

**Natural Places & Digital Spaces:
Challenges and Opportunities for Instagram in Biodiversity Conservation**

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ABSTRACT

Science communication through social media is an area of research that has gained much international interest. Yet there lacks robust information of environmental education on Instagram specifically, as well as its relationship to the fields of conservation biology and conservation management, which is where this research is most meaningful. This paper explores the proliferation of the social media platform, Instagram, into the field of conservation science by examining the opportunities and challenges in three case studies.

- ❖ **Chapter 1** investigates how Instagram has influenced protected areas and protected area management. Primary data is offered to demonstrate the influence that parks have over its visitors along with an outline of the current and future state of its use by parks.
- ❖ **Chapter 2** uses empirical and observational data to analyze the perspectives of 18 Science Communicators on the emergence of scientific engagement on Instagram. Concentrating on its impacts for wildlife biology and conservation, guidelines for ethical and effective science communication are offered.
- ❖ **Chapter 3** assesses the usability and reception of Instagram as a tool for environmental education based on experimentation, analysis and survey results. The dichotomy between humans and nature caused by technology (Kesebir and Kesebir, 2017) is challenged in this case study, through disseminating engaging environmental information on Instagram.

The 2018 IPCC special report revealed that the next 11 years are most crucial in maintaining global temperature increase below 1.5 degrees (IPCC, 2018) which requires implementing drastic changes to all levels of society. To address this need, this research will identify new opportunities and challenges for conservation biology from bringing environmental awareness and education to Instagram.

“Claiming that the ultimate goal of environmental education is the development of an environmentally literate citizenry, makes environmental education a deliberately political act.” (Cole, 2007).

FOREWORD

The nature and role of the following research project is explained within this paper as it relates to fulfilling the requirements of the Masters of Environmental Studies (MES) degree. The Faculty of Environmental Studies at York University has provided me with the unique opportunity to embrace interdisciplinarity through all aspects of my undergraduate and graduate career which has not only shaped my research but my perspective and approach to life as well. This directly allowed me to create many opportunities and experiences while conducting my research.

The Faculty of Environmental Studies (FES) has provided me with the flexibility to be able to tackle my initial research question of *“How can Eco-DRR be applied to an Ecohealth Framework to mitigate health impacts posed by coastal flooding in Guyana?”*. To fulfil my learning objectives of this topic, I was able to engage in experiential learning at York’s Eco Campus in Costa Rica, and create independent courses such as researching at the Caribbean Community Climate Change Centre in Belize. These invaluable experiences allowed me to realize the value, urgency and extent of this research and I decided that it may be better pursued in future endeavours. My focus shifted to one of my independent courses entitled, *“Analyzing the influences Instagram has on the field of conservation: awareness, protected area management, conservation education and human behavior”* which became my finalized research area to pursue.

Both topics relate to the Area of Concentration (AofC) of biodiversity conservation at their core and aim to better understand how biological conservation approaches can remain effective under changing circumstances. In fulfillment of broadening my understanding and application of the AofC, I was able to work on projects such as being a Biodiversity Monitoring Technician, intern with Climate Action Network Canada to organize a climate change conference (ClimaCon 2018) at York University, attend a luncheon with the Climate Caucus and Members of Parliament in Ottawa, and compile data on endangered and threatened species for Ontario Nature. My research journey allowed me to speak to professionals in the fields of climate change, conservation and Ecohealth which enhanced my learning experience overall and enriched the outcome of my final paper.

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I'd like to extend a special thank you to the professors who have shaped my graduate experience to be an enjoyable and prosperous one. Namely Tanya Chung-Tiam Fook who took the time to mentor me, Jose Etcheverry who always provided encouragement with his optimism, Martin Bunch and David Etkin who assisted in shaping my initial project along with Dr. Ulric Trotz with the Caribbean Community Climate Change Centre and last but not least, my Supervisor, Sheila Colla, who openly and promptly communicated throughout all stages of my research, offered opportunities that diversified my overall learning experience in FES, and most importantly, saw the breadth of my research before I did. Thank you all for believing in my potential and providing me the tools, connections and inspiration that will continue to inspire me in the climate change and conservation job sectors.

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Thank you to my Research Assistant, Lovelle Navos who undertook the role of data collection in Appendix A. Your enthusiasm to take on this project, punctuality and organization is greatly appreciated.

Finally, a huge thank you to my parents who have always encouraged my scientific curiosity through childhood, from engaging in philosophical debates, to giving me my first microscope. Thank you for always exploring the outdoors with my sisters and I from teaching us how to fish as a toddler, make my own fire, the interconnectedness of living things, and the benefits of maintaining a backyard garden. Thanks for answering my many questions about animals as a child, watching every nature documentary, and letting me play with worms even when it made you squeamish! As I grow, I have come to realize how my interactions with the outdoors and fondness for living things have shaped me as a person. More so, thank you for instilling values in me throughout my elementary years, which have allowed me to complete this paper and for suggesting I pursue graduate school in the first place, making me the first in our family to do so. Thanks to all my family and friends who showed me patience and undying support throughout the writing process; I could not have done this alone.

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BACKGROUND

Instagram (IG) is a visual-based social networking platform where users can share photographs and short videos of various content. The application began providing a creative outlet for users in 2010, and was strictly used to share photos and ‘follow’ other users. It has since then expanded to be one of the most widely used social media platforms that is significantly different from its origin. For instance, Instagram is seen to be an excellent marketing tool for businesses¹, entrepreneurs, social media influencers, celebrities and even politicians with its interactive interface and ease of access.

Along with the diversity that is represented among Instagram’s one billion, and growing, monthly users (Clement, 2019), the app itself has diversified its features and now includes animated filters, as well as live and temporary videos which are similarly seen on Snapchat. The *Instagram Story* feature was introduced to allow videos, photos, or typed messages to be posted in sequence, each lasting a few seconds to create a ‘Story’. As well, *Instagram Checkout* is a new feature that allows users to make in-app purchases from selected brands² and eventually book appointments for services (Instagram, 2019a). Driven by its focus on visual-based content, the app *Instagram TV* (IGTV) was created where viewers can watch and interact with live videos in full-screen for up to one hour (Instagram, 2019b). Instagram Stories have given users more of an interactive experience over the past year allowing them to answer, ask and share questions, discuss their opinion, participate in polls, answer multiple choice questions, all of which are tallied and saved within the app temporarily. More recently as of May 2019, it has become one of the first social media platforms to eliminate the number of ‘likes’ that are seen on a post, shifting the drive for users to produce content that resonates with them rather than compare the number of likes the content receives.

With all of these features and likely more to come, it is clear that Instagram is becoming an increasingly interactive and user-driven experience. Inevitably, this has led to the creation of

¹ 8 million businesses use business profiles worldwide predominantly the US, Brazil, Indonesia, Russia and the UK (Instagram, 2019).

² As of March 2019

virtual communities of people who share common interests Instagram which include: fitness, education, photography, social movements, beauty, food, travel and many others. Wildlife photographers, nature enthusiasts and conservation organizations alike have use this platform which led to a large community of users who share their appreciation for nature. Environment-related posts are also shared by businesses, activists, artists, NGO's and scientists in multiple formats. Such posts reveal a variety of topics to the public such as: eco-friendly products, tips to sustainable living, veganism, global carbon emissions, animal rights, politics, environmental justice and many others. This year, the most mainstreamed environmental topics internationally on IG include plastic pollution in oceans and climate change.

As this community has expanded, it is evident that Instagram has high potential to effectively and rapidly disseminating environmental related information, which is a relationship that is understudied. Science communication through social media is an area of research that has gained much international interest, yet there lacks robust information of environmental education on Instagram specifically, as well as its relationship to the fields of conservation biology and conservation management which is where this research will be most meaningful. The analysis of Instagram in this regard is divided into three chapters by first investigating how Instagram has influenced protected areas and protected area management, its usability in the transformation of science communication and third, its applications as a tool for environmental education.

CHAPTER ONE:

The Relationship Between Instagram and Protected Area Management

Introduction

The increasing trend of human populations living in cities is typically used to explain the weakening human connection to nature while urbanization rates remain consistent from the first half of the 20th century to the second in the U.S and U.K (Kesebir & Kesebir, 2017). However, the human disconnection from nature is more so correlated with technological changes overtime (Kesebir & Kesebir, 2017) and the ability for children to create memories in outdoor spaces is on the decline (Rivkin, 2000). Yet, considering that users can access their mobile phone virtually anywhere and anytime, along with our visual-oriented culture, (Lee et al., 2015) this research demonstrates how Instagram has become one of the most accessible ways to learn and appreciate nature from around the world. In fact, researchers argue that such artistic creations are crucial in compelling audiences to personify biodiversity problems and construct social relations when discussing conservation (Seppänen & Väliverronen, 2003). Instagram allows users worldwide to see outdoor spaces to which they would otherwise lack access. However, these images are not only generated by park visitors but are shared by the parks themselves which is a relationship this chapter will further investigate.

Historical Context

From the creation of national parks in Canada at the beginning of the 19th century, protected areas were primarily created to generate revenue by exploiting the scenic landscapes for consumption by affluent tourists (Shultis and Way, 2006) and locals, with conservation value being a convenient addition. National parks have been unable to directly interact with visitors and reach as wide of an audience as they currently do through Instagram.

When Canada's first national park³ was created in 1887, advertising was done in local newspapers and by the Canadian Pacific Railway Company who tried to increase passenger traffic

³ Banff National Park, Alberta, Canada

by publicizing the scenic and recreational attractions within the park (Lothian, 2010). The first attempt at providing the public with ecological information about the park was done through creating a small museum which was established 1894 (Lothian, 2010), most accessible by locals. The first illustrated pamphlet that introduced national parks in the Canadian Rockies was published in 1909. A lantern slide library was later organized in the 1920s (Lothian, 2010) to publicize attractions and conservation objectives at the national parks which was presented by lecturers.

As opposed to learning of national parks from newspapers, posters or conversations held among a small and elite group of people, the beauty of protected areas is seen worldwide through social media regardless of education, race, or ethnicity (Chou et al., 2009), enabling park information to be accessed by anyone who has access to Instagram. Instagram accounts that are run by protected areas or their tourism boards have a have a significant influence over their visitors. The data presented in Appendix A, demonstrates how national parks in Canada and the United States use their platforms to convey messages related to their lands and the size of their Instagram audience to date. Information collected in the dataset excludes pages for trails (@ExploreTheBruce), non-federal parks that are managed provincially (@OntarioParks) conservation authorities (@cvc_ca), and governmental bodies (@parks.canada) which implies that the cumulative amount of followers that are influenced by such pages are in fact, much greater than what is presented.

One of the cultural ecosystem services that parks provide is enjoyment of nature through recreation and tourism. This demand becomes increasingly valuable for industrialized societies (Willemen et al., 2015). Encouraging this profound amount of followers to explore the parks is not only beneficial to the individual, but can assist in funding for conservation projects within the park which can also improve park infrastructure.

As international attention develops on these Instagram pages that showcase the beauty of protected lands, content creators have a significant responsibility to accurately convey messages of park features whilst maintaining ecological integrity. Parks Canada (2018) defines ecological integrity as a challenging task which ‘involves keeping ecosystems healthy and whole

at a state where ecosystem biodiversity, structures and functions are unimpaired and likely to persist’.

When the first form of government-sponsored land use was established and national parks were created in the US, Canada, Australia and New Zealand (Shultis and Way, 2006), it is known that human displacement resulting from the establishment and enforcement of protected areas has troubled relationships between conservationists, rural and indigenous groups in many parts of the world (Brockington and Igoe, 2006). Unlike its origins which tended to be exclusionary and inaccessible to many, (Brockington & Igoe, 2006) Instagram has facilitated in allowing national parks to be much more accessible to a diverse audience allowing engagement with visitors and dissemination of park information worldwide.

In park management, combining landscape ecology, conservation biology and social constructivism to re-conceptualize protected areas has demonstrated that parks are not the static, untouched representations of pre-European Contact which they were initially constructed to represent, but now recognize that disturbance is a major component in ecological integrity (Shultis and Way, 2006). Since then, the opposing relationship between tourism and national parks began through the simultaneous desire to both preserve and consume landscapes (Boyd, 2000). This is a long-lasting contradiction as seen in the following present-day examples as they pertain to Instagram.

1. A New Age for National Parks

Instagram has provided an opportunity for parks to connect with their audience through live photo and video footage which has revolutionized the facilitation of information access for both visitors and park managers (Dias et al., 2004). In fact, over 60% of all national parks worldwide have Twitter or Instagram activity, which could potentially inform the global nature of conservation (Tenkanen et al., 2017). While not all platforms engage through a conservation-oriented lens, Instagram accounts for national parks are able to interact with their audience in a variety of ways (see Appendix A). Currently, majority of protected areas share images of their natural landscape to advocate for outdoor recreation. This is often done by sharing a scenic

landscape image, wildlife in the area or a natural feature of the park along with a caption related to the outdoors or the photographed object.

However, each page seems to vary in what they post depending on whether it is run by their tourism board or park managers. The findings in Appendix A indicate that most national parks in the states have individual accounts which may be overseen by the National Park Service (NPS) and Canadian parks are independently run. While collecting data, it was noticed that conservation areas in Ontario do not appear to have individual Instagram platforms, but instead are run by an umbrella page. For instance, @trca_hq represents 21 parks within the Toronto and Region Conservation Authority (TRCA), @OntarioParks governs over 330 parks across Ontario and @ConservationHalton accounts for 8 protected parks in the Halton region of Ontario.

TRCA parks originally ran individual accounts for each park⁴ but as of January 2019, they were terminated and amalgamated into one account run by corporate managers. Since then, the value that Instagram provided for one park in particular has been noticed, as the former⁵ social media manager noted that followers enjoyed receiving park-specific information and that Instagram provided the unique ability to communicate park events and updates in real time (S.Hislop, personal communication, May 2, 2019), which can no longer be accomplished as rapidly. It was also noted by S. Hislop that there “definitely had times where [the park had] increased visitors specifically based on a photo they had seen” specifically in response to the forest’s autumn colours (personal communication, May 2, 2019). In fact, the correlation between Instagram and the monthly visitation rates at parks were up to twice as strong as when compared to Twitter and Flickr (Tenkanen et al., 2017). Considering that some visitors discovered the park solely because of Instagram (S.Hislop, personal communication, May 2, 2019), it is evident that Instagram platforms for conservation areas have a direct impact on the individual visitor experience and can suggest that they have a significant influence over what visitors may value when on the trails.

Since the page termination, visitors have reported that they miss the instant updates that were previously provided by the park and feel that more of an effort needs to be taken to seek

⁴ As well as park management divisions such as Restoration

⁵ @kortrightcentre ran from March 2016 to January 2019 with approximately 2.5k followers

answers to their questions or other park related information (S.Hislop, personal communication, May 2, 2019) . For instance, instead of users searching for information park rules or camping regulations, which may not always be something they would consider, Instagram allows the information to come to them in the form of an image with an informative caption. Some pages organize their messages through saving Instagram Stories in the form of 'Highlights' so that information is even more accessible at a glance. This, along with other observations clearly demonstrate that Instagram plays a vital role in promoting natural parks for visitors and users themselves have expressed a preference for Instagram in accessing park information.

Other ways that protected areas use Instagram pages are especially useful when they update the public on trail closures due to erosion, flooding, ice or other hazards that may be present at the park. Some of these posts showcase a wide range of park features that reinforce park rules, (water safety, camping and visitor etiquette, hiking tips), park history, hosting weddings, seasonal festivals, school programs, family activities, and of course, to nature photos and daily wildlife sightings to draw visitors to the park.

Parks Canada (2018) states that they are responsible for both protecting the ecosystems of these natural areas and managing them for visitors to understand, appreciate and enjoy in a way that does not compromise their integrity. Such examples of protecting ecological integrity are seen on Instagram as some pages raise awareness of large mammals and other animals which may be concerning to some visitors can help eliminate fear to ensure animal encounters are safe and non-intrusive for both wildlife and visitors. For instance, the platform @banff_lakelouise posted video footage⁶ of a Grizzly Bear sow and her cub crossing a park road in front of a vehicle which reminds followers that protected lands are home to many. This message was also accompanied by a list of tips from Parks Canada on how to respect wildlife and stay safe. The positive impact that Instagram pages for protected areas can have lies in how accessible and visual-based the application is (Lee et al., 2015) which has a direct impact on visitor knowledge and experience.

Some parks encourage visitors to use certain hashtags when visiting, which promotes park photography to be posted on social media. While these hashtags may connect a community of

⁶ Shared by a visitor

people with common interests together and create a portfolio of images of similar locations, encouraging a wide audience who may not always be concerned with ecological impacts can be detrimental to the ecosystem services provided.

1.2 Changing the Physical Landscape

When comparing the usability of different social media platforms for visitor monitoring in protected areas, Tenkanen et al. (2017) found that Instagram provides consistently successful results. As well, Instagram is effective in disseminating and collecting park information over a wide audience and reduces accessibility challenges that may be faced by ethnic minorities (Rigolon & Flohr, 2014; Schuett & Bowser, 2006). However, attracting large numbers of visitors may depreciate the ecological value of protected lands which is the very asset that makes the area attractive (Dias et al., Scholten, 2004) for tourists and wildlife. There has recently been a substantial amount of discussion⁷ surrounding this concern in academia and public discourse, among social media influencers and journalists. Issues range from visitors' safety, information provision (Dias, E. et al., 2004) and park infrastructure damage which may also occur.

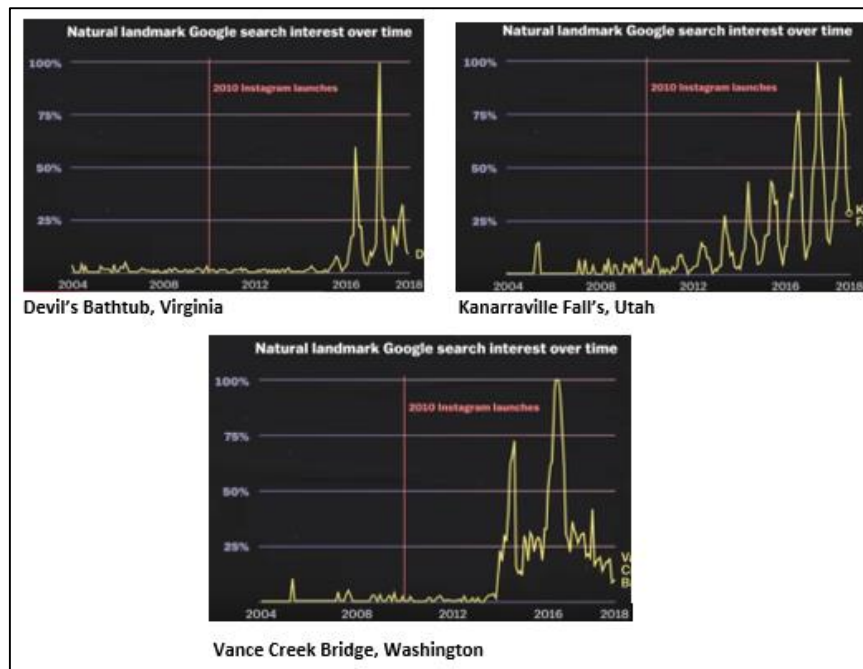


Figure 1: The rate of Google searches for three natural features in protected areas in the U.S. The red line indicates the year that Instagram was created. (Haubursin, 2019).

