11-16-2017

# A Study of the Urban Red Fox (Vulpes vulpes) Population in Baton Rouge, Louisiana Using Social Media

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# A STUDY OF THE URBAN RED FOX (*VULPES VULPES*) POPULATION IN BATON ROUGE, LOUISIANA USING SOCIAL MEDIA

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Science

in

The Department of Environmental Sciences

by
Ahsennur Soysal
B.A., Louisiana State University, 2015
December 2017

*I would like to dedicate my work to my parents, Hatice Soysal and Omer Soysal, for their continued and reassuring support in many ways which has been my foundation and major relief for me.*

*I also dedicate this thesis to my supportive, welcoming, and inspiring the College of the Coast & Environment at Louisiana State University and to its supportive and inspiring faculty and staff members and mentors who have provided such a warm, helpful, and encouraging environment and mentoring that has pushed me through the challenges, helped me grow personally and professionally to accomplish a project that has become bigger than the borders of the campus.*

# ACKNOWLEDGEMENTS

I would like to thank Dr. Linda Hooper-Bui for making this exciting research possible for me, for her work, support and enthusiastic engagement that has helped me propel this project into new heights, which enabled me to reach beyond my comfort zone to take on opportunities and form many connections across the city. Many thanks to Dr. Kevin Armbrust, Dr. Denise DeLorme, and Dr. Edward Laws, for taking me in, being supportive, embracive and welcoming, for their work and feedback on my thesis, and for enabling me to complete my Master's program. I sincerely appreciate it and could not have grown and accomplished these skills or goal without their mentorship.

We thank Dr. Becky J. Carmichael, science coordinator with the Communication Across the Curriculum program at Louisiana State University, for adding conceptual information that helped form the final manuscript and for revising it to make the manuscript clearer, more concise, and better structured. Also thanks to Dr. Paige B. Jarreau, Science Communication Specialist for the College of Science at Louisiana State University, for assisting us as our social media consultant to form the foundation of our social media campaigns and for advising us on how to analyze our social media metrics in general, as well as for introducing us to the online ArcGIS story map tool.

We also thank Jovann Armstrong and many other local residents for welcoming us onto their property to observe the foxes, and to Kristin L. Foss and Kathryn L. Cannon for their assistance in entering data and broadcasting the project. We are grateful to photographers John Hartgerink, Steve Uffman, and Amy Shutt, who worked with us to document the red foxes and provide permission to post their well-received fox photographs from Baton Rouge, Louisiana.

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# ABSTRACT

Foxes are timid yet resourceful animals that are integrated into many urban environments. Because they are elusive, collecting information about the number of urban foxes, their diet and spatial distribution, their interactions with the ecological community in their urban habitat, as well as residents' response to them, is difficult. Involving stakeholders to participate in the data collection on wildlife via citizen science on social media is one way to overcome this complication, while simultaneously engaging residents in the ecology happening around them. Therefore, we used social media as the platform to engage the public to document and map the foxes in Baton Rouge. Local residents were asked to post sightings and/or photographs of foxes they observed, with the location, onto our Facebook Page at Fox Finders of Baton Rouge, on Twitter at @FoxFindersBR, or on Twitter and Instagram with the hashtag #findfoxlsu. This information was added onto an ArcGIS story map. Types of public responses and engagement over time were also measured. The authors clarified people's misconceptions about foxes when questions were asked on our Facebook Page. On-site observations and trail cameras were also used in common locations to monitor the urban foxes, and the footage was shared on our page as well.

While we received only one fox sighting via Instagram and Twitter each, our Facebook Page generated 1132 "likes" and an average of 14% Page Engagement Rate during the first eight months. Along with Baton Rouge, people from 384 different cities and 16 countries have engaged with the page. In addition, 180 red fox sightings—including 61 photographs and eight videos—were submitted, with eight of the sightings coming from areas surrounding the city—outside the study area. From the feedback we have received on our Facebook Page, our research model successfully promoted citizen science by easily connecting residents to science, enabling them to engage with our team and local residents directly to learn about the wildlife around them, documenting and mapping many local urban foxes, and reducing misinformation about urban foxes.

# CHAPTER 1. INTRODUCTION

## 1.1 Fox Ecology

The red fox, *Vulpes vulpes Linneaus*, is the most widespread and abundant wild carnivore in the world, ranging across Europe and Asia to North America, parts of North Africa, and an introduced population in Australia (Malkemper, Topinka & Burda, 2014). Furthermore, foxes, especially the red fox, are known to be present and well-adapted to living in urban environments, mainly because they are omnivorous and scavengers that are able to take advantage of a city's anthropogenic food, its sources of shelter, and the absence of or protection from larger predators such as bears, wolves, and coyotes (Bateman, Fleming & Le Comber, 2012). Foxes are canids, or of the family Canidae, which is a lineage of carnivores that include dog-like mammals such as domestic dogs, wolves, coyotes, and foxes.

Red foxes are mostly carnivorous in general; thus, their main diet includes small game such as birds, insects, rodents, and lagomorphs (hares, rabbits, and pikas). They also eat fruits, nuts, berries, eggs, fish, frogs, lizards, and even worms (Saunders, 1988). In the urban environment, Contesse et al. (2004) have reported that about half of the diet of the urban foxes in Zurich, Switzerland that reside in the city's center consists of anthropogenic foods, with a dominance of scavenged meat. There were significant seasonal variations in the composition of their diet, which included invertebrates, birds, and cultivated fruits and crops as well. The latter was mostly consumed in the summer. A survey of three municipal districts in Zurich showed that 85% of households generated anthropogenic food that was accessible to foxes. The food consisted mostly of compost, fruits, berries as well as some pet and bird food. This overabundance of the supply of food most likely explains the continued increase in the number of urban foxes in Zurich. (Contesse et al., 2004).

In a study of urban red foxes' shelter and den site selection and home-range size, estimated areas of adult home range varied between 11.5 and 45.8 ha, where two to five shelter sites were used in each home range. Sixty-one percent of the 72 dens examined were in residential, public parks, school, or industrial lands, and the habitat categories in which dens were sited was not significantly different from those described for London (Marks 2006). Even in rural areas of southern Japan (Cavallini, 1992), it has been recorded that red foxes spend from 18% to 50% of their activity time around houses and move quickly from one village to another. The home range of the radio-tracked red foxes was 357–631 ha (minimum-convex polygon) or 288–518 ha, without apparent differences between the sexes. The sizes of home ranges observed in this study were found to be consistent with the sizes found in other temperate farmland. In addition, a few collected fox scats in this area showed that >50% of their diet was from anthropogenic sources. Domestic animals in those red foxes' diet comprised 31% of the volume of their diet, either from garbage dumps or actively predated, while human-related food amounted to >50% of the diet. In general, foxes are territorial and do not congregate in packs, but rather live in families during spring and summer when raising their kits (Saunders, 1988). Their range is usually not more than

Most portions of this thesis has previously appeared on the online journal PeerJ at https://peerj.com/preprints/2623/

50 $km^2$ in diameter. Although they are predominantly crepuscular (Anonymous, 2016) meaning they are most active and on the hunt during dawn and dusk, they can be active any time of day (Saunders, 1988). They are especially nocturnal in urban areas when they can hunt without much presence of humans, but it is not unusual to observe them during the day in the city, either (Anonymous, 2016). City life can present challenges for these mammals, especially vehicular traffic; collisions with vehicles may be their major cause of mortality (Baker et al., 2007). In a study of the demography of two urban fox populations in Bristol and London between 1971 and 1977, where the populations' structure and monthly mortality rates were compared, 44% and 39% of the foxes survived to the following year, respectively, with road accidents being one of the main reasons of death in both cities. Hence, a stable population in London was maintained by increased productivity. In Bristol, the fox population structure remained constant regardless of population density and hence habitat quality (Harris 1987). Thus, the red fox is not under threat in its range in general because of its ability to cope well with humans and adapt to an urban environment. Because of this and their sheer abundance, foxes can act as a surrogate for other species that are more difficult to study.

