. "Wildlife observation" was the top reason why volunteers wanted to visit the park, scenery was second, and Denali (the mountain) was third (Figure 4.2 Reasons for visiting the park, n=32.). The preference toward viewing wildlife shows that there may be interest in a citizen science program focused on wildlife.

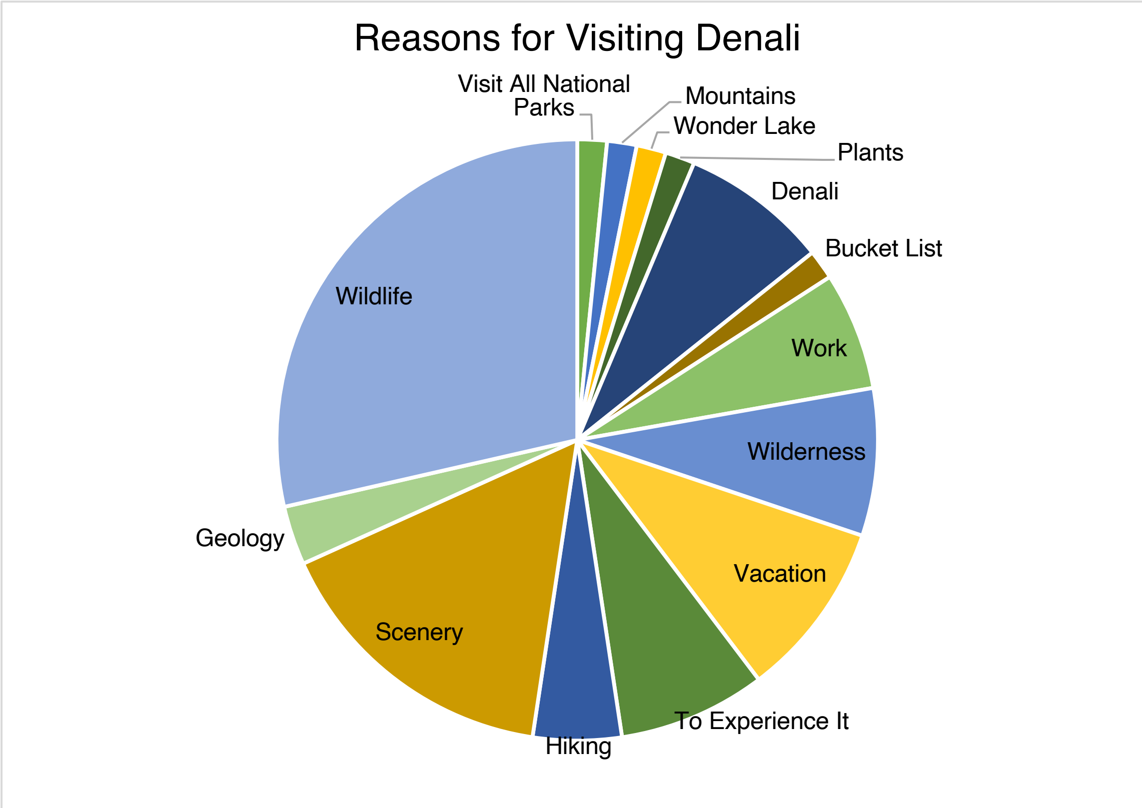

Figure 4.2 Reasons for visiting the park, n=32.

In both the pre-visit survey and the focus group survey volunteers were asked which wildlife they wanted to see in the park (Figure 4.3 Wildlife Volunteers Most Want to See in the park. This question was asked in the focus group survey n=32 and the pre-visit survey n=131, both surveys n=163.). Unsurprisingly, the volunteers choose the "Big-5" as their top choices. The "Big-5" refers to the large charismatic mega fauna in the park: Grizzly bear *(Ursus arctos horribilis),* Caribou *(Rangifer tarandus),* Moose *(Alces Alces),* Dall sheep *(Ovis Dalli),* and Wolves *(Canus Lupus)*. The volunteers chose some of the rarer wildlife in the park, since only about 5% of visitors see wolves in the park and even more rare are: Wolverines, Lynx, and Wood frogs.

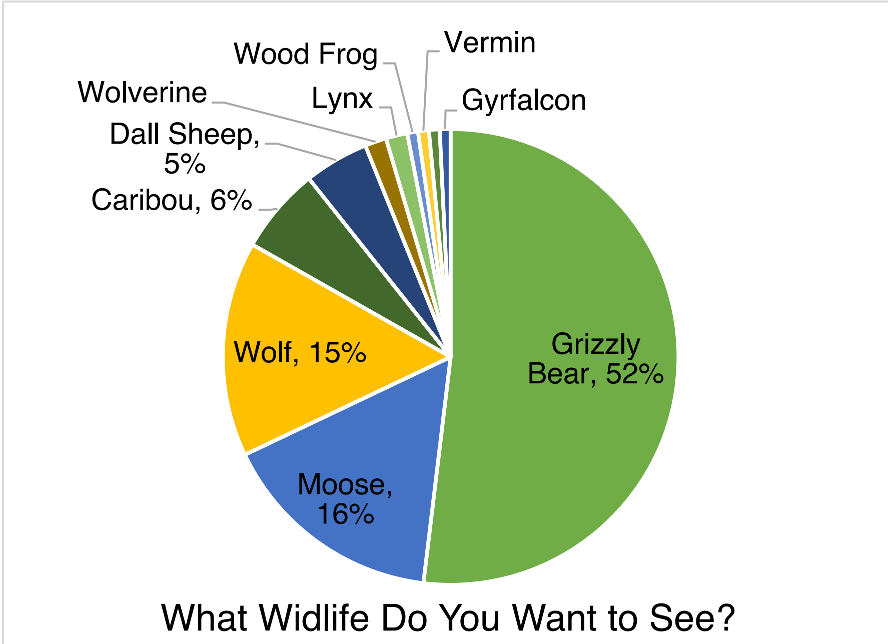

Figure 4.3 Wildlife Volunteers Most Want to See in the park. This question was asked in the focus group survey n=32 and the pre-visit survey n=131, both surveys n=163.

4.2 Species Observation Data

This section describes the species observation data collected by the volunteers through the Map of Life-Denali application. The volunteers' preference for the "Big-5" is reflected in the observations made in the mobile application. In total, 1,200 wildlife and plant observations were recorded. While most of the observations were mammals, volunteers also recorded birds, plants, and one amphibian, the Wood frog. Figure 4.4 Bird Species observed by the volunteers, 196 total bird observations were made, 157 made by tourists, 39 made by residents.shows the different bird species recorded by volunteers. The most common bird recorded by volunteers (both residents and tourists) was Ptarmigan (*Lagopus*). These birds are easily identifiable, and easier for a novice birder to record. Golden Eagles and Magpie are the second most commonly recorded. Eight other fairly rare species were recorded as well.

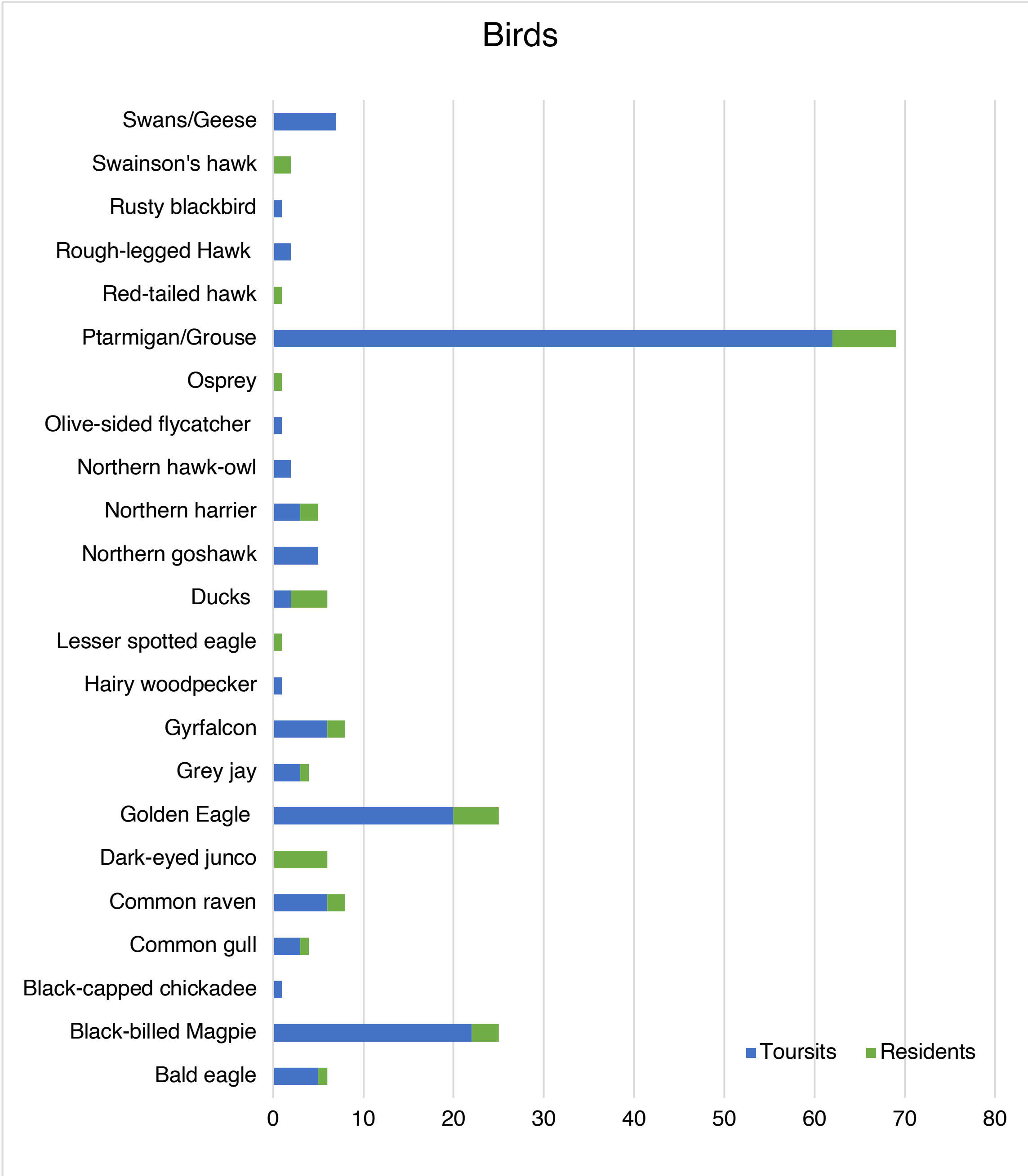

Figure 4.4 Bird Species observed by the volunteers, 196 total bird observations were made, 157 made by tourists, 39 made by residents.

Volunteers recorded more mammals than birds, plants, or amphibians, Figure 4.5 shows the number of mammal observations made by the volunteers. Caribou were the most recorded animal by tourists and residents. Caribou were one of the top species volunteers wanted to see in the park (Figure 4.5 In total 959 mammals were recorded by the volunteers, 807 record by tourists, and 152 recorded by residents.). The abundance of Caribou (over 2,500 currently in the park area) and their natural habitat near the park road may be factors in the large numbers of recordings.

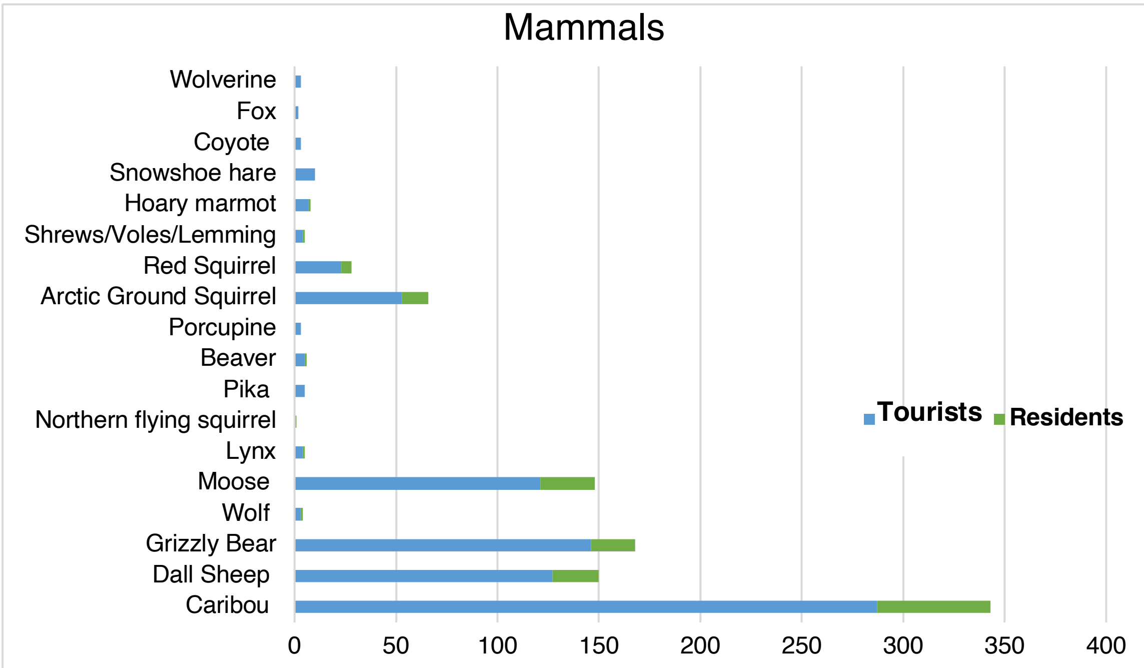

Figure 4.5 In total 959 mammals were recorded by the volunteers, 807 record by tourists, and 152 recorded by residents.

The top four recorded animals (birds or mammals) are four of the “Big-5”, Caribou, Grizzly Bear, Dall Sheep, and Moose. Only four wolves were recorded, 3 of these wolf observations were made by tourists. This lack of wolf sightings is not surprising, since only about 50 wolves live within the park boundaries (Kilkus et al. 2011). Other rare sightings include: lynx and wolverine. Volunteers recorded common wildlife like Common gulls, Grey jays, and Ground squirrels, but the number of recorded observations does not reflect the possible actual observations of these species. The volunteers were likely to see more common small mammals and bird like squirrels, jays, and gulls than they recorded with the mobile application.

4.3 Results for Research Question 1

The first research question aims to examine the difference between the tourist and resident volunteers. This research question is addressed using responses from the pre and post-visit surveys, and spatial data from the Map of Life-Denali mobile application. Results for this question are divided into three parts: data quality, place attachment and educational outcomes.

4.3.1 Data Quality

The difference in data quality between the residents and tourists is assessed through creating heat maps and a geographical overlay analysis, which shows if the tourists and resident volunteers are making observations of a particular species in the same location, in other words how consistent are these spatial data. Study area residents are the benchmark to which the tourist data are compared. The hypothesis is; the majority (>50%) of these species observations from the tourists and residents were collected in similar locations. Through the analysis of the heat maps and the overlay analysis, on average the tourist data overlap 67.12% with the resident data.

The "Big-5" mammals are the focus of the overlay analysis and heat maps were created from resident and tourist species observation data for four of the "Big-5" mammals (Grizzly bear, Caribou, Moose, and Dall sheep). Maps were not created for Wolves because only three wolf observations from tourists, and one observation from a resident were recorded. These heat maps show, in raster layers, the density of wildlife observations over the course of the study period (June- September 2016) for residents and for tourists. The value of each cell in the raster layers represents the number of species observations made in that cell. The raster layers were then used in a spatial overlay analysis to identify where the species observations from these two groups overlap. The remainder of this section details the differences between resident and tourist observations, for each of the four species, Grizzly bear, Caribou, Moose, and Dall sheep.

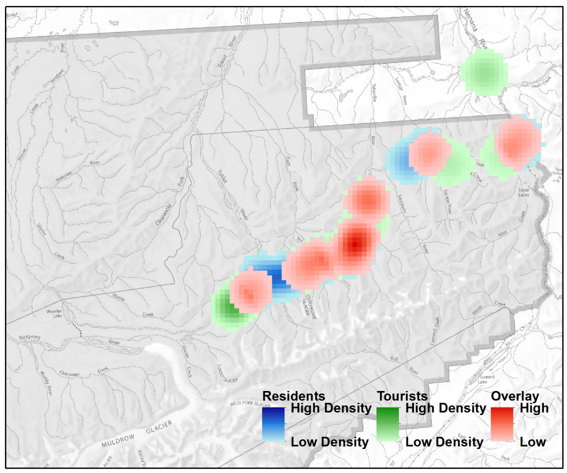

Figure 4.6 Grizzly Bear Observations (with resampled tourist data due to differences in sample size-resampling methods described in the Methods section)

The tourist (green) and resident (blue) Grizzly Bear observations reflect similar hot spots, this is determined by the overlay layers (red) (Figure 4.6). These raster layers were derived from 21point observations from the residents, and a random sample of 21 point observations from the tourists. Darker colors represent hot spot areas, i.e., an area with a high density of observation points. The total area of overlap is 502 km^2. The tourist observations overlap 66.93% with the resident observations, thus a majority of the tourist observations overlap with the resident observations. The darker red area represents the overlay raster layer, where there is a greater consistency amongst these data. There are some hot spots seen in the tourist data that are not consistent with the resident's data and vice versa, however, the overlay shows consistent hot spots in known areas of Grizzly Bear habitat in the park.

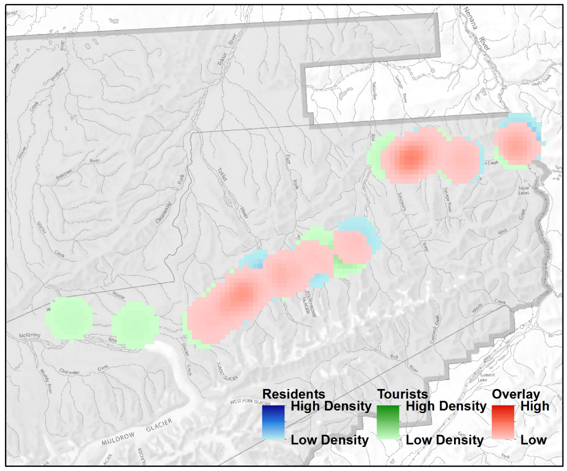

Figure 4.7 Caribou Observations (with resampled tourist data)

The Caribou observations made by tourist and resident volunteers are represented in Figure 4.7. This map shows areas of hot-spots from each volunteer group, and the areas where these data overlap is shown in red. The total area of overlay with the resampled tourists' data are 613km^2. The tourist observations overlap 70.13% with the resident observations, so a majority of the observations overlap. The hot spot areas are not as pronounced as they were with the bear observations, but, the area where there is greater consistency amongst the two samples (darker red areas) are in known areas of Summer Caribou habitat in the park.

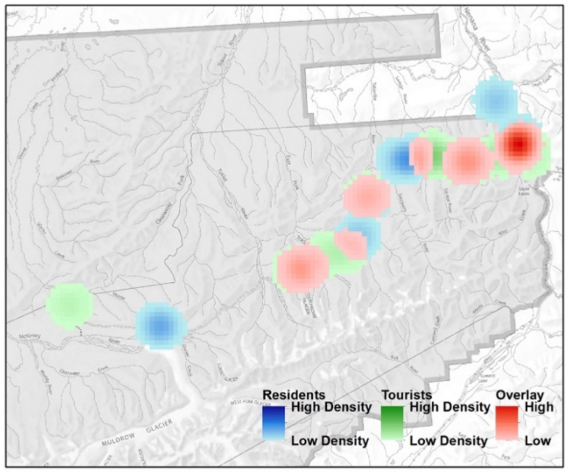

Figure 4.8 Moose Observations (with resampled tourist data)

Tourist and resident Moose observations are depicted in Figure 4.8. Areas of darker blue (resident observations) or green (tourist observations) represent hot spots, an area of a higher density of observation points. The total area of overlay is $422km^2$. The tourist observations overlap 65.73% with the resident observations. The overlay area (red) shows where the two sets of observations overlap, and the darker red area indicates a higher consistency amongst these data. It is expected to see a high density of Moose observations near the park entrance area (upper right-hand side of the map), this well-known Moose habitat.

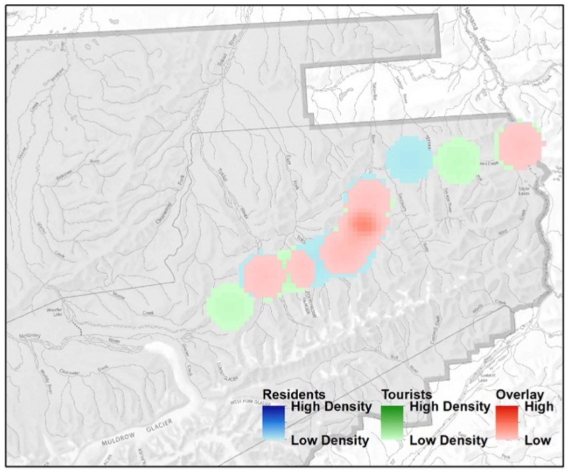

Figure 4.9 Dall Sheep Observations (with resampled tourist data)

The tourist and resident Dall Sheep observations are depicted in Figure 4.9. The total area of overlay is 374km^{2}. The tourist observations overlap 65.72% with the resident observations. The tourist observations are shown in green and resident observations in blue. The main areas of higher consistency in this map occurs around the Teklanika area of the park, between mile markers 30 and 35 on the park road, which is an area known for summer sheep habitat.

Table 4.1 Overlap between Resident and Tourist Species Observations

	Area of Tourist Observations (km^2)	Area of Resident observations (km^2)	Area of total overlay (km^2)	Percentage of area where tourist data overlaps with resident data	Percentage of area where resident data overlaps with tourist data
Grizzly bear	750	632	502	66.93%	79.4%
Caribou	874	708	613	70.13%	86.58%
Moose	642	704	422	65.73%	59.94%
Dall sheep	569	518	374	65.72%	75.22%
Average Area of Overlap				67.12%	75.28%

Table 4.1 shows the area of overlap for each species and an average area of overlap for these tourist and resident data. The majority of the tourist data does overlap

with the resident data (67.12%). An even larger percentage of the resident data overlaps with the tourist data, (75.28%). This is likely due to the larger spatial distribution of these tourist data.

4.3.2 Place Attachment

The second part of the first research question explores the difference between tourists and residents in their place attachment toward the park. Place attachment is an important outcome for citizen science volunteers because volunteers will feel motivated to participate in the program if they feel a connection to the study area (Haywood 2014). The three different components of place attachment are place dependence, place identity, and place affect, were examined through analyzing the word choice questions in the pre and post- visit surveys and responses to four of the Likert scale questions in the Post-Visit survey. To help address this portion of the first research question, two hypotheses were developed

1. Residents will have a greater pre-visit place attachment to the park.
2. Visitors will have a greater increase of place attachment

Analysis of the word choice portion of the pre and post-visit was used to address the above hypotheses. Residents did in fact display more pre-visit place attachment in the park, and tourists did have a greater increase in place attachment using the post-visit survey. Results from the Likert scale questions in the post-visit survey provide more results to address place attachment. The tourists and residents also agreed that the mobile app helped them feel connected to the park, but differ on their opinion as to how the program helps them be connected to nature.

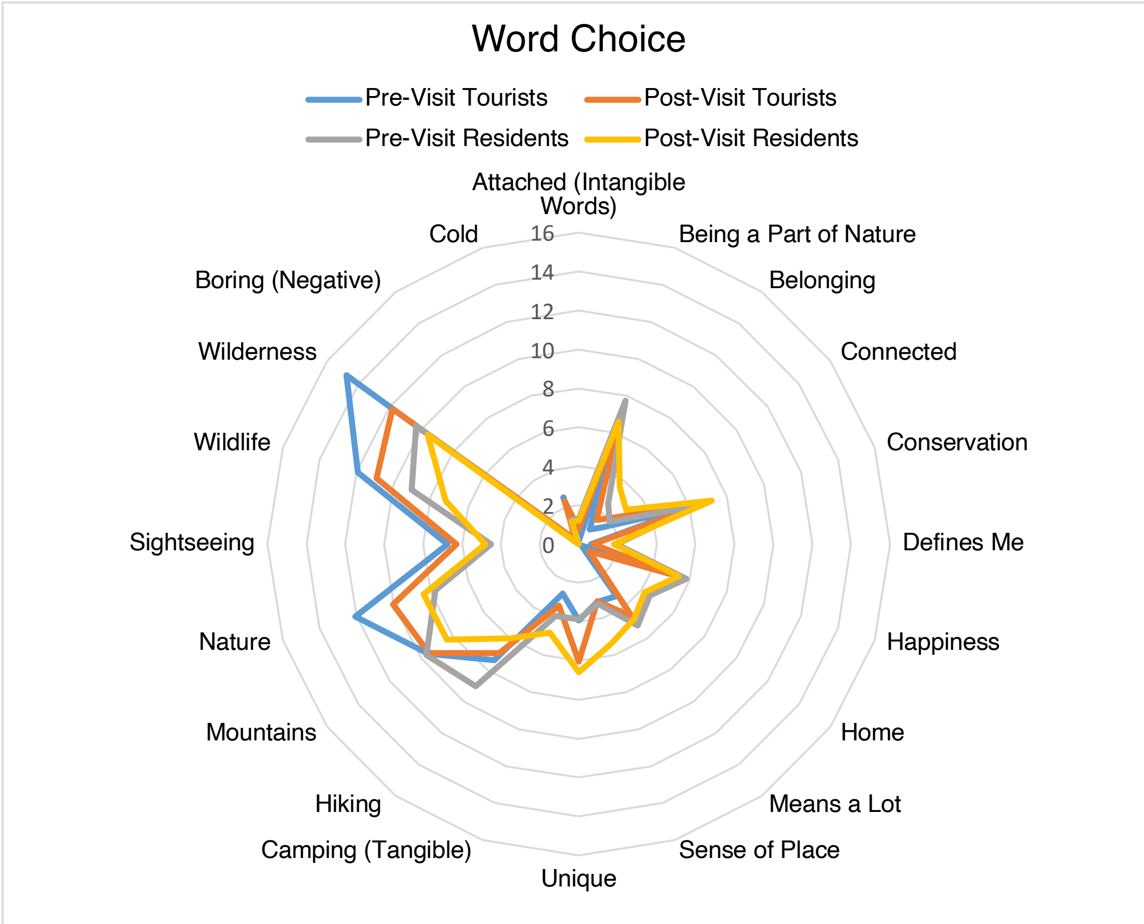

Figure 4.10 Word Count Results from the pre and post- visit surveys. Shows the percentage that a word was chosen out of the total number of words. Pre-visit survey tourists n= 637 words, Pre-visit survey residents n= 155 words, post-visit survey tourists n= 778 words, post-visit survey residents n= 167 words.

The same words appeared in the pre and post- visit surveys, and participants could choose as many words as they wanted. As described in the last chapter, the words were categorized as: tangible, intangible, or negative words. Figure 4.10 shows each word/phrase starting with the intangible words and moving clock-wise to tangible then ends with negative words.

Figure 4.10 shows the frequency that a word was chosen. For example, “wilderness” is chosen most frequently in each survey and amongst both groups. The most frequently chosen intangible word/phrase is “being a part of nature.” Similar trends emerge between the surveys and the volunteer groups. “wildlife” and “wilderness” were popular words in both surveys and between both groups. The residents did choose a few unique words, for example in the post-visit survey residents chose “home” and happiness” more than they did in the pre-visit survey. Negative words were rarely chosen, only one volunteer (a tourist) chose “boring” in the post-visit survey.

Table 4.2 Word Choice Results, Percentage of word chosen, from the total amount of words chosen in each survey by each volunteer group.