⁷ Topics of Nature going viral or the consequences of geotagged images are recently entering

Three natural features in American national parks were analysed upon recognition of a significant increase in visitor amounts. Haubursin (2019) recognized that the frequency of Google searches for these locations increased years after Instagram was launched. As depicted in Figure 1 above, while there has been a stark increase in Google searches for these locations roughly in the year 2014 after Instagram was launched. It is evident that the increase in visitor amounts are unprecedented and the drive instigated by social media plays a strong role. However, Instagram is not proven to be the sole cause but is likely a pivotal driver. Due to this, parks must shift their focus more on visitor expectations, as the intensive use of parks and natural areas poses sustainability issues and creates new problems to park management (Dias et al., 2004).

Interestingly, when visitors frequent protected lands, there are similar photographs that are often posted which later develop into a trend which lures Instagrammers to the park. While these photos succeed in showcasing the beauty of the ecological features, the saturation of similar photos posted by thousands of others encourages many to follow suit, regardless if they have been captured in accordance to park laws or align with conservation ethics. Unfortunately, it can not be assumed that everyone visiting natural spaces interact with the land carrying common ethical values, based on the consequences outlined in this section.

This section will focus on providing examples of environmental degradation that occurred as a possible result of Instagram's strong influence over people's behavior at parks. It is important to note that Instagram is not the sole factor to blame and that the tension between tourism and conservation efforts originate from the core creation of protected area origins which were tourism-focused (Boyd, 2000; Shultis & Way, 2006).

1.2.1 Horseshoe Bend

Parks which were not designed to cater for the large crowds that are often seen at national parks, experience these tensions more than others as they lack the infrastructure required to keep both humans and the environment protected. For instance, Horseshoe Bend located in the Colorado River, Arizona, saw 100 thousand visitors in the year Instagram was created, which increased to 2 million visitors just eight years later (Haubursin, 2018, 0:32). The sudden change in visitor amounts was not a result of any marketing push but instead, from geotagged photos on social media (Haubursin, 1:00, 2018). The federally protected area which once had no infrastructure is now projected to have a parking lot built along with a welcome

centre, bathroom facilities, a viewing deck with safety railings, laser-equipped signs to count visitors, and a trail will be created lined by limestone blocks to protect the surrounding environment (Haubursin, 2:50, 2018). One can assume that the expense of creating park infrastructure in response to a sudden growth in popularity can alter the funding and prioritization of conservation projects. Park representatives mentioned that they do not want to stop people from taking the iconic photograph at the cliff's edge but can only implore that people be safe (Haubursin, 3:09, 2018).



Figure 2: A compilation of popular photographs taken at Horseshoe bend, Arizona, publically posted on Instagram which demonstrate trends created from posting similar photographs

1.2.2 Kaaterskill Falls

It isn't uncommon for people to engage in dangerous activity for the sake of taking a photo for Instagram. In fact, people have lost their lives from taking or posing for pictures in cases at Kaaterskill Falls, New York (Shannon, 2018). The state has since spent 1.25 million dollars at the Kaaterskill Wild Forest to make the site more accommodating for people who are driven by social media to take the iconic photograph, including a 200 step staircase through the falls (Shannon, 2018). The staircase is located at an area that was once restricted from visitors, located well beyond the official marked trail (Shannon, 2018). This is yet another example of how visitor's

actions, including those following trends, can impact park management strategies and quite literally shape the landscape.

Much like at Horseshoe Bend, the forest will soon have two parking lots, a viewing platform, warning signs, hand railings and a bridge along with new park rules that will ban fires, alcohol consumption, glass containers, standing six feet near the cliff's edge and swimmers from entering within 150 feet of the waterfall (Shannon, 2018). The increased amount of traffic through the park poses a threat to the surrounding ecology and people themselves but perhaps it has also been a catalyst for parks to make appropriate enhancements so that visitors have a safer experience.

1.1.3 Scarborough Bluffs

A Canadian example of similar disregard for park signage can frequently be seen at Bluffers Park located near Toronto, Canada. The location is a restoration area made of limestone cliffs which has been known to have high erosion rates since the 1980s (Eyles & Howard, 1988). Often, the main driver for visitors to climb the unstable bluffs, are to capture photographs such as those in Figure 3.

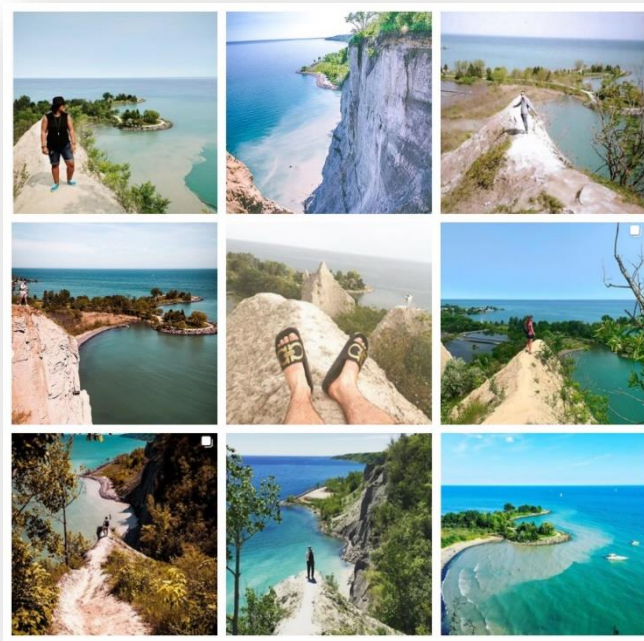


Figure 3: A compilation of popular photographs taken at Scarborough Bluffs, Ontario, publically posted on Instagram which demonstrate trends created from posting similar photographs

After visiting the park in person, it is certain that the perspectives in the photos above cannot be achieved without climbing the bluffs and standing on a narrow, quickly eroding cliff, which is prohibited by the park. Park regulations are not only created for the sake of preserving natural spaces and its ecological significance but also to keep visitors safe⁸. The area was later closed off to conduct an ecological restoration project conducted by the Toronto and Region Conservation Authority (TRCA, 2019) and has a notice of caution explaining shoreline erosion risks which can compromise the path's edge. This sensitive area has long been susceptible to erosion due to high water levels in Lake Ontario and ice storms (TRCA, 2019). At this location, over 70 landslides occurred in 2017 alone, (Cheung, 2017) and the increased amount of visitors on restricted areas place an added amount of pressure on the surrounding ecology.

1.1.4 Walker Canyon

A desert grassland in California known to succumb to drought and dry soils, experienced a 'super bloom' of wildflowers along Walker Canyon and Lake Elsinore. This phenomenon attracted a flood of visitors to parks in the surrounding area to photograph the flora, particularly the Orange California Poppy.



Figure 4: A compilation of popular photographs taken at Walker Canyon, California, publically posted on Instagram which demonstrate trends created from posting similar photographs

⁸ In May 2019, two people were rescued after ignoring signage and falling over 50 feet off of the cliffs (City News, 2019).

Despite growing along the steep sides of the canyon, the blooms gained an unprecedented amount of attention from social media influencers on Instagram, as seen in Figure 4 above. The photograph in the middle row at the left, was posted by YouTube to their millions⁹ of followers. This has been criticized to be a careless act as the flora is directly damaged and their large audience may be encouraged to do the same or assume that this behaviour is allowed.

Despite the fact that going off-trail is discouraged (National Parks Service, 2018), signage is posted throughout the parks reminding visitors not to go off trail and to avoid trampling on the vegetation. However, thousands of visitors continued to bypass these signs regardless, killing plants and compacting soil so frequently that unofficial trails were created. While trampling remains a common area of study and is a type of impact where the stress and response relationship is relatively well known, (Buckley, 2000) park trails and campsites generally comprise of only 1%–2% of a park (Shultis & Way, 2009). Once this begins, it often encourages others to do the same resulting in extensive damage as seen below.



Figure 5: Soil exposure and vegetation loss due to increased visitor amounts at Walker Canyon, CA. Photographs from @worldsokayesthiker

⁹ YouTube has 20.7 million followers on Instagram as of July 2019

The images above demonstrate the extent of damage that can occur only over a 2.5-week¹⁰ period. Not only does this depreciate the aesthetic value of the park but has ecological implications as well. For instance, compacted soils from hiking can alter soil chemistry and biota, reduce porosity and water-holding capacity, inhibit seed germination and future plant growth which affects plant and animal populations (Cole, 2004). This can also impact flight activity during foraging by pollinating insects (Spaethe et al., 2001) and result in habitat loss by insects and small mammals.

After tens of thousands of tourists visited to capture the Instagram-worthy shots, city officials were forced to close the area due to the increased traffic off-trails in fear that the soil compaction may prevent the natural phenomenon from happening again (Maida, 2019; Cole, 2004). In an effort to mitigate the amount of traffic at Lake Elsinore, near Walker Canyon, a list of alternative locations was provided to the public of alternate parks to visit where poppies can be seen (Plevin, 2019). However, this only extended the range of poppy field degradation that ensued. Additionally, the city offered shuttle busses for visitors to enter the park (Hayden, 2019) and some areas at the park were fenced off specifically for people to take photographs (Maida, 2019).

The overcrowding and ecological damage ensued was disheartening to many, and even led to the creation of an Instagram platform. The page @PublicLandsHateYou has an audience of 57.6K followers who share this concern or would like to learn how to avoiding certain practices on protected lands such as starting fires, rock stacking, geotagging, feeding wildlife, and following park guidelines. In several cases, the page has succeeded in convincing users to remove images which promote ecological degradation and instead use their platform to publically explain what was done wrong. The page has publicized people who openly violate the park laws including citizens, famous influencers and organizations. While some argue that Instagram drives visitors to take photos resulting in high traffic, overcrowding, it can also provide effective solutions, target those liable, and educate a large audience in real-time about navigating public lands with minimal impact.

¹⁰ The photograph on the left was taken on March 4th 2019 and the other on March 22nd 2019.

1.3 Conclusion

Stronza (2019) argues that photography, which has been a driving force in establishing national parks for 150 years, can establish a sense of appreciation of nature and greater chances for environmental stewardship overtime. While this is true, and while the presence of National Park information has multiple benefits for many stakeholders, the dissemination of information on Instagram may be so effective that it can also contribute to negative ecological impacts. Through analysing the numerous benefits and challenges that have emerged for park protection, it is clear that Instagram has an influential role in the way parks are managed and may impact the ways they are protected in the future. An interesting area for future research would be to measure the amount of trail users that discovered the area from Instagram exclusively which can be asked prior to entering the park. This data can be used along with observing whether there was an increase of traffic on trails, which can be useful in future park management. Data collection through social media eludes to the following section.

2. Applications in Conservation Efforts

Much like with climate change capacity building, the need to reach all sectors of society has infiltrated ecological science (Hampton et al., 2013) which can be done through data collection on Instagram. While the use of imagery can be useful in conveying messages of conservation (Ward, 2008), assessing social media data can potentially play an important role in conservation science by providing insight from a wide range of users on spatio-temporal patterns and public values which can identify threats to biodiversity and opportunities for conservation. (Di Minnin, 2015). The following is a brief review on how social media platforms have been used in conservation work, whereby Instagram will likely play a vital role in shaping future research.

2.1 Applications in the Field

Social media has also been used as a tool for environmental management to better understand public perceptions of cattle grazing on conserved lands (Barry, 2014). As well, through using combined criteria to determine how attractive species are for global wildlife tourists, Willeman et al. (2015) analyzed photos posted on social media of over 2,000 African

animals and plants to determine the most liked species. Based on this finding combined with species range data, researchers were able to assess tourism potential of protected areas based on attractive species occurrence (Willeman et al., 2015). Combining social media data in conservation research will likely become more popular overtime as the Instagram database becomes more saturated and researchers begin to recognize the accessibility and ease of access of retrieving such data from the platform.

2.2 Applications by Parks

Along with the many pages run by the American National Park Service (NPS), one Instagram page in particular¹¹ looks for the public's assistance in investigative and park law enforcement work. This includes searching for visitors who threaten ecological integrity of the space by violating park laws. Examples of incidents occurred in 2019 include: poaching wildlife such as a Green Sea Turtle (EN) Gray Snappers (LC), Mountain Lion (LC), Crocodile (VU), Coyote (LC), Elk (LC) starting a wildfire at an illegal campsite, theft of 500 cacti¹², illegally swimming in and polluting water home to the endemic Devil's Hole Pupfish (CR), a dog attack to a Guadalupe Fur Seal (LC), pollution or habitat degradation issues such as driving over restricted beach zones protecting Piping Plover (NT¹³) habitat and vandalism that could be ecologically degenerative. This form of education and outreach directly involves citizens in ecological protection, providing a sense of responsibility to protect lands and an awareness of park rules whilst lessening the authoritative dynamic that can deter citizens from visiting these spaces (Bell et al., 2019). This relationship that is created also improves accessibility in reporting such issues thereby increasing the conservation value of protected areas as a whole.

2.2.1 Geotagging

As with many social media platforms, the location of each Instagram post can have a geotag attached to it which can indicate the location as a wide area or as specific as the GPS coordinates. Tagged photos can be valuable for conservation research such as generating hotspot

¹¹ @specialagent_nps

¹² Federally protected. Not listed under the Nevada's Species List. (US Fish and Wildlife, 2017)

¹³ As per the IUCN Red List of Threatened Species (LC=Least Concern, NT= Near Threatened, VU=Vulnerable, EN=Endangered, CR= Critically Endangered).

maps and distribution models of temporal and spatial patterns in two protected areas of high conservation value which Walden-Schreiner (2018) did on Flickr. In addition, when Hausmann et al., (2017) realized that there was a lack of visitation data across Africa, consultation of images on Instagram became their primary methodology. In other studies, remote sensing and crowd-sourced geotagged information from social media can identify spatial conservation gaps and pressures in real time (Levin et al., 2015). Though less studies have been conducted on this application through Instagram specifically, geotagging is readily done by users on this platform.

As the correlation between geotagging and ecological damage from high traffic becomes more understood, there is a growing movement in the nature photography community that has stopped geotagging. In 1999, the Leave No Trace organization created a set of principles for people to use while they are outdoors. In 2018, new social media guidance was offered suggesting that park visitors geotag mindfully, with caution (Walsh, 2019). More recently, as part of the ‘tag responsibly’ movement, visitors are also encouraged to tag the general area as opposed to a specific location in order to protect areas from high tourism, overcrowding, and destruction while still supporting conservation efforts (Holson, 2018). An example of some general tags that have replaced specific locations include “Tag Locations Responsibly, Keep Jackson Hole Wild” (Holson, 2019). There are many parks that are underappreciated however, which led to a citizen ‘photo challenge’ led by NPS called ‘Find your Park’ to encourage visitors to find natural areas closest to their homes (Stronza, 2019).

There is current debate on Instagram surrounding geotagging images that include wildlife species. When monitoring biodiversity using Instagram data, geotagging is the most reliable way to know where a species was found or identify the species range. While environmental educators and conservationists agree that their habitats should be protected from large communities it is also useful to educate the public on where certain species thrive. However, choosing not to geotag to protect the species and to deter others from visiting the area has been criticized to be an elitist and exclusionary approach. Viewers of the post would be excluded from certain outdoor experiences and it is assumed that they would visit the area in a less ethical¹⁴ manner than researchers in the field.

¹⁴ See ‘Leave No Trace’ Guidelines for outdoor ethics

However, tagged photographs from citizens can empower communities to document changes seen in their environment which is done through a movement called 'I See Change'. These posts are paired with weather and climate data to investigate larger climate trends (I See Change, 2019) and are often attributed to the hashtag #ISeeChange. Applying this to conservation has been done in similar ways by iNaturalist or BumbleBeeWatch. More important than collecting data, these community-based endeavours allow the user to feel as if they are a part of the future they want to see and empower communities to take charge and seek climate solutions or even acknowledge how climate change impacts their lives.

2.3 Citizen Science

As a result of raising awareness to visit natural areas, DiMinin et al (2015) argue that more people could potentially get involved with data collection and therefore become more aware of biodiversity conservation. Though there are apps that exist like iNaturalist¹⁵ which allow users to create a database of wildlife species with location tags, Instagram can appeal to users outside of the naturalist scope who are unaware of such tools. While iNaturalist has a larger database, Instagram seems to collect biodiversity data from a wider range of sources however it can be assumed that majority of these sources may be unaware that their findings can contribute to citizen science. Those who are aware may use hashtags similar to #iPhoneScience. A great example of such users include birders on Instagram who take geotagged photographs of birds along with a description of their observation or interesting find such as hybrid species. Hashtags of the Latin name of the species can also be observed along with a list of locations that it can be found in, giving a sense of the species range. Many of these users as well as those who photograph plants have rich databases that can be valuable if applied to scientific work. If citizens had the opportunity to contribute to scientific or conservation work, it may heighten their environmental consciousness and support science-based conservation policy and efforts.

Another interesting application of Instagram in future citizen science and conservation work relates to high traffic areas at parks. Similar to iSeeChange where weather related changes

¹⁵ An online social network of people sharing biodiversity information to connect people to nature and generate scientifically valuable data from its archives

are recorded, photographs of changes in protected areas can be documented such as litter accumulation over time in one specific area, differences in soil compactness or erosion, or sea level changes. In fact, an example of such valuable observations is seen in Figure 5 which an Instagram user submitted to the researcher for this particular study, contributing to social science as a whole. It is nearly impossible for scientists to be at multiple locations at once and gathering observations from all levels of society is important to increase resiliency and capacity-building in science.

2.4 Conclusion

Shultis and Way (2009) argue that land managers need to adapt to a new paradigm that reflects and supports this philosophical change in conservation principles moving to a 'post-normal' science which can embrace the convergence between Instagram and conservation science to meet environmental objectives. It is clear that Instagram has an incredibly influential role in the way that parks are managed, treated and perceived. Applications explained and suggested in this section demonstrates that if used responsibly and when paired with scientific endeavours, Instagram can have an influential role in research and therefore future environmental policy implementation.