Thus, the presence of foxes in cities presents a unique opportunity to study a common, relatively large mammal that is integrated into urban life. Studying the fox population, ecology, and behavior can lead to a better understanding of the role these animals play in our urban ecosystem. City-dwelling foxes give opportunities for citizen science. Hence, this research used social media to engage the public to help locate, document, and map sightings of the red fox population in Baton Rouge, Louisiana, specifically to further examine their diet, distribution, behavior, as well as their role and interaction in an urban habitat. We predicted that these aspects of urban fox ecology for Baton Rouge would be similar to that of other cities with urban foxes and known literature. In addition to mapping sightings of local foxes via social media, a main part of this project has been promoting and measuring engagement in citizen science by connecting residents to the science occurring immediately in their own environment in an easy and interesting way. The community was asked to post photographs of foxes they observed, along with the location, onto our Facebook Page "Fox Finders of Baton Rouge," on Twitter at @FoxFindersBR, or on Twitter and Instagram with #findfoxlsu. This information was mapped onto an online ArcGIS story map.

### 1.2 Citizen Science and Social Media

Over the last 20 years, the use of the Internet has increased exponentially. Social media are the collective online communication channels intended community-based input, interaction, content-sharing, and collaboration. These platforms comprise of websites and applications for social networking and microblogging, and wikis through which users create online communities to share information, ideas, personal messages, and other content, including videos (Rouse 2016). These platforms, in which people network virtually and create, share, and exchange information, have had an extensive reach. One in four people globally has a social media account. The most popular social media platform has been Facebook, with over 1.3 billion users from 2004 to 2014, followed by Twitter with over 250 million users (Howarth, 2014). According to the Pew Research Center, 65% of American adults use social networking sites, an increase of 7% from 2005 to 2015. Furthermore, 58% of rural residents, 68% of suburban residents, and 64% of urban residents use social media sites (Perrin, 2015). One main use of social media has been to share

photographs of people and places. Increasingly, location services have been enabled, and these data can be used to later locate where and when a photograph was taken. In addition, smartphone ownership in emerging and developing nations has risen at an extraordinary rate, with an increase from a median of 21% to 37% between 2013 and 2015. In 2015, the global median for smartphone ownership was reported to be 43%, while the U.S. median was 72%. Once online, 76% of internet users across the 40 countries surveyed use social networking sites, such as Facebook and Twitter (Poushter 2016).

Because smart phones (which include cameras to capture the science) and social media have become a predominant part of daily life, they provide a platform for the public to easily get involved in the science around them, i.e. citizen science. Citizen science, also known as community science, crowd-sourced science, or volunteer monitoring, is "the practice of public participation and collaboration in scientific research to increase scientific knowledge. Through citizen science, people share and contribute to data monitoring and collection programs." Although it's a new term, people have been contributing to scientific research for years, with this trend emerging with widespread use of the internet and smartphones (Ullrich, 2012). Recent focus has been based not on ""scientists using citizens as data collectors," but "citizens as scientists," which includes community-based monitoring (CBM) to address common environmental concerns of the community and can further involve community-based management. This recent focus on citizen science has the advantage of involving participants in every stage of the process, from defining the problem through communicating the results and taking action, with scientists as guides. Citizen science has the benefits of engaging stakeholders and the public in local issues, and also providing an advantage to government agencies as a cost-effective method for environmental monitoring, management, and conservation. The citizen science approach has its challenges, however; these limitations mainly involve CBM organizational issues, data collection issues (such as some limitations of using smartphones), and data use issues. These can further be defined as lack of volunteers and networking opportunities, information access challenges, data inaccuracy, lack of participant objectivity such as participants not providing adequate sample sizes, and difficulty of outputting the data to decision-makers or journals. The advantages of citizen science are substantial and the disadvantages can be overcome (Conrad, 2011).

In relation to data collection, one study was able to systematically collect citizen observations of red foxes in urban areas from the database of newspaper articles (as well as reference books and academic textbooks) in Finland (Vuorisalo, 2014). But social media present a more popular, practical, and effective opportunity to increase data collection via citizen science, while educating local residents and the general public about wildlife in general. Collecting such data would normally take much time, effort, and financial support. In addition, this model also provides an interactive and direct communication between scientists and the community, which allows the different groups to benefit from an exchange of important feedback and engage in many aspects of science with ease. Others contend that social media may be an effective way to recruit low-prevalence and invisible participants (King, O'Rourke & DeLongis, 2014).

Because a social medium, especially Facebook, is a transformative platform for quickly or almost instantaneously acquiring data from the general public or local residents, we anticipated it to be an efficient tool for documenting and mapping local urban foxes as well as easily engaging

residents in science occurring around them by encouraging them to simply observe their urban ecosystems and quickly share their fox sightings and fox location information with us on our social media pages. This study thus tested whether ecological data on urban wildlife, specifically foxes, could be effectively gathered via citizen science using social media. We hypothesized that there would be an increase in the number of engaged local citizens and fox sightings over time, especially during the foxes' breeding season in the spring, leading to an increase in the social media metrics of our Facebook Page's reach and engagement.

# CHAPTER 2. MATERIALS AND METHODS

## 2.1 Using Social Media as a Research Tool

We started the public Facebook page Fox Finders of Baton Rouge (https://www.facebook.com/findfoxlsu/) on 31 August 2015 as a social platform where the community was initially asked to submit photographs of foxes sighted, along with the location, onto the page. Local residents were simply asked to follow the three steps below to contribute to the project of mapping Baton Rouge foxes:

Help us at LSU Map the foxes in BR:
1. Take Photograph
2. Tag Location (GPS enabled or nearest cross streets)
3. Post on page or Instagram with #findfoxLSU

However, most participants also voluntarily provided other information regarding the foxes they observed, such as the date(s), time(s), and number of foxes seen including from previous encounters, as well as the foxes' behavior. This information was also provided when we further requested it from participants. Fox sightings without photographs and sightings around the areas surrounding Baton Rouge were also accepted as data from participants. These data were collected through 30 April 2016 for a total of eight months to be mapped onto an online ArcGIS interactive story map.

Baton Rouge, LA was chosen as the most convenient area of study to conduct this research and given that our team members have been long-time residents of the city. To reach out to as much of the community as possible to engage them in the research, the project was broadcast via many local outlets. These included promoting the page to our personal contacts or friends on Facebook and Nextdoor.com of two of the authors (AS and LMHB) as well as to the community via flyers around 17 locations in the city, and through local news media such as DIG magazine, WAFB, and WBRZ.

To continue to inform and engage the audience on the Facebook Page, interesting posts and facts about foxes were published on the page. People's comments, emails, and questions were also immediately addressed. Participants' posts on a page remain in the page's Visitor Posts section and can only be viewed by their Facebook friends' news feed or by those who visit the section itself. Therefore, participants' incoming photographs and videos of foxes submitted to Instagram with #findfoxlsu or to the Fox Finders Facebook Page were also shared by the authors as public posts on the page, and viewers were subsequently reminded to keep looking for the foxes around their surroundings. An exception to sharing participants' posts was photograph(s) or video(s) that portrayed that the foxes were being explicitly or implicitly fed; these were not commented on or shared by us because we took a neutral stance to passively observe residents' dealings with wildlife.