	Tangible Words		Difference	Intangible Words		Difference
	Pre	Post		Pre	Post	
Tourists	65.14%	58.56%	↓ 6.58%	32.33%	38.56%.	↑6.23%
Residents	54.19%	49.10%	↓5.09%	44.51%	49.70%	↑5.19
Difference	10.95%	9.46%		12.18%	11.14%	

Residents chose fewer tangible words than tourists, in the pre and post-visit survey, however, they chose more intangible words in the pre and post-visit surveys. Both the residents and tourists chose fewer tangible words, but more intangible words in the post-visit Survey (Table 4.2). Intangible words, were used in the survey to identify a sense of place attachment/sense of place. While the residents chose more intangible words in the post-visit survey (this indicates they have more place attachment toward the park), the tourists do have a greater increase in the percentage of intangible words chosen (6.23% increase from the Pre to the Post-visit survey). Tourists had an *increased* sense of place attachment after their visit to the park.

Table 4.3 Difference in Place Attachment Chi Square Results, Comparing Tourists and Residents Intangible Word Choices in the pre and post-visit survey.

	Chi Square Results (significance $p<.05$)
Pre-Visit Survey	p= .01
Post-Visit Survey	p=.02

To compare the statistical difference between the residents and tourists and their word choice responses, Chi square statistics were performed on the word choice results (Table 4.3). The amount of tangible, intangible, and negative words chosen by the tourists and residents in the pre-visit survey is not statistically significantly different (p=.01). The difference between Residents and Tourists choice of tangible, intangible, and negative words in the post-visit survey was also not statistically significantly different (p=.02). There is not a statically significant difference between the words chosen by the residents and tourists in either survey.

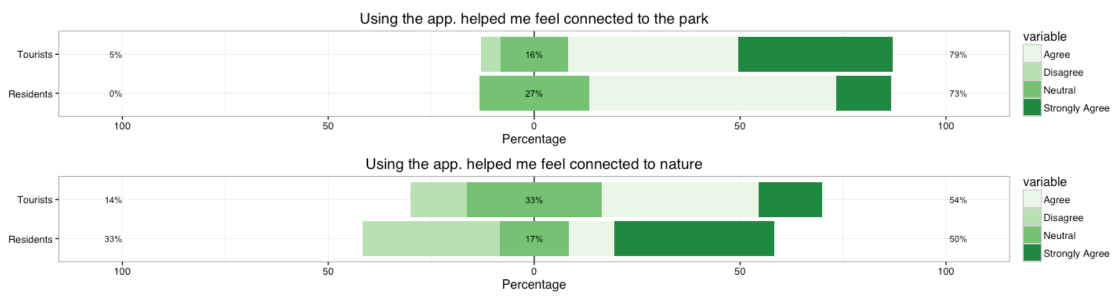

Figure 4.11 Likert Scale Responses, n=119

In addition to analyzing the results of the word choice questions, the results from four of the Likert scale questions asked in the post-visit survey were also used to assess place attachment of the volunteers (Figure 4.11). The first two questions ask if the citizen science program helped the volunteers feel more connected to park, or nature. While both residents and tourists agreed, or strongly agreed, that the mobile application helped them feel connected to the park, tourists chose “strongly agree” more than residents. Residents also agreed less with the statements about the project helping them feel connected to nature, 31.2% of residents disagreed with this statement, this is a 21.74% difference between the two groups. The results from these two questions show that while the volunteers felt the application helped them feel connected to the park, they did not feel as strongly that the application helped them feel connected to nature.

Table 4.4 Chi Square Results from Park and Nature Likert Scale Questions, Comparing Tourist and Resident Reponses, n=128

	Chi Square Results (significance p<.05)
Connectedness to the park	p=.2
Connectedness to nature	p=.08

There is not a significant difference (p=.20) in the resident and tourist responses to the questions regarding the program increasing their connection to the park (Table 4.4). There is a significant difference (p=.08), however, in the questions regarding the program and the volunteer's connectedness to nature. The tourists agreed with this statement more than residents. There is a distinction between the definition of park and nature that should be examined.

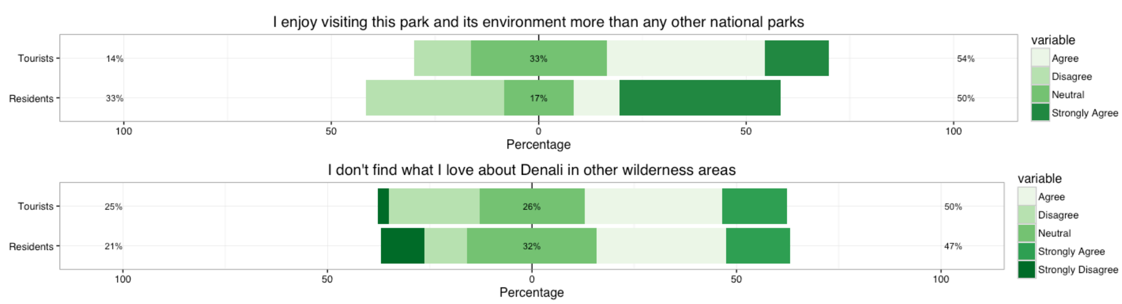

Figure 4.12 Additional Likert Scale Place Attachment Responses, n=128.

The next two Likert scale questions from the post-visit survey ask volunteers if they feel Denali NP&P is unique or has special meaning for them. Tourists more strongly agreed with the first statement, "I enjoy visiting this park more than any other national parks" more than the Resident volunteers. Additionally, residents disagreed with this statement more than tourists (Figure 4.12). The second question, "I don't find what I love about Denali in other wilderness areas" shows little difference between the residents and tourists responses. Both groups mostly agreed, or were neutral, on this statement.

Table 4.5 Chi Square Results from Enjoyment of the Park Likert Questions, n=128

	Chi Square Results (significance p<.05)
Enjoyment of visit Denali more than other parks	p=.38
Don't find in other parks what I enjoy about Denali	p=.58

The two groups responses to the questions regarding their enjoyment of their visit to Denali more than other park, were not statistically significantly different (p-value = 0.38) (Table 4.5). The responses to the question "I don't find in other parks what I enjoy about Denali" were also not statistically significantly different (p-value = 0.57).

4.3.3 Education

A major objective of this citizen science program and many others, is to deliver a positive educational experience for the volunteers. The first research question asks if there are differences in the educational outcomes of the program between the resident and tourist volunteers. Analysis of the quiz section of the surveys, and responses to the Likert Scale questions in the post-visit survey, were designed to address this portion of the first research question. The quizzes were scored and raw scores were turned into percentages. The quiz questions consisted of basic wildlife knowledge, wildlife safety, basic ecosystem knowledge, and conservation and climate change questions. Two hypotheses were created to address this portion of the research question

1.Residents will have a greater pre-visit knowledge of the park.

2.Tourists will have a greater increase in knowledge of the park

As shown in Table 4.5 the residents did have greater pre-visit knowledge, as determined by their quiz score in the pre-visit survey quiz. As expected the tourists exhibited a greater increase in knowledge of the park, using the difference between the pre-visit survey quiz and the respective post-visit survey quiz scores. In order to examine if this increased knowledge was a result of participating in the program and using the mobile application, volunteers were also asked if they felt the application enhanced their educational experience.

Table 4.6 Differences in Quiz Scores n=136.

Quiz	Residents	Tourists	Difference
Pre-Visit Survey	89.79%	59.84%	30.25%
Post-Visit Survey	92.51%	77.37%	15.14%
Difference	2.72%	17.82%	

The quiz sections of the pre and post-visit surveys were analyzed to determine if there are differences in the educational outcomes between the resident and tourist volunteers. The quizzes were scored for each volunteer then scores were averaged for each group, residents and tourists. Table 4.6 shows the average scores from the pre and post-visit survey quizzes and the differences between the two groups. The Residents had higher scores for both the quizzes.

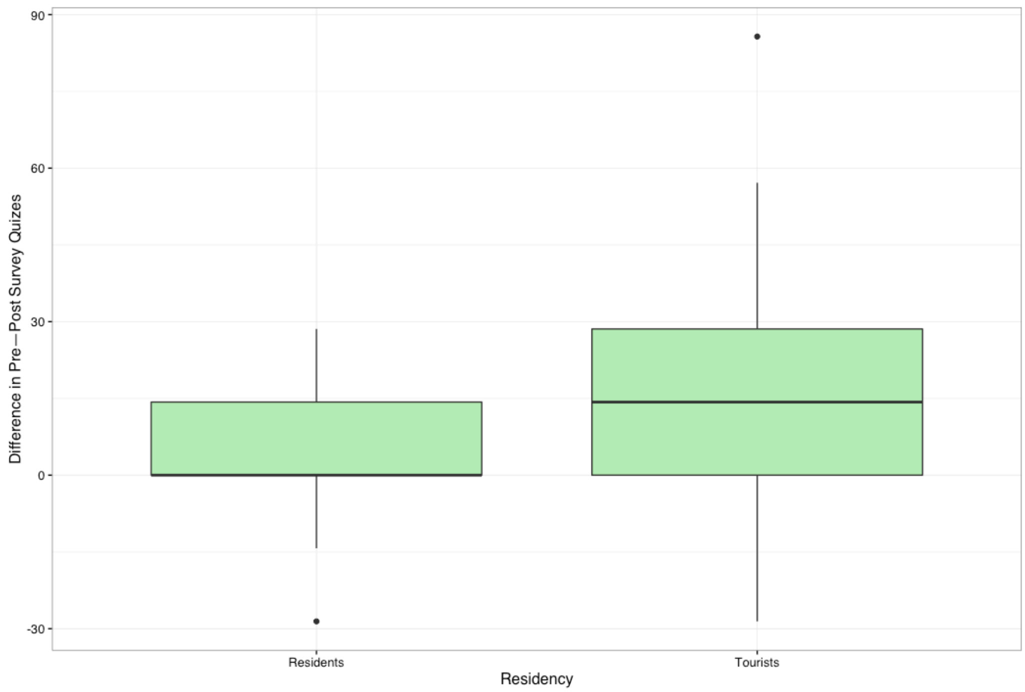

Figure 4.13 Difference in quiz scores, n=136, 22 tourists, 118 residents.

Although the residents had higher pre and post-visit survey quiz scores overall, tourists have a greater difference (improvement) between their quiz scores, showing a 17.82% increase (Figure 4.13). The average difference between the residents scores in the pre and post-visit survey quizzes is essentially zero, since many of the residents did quite well on the first quiz (52% of the residents scored 100% on the first quiz). A few of the volunteers' quiz scores decreased from the pre-visit survey quiz to the post-visit survey quiz.

Table 4.7 Statistical Analysis of Pre and Post-Visit quiz score differences

	Wilcoxon Test p- value (significance p<.05)	Effect Size
Residents Pre and Post-Visit Quiz Scores	p= .41	-0.17
Tourist Pre and Post-Visit Quiz Scores	p < .00001	-0.62

There is not a significant difference between the Residents Pre and Post-visit quiz scores (p=.4441) but there is a statistically significant difference between the tourists pre and post-visit quiz scores (p-value = 3.219e-11) (Table 4.7). Measuring the effect size with Cohen Criteria benchmark of 0.5, shows there is not a major difference between pre and post-visit quizzes scores for residents but a larger positive difference between tourist pre and post-visit quiz scores.

Table 4.8 Statistical analysis of difference between residents and tourists in each survey quiz

	Wilcoxon Test (significance $p<.05$)	Effect Size
Pre-Visit Scores and Residency	P < .00001	0.44
Post-Visit Scores and Residency	P < .00001	-0.34

Looking at the difference between pre- visit survey quiz scores and residency status, there is a significant difference between pre-visit survey quiz and residency (Table 4.8). The same result is found with the post-visit survey quiz. However, the residuals from the Wilcoxon test show a larger effect size with the pre-visit survey quizzes, which means there is a bigger effect of residency status on quiz scores in the pre-visit survey quiz.

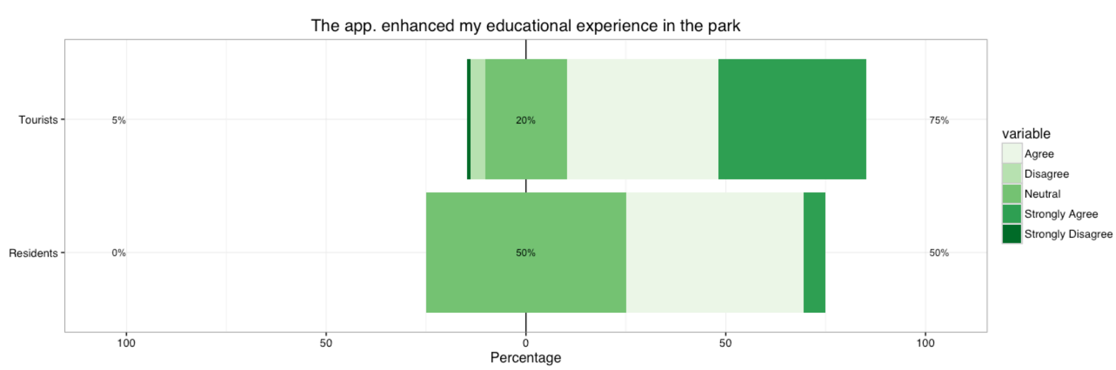

Figure 4.14 Likert Scale response, using "the application enhanced my educational experience in the park", n=126.

The volunteer's gain in knowledge can be attributed to many factors, not just the use of the application and involvement in the citizen science program. Visitors interact with Park Rangers, Bus Drivers, and Guides in the park. Additionally, they are exposed to interpretive signs and exhibits. To get a sense of how much participating in the citizen science program influenced the volunteers increase in knowledge, in the post-visit survey they were asked to rate how much they felt the application enhanced their educational experience in the park. Volunteers showed differences in their feelings toward the program's influence on their educational experience. There is a 32% difference between tourists and residents who said they strongly agreed with the statement (Figure 4.14). Tourists felt more strongly that the program enhanced educational experience in park, only 0.83% of the tourists strongly disagreed that the application enhanced their educational experience. While no residents disagreed with the statement, many of them felt neutral, or agreed with this statement. There was no significant difference in the responses to this question between the two volunteer groups ($p=.01$).

4.4 Research Question 2 Results

The second research question aims to examine how a data fitness for use assessment can be used to measure data quality and utility in citizen science. The STAAq (Spatial Scale, Temporal Scale, Aptness, and Application) assessment was developed to measure data quality of the VGI gathered through the Map of Life-Denali application. The STAAq assessment for DFFU consists of four components of spatial data quality: Spatial Scale, Temporal Scale, Aptness, and Application. The VGI is compared with two other authoritative datasets, ROAR, and NPS data detailed in Chapter 3. This assessment determines which dataset is fit for use in two example research questions. These example research questions are stated below. These are examples of potential research questions; however, I do not aim to answer these research questions, but instead aim to determine which data are best relative to the particular research question.

1. How does the spatial range of Grizzly Bears in Denali National Park and Preserve vary in recent summer seasons?
2. What is the spatial range of the Denali Caribou Herd's migration within the park?

These example research questions are addressed separately using species observation data from the three sources discussed in the last chapter. Each of the example research questions required a different spatial and temporal scale, and different needs for aptness (Table 4.9). The application component is addressed for both questions with species distribution modeling (SDM), however the environmental variables used in the SDMs are different for each question.

Table 4.9 Example Research Questions Data Quality Requirements

Desired Data Quality	Spatial Scale	Temporal Scale	Aptness	Application
Grizzly bear	Data must cover the national park area and have a high quality of spatial resolution	Must cover the last five years, with data collected frequently during the summer	Must be in agreement with the other datasets	Must perform well in Species Distribution Modeling of summer bear distribution in Denali
Caribou	Data must cover the national park area, does not need a high resolution.	Must cover at least 10 years with data collected year around.	Must be unique	Must perform well in Species Distribution Modeling of year around Caribou habitat in Denali

The three (q=3) datasets are ranked based on performance of each of the four components (Spatial Scale, Temporal Scale, Aptness, and Application) and elements of those components. The rankings from each element are averaged together to create the final rank for the component, then finally the ranks from the components are averaged and ranked to create a final overall ranking. A ranking of 1 is best.

A unique aspect of the STAAq assessment is the ability to assess data fitness with little to no metadata, or additional datasets to compare the VGI to. For the two example research questions "authoritative" data are used to compare the Map of Life-Denali VGI. Metadata are missing or limited for the ROAR data and the MOL data.

4.4.1 STAAq Assessment

The STAAq assessment is used to determine which of the three datasets: MOL-Denali, ROAR, or NPS data are best fit to be used to address two example research questions. Before the assessment is tested the desired outcomes for each element and component were determined. This allows the datasets to be ranked based on how well they meet these desired outcomes.

For the first example research question the desired spatial scale is a spatial extent which covers the entire park area, and a high spatial resolution to examine distributions near areas frequented by humans. The desired temporal scale of these data is data which is collected daily during the summer (June – September) for the last 5 years. For the aptness assessment, since these data are being used for modeling a specific time frame, and a more recent smaller spatial extent, these data should not be unique, so the error of omission is preferred. For the application assessment, these data are used in SDMs, environmental variables include: summer precipitation, temperature, slope, elevation, and land cover. The dataset with the highest AUC (area under the curve) statistic is given the highest rank.

Ultimately the ROAR dataset was determined to be the most "fit for use" to address this example research question regarding summertime Grizzly Bear distribution in the park. The next sections detail the four components of the STAAq assessment, and how the datasets performed with each component.

For the second example research question, regarding Caribou distribution, winter habitat and summer habitat spans different ecosystems within the park boundary, so this model wants to capture this distribution throughout the year. Thus, data which covers a large time span is needed, but does not need to be collected frequently, it should cover most of the park, but does not need to be high resolution. The most fit dataset should be unique, preference for the error of commission, and the most fit dataset should perform well in the species distribution model.

4.4.1.1 Spatial Scale

The spatial scale component of the STAAq assessment examines the spatial scale of each dataset through spatial extent and spatial resolution. The datasets were ranked in each element, then the overall ranking for the spatial components was determined by averaging the rankings of the datasets in each element.

4.4.1.1.1 Spatial Extent

Spatial extent refers to the spatial area covered by these datasets. The first example research question (EQ1) asks about Grizzly bear distribution in Denali National

Park and Preserve, thus the desired spatial extent is the park boundary. Datasets whose extent covers more of the park area are given a rank of 1.

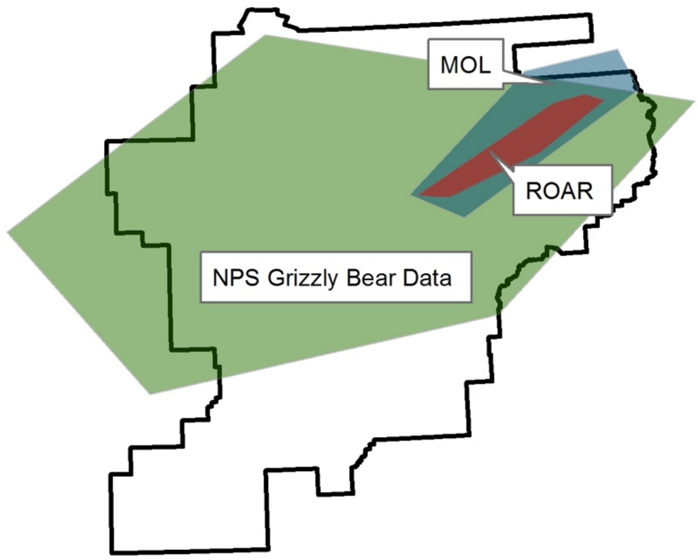

Figure 4.15 Spatial Extent EQ1, Convex Hull for each dataset (the black outline represents the Denali Park boundary).

Figure 4.15 shows the extent of each datasets for EQ1. The extent was determined by calculating the convex hull around the set of data points. To determine which datasets more closely matched the desired extent, the percentage of area of the dataset that falls within the park boundary was calculated (Table 4.10).

Table 4.10 Spatial Extent EQ1, Percentage of desired extent covered and rankings

Data set	Extent Coverage	Rank (1 is best)
MOL	7.8%	2
ROAR	2.8%	3
NPS	67.3%	1

The NPS Grizzly Bear dataset covers 67.3% of the park area, and thus received a rank of 1 (Table 4.10). The MOL received a rank of 2, and the ROAR data third because these data extent covered the least amount of the park. The extent which covers the park area the most is preferred in this case, because the example research question addresses Grizzly bear distribution in the entire national park.

The second example research question (EQ2) asks about Caribou distribution in Denali National Park and Preserve, thus the desired spatial extent is the park boundary. Datasets whose extent covers more of the park area are given a rank of 1.

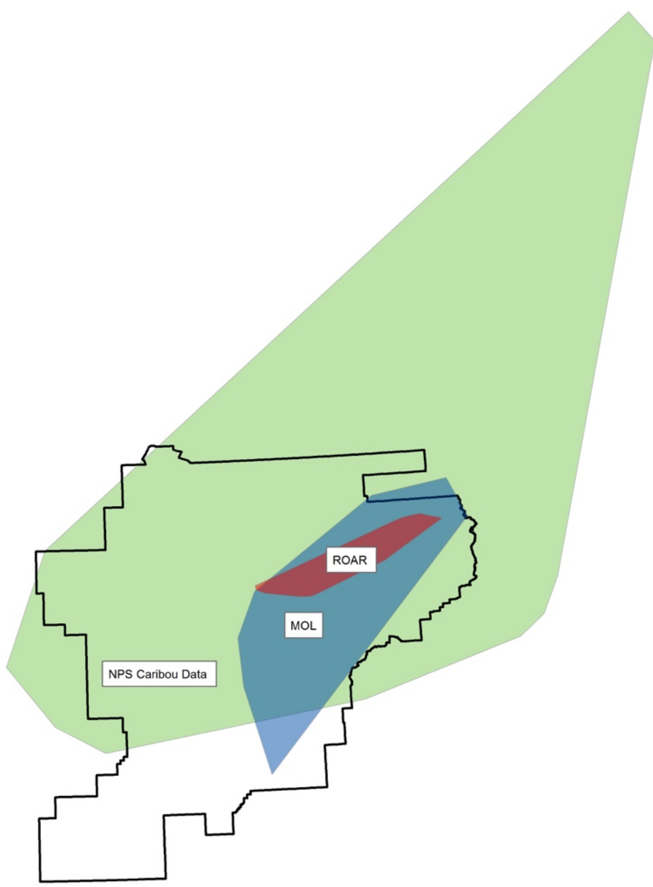

Figure 4.16 Spatial Extent of the three Caribou datasets, EQ2

Figure 4.16 shows the extent of each caribou dataset. The extent was determined by calculating the convex hull around the set of data points. To determine which datasets more closely matched the desired extent: the percentage of area of the dataset that falls within the park boundary, was calculated (Table 4.11).

Table 4.11 Spatial Extent Rankings, EQ2

Dataset	Extent	Rank
MOL	24.9%	2
ROAR	4.46%	3
NPS	76.7%	1

The NPS Caribou datasets covers 76.7% of the park, and thus received a rank of 1 (Table 4.11). The MOL data was ranked second, and the ROAR data was ranked third because this dataset covered the least amount of park area. The extent which covers the park area the most is preferred in this case because the example research question addresses Caribou distribution in the entire national park.

4.4.1.1.2 Spatial Resolution

Spatial resolution is the second element of the spatial components of the STAAq assessment and refers to the resolution at which the data were collected. For the first example research question, the desired spatial resolution is high, in the case of species observation point data, and points which were collected with less spatial error are considered high resolution. Since this question addresses bear distribution in a short time frame, during the summer season (high visitation time), a high spatial resolution is desired to examine if Grizzly bear distribution occurs in areas of human activity.

Spatial resolution can be determined by the method of data collection. The NPS dataset was collected with radio collars, and these collars average <5 meters of error. The ROAR data were collected by paid observers on a shuttle bus and these observers only recorded species within 50 meters of the park road, so their GPS point may be 50 meters away from the actual location of the animal. The MOL data was collected in a similar manner, but volunteers (who were either hiking, or on the bus) recorded observations that could be up to 1,000meters away (i.e., looking at Grizzly Bears through binoculars).

Table 4.12 Spatial Resolution Rankings, EQ1

Data set	Resolution	Rank
MOL	<=100-1000m (Cell phone GPS)	3
ROAR	<=50m (Cell tablet GPS)	2
NPS	<5m (Radio Collar)	1

Table 4.12 shows the spatial resolution of each dataset for the first example research question (EQ1), and the final ranking for the spatial resolution element. The NPS dataset received a rank of one for the spatial resolution element, because these data were collected at high resolution, with less error. This is largely due to these data collection method, radio collars are placed on the bears, whereas the other two datasets were collected through GPS locations on tablets, or smartphones.

For the second example research question (EQ2), the desired spatial resolution is high, in the case of species observation point data, since points which were collected with less spatial error are considered high resolution. To address this example research question spatial resolution does not need to be high, thus the spatial resolution for these datasets can be coarse. Any dataset that has a resolution, less than or equal to 50 meters, is considered fit for use, and given a rank of 1.

Table 4.13 Spatial Resolution Rankings, EQ2

Data set	Resolution	Rank
MOL	<=100-1000m (Cell phone GPS)	3
ROAR	<=50m (Cell tablet GPS)	1
NPS	<5m (Radio Collar)	1

Table 4.13 shows the spatial resolution of each of the datasets for the second example research question and the ranking of the datasets for this component. Both the ROAR and NPS datasets have a rank of 1 because they meet or exceed the desired spatial resolution. The MOL data are the coarsest collected at a resolution of 100-1000 meters, this dataset has a rank of 3.

Table 4.14 Spatial Component Rankings, EQ1

	Rank
MOL	2
ROAR	2
NPS	1

The rankings from each spatial element were averaged to create this final ranking for the spatial components for the first example research question, EQ1. These elements could be weighted, if desired. For the desired spatial resolution, the NPS is ranked 1, and the ROAR and MOL data are tied with the ranking of 2 (Table 4.14).

Table 4.15 Combined Spatial Scale Ranking, EQ2

	Rank
MOL	2
ROAR	2
NPS	1

The rankings from the two spatial elements are averaged, then ranked, to create a composite spatial scale ranking for the second example research question, EQ2. The NPS data are ranked 1 and the MOL and ROAR data are tied for second (Table 4.15). The NPS is the dataset with the closest extent to the desired extent, and the NPS data was tied with the ROAR data for the necessary spatial resolution.

4.4.1.2 Temporal Scale

Each dataset included temporal information for each observation, for the NPS dataset month and year was recorded. For the ROAR and MOL datasets month, day, year, and time of day was recorded. The NPS data also contained temporal information in the metadata. Depending on the dataset, however, each of the elements for the temporal scale component may be evaluated without metadata. The temporal component includes three elements: Event, Resolution, and Extent. The performance of each of the datasets in each of the elements is detailed below.

4.4.1.2.1 Event

Event refers to when the data were collected. The desired time of events for the first example research question is recent (last 5 years) collected during the Summer. Thus, the dataset, which was collected more recently and contains data collected during the Summer, is given a rank of 1.

Table 4.16 Temporal Event Rankings, EQ1

	Event	Rank
MOL	Summer 2016	1
ROAR	Summer 2016	1
NPS	Year around except denning time, Most recently 2009	3

The MOL and ROAR received a ranking of 1 for the temporal event element because both were recently collected and collected during the summer time (Table 4.16). The NPS data was also collected during the summer but not within the last 5 years so this dataset received a rank of 3.

Since the second example research question examines the distribution of Caribou throughout the year the desired event for these data is year-round data collection, the recentness of these data are not as important as the year-round coverage.