3. Shaping our Perceptions of the Outdoors

The relationship between photographs and nature have a profound impact on the human mind as it constantly shapes nature into cultural representations (Seppänen & Väliverronen, 2003). Content on Instagram can play a key role in the production of meanings (Seppänen & Väliverronen, 2003) and can mould our perception of nature, which can thereby become a determining factor in our care for it. If more time is spent on social media than outdoors on a daily basis, natural places can be brought to the attention of many, but can also impact our perception of the outdoors. This section explores Instagram's role in altering our perception of nature through diversifying the outdoors and creating a romanticized image of nature, paired with the language used in popular hashtags which can have implications for conservation practices and future research.

3.1 Bio and Human Diversity

The concept of 'diversifying the outdoors' has received an increased amount of attention (#diversifytheoutdoors) upon recognition of the fact that 78% of those who visit American federal parks are white¹⁶ (Bell et al., 2019) while Asian Americans, African Americans and Hispanics often feel uncomfortable doing so (Weber & Sultana, 2011). The discourse surrounding diversifying the outdoors is a ramification of the creation of national parks in North America which involved ethnic cleansing (Kantor, 2007) and forcible removal (Spence, 1999) of Indigenous communities.

For example, legal efforts were pursued to stop Indigenous groups from living and using the land at Yellowstone National Park under the guise of violating Wyoming game laws which led to the first American creation of an artificially, 'uninhabited wilderness' (Kantor, 2007). Removing Indigenous groups along with their cultural history on these lands continued without the recognition of treaty rights as subsequent national parks were created (Kantor, 2007). The creation of Canadian national parks is not exempt from this history. Considering that Indigenous groups were removed from Banff National Park and were subsequently banned to enter despite the creation of towns within the park which catered to visitors in the 1930's, some researchers argue that this exclusion occurred for reasons other than creating a 'wilderness' façade (Binnema & Niemi, 2006). Since then, National parks continue to be white-dominated spaces in terms of how they are managed, conserved, studied, owned and accessed (Mock, 2014).

The feeling of violence remains among some members of the Hispanic American community who noted feeling threatened by the authoritative park ranger uniform as well as experiencing psychological discomfort as Californian park rangers carry firearms while on duty (Bell et al., 2019) for instance. The racial divide was not a challenge faced exclusively by the Indigenous or Hispanic. Before the civil rights movement in America, national parks were segregated by black and white Americans in accordance to local practice, leading to reduced opportunities to experience nature and appreciate wildlife (Dolin, 1988). Despite the fact that we were all intrinsically connected to Indigenous land at one point in our ancestral history, often viewing mankind in harmony with nature (Dolin, 1988), it has been found that some black Americans learned to hate land itself, through slavery in America, (Dolin, 1988).

¹⁶ Study conducted by National Parks Service that surveyed Americans

Hence, the emergence of particular Instagram pages has subsequently created a larger community which demonstrates a necessity for representation by people of colour (POC) to express themselves in outdoor spaces and engage in conservation biology or related environmental fields. Grant (2018) states that despite feeling academically prepared, POC are still intimidated to pursue a career in conservation where their perspectives have been historically underrepresented in the field. Considering that the majority of Instagram users (71%) are under the age of 35 (Clarke, 2019), providing access to images of POC doing science or other work outdoors can normalize such activities and inspire youth through representation in the field. Allowing youth to visualize inclusion of diverse ethnic backgrounds in nature can lead to a field that better represents the values and understanding of multiple cultures in the future. This can allow for more innovative solutions (Van Knippenberg et al., 2004) in conservation management.

Therefore, Instagram can be a powerful tool in reducing the feeling of exclusion that some communities may feel in venturing outdoors and provides a space for POC to express their knowledge and embrace their interest in the outdoors. Data collected in Appendix D catalogues Instagram pages that strive to normalize a diverse outdoors, thereby shaping public perception. Upon reflecting on the motives behind creating such pages as well as the thousands of followers who share an interest in the content, there is in fact a lack of diversity outdoors and that Instagram has provided a space for others to defy the norms and be encouraged by a community that seeks to normalize inclusion.

Considering that that the pre-movement era of environmental mobilization was comprised of elite white, middleclass males who were influenced by cultural nationalism, frontierism and transcendentalism (Taylor, 2002), creating this space is significantly important. Refocusing on the identity of those who do conservation work will transform the effectiveness and relevance of conservation (Grant, 2018) and research which represents the broader populations concerns, needs and aspirations (Gould et al., 2018). Using Instagram to shape public perception, and inspire youth of diverse backgrounds can thereby lead to a diversified field outdoors and academic research in years to come.

3.2 Hashtag analysis

Hashtags (#) are often used on Instagram captions by means of categorizing posts and compiling it with other relevant content. Hashtags that are popularly attributed to nature or outdoor photography can frame the way that the outdoors is perceived and eventually, influence the field of conservation. Proof of this lies within the creation of parks in America and Europe during the eighteenth century where unless a landscape suited the ‘sublime’ portrayal of wilderness at the time, it was not worthy of protection (Cronon, 1996). Popular hashtags show that modern day tourists, avid hikers or artistic admirers on Instagram, lust over the idea of ‘wilderness’, perhaps because such places are become less common. These include #explorethewild (41K posts), #wildernessculture (10M posts), #trustthewild (111k posts), #wildernesstones (118K posts) #wildvisuals (71K posts), #wildlife (23M posts), #wildgeography (343K posts) and others. Interestingly, 250 years ago there would not be nearly as many people wandering to remote areas in search of ‘the wilderness experience’ and it seems that Instagram imagery can offer a false notion of vastness, contributing to the ‘frontier myth’, an illusion of exploring open spaces without trails, maps, guides, nor equipment (Cronon, 1996). This idea of dominating the outdoors or exploring with a sense of ownership can be seen in many other hashtags such as #discoverearth (8.5M posts), #beboundless (144K posts), #FindYourPark (also #EncuentraTuParque) which is promoted by the National Park Service or #mybanff which is promoted by Banff National park’s tourism board. Below are examples that depict how language surrounding hashtag use can communicate different meanings among users either consciously or subconsciously.

#trustthewild -Why wouldn’t we trust the wild? This plays on the idea that the wild should not already be trusted and by doing so, it gives the notion of ‘venturing out’ and doing something risky. While this hashtag may appear to describe the outdoors and bring light to outdoor activity, it can strengthen the divide between humans and nature and reinforce the idea that ‘wild’ is not always to be trusted.

#FindYourPark- This hashtag was created with good intention, in allowing visitors to find local parks around them which can lessen the impacts that increased trail traffic can have (Stronza, 2019). This also gives citizens appreciation for the common areas around them that may be overlooked. However, inclusion of the word 'your' can provide an image of parks as something to be owned or governed by an individual, and not something that we live among with equal values. The use of the possessive pronoun implies that a hierarchy exists over parks and nature instead of eluding to a sense of dependence, as we rely on ecosystem services for survival.

#womenwhohike – This along with #mountaingirls attempts to challenge the historically male-dominated activity of hiking (Dooley, 2016) and try to reinforce the idea that women explore the outdoors as well while promoting health benefits of nature which is on the decline for girls and women (Spencer, 2018). On the other hand, for those who have already normalized the fact that women hike in their minds may find it strange that the correlation between the two ideas are even worth mentioning. This then leads the individual to ponder whether women hiking is something to be questioned at all.

#roamanywhere - At times, hashtags associated with nature can often provide a false notion of vastness although there are some areas that remain untouched or are under threat. This false imagery can be dangerous in allowing users to believe that pristine land surrounds us and that conservation issues or other threats to these spaces are not prevalent. More accurate hashtags that describe the relationship with outdoors realistically that highlights nature as something fragile yet resilient, to be admired and preserved while encouraging outdoor recreation include: #outdoorenthusiast, #wearestillwild, #lifelifeoutdoors, #hikemore, #protectnature, #conservationphotography, #natureislife, #appreciatenature and #loveearth.

Considering that the change in use of the word 'wild' in the English language has directly influenced human behavior over time (Cronan, 1996) and as hashtags continue to play a key role in modern-day technological communication, the evolution between nature, language and human behaviour will continue to evolve and shape our perception of the nature that is to be protected at the time.

3.3 Ecotourism

Images of human interaction in wild spaces is dominated by Instagram influencers and world travelers who may often intentionally or unintentionally promote certain behaviours among audiences. The three most favoured destinations among eco-tourists are Costa Rica, South Africa and Galapagos Islands (Singh, 2018) which are not surprisingly, 'biodiversity hotspots' that are rich in biodiversity and are highly threatened due to human activity. This has directly impacted tourist behaviour and makes certain locations more popular than others. Ecotourism has been long promoted for its importance in supporting both biodiversity conservation and economic development (Hausmann et al., 2017). Social media has replaced traditional methods of marketing by travel agencies, as people rely on other users' personal experiences at a location (Singh, 2018). As more social media data from Instagram will become more available in the near future, protected area management and tourism marketing for parks can become more informed (Hausmann et al., 2017). For instance, social media has revealed motives and intentions of those travelling to sub-Saharan protected areas (Jausmann et al., 2017) which is conducive to learning about how to effectively bring conservation issues to light and what features to highlight in protected areas.

While ecotourism practices allow visitors to fulfil their desire to connect with and learn about a new ecosystem, it can also have detrimental effects to the surrounding biodiversity. Moreover, some lodges or wildlife sanctuaries may claim to serve ecological benefits but are in fact created in unethical ways and are profit-driven, thriving on uninformed tourists who may have good intentions. In fact, there is evidence of travel attractions that operate under the guise of ecotourism which extract individual animals from the wild to facilitate wildlife selfies (Lenzi et al., 2019). Currently, most wildlife and ecotourism is an unsustainable practice lacking regulation, thriving on misinformation, endangering animals at the individual and larger population level, due to, as Lenzi et al. (2019) argue, the fact that it lies within an anthropocentric, neoliberal capitalist paradigm. Activities which appear to be 'eco-friendly' which are heavily promoted on Instagram but actually have detrimental impacts to wildlife or the environment include elephant riding in Bali (Lenzi et al., 2019), dolphin and other cetacean ecotourism (Walker & Hawkins,

2013), taking selfies with sloths (Lenzi et al, 2019) or the infamous swimming pigs in the Bahamas (Hurtibise, 2019). On the other hand, Instagram often facilitates the proliferation of social media campaigns to increase accountability of stakeholders, and with educating the public on ethical animal encounters, which is why social media is often described to be a 'double edged sword' (Lenzi et al., 2019).

3.4 Conclusion

NGO's and conservation organizations readily use the platform to inform their audience including donors of conservation threats and efforts that are undertaken. Still, social media platforms also provide a venue for sharing biodiversity related content and posts on nature experiences (Di Minnin et al., 2015). Considering that images of ecotourism, outdoor exploration, diversifying the outdoors and hashtags are seen by billions of users on a daily basis, Instagram can have a significant impact on the way we perceive the natural world. This in turn, can influence the perception of the outdoors as being vast and pristine when in fact it is threatened, and can create false conceptions the wilderness that is to be preserved.

CHAPTER TWO: Exploring the Value, Use and Role of Instagram in Conservation Biology based on the Perceptions of Science Communicators

1. Introduction

Given its visual-based, and highly interactive user-generated interface, Instagram has completely transformed the way that many industries operate as well as digital communication as a whole. The social media platform encourages users to interact, shop and learn from others on a global scale through photo and video sharing. In under one decade, since its release, Instagram has provided scientists with a unique opportunity to present their findings and research and engaging in scientific discourse among the public. The translation of scientific knowledge in simple engaging terms is known as Science Communication (SciComm). Perhaps unintentionally, the platform has given rise to a new and transformative method of SciComm that is also referred to as 'Science Storytelling'. Recently, there has been an emergence of an interconnected group of thousands of Science Communicators (SciComms) at various career stages who use the platform to make their lab and fieldwork accessible to broader audiences (Jarreau, et al., 2019). This differs greatly from other social media platforms as SciComms can offer their audience a 'behind the scenes' perspective into their lives and explain scientific topics on a more personal level. In fact, a study by Jarreau et al., (2019), demonstrates that public perceptions of scientists will be improved directly by using Instagram given its power to bring scientists and non-scientists together.

Not only have communicators been able to use their platform to share knowledge and reach their personal objectives, users have been highly receptive and demonstrate a keen interest for acquiring scientific knowledge informally. According to Burns et al. (2003), effective science communication is the 'sharing of science-related knowledge whereby one's efforts have a palpable impact on knowledge users'. After conducting a study based on representative survey data from Switzerland, Schafer et al., (2018) investigated public attitudes and perceptions of receiving science information and found that online sources and social media have gained importance with regard to scientific issues. Furthermore, ways in which people perceive and

evaluate science-related information influence the outcome of science communication and attitudes toward science (Schafer et al., 2018).

Since many recent environmental problems become more removed from our everyday sphere of observation, we largely rely on the information and interpretations produced by experts and the media (Seppänen & Väliverronen, 2003). Instagram SciComm offers the combination of both these elements whereby the social media platform is an effective tool in communicating and creating involvement in cultural, political, and scientific circles (Claussen et al., 2013). In addition, the visual format of Instagram allows SciCommers to offer complex ideas in emotionally-exciting, simplified doses which compliment the shortened attention span of the past two generations (Lucky & Matthews, 2010) who frequently use Instagram and who can impact the future prioritization of conservation efforts.

Since social media has allowed the role of users to shift from passive recipients of information to active generators of information (Stewart and Pavlou, 2002), investigating how new technologies influence the way that scientists disseminate their work and knowledge (Stilgoe & Wilsdon, 2008; Cooke et al., 2017) is a growing area of international research and practice. Yet, there lacks robust information of science communication on Instagram specifically, as well as its relationship to conservation biology and conservation management, which is where this research will prove to be most meaningful.

1.1 Problem Statement

The loss of biodiversity is one of the most critical current environmental problems threatening valuable ecosystem services and human well-being (Ceballos et al., 2015) as we live through a conservation crisis that is heightened by the uncertainties of climate change. As the most recent Intergovernmental Panel on Climate Change (IPCC) report revealed, the next 10 years will be the most crucial of our time. Global temperature increase must not exceed 1.5 degrees (IPCC, 2018) without catastrophic consequences occurring, which will further threaten biodiversity and the longevity of conservation efforts. On average, there has been a 60% decline in mammal, bird, fish, reptile and amphibian populations over 40 years, linked directly to human-induced habitat loss and overuse of wildlife (WWF, 2018). To address this problem, this research will identify new opportunities in making conservation education and other scientific information accessible for audiences on Instagram to create a more informed society. While social media data

have been extensively used in numerous fields of science, examples of their use in conservation biology are still quite limited (Di Minn et al., 2015).

1.2 Objective

This study examines how scientific information is presented, measured and valued on Instagram, concentrating on its impacts in the field of wildlife biology and conservation. This study provides evidence that there is substantial value for conservation scientists to use Instagram as a science communication tool in order to raise awareness of issues and educate the general public which can potentially shape conservation policy.

2. Method

An observational approach was employed over the course of 8 months to determine how Science Communicators ('SciCommers') use their platform, how they interact with their followers, and what opportunities or challenges exist. Then, 25 successful science communicators were contacted through Direct Messaging on Instagram which led to interview-based data collection and analysis. Upon collecting data from a sample size of $n=18$, the perspectives of SciCommers were coded, tallied, and categorized to gain an understanding of how and to what extent the platform can be of value for conservation science.

2.1 Method: Participant Selection

Participants were selected based upon criteria developed by the researcher. The criteria were designed to ensure that participants had a baseline understanding and valid experience to be considered an 'Instagram Science Communicator' for this study. It also enhanced the key-participant nature of the interview process whereby only expert participants who had attained extensive, first-hand knowledge with SciComm on Instagram were involved. The aforementioned qualifications outlined that the participant must:

1. Have or is currently pursuing a degree at the masters or doctoral level **OR** is a professional in their field.
2. Study or is a professional in a traditional science, conservation, environmental education or related discipline.
3. Self-identify as a science communicator.
4. Have one of the terms 'SciCommer', 'SciComm', 'science storyteller' or a related description in their Instagram profile biography.
5. Have at least 1k followers on their science communication platform to date.

Once a 'Participant Selection Criteria Checklist' was complete by the participants, purposeful sampling was employed to determine whether they would be a qualified participant for this study. In some instances, if one of the requirements were not satisfied, the participant provided an explanation which confirmed their academic legitimacy and public influence as a SciCommer as determined by the researcher. This initial screening resulted in a sample size of 18 key-informants of varied science disciplines, predominantly specialized in wildlife or conservation biology. Once chosen, consent forms with ethics approvals were signed. The sample group had representatives from Canada, the United States, Australia and the United Kingdom. The largest audience on a single platform is 58,700 followers with an average mean of 6,156 followers and a cumulative influence equating to 110,813 followers reached worldwide¹⁷.

2.2 Method: Interviews

The initial method of data collection involved conducting semi-structured interviews whereby questions guided the conversation while still allowing participants to explain their personal experiences in greater detail as they saw fit in conveying their message. This method often discourages participants from responding in what they believe is the 'preferred social response', whether it is true or not (Barriball & White, 1994). While this method was successful for participants who engaged through video conference calls, it was later found that not all participants could engage this way which slightly altered the interview design.

Whether conducting field work in remote areas or being in conflicting time zones, many participants opted to submit the interview responses online which resulted in more of a survey format rather than a fluid conversation between the participant and researcher, as intended. While data responses are of great value, the conversational dialogue became a one-way discourse which resulted in less detailed responses in some instances. Sampling continued upon conclusion of the study period and when saturation of information occurred, at which point common trends were found and no new information was emerging from the data.

3. Results

Based on interview and survey data, results demonstrate that if used appropriately, Instagram can in fact be a valuable tool for science communication, presenting unique

¹⁷ Accurate as of July 2019

opportunities for both conservation science, and the scientists themselves. Overarching themes from the results were categorized and tallied to determine the frequency of responses. A summary of five key trends is presented in Table 1 below, with further analysis explained in the next section. Supplementary participant remarks are been included in Appendix B which support these trends.

Response Frequency	Primary form of SciComm	Is SciComm education measurable?	Indicators to measure effective SciComm	What IG has for SciComm that other platforms lack	Goals of SciComm IG pages
High (75%+)	Instagram (89%)	Yes (88%)	Comments (82%) Generating conversations through DMs or Comments (77%)	Reasons related to accessibility & community (100%)	
Moderate (45-74%)			DMs (47%)	Visual-based style of app & storytelling (71%) Ability to reach a wide and diverse audience (47%)	To raise awareness/compassion and to educate (65%)
Low (>45%)	Instagram along with outreach events/ place of employment (35%)	Yes, with difficulty/ uncertain (29%) No (5%, 1 response)	Shares, Reposts, Insights (29%)	Ability to create a relationship with audience (24%) Provides a creative outlet/Can create personalized content (18%)	To build a community/ share personal research (23%) To humanize scientists (12%)

Table 1: Summary of key responses from Science Communicators related to the usability of Instagram for Science Communication

4. Discussion

All participants reported that Instagram is their primary tool for science communication, unless professionally employed to do so at their workplace¹⁸. Approximately one fifth (22%, 4 of 18 participants) describe Instagram to be their primary tool in addition to other SciComm activities such as speaking at outreach events or other social media platforms. Due to the diverse specializations of each SciCommer as well as geographic range, age and gender, the results from this sample group can be quite reflective of the many motives, thoughts and experiences that exist among the larger Instagram SciCommer community. What was perhaps most fascinating in this data analysis is that while each SciCommer had their own area of expertise and created their Instagram pages for a reason unique to their own, overarching themes were presented in responses which are outlined below.