To analyze the social media metrics, we used the Facebook-provided Insights feature that automatically provided data for page and published post performance (best defined by Facebook users' engagement rate with our page or posts) by recording and graphing user interactions and

other metrics over time. Some of the metrics being captured by Facebook Insights include page "likes", people (or unique Facebook users) reached, people engaged, the times Facebook Page fans were online, fans' demographics and engagement with a page posts, posts' reach and engagement rate, and reach and engagement for each type of post (status, links, photographs, or videos). Therefore, we used Facebook Insights to help determine the type of content that is most popular and the best time of day to publish posts. These metrics determined the success of our posts. Furthermore, the data for the page as well as for the posts were separately exported as Excel files from Facebook's Insights feature. These exported data provided access to much more extensive metrics for page administrators that were not visible in the page's Insights interface. These files were exported for statistical analysis and further data calculations.

Table 1 lists definitions of the social media metrics based on the Facebook exported data and Insights section.

**Table 1.** Facebook Page metric definitions

| Facebook Page Performance | Facebook Page's Post Performance |
|---|---|
| **Daily Total Reach** | **Lifetime Post Total Reach** |
| Number of people who have seen any content associated with the page (unique users), including posts, posts of others to the page, and mentions<br><br>Can include the number of people beyond just the page's fans | Number of people the page post was served to (unique users) |
| **Daily Page Engaged Users** | **Lifetime Engaged Users** |
| Number of people who engaged with the page. Engagement includes any click or story created (unique users)<br><br>Specifically, the number of people who have liked, shared, commented on, or clicked (if applicable) anywhere on the page in addition to posting to the page's timeline, sharing or mentioning the page, or tagging the page in a photograph | Number of people (unique users) who clicked anywhere in the posts:<br><br>Lifetime Talking About This<br>(number of people (unique users) who created a story about your page post by interacting with it)<br>+<br>Lifetime Post Consumers<br>(number of people (unique users) who clicked anywhere in your post) |

We calculated a more accurate Lifetime Engaged Users metrics than the one provided by the Facebook Insights' exported data for the 114 posts we published. This was done by adding the Lifetime Talking About This (the number of people or unique users who engaged with our posts via post likes, comments, or shares), to the Lifetime Post Consumers (the number of people or unique users who engaged with posts via link clicks, other clicks, or viewed our photographs or videos) on our posts, because all these are ways people can engage with a post. This was used to calculate the Post Engagement Rate. Engagement Rate is "the number of people our page content or post reached who then liked, commented, shared or clicked on our post." Thus, this metric was calculated for our page data and our page's posts data as:

$$\text{Engagement Rate} = \frac{\text{Engagement}}{\text{Reach}} \times 100\%$$

Engagement here can refer to Daily Page Engaged Users, or for the page posts, Lifetime Engaged Users. Likewise, reach can refer to Daily Total Reach for the page metrics or the Lifetime Post Total Reach for the posts we published on the page. The social metrics that were manually recorded between 31 August 2015 and 30 April 2016 were the types of comments people posted, people's concerns about foxes, their questions about foxes or the research, and limitations people encountered trying to obtain a fox picture or a good picture. We recorded the number of fox photographs, the reported location of the fox, the date the fox sightings were posted to the page, as well as the time or date the foxes were seen, the number of foxes sighted, and other extra information about the sightings most participants provided. The data for each fox sighting were incorporated in the online ArcGIS story map.

### 2.2 Online ArcGIS Story Maps

ArcGIS story maps, powered by ESRI, are an online open source tool that presents data geographically in an efficient and compelling form (Stephenson, 2016). To establish the story map, an online ArcGIS account was made, selecting the shortlist option and street view as the type of base map. The City Limit of Baton Rouge and World Transportation map layers were added in order for the city boundary and street/area labels to be displayed. The ArcGIS tutorial provides a downloadable package that includes a template CSV data file for the fox sightings information to be added to, as well as the coding file index.html for formatting the map features. The story map was then hosted on the web via http://coastandenvironment.lsu.edu/hooper-bui/disaster-ecology/index.html. The URL for each photograph was added to the picture URL column in the CSV data file. Lastly, the CSV data file was added as another layer onto the story map.

For this study, three tabs on the map were created as follows to display each red fox sightings from citizens: BR Foxes (Baton Rouge Foxes), Road-killed Foxes, Surrounding Areas for foxes sighted in areas near Baton Rouge as reported on the Fox Finders of Baton Rouge Facebook Page. A clickable bookmark menu for the seven common locations of foxes in Baton Rouge was established as a frame of reference on the map's web page.

## 2.3 Ecological Approach

In addition to the Facebook Insight's social media metrics, citizen scientists provided important ecological information about the local urban fox population, most of which were reported by participants without initially being requested. These included foxes' exact location or nearest cross-streets, the date(s) and time(s) the foxes were seen, including previous encounters, foxes' interaction with people, domestic cats and dogs, and the number and location of foxes that are receiving supplementary feeding, living in city drainage/storm culverts, or have been road-killed.

When collecting fox data from local residents, a neutral stance was taken in order to naturally observe the public's interaction with the urban fox population and the effect humans have on the natural state of the foxes. Thus, participants' reports that showed or implied that foxes were receiving supplementary feeding directly or indirectly (for example, via cat/dog food) were ignored but left remaining on the Facebook Page. People's misconceptions, questions, and concerns they had about foxes were addressed in response to their comments on the Facebook Page.

Additionally, we deployed seven trail cameras in common fox locations beginning on 25 January 2016, four of which were placed in the yards of welcoming residents who had foxes coming into their yard or living under their house, including two at University Lake (LSU Bird Refuge and nearby house), four around the Highland Road/Kenilworth Parkway area in residents' yards, and one by an oak tree on Highland Road where another fox family was staying. These trail cameras or infrared game cameras took 30-second video clips, during day or night, whenever a nearby movement activated their motion detector. These clips were later processed and a time-lapse video of interest involving the foxes during certain weeks in spring were shared on our Facebook page for the public. We stated that maintaining the privacy of residents' exact addresses and the foxes living area was our main priority and very important to keeping both parties safe and their environment undisturbed. We asked citizen scientists to post general locations or send us a private message of the more specific area/cross-streets where the foxes were staying instead. Because the foxes were simply observed directly by people or via trail camera and participants were made aware of these ethical protocols, our project was approved for exemption from oversight to conduct the study by the Institutional Review Board of Louisiana State University (IRB# E10014). As approved by this board, informed consent from all subjects was obtained online by posting and pinning the consent form to the top of our Facebook Page, where it was the first statement for the subjects to read when they viewed our page.

Therefore, this research study was an interdisciplinary study that involved ecological, social, and technological aspects. It took a multi-method approach of using technology as well as citizen science, or community-based monitoring, through social media for studying an urban red fox population. It required a basic level and effort from citizens to be able to operate a smartphone and a social media account in addition to be able to identify a red fox. Citizens had to simply report fox sightings, preferably with photographs, in simple text format as comments onto our social media pages, without having to complete any online form. The study involved the use of trail cameras and avoided surveying or tagging the red foxes as to not disturb their natural state or behavior.