Table 4.17 Temporal Event Rankings, EQ2

All Data	Event	Rank
MOL	Summer 2016	2
ROAR	Summer 2016	2
NPS	Year-round most recent 2009	1

The NPS data were collected year around and are ranked 1 (Table 4.17). The MOL and ROAR data are only collected during the Summer months (June-September). Winter and Summer Caribou habitat can vary and thus it is important that the dataset covers more than one season to address this particular research question.

4.4.1.2.2 Temporal Resolution

Temporal resolution refers to the frequency of data collection. The desired temporal resolution for the first example research question is almost daily collection of data. This is influenced by the desired temporal event, because the question addresses Grizzly Bear distribution during only during the summer. Frequent data collection is necessary to get an accurate distribution of these data during this short time frame.

Table 4.18 Temporal Resolution Rankings, EQ1

	Resolution	Rank
MOL	Almost Daily (with multiple observations made on a collection day)	1
ROAR	Almost Daily (with multiple observations made on a collection day)	1
NPS	Twice a month	3

The MOL and ROAR datasets both received a ranking of 1 because the data were collected almost daily (and multiple observation were made on collection days) (Table 4.18). Since the NPS data were collected with radio collars, the location of the bear was only collected twice a month, thus this dataset received a ranking of 3.

To address the second example research question the Caribou data does not need to be collected frequently, so less frequently collected data are acceptable, or adequate for this research question. At least once a month is desired.

Table 4.19 Temporal Resolution Ranking, EQ2

All Data	Resolution	Rank (1-3)
MOL	Almost Daily	1
ROAR	Almost Daily	1
NPS	Twice a month	1

The NPS data were collected twice a month from radio collars on selected number of Caribou. The MOL and ROAR data are collected almost daily. Each dataset is ranked because all are collect at least once a month (Table 4.19).

4.4.1.2.3 Temporal Extent

Temporal extent refers to the length of time the data were collected. The desired temporal extent for the first example research question is around 5 years, so using data collected over multiple years provides a more averaged depiction of Grizzly bear distributions, and quiet bias from year to year. Datasets collected over multiple years received higher rankings.

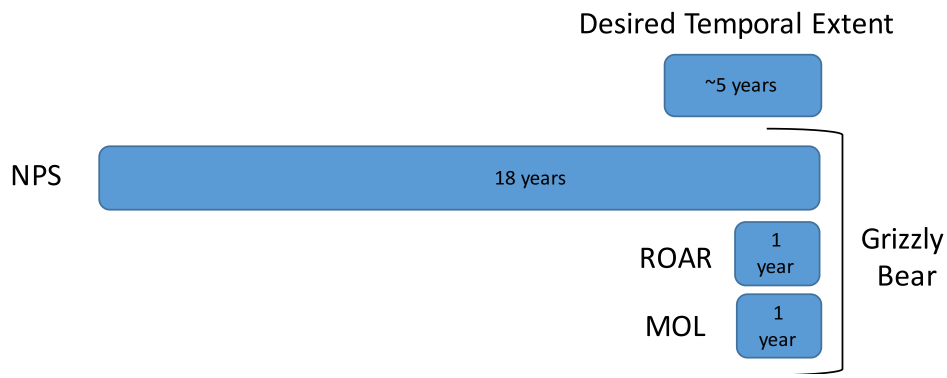

Figure 4.17 Temporal Extent of the three Grizzly bear datasets, EQ1

Table 4.20 Temporal Extent Rankings, EQ1

	Extent	Rank
MOL	1 year	2
ROAR	1 year	2
NPS	18 years	1

The NPS data has the largest temporal extent and therefore received a rank of 1 (Figure 4.17 and Table 4.20). The MOL and ROAR datasets only contain one summer season of data and therefore are tied at a rank of 2.

The desired temporal extent for the second example research question is 10, or more, years of data. Since the example research question asks to examine the historical winter and summer distribution of Caribou, it is important to have a temporal extent which covers multiple years.

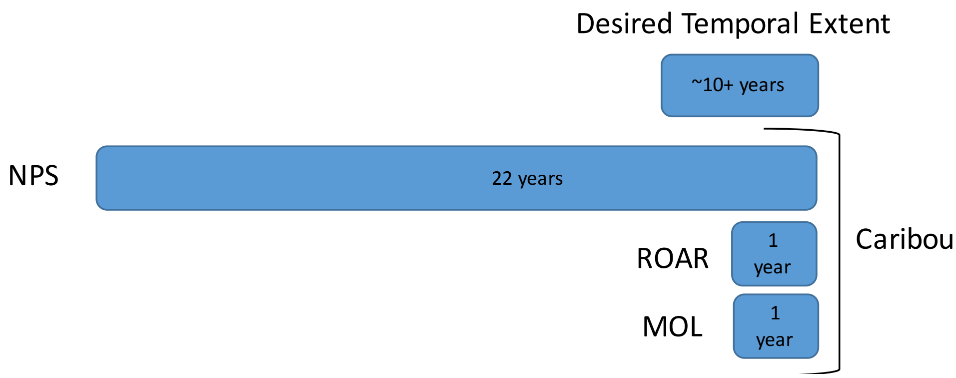

Figure 4.18 Temporal Extent of the three caribou datasets, EQ2

Table 4.21 Temporal Extent Ranking, EQ2

	Extent	Rank (1-3)
MOL	1 year	2
ROAR	1 year	2
NPS	22 years	1

The NPS dataset has the largest temporal extent, and therefore is ranked 1 (Figure 4.18, and Table 4.21). The MOL and ROAR datasets only contain one summer season of data and therefore are tied with a rank of 2.

Table 4.22 Temporal Component Rankings, EQ1

	Rank
MOL	1
ROAR	1
NPS	3

For the first example research questions, EQ1, the rankings for each dataset for the temporal elements were averaged then ranked to create the final Temporal scale rankings. The MOL and ROAR datasets are tied at a rank of 1, while these datasets did not match the desired temporal extent, they did match the desired temporal events, and temporal resolution (Table 4.22).

Table 4.23 Temporal Scale Ranking, EQ2

	Rank
MOL	2
ROAR	2
NPS	1

For the second example research question, EQ2, the rankings for each dataset for the temporal elements were averaged then ranked to create the final Temporal scale rankings. The NPS dataset is ranked 1 and the MOL and ROAR datasets are tied at a rank of 2 (Table 4.23). The NPS data matched the desired temporal scale components: temporal events, temporal resolution, and temporal extent.

4.4.1.3 Aptness

The aptness component assesses the uniqueness of the datasets, and is the only component in which two, or more datasets are needed. In some cases, error of commission (uniqueness) is preferred (this is when the datasets include data that is not in other datasets), thus the user prefers to take the risk that false data may be included in the datasets (the dataset has data that may not actually exist). In other cases, the error of omission is preferred (the dataset is not unique), but this dataset might be leaving out data that may actually exist.

For the first example research question the error of omission is preferred, meaning the dataset that is least unique receives a rank of 1. Agreement (not uniqueness) is preferred for this example research question because the desired temporal and spatial extent is detailed. Raster layers were created for each of the point datasets based on the number of observations in each cell (1000m x 1000m).

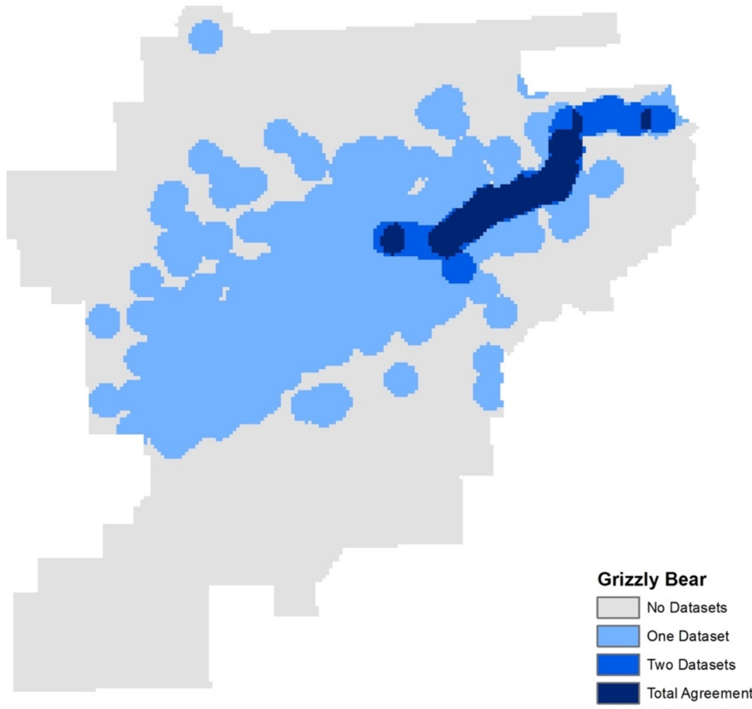

Figure 4.19 Agreement of Q datasets, EQ1

Figure 4.20 Agreement of Q datasets, Grey areas are where no datasets have data, blue are areas of agreement, red areas are unique, EQ1

Table 4.24 Agreement Component Rankings, EQ1

	Uniqueness	Total Agreement	Rank for Aptness
MOL	7.5%	59.8%	2
ROAR	0.804%	64.62%	1
NPS	88.9%	7.495%	3

The ROAR data are almost in total agreement with the other two datasets, meaning that much of these data in the ROAR dataset is also reflected in the other two datasets (Figures 4.19 and 4.20, and Table 4.24). Since the error of omission is preferred in this example research question the ROAR dataset is given a rank of 1.

For the second example research question, the error of commission, uniqueness, is preferred. This is because the example research question examines Caribou distribution for a vast spatial and temporal scale.

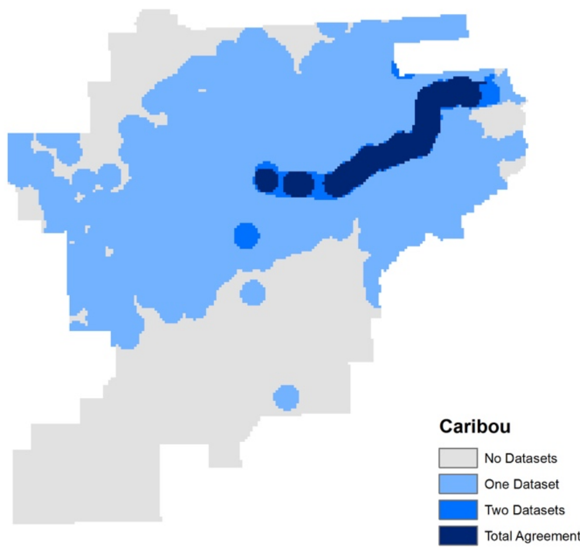

Figure 4.21 Agreement of the datasets, the grey is area with no data, the darkest blue represents area where all three datasets agree. Area of total agreement is 987km², EQ2

a. MOL b. ROAR c. NPS

Figure 4.22 Uniqueness of the datasets, a. MOL, b. ROAR, and c. NPS. Gray areas represent no data, blue areas indicate that the datasets agree, red is areas of uniqueness, EQ2

Table 4.25 Rankings for Agreement Component, EQ2

	Uniqueness	Agreement	Rank
ROAR	0.41%	82.31%	3
MOL	16.475%	69.21%	2
NPS	90.9%	6.98%	1

The NPS data are most unique of the datasets, meaning that much of the data reflected in the NPS dataset is not in the other two datasets. Since the error of commission, uniqueness, is preferred in this example research question the NPS dataset is given a rank of 1 (Figure 4.21 and 4.22, and Table 4.25).

4.4.1.4 Application

For the first example research question, there is only one element for the application component: the performance of these datasets in species distribution models (SDM). The species distribution models were created with the software package Maxent. These models use species occurrence data with environmental variables to predict the distribution of a particular species. The same environmental variables were used for each model–slope, elevation, land cover, and summer precipitation, and temperature. The model outputs include an analysis of variable contributions, which provides an estimate of how much each environmental variable contributed to the model. In order to better understand the model performance, the contribution of the environmental variables are examined, however, the final ranking for the application component is based on the AUC (area under the curve) statistic, which is another output of the Maxent package. The AUC closest to 1 is given the highest rank (1).

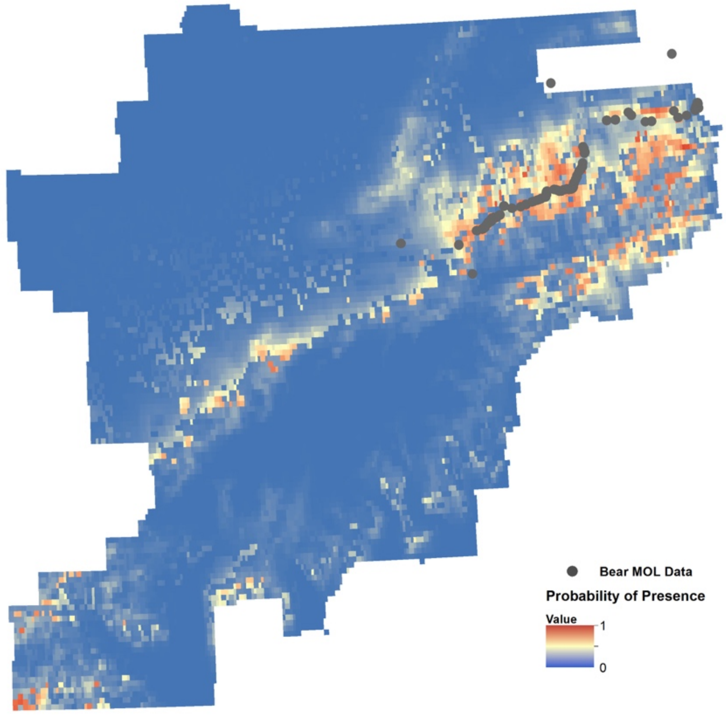

Figure 4.23 SDM made with MOL Grizzly Bear data

The SDM created with the MOL dataset is depicted in Figure 4.23. This model had an AUC of 0.950. The resulting map show areas which have more probability of the presence of Grizzly bears (warmer colors) and areas with low probability of presence (cold colors). The area to the north east of the park (where many of the observation points were collected) has many areas of high probability of occurrence, since these areas are of known bear habitat. The large blue area in the middle of the park is the location of the Alaska Range and Denali, we do not expect to find bears at 20,000 feet elevation. The elevation and land cover variables contributed most to the model. The slope variable contributed the least to the model.

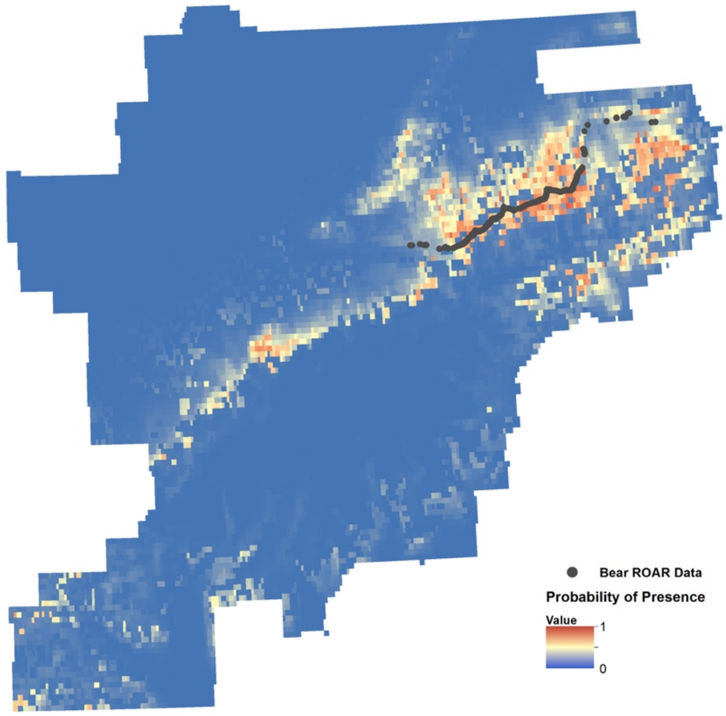

Figure 4.24 SDM made with ROAR Grizzly Bear data

The SDM output using the ROAR data are similar the MOL data, since both datasets were collected on and around the park road area (Figure 4.24). Like the MOL model, elevation and land cover contributed more than the other environmental variables in the model. Slope and summer precipitation contributed the least to the model. Similarly, to the MOL model, the areas of red are reflective of known bear habitat areas in the park. This model did outperform the MOL model by a small margin (AUC= 0.963).

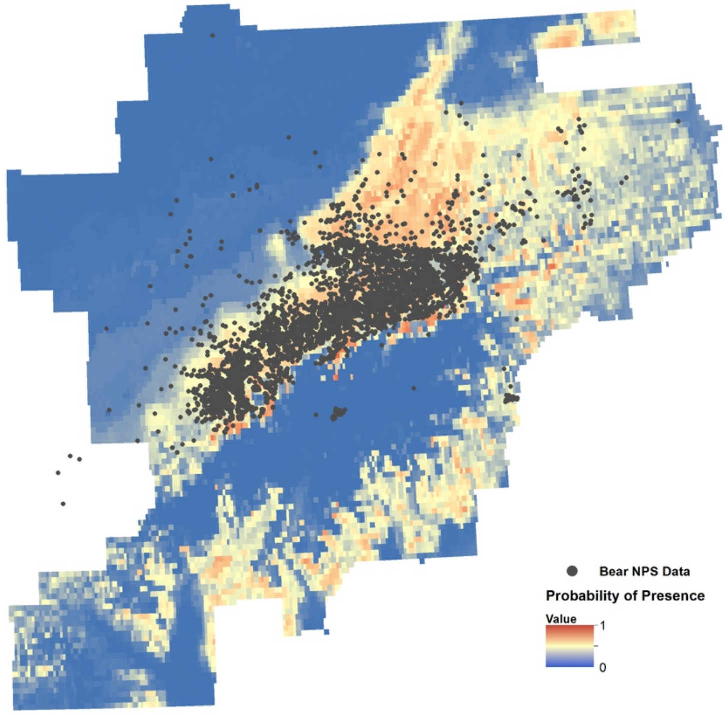

Figure 4.25 SDM made with NPS Grizzly Bear data

The SDM model using the NPS dataset performed worse than the other two models (AUC = 0.847) (Figure 4.25). The Summer precipitation and land cover variables contributed the most to the model. Slope contributed the least to the model.

Table 4.26 Application Component Ranking

Bear	AUC	Rank
MOL	.950	2
ROAR	.963	1
NPS	.847	3

The ROAR dataset had the highest AUC, and received a rank of 1 (Table 4.26). For the NPS model, the land cover variable contributed the most to the model, while slope contributed the least, like in the other two models, however one of the most important variables was summer precipitation in the NPS model, which contributed the least in the ROAR model. The differences in variable contributions may be caused by the spatial extent of the datasets, since the MOL and ROAR data are clusters around the park road, the model may be relying on variation in each of the environmental variables in that area. Land cover is an important factor for Grizzly Bear habitat, since bears generally prefer open tundra and are not often found lingering in dense boreal forest areas.

For the second example research question, exploring Caribou distribution in DNP&P, there is only one element for the application component, the performance of these datasets in species distribution models (SDM). As previously mentioned, the species distribution models were created with the software package Maxent. These models use species occurrence data with environmental variables to predict the distribution of a particular species. The same environmental variables were used for each model–slope, elevation, land cover, summer precipitation and temperature, winter precipitation and temperature, fall precipitation and temperature, and spring precipitation and temperature. The model outputs include an analysis of variable contributions, which provides an estimate into how much each environmental variable contributed to the model. In order to better understand the model performance, the contribution of the environmental variables are examined, however, the final ranking for the application component is based on the AUC (area under the curve) statistic, which is another output of the Maxent package. The AUC closest to 1 is given the highest rank (1).

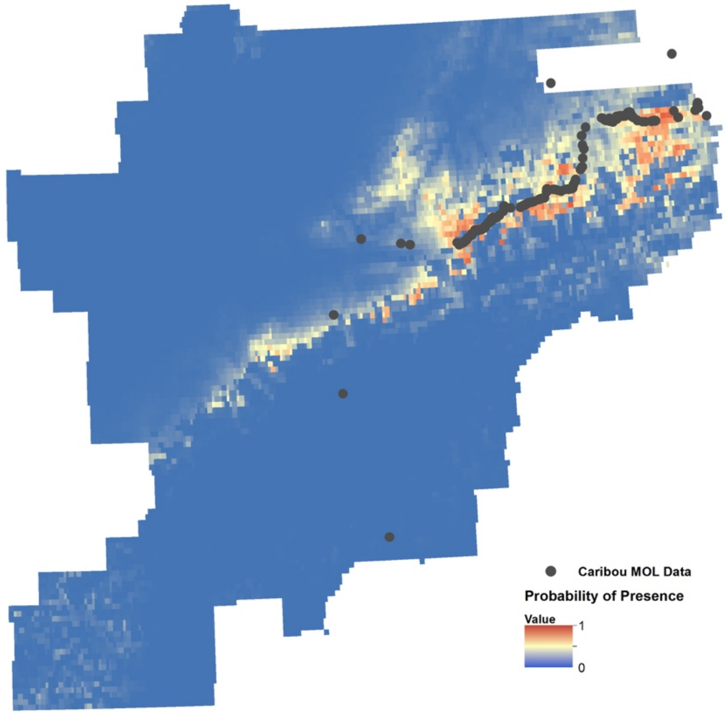

Figure 4.26 SDM made with MOL Caribou data

The SDM created with the MOL is depicted in Figure 4.26. This model had a AUC of 0.961. The resulting map show areas which have more probability of the presence of Caribou (warmer colors) and areas with low probability of presence (cold colors). The area to the north east of the park (where many of the observation points were collected) has many areas of high probability of occurrence, as these areas are of known Caribou habitat. The large blue area in the middle of the park is the location of the Alaska Range and Denali, and we do not expect to find Caribou at 20,000 feet elevation. The elevation and land cover variables contributed most to the model. The summer temperature variable contributed the least to the model.

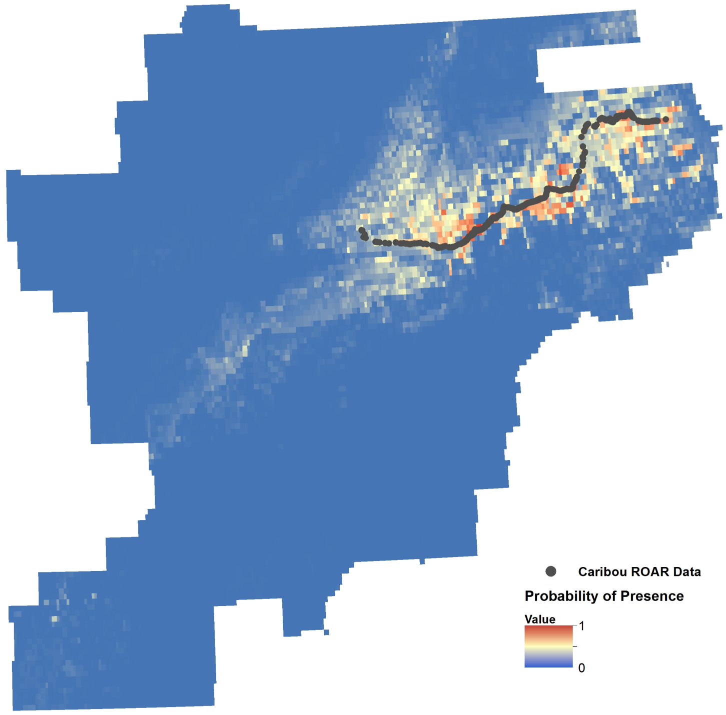

Figure 4.27 SDM created with ROAR Caribou data

The SDM output using the ROAR data is similar the MOL data, since both datasets were collected on and around the park road area. Elevation and fall precipitation contributed more than the other environmental variables in the model. Spring precipitation contributed the least to the model. Similarly, to the MOL model the areas of red are reflective of known Caribou habitat areas in the park (Figure 4.27). This model did outperform the MOL model by a small margin (AUC= 0.979).

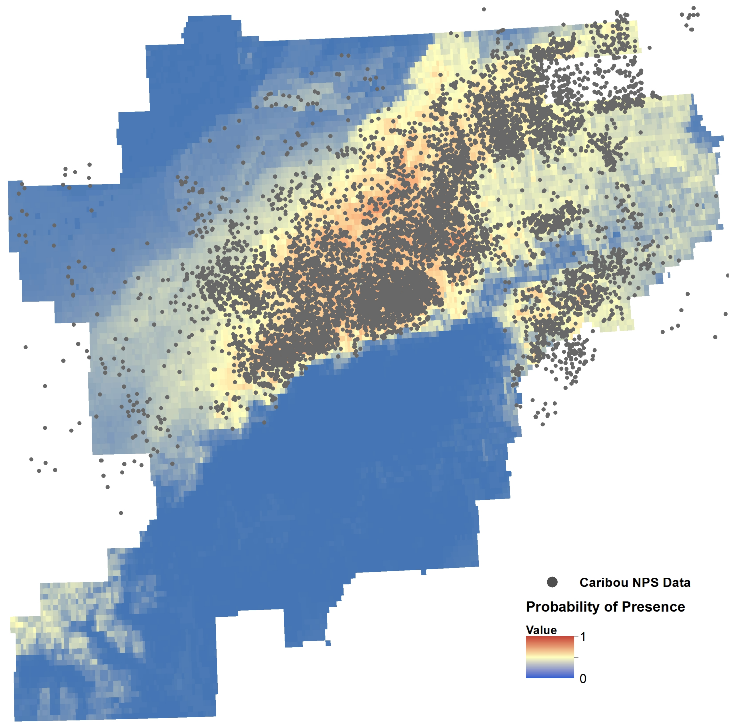

Figure 4.28 SDM created with NPS Caribou data

The SDM model using the NPS dataset performed worse than the other two models (AUC = 0.804). The winter precipitation and fall precipitation variables contributed the most to the model. Winter temperature and slope contributed the least to the model (Figure 4.28).

Table 4.27 Rankings for Application Component, EQ2

Caribou	AUC	Rank
MOL	.961	2
ROAR	.979	1
NPS	.804	3

The species distribution model made with ROAR data had the highest AUC, so this dataset is given a rank of 1. (Table 4.27). Fall precipitation contributed significantly to both the ROAR and the NPS models, and the elevation variable contributed to the MOL and ROAR models. These differences in variable contributions may be caused by the spatial extent of the datasets, since the MOL and ROAR data are clusters around the park road, and the model may be relying on variation in each of the environmental variables in that area.

4.4.1.5 Final STAAq Rankings

For the first example research question, each dataset is assigned a final STAAq ranking, which is the average of the four component rankings. The highest ranking is 1, this indicates the dataset that is the most fit for use.

Table 4.28 Overal Rankings for First Example Research Question

Dataset (Q) Grizzly Bears	S (Spatial)	T (Temporal)	A1 (Aptness)	A2 (Application)	Rank
MOL	2	1	2	2	2
ROAR	2	1	1	1	1
NPS	1	2	3	3	3

In this example case study the ROAR data are ranked 1st in the STAAq assessment (Table 4.28). Thus, the ROAR dataset was the most fit for use in this example research question. The ROAR data do not closely fit the desired spatial scale, since it only covers a small portion of the study area. However, this dataset does fit the temporal scale, was the dataset most in agreement, and had the best performance when used in a SDM.

Table 4.29 Overall Rankings for Second Exmaple Research Question

Dataset (Q) Caribou	S (Spatial)	T (Temporal)	A1 (Aptness)	A2 (Application)	Rank
MOL	2	2	2	2	3
ROAR	1	2	3	1	2
NPS	1	1	1	3	1

For the second example research question, the NPS dataset is ranked 1 and considered most fit for use (Table 4.29). Though it performed the worst in the Species Distribution Model, it fit the spatial and temporal needs of the research problem.