The most common words used to describe the goals of SciComm pages include ‘awareness’ and an equal amount of ‘inspire’ and ‘encourage’. Though many SciCommers began their Instagram account as a personal page, it later developed into a SciComm platform for one of the four following motives, ordered by most to least common response:

1. To encourage compassion for wildlife or the planet
2. To educate or raise awareness about specific issues or topics
3. To converse with a global community with similar interests related to their research
4. To humanize scientists

4.1 Why Instagram?

Science Communicators of today’s age flock to Instagram to share their content primarily due to the features it provides unlike any other app currently in use and the community that exists on it. Many expressed a preference to creating posts that are fun, creative, visually stimulating and engaging in a format that can communicate science through humour, and personalization that is much less limiting than other networks such as Twitter¹⁹ for example. Though some SciCommers engage with Twitter, others felt that Instagram provided more of a creative outlet.

¹⁸ 2 of 18 (11%) participants reported that Instagram was their secondary mode of SciComm only due to the fact that they were employed to do so in-person.

¹⁹ Strong scientific community on Twitter that is often much more evidence-based. Twitter limits users to 30 characters per tweet.

Imagery

Majority of participants (13 of 18, 72.2%) prefer Instagram for their science communication over other social media platforms due to its focus on imagery and photography which allows them to engage in visual story telling as the principal form of communication. It allows for interactive and personalized content which is enhanced through Instagram Stories, which epitomize the short attention spans of users and give them the fast, varied and dynamic content they want (S.Pavelle, personal communication, April 28 2019). 'Through photographic communications, society can reconnect with the natural world, scientific knowledge can connect to public understanding, and science-based advice can connect to public policy' (Ward, 2003).

Accessibility

The second most common response was that Instagram provides the opportunity to educate a large and diverse audience (9 of 18, 50%). While social media continues to evolve, it can be said that at the time of this study, Instagram is the most popular and frequently used social media network and educating a large audience through this avenue is definitely possible especially while Instagram translates captions under photographs within the app. Other research shows that Virtual Social Networks (VSN) enable relationships to develop between users with shared beliefs, interests, values, or similar experiences, despite geographic, socio-economic, cultural, or other communication limitations that would have prevented or decreased the likelihood of such relationships in the past (Luck & Matthews, 2010).

Community

An overwhelming positive response exists in regard to the conversations had among SciCommers or with members of the public and the sense of a community that they would not have been able to conceive without Instagram. It has been described by SciCommers as the most current VSN app in the present day, where receiving the most engagement from a large positive community is a huge driver. The community has been described by participants as 'tight-knit', 'positive', 'inspiring' and 'accepting'. The diversity, overall mindset of the people on the platform and types of accounts is what draws many communicators to invest their time, energy and resources as opposed to Facebook or Twitter (A. Morrison, personal communication, May 1 2019). Many participants referred to their followers as 'friends' as they have been able to develop personal

connections with fellow scientists and members of the public due to the visual nature of the app paired with its interactive interface.

4.2 Challenges

Instagram algorithms provide users with content that the calculation determines is most relevant to the user. However, SciCommers are critical of this function as it has affected the quantity and the range of followers each post reaches. One of the goals of this community is to present SciComm posts to an audience with a varied range of knowledge and interests but the algorithm has led participants be concerned that their posts are being shared to those who are either already well-informed, have an existing interest in the content posted, or are fellow SciCommers. A study conducted by Lee et al., 2013, indicated that the reason that users have Instagram is to browse photos related to their interests and therefore, may need to have an existing interest in the environment, prior to discovering related pages. Since reaching a diverse audience is a key factor for SciCommers to use Instagram, this can potentially impact the SciCommer's engagement on the app over time as the algorithm can limit efforts to bridge the science communication gap. One way to challenge this is to use a mix of science-specific and non-science hashtags to allow posts to appear on the feeds of those who may not regularly follow science content (Jarreau et al.,2019) however this does not solve the issue.

Secondly, personal challenges that SciCommers face is with consistency in posts. To combat this, some have opted to post when they are inspired to share a specific message or when they have a photograph to share so that the motive does not revolve around frequency of posts. As well, some have expressed difficulty in encouraging others to read the full caption in a post and not being able to measure how much they have read. One method that been tested (in Case Study 3) is to place a 'call to action' at the very end of the post, and the amount of people who complete the task will give you a rough estimate of how many read the full post. The final personal challenge that was expressed is convincing the public that their small actions can have larger impacts and that their voice can inflict change. In this regard, posting content that is not only informative but is also empowering and inspiring is essential.

Thirdly, SciCommers expressed concern in regard to content posted by others, in terms of how wildlife is handled which can lead to dangerous miscommunication for conservation.

Many times whether from non-professionals or SciCommers themselves, photos handling wild animals fail to mention that the animal was held under a permit with a specific research objective. Improving the human-wildlife relationship can be done effectively with purposeful contact in demonstrating a point but places the animal under stress and often disrupts the animal's routine. Some participants mentioned that this can have more of a negative impact on wildlife than positive as people will assume that it is safe to approach certain animals for their amusement. Another behavior that SciCommers felt challenging was from pages that promote human-wildlife interactions with exotic pets, thereby supporting the illegal pet trade which is heavily reliant on social media. When these pets are not properly taken care of, they are often released into the wild, damaging the surrounding ecosystem that they are not native to. Third, concern was expressed surrounding animal exploitation under the guise of conservation. Photos may promote ecotourism to companies that are falsely advertised to be sanctuaries. A final concern shared by participants is accuracy in posts as one SciCommer mentioned that they saw a SeaWorld animal trainer with 30k followers mention that orcas prefer living in captivity which not only misinforms the public but advocates for wild orcas to go in captivity (M.Risi, personal communication, June 13, 2019). When citizens are misinformed and do not accurately understand what is happening in the ocean, they may be less inclined to support science-based conservation solutions (Shiffman, 2019b).

Challenges that participants did not mention but were observed by the researcher are the dangers in over-simplifying environmental issues which make smaller issues seem like the main problem (Shiffman, 2019a). While users may be interested in attaining evidence-based knowledge or aspire to become future scientists who seek mentors in the field may not be aware of the terms 'Science Communication' or 'Science Storytelling'. As a result, they are less likely to search for #scicomm or view related posts, unless they are already involved in the community in some way. The attempt to be accessible can become exclusionary in this way, unless a variety of hashtags are used.

4.3 Motivations

While SciCommer goals are clear, the motivations behind sharing their work to the world is what differentiates them. In most instances, the very challenges listed above, are the driving

forces that encourage them to persist. When SciCommers discussed their motives for producing content on Instagram, it was clear that they are all passion-driven and 3 commonalities exist:

1. The most common response revolved around the major theme of encouraging a sense of appreciation for the natural world paired with being driven by the conservation crisis, and environmental degradation. More specifically, while some strive to foster an awareness of how fascinating wildlife can be, others attempt to inspire a change of thought, such as to dispel fear and replace it with understanding or compassion.
2. The second most common theme included sharing events and pitfalls throughout their career path (academic or in the field) along with photography of animals that are encountered during field work or data collection.
3. Lastly, others are motivated by 'the challenge of reaching an audience who would not typically gravitate toward nature-based content' (S.Pavelle, personal communication, April 28, 2019) as well as to 'show children of colour that there are people in the field who look like them and that it is okay to be a nature nerd' (B.Almon, personal communication, May 16, 2019).

4.4 Educational Indicators

Majority of participants (16 of 18, 88.8%) agree that measuring effective SciComm education on Instagram is in fact possible, four of whom think that it can done with difficulty. Methods that SciCommers use to determine whether a learning point was communicated effectively can be narrowed down to three major indicators: engagements through comments, conversations in direct messages (DMs) and behavioral changes. Other indicators mentioned include using Instagram Insights (see Appendix F for example of data obtained from this feature), the amount of shares and reposts.

Comments

The most common indicator reported was analyzing the amount and type of comments received on a post to help determine whether a learning point was communicated effectively (15 out of 18 participants 83.3%). Almost all SciCommers agreed that the number of 'Likes' would be a highly unreliable determinant as it does not indicate whether the content on the post was read. At times, there are robots or fake accounts that generate likes on posts so it was appropriate that

the data ruled out this factor. Their examples of comments that allow them to measure education were organized by the following 3 circumstances:

- a) When a conversation is initiated about the topic which sparks a discussion or healthy, thought-provoking debates between followers and the SciCommer;
- b) When a follower states that a learning point has emerged (they learnt something new, found the topic interesting, didn't know something prior to reading the post, share a change in perception) and;
- c) When a follower is already aware of the issue and thanks the SciCommer for raising awareness of the topic.

Direct Messages

Approximately half of participants reported that engaging with comments would generate a conversation about the topic through a Direct Message (DM) related to the post itself. Some also explained that receiving DMs related to Instagram Stories were an even stronger indicator than Comments as it would allow them to answer more specific questions, expand upon ideas and engage in critical thought with their audience. Two participants specifically see determine if a conversation ensues to be a success. In some cases, speaking with many users regularly can allow SciCommers to see the growth in their knowledge over time. (Rebecca Robertson, personal communication, May 10, 2019). Others have received DMs from teachers or students saying that they used their content in the classroom (S.Pavelle, personal communication, April 28, 2019) or have received feedback regarding how the page inspired them and benefitted their personal life or career in some way (J.Panazzolo, Personal communication, April 19, 2019)

Behavioural Changes

Some examples of behavioural changes that can be viewed within the app include improved results on quizzes that are shared on IG Stories over time or using Instagram Insights which show user engagement patterns. Other behavioural changes observed that have a direct conservation impact are less measurable on the app directly but have been expressed through DMs or Comments.

Examples of when IG SciComm influenced user behaviour:

- a) Popular IG influencers, everyday people and organizations have deleted harmful pictures or modified the caption to acknowledge that they engaged in activity on protected land that can harm biodiversity, to encourage others not to make the same mistake. (Anonymous participant, personal communication, June 10, 2019).
- b) A Conservation Organization in Australia removed an image handling a lemur after a SciCommer explained the negative impacts of handling wild animals such as disease transmission, behavioral issues and dietary problems.
- c) Followers became more mindful in allowing their cats to wander outdoors after learning that they are the leading cause of bird declines worldwide (A.Israel, personal communication, May 9, 2019).
- d) People donating money or signing petitions that they wouldn't have otherwise engaged with prior to reading the SciComm post (converting Rattlesnake Roundup to an educational event, [E.Browning, personal communication, May 5, 2019] stopping a flying fox cull, etc.).
- e) Users explained their fascination for arachnids and regret fearing them throughout their life, prior to reading SciComm posts (R.Roberston, personal communication, May 10, 2019).
- f) Users expressed enthusiasm of how their Instagram Quiz results have improved show that the person themselves is motivated by their educational breakthrough.
- g) Raising awareness of toxic working conditions of a member in the community and allowing them to flee their conservation work in Indonesia (J.Panazzolo, personal communication, April 19, 2019)

4.5 Opportunities for Science Communicators

Despite the very obvious benefit of sharing science-based knowledge to the general public which results in a more informed society, compassionate towards nature, the results from this case study prove that can also offer opportunities that benefit the science communicator.

Participants shared that an unexpected outcome of communicating science on Instagram is the direct access to international contacts in the conservation field and other opportunities that it provides. The most common response is that the platform led to recognition from reputable accounts whereby in about 50% of these cases, the SciComms were able to gain professional experience or are currently employed in their field solely due to a Direct Message conversation. About 25% of this group were able to travel for these experiences in various locations ranging from British Columbia to Japan. Participants shared opportunities that emerged directly from having successful IG SciComm pages which are listed below:

- Conservation Jobs: Hosting a television show for Animal Planet, working with The Wildlife Trusts and producing content for BBC SpringWatch and BBCEarth, working with exotic wildlife at a rescue centre, being an Ambassador Lead for One Species, and being a Social Media Coordinator for a Conservation Organization
- Collaborations: academic writing, blogs, publishing in national magazines (UK), contribute to research and data collection (such as this case study)
- Speaking: Guest speaker invitations for events, creating Environmental podcasts, being filmed for educational wildlife videos
- Product Promotions: Receiving free merchandise to promote on the page by collaborating with companies related to healthy/sustainable living or whose proceeds go to conservation efforts
- Mental Health: A number of participants reflected on the personal value of being a part of an international support system where challenges and pitfalls are shared and overcome through graduate studies, in the field, or through unemployment in conservation. However, others have noted the toll it has taken on their mental health to keep producing content and to constantly be in the public eye.
- Networking: Being able to build upon ideas with like-minded individuals and expand critical thinking skills as well as having international friends in similar fields were common themes reported. Using their influence to help a conservationist in Indonesia flee from a toxic workplace.

Other benefits that were not mentioned by SciCommers include the social aspects related to humanizing scientists whereby sharing personal information combined with scientific research fosters trust and positive perceptions of scientists by the public. Growing evidence shows that ‘scientist selfies²⁰’ garner public trust (Jarreau et al., 2019). In addition, representing women in STEM and women in outdoor spaces interacting with socially-perceived ‘dangerous’ wildlife, breaks barriers and challenge perceived norms of women. This supports the findings in the study by Jarreau et al., 2019, where the team found that seeing a series of female scientist selfies on Instagram significantly shifted gender-related stereotypes, such as the association of STEM fields being male-dominated. In fact, the study group of which this case study data is based upon were mostly female Science communicators. Contradicting stereotypes of scientists and personalizing the research experience can greatly impact the scientist at an individual-level and can shape the future of their related field as a whole.

Finally, Al-Daihani et al., (2018) urge universities, academic libraries and other relevant departments to consider the value of social media for academics and recognize that social media is causing a shift in scholarly communication. Recently, some SciComers as well as academic have been seen sharing recommendations of academic literature through IG Stories or an image of a scholarly article title. The emergence of academic literature in Instagram feeds can link ideas between multiple stakeholders and inform audiences, which can lead to the production of innovative ideas in conservation research. In reference to comment type a) some scientists shared their fascination with the platform, in being able to engage with other’s perspectives about their field which would provoke critical thought about their work which could not have happened without the community that has been fostered specifically on Instagram.

5. Proposed Guidelines

Based on overall findings of this research pertaining to what makes science-based communication successful on Instagram and what scientists are wary of, it is evident that there are certain aspects to avoid and others to include in a SciComm post that is imperative to its ability to accurately inform citizens. Supported by the values shared by this study group, key

²⁰ The page @ScientistSelfies (6.6K followers) showcases scientists in their respective field taking selfies. This research project investigates how scientists’ Instagram posts may change public perceptions of scientists

elements described when creating their own Instagram posts have been extracted to formulate the guidelines below. Academics and non-scientists alike may follow these guidelines to effect change and raise awareness towards complex issues such as ecological triage or speciesism in conservation, environmental advocacy and climate change.

Guidelines for Effective & Responsible Conservation SciComm:

1. **Context:** This is critical namely for biologists who handle wildlife. As visual communicators, it is essential to provide context behind why a human-wildlife interaction is occurring and whether the animal is being held under a research permit. This can be done in the post caption, or in the Instagram bio. Allowing the public to understand that there is a specific goal that is trying to be achieved, will reduce the assumption that wild animals can be held safely for any reason, and they may be less inclined to do so themselves.
2. **Legitimacy:** Ensure posts are well-researched and are not opinion-based. When having a large number of followers on the Instagram platform, there is a sense of accountability to accurately provide information and a sense of responsibility to advocate for their cause. Producing quality posts is of strong value to this study group as this also garners public trust, strengthens their reputation and improves the citizen-scientist relationship.
3. **Tag Responsibly:** Geotagging is a challenge for scientists interested in conservation. While it is important to share where a natural feature was seen or where wildlife habitat is located to educate others, it is crucial that the image shared does not harm the species or surrounding wildlife by encouraging a large population to visit (see Chapter 1). Using generalized location tags that describe a region, or 'responsible' geotags that are offered by some protected parks are viable solutions to this conundrum.
4. **Call to Action:** It is important to give followers a sense of encouragement through posts. Especially with environment-related content, the information offered can often describe issues to be unsolvable. Providing followers with information on what they can do to alleviate the problem, organizations to donate to or offering petitions to sign are all

effective tools that encourage public empowerment which participants have used. Ending posts or Stories on a positive note is something to consider, when appropriate.

5. **Make it fun!** Instagram encourages creativity through the use of video, GIFs, drawing, special effects and other art forms that scientists are encouraged to use in their media. Sharing knowledge in a fun way that incorporates humour can challenge stereotypes of the elitist disposition that scientific research may have and improves accessibility of science-based information. This is notably done by scientists engaged in environmental activism to demonstrate how fascinating and exciting nature can be. Doing so contributes to the goal of humanizing scientists without impacting their perceived quality of knowledge (Jarreau et al., 2019) while encouraging future acceptance of science-based conservation policy.

6. Conclusion

This study explored the current status of SciComm on Instagram and its implications to biodiversity conservation and related fields. Based on empirical evidence that is further supported by academic literature, we can conclude that this study demonstrates that science communication on Instagram has an overall positive review from Science Communicators as it has catalyzed growth and visibility of a diverse, humanized and accessible scientific community. Common themes expressed by Science Communicators in this study allow us to better understand what makes Instagram a successful science communication tool, how the app is being used by scientists, what parameters can identify the effectiveness of education, its limitations as well as opportunities it can offer SciCommers and their followers. While challenges are presented on Instagram such as misinformation, harmful practices under the guise of conservation and heavy ecotourism promotion, participant responses were able to offer guidelines for responsible science communication practices related to biological conservation on Instagram.

Overall, when used responsibly, this social science analysis shows that there is a greater positive relationship than negative between science communication and Instagram which has created a revolutionary avenue to raise awareness of conservation issues, educate the general

public whereby public engagement and awareness can shape conservation priorities (Toussaint, 2005) and policy.