## 2.4 Statistical Analyses

Fourier analysis, which is used in modeling periodic phenomena (waves, time series data, etc.), was used to analyze the Page's Daily Total Reach and Daily Engaged Users for the first 88 days of data collected to determine if there were periodic patterns to the data because these two top metrics illustrate Facebook page performance that are a result of citizen scientists' engagement with the page. An analysis for the Daily Engaged Users for the first 245 days of data overall was also conducted. A Fourier analysis requires that there be no long-term trend to the data and that the variance of the data be independent of time. The reason is that there is no way a series of sines and cosines can explain a long-term trend or a situation where the amplitude of the signal is monotonically changing over time. The Fourier analysis fits sines and cosines to the detrended data. If the detrended data have a period of one week but are not sinusoidal, the Fourier analysis will fit the time series to sines and cosines with periods of one week, and furthermore it will include sines and cosines with higher-order harmonics, i.e., sines and cosines with periods of 7/2 days, 7/3 days, and so forth.

# CHAPTER 3. RESULTS

## 3.1 Social Media as a Tool of Scientific Engagement

Our Facebook Page Fox Finders of Baton Rouge received 1132 Facebook "likes" or fans in eight months of data collection. The news media that broadcast our project, such as DIG magazine, WAFB, Nextdoor.com, as well as personal Facebook friends were effective in gathering more page likes.

Figure 1 shows the main metrics of our Facebook page performance—Page Likes, Daily Total Reach, and Daily Engaged Users—along with the Page Engagement Rate.

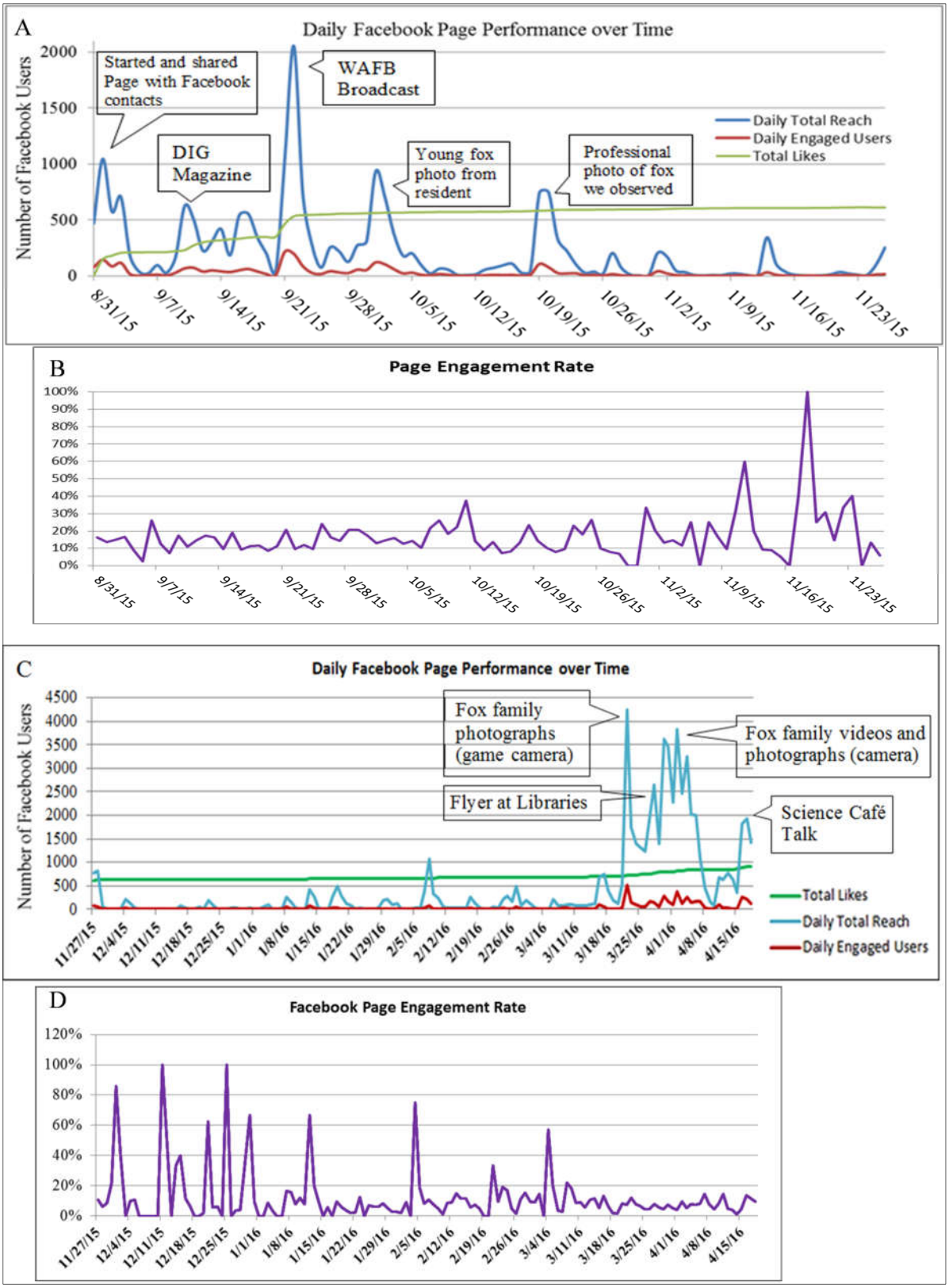


**Figure 1.** Daily Facebook Page reach and response between 31 August 2015 and 30 April 2016 (caption cont'd)

(A and C): The “Fox Finders of Baton Rouge” Facebook Page’s daily performance metrics according to the number of Facebook users who have liked, to whom any of the page content reached, and who engaged with the page between 31 August 2015 and 30 April 2016. The peaks in cumulative or Total Page Likes and/or Daily total Reach are explained by our broadcast of our project or posts of well-liked foxes that led to higher public interest and/or involvement.
(B and D): Daily Page Engagement Rate, which is the ratio of Daily Engaged Users over Daily Total Reach from the graph above.

The average Daily Total Reach was 393 people (±719) and the average Daily Engaged Users for our page was 38 people (±69) during the eight months. The average Engagement Rate was 14% (±16%). A very high Page Engagement Rate does not necessarily mean high page performance for that day because high Engagement Rate is the result of the engagement being close in value to total reach regardless of whether both values are high or low. The days when the Daily Total Reach was lower than the Total Page Likes or followers of our Page indicate that not all page content, which is comprised of posts we published, reached all of the fans. The instances when the Daily Total Reach was higher than the Total Page Likes for that day indicate that page content, especially our posts, reached other users beyond the page fans. This is due to fans sharing the page or any of its contents to those beyond the page’s fans and/or from Facebook users viewing our public page after hearing about it from news media.

The time series analysis, which was performed for the Page’s Daily Total Reach and Daily Engaged Users for the first 88 days, is presented in Figure 2. (Performing this analysis for the eight months of data gave corrupted results by the obvious long-term pattern in the data, due to the fact that the number of engagers was high initially and high toward the end and low in the middle. This corresponded to media attention to the project, which disrupted the periodicity of the cycle). Because the detrended data have a period of one week but do not look exactly like sines and cosines, the Fourier analysis fit the time series to sines and cosines with periods of one week, and furthermore it included sines and cosines with higher order harmonics, i.e., sines and cosines with periods of 7/2 days, 7/3 days, and so forth. That is why in both cases, there was a peak at a frequency of about 1/7 = 0.14, and then approximately 2/7 = 0.29 and 3/7 = 0.43. The periods are not coming out at exactly those frequencies because this is a discrete Fourier analysis, and it can only detect integer multiples of the fundamental frequency, which is determined by the number of data points in the time series. To get confidence intervals, the 88-day time series was divided into 4 "ensembles", each with a length of 22 days. Because it takes 2 points to determine the characteristics of a frequency (the phase angle and amplitude, or equivalently, the amplitudes of the sine and cosine with that frequency), 22 data points will yield 11 frequencies. The frequencies were 1/22, 2/22, 3/22... 11/22. Thus in fact, there was not a frequency of exactly 1/7, but there was a frequency very close to that, 3/22 or 0.136. The higher harmonics in the case of the Daily Total Reach occurred at 0.273 and 0.409. In this case, there was only one higher harmonic at 0.273.