4.3.2 Comparing the STAAq results from the two research questions

This DFFU assessment, STAAq, was designed to test the fitness of data for a specific purpose, and is especially designed for volunteered geographic information. This assessment does not require extensive metadata like other assessments, and can be implemented with only one dataset (the aptness component would not be used in this case). The STAAq assessment was tested in two case studies, with q=3 datasets. The first case study's research question refers to recent Summer Grizzly Bear distribution in Denali. The second case study refers to historical year-round Caribou distribution in Denali. Data for the assessment came from the same sources, Map of Life which is Volunteered Geographic Information, ROAR data collected from trained and paid volunteers, and NPS data collected through various multi-year radio collar and GPS locations. The Map of Life came in second in both example case studies.

4.5 Research Question 3 Results

This section describes the results from the third research question of this dissertation:

> How can the volunteer and scientific outcomes of citizen science be measured, and ultimately integrated into park management and planning?

The aim of the third research question is to measure the outcomes of the Map of Life- Denali citizen science project through an educational and scientific outcomes assessment. The results of the citizen science project and this assessment were presented to park officials to discuss possible integration of the project into park management and planning. Ultimately, the park officials were pleased with the educational outcomes of the Map of Life-Denali program, but were not convinced that the scientific outcomes were successful. The program will be used as part of the interpretive experience in the shuttle busses and tours busses operated by Aramark, and these collected data will be provided to Denali NP&P. However, some park officials are still uncertain how these data can be used in the future.

This section is divided into two sections. The first section is an outcomes assessment, which includes an educational assessment and the scientific assessment. The second section analyses the opinions and feedback from the volunteers, and park officials, to assess how this citizen science can be integrated into park management and planning.

4.5.1 Outcomes Assessments

The methods for the outcome assessment that were presented in Chapter 3 are used to assess the educational and scientific outcomes. Educational and scientific goals were developed through the meetings and focus group interviews with the park service staff. The two outcomes assessments will be discussed in the next two subsections, the educational outcomes assessment, and the scientific outcomes assessment.

4.5.1.1 Educational Outcome Assessment

The outcome assessment and the specific steps of the assessment to measure educational outcomes are depicted in Figure 4.29. The first step in an outcomes assessment was to establish general goals. For this case study the educational goal of the Map of Life-Denali program is for the program and the application to be an effective educational tool, especially as a means to provide wildlife safety information to volunteers. Details on how this goal was developed is presented in the Methods chapter.

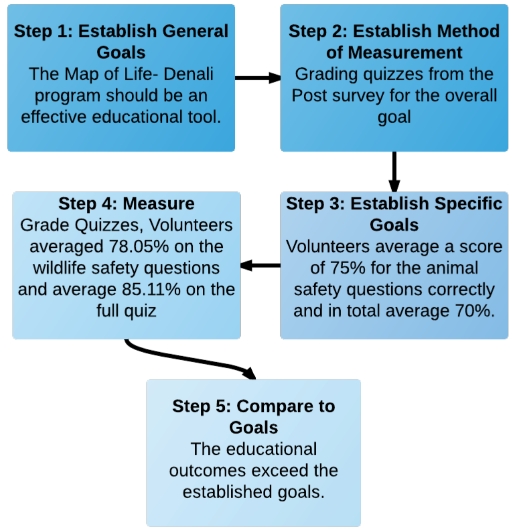

Figure 4.29 Educational Outcome Assessment

The second step in the outcome assessment is to establish method of measurement. The overall performance on the post-survey quiz was used to assess if the application is an effective educational tool. The third step of the assessment is to establish specific goals. For the Map of Life – Denali program to be deemed an effective educational tool, the volunteers should average a >= 75% correct score for the wildlife safety section of the post-visit quiz, and >= 70% correct for the overall post-visit quiz. The fourth step of this assessment is to measure the outcomes. The educational goals are being measured through the scores from the post-visit survey quiz. These steps are discussed in more detail in the methods chapter.

Table 4.30 Post-visit Survey Quiz Results, n=136.

Question type	Tourists	Residents	Average Score for all Volunteers
Wildlife safety	70.5	85.6	78.05
General	77.92	93.6	85.76
Ecosystem and climate	85.46	97.6	91.53
Aggregate Score	77.37	92.51	85.11

The last step in the assessment was to compare the outcomes to the goals. In this case the specific goals of the program were for volunteers to average a 75% correct or better score on the wildlife safety questions, and at least 70% on the overall quiz. These benchmarks were established after initial meetings with park officials. Overall, the volunteers averaged 78.05% on the wildlife safety questions, and 85.11% on the complete post-visit quiz (Table 4.30). Both goals were met. The educational outcomes were positive, and the program is considered an effective educational tool.

4.5.1.2 Scientific Outcomes Assessment

The scientific outcomes assessment and the specific steps are depicted in Figure 4.30. The first step in the outcomes assessment is to establish general goals. For this case study, the general scientific goal is: the volunteered geographic information collected by volunteers, via the mobile application, should be useful for sighting indexes in Denali National Park and Preserve.

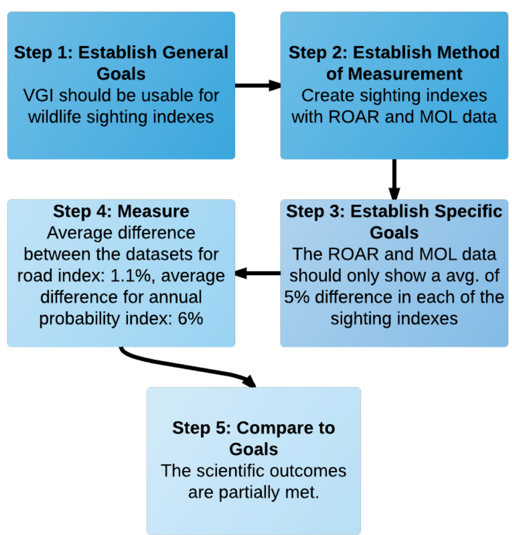

Figure 4.30 Scientific Outcomes Assessment

The second step is to establish a method of measurement. Two different sighting indexes, a road sighting index and annual probability of sighting index are created with the MOL data and with Ride of Observe and Record (ROAR) data (Appendix I). The third step is to establish specific goals. For this case study, the specific goals of the scientific outcomes assessment are that these ROARS and MOL datasets should only show an average of <= 5% difference in each of the indexes. This benchmark was established after initial meetings with park officials. Details regarding these steps, and how they were formulated are found in the Methods chapter.

The fourth step is to measure the specific scientific outcomes. The scientific outcomes of this citizen science program are assessed by comparing the performance of the MOL dataset in two sightings indexes: the road sighting index and the annual probability of sighting index. The results from these comparisons are detailed below.

The differences in the probability of sighting at each mile was calculated, then averaged for each species considered part of the "Big 5" − Caribou, Moose, Grizzly Bear, Dall Sheep, and Wolf. This average difference gives an indication of agreement between the two datasets.

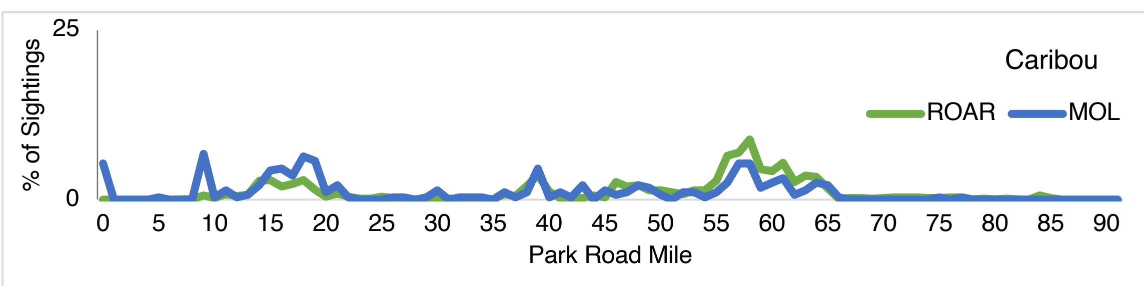

Figure 4.31 Caribou Road Sighting Index, y axis is road miles, and x axis is % of sightings which occurred at that road mile.

The average difference in probability of sighting of caribou per mile is 0.8%. There is a hotspot between mile 15 and 20 for each dataset, and between miles 55 and 60 (Figure 4.31). The MOL data has some unique hotspots, at mile 0 and 10, but the hotspot at mile 0 may be user error.

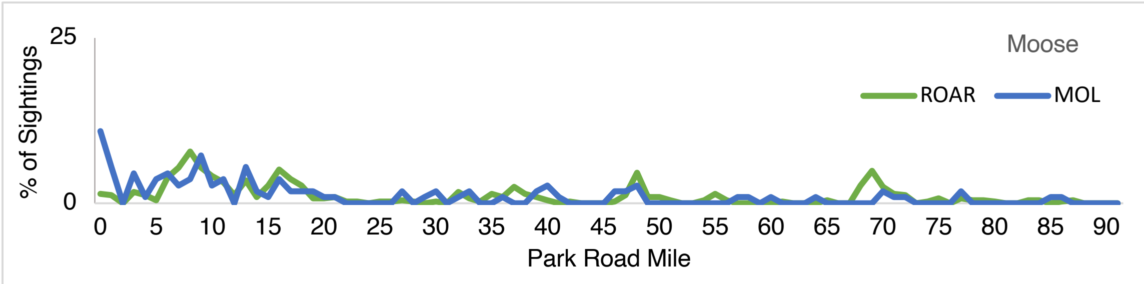

Figure 4.32 Moose Road Sighting Index

The average difference in the probability of moose sightings is 0.96%. The hotspots generally correspond, however the MOL dataset shows a hotspot at mile 0 (Figure 4.32). This can either be user error, or users may be recording wildlife while staying at the Riley Creek campground, or hiking near the park entrance.

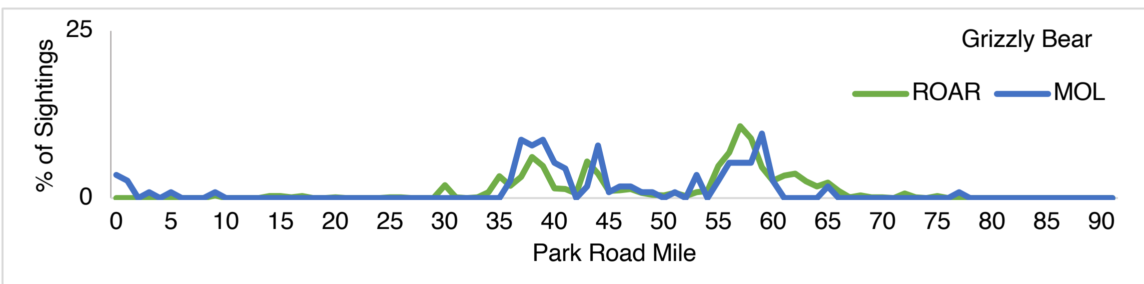

Figure 4.33 Grizzly Bear Road Sighting Index

The average difference in Grizzly Bear sightings is 0.91%. The hotspots (between miles 35-40, 40-45, and 55-60) for each of the datasets correspond (Figure 4.33). These are areas of known bear habitat.

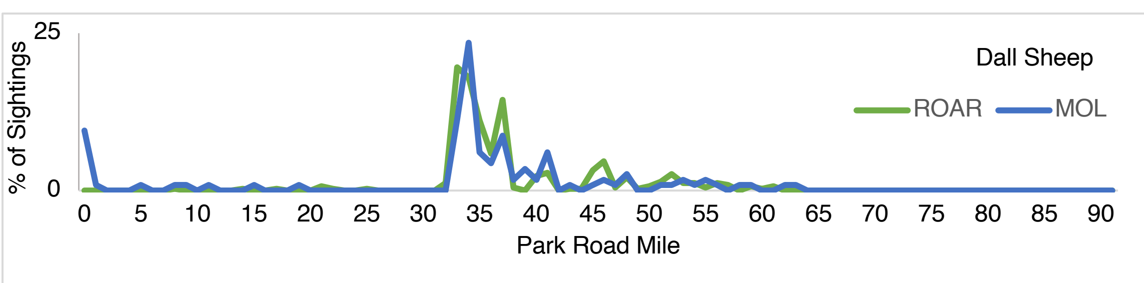

Figure 4.34 Dall Sheep Road Sighting Index

The average difference in Dall Sheep sightings is 0.76%. The major hotspot occurs between mile 30-35, this is a known area of sheep habitat (Figure 4.34). The MOL data shows a hotspot at mile 0. This is likely user error, since it is not expected to have sheep sightings in this area.

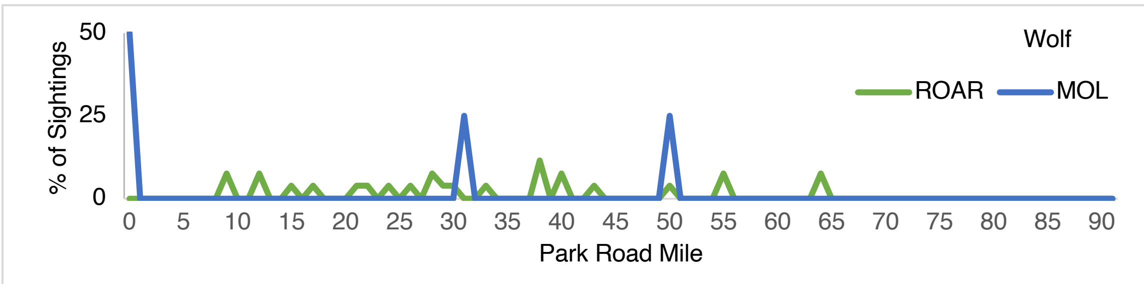

Figure 4.35 Wolf Road Sighting Index

The average difference in wolf sightings is 2.09%, and is the highest difference between the datasets. The MOL data, however, have only four wolf observations, and 2 of these occurred at mile 0 (hence 50% probability at mile 0) (Figure 4.35). While it is not completely unlikely to have a wolf sighting at mile 0, it is uncommon, so these observations may be user error, or misidentification of a sled dog. With such a small sample size the actual difference between the ROAR and MOL data in this case cannot be determined.

Table 4.31 Sighting Index Differences (Note: Wolf sample size is very small, ⅄ not including wolf, ★ including wolf

	Caribou	Moose	Grizzly Bear	Dall Sheep	Wolf	Average Difference
Average Difference	.80	.96	.91	.76	2.09	0.85%⅄ (1.1%★)

The average difference between all the road sighting indices is 1.1% (Table 4.31). Although the probability at the mile markers differ, the trends (Hot spot and cold spots) are similar between the MOL and ROAR data. The MOL data shows some possible user error, with a few unlikely sightings at mile 0. For example, if users use the “pin” setting in the mobile app to record wildlife sighting location instead of relying on current GPS location, they may be recording sightings where they first downloaded the application, generally at the WAC (Wilderness Access Center) where visitors board the park buses.

This sightings index provides an annual probability of seeing a particular species in the park. This index is used to assess the probability of observing a particular species during a visit to the park. The probability of seeing the “Big-5” (Caribou, Moose, Grizzly Bear, Dall Sheep, and Wolf), Lynx, Golden Eagle, Fox, and Coyote were calculated for this index.

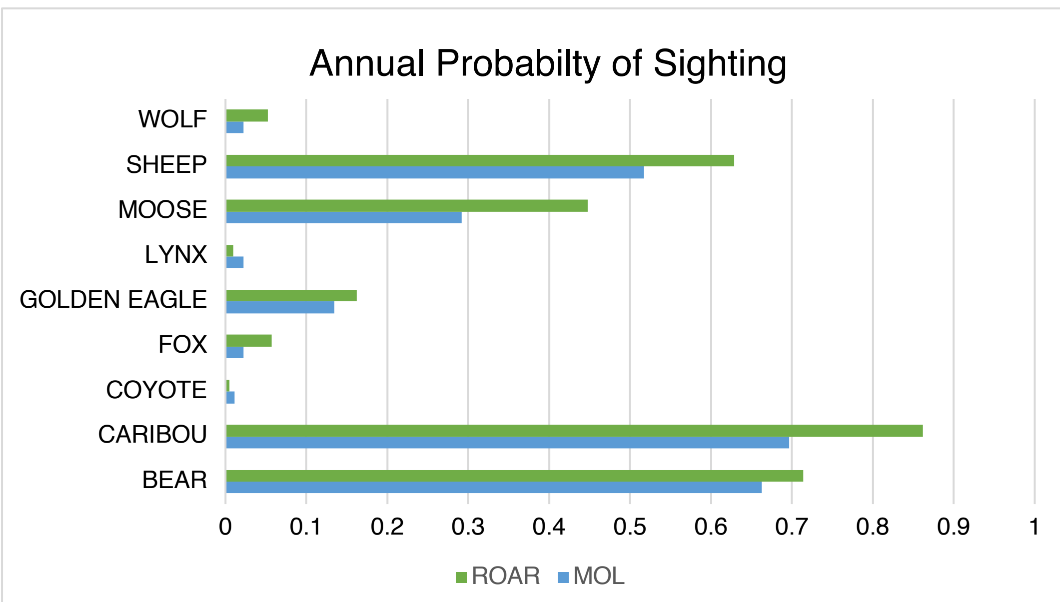

Figure 4.36 Annual Sighting Index

This index is derived from the total trips data collectors took into the park and the number of trips during which the specific species was observed. A trip is considered a bus ride between mile 15 (Savage River check point), and mile 66 (Eielson Visitor Center). The ROAR data collectors took 210 during the summer of 2016, the MOL volunteers took 89 trips. The MOL application did collect trip information, as each sighting was assigned a trip ID, the month, day and shuttle bus trip number. Sightings which occurred beyond the Savage River to Eielson section of the road were eliminated, and thus if the only observations that occurred in the trips were outside the area, the entire trip was eliminated. The average difference between the datasets in this index is 6% (Figure 4.36).

The last step in this assessment is to compare the outcomes to the specific goals. The goals of the scientific outcomes for this project were to have no more than a 5% difference between the VGI datasets and the authoritative dataset. The goals of the scientific outcomes of the project are partially met. The overall average difference between the datasets in the road index is only 1.1% which meets the goal. In the annual probability index, however, the difference between the datasets is 6%, and this exceeds the goal by 1%. Therefore, the MOL dataset partially meets the scientific goals of this project.

4.5 Park Integration

Integration of the program and its outcomes into park planning and management is detailed in this next section. For the park to adopt the program and the outcomes, officials wanted to know more about the volunteers of the program and their opinions, thus this section is divided into three parts; opinions of the volunteers, opinions from the park management, and an integration plan.

4.5.1.3 Opinions of the Volunteers

Opinions and feedback from the volunteers are highlighted below. Volunteers were asked for feedback and their opinion about the program in the post-visit survey, and during the focus group sessions. Feedback from the volunteers included: application usability, effectiveness as an educational tool, and overall satisfaction of the program. Analyzing this feedback from the volunteers is crucial for the continuation of this program, and the integration of this program into park management and planning.

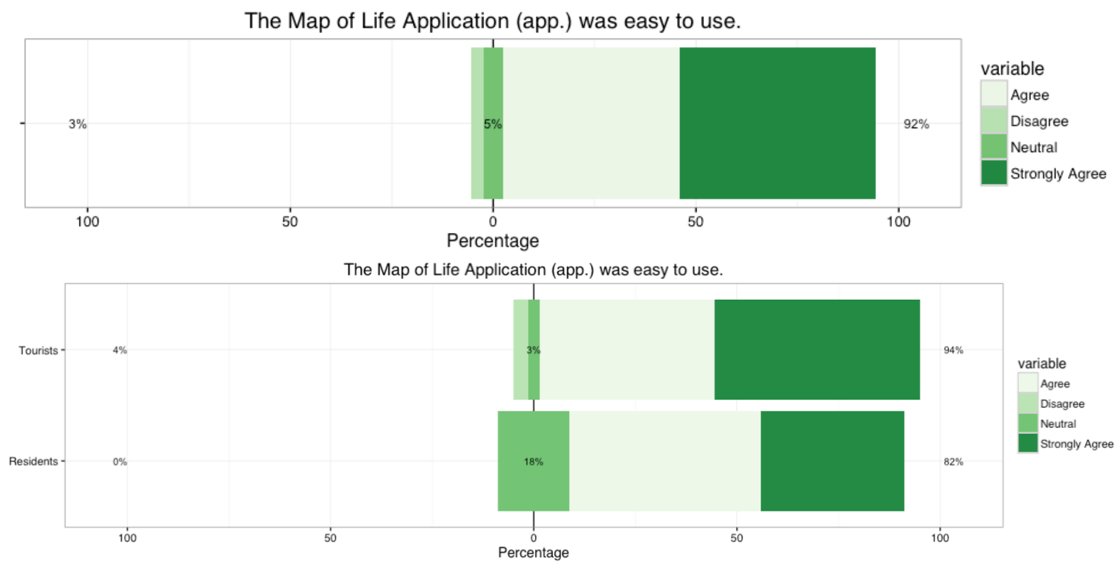

Figure 4.37 The Map of Life app was easy to use, total n=126.

The volunteers strongly agreed that the application was easy to use (48.71%), an additional 43.65% agreed with this statement (Figure 4.37). None of the volunteers strongly disagreed with this statement, only 3.17% disagreed (meaning they thought the application was hard to use), and 4.76% felt neutral about this statement. The difference between the tourist's and resident's responses in this question was not statistically significant (Figure 4.37).

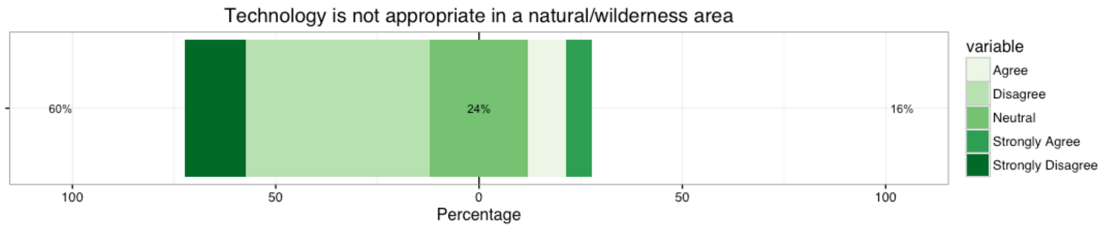

Figure 4.38 Technology is not appropriate in a natural/wilderness area – Composite of all volunteers, n=128

The volunteers largely disagreed (45.31%) with this statement, meaning they think technology is appropriate in a wilderness area, plus an additional 14.84% strongly disagreed with this statement (Figure 4.38). Neutral was the second most common response (24.21%). While, 9.37% agree and 6.25% strongly agree with this statement, which indicates that these volunteers feel technology is not appropriate in a wilderness area. The difference in responses from the two groups of volunteers, residents and tourists, were statistically significant (p-value = 0.002).

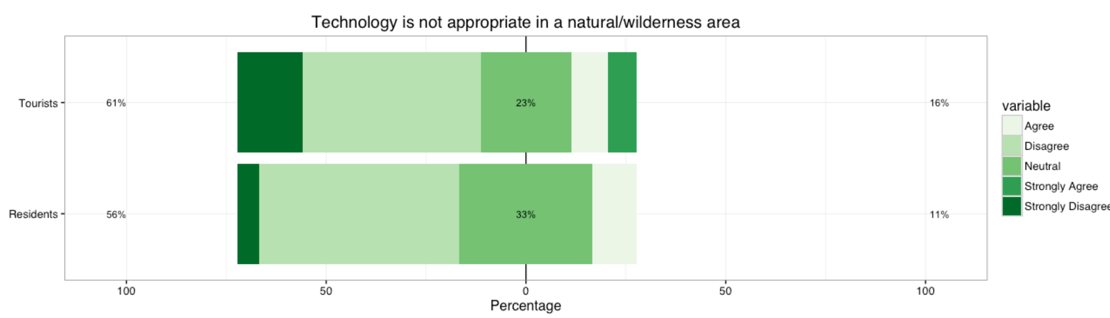

Figure 4.39 Difference between tourists and residents in their responses to the statement that technology is NOT appropriate in a natural/wilderness area.

Most of the volunteers felt technology is acceptable in a wilderness area, the most volunteers disagreed with the statement that, technology is NOT appropriate in a wilderness area, however, the tourists chose strongly disagree more than the residents (a difference of 8.06%) (Figure 4.39). None of the residents chose strongly agree, however

11.67% of the tourists chose strongly agree, meaning they do not think technology is appropriate in a wilderness area.

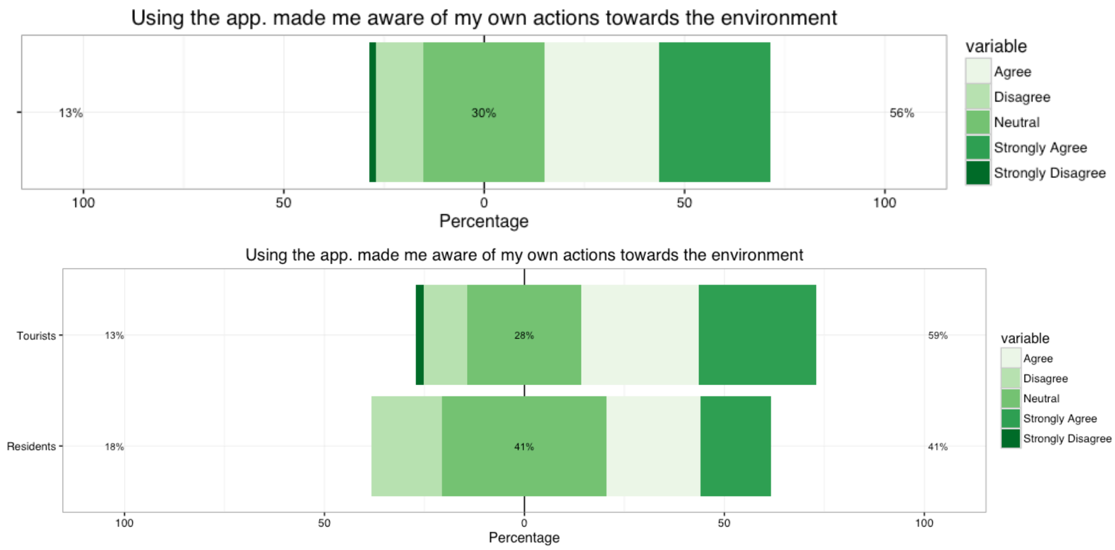

Figure 4.40 Difference between tourists and resident's responses to the app making them aware of their own actions toward the environment, total n= 126.

In the post-visit survey the volunteers were asked if they felt the app made them aware of their action towards the environment, and the tourists almost equally felt neutral (29.50%), agreed (29.50%), or strongly agreed (28.68%) with this statement (Figure 4.40). Only two percent of the tourists strongly disagreed with this statement and 11% disagreed with this statement. Residents, however mostly felt neutral about this statement, and none of the residents strongly disagreed.

The citizen science program and the application is designed to be a tool for educating volunteers about: wildlife safety, general facts about the park and conservation efforts, and the environment. Volunteers were asked to rate this statement to get a sense of how the program impacts environmentalism. Most of the volunteers felt neutral about this statement (30.15%), almost the same number of volunteers agreed (28.57%), or strongly agreed with this statement (27.77%). A small percentage, 1.58%, of volunteers strongly disagreed with this statement, and 11.9% disagreed with this statement. There is a statistically significant difference between the responses from the residents and tourists (p=.002).