6.1 Limitations

Within a quantitative survey design, determining sample size and dealing with nonresponse bias is essential (Kotrlik et al., 2001) which is why a sample size greater than 18 is recommended in future study. While there was redundancy in responses which gave the researcher certainty in the validity of research quality, variance in margin of error would be reduced if $n < 18$. It should be noted that very established SciCommers with a substantial influence over Instagram at a doctoral level of study or professionals employed by well-known conservation organizations expressed great interest in this study but were unable to participate until after the study period. They may be included in future study. Gathering data from SciCommers in underdeveloped nations would also be of value in future study.

CHAPTER THREE: Applications of Instagram as a Tool for Environmental Education

1. Introduction

What began as a personal wildlife archive, the Instagram page @wildandfree.mb has become a platform that raises environmental awareness through an educational lens showcasing encounters with flora and fauna in both urbanized and undisturbed habitats. Creation of this page stemmed from being an outdoor Environmental Interpreter at a conservation area, teaching children of an array of environmental topics. Upon recognizing that children have been having less experiences in outdoor spaces, the researcher sought to discover whether the same can be said for adults. In order to do so effectively, the researcher determined that the information must be provided in small doses so that the task of learning does not appear too daunting nor time-consuming to the individual and must be engaging and should be easily accessible on a device that is readily used in daily interaction, which made Instagram the ideal contender. This study combines an observational approach, experiment, and survey results to examine the reception of environmental education across a broad audience. This is then supported by or compared to the results discussed in Chapter 2. By doing so, this study tackles the question of “Can Instagram be a valuable tool for Environmental Education?”

In a study conducted by Nerlich et al. (2009), the relationship between climate change communication and behaviour change was analyzed, which demonstrates the role of language in conveying climate change issues and emerging theories of climate change communication. This perspective was used in carefully presenting environmental information which discussed climate change or other issues. Other studies have looked at socio-demographic variables on citizen concern for global warming and how climate change communication can be improved across ideological divides (Zia & Todd, 2010) which demonstrates that there is a need for dissemination of such information.

Social scientists have observed that social media has increased individuals’ connectivity and enables users to have direct participation (Chou et al., 2009). Instagram is unique as participants will be able to provide input on certain topics, influence content generation, may participate in polls, and share their personal experiences through discussions to create linkages with larger

trends. Much of this interactive component encourages participatory action and active theorizing throughout the study duration which is fundamental to action research. Considering that humans are emotional beings and images can foster a sense of care and communicate to a broad audience instantaneously, Instagram was used to post images of a wide variety of flora and fauna that is found locally or internationally along with interesting facts to appeal to diverse audiences.

2. Experimental Design

This experiment involves actively running an Instagram account (@wildandfree.mb) that strives to make conservation and climate change information more accessible to the public through environmental education. Specifically, this will be done by generating content related to species awareness, environmental advocacy and conservation biology. Part of generating content on social media will require the researcher to remain updated on current conservation, climate change and environmental issues, both at the local and global level. This was done through consulting historical documentaries, podcasts, news articles, academic literature and government sources.

Original photographs and videos of wildlife were shared along with information related to the organism. Species were identified using a dichotomous key, mobile identification software such as iNaturalist, or involved followers in the identification process. Along with the photograph or image, depending on the topic being discussed, data visualizations were used in IG Stories to convey messages about quantitative data through a medium that is easy for non-scientists and the general public to access. Academic and non-academic sources will be consulted to solidify the information that is posted and to ensure that content is current and relevant. All photographs used are owned by the researcher, unless otherwise stated in the photograph description where credit was given to the owner who shared the image.

While this experiment focused on knowledge mobilization, the researcher also analyzed how participants respond to these forms of interactive content and record results generated from polls. This was done by compiling data results from polls, coding comments and interactions from participants, categorizing engagement and noting when a change in perspective arose. The results are represented by tables or graphs and include numerical data to support the qualitative

observations. This is a direct example of an action research cycle, which will be repeated throughout the duration of the project and takes constant attention to holistic perception (Ariizumi, 2005). This helped to determine what the audience was interested in learning about and what level of exposure to environmental topics they came with.

The researcher combined different features offered by Instagram to disseminate information in the most engaging way to appeal to broad audiences. These features include: Instagram Stories, Highlights, Polls, Ask a Question, and GIFs. The researcher then analyzed the way the community reacted to certain content which was qualitatively measured through viewing poll results, Instagram Insights, views, likes, comments and conversations generated. Instagram is unique as followers were able to provide input on certain topics, thereby influencing content generation. Much of this interactive component encourages participatory action and active theorizing throughout the study duration which is fundamental to this research.

Quantitative data was generated to support qualitative findings related to the audience's perception of environmental issues as well as public engagement on certain topics. Feedback on the page was received from survey results of a sample size of $n=30$ where participants engaged with the platform between 5 months to just over 1 year. Survey data results, qualitative findings and Instagram data as combined in attempt to measure the effectiveness of educational impact from the platform. Results are compared to findings from the perspectives of Science Communicators in Chapter 2.

2.1 Method: Posts

Generating posts and communicating science on Instagram was done with acknowledging that information will be received by a generation of users under the age of 35 (Clarke, 2019) who use Instagram the most, process information quickly, and are efficient multi-taskers (Luck & Matthews, 2010). Knowing this, posts had to be aesthetically intriguing for captions to be read and compelling enough to remind people why wildlife is worth protection. This includes the less-appreciated species such as types of insects²¹. Posts encompassed a variety of topics such as endangered species, increasing species awareness, human and wildlife conflicts, and presenting

²¹ See results in Appendix F showing an overall positive trend of 'liked' insect species on @wildandfree.mb over time based on posts between 2017-2018, prior to initiating this study

common flora and fauna with less-known facts. Captions were created to attract and maintain interest. This was done by including a question or statement that would engage the reader to click 'read more'. Then, small pieces of information were shared separated by points (.) to increase legibility and avoid overwhelming the reader. The beginning of each point used an 'emoji' (a small image icon) to add colour and animation.

Example 1

For plant images, I enjoyed including historical context by including indigenous interactions with the plant. Describing plants from their historical usages gave followers a unique perspective about common species that may be overlooked in everyday life as well as raise awareness on the history of the land that is lived on.

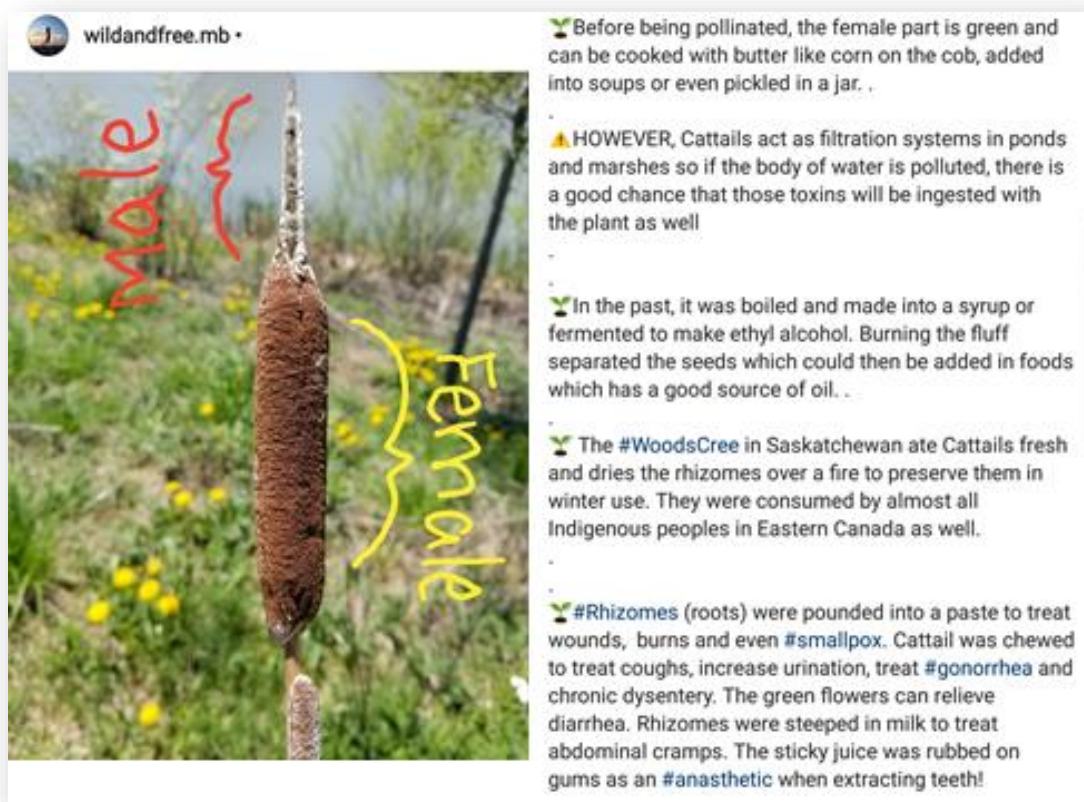


Figure 6: An example demonstrating how common, overlooked species can be presented in an engaging form by adding drawings, emojis and historical information. (Posted on @wildandfree.mb, May 19th, 2019)

The second example below is provided to demonstrate the integration of historical Indigenous uses of a species as well as citing academic literature in the caption along with hashtags of the source. As well, a general geotag, 'Ontario', is used which is located below the Instagram handle, on the top left corner of the image.

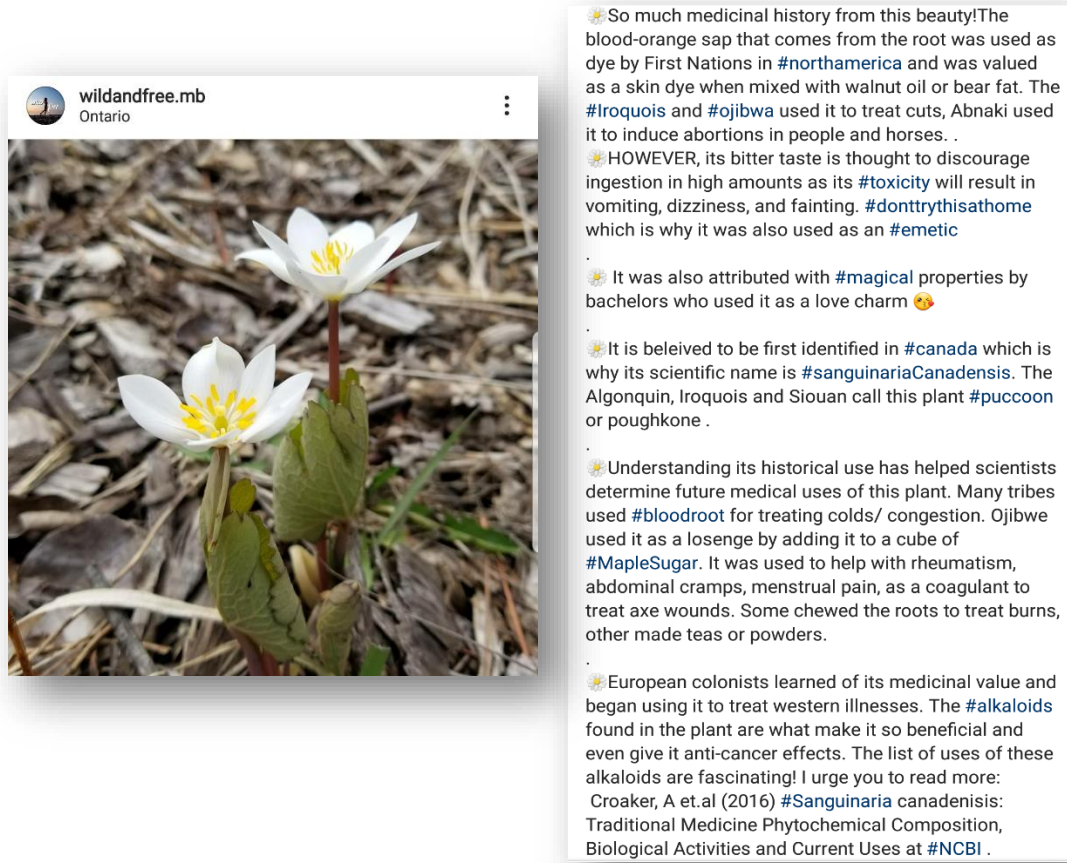


Figure 7: Educational post about Bloodroot (Posted on @wildandfree.mb May 2nd 2019)

Example 2

When posting about an environmental issue that may be problem-based, two techniques employed were to include humour in the post to keep users engaged, and to provide a solutions-based conclusion at the end whether it be signing a petition or inspiring local action. The following post in particular was successful in reaching audiences as followers engaged in comments and shared stories of their local observations on water pollution as well as ways that

they take environmental action in their community. This conversation may in turn, inspire others to do the same.

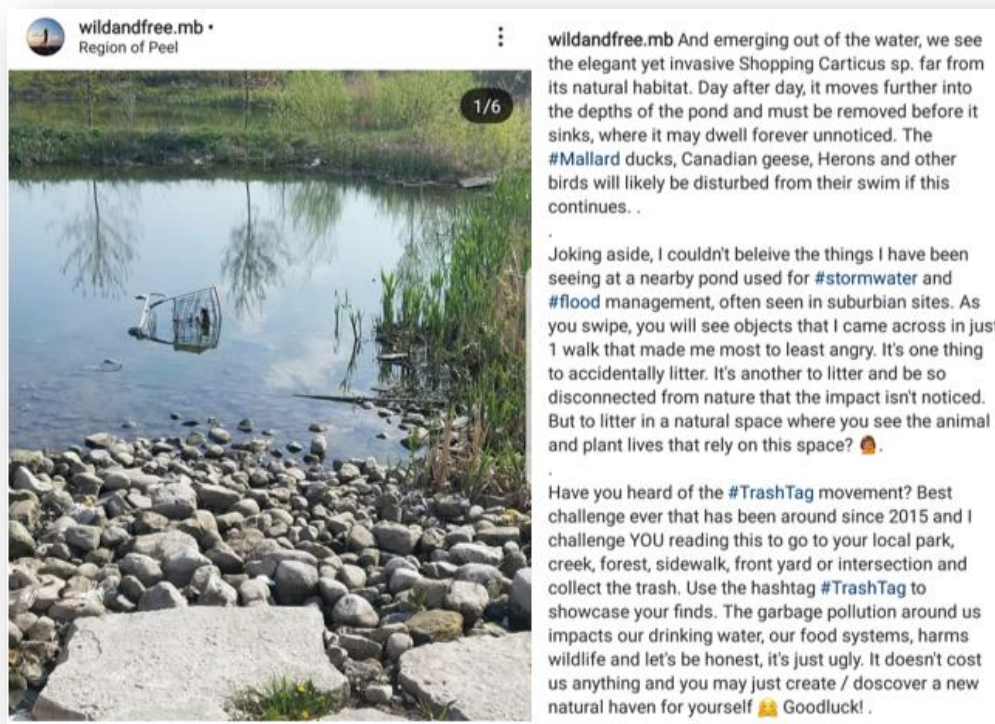


Figure 8: An example of integrating humour and a solutions-based conclusion to empower followers (Posted on @wildandfree.mb May 22nd 2019)

2.2 Method: Stories

Disseminating information was also done on IG Stories which is useful as 500 million people use IG Stories everyday (Clarke, 2019). This included live video updates of wildlife encounters or employed a 'visual storytelling' format with multiple posts and short bodies of text. Additionally, the lack of public advocacy that stems from a lack of awareness of environmental issues led the researcher to share news updates of global environmental issues. Screenshots of news articles were taken that included the headline, news source and author along with the addition of text, drawings or GIFs.

This brought hidden issues that are not often broadcasted to the public eye and sometimes expanded on the issues and explained how these issues can impact the individual at a local level. These were positively received as many followers responded to the issues via DMs expressing that the news was new knowledge learnt. Other news items included conservation

breakthroughs and innovations related to climate change or significant dates such as 'Earth Day'. As the experiment progressed, Instagram created the 'Poll' option on IG Stories which made this function much more interactive (see Figure 9). By using these features, I was able to create games, to share environmental information and later view the opinions of followers and answer their questions.

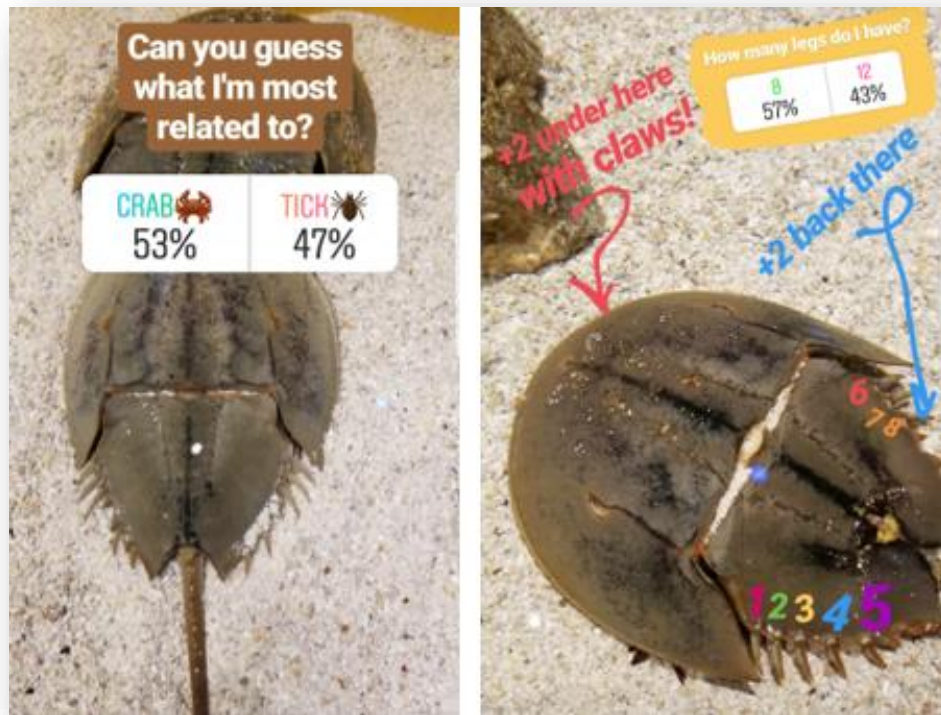


Figure 9: An example of using the IG Story feature to discuss Horseshoe Crab harvesting. Both Stories use an interactive game approach to education by using the IG Poll option (@wildandfree.mb)

The researcher also documented conferences that were attended, personal research updates and other highlights encountered through academia which was done by SciComms as well. This offered transparency in the relationship between followers on a more personalized level, as discussed in Chapter 2.

3. Results & Discussion

Upon conclusion of this study, the page has grown to an active community 405 followers²². The following results present observational trends noticed from user interactions on the page as well as data from Instagram Insights. This observational data is paired with survey results based on the follower perspective.