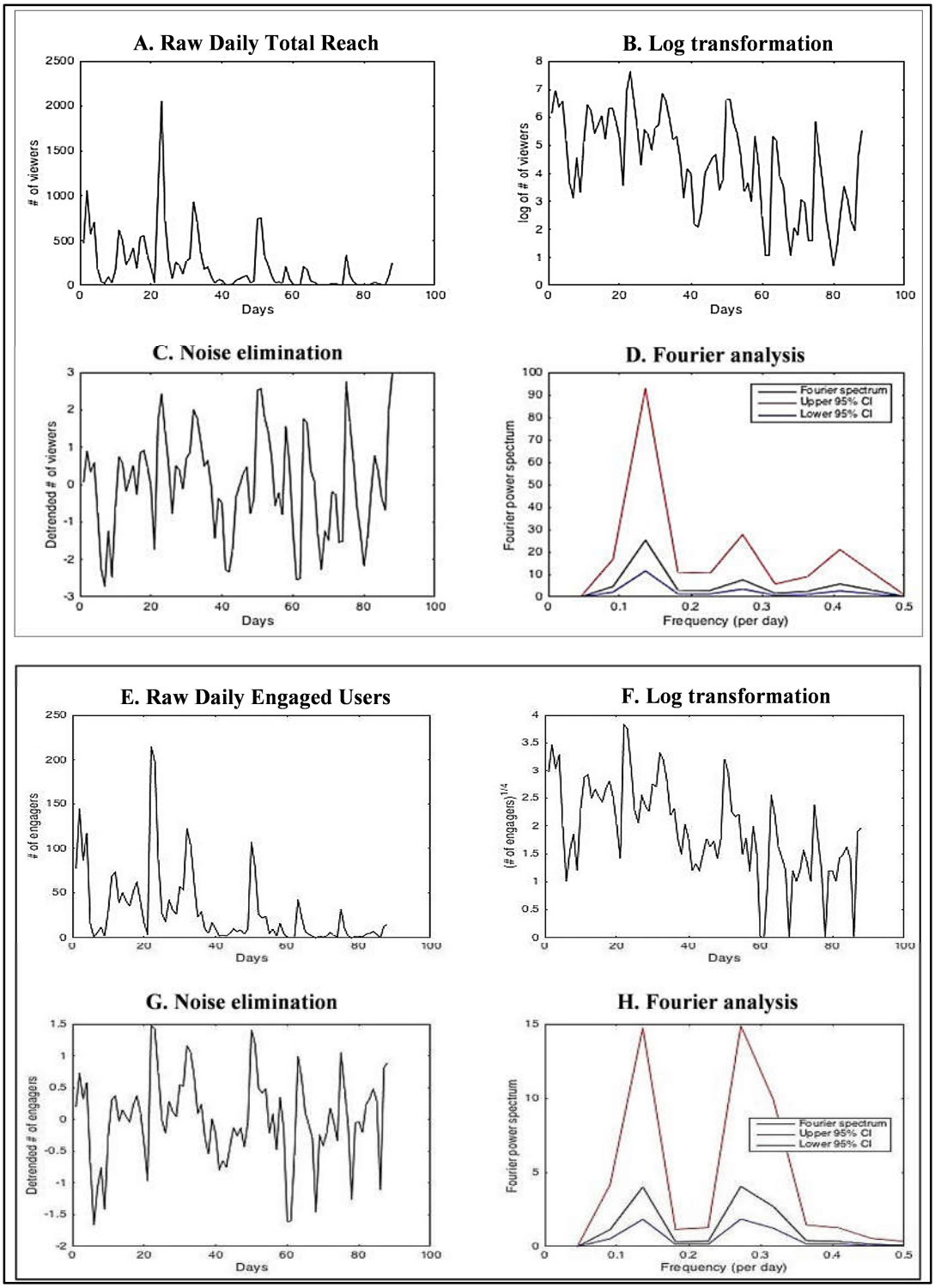


**Figure 2.** Steps in the Fourier analysis for Daily Total Reach or number of total viewers (A-D), and Daily Engaged Users with our Facebook Page or any page content (E-H), from 31 August 2015 to 26 November 2015

(A and E) The raw social media metrics for the Facebook Page over the first 88 days of data collection.

(caption cont'd)

(B and F) The data that have been log transformed to eliminate the level of noise that apparently has become less and less over time. The level of noise now is basically constant, but there is a downward trend in the data.
(C and G) This is eliminated in the bottom left graph, by taking the difference from drawing a straight line through the data and subtracting its values from the data, which did not result in portraying much of a trend here.
(D and H) The power spectrum of the Fourier transform as a function of frequency along with the 95% confidence interval to the power spectrum. A frequency is judged to be significant if its lower 95% CI is higher than the upper 95% CI of adjacent peaks. In this case, the frequency of 1 per 7 days is considered significant because the blue curve at that frequency is above (barely) the red curve of adjacent frequencies.

Therefore, the Fourier analyses demonstrate that there is a 7-day periodicity, and three trends are evident: the variance decreased with time, the average number of Daily Total Reach or Daily Engaged Users decreased with time. After those two trends have been factored out, it becomes apparent that there is a 7-day cycle to the number of Daily Total Reach to users and Daily Engaged Users.

,In addition, as given by the Insights tool, 217 people have reached our Facebook Page through 18 other websites (16 main websites when duplicate URL domains were excluded) that served as external referrers over the course of the first 88 days of data collection (Facebook Insights feature no longer provides the figure for this information except for the most recent month, but it provides the full list of external referrers in its exportable data). Clicking and dragging over the timeframe of the graph revealed further analysis about the external websites (Figure A1). For the full eight months of data, 640 people were directed to our Facebook Page through 109 other websites (total of 49 main websites when duplicate URL domains were excluded).

Furthermore, the demographic data about the people who liked our page showed that 69% of the page fans were women, mostly between the ages of 25 and 64, while 30% were male, mostly between the ages of 25 and 44 for the first 88 days (Figure 3). The demographics for the first eight months were very similar, where 68% of the page fans were women, mostly between the ages of 25 and 54, while 31% were male, mostly between the ages of 18 and 44.