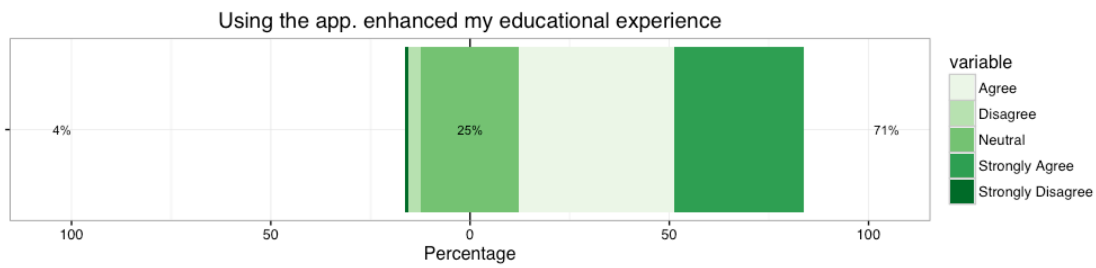

Figure 4.41 Using the app enhanced my educational experience, total n=126.

Most volunteers agreed, or strongly agreed that the application enhanced their educational experience (71%) (Figure 4.41). Less than 4% of volunteers disagreed or strongly disagreed with this statement.

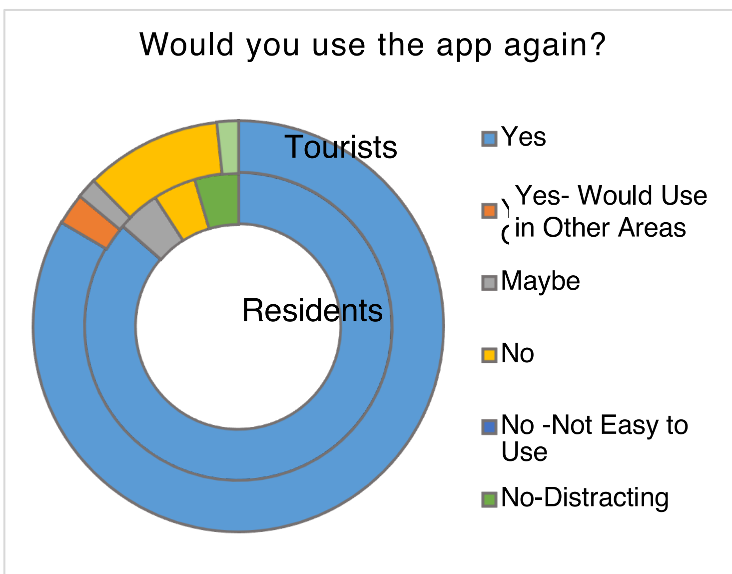

Figure 4.42 Would you use the app again, n=136

Most volunteers would use the Map of Life application again (87.8%) (Figure 4.42). There was not a significant difference between the responses for this question between the residents and tourists ($p = 0.8161$), 86% of residents would use the application again, as would 85% of tourists. Volunteers cited they would use it in other areas, while some said they would use it again if it is for another research project. A few thought it was distracting a few thought it was not intuitive to use, and a small number just responded “No”.

Volunteers who participated in the focus groups completed a questionnaire where they were asked to respond to statements about their participation in citizen science, specifically the Map of Life- Denali program. Figure 4.43 shows the responses from the survey questions. Volunteers agreed, or strongly agreed, that they enjoyed being engaged during their visit to Denali. They also agreed, or strongly agreed, that educational and interpretive experiences are important to them during their visit. The volunteers enjoy participating in citizen science programs and enjoyed participating in the Map of Life - Denali program, and would use the Map of Life application in other areas. In the survey only 5 of the 36 people who answered the questions had participated in citizen science before.

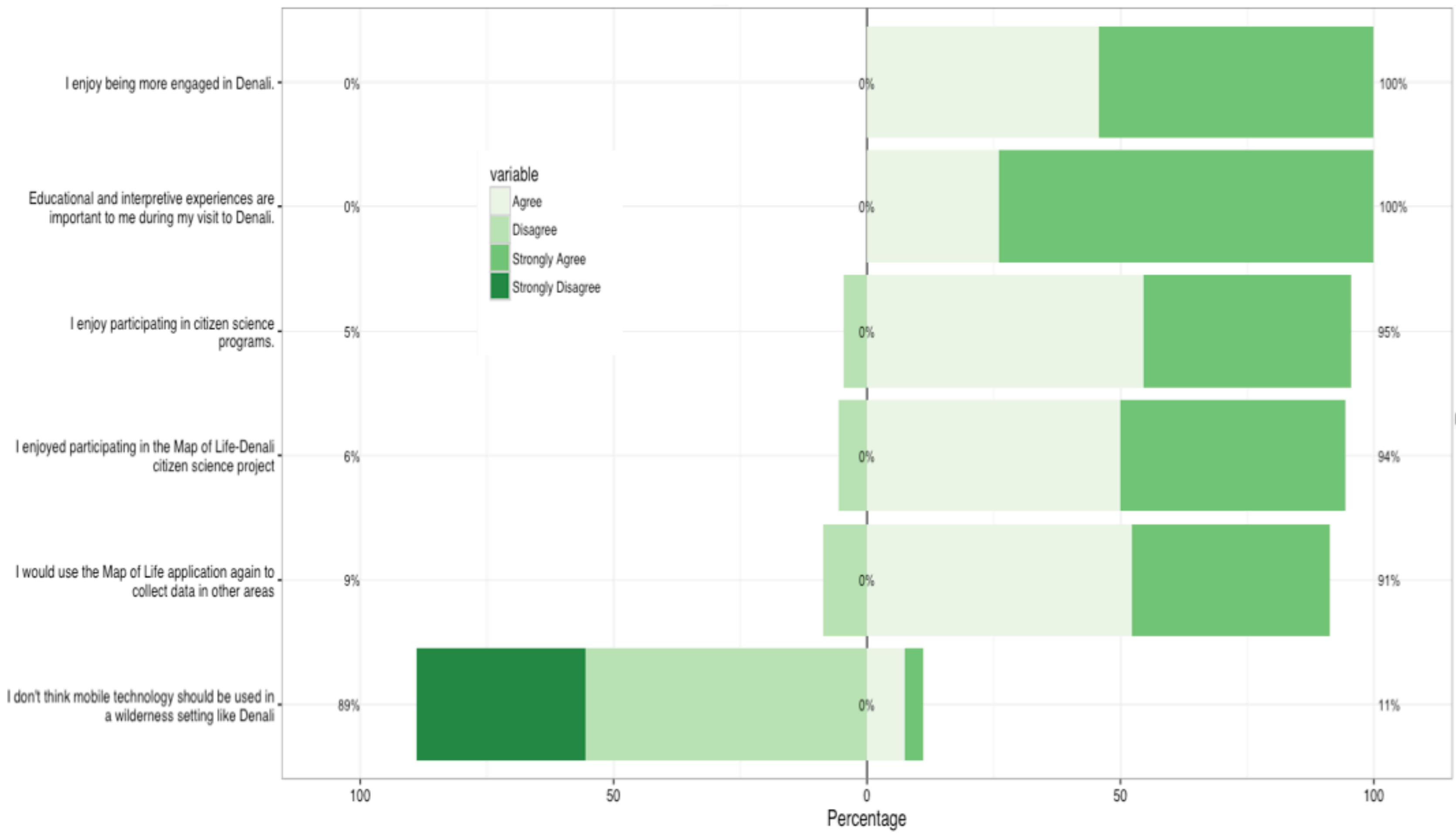

Figure 4.43 Results from the Focus Group Survey, n= 32.

The use of technology in a wilderness area like Denali is a reoccurring question in the Park Service. Denali NP&P was unsure how visitors would respond to using a mobile application in the park. Like the volunteers who participated in the post-visit survey, they disagreed that technology is not appropriate in a wilderness area (Figure 4.39). Feedback gathered from the post-visit survey and focus group surveys (Table 4.33) show that the volunteers were okay with using technology in park, but were not okay with cell phone towers and Wi-Fi being available within the park. Currently Wi-Fi and cell phone service is only available at the park entrance area. Volunteers were concerned that one person's technology use may impact another visitor's experience in the park. Volunteers also noted that they felt technology was acceptable only if it was for educational purposes.

Table 4.32 Using Technology in the Park, n=31

What are your opinions of using mobile technology in the park? (Codes)	Frequency
Technology is sometimes OK (Only if it does not impact other people's Experience)	3
Technology is OK	10
Education, Learning and Engagement	15
Technology is not OK	3
Distracting	3
Do not want Wi-Fi or Cell Service in the Wilderness	1
No Opinion	2

Open ended questions in the post-visit and focus group surveys provided the volunteers with the opportunity to provide feedback about the citizen science project and mobile application. Most of the feedback was positive: volunteers enjoyed the program, and felt it was a good educational tool (Table 4.34). Some volunteers provided negative feedback, mostly citing that the program and application were distracting them from experiencing the park and being in nature.

Table 4.33 Would the Volunteers use the app again? N=88

	Negative, does not want to use it again	Negative Feedback-Distracting	Neutral Feedback	Positive Feedback-Enjoyed it	Positive Feedback-Educational Tool
	2.2%	12.5%	2.2%	63.6%	19.31%

Volunteers were also given the opportunity to indicate any usability issues they had with the Map of Life - Denali application (Table 4.35). Overall, there were very few usability issues. Some felt the application was hard to use, or had issues with the offline functions.

Table 4.34 Volunteer Feedback, Usability of the app, n=8.

Feedback	Residents	Tourist	Total
Species Identification Issues	0	1	1
Survey Issues	0	1	1
Hard to Use	1	2	3
Offline Usability Issues	1	1	2

In order to improve the app and the program, volunteers were asked to provide feedback and ideas for improvement (Table 4.35). Most responses were concerned with the species photos and descriptions, as volunteers wanted to see more species photos and an expanded description of the species in the species lists. This indicates that the volunteers were using the application as a field guide (Table 4.36)

Table 4.35 Volunteer Feedback, app functionality, n=32

Feedback	Residents	Tourists	Total
Improve App Instructions	0	4	4
User Interface	2	1	3
Registration	1	1	2
Improve Species Photos and Descriptions	1	11	12
Share Users Observations	0	5	5
Add More Species	0	4	4
Other	0	1	1
Record Number of Animals with Observation	1	2	3
Include Photos with Observation	1	3	4
Use Offline or Online Capability in Other Areas or Parks	1	3	4

In addition to surveying people who used the Map of Life – Denali application, a non-response survey was conducted to examine why people did not want to use the application, or who could not use it (Figure 4.44). Most people had some reason why they couldn't download the application, either because they had an Android OS phone (for the first two months of the program the app was only available on iPhone), or had older cell phones (non-smart phones). Some people were in a rush to catch a bus, or dog show demonstration, and did not have time for the application download, although most of these people were given a flyer describing the program. Some people just ignored me (passively surveying people).

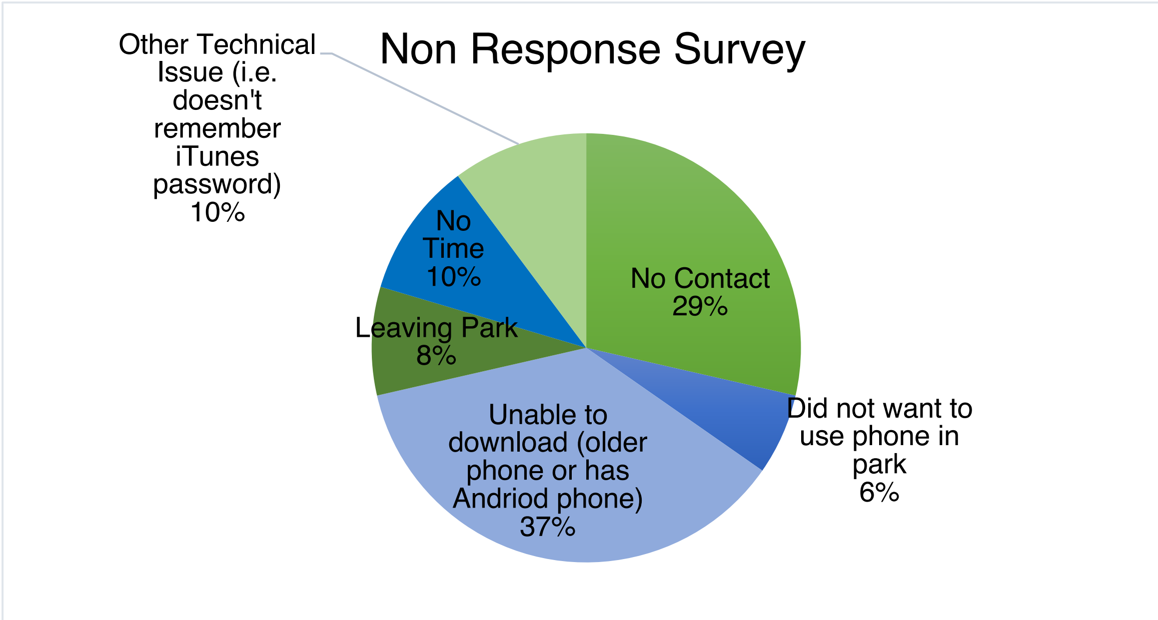

Figure 4.44 Results from the Non-Response Survey, n=55.

4.5.1.4 Opinions of the Denali National Park Management

Three focus groups and a series of small group meetings were held with park officials and Aramark representatives. The goal of these workshops was to discuss the integration of the application into park policy and management. The notes from the three focus groups and sets of meetings were analyzed using content analysis. The results from these focus groups and future plans for integration of the Map of Life-Denali citizen science program are discussed below.

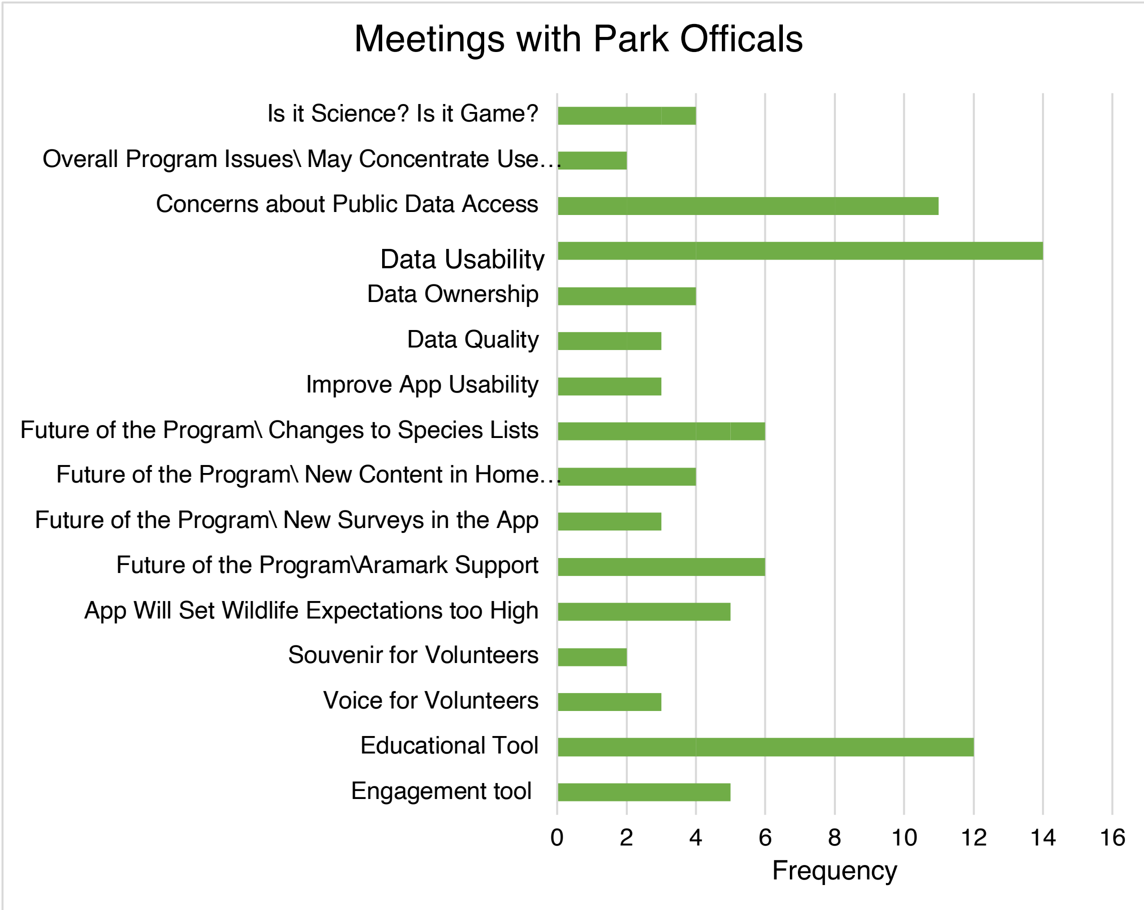

Figure 4.45 Feedback from meetings with NPS officials, frequency refers to the number of times the topic/code was discussed during the focus groups.

These three focus groups and sets of meetings with park officials and Aramark officials covered the development of the citizen science program and the possible integration of the program into park planning and management. Figure 4.45 shows themes that were derived from the focus groups and other meeting notes. These themes reflect the most frequently discussed topics during the focus groups and meetings. The park officials provided suggestions for improving the function of the application and "in app surveys", but the main points of discussion centered on two common themes: data usability concerns and educational benefits of the program.

Concerns regarding the data collected by the volunteers was discussed frequently in the focus groups and meetings with park officials. Data usability, ownership, and access were common topics in the focus groups and meetings. Some of the park officials did not see how the citizen science data can currently be used for park research and planning. They also felt that the program should have had a specific research question to answer with these data from the beginning of the program. Other officials however, thought that gathering data for potential later use is acceptable. Although the citizen science data was used in sighting indexes and species distribution models, and performed well in these models, some park officials are still hesitant to use the citizen science data for these purposes in official reports, while other park officials disagree with that hesitation.

Data ownership is a topic that did not come up until the final focus group and set of meetings, however, a large amount of time was spent on this topic. Currently, a contract between myself, Map of Life, and Denali NP&P, requires Map of Life to share data collected through the Map of Life-Denali application. A similar contact needs to be written for the long term to ensure the data are shared with Denali NP&P, and Aramark. Ultimately, Map of Life (MOL) and Yale University own these data, however, some park officials still expressed concerns about data ownership, particularly about the control over data access.

The release of data was a reoccurring topic that came up in all focus groups and meetings. The MOL team at Yale want to publicly release these data (at the time this was written is has not been released) but the park service is worried about the ethical issues this may create. Currently, MOL plans to publish these data on their website and allow the public to use an interactive mapping tool to create distribution and range maps. MOL also would like to allow the public to download these data eventually. Aramark would like to display these data on their website, for marketing purposes, as well. The park service and MOL are considering the delayed release of data and aggregating these data spatially. These data may not be released in real time (which is not possible because its offline design) and the coordinates of the sightings may be aggregated so the exact location of the sightings is not displayed.

Although the park officials had differing opinions on the scientific usability of these data, the officials did agree that the citizen science program was a successful educational tool. The park officials were pleased with the volunteers' feedback, and the field guide quality of the MOL application. They also felt the application was a good way to engage children while visiting the park. The park officials and Aramark agreed the mobile application could be an effective educational tool on the shuttle buses and tour buses.

The volunteer feedback was presented to park officials in the second and third focus groups and meetings with park officials and Aramark. Park officials were pleased to see the volunteers thought the application was easy to use, and would use it again. They also were pleased to see that the application helped volunteers feel engaged in the park and felt their educational experience was enhanced by the app. For people who want to use their smartphones in the park, this program is a great way to engage them, due to its offline capability. The park officials particularly are interested in using the home page to convey information about such topics as wildlife safety.

The main app usability feedback from the volunteers included improving species photos and descriptions, which indicates the volunteers were using the app as a field guide, part of its intended purpose. The park officials and Aramark believe the field guide aspect of the app is important and agreed that some species photos and descriptions need to be improved. This field guide aspect of the app can also help volunteers identify plants and animals that may been pointed out by the shuttle/tour bus driver, or provide them with more in-depth information on a particular plant, or animal.

A few volunteers described the Map of Life-Denali application as "Pokémon Go" for real animals. This game aspect of the app can be appealing to children. In recent years, the park and Aramark have been more open to the use of technology within the park and they agree that a mobile phone-based application, like Map of Life, is a way to have people engage in the park through technology.

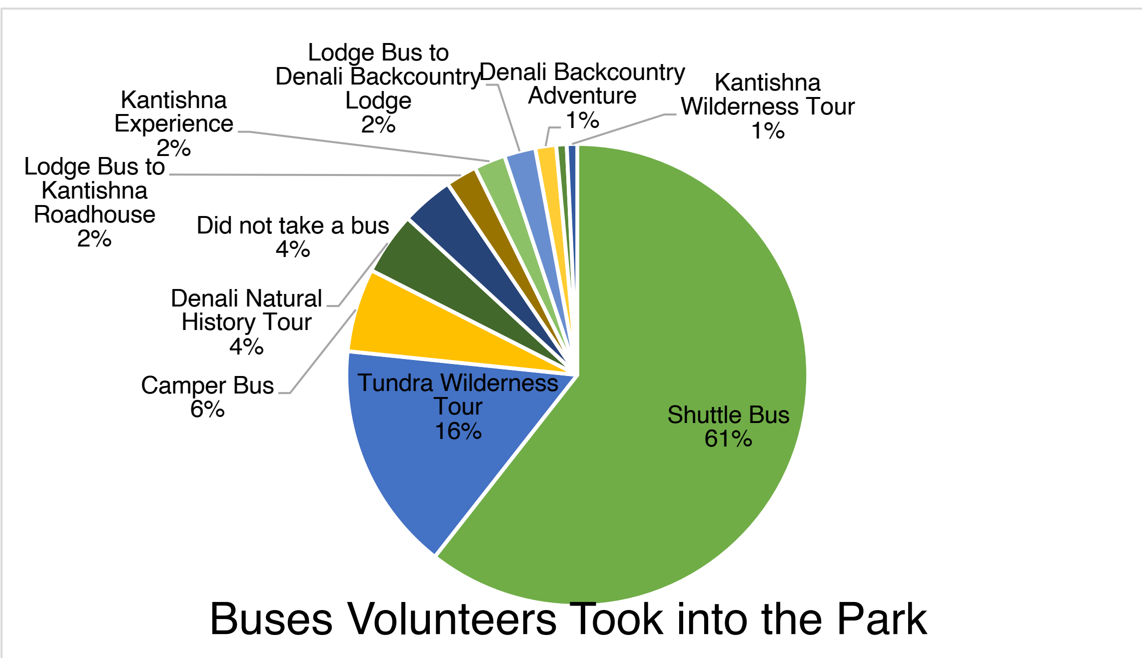

Figure 4.46 Buses Volunteers Took into the Park.

Visitors– unless under a special permit– must take a park-service authorized shuttle bus, tour bus, or lodge bus to travel into the park. Each bus makes wildlife observation stops, but the drivers provide different levels of narration. In the pre-visit survey volunteers were asked which bus they took into the park. Most visitors who volunteered rode shuttle buses, or the Tundra Wilderness Tour into the park (Figure 4.46). Visitors who took the shuttle bus do not get a fully narrated tour while in the park (although several of the shuttle bus drivers provide narration during the drive)–however, the TWT is a fully narrated tour. Aramark and the park officials believe Map of Life-Denali can provide shuttle bus riders with more information if they want it, and can even supplement the narration on the tour buses.

4.5.1.5 Plan for Integration

During the third focus group and set of meetings the park service officials agreed they would not be the main sponsor of the application in the park, instead they would support Aramark's partnership with Map of Life and support the program in the park. This decision stems from newly adopted National Park Policies which make it difficult for a park to sponsor, or develop a mobile application. The decision was also made because Aramark's new concession contract with the park service for Denali NP&P, requires them to develop, or support, a wildlife observation application, where visitors record wildlife sightings and these data are provided to the park service. A partnership between Aramark and the Map of Life to support the mobile application will fulfill this contract requirement.

Aramark plans to integrate the program and use of the app into both the shuttle bus and tour bus itineraries. They plan to focus on the field guide aspect of the app. Bus drivers, other Aramark employees, and park officials will receive training about how to use the application and how the citizen science program operates. Bus drivers will be encouraged to incorporate the program into their tours and narration.

The species data collected through the Map of Life –Denali app will be owned by Map of Life at Yale University; however, a contract will be made between Map of Life, Aramark, and Denali NP&P to ensure that Map of Life shares these data. Aramark would like to use these data to display maps of species sightings on their website and at the Wilderness Access Center where visitor board their buses.

The citizen science program and app will be advertised on the Aramark website, the Wilderness Access Center, park campgrounds and local hotels. This allows visitors to download the app well before they enter the park. Advertisement includes posters and an infographic showing visitors how to download and use the application and explain the purpose of the citizen science program.

The surveys from Summer 2016 will be removed from the application, and a new end-user feedback survey will be included in the app. Representatives from Map of Life, Aramark, and Denali NP&P will work together to ensure the application data are kept up to date, and park specific information is correct. The re-launch of the Map of Life-Denali app will occur during the Summer 2017, and the program will be reviewed after the Summer implementation by Map of Life, Aramark, and Denali NP&P to determine if support will continue.

4.6 Concluding Remarks

These results provide insights into the role of tourists in citizen science. The first section of results regarding the first research question show that tourists and resident volunteers provided similar data, and have similar place attachment and educational outcomes in citizen science. The second section regarding the second research question shows that data fitness for use is a legitimate way to approach citizen science data quality. The third section tell us that citizen science data quality is still an issue, however, the educational merits of citizen science are not. A discussion of these results is in the next chapter.

CHAPTER 5 DISCUSSION

The aim of this dissertation is to advance understanding of tourist-centric citizen science programs. Three research questions were formulated, each addressing a short-coming found in the citizen science literature. These short-comings fall into three categories, first, the concept of 'volunteer' is used as a catch-all without considering how different demographics (e.g., residents, and visitors) affect both volunteer and scientific outcomes of citizen science. Second, no standardized approaches to assess the quality of citizen science datasets exist. This has led to questions about data validity, accuracy, and therefore utility (Bonney et al. 2014). Third, the educational and scientific outcomes of these programs are not routinely or strategically measured, or integrated into policy and planning (Brossard, Lewenstein, and Bonney 2005). Hence, how successful these programs are, remains unknown.

This study shows that tourist and resident volunteers have similar education and place attachment outcomes, and that they also produce similar datasets. This project then evaluated citizen science datasets through a data fitness for use assessment, instead of a traditional assessment of data accuracy and quality. The outcomes of the citizen science program were evaluated, and possible integration of these outcomes was discussed with stakeholders (Denali National Park and Preserve officials and Aramark representatives).

Results from the three research questions are discussed in separate sections in this chapter. Subsection for each of the research questions include; contributions, effectiveness, and challenges. Contributions refers to the contributions that this research made to the citizen science literature. Effectives refers to the replicability of the methods, the generalizability of the results, and success of the study. Lastly the challenges section refers to issues and problems that occurred during the study and analysis of the results.

5.1 Research Question 1

What are the differences between residents and tourists, in data quality and volunteer outcomes in citizen science?

The first research question explored the difference between tourist and resident volunteers, compared data these groups produced, and analyzed the difference in both scientific and volunteer outcomes. The following sub-sections of this chapter discuss the contributions, effectiveness, and challenges found in these results.