3.1 Results: Posts

Human-wildlife conflict was presented on multiple occasions, and it was found that this theme gained much interest where posts related to urban ecology. The images and video demonstrated that urbanized areas can be significantly important for providing wildlife habitat and can act as corridors. Posts in this series include wild turkeys passing through a subdivision, a young doe running through a backyard (128 views), and a fox playing with her kits in a concreted backyard (148 views). These images resonate with people quite well as it may remind them of a similar encounter or perhaps because the human-wildlife conflict is so visibly evident.

According to Instagram Insights, the age distribution of followers shows that majority (77%) of @wildandfree.mb followers are between the ages of 18-34, 57% of whom are from Canada and 35% of those are from the GTA (see Appendix F for more details on follower distribution Instagram Insights). Feedback from survey results and comments on posts support the idea that followers enjoy learning about local wildlife so that they may apply knowledge to their daily lives, which may reflect on the engagement of species posted from Southern Ontario. Below, the survey data results are measured on a scale ranging from 1-5 indicating 'rarely' to 'very often' to better understand how users engaged with the page.

²² As of June 2019

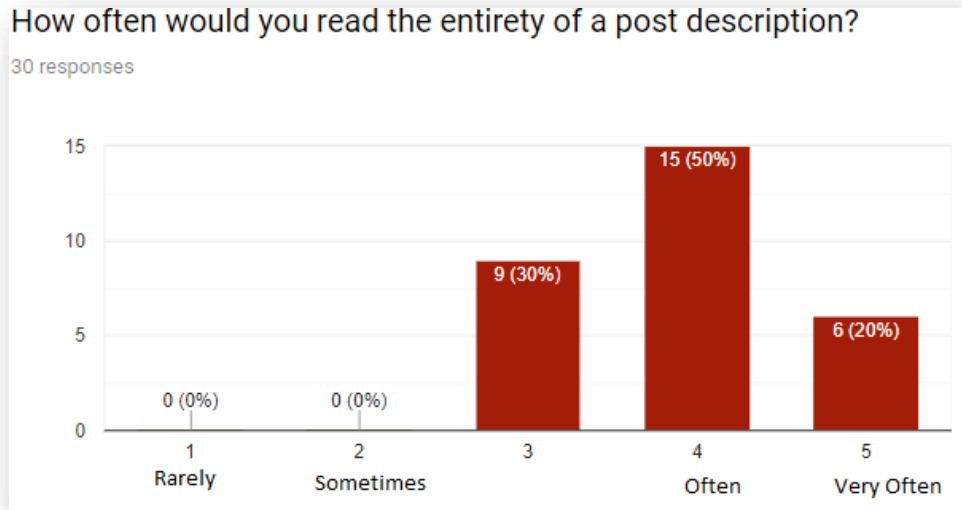


Figure 10: Participant survey results demonstrating the amount of users that would read the entirety of a caption on @wildandfree.mb

Encouragingly, the entirety of captions was often read 70% of the time despite the length of some. No participants reported that they would view the image alone and all participants read captions to some degree. This can perhaps reflect positively on the layout of the caption which is divided into segments for ease of access. This also proves that the general audience is interested in the information provided, further demonstrating that such dissemination of environmental information is needed.

3.2 Results: Stories

According to Instagram Insights, IG Stories on @wildandfree.mb are seen by 100 people on average. The researcher categorized effective or memorable Stories in a feature called 'Highlights' so that they can be viewed for more than a 24-hour period. These highlighted categories are named, "Research", "Poll data", "Conserve", "Controversy" and others. The results in Figure 12 below indicate that there are varying factors that influence whether a user would participate in such Instagram Polls.

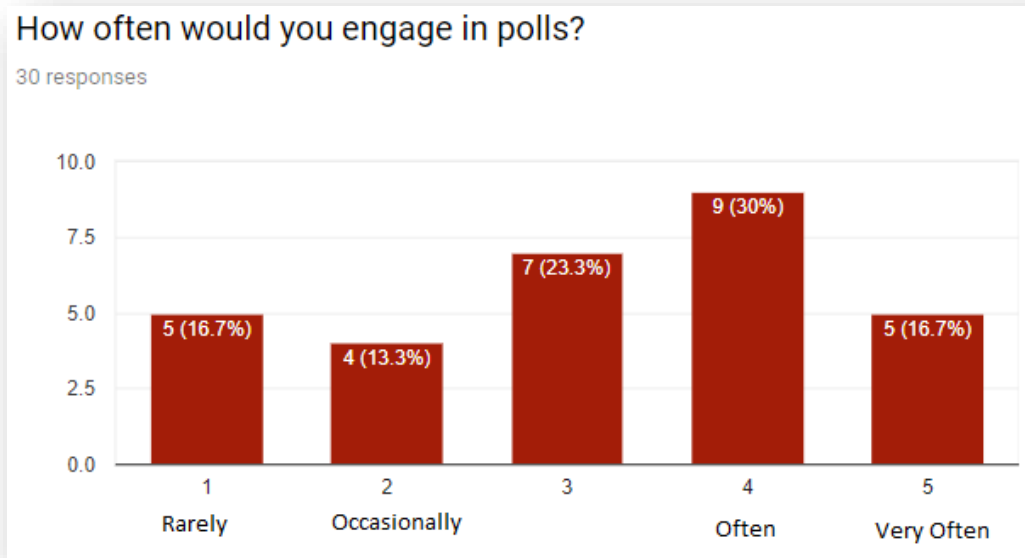


Figure 11: Poll engagement results on @wildandfree.mb

Reasons behind why 30% of participants ranked their level of engagement as a 1 or 2, was primarily due to lack of time or not seeing the stories on their page (as mentioned by 33% of this group). The way that IG Polls are presented are meant to be a welcoming and educational space where making mistakes are welcome. The researcher often shares that this information was recently learned by the educator herself and try to make Polls appear more like a game than a test.

In fact, an important part of advocacy work is to show vulnerability and admit imperfection when seeking collaboration and assistance to solve complex problems (Lee, 2017). Still, a small portion of participants mentioned that they felt intimidated or ashamed if they did not know the correct answer which discouraged them from participating (6%). The final reason users were discouraged to engage in Polls was the lack of options given and thinking that both answers were correct. At the time of this study, Instagram only had a poll with 2 options but when the study concluded, the Multiple Choice feature was introduced which gives users up to 4 options and tells them what the correct answer is right away.

Reasons why 70% of participants were more inclined to engage in Polls include the ease of access in answering, short amount of time it requires, and being encouraged to discover whether their answer was correct. Most participants shared that they were interested in the content itself and became personally curious to know what the correct response was and sought to gain personal knowledge about the topic. Individuals who are in the field or study related disciplines mentioned that they enjoyed reassuring themselves of whether they knew certain facts.

Lastly, and perhaps most interestingly, participants reflected on the platform’s overall contribution to their general knowledge by comparing their level of skill prior to following the page and afterward. Results are presented in Figure 13 below.

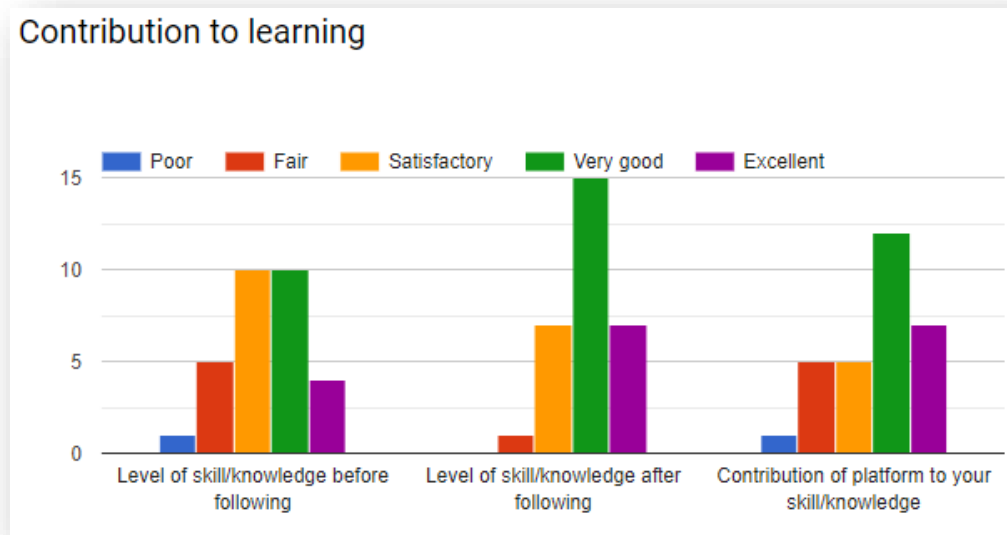


Figure 12: Participants reflect on knowledge comparison prior and after following @wildandfree.mb

As Figure 13 indicates, the blue, red and orange bars reflect a poor, fair and satisfactory level of understanding. The height of these bars significantly decreased when participants ranked their knowledge after following the page. Results show that the platform was quite effective as no participants ranked their level of understanding as ‘poor’. The third category on the right allowed participants to reflect on the platform’s impact on their personal knowledge as a whole. While majority of participants ranked this as ‘very good’ the variety of responses can be based in the fact that majority of users are already environmentally-inclined or are involved within the

conservation field in some way. Those involved in the field mentioned that they ranked their answers in the blue-orange range while others with interdisciplinary backgrounds ranked between the green-purple range, on average.

4. Educational Indicators

Based on the education indicators listed by SciCommers in Chapter 2 to measure effective science communication, the following reflection is provided in regard to how they relate to the environmental education platform @wildandfree.mb.

Likes

During the course of this study, Instagram removed the visibility of amount of likes a photo receives and this information is privately known to the viewer only. For reasons explained in the previous chapter, the number of 'likes' were not considered as a determinant of education in this study. However, milestones were acknowledged such when Rainforest Alliance liked a post about a frog the researcher found in Costa Rica or if professionals in the field liked the content posted. Also, although the researcher was unsure of how reptile and insect species would be perceived by users, it was found that these engaged curiosities of viewers and misconceptions of the animal were revealed. Through this project, it was found that when others gain knowledge about something they have socially been taught to stay away from, a sense of fear is often lost. In other words, when the sense of purpose is attributed to an animal, there is a greater chance for its presence to be accepted. This was done by either addressing how fascinating a creature is, describing its large-scale benefits, or through showcasing interactions with children safely handling the species.

Comments

Comments and Direct Messages were found to be the most relevant measures in determining how effectively educational content was received, particularly when a conversation was generated. Users shared their personal stories, experiences and observations relating to the topic of discussion and through engaging in discussions with other followers, were able to create linkages with larger trends. There are two categories of comments which indicate that a learning

point has been achieved: 1) when the user explicitly explained that they have learnt something new or share their interest on the material learnt or 2) when a post provokes thought where a question is asked or the user adds information based on their personal experience and a conversation is ensued.

This was seen by a user who shared their observations from their family's farmer almanac in regards to climate instability in their region, which later developed into a conversation between myself and the user. I did not only notice the value in engaging in such discussions and having these conversations visible to the general public to read, but also realized that my page gave others an opportunity to share their observations on a platform that they may not otherwise been able to. I also realized that they felt comfortable enough to share their personal experiences in a safe space which was a strong indicator that the ways in which I presented certain topics were not only accessible but fostered an accepting community.

Though there are many examples of this which can be viewed on the page, select few are presented in Appendix E which demonstrate each of these categories. These examples were primarily collected from comments on posts or Stories, as well as Direct Messages, or personal messages sent to myself, the page creator before and during this study. They are offered to gain a better understanding of how environmental education has been received by the public thus far on Instagram and may be indicative of its educational value.

To test the theory presented by Jarreau et al., (2019), posts were shared that included 'selfies' to see whether this gained more interest among followers to connect the audience to myself, the content creator. Interestingly, these posts did in fact received most engagement as revealed from Instagram Insights. In support of their findings, this may also challenge stereotypes of women of colour in outdoor spaces, and shift gender-related stereotypes (Jarreau et al., 2019) of outdoor occupations, which may attribute to the success of these posts.

Behavioural Changes

As described in the findings from Chapter 2, one of the most effective indicators that informed the communicator that a message was effective is when followers demonstrate or share how the page has influenced their behaviour. Interestingly, most changed behaviours were

only discovered through analysis of survey results, otherwise the behavioural changes would not have been known. The following are examples of such changes expressed in survey results:

- a) **Inspiration to use the platform for Environmental Education:** The page influenced at least 3 other peers to use their personal Instagram platforms to actively engage in discourse surrounding environmental issues in their area of expertise or geographic region through stories and posts. Inspiring others to engage in environmental advocacy and sharing their personal research is a huge indicator of success as education from diverse platforms will provide multiple perspectives on the knowledge shared. Having diverse voices spread awareness across multiple environmental issues is powerful in effecting change. Ex: *“Your page encouraged me to use my own social media platform to foster environmental education!”*
- b) **Greater sense of awareness:** At least 5 participants expressed becoming more mindful of the wildlife around them on a daily basis or when walking through nature and applying knowledge learned Ex: *“Applied knowledge throughout local nature trails”; “I notice a few more details in wildlife thanks to the page”; “Its has definitely raised my awareness and made me more conscious of my surroundings and my actions on a daily basis”; “the IG page has influenced my behavior in terms of observing wildlife more frequently in daily life especially in terms of different seasons...”*
- c) **Reducing Plastic Consumption-** One participant reported using less plastic bottles because of the awareness of plastic pollution provided on this page, and another mentioned that they purchased a biodegradable toothbrush because of this page.

These examples express that Instagram can have an influential role in influencing human behaviour and that Instagram is an effective tool for environmental educators. The overall findings reflect upon the goal of this page which is to awaken a deeper level of mindfulness, for people to take notice of the nature in their daily interactions.

4.2 Limitations of the platform in Education

As an educator, the researcher was unable to cite sources in captions. Although this is a non-academic platform, it would be interesting if including a reference would create a link to the information source for followers to view. At times, the researcher would refer to a certain article, author or write the online source as a hashtag. This was much more difficult when multiple sources were consulted to generate a post along with character limits on captions which often led to some references being omitted. As well, due to the mobile-only format of the app, spelling errors can be common in long bodies of text. Both of these factors may potentially impact the perception of credibility of the educator by experts, but did not affect the message that was being conveyed to the general public.

Along with keeping informed of environmental trends and climate change news to update IG Stories, generating posts themselves can be quite time-consuming with each post taking at least half an hour to create. This includes editing and compiling images, researching information about the topic or species, identifying the species, and pairing it with effective solutions when appropriate. However, when posts were shorter due to lack of time and only included 3-5 facts, they were still well-received by followers.

As well, consistency in creating these posts is important in ensuring that posts reach a wide audience due to the algorithm Instagram uses. An attempt at using a post-planning app was made, whereby posts are made in bulk and can be released to the app at a scheduled time, however this did not alleviate the amount of time that creating engaging and accurate quality posts demand.

As an Environmental Education platform, similar to what was discussed in the previous chapter, the Instagram algorithms made it exceedingly challenging to increase the amount of followers on the page and to reach a diverse audience, despite the use of hashtags. In fact, a study indicated that the reason that users have Instagram to browse photos related to their interests (Lee et al., 2013) and therefore, may need to have an existing interest in the environment, prior to discovering related page which was proven by participant's responses in Figure 13 below.

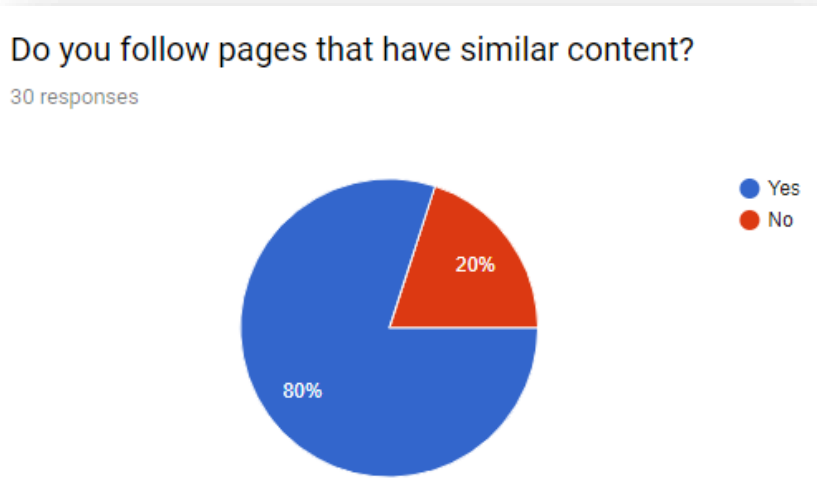


Fig 13: Majority (80%) of participants report that they follow pages that share similar content as @wildandfree.mb which may be due to the restrictions derived from the Instagram algorithm.

To mirror the feelings expressed by SciCommers in Chapter 2, the Instagram algorithm may limit the amount of followers that can see content based on their interests and engagement with similar pages. While many benefits are presented by the ease of access and knowledge-sharing capacity that Instagram has as an educational tool, it was also noticed that certain trends and marketing schemes can lead to misinformation of environmental issues. For instance, there is currently immense pressure on consumers who follow environmental pages, to stop using plastic straws and to purchase an array of plastic straw alternatives to alleviate the plastic pollution problem. Similar alternatives such as the bamboo toothbrush were presented as a solution to reduce the amount of waste production. However, viewing this imagery as a daily reminder of the same information can wrongly convince users that these are the main threats if not the sole issue entirely (Shiffman, 2019) when in reality, cigarette butts are the largest ocean contaminant (Nace, 2018).

While it may be good at rallying or inspiring an audience to think about behavioural changes and raise awareness of environmental issues, some posts of this genre can be alarmist or have a marketing agenda behind posts. Users should be cautious of information that may oversimplify environmental issues which can lead to a misinformed public. Information can be

consulted from conservation organizations, climate change platforms or science communication pages who have legitimacy in their content. (See suggested guidelines in Chapter 2).

The final limitation of the tool is that it, of course, can not replace outdoor environmental education where participants engage in experiential learning in a natural environment surrounded by the biodiversity they are learning to conserve. While viewing wildlife and nature on the mobile platform is convenient and may spark an interest in a topic or raise awareness about other issues, creating memories outdoors, for exposure to nature can be a defining experience (Driessnack, 2009). Additional feedback and testimonials of the page are included in Appendix E, which demonstrates that there is not only a need for the proliferation of environmental information on social media apps but that it has been positively received by the general public.

5. Limitations

Conservation organizations have recognized the capacity that Instagram has in encouraging the public to advocate for mitigating wildlife threats and donating to support conservation efforts. While such organizations have an immense influence ranging from NGOs, grassroots organizations or world-renowned conservation organizations²³ they were not heavily considered in this analysis.