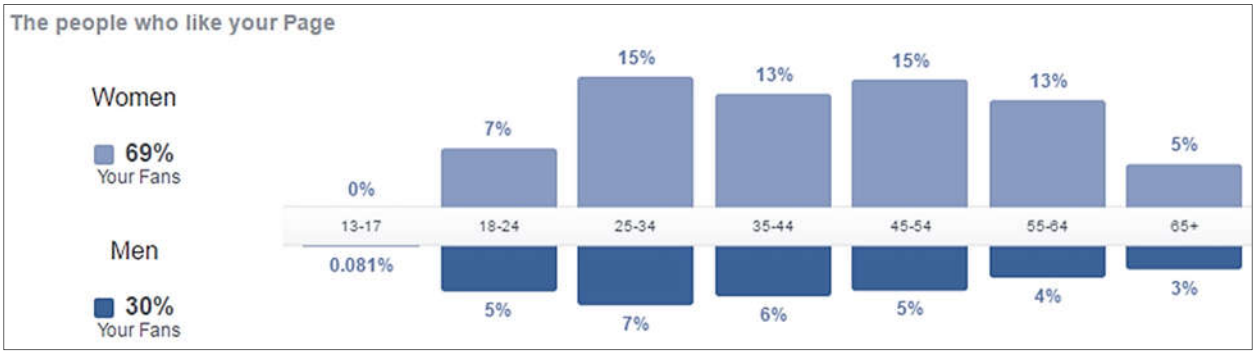

**Figure 3.** Demographics of the people who "liked" our Facebook Page between 31 August 2015 and 26 November 2015

Interestingly, our page's outreach included Facebook fans (those who liked our page) as well as users Talking About the Page (those who were sharing any story about the page, including fans) from 384 different cities within 16 countries total for the eight months of data collection. Table 2 lists the associated countries and cities for the first 88 days of data. The cities within each state are listed alphabetically, while the states are listed based on their distance from Louisiana, approximately. An entry containing only the state indicates that there was multiple cities associated with that state whose data was summarizes into one entry. However, while the total number of People Talking About the Page in the U.S. by city added up to the total number of People Talking About the Page in the U.S. as a country (given daily via Facebook's exported data), there was an apparent error because the same was not true for Total Page Likes (listed as cumulative values provided by Facebook's data). Specifically, Total Page Likes in the U.S. by city did not add up to Total Page Likes in the U.S. as a country, while Total Page Likes by all countries added up to the actual Total Page Likes at the time, which was 612 likes.

**Table 2.** The list of countries and cities associated with Facebook Page fans and the corresponding number of Total Page Likes and People Talking About the Page between 31 August 2015 and 26 November 2015.

| Country | Total Facebook Page Likes | Total no. of People Talking About the Page | City/State | Total Facebook Page Likes | Total no. of People Talking About the Page |
|---|---|---|---|---|---|
| United States | 607 | 684 | Baton Rouge, LA | 375 | 458 |
| Australia | 1 | - | Baker, LA | - | 5 |
| United Kingdom | 1 | - | Central City, LA | 8 | 9 |
| Georgia | 1 | - | Denham Springs, LA | 11 | 17 |
| Germany | 1 | 1 | Gardere, LA | 5 | - |
| India | 1 | 1 | Gonzales, LA | 10 | 8 |
| Netherlands | - | 1 | Grand Lake, LA | - | 8 |
| Switzerland | - | 1 | Greenwell Springs, LA | - | 2 |
| | | | Inniswold, LA | 15 | - |
| | | | Lafayette, LA | 3 | 11 |
| | | | Livingston, LA | 2 | 2 |
| | | | New Iberia, LA | - | 6 |
| | | | New Orleans, LA | 8 | 14 |
| | | | Oak Hills Place, LA | 5 | - |
| | | | Old Jefferson, LA | 6 | - |
| | | | Plaquemine, LA | 2 | 2 |
| | | | Ponchatoula, LA | - | 2 |
| | | | Port Allen, LA | - | 2 |
| | | | Prairieville, LA | 7 | 10 |
| | | | Saint Francisville, LA | 2 | 3 |

(table cont'd)

| Country | Total Facebook Page Likes | Total no. of People Talking About the Page | City/State | Total Facebook Page Likes | Total no. of People Talking About the Page |
|---|---|---|---|---|---|
| | | | Shenandoah, LA | 18 | - |
| | | | Village St. George, LA | 5 | - |
| | | | Walker, LA | 4 | 5 |
| | | | Watson, LA | 7 | 2 |
| | | | West Baton Rouge, LA | 2 | - |
| | | | Zachary, LA | 9 | 7 |
| | | | Other cities in LA | 11 | 41 |
| | | | TX | 26 | 20 |
| | | | MS | 2 | 2 |
| | | | AR | - | 4 |
| | | | OK | 2 | 3 |
| | | | AL | 1 | 3 |
| | | | NM | - | 3 |
| | | | GA | 1 | 2 |
| | | | AZ | 2 | 3 |
| | | | CA | 4 | 7 |
| | | | FL | 1 | 5 |
| | | | Sumter, SC | - | 1 |
| | | | Boulder, CO | - | 1 |
| | | | Omaha, NE | - | 1 |
| | | | Leesburg, VA | - | 1 |
| | | | KY | - | 1 |
| | | | NJ | - | 3 |
| | | | NY | - | 3 |
| | | | OH | - | 1 |
| | | | OR | 1 | 2 |
| | | | MT | 1 | - |
| | | | PA | - | 1 |
| | | | Washington, DC | - | 1 |
| | | | Ann Arbor, MI | - | 1 |
| | | | San Juan, Puerto Rico | 1 | 1 |

Given this information, 99% of the Total Page Likes and 99% of People Talking About the Page were from the United States, whereas within the United States, 67% of the Total Page Likes and 67% of the People Talking About the Page were from Baton Rouge. The fact that the total

number of People Talking About the Page, hence engaging with our page on Facebook, was usually higher than the Total Page Likes signifies that the page or its content reached users beyond the page fans and across many different locations.

We also analyzed the social media metrics for the posts we published on our page (Figure 4), which comprises the bulk of any Facebook Page and is the main content that Facebook users view and engage with. The exported data from Facebook provide lifetime values rather than daily values for posts, which are the cumulative count for each of our post metrics for the chosen timeframe (31 August 2015 to 30 April 2016, in this case). As illustrated in Figure 4, the main metrics for performance of published posts are Lifetime Post Total Reach, and Lifetime Engaged Users, which consist of Lifetime Talking About This (unique users who have liked, commented on, or shared each post) and Lifetime Post Consumers (unique users who have clicked on any link, photographs or videos, or other clicks).