5.1.1 Contributions

Tourists and resident volunteers did display some differences in data quality, place attachment, and educational outcomes, however, these differences do not indicate that tourists are poor citizen science volunteers. Tourists produced more species observation data than residents, however random samples were taken from these tourist data to match the sample size of the resident data. With the random sample, the majority of these data overlapped with resident data. After this involvement in the program tourists and resident volunteers do not display a significant difference in their place attachment to the park, but do show a difference in how they define the terms 'nature' and 'park'. There is a significant difference in their educational outcomes, however, the tourists do gain measureable knowledge through their participation in the program.

The first portion of the first research question aimed to examine differences in data quality between the tourists and resident volunteers. In order to examine if the tourists were producing data that is on par with the residents, this research tested how much the tourist and resident datasets overlapped. The hypothesis that a majority of these tourist data would overlap with the resident data was shown to be true, through this analysis.

Although these volunteers were from different groups: the tourists and the residents produced similar data. This shows that differences between residents and tourists may not impact data quality, or data production. This contributes to the understanding of how different groups of volunteers produce data, and quality of their respective datasets. Other research has examined differences in data quality between age groups, or educational levels, and one such study found that age and educational level can affect data quality (Delaney et al. 2008). This study expands on this understanding of demographics of volunteers and data quality, through looking at residency status.

Place attachment was determined by choosing words related to place attachment– the intangible words- in the word choice portion of both the pre and post-visit surveys, and through multiple Likert scale questions in the post-visit survey. In the pre-visit survey, the residents exhibited a greater sense of place/place attachment than the tourists, before they participated in the citizen science program and used the mobile application. However, the tourist data displayed a greater increase in the choice of intangible words from the pre-to the post-visit survey, demonstrating that they had a greater increase in place attachment. These outcomes align with the hypothesis that the residents would have a greater place attachment in the pre-visit survey, but the tourists would have a greater increase in place attachment. The Likert scale questions go beyond the hypothesis somewhat, and examine how the participants feel the citizen science program influenced their place attachment to the park, and to nature. Both the tourists and the residents felt the program helped them feel more connected to the park, but not necessarily with nature.

The tourists did not begin the program with as much place attachment as the residents, but the word choice questions show they gained more place attachment through participation in the program. Citizen science thus can help tourists (or other classes of volunteers) gain a sense of place, and place attachment, to the facility they are visiting. This analysis, and these results, expand the understanding of place attachment and citizen science volunteers, and specifically, the difference in place attachment between different volunteer groups.

Both the residents and tourists felt the program helped them feel connected to the park, but less connected to nature. This poses an interesting rhetorical question of semantics: “What is the difference between the park and ‘nature’, and can a citizen science project really connect you to nature?” This is an interesting division between what the definition of a national park, and what nature, is. The responses to these two questions show that the volunteers may have different definitions of ‘park’, and ‘nature.’

The term ‘park’ may be thought of as the infrastructure of the natural surroundings, and the management of the area. The term ‘nature,’ on the other hand, may be defined as the wilderness and backcountry areas, well away from park infrastructure. Volunteers were mainly using the mobile application on the bus, or near park infrastructure, such as maintained hiking trails and rest stops along the road. Perhaps volunteers felt the program had more impact on their experiences in these areas, and felt these areas denote the ‘park.’ If the volunteers did not use the application while backpacking, or in trail-less areas, they did not feel the application enhanced their experience in ‘nature.’ Most of these species observation data from the application occurs in areas near the park road, while other points seem to occur along popular hiking areas, just off the park road. Most points are not more than a kilometer off the park road, which indicates that the volunteers were not using the application too far into the backcountry.

The results from the quizzes in both surveys were used to address two hypotheses (resident volunteers will have a greater knowledge of the park before they participate in the citizen science program, and tourist volunteers will have a greater increase in knowledge before and after they participate), and these results showed the hypotheses are in fact correct. Residents had higher scores in the pre-visit quiz, but the tourist quiz scores increased significantly in the post-visit survey. The quiz was used to assess the volunteers' general wildlife knowledge, basic animal safety skills, and understanding of conservation issues.

Tourists gained knowledge about the park and its wildlife (and were enthusiastic to do so, as found through content analysis of the open-ended surveys responses) through the Map of Life-Denali program, which is one of the primary desired outcomes of citizen science: scientific literacy and the gain of knowledge (Bonney et al. 2009a). While tourists may not start out knowing as much about the area, as residents, they successfully learned about the area, meeting a key desired outcome of citizen science.

The tourists gained more knowledge than the residents, because, more than likely, they were likely unfamiliar with the park, the wildlife, and wildlife safety rules. However, through participating in the program, and spending time in the park, the tourists increased their knowledge of the park. Additionally, according to their responses, they felt the application enhanced their educational experience in the park. It is likely that the residents already knew more about the park, so they felt the application did not enhance their educational experience. Possibly, the program offered too much elementary knowledge for the resident participants.

For tourist volunteers the application was a great educational tool, however, it offered only basic information about the park, and the wildlife. The information presented in the application may need to be reworked to appeal to the educational expertise of volunteers who are more familiar with the park. Different volunteer groups may get different educational outcomes from a project depending on what they already know about the study area, or project itself.

5.1.2 Effectiveness

The methods used in this analysis can be applied to assessing data quality and volunteer outcomes for other classes of volunteers and can translate to other environments and citizen science programs. This study is also generalizable to other demographic groups of volunteers, can be replicated with other groups of tourist volunteers. The study was successful in adding insight into the validity of tourist-centric citizen science programs.

Methods used in this analysis of tourist and resident volunteers, can be used to look at other volunteer groups, other study areas, and other citizen science programs. Other possible volunteer groups to examine are volunteers of different income levels, nationalities, and abilities (i.e. hearing or visually impaired volunteers, or volunteers with learning disabilities). The overlay method used to assess the tourist and resident spatial data can be used to assess data from other groups of volunteers, and can be used on other categories of spatial data. The methods used in this analysis to assess place attachment and educational outcomes, can also be applied to assessing volunteer outcomes for other types of volunteers.

Although this research focused on tourists, this analysis shows that given the proper program, different groups of volunteers (other than tourists and residents) may produce comparable data and may not have significantly different volunteer outcomes. The results from this analysis of these spatial data shows that tourists can be effective volunteers in citizen science, and should open the door for more tourist volunteers collecting usable data. The volunteer outcomes (including place attachment and education) were similar between the tourists and residents. Different groups of volunteers may not have such different volunteer outcomes in a program.

The results from the first research question adds to the validity of tourist-centric citizen science through examining differences and similarities between two different groups of volunteers and their data, place attachment, and knowledge gain. The results from the data quality analysis show that the tourists in this program produced data that is comparable to the residents. Citizen science data can be valid data regardless of the volunteers. The analysis of place attachment shows that tourists can exhibit place attachment to a place after they participate in citizen science. For protected areas like national park, visitors place attachment is key for the support of the conservation of the area. The results from the educational outcomes analysis add to the knowledge of how different classes of volunteers can have variations in the educational outcomes of citizen science programs. Regardless of the type of volunteer, an educational experience can be gained from participating in citizen science.

5.1.3 Challenges

The make-up of the two sample was the main issue with this analysis and addressing this research question. Reflecting park visitation composition, more tourists participated in the program, thus the sample sizes of resident and tourist data collected through the application, and the samples sizes of the survey responses were different. Also, the definition of resident was flexible in this case because it is difficult to find true residents of Denali NP&P.

The difference in sample size issues was addresses by using random samples from the tourist's species observation data for the data quality analysis, and using statistical tests that are not largely affected by sample size in the place attachment and education analysis. These tourist data involved more sightings, and was more disperse, reflecting the much greater proportion of tourists in the park visitor population. The process to address sample size differences is complex for spatial data, and this type of analysis. Random samples were chosen from these tourist's data to reflect the same number of observations in the resident dataset. The random samples were then averaged, to create a final assessment of, on average, how much the tourists' samples overlay with the residents' samples. This method should be further refined and possibly be replaced by an automated bootstrapping approach.

While the tourists did produce comparable data to the residents, the tourists had more random sightings, and possible misidentifications, simply reflecting the large proportion of tourists that are visiting the park. Thus Linus' law comes into effect (Muki Haklay 2013), meaning that with more people collecting data the more accurate these data become.

The place attachment analysis used responses from the surveys as a proxy for actually measuring place attachment, this is not an error-free method. This analysis leaves some questions unanswered, and revealed a few new questions, such as: “How did the tourists become so attached to this place in such a short amount of time (less than one or two days)? How do we know the application helped with place attachment, and how much of an impact did it have? How long does this place attachment last?”

Similarly, in the place attachment analysis we do not know if the educational increase measured by the post-visit surveys is primarily due to the mobile application, or to other influences. The visitors ride shuttle buses, and are exposed to many educational moments during the trip. They were asked if they felt the application increased their knowledge, using the Likert scale questions, and while many agreed with that statement, we do not know if the application was truly the primary contributor to the tourist volunteers having a significant increase in knowledge. It would have been useful to do an additional survey and quiz those people who did not use the mobile application during their visit, to assess how much application-equivalent knowledge they had, after the bus ride. This was not within the scope of this study.

5.2 Research Question 2

How can a Data Fitness for Use (DFFU) assessment be used to measure data quality and utility, in tourist-driven citizen science?

The second research question addresses the measurement and assessment of citizen science data for accuracy and quality in terms of fitness for use. Many methods of assessing citizen science data accuracy exist, yet, citizen science data are generally considered to be of lower quality, than comparable authoritative datasets, because nonexperts are collecting these citizen science data. However, these citizen science data may not in fact be low-quality for particular purposes, as these data may be fit for one specific application, but not another. Thus, this research project developed and tested a fitness for use assessment, instead of using a simple data quality assessment. The STAAq assessment looks at what the datasets are intended to be used for, first, then assesses the usability of these data for that specific purpose, by comparing these data to data from other datasets.

5.2.1 Contributions

The STAAQ assessment was tested to characterize data fitness for use in citizen science data. Citizen science data are typically not looked at for data fitness, but rather just data quality, or accuracy. The STAAq assessment shows data fitness for a specific application instead. The STAAq assessment provides the first iteration of data fitness for VGI and citizen science datasets, and addresses citizen science data quality, using a different methodology.

This assessment differs from other DFFU assessment because it does not rely on metadata, and can also provide a fitness assessment of just one dataset. Other DFFU assessment like Pôças et al. (2014) and Shimizu (2014) require metadata to assess different quality indicators. Citizen science data/VGI often is missing metadata. The STAAq assessment can also provide a measurement of data fitness if only one dataset exists for the particular study area. In some cases, VGI are the only data that exist for a particular study area.

5.2.2 Effectiveness

The STAAq assessment was developed to be a robust assessment which can be used to assess data fitness for a variety of datasets and research question. The assessment was developed with VGI in mind, and through testing the assessment with two example research questions, the VGI was shown to be the second most fit for use dataset. This results from testing this assessment on two example research questions show that the assessment provides a quantifiable assessment of data fitness.

This data fitness for use assessment addresses perceived concerns related to data quality, and how to assess fitness of VGI and citizen science data. This fitness for use assessment is not only relevant for VGI, but can be used with many other types of data and models. The elements and components of the assessment can be modified, or weighted, to fit the needs of the user.

Two example research questions were developed to test the STAAq assessment, and to see how the VGI faired when compared to two authoritative datasets. These MOL data was ranked second out of three for both examples. This shows that citizen science data/VGI can outperform authoritative datasets when fitness for use is considered.

The STAAq assessment provides a way to measure fitness for use when metadata are not present, or even when authoritative datasets do not exist (both are sometimes the case with citizen science data). The results from the STAAq assessment can be included within the metadata for each dataset, and provides an example of what these data has been used for, and what these data has previously been considered fit for. A key aspect of this assessment is that it can be used when an authoritative dataset is not available, or even when only one dataset exists, so it can be used to partially give a DFFU assessment.

5.2.3 Challenges

The STAAq assessment is an effective way to examine DFFU of VGI, however employing and testing this assessment did pose some challenges, and revealed that some improvements and refinements can be made. Challenges posed by each of the components will be discussed below, as well as a short discussion of the challenges from the DFFU assessment as a whole.

For the spatial components, elements may be added. For example, an element related to the clustering of data in a given area, because if you wanted to narrow down the spatial extent of the Grizzly Bear to the park road area, these authoritative NPS data would still cover additional areas. This could be tied with the other data, even though the observations may be more dispersed in the narrower area of study.

The spatial and temporal components were tied to the method of data collection. The occurrence of event elements may be divided into two more elements; time of event and timeliness. These ROAR data exist for multiple years, but since it is only collected every summer, these data may muddle a distribution model, but it is useful for comparing sightings indices year to year. These MOL-Denali data will be collected again this summer (2017). It may be interesting to update these distribution models with data from multiple years, since the multi-year nature of the datasets may bump up the MOL data's ranking in the DFFU assessment

The aptness component is the only component which requires other datasets for comparison, and it only performs a binary assessment - whether data for a particular attribute is present, or not. It would be interesting to expand this assessment to be able to test magnitude of the attributes. Also, it would be interesting to use the aptness components for vector data in addition to raster data. Due to the scale of the models, and the clustering of the points from the ROAR data, the summer precipitation and temperature, were basically ignored in the model, since elevation and land cover vary more greatly in the area where these observations are clustered. These two variables, summer precipitation and temperature, were more impactful to the models for these SDM data. The models used in the study were only examined with summer precipitation and temperatures data, however, when the models are run with more variables, elevation and land-cover are still significant, however, less so in the models. AUC is not the best way to look at the performance of the species distribution model, however it is the easiest output to get on model performance.

5.3 Research Question 3

How can the educational and scientific outcomes of citizen science be measured, and ultimately integrated into park management and planning?

The success, or the expected outcomes, of typical citizen science projects are not often measured, or not measured systematically. In turn , the success of the educational outcomes is often questioned (Brossard, Lewenstein, and Bonney 2005). Additionally, decision makers, in research settings, are not typically using citizen science data, as a result of skepticism (Conrad and Hilchey 2011). With this negative perception, these programs are not being incorporated into long-term educational initiatives, or resource planning and management. By using a mixed-methods approach (qualitative and quantitative research methods) this research assessed the educational and scientific outcomes of this citizen science project through analyzing the knowledge gained by the volunteers, and assessing the quality of their datasets. These assessments revealed that the educational and scientific goals were met, and attested to the usability of the project approach. The results of these assessments were subsequently presented to the project stakeholders, Denali National Park and Preserve management, and Aramark (NPS concessionaire) officials. Feedback from the volunteer participants was also presented during these meetings with the stakeholders.

5.3.1 Contributions

The analysis of meetings and focus groups, with the stakeholders and volunteers, gives insight into how citizen science can be incorporated into park policy and management, and why citizen science has yet to be integrated. The outcomes assessment was developed to examine the educational and scientific outcomes of the Map of Life – Denali project. The results from these assessments and feedback from volunteers and park officials were presented in a final focus group with park management and concession officials in March 2017. These outcomes assessments provided quantitative evidence of the effectiveness of this citizen science program.

Feedback from the volunteers was mostly positive, as volunteers generally felt the application was easy to use. This is likely because these volunteers, were just that, volunteers. They were open to trying out the program and participating in the project. Also, visitors to national parks are often interested in having an educational experience during their visit (based on results from the volunteer focus group survey). These volunteers, especially the tourists, were not only vising a national park, but a remote park, which many of tourists have never visited before. These visitors are likely to be interested in learning more about the park and trying different things to enhance their experience in this remote area.

Many of the volunteers said they would use the application again, and felt the program enhanced their educational experience in the park. However, they had constructive feedback about how the program and mobile application could be improved They asked for better species descriptions, and the ability to add their own photos, perhaps even the ability to combine both sources of photos into the MOL-Denali database. The volunteers see the application as a digital field guide which they can then use to record their wildlife sightings. This field guide aspect of the program, and application, can be a supplement during their bus tour in the park.

Some of the park officials were convinced of these data usability after reviewing the outcomes of the scientific assessment, which showed data collected from the MOL-Denali application performs like ROAR data, when considered in road and annual sighting indices. A few park officials, however, do not think these MOL data are useful to the park, mainly because they think the MOL data are not unique, or not applicable for any of the park's existing research questions. The park officials were also split on the idea of collecting data for data's sake, and stockpiling these data to be available for park officials and outside researchers. These data collected by volunteers in Denali National Park, and other places, through the Map of Life application is used by MOL to enhance their range maps, and on their website. However, the park staff do not universally agree on whether these data are useful for the park itself.

Volunteer participants want to be engaged in the scientific process, and know that their contribution matters. The park could adopt this program in a simple form, and only use these resulting data for simple sighting indices. The focus groups and meetings held with the park service provides valuable insight into why citizen science programs have yet to be widely integrated into policy and management.

As to why citizen science has yet to be integrated into park policy and management, these focus groups reveal that, there is still a cultural distrust of citizen science, in terms of educational merit, but primarily in scientific merit, among some park officials. If the citizen science project is purposely designed up-front to address a specific research question, the scientific outcomes may be more likely to be incorporated into park policy and management. However, some citizen science projects are developed without a research questions in mind, and data are collected for potential future use. This approach was discussed in the focus groups as well, and while some park officials agreed that collecting data for the sake of collecting data is fine, and these data may become more useful a time goes on.

5.3.2 Effectiveness

The outcomes assessment examined educational and scientific outcomes of the Map of Life-Denali program, the framework for the assessment can be applied to other programs and other outcomes of citizen science. The results of this assessment show that the educational and scientific goals were achieved, however the park service is still hesitant to use these species observation data for park management, this reflects an ongoing distrust of citizen science. The park, however, does think the program has educational benefits and can be an effective educational tool for the park.

The outcomes assessment developed to assess the educational and scientific outcomes of this program provides a robust, but simple, way to evaluate outcomes of citizen science. There is not a standardized way to measure volunteer, or scientific outcomes, because the scientific needs of each project are different. However, it could become more commonplace to assess and report these outcomes. The outcomes assessments were shown to be effective, and can be incorporated into the design of many other citizen science programs. This outcomes assessment can also be used to examine other outcomes of citizen science, including place attachment of volunteers.

These results demonstrate a commonly found distrust of citizen science, specifically of citizen science produced data. The results from the focus groups can be used to inform other projects, and provide some insight in order to engage stakeholders in citizen science. Meetings and focus groups with stakeholders should be conducted with any citizen science program. Applying the insights from these sessions shapes the assessment of the outcomes, and provides a framework to present volunteer and scientific outcomes to stakeholders.

Feedback from the Park Service staff indicates that the application has proven itself an effective educational tool, and specifically, a great tool for getting visitors to engage with the park. Park Service staff also indicate that the application is useful as a field guide. While the program provides another method to get visitors engaged in the park, some park staff members are not sure if the project should be considered science, since visitors are not using the application to answer a specific research question. Without the link to a specific research question they felt it has limited scientific research utility.

5.3.3 Challenges

While shown to be effective overall, the development and implementation of the assessments provided some challenges. Analyzing and presenting feedback from volunteers and park officials also provided some challenges in this research.

Through the surveys in the application and the volunteer focus groups, the volunteers provided both positive and critical feedback for the program. Many volunteers said they would use the application again, however, there is currently no mechanism in place for this research to see if volunteers used the MOL mobile application in another location, after their visit to Denali. Examining retention of volunteers is important for successful citizen science, if volunteers quit the program then the program may not meet the needs and desires of the volunteer and the program will need to rely on a recruitment of new volunteers. In order to implement this, volunteers need to be surveyed a few weeks to months after their initial participation in the citizen science program, these surveys can ask questions regarding their participation and satisfaction in the program.

The outcomes assessment was used to evaluate the education and scientific outcomes of the Map of Life-Denali program; however, this assessment was developed to be generalizable and applicable to different types of citizen science outcomes. In turn, the assessment may be too general. For the educational outcomes assessment, it is hard to determine, if using the mobile application is the primary contributor to the learning, or volunteers learned from other sources in the park, such as Rangers, guided hikes, interpretive signs, and going to the visitor center. In order to identify, and rank with level of greatest impact, these educational influences, a new survey of visitors who did not use the mobile application would have to be done. The real question of course is whether the mobile application is better than other methods – such as not using the tool, or just going to the visitor center.

The scientific assessment only assessed these data based on how these data compared to ROAR data. This was determined early on through meetings with two park biologists, however, other park officials were not consulted until after the program was underway. Different data applications (like bird diversity monitoring) could have been examined if more park officials were consulted at the formative stages of research. The park service staff generally agreed that the application is a great educational tool for park visitors, but were still not convinced that the scientific data it captures was useful, even after examining the results of the scientific assessment.

To convince the park service to use these data collected as "scientific data," a specific research questions needed to be developed, in advance. Instead, these data were collected for potential use for the Road Ecology Program, and to possibly supplement ROAR data in the sighting indices. However, the development of a research question that cannot already be answered with existing data may have been a way to get the park service to accept the validity of these data.

The results from the educational and scientific outcomes were presented during focus groups with park officials. Organizing the focus groups with the park officials was done mostly through a primary contact person within the park service. The attendance of these focus groups varied widely based on timing of the meeting, and advertisement of the meeting. Some of the attendees of the later focus groups would have been useful attendees of the first focus group, to capture their feedback and insights that could have been used earlier in the program design. For instance, officials who insisted that the program have specific research questions to answer only attended the second and third meeting. If they attended the early meetings, perhaps a specific research questions could have been developed for these MOL-Denali data to answer.

The lack of a specific scientific research question in mind for the volunteer collected data was common topic of discussion during the third focus groups. At first the park was interested in reviewing these data, but did not have a research question they wanted to answer. However, some park officials are adamant that a research question is needed, in advance. Collecting data, simply for the sake of having data, might be sufficient, or should citizen science programs always be developed with a specific scientific research question in mind. A multi-year study using the MOL-Denali program may address some of these concerns, compiling a more significant dataset for comparison purposes. Some Park officials are still hesitant about the scientific research value of the program. Park research staff members were understandably hesitant to abandon their authoritative data collection methods.

5.4 Overall Discussion

This research shows that tourist-centric citizen science programs can be successful, and the tourist volunteers can produce equal scientific and educational outcomes to those produced by resident volunteers. Data fitness for use is a valid procedure for assessing the usability of citizen science data. This research also shows that stakeholder engagement is key, but there is still a hesitation to use citizen science data.

CHAPTER 6 CONCLUSIONS AND FUTURE WORK

The popularity of citizen science programs is growing. These programs provide an avenue for bi-directional flow of knowledge between the public and scientists, however, the exact program details and dynamics leading to different outcomes have not been well documented. This research addressed three short-comings found in the citizen science literature. First, the concept of 'volunteer' is used too broadly, without considering how different demographics (e.g., young, old, wealthy, poor, local inhabitants, and visitors) can influence both educational and scientific outcomes of citizen science programs. Second there are no standardized approaches to assess the quality of citizen science datasets. Third, the educational and scientific outcomes of these programs are not routinely or strategically, measured, or formally integrated into policy and planning (Brossard, Lewenstein, and Bonney 2005).

6.1 Contributions and Major Findings

The focus of this research, understanding tourist volunteers, gives valuable insight into a large population of potential volunteers, and shows that tourist volunteers can produce useful data, and achieve a project's desired educational outcomes. This project shows that although the tourist and resident volunteers start the program with different levels of knowledge and place attachment, they achieved similar outcomes, and the tourists measurably gained place attachment and knowledge during their participation in the program. The two groups of volunteers also produced similar data. It is important to remember that these data collected by the volunteers are simply observations, and not a sufficient sample size to estimate the species population. However, with more observations, temporal and spatial analysis can be done with potentially more precise population estimates from citizen science data.

This project is expected to generate interest from other, tourist-centric locations, such as: other national parks, protected areas, and cultural heritage sites. Citizen science can help people learn about the area they are visiting, while producing scientific data to support that area (Groffman and Stylinski 2010). Specifically for protected areas, these programs can change people's interaction with nature, change the quantity and resolution of biodiversity data, and create new ways to enjoy and experience nature (Jepson and Ladle 2015).

The familiarity that many people have with mobile technology, and mobile applications, prompted the use of this technology for tourist-centric citizen science. This study showed that even though volunteers do not have cellular phone service within the park, during the bus tours, they were still able to use some of the functionality of their smartphones. Although inviting technology, like smartphones into protected areas, such as a national park, is a potential distraction from nature, the use of this kind of technology is inevitable. Thus, a careful and sensitive integration of technology into these natural settings, through citizen science and educational programs, is a way to engage the people who are already familiar with this technology, in an informative way. With mobile technology, the citizen science program can push the envelope of what the volunteers and scientific research can achieve, i.e. higher quality data, and more volunteer independence (Boulos et al. 2011; Dickinson et al. 2012; Hart et al. 2012; Roy et al. 2012; Starr et al. 2014 Coleman 2010; Devisch and Veestraeten 2013).

The advent of new mobile phone-based technologies has made it is easier for the public to collect raw data. As a result, citizen science and VGI are facing potential big data issues. Data quality and data fitness for use assessment is essential to successfully utilize big data datasets, recognizing that greater volumes of data are coming from multiple sources. (Shimizu 2014). This work utilizes a DFFU assessment technique, which can help make decisions on using different datasets for different models and analysis, where the end use requirements dictate the precision of collection techniques. This standard can be used for other volunteered and non-traditional data sets, like mined data from social media, sensor data, etc. Getting the scientific community to trust citizen science data, especially VGI, is a fundamental challenge. By developing methods such as this data fitness for use assessment, citizen science data and VGI will become more accepted by the scientific community.

The scientific and educational outcomes are two critical success factors of citizen science. Measuring these outcomes is crucial to determine program success. This research evaluates the educational and scientific success of the citizen science project in Denali National Park and Preserve, and additionally developed repeatable citizen science outcomes assessment which was used to measure both the educational and scientific success of the Map of Life-Denali citizen science program. Assessments like this one, developed through this dissertation, are necessary, since the educational and scientific impacts of citizen science have not been effectively evaluated and measured (Bonney et al. 2009a;Bonney et al. 2009b; Dickinson et al. 2012).

6.2 Limitations and Future Directions

The aim of this research is to better understand the role of tourists in citizen science, and while this research did achieve this goal, some limitations of the research were discovered and directions for future research were identified. The main limitation of this research is the short timespan during which the study took place, since data was only collected for one Summer season in the study area, Denali National Park and Preserve. Limitations found through the analysis of each of the three research questions is discussed below.

The limited time frame in which these data were collected created limitations in this research in terms of a small sample size for both the surveys, and the species data. These small sample sizes impacted the results from an analysis for the first research question, examining the difference between resident and tourist volunteers in terms of data quality, place attachment and educational outcomes. The difference in sample sizes between the tourists and residents was large– there were many more tourist volunteers than residents, which made it difficult to compare the species data between the groups.

Residents were not captured very well in this case study, since most of the visitors to Denali are tourists, and even some residents could be considered tourists, if they have not been to Denali before. The sample sizes captured in this case study reflect the proportion of tourists versus residents who visit the park. However, this large difference in sample size is not ideal to really capture the differences between the two groups in terms of their participation in citizen science.

To expand upon the first research question, future direction includes examining other volunteer groups, and comparing volunteers and scientific outcomes of these different groups. Additionally, it would be interesting to examine the volunteer's motivation to participate and measure volunteer retention rates, between groups. Also, examining differences within volunteer groups in terms of other demographic factors, such as older and younger tourists may reveal more effective recruiting approaches. Additionally, using a case study in a different study location which includes a higher population of potential resident volunteers would provide a means to more precisely capture the differences between resident and tourist volunteers.

For the second research question, dealing with data fitness for use, small sample size was also a limitation. If more data was collected, the VGI may have been found to be more fit for use in the example research questions. The STAAq assessment was only tested with two other datasets and for one model, however, a more extensive test of the assessment should be done. The STAAq assessment should be used to test data for other applications, besides species distribution modeling, and should be tested with a single dataset.