6. Conclusion

Cultural ecosystem services are defined by people's perception of the environment (Willeman et al., 2015), which is why imagery on Instagram can be crucial for conveying messages about conservation. Impressively, there was a unanimous agreement among participants that Instagram can be a valuable tool for environmental education (100%). Considering that users can access their mobile phone virtually anywhere and anytime, this mobile-only characteristic of Instagram, along with our fast-paced culture, potentially creates different user behavior than

²³ National Geographic has a strong presence in wildlife photography photos on Instagram and run a wide range of pages such as @natgeo, @natgeoadventure, @@natgeoyourshot, @natgeotravel, @natgeochannel, @natgeofineart, @natgeowild, @natgeo.la, @natgeoimagecollection, @natgeomaps, @natgeoexpeditons and the list goes on.

other social media platforms (Lee et al., 2015). Researchers argue that artistic creations help us connect with nature and are crucial in our time when nature needs our attention and care more than ever (Kesebir & Kesebir, 2017). For instance, conservation photographs that directly showcase the natural world have a unique opportunity to help connect people to the environment which may then inspire environmental action to be taken (Ward, 2003). Instagram is especially powerful in this sense, as the visual is interpreted in a matter of seconds and can be enough to break misconceptions such a powerful tool in communicating these ideas, as they can be easily understood by looking at an image.

Overall, the positive reception of this page as well as the inspiration it has given to others in engage with environmental education on their own platforms demonstrates that there is not only an interest but a necessity for this information to be disseminated and readily available. Similar to the feelings expressed by SciCommers, the positivity that is shared across the Instagram community is incredibly positive and encouraging pertaining to environmental issues, and is a key motivator in content generation. Information availability is instrumental to environmental education and awareness as it fosters attitudes, motivations, and commitments to make informed decisions, take responsible action (Dias et al., 2004) Instagram, if used effectively, is a powerful tool that can and create an environmentally-literate citizenry (Cole, 2007) and inspire catalysts of change to protect the environment which sustains us.

IN SUMMARY

Barnosky's (2015) analysis revealed that if the background rate for species extinctions is about 2 per million species-years, we should expect one species to become extinct every 100 years, if applied to the amount of species we have today. However, the reality is occurring 28-67 times faster than this expected rate, equating to approximately 43 extinctions over the past 100 years. This rate can lead to the sixth mass extinction on earth (Barnosky, 2015).

Beyond connecting millions of people worldwide, this paper reframes social media to be a powerful tool in protected area management, science communication and environmental education. Instagram has allowed multiple levels of society to raise awareness and learn about environmental issues, especially those pertaining to biodiversity conservation (Lenzi et al., 2019). We are in a pivotal point for environmental education where climate change issues proliferate the masses and when social media is so prevalent. In this regard, it is the opportune time to examine how these factors will and has shaped conservation biology. The exploration of three chapters analyze different ways that Instagram is currently being used and how it has impacted and will continue to shape conservation and related fields.

In summary, this research began by analyzing how Instagram has impacted protected area management physically, ecologically and socially. Then, the views of scientists from multiple nations were consulted to determine opportunities and challenges that are presented for conservation science. Last, environmental education on Instagram was put into practice which resulted in growth of a more aware and environmentally engaged community. Findings from these three chapters demonstrate that when used meaningfully, Instagram is an incredibly useful tool that will continue to shape the future of conservation science and environmental action.

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APPENDIX A: PRESENCE OF NATIONAL PARK PLATFORMS ON INSTAGRAM

National Park (NP) (Canada & US)	Instagram Account	Information Posted	Number of Followers	Run by NP?
1. Akami-Uapishk-KakKasuak-Mealy Mountains National Park Reserve (NL)	N/A	N/A	N/A	N/A
2. Aulavik National Park (NT)	@parcs.canada (only instagram to post about NP)	general information, photography	17.6k	No
3. Auyuittuq National Park (NU)	@explorecanada @parks.canada @cangeo	nature, attractions, culture, adventure, cities, food & drinks, polar bears, general info, photography, general info, photography	1.5m 238k 66.5k	No Yes No
4. Banff National Park (AB)	@banff_lakelouise @alberta_parks	tourism/recreation, general info, ambassadors	183k 31.2k	No Yes
5. Bruce Peninsula National Park (ON)	@ontariotravel @explorecanada @ontarioparks	guide, festivals, tourism, recreation, birding/wildlife	262k 1.5m 112k	No No Yes
6. Cape Breton Highlands National Park (NS)	@visitcapebretonisland @ns_parks	general info, tourism, food, activities, recreation, culture	20.4k 1,447	No Yes
7. Elk Island National Park (AB)	@travelalberta @exploreedmonton @alberta_parks	rural alberta, outdoors, recreation, activities tourism	651k 83.2k 31.2k	No no yes
8. Forillon National Park (QC)	@parks.canada	polar bears, general info, photography	238K	yes
9. Fundy National Park (NB)	@destinationnb	tourism	29.3k	no
10. Georgian Bay Islands National Park (ON)	@georgianbayislands @ontarioparks	general information, photography, wildlife, recreation	14 112k	no yes
11. Glacier National Park (BC)	@yourbcparks	Croteau Lake, student rangers, park rangers, Instagram challenges, wildlife, recreation	63.7k	yes
12. Grasslands National Park (SK)	@tourismask @saskparks @saskregionalparks	general info, tourism, Duck Mountain, recreation,	54.8k 4,373 836	no yes

		wildlife, photography, contests		yes (run by regional park)
13. Gros Morne National Park (NL)	@visitgrosmorne	general information, photography, wildlife, recreation	2,197	not sure
14. Gulf Islands National Park Reserve (BC)	@yourbcparks	Croteau Lake, student rangers, park rangers, Instagram challenges, wildlife, recreation	63.7k	yes
15. Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve, and Haida Heritage Site (BC)	@gohaidagwaii @yourbcparks	tourism, recreation, wildlife, Croteau Lake, student rangers, park rangers, Instagram challenges	14.1k 63.7k	no yes
16. Ivvavik National Park (YT)	N/A	N/A	N/A	N/A
17. Jasper National Park (AB)	@jaspernationalpark @alberta_parks	photography, recreation, general info, ambassadors	10.9k 31.2k	not sure (most likely not) yes
18. Kejimikujik National Park and Historic Site (NS)	@ns_parks	general info, recreation	1,447	yes
19. Kluane National Park and Reserve (YT)	N/A	N/A	N/A	N/A
20. Kootenay National Park (BC)	@yourbcparks	Croteau Lake, student rangers, park rangers, Instagram challenges, wildlife, recreation	63.7k	yes
21. Kouchibouguac National Park (NB)	N/A	N/A	N/A	N/A
22. La Mauricie National Park (QC)	N/A	N/A	N/A	N/A
23. Mingan Archipelago National Park Reserve (QC)	@parks.canada @tourismquebec	polar bears, general info, photography, tourism	238K 111k	yes no

24. Mount Revelstoke National Park (BC)	@yourbcparks	Croteau Lake, student rangers, park rangers, Instagram challenges, wildlife, recreation	63.7k	yes
25. Nahanni National Park Reserve (NT)	N/A	N/A	N/A	N/A
26. Nááts'ihch'oh National Park Reserve (NT)	N/A	N/A	N/A	N/A
27. Pacific Rim National Park Reserve (BC)	@yourbcparks	Croteau Lake, student rangers, park rangers, Instagram challenges, wildlife, recreation	63.7k	yes
28. Point Pelee National Park (ON)	@ontarioparks	general info, recreation, wildlife	112k	yes
29. Prince Albert National Park (SK)	@saskparks	general info, Duck Mountain, recreation, photography	4,501	yes
30. Prince Edward Island National Park (PEI)	@explorecanada @parks.canada	nature, attractions, culture, adventure, cities, food & drinks, polar bears, general info, photography	1.5m 238k	No yes
31. Pukaskwa National Park (ON)	@ontariotravel @parks.canada @ontarioparks	guide, festivals, tourism, general info, recreation, birding/wildlife	262k 238k 112k	no yes yes
32. Qausuittuq National Park (NU)	N/A	N/A	N/A	N/A
33. Quttinirpaaq National Park (NU)	N/A	N/A	N/A	N/A
34. Riding Mountain National Park (MB)	@clearlakecountry @explorecanada	general info, eats, stay, events, explore, services, shop, nature attractions, culture, adventure, cities	10k 1.5m	yes no
35. Rouge National Urban Park (ON)	@ontarioparks	general info, recreation, wildlife	112k	yes
36. Sable Island National Park Reserve (NS)	@ns_parks	general info, recreation	1,447	yes
37. Sirmilik National Park (NU)	@parks.canada	polar bears, general info, photography	238K	yes
38. Terra Nova National Park (NL)	N/A	N/A	N/A	N/A

39. Thousand Islands National Park (ON)	@ontariotravel @ontarioparks	guide, festivals, tourism, recreation, birding/wildlife	262k 112k	no yes
40. Torngat Mountains National Park (NL)	@explorecanada @newfoundlandanadlabrador	nature, attractions, culture, adventure, cities, food & drinks, general info, heritage/culture	1.5m 114k	no no
41. Tuktut Nogait National Park (NT)	N/A	N/A	N/A	N/A
42. Ukkusiksalik National Park (NU)	N/A	N/A	N/A	N/A
43. Vuntut National Park (YT)	@parks.canada	polar bears, general info, photography	238K	yes
44. Wapusk National Park (MB)	@cangeo @explorecanada	general info, photography, nature, attractions, culture, adventure, cities, food & drinks	66.5k 1.5m	no no
45. Waterton Lakes National Park (AB)	@travelalberta @watertontourism	wood buffalo, eats, Medicine Hat, snow activities, cabins, Northern lights, recreation, food fest, events, general info	652k 3,526	no no
46. Wood Buffalo National Park (AB)(NT)	@travelalberta @parksCanada	wood buffalo, eats, Medicine Hat, snow activities, cabins, Northern lights, recreation, polar bears, general info, photography	652k 238k	no yes
47. Yoho National Park (BC)	@yourbcParks	Croteau Lake, student rangers, park rangers, Instagram challenges, wildlife, recreation	63.7k	yes
48. Acadia National Park (ME)	@acadianps	light house, general info, wildlife, safety/fire activity, tourism, recreation	230k	yes
49. Arches National Park (UT)	@archesnps	recreation, scenery, fauna, wildlife, events, history, general info	196k	yes
50. Badlands National Park (SD)	@badlandsnps	general info, recreation, wildlife, ranger programs, safety, events	142k	yes
51. Big Bend National Park (TX)	@bigbendnps	wildlife, safety, recreation, nature, exhibits	149k	yes

52. Biscayne National Park (FL)	@biscaynenps @biscaynenationalparkinstitute @biscaynenaturecenter	marine patrol, sea life, volunteer, pollution/litter, safety, general info, snorkel boat, lighthouse, recreation, tourism, summer camp, education	60.4k 841 1,732	yes no no
53. Black Canyon of the Gunnison National Park (CO)	@blackcanyonnps	general info, events, recreation, programs	23.4k	yes
54. Bryce Canyon National Park (UT)	@brycecanyonnps_gov @visitbrycecanyon	festivals, general info, camping, junior rangers, safety/fire, wildlife, tourism, recreation/activities	111k 153	yes no
55. Canyonlands National Park (UT)	@canyonlandsnps @cnhmoab	general info, fauna, wildlife	78.7k 801	yes no
56. Capitol Reef National Park (UT)	@capitolreefnps @capitolreefcountry	general info, wildlife/fauna, tourism, recreation	51.1k 188	yes no
57. Carlsbad Caverns National Park (NM)	@carlsbadcavernsnps	general info, wildlife, recreation, research, rescues, history	45.4k	yes
58. Channel Islands National Park (CA)	@channelislandsnps	general info, recreation, ecosystem management, events, wildlife, volunteer	24.9k	yes
59. Congaree National Park (SC)	@congarreenps	general info, events, volunteer, safety/fire, recreation, wildlife, education, history	11.2k	yes
60. Crater Lake National Park (OR)	N/A	N/A	N/A	N/A
61. Cuyahoga Valley National Park (OH)	@cuyahogavalleynps	volunteer, park alerts, general info, history, programs, recreation, wildlife, events, photography	52.9k	yes
62. Death Valley National Park (CA)(NV)	@deathvalleynps	weather/rain, junior ranger educational books, events, conditions, fauna, pollution/litter(release of balloons)	199k	yes

63.	Denali National Park (AK)	@denalinps	wildlife, recreation, general info, ranger programs, volunteer, dog sledding	211k	yes
64.	Dry Tortugas National Park (FL)	@drytortugasnps	general info, wildlife, events, history, safety, recreation	51.4k	yes
65.	Everglades National Park (FL)	@evergladesnps	internships/opportunities, jobs, channel markers, boat tours, safety/fire management, wildlife, general info, recreation	48.7k	yes
66.	Gates of the Arctic National Park (AK)	N/A	N/A	N/A	N/A
67.	Gateway Arch National Park (MO)(IL)	@gatewayarchnps @gatewayarchstl @gatewayarchpark	general info, junior rangers, tourism, events, history, recreation, museum, weather	2,973 24.7k 10.6k	yes no no
68.	Glacier Bay National Park (AK)	@glacierbaynps	general info, wildlife, tourism, recreation, ranger activity	42k	yes
69.	Glacier National Park (MT)	@glaciernps	wildlife, general info, road status, safety, glaciers, fire, aquatic invasive species, recreation	702k	yes
70.	Grand Canyon National Park (AZ)	@grandcanyonnps	general info, events, prescription fires, history, fauna, recreation, tourism	550k	yes
71.	Grand Teton National Park (WY)	@grandtetonnps	berry fire, teton skies, wildlife, road safety, recreation, fauna, events, volunteer, peace officers	408k	yes
72.	Great Basin National Park (NV)	@greatbasinnationalparkguide	general info, wildlife, recreation, tourism, app/guide	11.6k	no
73.	Great Sand Dunes National Park (CO)	@greatsanddunesnps	general info, science of water flow, recreation, wildlife, science Saturdays, history, events, workshops, education	16k	yes
74.	Great Smoky Mountains National Park (NC)(TN)	@greatsmokynps	artist residence, volunteer, fauna, wildlife, events, recreation, history,	341k	yes

		rehabilitation projects, park maintenance		
75. Guadalupe Mountains National Park (TX)	@guadalupemountainsnps	wildlife, recreation, general info, fauna, events, employees, junior rangers, volunteer, contests, history	65.2k	yes
76. Haleakalā National Park (HI)	@haleakalanps	events, history, general info, internships, flora/fauna, history, wildlife, volunteer, culture/beliefs	24.4k	yes
77. Hawai'i Volcanoes National Park (HI)	@hawaiivolcanoesnps	wildlife, research, general info, history, recreation, culture, fauna/flora	148k	yes
78. Hot Springs National Park (AR)	@hotspringsnps	general info, recreation, events, volunteer, education, programs	2,735	yes
79. Indiana Dunes National Park (IN)	@indianadunesnps @indianadunes	general info, wildlife, flora/fauna, history, research, junior rangers, maple sugar, volunteer, events, recreation, tourism	8,442 6,142	yes no
80. Isle Royale National Park (MI)	@isleroyalnps	general info, recreation, wildlife, winter study, events/programs	27.2k	yes
81. Joshua Tree National Park (CA)	@joshuatreenps	joshua trees, west entrance, shuttle bus, recreation, wildlife, environmental protection, general info, photography, research/field work, art, volunteer, flora/fauna	307k	yes
82. Katmai National Park (AK)	@katmainpp	plan your visit, bears, volcanoes, salmon, human history	34.6k	yes
83. Kenai Fjords National Park (AK)	@kenai fjordsnps	wildlife, flora, general info, employment, research, events, environmental changes, plant management, recreation	45k	yes
84. Kings Canyon National Park (CA)	N/A	N/A	N/A	N/A

85. Kobuk Valley National Park (AK)	@kobukvalleynps	Camp Willow, July 4th fest, wildlife, events, general info, dog mushing, flora/fauna, fieldwork	2,171	yes
86. Lake Clark National Park (AK)	@lakeclarknps	general info, flora/fauna, recreation, environmental processes, wildlife, programs, volunteer	61.2k	yes
87. Lassen Volcanic National Park (CA)	@lassennps	general info, science, wildlife, recreation, art, camp, events, history	18.9k	yes
88. Mammoth Cave National Park (KY)	@mammothcavenps	general info, wildlife, tours/tourism, history, caves, recreation, flora/fauna, junior rangers, education, safety, events	1,586	yes
89. Mesa Verde National Park (CO)	@mesaverdenps	fauna/flora, recreation, general info, culture/heritage, events, history, wildlife, volunteers, tours	9,195	yes
90. Mount Rainier National Park (WA)	@mountrainiernps	live webcams, avoid crowds, plan your visit, spring opening, general info, recreation, wildlife, history, flora/fauna, rehabilitation	208k	yes
91. National Park of American Samoa (AS)	@np_american_samoa @npsamericansamoa	history, coral, culture/heritage, recreation, wildlife, sea creatures, general info, flora/fauna	11.6k 6,445	yes no
92. North Cascades National Park (WA)	@sequoiakingsnps	general info, fire safety, wildlife, prescribed burns, recreation, shuttle, flora/fauna, history	177k	yes
93. Olympic National Park (WA)	@olympic_nps	Bark Rangers, Huckleberry, Summer Kids Program, Alt Text, 200k, Winter Newspaper, Buffalo Soldiers, Highlights, recreation, general info,	228k	yes

		flora/fauna, wildlife, wilderness Wednesday		
94. Petrified Forest National Park (AZ)	@petrifiedforestnps	wildlife, recreation, flora/fauna, history, petroglyphs, general info, event	71.8k	yes
95. Pinnacles National Park (CA)	@pinnaclesnps	general info, wildlife, flora/fauna, internship, recreation	6,855	yes
96. Redwood National Park (CA)	@redwoodnps	redwood trees, wildlife, flora/fauna, volunteers, recreation, general info, events/festivals	167k	yes
97. Rocky Mountain National Park (CO)	@rockynps	general info, recreation, wildlife, safety	477k	yes
98. Saguaro National Park (AZ)	@saguaronationalpark	snow day, scenic cruise, dragonflies, javelina, skulls, kangaroo rat, flora/fauna, wildlife,	110k	yes
99. Sequoia National Park (CA)	@sequoiakingsnps	general info, fire safety, wildlife, prescribed burns, recreation, shuttle, flora/fauna, history	177k	yes
100. Shenandoah National Park (VA)	@shenandoahnps	general info, safety, recreation, wildlife, history, festival/events	167k	yes
101. Theodore Roosevelt National Park (ND)	@theodorerooseveltnps	general info, wildlife, recreation, flora/fauna, festivals	22.6k	yes
102. Virgin Islands National Park (VI)	@virginislandsnps	general info, historic preservation, flora/fauna, internship, history, heritage/culture, wildlife, volunteers, recreation	17.1k	yes
103. Voyageurs National Park (MN)	@voyageursnps @voyageursnpa	quarter release, park maintenance, volunteers, wildlife, education, safety, flora/fauna, tours, opportunities, recreation	19.7k 1,978	yes no
104. Wind Cave National Park (SD)	@windcavenps	general info, wildlife, flora/fauna, recreation, volunteer, cave restoration, research	31.3k	yes