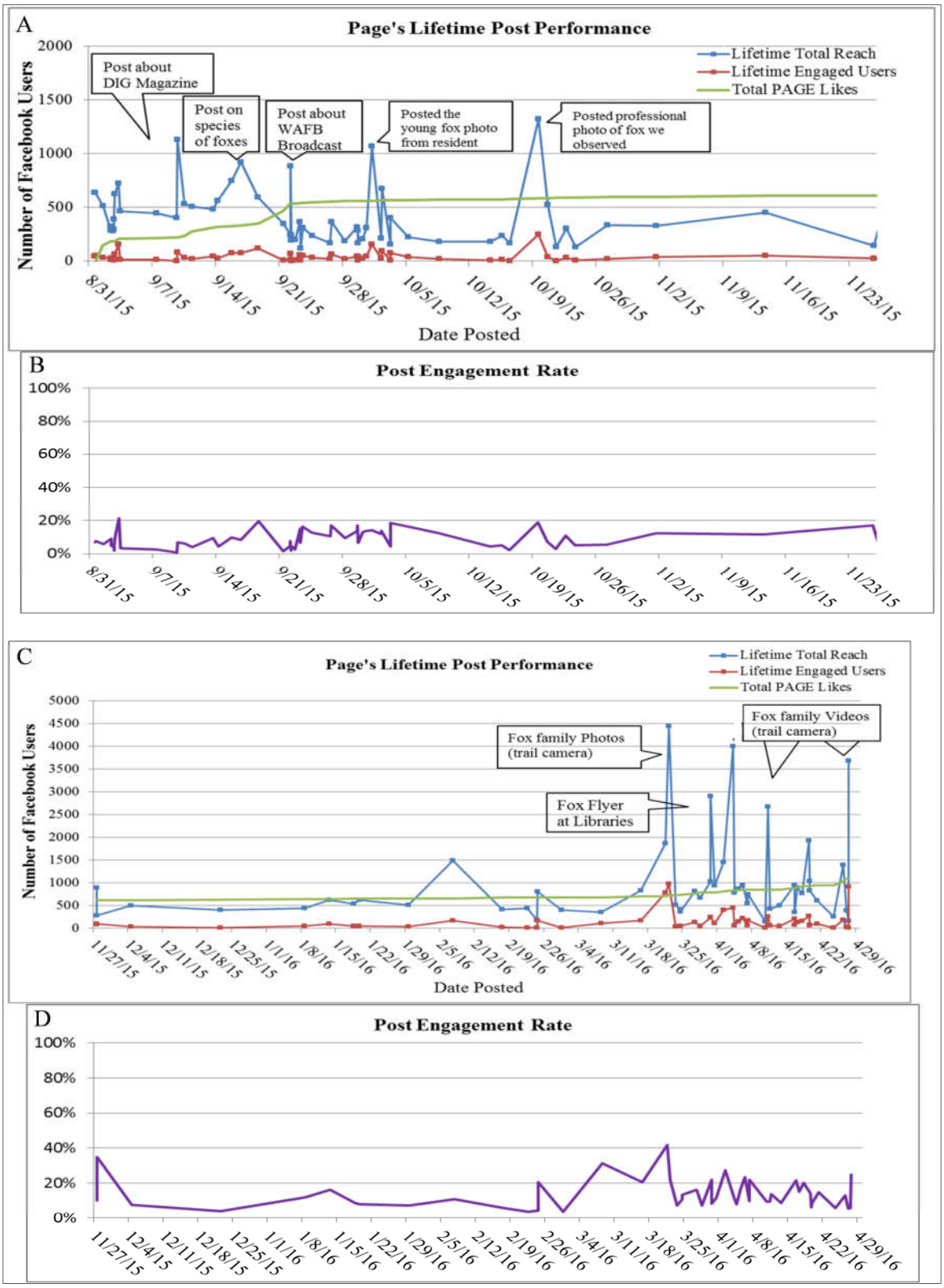


**Figure 4.** Lifetime reach and response to the posts we published on our Facebook Page between 31 August 2015 and 30 April 2016
(figure cont'd)

(A and C): Our "Fox Finders of Baton Rouge" Facebook Page's lifetime or cumulative performance metrics for the posts we published on the page for the first 88 days between 31 August 2015 and 26 November 2015, and the sources for the peaks in Lifetime Total Reach and/or Lifetime Engaged Users. The cumulative or Total Page Likes for that day were also plotted as a baseline for comparison.
(B and D): Lifetime Engagement Rate for our posts was calculated, which is the percent ratio of Lifetime Engaged Users over Lifetime Post Total Reach.

When comparing Lifetime Post performance with the Daily Page performance, it is important to note that we did not publish a post to our page every day and that we occasionally published more than one post per day. The average Lifetime Post Total Reach was 674 people (±736) and the average Lifetime Engaged Users was 94 people (±156) for those eight months. The average Post Engagement Rate was 11% (±7%).

As with the Facebook Page rates, a high Post Engagement Rate does not necessarily mean high post performance. The incidents when the Lifetime Post Total Reach was lower than the Total Page Likes indicate that not every post reached all of the fans of the page. The instances when the Lifetime Post Total Reach was higher than the Total Page Likes for that day indicate that our posts reached other users beyond the page fans. This is due to fans sharing the posts with others on Facebook and/or from users viewing our page after hearing about it from news media to which we broadcasted.

Posts that included videos or links were more successful in reaching Facebook users (Figure 5), whereas posts that included photographs received the highest average engagement—specifically post clicks—from users.

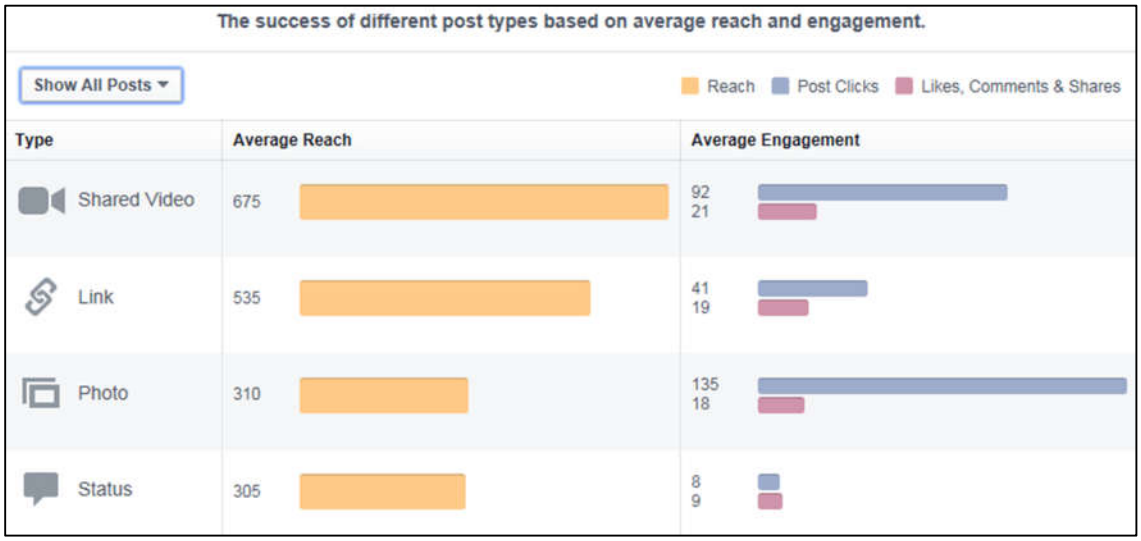


**Figure 5.** Facebook users' reach and response to the posts we published on our page by type between 31 August 2015 and 30 April 2016. This figure was provided by the Facebook Insight feature.

Furthermore, table 3 presents the average post performance metrics manually sorted by category. Posts that included fox photographs or videos from our trail cameras or videos (either from others or from trail cameras) were the most successful in reaching and having engaged the most Facebook users.

**Table 3.** The social media metrics sorted by categories of posts we published on our Facebook Page between 31 August 2015 and 30 April 2016. Some categories do overlap by consisting of some of the same posts.

| **Type of Post We Published on Page** | **No. of Posts** | **Average Lifetime Post Reach** | **Average Lifetime Engaged Users** | **Average Post Engagement Rate** | **Standard Deviation** |
|---|---|---|---|---|---|
| Trail Camera (photographs or videos) | 16 | 1723 | 274 | 16% | ±5% |
| Videos (from others or from trail cameras) | 11 | 1605 | 221 | 13% | 5% |
| Photographs (from others or from trail cameras) | 37 | 738 | 117 | 14% | 6% |
| Others' Submission of Fox photographs or videos shared by us (to our Page) | 32 | 543 | 74 | 13% | ±6% |
| Project Updates | 29 | 494 | 71 | 11% | ±10% |
| Fox Facts | 18 | 528 | 62 | 10% | ±6% |
| Funny | 4 | 383 | 33 | 7% | ±4% |
| Fun | 11 | 344 | 21 | 6% | ±2% |
| Posts with Erred Metrics | 2 | - | - | - | - |
| **Overall** | **112** | **674** | **94** | **11%** | **±7%** |

Based on observations recorded in others' comments and posts on Facebook, the public's response on our page has been very positive, with 120 supportive/enthusiastic comments about foxes or the research project. Comments where participants mentioned or tagged others in order to engage them were also counted as supportive comments. Seven general questions were asked about foxes, such as what time of day foxes are seen, if foxes are generally skinny, if they are common alongside a major road, and how to identify a fox den, and we answered them. Questions/concerns about foxes being the object of hate and target of violence or a threat to people or pets were raised 20 times by residents. Only one critical comment was made by a participant regarding the research. Furthermore, a few weeks after reminding others about our upgraded ethics policy to maintain residents' exact addresses or the foxes' living area private starting 27 April 2016, the citizen scientists started to adopt and take notice, and nobody's sightings had to be hidden for not being careful in following these instructions.