Future directions for researching Data Fitness for Use in citizen science includes refining the STAAq assessment process, but also comparing this assessment technique to other methods of data quality evaluation. The STAAq could be automated and include web interface components, and possibly a simplified GUI (Graphical User Interface) to allow researchers to examine data fitness easily. The assessment should be tested with standalone datasets, to determine how the assessment can evaluate fitness for use when there are no authoritative datasets for comparison. The STAAq should be tested with other components, and applications.

The third research question included measuring the outcome of the citizen science program through an outcomes assessment and examining how the program can be integrated in to park policy and management practices. Limitations for this portion of the research included managing the logistics of the focus groups with park visitors, and with park officials. The focus groups with visitors were widely advertised to anyone who was visiting the park. Some attendees had no prior knowledge of the citizen science program, and had not yet downloaded the mobile application.

The focus groups and meetings conducted with park officials were mainly organized through my point of contact with the park service, While I had some control over who I met with, and who was invited to attend each of these focus groups, some officials who weren't included until the final focus groups would have made useful contributions to earlier focus groups, and helped shape the objectives and implementation. Also, these focus groups were conducted for park officials only, when they should have been open to park service concessionaires, who operate under contract to the park service, such as Aramark. To include the concessionaire, an interested stakeholder in the program, separate meetings were held to share program status and results. Another limitation of this research, that became apparent during the final focus group meetings with park officials, was the lack of a specific scientific research question that they would have liked to have these citizen science data answer. The park staff generally took a "wait and see" approach to this program. This was also a point of contention amongst several park officials, who did not universally agree on whether citizen science is useful for just data collection to simply collect data, or if there should be a research question driving data collection.

To truly assess if the program is ultimately successful, and integrated into planning and management, the Map of Life-Denali program must continue for another season or more, then be reevaluated. Other uses of these data should also be examined, for example, the park service is thinking of exploring usability of these data in terms of wildlife research and ecological modeling. Social science uses of these data have not yet been explored. The species data collected through the application may be useful for social ecology purposes, such as examining human-wildlife interactions, and visitor wildlife viewing expectations.

This research only examined the role of tourist volunteers in basic data collection. The outcomes of this citizen science project can be compared to others which require different skills from the tourist volunteers. This will further enhance the understanding of tourists in citizen science. Expanding the use of the Map of Life application to other protected areas is another future direction for this research. Additionally, surveying volunteers months after they visit the park, is a potential future direction for this research. These surveys will provide insight into volunteer retention, whether they kept using the standard MOL application in other places, and the retention of knowledge and place attachment.

6.3 Closing

Citizen Science creates opportunities for both volunteers and scientific researchers to gain knowledge, and produce usable scientific data. Researching the capabilities of volunteers, characteristics of these data, and measurable outcomes of these programs, is a prerequisite to ensure successful programs for both the volunteers, and scientists. This research examined three recognized short-comings of citizen science; understanding different groups of volunteers, data quality assessment, and evaluation and integration of volunteer and scientific outcomes. The primary objective of this research is to advance the understanding of tourists in citizen science.

This study's analysis demonstrated that tourists can be effective citizen science volunteers. Tourist and resident volunteers produced similar data, and after their participation in the program exhibit similar place attachment and educational outcomes. Tourists are not widely used as citizen science volunteers; however, I believe with the appropriately designed program, and well defined volunteer roles, tourists can be very successful volunteer contributors.

This study also shows that data fitness for use is a valid way to examine citizen science and VGI data. Data quality is commonly discussed in the citizen science literature; however, the Data Fitness for Use approach has not been previously tested with citizen science data. This research developed, then tested the STAAq assessment which examines the fitness of VGI for a particular application. This stresses that not all data are created equal, and different datasets may be appropriate (or deemed adequate) for different purposes.

This study also showed that program outcomes can be easily evaluated, and this is an important step in evaluating the effectiveness of the overall program. Volunteer feedback, and stakeholder feedback, is also important in program evaluation. This study aimed to explain how citizen science can be integrated into park policy and management. Focus group meetings with park officials, and Aramark (NPS Concessionaire), resulted in their commitment to utilize this program in conjunction with visitor-focused educational programs in Denali NP&P. While this is now recognized as an effective educational tool, there are no concrete plans to use the scientific data, yet. However, through these meetings there are many ideas, discussed above, that have identified possible future plans for the dataset. The project will be integrated into the bus tour itinerary of Denali, through the formal Aramark concession agreement.

Citizen Science has been shown to be an effective educational tool for tourist areas, however, the validity of these data for scientific research purposes are still questioned. The volunteers in this program were overwhelmingly satisfied and felt the program enhanced their educational experience in the park, and helped them feel more connected to the park. While Park officials acknowledged these benefits of the program, they are still reluctant to abandon their traditional data acquisition techniques. In recognition of this lingering reluctance to adopt the scientific aspects of the program, perhaps by examining a specific social science, or social ecology, research question would be an appropriate use of these data, until Park officials develop greater confidence in the data acquisition process. The long-term value of this program will be dependent upon the park service taking ownership of the foundation that has been developed here, and making strategic enhancements over time to increase the utility of the datasets, from a scientific research perspective. This can provide a very cost-effective approach to collecting observations, compared to the ROAR data collection process, which involves compensation for participants.

Citizen science can inspire different groups of people to participate in scientific research. This research project demonstrates that different groups of volunteers can be effective citizen science volunteers, if the program is appropriately designed for the target volunteers. In this case, a simple mobile application was used to allow tourists and resident volunteers with little to no training to participate in the program.

The use of mobile technology was essential for this program. Volunteers did not need extensive prior training on how to use their own smartphones, nor how to download the Map of Life – Denali application. The application was specifically designed to be intuitive, and easy to use, and operate when an Internet connection is not available. Utilization of mobile technology, and the development of applications like Map of Life, are becoming more common in citizen science programs, and the ability to use a volunteer's personal device is an extremely cost effective way to collect data.

Advances with mobile technology, including software applications and hardware sensor type device add-ons (i.e. Land-Zandstra et al. 2016) allow many different types of data to be collected, beyond simply the point location of an animal. Depending on the program, different levels of data collection may be appropriate for different volunteers, because mobile technology allows this flexibility in citizen science.

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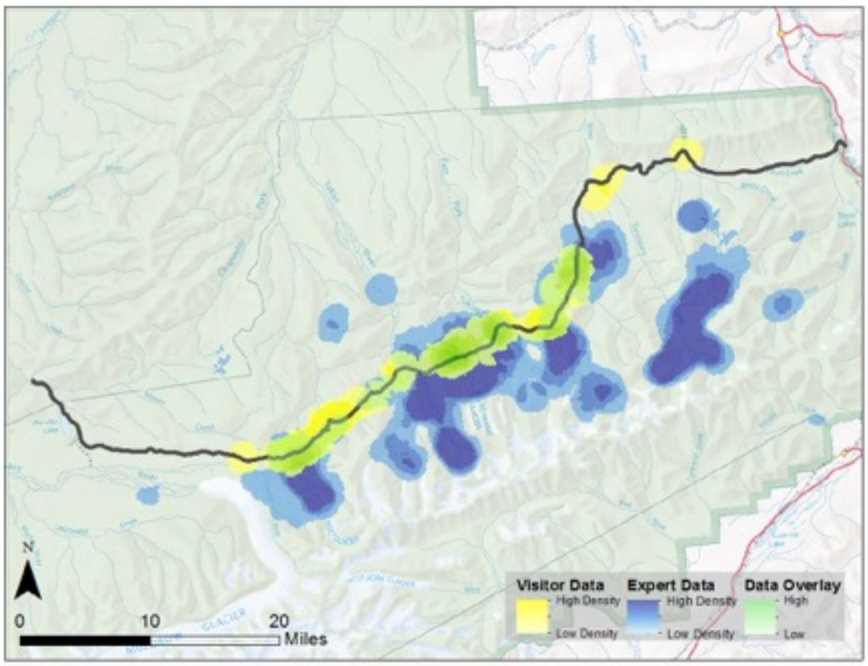
APPENDIX A

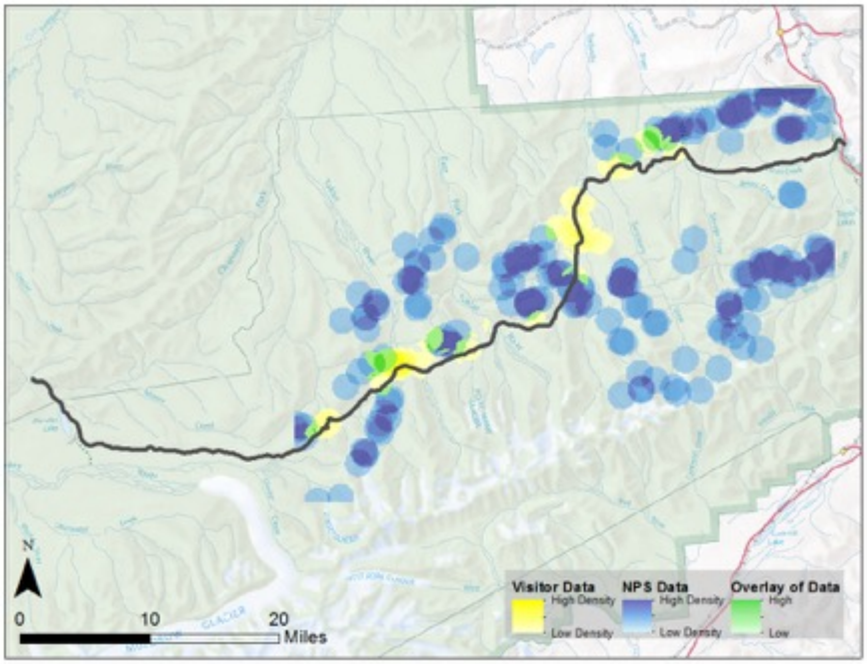
PILOT STUDY RESULTS

A pilot study was conducted in Denali National Park and Preserve during the Summer of 2015. This pilot study provided an avenue for the development of a mobile application that will serve as one of the components of my dissertation research. The goal of this study was to examine the willingness of park visitors to participate in a citizen science program, use technology in the park, and provide spatial data of their wildlife observations. During this pilot study, meetings were conducted with the Denali National Park managers, to gain feedback on the development of the mobile application, and citizen science program.

During the pilot study participants completed a short survey and mapped wildlife observations on a tablet device with a Computer Assisted Interview (CAI) application. The application was loaded with topological maps and satellite images of the park; so, the visitor can toggle between the maps and "draw" on the map to indicate where they observed wildlife in the park. In additional to a "map tab", there was also be a survey tab in which I input the volunteer's responses to interview questions. Using this technology during the interviews provided a basis for understanding how park visitors may use a mobile application to track their individual wildlife observations in the park. The mapping application provided information on which animals are most commonly seen, and where those observations take place. The wildlife observation data gathered from these interviews were used to perform a preliminary analysis on the accuracy and validity of VGI. This provided a basis of knowledge before developing the mobile application. The CAI used to collect wildlife observation data from the visitors provides an example of what the citizen science data may be like using the proposed mobile app. The visitor species data collected is compared to data collected by the National Park Service (NPS) in species density maps. These data collected from the CAI is concentrated in park road area. The park road is the only public access into the park. These data represent a wide variety of the wildlife species present in the park. Overlay analysis was performed to compare the visitor data to expert gathered data (obtained from the NPS). This showed that the distribution of the various species represented in the datasets is similar, especially in areas of high species density. Refer to Figures 1 and 1.



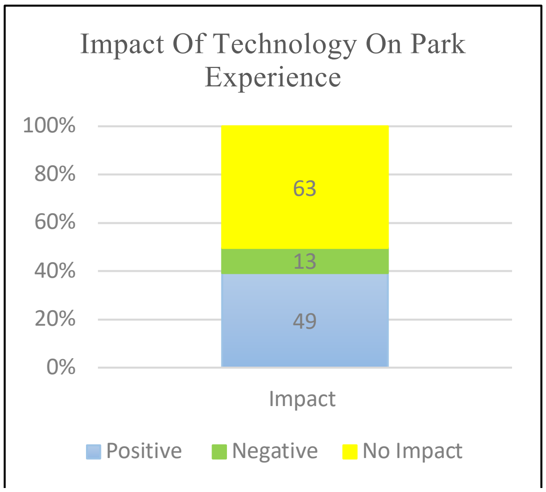
Bear Observations



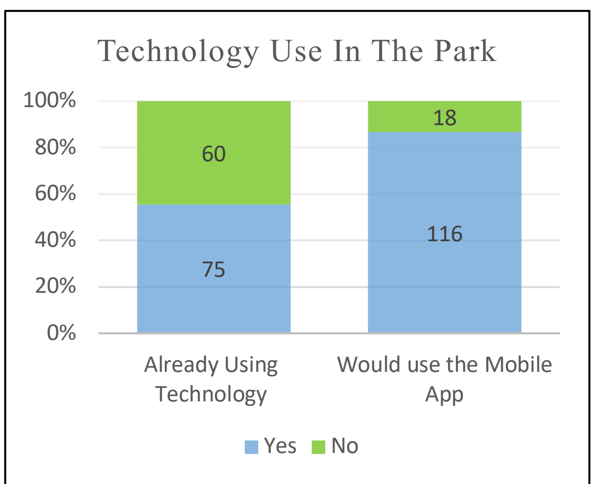
Sheep Observations

The survey questions sought to understand where they have seen wildlife in the park, their opinion on using technology, like a mobile application, and their opinion on providing data to the park. The visitors were asked basic demographic information, such as age range and country of residence. These interviews focused on wildlife observation along the park road. Feedback from these users was used to inform development of the mobile application.

Simple descriptive statistics were used to perform exploratory data analysis on the pilot study data. One hundred and fifty-nine visitors were surveyed at various locations in Denali National Park and Preserve. Over half of the surveyed visitors, 55.5%, used some kind of technology in the park, mainly taking photos on their mobile phones. A majority, 86.5%, of the visitors stated they would willingly use the mobile application. Both the National Park Service (NPS) and visitors want the application to be an educational tool, and many of the visitors specifically want the application to have access to the phone's camera. Half of the surveyed visitors reported that the use of technology in the park would have no impact on their experience in the park. Some reported that technology would actually have a positive impact on their experience in the park, citing that it would help them feel engaged, and help them learn more about the park. Refer to Figures 3 and 4.



Impact of technology on the visitor' experience



Use of Technology in the Park and Potential Use of the Application

APPENDIX B

PRE-VISIT SURVEY QUESTIONS

Map of Life - Denali (Pre-Visit Survey)

Please take this survey upon downloading the Map of Life app.

Participation Consent

You are invited to participate in the testing of the Map of Life-Denali mobile application, in addition to downloading the mobile app, you will also be asked to fill out two surveys, one before your trip into the park and the second immediately after your visit. You have the right not to answer any question, and to stop participation at any time. Your participation in this study is voluntary. If you choose not to participate or to withdraw from the study at any time, there will be no penalty. You must be 18 or older to participate in the study. **Completion of the survey will be considered your consent to participate.** Your responses will be confidential. The results of this study may be used in reports, presentations, or publications but your name and email will not be used. If you have any questions concerning the research study, please contact the research team at: wentz@asu.edu. If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU Office of Research Integrity and Assurance, at (480) 965-6788. Please let me know if you wish to be part of the study.

1. Which Country/ U.S. State are you from?

2. Age?

3. Email Address

Your email will only be used link your survey responses to your wildlife observation from the mobile app, this information will be secured server at ASU and will be deleted upon the completion of this study.

4. How many times have you visited the park?

- ○ First Time
- ○ 1-4
- ○ 5-10
- ○ I live/work in or near the park seasonally or year around.

5. Which Bus are you taking into the park?

- ○ Denali Natural History Tour
- ○ Tundra Wilderness Tour
- ○ Kantishna Experience
- ○ Shuttle Bus (Green Bus)
- ○ Camper Bus (Green Bus)
- ○ Denali Backcountry Adventure
- ○ Kantishna Wilderness Tour
- ○ Lodge Bus to Denali Backcountry Lodge
- ○ Lodge Bus to Kantishna Roadhouse
- ○ Lodge Bus to Camp Denali/Northface Lodge
- ○ Did not take a bus

APPENDIX C

POST-VISIT SURVEY

Please take this survey after you visit the park.

1. Email

Your email address will be used to link your wildlife observations and your surveys.

Denali Wildlife Quiz

Please answers these questions to the best of your knowledge.

2. How far must you stay away from a bear?

- ◯ 100 Yard (meters)
- ◯ 300 yards (meters)
- ◯ 25 yards (meters)
- ◯ 700 yards(meters)
- ◯ I Don't Know

3. What is an indication of climate change in the park?

- ◯ Wildlife behavior changes
- ◯ Tree Line moving higher in elevation
- ◯ glacier melt
- ◯ All of the above
- ◯ I Don't Know

4. Which bird turns all white during the winter?

- ◯ Ptarmigan
- ◯ Mountain Chickadee
- ◯ Common Loon
- ◯ Gyrfalcon
- ◯ I Don't Know

5. True or False, Denali's wolf population has lost nearly 2/3 of its previous population levels.

- ◯ True
- ◯ I Don't Know
- ◯ False

6. What are the two major ecosystems in the park?

- ◯ Tundra and Tiaga (Boreal Forest)
- ◯ Tundra and Rainforest
- ◯ Tiaga and Temperate Forest
- ◯ I don't Know

7. True or False, both male and female Caribou have antlers?

- ◯ True
- ◯ False
- ◯ I Don't Know

8. What should you do if you are confronted by a moose?

- ◯ Stand your ground
- ◯ Throw rocks
- ◯ Run
- ◯ Play Dead
- ◯ I Don't Know

<u>Map of Life- Denali</u>

Please provide your opinion of the mobile application and how it has impacted your park experince below.

9. Which words or phrase would you use to describe Denali National and Preserve?

- [ ] Wilderness
- [ ] Home
- [ ] Wildlife
- [ ] Attached
- [ ] Sense of Place
- [ ] Cold
- [ ] Sightseeing
- [ ] Connected
- [ ] Nature
- [ ] Boring
- [ ] Happiness
- [ ] Conservation
- [ ] Other (please specify)
- [ ] Hiking
- [ ] Expression of who I am
- [ ] Mountains
- [ ] This park defines me
- [ ] Camping
- [ ] This park means a lot to me
- [ ] Belonging
- [ ] Favorite National Park
- [ ] Enjoyment
- [ ] Unique
- [ ] Knowing
- [ ] Being a part of nature

10. Please rank the statements below

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The Map of Life Application (app.) was easy to use.	◯	◯	◯	◯	◯
The app. enhanced my educational experience in the park.	◯	◯	◯	◯	◯
Using the app. helped me feel connected to the park.	◯	◯	◯	◯	◯
Using the app. helped me feel connected to nature.	◯	◯	◯	◯	◯
Using the app. made me aware of my own actions towards the environment.	◯	◯	◯	◯	◯
Technology is not appropriate in a natural/wilderness area.	◯	◯	◯	◯	◯
I enjoy visiting this park and its environment more than any other national parks.	◯	◯	◯	◯	◯
I don't find what I love about Denali in other wilderness areas.	◯	◯	◯	◯	◯

11. Would you use the Map of Life app again, either in Denali or elsewhere?

◯ Yes

◯ No

◯ Other (please specify)

12. What is your overall opinion of the Map of Life-Denali Application

Please include any recommendations for additional functionality of the app, such as photo observations, connection to social media, etc.

Thank you for your participation.

You will be entered to win a $100 Amazon.com gift card, you will be noticed via email if you won.

If you have any questions please email Heather Fischer, heather.fischer@asu.edu.

APPENDIX D

VOLUNTEER FOCUS GROUP SURVEY

Consent: Your participation in this study is voluntary. If you choose not to participate or to withdraw from the study at any time, there will be no penalty. You must be 18 or older to participate in the study.Completion of the survey questions will be considered your consent to participate.There are no foreseeable risks or discomforts to your participation. With your permission, the interview will be recorded with a digital audio recording device. Your responses will be confidential and only the research team will have access to the recordings. The recordings will be deleted immediately after being transcribed and any published quotes will be anonymous. Let me know if, at any time, you do not want to be recorded and I will stop. The results of this study may be used in reports, presentations, or publications but your name and email will not be used. If you have any questions concerning the research study, please contact the research team at: hafische@asu.edu

1. Email Adress

2. Age?

◯ Under 25 ◯ 25-30 ◯ 31-40 ◯ 41-55 ◯ 56-65 ◯ 66-75 ◯ 76+

3. Where are you from?

4. Why did you want to visit the park?

5. Which animals are you most interested in seeing?

6. Have you engaged in citizen science programs before?

◯ Yes ◯ No

7. Why do you participate in citizen science programs?

8. Please rate the following statements

	Strongly Agree	Agree	Somewhat Agree	Disagree	Strongly Disagree
Educational and interpretive experiences are important to me during my visit to Denali.	○	○	○	○	○
I enjoy participating in citizen science programs.	○	○	○	○	○
I enjoy being more engaged in Denali.	○	○	○	○	○
I enjoyed participating in the Map of Life-Denali citizen science project	○	○	○	○	○
I would use the Map of Life application again to collect data in other areas	○	○	○	○	○
I don't think mobile technology should be used in a wilderness setting like Denali	○	○	○	○	○

9. What are your opinions of using mobile technology in the park?

10. Any other comments about the Map of Life app or citizen science?

APPENDIX E

PARK OFFICIAL FOCUS GROUP QUESTIONS

Introduction

Heather Fischer has asked you here to discuss the Map of Life-Denali Citizen Science Program. This program focuses on the use of the Map of Life mobile application, which allows visitors to geo-tag their wildlife observations while in the park. The educational goal of this project is to provide an interpretive and educational experience for park visitors through the use of the mobile application. The scientific goal is to collect species observation data to be used for REP planning and reports.

Focus Group 1:

The mobile application will be introduced to the focus groups; they will be encouraged in advance to download it to their phones. Heather will also have a live demo of the application to show the focus group how the app works. The volunteer surveys were presented to the focus group for feedback.

1. Do you agree with the general educational and scientific Goals of the citizen science project?
2. What should the participants be learning from the program?
3. What kind of data do we expect to get out of the program?
4. Should more specific goals be created for the project? If so what should these goals be?
5. How can the citizen science project be advertised and integrated into educational initiatives and program this summer? How can it be integrated long-term in these programs?

6. How can the scientific outcomes of the citizen science project be integrated using data from the program, into park planning and management?
7. What is the baseline of knowledge for the “quiz” section of the surveys?
8. What is the baseline of agreement for the comparison of the VGI and ROAR data sighting indices?
9. Overall opinions of the survey questions.
10. What are your opinions of the mobile application?

Focus Group 2:

Present the outcomes of the educational and scientific assessment.

1. Did the program meet our educational and scientific goals, why or why not?
2. Did the program meet the scientific goals, why or why not?
3. Will the VGI be integrated into park reports and planning processes? Why or why not?
4. What improvements should be made to the citizen science program? To the mobile application?
5. How will the program be integrated into educational initiatives next summer?
6. How will the data be integrated into park planning and management long-term?

Focus Group 3:

Present the outcomes of the educational and scientific assessment.

1. Did the program meet our educational and scientific goals, why or why not?

7. Did the program meet the scientific goals, why or why not?
8. Will the VGI be integrated into park reports and planning processes? Why or why not?

9. What improvements should be made to the citizen science program? To the mobile application?
10. How will the program be integrated into educational initiatives next summer?
11. How will the data be integrated into park planning and management long-term?

APPENDIX F

NON-RESPONSE SURVEY

1. Non-Response Cause

- ◯ No Conact
- ◯ Refusal
- ◯ Not Able

2. If Refusal, Why?

- ◯ Does not want to participate
- ◯ Does not want to use phone or download app
- ◯ Will not speak with me
- ◯ Other (please specify)

3. If Not Able, Why?

- ◯ Does not have phone (or iPhone until Android is ready)
- ◯ Does not have time to download
- ◯ Leaving the park
- ◯ Other (please specify)

4. Demographics, No Contact

- ☐ Young (18-30)
- ☐ Middle Aged (30-60)
- ☐ Older (60+)
- ☐ White
- ☐ Black
- ☐ Latino
- ☐ Asian
- ☐ Other (please specify)

5. Demographics, Refusal

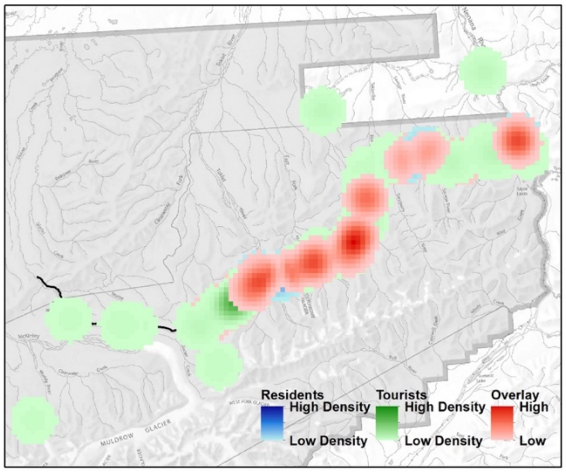
- [ ] Young (18-30)
- [ ] Middle Aged (30-60)
- [ ] Older (60+)
- [ ] White
- [ ] Black
- [ ] Latino
- [ ] Asian
- [ ] Other (please specify)

6. Demographics, Not Able

- [ ] Young (18-30)
- [ ] Middle Aged (30-60)
- [ ] Older (60=)
- [ ] White
- [ ] Black
- [ ] Latino
- [ ] Asian
- [ ] Other (please specify)

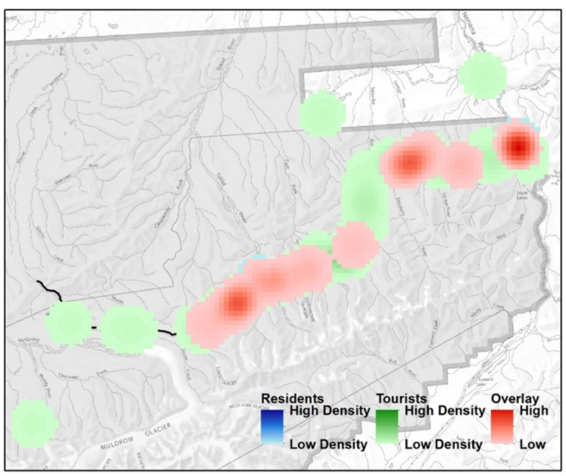
APPENDIX G

DATA QUALITY ANALYSIS MAPS



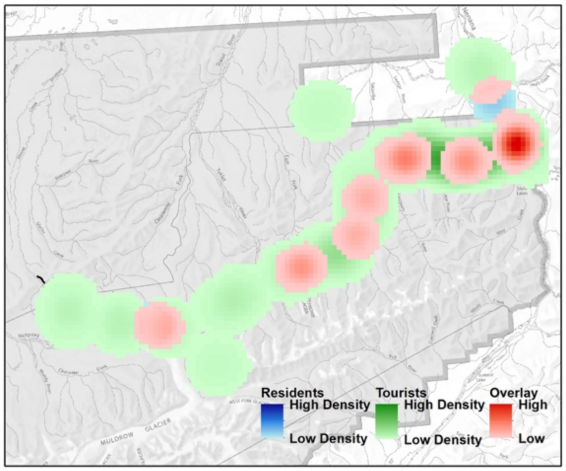
Grizzly Bear Observations, Residents provided 21 observations from 8 volunteers, and Tourists provided 137 observations from 77 volunteers.