105. Wrangell-St. Elias National Park (AK)	@wrangellstenps	staff overview, Ahtna, backpacking, glaciers, cabins, Jokulhlaup, Aurora, salmon, volcanoes, gold mines hike, fireweed, Alpinist, wildlife, recreation, history, junior rangers	13.9k	yes
106. Yellowstone National Park (ID)(MT)(WY)	@yellowstonenps	wallpapers, InstaMeets, wildlife, recreation, projects, park protection	863k	yes
107. Yosemite National Park (CA)	@yosemitenps @yosemiteconservancy	spring weather, winter, Lyell Glacier, fall weather, recycle, Half Dome, Mist Trail PSAR, recreation, volunteer, adventures, webcams, field notes, history, junior rangers	1.4m 41k	yes no
108. Zion National Park (UT)	@zionnps	general info, art, vegetation, recreation, wildlife, flora/fauna, history, park protection, safety, events, volunteer, wildlife protection	614k	yes

APPENDIX B: INTERVIEW EXERPTS FROM SCICOMM PARTICIPANTS

Value/Challenge	Interview Excerpt
Reaching wide audiences Visual-based platform	<i>"I think the platform of Instagram and its incredible reach has arrived at just the right time to rally as many people together to take note of what's happening to the environment and do something about it. Behavioral change is one of the most valuable aims of public engagement, and I think the intense visual nature of Instagram and its daily massive community can only benefit from having wildlife and natural spaces infiltrate their feed... What a privilege to have a platform like that at a time when we need it most!" –@SophiePavs</i>
Reaching wide audiences	<i>"The Science community on Instagram is growing every day and is an imperative tool for social media SciComm" - @MericanBarbarian)</i>
Storytelling, raising compassion, humanizing scientists	<i>"Another thing I learned from my research is that we don't change people's minds and we don't inspire action by throwing facts and figures at people. Stats are great for scientists but they aren't great for people who don't already have a connection to something that you care about, ... but if you want to inspire a heart change you need to connect with them on an emotional level." - @AlexoftheWild</i>
Empowerment, fostering a sense of community	<i>"I have been able to help conservationists from all over the world to feel united instead of oppressed." – @LonelyConservationsits</i>
Raising compassion to effect change	<i>"If society doesn't care about science, then it is difficult to convince a community that our government policies and general conduct need to be informed by scientific fact." – @ForestladySteph</i>
Humanizing scientists, creativity-based platform, sense of community	<i>"This is the platform upon which I have received the best engagement, developed the best relationships, and enjoyed the most, so I simply continue with it because of that. I also love the photo side of it, coupled with the storytelling approach to captions... it's creative and more enjoyable than other platforms" ~@ConservationistKrissy</i>
Reaching wide audiences; posing risk to ecology	<i>"There are both positives and negatives when it comes to social media and has seen it both. Instagram has brought so much attention to these super cool outdoorsy spots, but with that attention brings lots of people who may not respect that land." - @TheWildGingerBeast</i>
Reaching wide audiences; algorithm	<i>"I find the algorithms that Instagram uses to promote posts to be frustrating. The amount of people that Instagram will show your posts to seems to be completely independent of the quality of said post. Sometimes I'll get 1200 views from hashtags and other times I'll only get 12 views from hashtags." - @brendan6744</i>

APPENDIX C: SCICOMMER IG HANDLES

Participant*	Expertise/Position	IG Handle
Alex Morrison	Wildlife biologist, PhD & professor	@alexofthewild
Alexandra Israel	Wildlife biologist, Wood thrush researcher	@alexxisrael
Becca Robertson	Entomologist, researcher	@biggirlbecca
Billy Almon	Biologist, biomimicry specialist, educator	@billy_biology
Brandon Delaney	Conservation Officer	@mericanbarbarian
Brendan Boyd	Biologist, PhD candidate	@brendan6744
Cylita Guy	Ecologist, PhD, specializing in bats	@cylitaguy
David Shiffman	Marine Conservation Biologist, PhD	@whysharksmatter
Emma Browning	Herpetology Technician	@herpetologistemma
Jessie Panazzolo	Conservation Ecologist	@lonelyconservationists
Krissy Middleton	MSc Conservation and Biodiversity	@conservationistkrissy
Michelle Risi	Seabird Field Biologist	@michelle_on_goughisland
Noeline Subramaniam	Leopard Gecko wound healing, PhD candidate	@thespicyscientist
Sarah Kelehear	Naturalist, Salamander researcher	@salamander_sarah
Sean Laughlin	Naturalist, Field Scientist	@thewildgingerbeast
Sophie Pavelle	Science Communicator, MSc	@sophiepavs
Stephanie Martin	Tropical Rainforest Ecologist	@forestladysteph
Stephanie Schuttler	Wildlife biologist, conservationist, PhD	@fancy_scientist

*Not all participant names are included for confidentiality.

APPENDIX D: EXAMPLES OF IG PLATFORMS DIVERSIFYING THE OUTDOORS & ENVIRONMENTAL MOVEMENT

Instagram Page	Followers	Bio/Description
@melaninbasecamp	21.1K	“We are people of colour in the outdoors. Tag #melaninbasecamp and help diversify the outdoors.” The page features diverse POC doing outdoor activities such as surfing, hiking, mountain climbing, skydiving etc.
@beinggreenwhileblack	4.9K	“Visually reclaiming the greenness of Blackness” This page creates a community by reposting other Instagrammers or people of inspiration along with topics related to environmental justice.
@blackgirlstrekkin	6.8K	This page focuses on education, conservation, diversity and inclusion in the outdoors and shares experiences of POC hiking along with planning ‘meet-ups’ for others to join.
@brownpeoplecamping	22.5K	“Proud south Asian Muslim American woman diversifying public lands and outdoors one story at a time”
@zerowastehabesha	10.3k	Ethiopian American who shares her experience with a zero waste lifestyle and environmental justice. She also examines attempts toward environmentalism and critically analyzes them through various lenses. She occasionally engages with her audience through live streaming videos where she explores concepts of bio-piracy and environmental racism.
@outdoorasian	2.2k	“Building a community of Asian & Pacific Islanders in the outdoors. “
@brownpeoplehiking	298	“Promoting, encouraging and embracing diversity in the mountains by creating a forum to celebrate, love, and share a passion for the great outdoors.”
@black.guys.travel.too	74.6k	Featuring black men traveling in outdoor locations across the world, challenging societal norms
@blackgirlstraveltoo	122k	“We are a global travel community that create tools, tips, and self empowering trips for women travelers.”
@browngirlstravelling	5.3k	Featuring brown women traveling in outdoor locations across the world

@unlikelyhikers	67.2	"Diversity + Inclusion + Representation + Body Liberation Outdoors!"
@akunahikes	7.6k	Sharing hiking updates
@rahawahaile	3.9k	Eritrean American showcasing updates from the Appalachian Trail and research. "Desire to amplify the voices of women of colour in an industry known to use them or challenge their lived experiences..."
@outdoorafro	19.9k	"We celebrate & inspire Black leadership in nature"
@nativewomenswilderness	22.3k	"A gathering to share stories, to learn, and to support other Native Women in the Wild. "
@gogreensavegreen	34.2k	"By a WOC for POC. For those who don't know if they can actually make a difference" Focuses on environmental education
@browngirl_green	3.3k	"Jew-Pina environmentalist. Trying to save the planet one post at a time" Focuses on environmental education

APPENDIX E: EDUCATIONAL INDICATORS FROM PARTICIPANT REMARKS

The following are a sample of comments from posts on the Instagram page @wildandfree.mb, Direct Messages to the creator, survey results, as well as testimonials about the page which are all reflective of the way that environmental education has been received by the public and may be indicative of its educational value.

- 1) Survey responses to “Do you think that Instagram can be a valuable tool for conservation or environmental awareness?”

Perceived value from user	User Response
Instagram is the most current social media platform to get information	“Absolutely... IG, in my opinion, is the most current social media tool that can help with environmental education”
	“Awareness starts on social media”
	“Yes, insta (IG) is pretty much my only tool since I don't watch news or look much stuff up myself”
	“Yes especially for my generation as people are beginning to become more aware and sharing the same message of saving the environment and protecting our earth”.
Accessibility	“...it has a lot interesting info and I think it’s valuable for people who are interested/concerned about the environment but don’t necessarily study or work in the field.”
	“Yes! The best way to get others attention and inform them and hopefully allow them to become more aware is social media. I prefer Instagram over many other platforms and find myself always seeing this pages posts and never missing out”.
	“I did not realize that you could collect data from the questions you as in your Story feature. My roommate even mentioned that she loves how much detail is in each description of each photo. Well thought out!”
Ability to apply their own knowledge for those already in the field	“Makes me fact check myself”
	“I’ve got many of the same values as the page promotes, and am a person of color

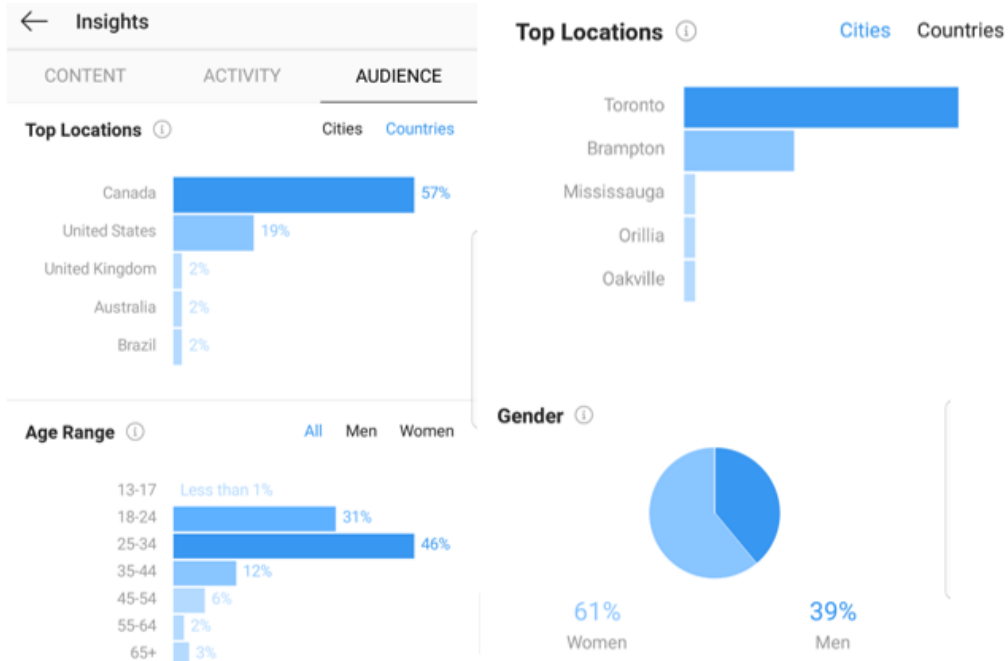
	myself, so I mostly just draw inspiration from the page to keep engaging with the world around me”
	“She advocates for climate action but balances out the doom and gloom with reminding followers of the beauty of nature and the little things”

2) Types of comments from posts shared on @wildandfree.mb that reflect upon education

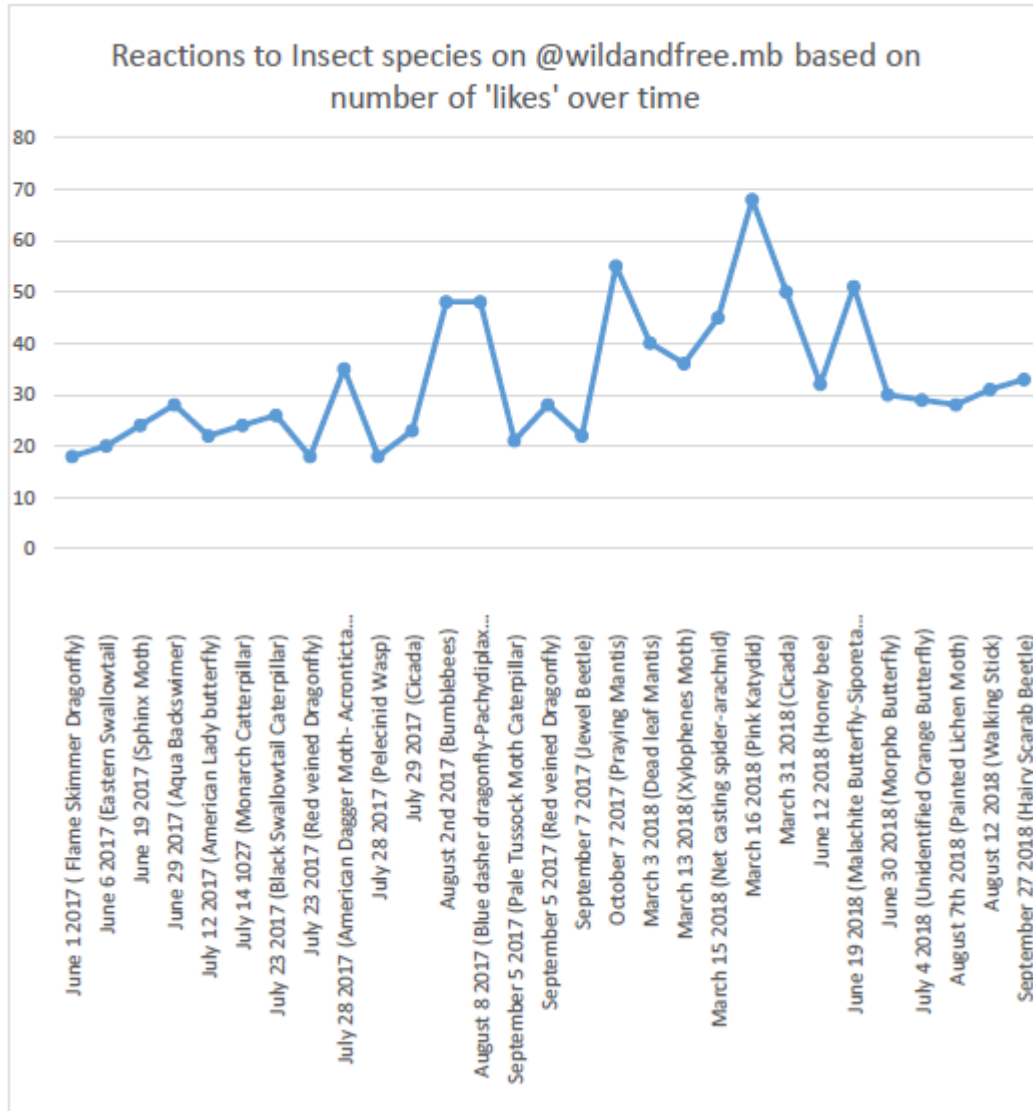
Types of Comments			
Breakthrough: New information received	Growth: Expands on existing knowledge	Reflective: Provokes critical thought/ questions lead to conversation	Community: Shared concerns and interests
<p>“Omg awesome post! I did not know about this!” (Jan 5th 2019; post about Cormorant cull in Ontario)</p> <p>“wow that’s definitely a fun fact for the day” (Jan 11th 2019, Canadian geese post)</p> <p>“wow I did not know! So cool” (April 7th 2019, Lionfish post)</p> <p>“This is cool” (Jan 27th 2019; horseshoe crab post)</p> <p>“Woah that’s insane! Australian birds just rip bark off and scream” / “Wow those are BIG</p>	<p>“great work with your wildandfree account, I enjoy the facts and tidbits. Re: SARO article, thank you for bringing this to light!” (Jan 25th 2019)</p> <p>“I don’t know much about honey bee ID in terms of queen vs worker but I know it would be a female if she’s carrying pollen” (June 12 2018; bee post)</p> <p>““This is a very similar issue they are experiencing around Bocas, there’s a lot of island erosion from development and coral loss. I haven’t seen this project specifically being utilized there yet so hast really</p>	<p>“They aren’t afraid of humans?” (June 22 2018; Coati post)</p> <p>“Wait does this have two berries on each stalk? I just posted about twinberries native to my region and then I was checking out your account after checking your latest post and now I’m freaking out a little, this is so cool! I wonder if they’re related!” (Sept 24th 2019, Creeping strawberry)</p> <p>“Woah took me a while to see that” (April 28th 2019; Garter snake camoflauge)</p>	<p>“I think its amazing what you do with your Instagram page, I want to start promoting my own research that way too! I think its an excellent tool for environmental education.” (Jan 12th 2019)</p> <p>“The general public needs so much more education on urban ecology so the more often people see it, the better. we need this info to have more presence on social media! keep it up”</p> <p>“Look at all the gziibnashk, scouring rush, bone medicine, super tasty tea!” (Oct 28 2018; sharing</p>

<p>holes! Or is the photo warping my sense of size?" (March 29th 2019, Pileated Woodpecker post)</p> <p>"So cool!"/ "This is so interesting, love it M!..."/ "Wow so cool! Very informative!" (March 20th 2019, Indigenous, maple syrup making)</p>	<p>interesting!" (March 12th 2019, Monkey river post)</p> <p>"I definitely hear a red winged black bird and I think I hear a cardinal and American robin too!" (March 14 2019, seasonal change post)</p> <p>"Male?" (July 14, 2019; a participant applying knowledge from IG story to correctly identify sex of a monarch butterfly)</p>	<p>"Stingrays are my jam! I hate that we can't convince more people about the real threat of climate change even though all the research is out there!" (Jan 4th 2019; stingray post)</p> <p>"Wow seven species?" (Jan 11th 2019, Canadian geese post)</p> <p>"What do the ants get out of babysitting their larvae" and as quick distinction, if I remember correctly, butterflies have little nubs on the ends of their antennae and moths don't" (June 2nd 2019, Silvery Blue butterfly post)</p> <p>12 comments of personal opinions related to uman-wildlife conflict with urban coyotes posted on July 12th 2019</p> <p>"All beaches seem to be affected by this, every summer seems to be more drastic" (June 29th 2019, local tides)</p>	<p>personal Anishnaabe knowledge of plant)</p> <p>"This is ridiculous. I'm always cleaning and picking up things in the woods and near water ways .It's crazy what people will dump" (May 22nd 2019, local water pollution post)</p>
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APPENDIX F: INSTAGRAM INSIGHTS DATA



APPENDIX G: REACTIONS TO INSECT SPECIES



*Data was compiled in 2018, based on content posted between 2017-2018, prior to this study.