The overlay area for the Grizzly Bear observations is 603km^2 (47.39% total overlap), 48.7% of the tourists observations overlap with resident observation, 95.40% if the residents overlap with the tourists observations (Figure 5.3). The red represents where these data overlaps, also depicts hotspots–areas where there is a high density of observations. The darker red shows hotspots which overlap. The residents observations are not very visible in the figure 5.3, it overlaps over 95% with the tourists data.



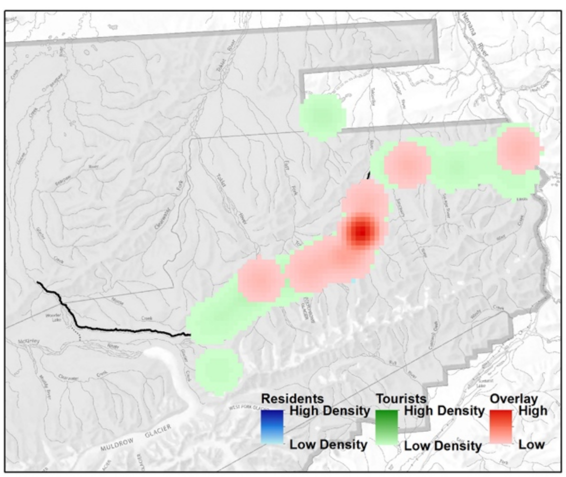
Caribou Observations, tourists provided 254 observations from 76 volunteers, residents provided 47 observations from 9 volunteers.

The total overlay area is 696km^2 (30.0%), the tourist observations overlap 79.63% with the resident observations, the resident observations overlap 98.30% with the tourist observations. In figure 4.5 the red represents the area of overlay, the blue represents the residents observations, and the green represents the tourist observations. The darker colors represent "hotspots" or areas of a high density of observations. The "hot spot" in the overlay area shows where hotspot of the residents and tourists data overlap with one another. The "hotspot" areas on the map are known areas of summer caribou habitat in the park.



Moose observations, Tourists provided 97 observations from 59 volunteers, and residents provided 20 observations from 13 volunteers.

The area of overlap is represented in red (Figure 4.7), the total area of overlap from the two observations datasets is 681km^2 (23.9% total area overlap). The tourist observations (green in figure 4.7) overlap 74% with the resident observations. The resident observations (blue in the figure 4.7) overlap 96.73% with the tourist observations. The darker areas on the map show areas of hotspots which indicates a higher density of sightings. The overlay (red) shows where the two sets of observations overlap the darker red area indicate shared hotspots, where both datasets have a higher density of observations. It is expected to see a high density of moose observation near the park entrance area (upper right-hand side of the map), this known moose habitat. The other overlaid hotspots also occur in areas of known moose habitat.



Sheep Observations, 64 tourists recorded 118 observations, 18 observations were recorded by 7 residents

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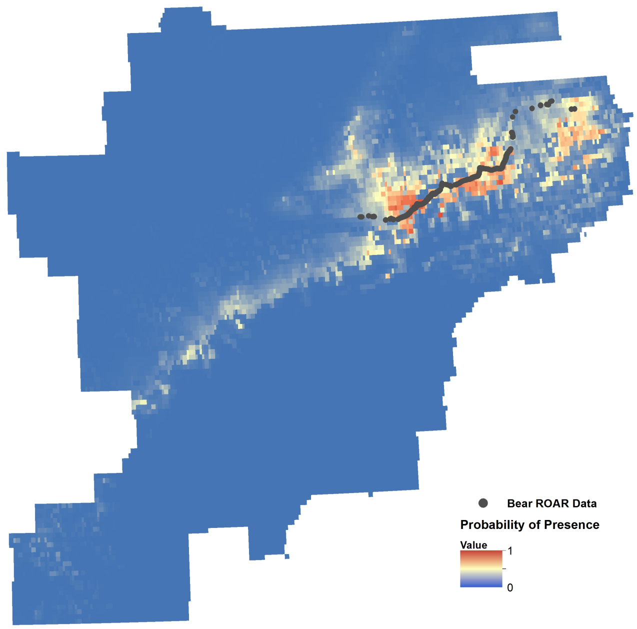
The total overlapping area is 518km^2, the tourist observations overlap 47.39% with the resident observations, the resident observation overlap 100% with the tourist observations. The overlay area, shown in red in figure 4.10, shows where the tourist and resident observations overlap. The darker red shows hotspots, where high densities of resident and tourist observations overlap. The resident data is covered by the overlay in this map because the resident observations overlap 100% with the tourist observations. The tourist observations are shown in green. The main hotspot in this map occurs around the Teklanika area of the park, around mile marker 30-35 on the park road, this is an area known for summer sheep habitat.

APPENDIX H

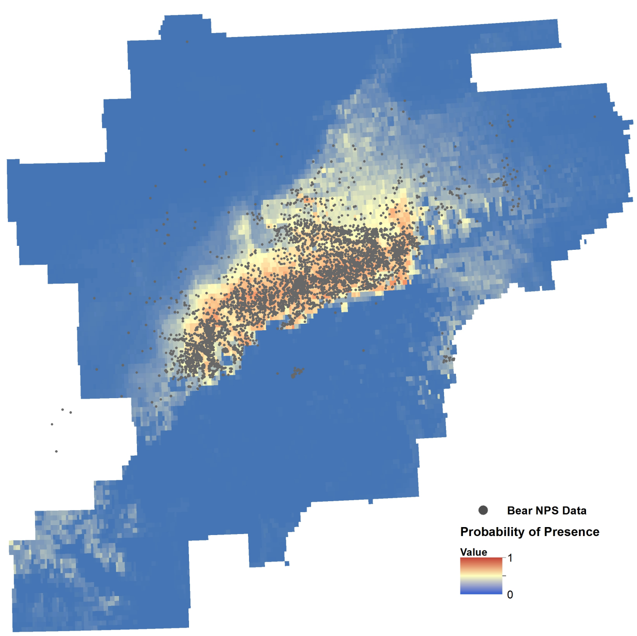
SUPPLEMENTAL SPECIES DISTRIBUTION MODELS

SDM models

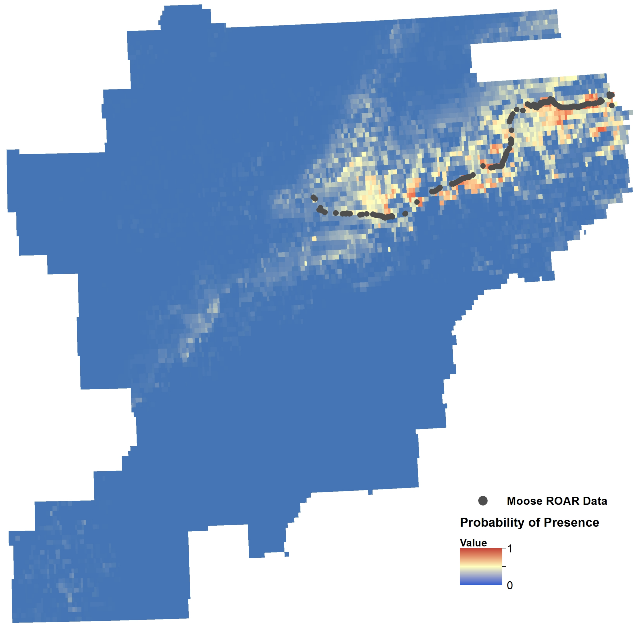
Species distribution models were performed for each of the 5 selected species, bear, caribou, moose, Dall sheep, and wolf, for each of the datasets, ROAR, and NPS. Each model was executed using the same environmental variables, seasonal precipitation, seasonal temperature, land cover, elevation, and slope. This case study focuses on wildlife presence during the summer season.



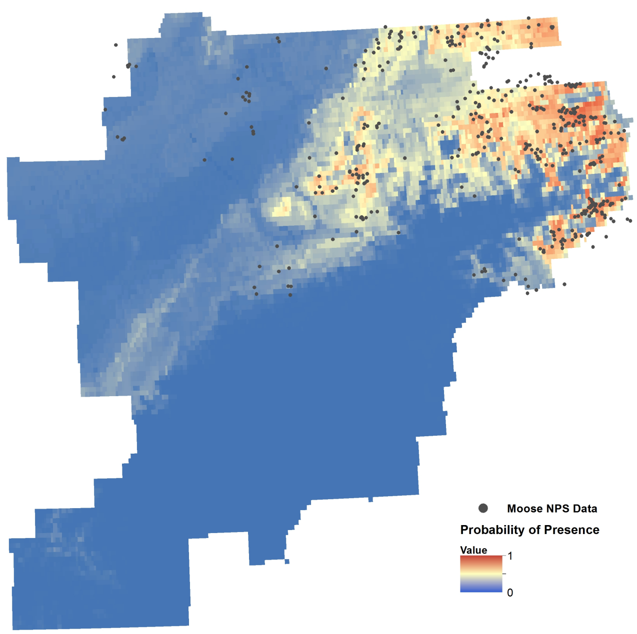
Grizzly bear ROAR



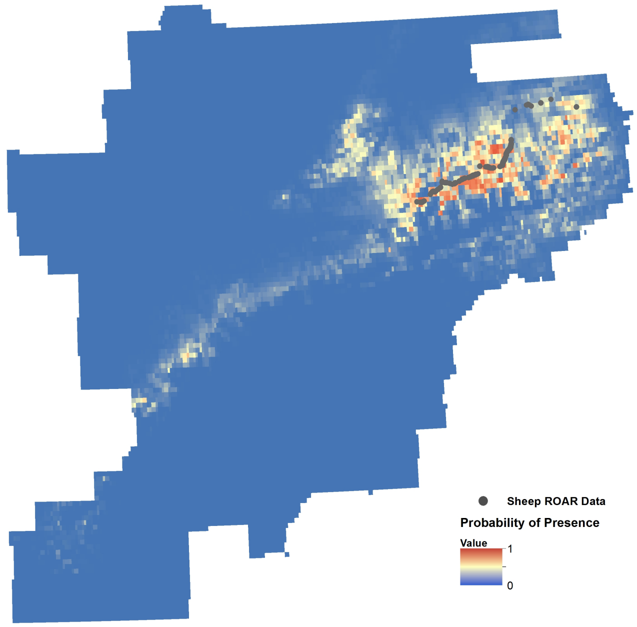
Grizzly bear NPS



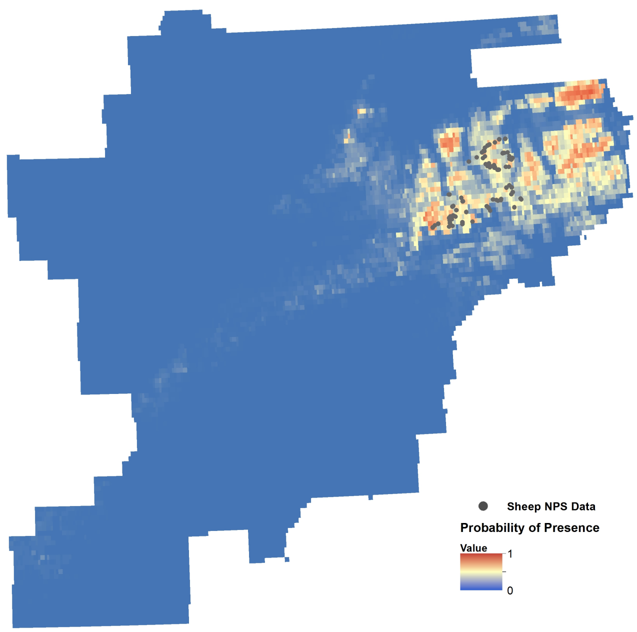
Moose ROAR



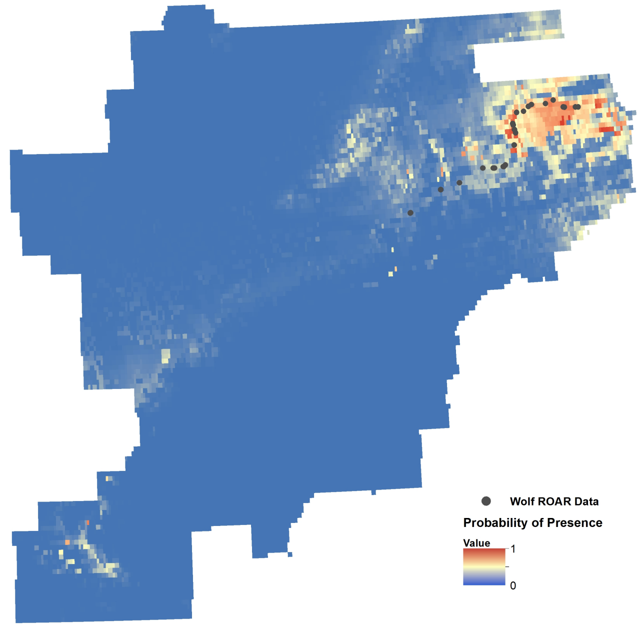
Moose NPS



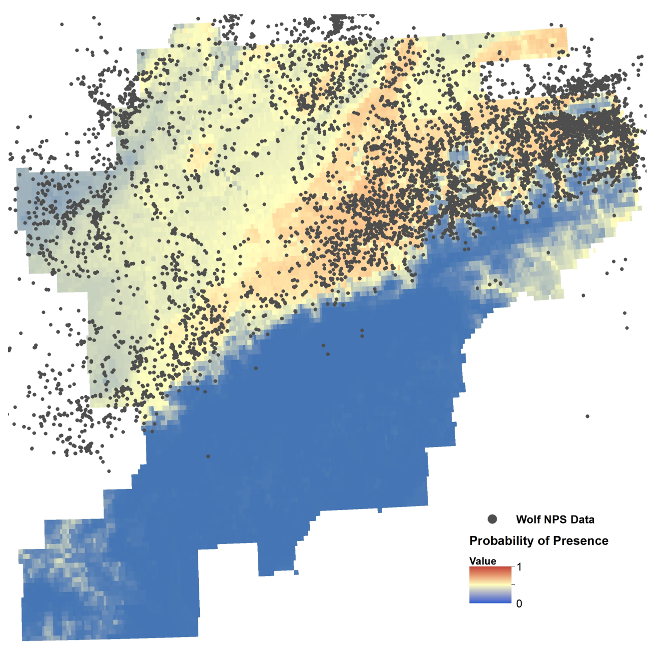
Dall sheep ROAR



Dall sheep NPS



Wolf ROAR

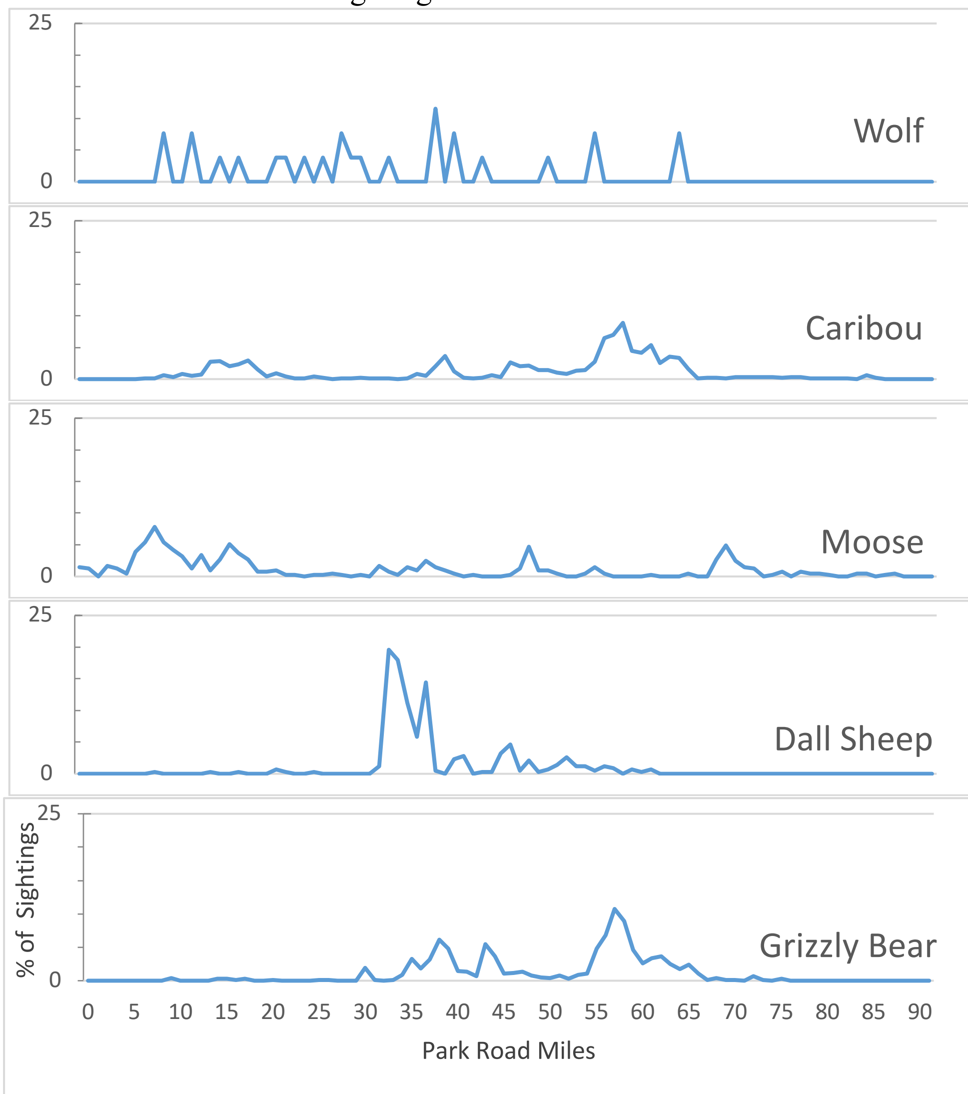


Wolf NPS

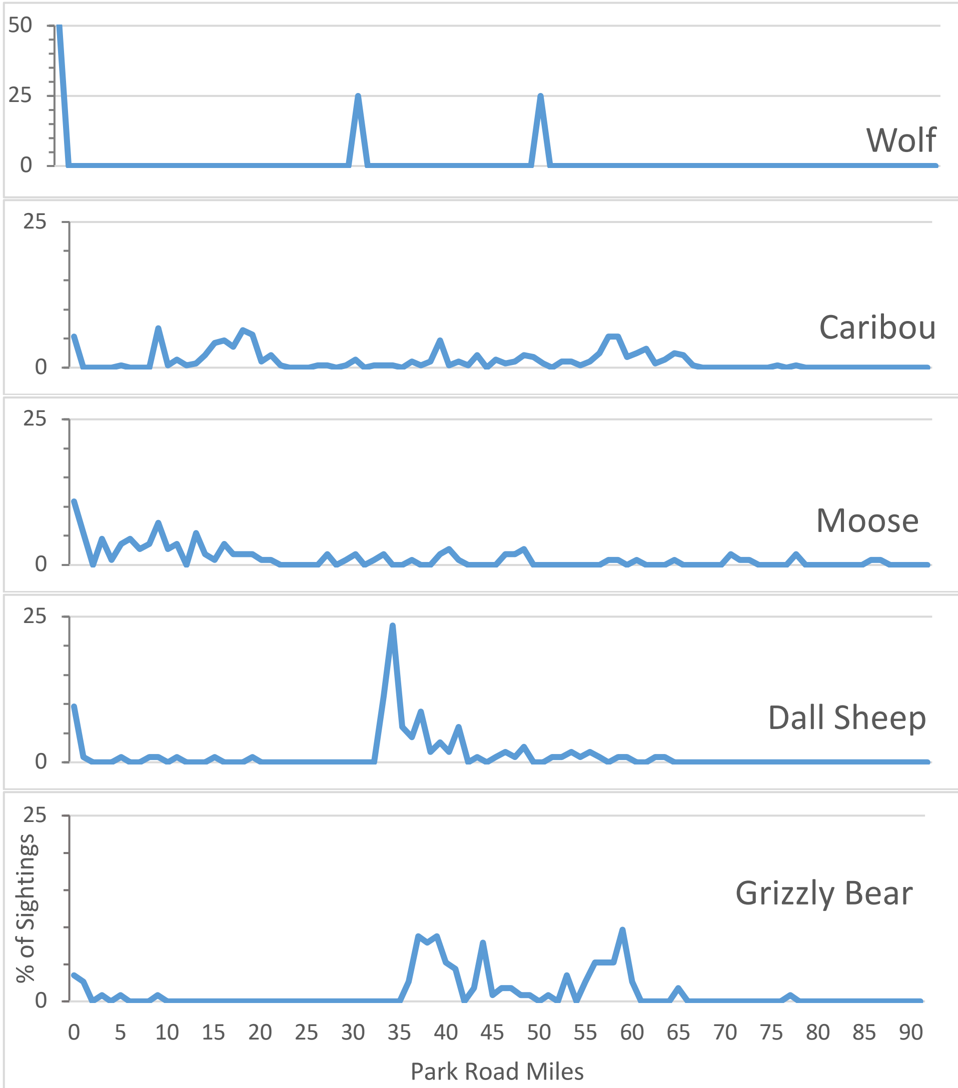
APPENDIX I

ROAD SIGHTING INDEXES

Road Sighting Index with ROAR data



Road Sighting index with MOL Data



APPENDIX J

RESEARCH APPROVALS AND PERMISSIONS

SCIENTIFIC RESEARCH AND COLLECTING PERMIT Grants permission in accordance with the attached general and special conditions United States Department of the Interior National Park Service Denali	Study#: DENA-00905 Permit#: DENA-2016-SCI-0002 Start Date: Jun 01, 2016 Expiration Date: Aug 31, 2016 Coop Agreement#: Optional Park Code:

Name of principal investigator:
Name: Mrs Heather Fischer **Phone:**8018703365 **Email:**hafische@asu.edu

Name of institution represented:
Arizona State University

Co-Investigators:

Study Title:
Tourist-Volunteers and Citizen Science: Case Study in Denali National Park and Preserve

Purpose of study:
The National Park Service's and Denali National Park and Preserve's Centennial is fast approaching. With these milestones in mind, focus has been placed on how the park service can generate a new generation of visitors, and park supporters. This focus lends itself to developing new visitor-centric citizen science programs geared toward using familiar technology, like mobile applications to engage a new generation of park visitors. A citizen science program will be developed specifically for Denali National Park and Preserve in Alaska. The program will require volunteers (both residents and visitors) to record their wildlife sightings (data will include species name and location of sighting) within the park, using a mobile phone-based application.

In these programs, public volunteers are actively engaged in scientific research, mainly through data collection, but at times through research project design and data analysis. This engagement enables volunteers to gain valuable knowledge while providing support to the scientific research (Brossard, Lewenstein, and Bonney 2005b; Conrad and Hilchey 2011; Gouveia et al. 2004). This creates a bidirectional flow of knowledge between the public and scientists, which can produce positive research and educational outcomes for the program (Gouveia et al. 2004; Brown, Kelly, and Whitall 2014; Couvet et al. 2008; Rick Bonney et al. 2009; Tulloch et al. 2013; Bonney et al. 2014).

The proposed work stems from Heather Fischer's dissertation research, which seeks to advance the understanding of citizen science tourist-volunteers. In order to develop a successful citizen science program for a tourist destination like national parks, the impact of tourist volunteers of the research and educational outcomes of these program must be better understood. Tourists may not be the ideal volunteer for certain citizen science as they generally do not have time to be trained to participate in the program, or will be unable to participate in the program long term. However, tourists represent a large pool of potential volunteers, who can be used to collect large datasets and they are typically eager to learn more about the area they are visiting.

Subject/Discipline:
Social Science

Locations authorized:
Visitors Center, Murie Science and Learning Center, Backcountry Information Center, Riley Creek Campground

Transportation method to research site(s):
Park Busses and private car.

Collection of the following specimens or materials, quantities, and any limitations on collecting:

Name of repository for specimens or sample materials if applicable:

Specific conditions or restrictions (also see attached conditions):
OMB approval required before NPS staff may distribute survey tool.

The following are a few of the major considerations about research in Denali National Park and Preserve.

ALL PROPOSALS:

SAFETY

The safety of researchers, park staff, visitors, and wildlife is always the first priority. Researchers must obtain training in road safety and bear safety, if applicable. IT IS EXTREMELY IMPORTANT TO COMPLY WITH FOOD STORAGE GUIDELINES so that wildlife, especially bears, do not get access to food. Researchers sign a bear safety sheet acknowledging that they have read the guidelines for bear safety.

PARK ACCESS
Researchers must request access into the backcountry overnight (backcountry permit). Researchers must justify any requests for use of private vehicles along the road corridor (why not use a shuttle bus?) or access by aircraft into Denali wilderness.

WILDERNESS
Researchers should plan research with wilderness and "Leave No Trace" ethics in mind. Access research sites by durable surfaces(e.g., river bar, rock) where possible; make repeated measurements at sites without backtracking to minimize trampling; move campsites every two days; remove any temporary flagging; etc. If you are planning to conduct your work in designated or eligible wilderness within the park, some useful information for planning your work can be found by navigating to http://www.nps.gov/akso/science.html and selecting the link to "Wilderness Research in Alaska's National Parks".

COLLECTING
If collection of specimens or objects is approved, and if specimens or objects will not be destroyed in analysis, researcher must contact Museum Curator prior to collecting to obtain an accession number which will be used in all field notes, and linked to photographs, and other associated information about the specimen or object. Collections from Denali are government property. Loan agreements must be arranged to house the specimen or object at a place other than the Denali museum collection for short or long periods of time.

DATA and REPORTS
Researchers provide copies of their field notes, data, and photos (for archiving) and copies of the final report, any publications and abstracts, and dissertation or theses to Denali research administrator for the Denali technical library.

LINKING RESEARCH AND EDUCATION (SHARING YOUR RESEARCH)
Because research and the communication of research results are valued by Denali staff, researchers at Denali are strongly encouraged to include in their studies an educational component. The educational component is very flexible and depends on the nature of the research. The educational component is in addition to information in the Investigator's Annual Report. The educational component provides an opportunity for the investigator to share his/her research findings, and for the park to benefit from the knowledge gained about park resources. There are unlimited options for the format or approach of the educational component. Examples include giving a program for a general park audience, developing a research-based curriculum for classroom or website use, providing text and photos for a two-page fact sheet (handout), and creating popular articles, book chapters, or other media. Ideas can be discussed with park staff (i.e., research administrator and park research liaison, or the education coordinator of the Murie Science and Learning Center).

Lots of useful information for researchers can be found on Denali's webpage: www.nps.gov/dena/naturescience/research

Recommended by park staff(name and title):

[signature]

Reviewed by Collections Manager:

Yes ____ No X

Approved by park official:

[signature]

Date Approved:

[handwritten date]

Title:

Deputy Superintendent

I Agree To All Conditions And Restrictions Of this Permit As Specified
(Not valid unless signed and dated by the principal investigator)

[signature] (Principal investigator's signature)

5/3/16 (Date)

THIS PERMIT AND ATTACHED CONDITIONS AND RESTRICTIONS MUST BE CARRIED AT ALL TIMES WHILE CONDUCTING RESEARCH ACTIVITIES IN THE DESIGNATED PARK(S)

EXEMPTION GRANTED

Elizabeth Wentz
Liberal Arts and Sciences, College of (CLAS)
480/965-5619
WENTZ@asu.edu

Dear Elizabeth Wentz:

On 3/15/2016 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Tourist-Volunteers and Citizen Science
Investigator:	Elizabeth Wentz
IRB ID:	STUDY00003874
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• RecruitmentScript, Category: Recruitment Materials; • TouristCitSciConsent, Category: Consent Form; • Tourists In Citizen Science Protocol, Category: IRB Protocol; • Survey Questions, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 3/15/2016.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc: Heather Fischer
Heather Fischer
Elizabeth Wentz