As confirmed with every week of data collection, Facebook Insights feature illustrates that most Facebook fans were online between 2 am and 2 pm UTC (9 am and 9 pm in Baton Rouge)

basically on any given day of the week. Thus, almost all of our Facebook posts, the contents of which included mostly fox facts and re-sharing submitted fox photographs, were published in the mornings or evenings to reach more people. Post Reach also depends on viewer's engagement and popularity of the post.

### 3.2 Data Collection on Urban Foxes via Social Media

The Facebook Page Fox Finders of Baton Rouge was also a success in locating and gathering different information efficiently on local foxes throughout the eight months of data collection. Due to our page having reached online users from different locations, fox sightings from the surrounding areas outside of the city of Baton Rouge were also submitted by participants. Although our primary target audience was the Baton Rouge community, fox sightings and photographs from participants beyond the city were also accepted and accounted for in our data. Interestingly, almost all of the participants who reported observing foxes also provided information beyond what was required. These included the date and/or time the foxes were actually seen, the number of foxes observed, whether the foxes were seen regularly, whether they were sighted in the resident's yards, whether they were road-killed, and/or the foxes' behavior. Thus, the time and date the fox sightings or photographs submitted on the page may not represent the date or time the fox(es) was/were actually witnessed. Although we did not require this information until March 2016, most participants did explicitly provide the date and/or time fox(es) were seen on their own. Furthermore, three people did report sighting some foxes in 2014 and five people reported sighting foxes within the last several years.

Within eight months of data collection from social media, 180 total fox sightings were reported by local participants for a rough estimate of 140 foxes in Baton Rouge and eight surrounding areas. From these sightings, only one fox sighting was received from Twitter and Instagram each with the hashtag #findfoxlsu, and 10 sightings were reported via Nextdoor.com. The remaining 169 fox sightings were reported through Facebook. Out of these total sightings, 172 sightings of about 115 foxes were from Baton Rouge, while eight sightings of about 25 foxes were from the surrounding areas. Almost all of the sightings were of red foxes, whereas only an estimate of five gray foxes was spotted, particularly in the Recreation and Park Commission for the Parish of East Baton Rouge (BREC) Swamp and Zachary, LA (Table 4).

When we started this project, we did not know if the residents of Baton Rouge could accurately identify a red fox. In addition to the eight fox videos received, the 172 sightings from Baton Rouge included a total of 61 fox photographs submitted, 46 of which were clearly identifiable as a photograph of a fox or foxes. From these 61 photographs, 53 photographs (of which 38 were identifiable) were from Baton Rouge, while eight photographs (seven of them identifiable) were from the surrounding areas (Table 4). Data collection was limited in the cases of 24 people who stated that they could not take a photograph, or any clear photograph, of foxes they sighted either because they were driving, the foxes were mobile, and/or it was dark outside.

**Table 4.** Total number of fox sightings and estimated number of foxes in Baton Rouge and surrounding areas. This information was obtained from reports given by local participants via Facebook, Twitter, Instagram, or Nextdoor.com as well as our on-site observations (between 31 August 2015 and 30 April 2016).

| **Fox Sightings from Social Media** | |
|---|---|
| **Baton Rouge** | |
| 172 sightings (53 photographs) | ~115 foxes estimated |
| **Surrounding Areas** | |
| 8 sightings (8 photographs) | ~25 foxes estimated |
| **Total** | |
| **180 sightings (61 photographs)** | **~140 foxes estimated** |

These numbers do not exactly match the number of points (of fox sightings/photographs) on the story map because some sightings or photographs were of the same fox (as stated by the same resident), and the same foxes can be witnessed at different addresses nearby. However, these possible duplicates in the estimated number of foxes were accounted for as much as possible, especially with several participants mentioning sighting the same foxes over time or mentioning that they observed the same fox others have also sighted. Those who mentioned they have sighted a "couple" were counted as two foxes, "some" foxes were counted as three foxes, while those who mentioned sighting "several" foxes were counted as five for the purposes of obtaining an estimate of the number of local foxes. (We decided on those definitions *a priori* in August 2015) In addition, foxes or groups of foxes sighted within a 0.25 mi. were counted as the same fox or group of foxes, unless individually counted by residents and/or our field observations.

For the number of fox sightings reported over the course of the eight months, Figure 6 does not necessarily represent the date they observed the fox(es); in seven of the sightings, participants reported seeing the fox(es) before 31 August 2015 (when our Facebook Page was created). Broadcasting our project (especially through the two news media) allowed us to bring in a larger audience, leading to high numbers of fox sightings reported. Thus, the initial peaks in citizens' Facebook engagement and reported fox sightings are a result starting the project. Once this is excluded, this study supports our hypothesis that there would be an increase in the number of engaged citizens and fox sightings over time, especially during the spring.

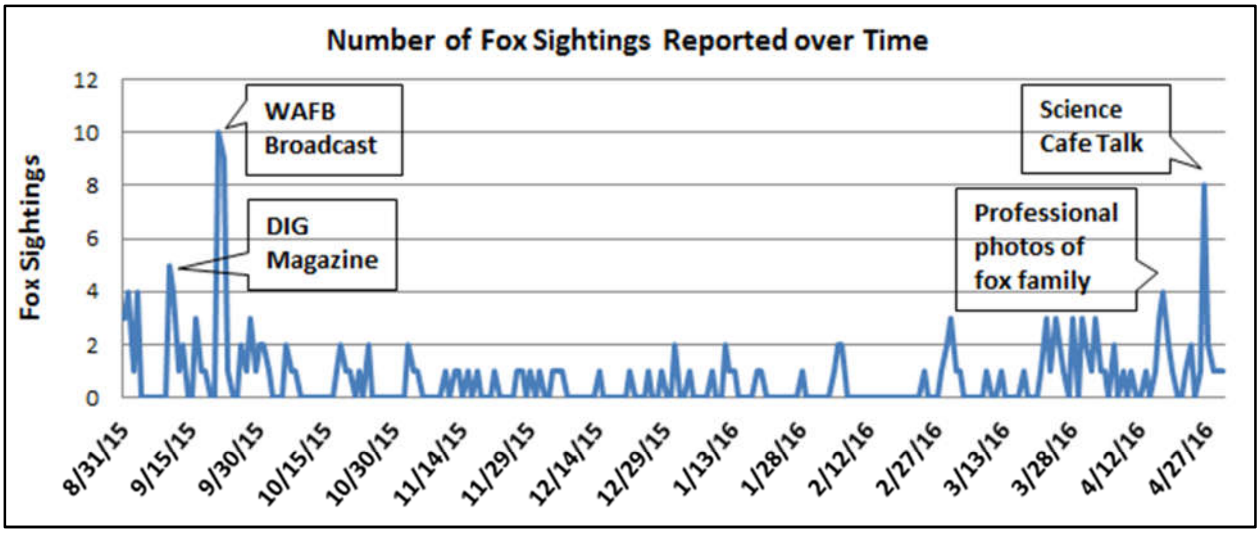


**Figure 6.** Daily number of fox sightings local residents have reported on social media over time, for a total of 180 sightings.

Given the 160 out of 180 sightings from participants who also provided the time(s) of day they observed or regularly observed fox(es), 65 sightings were reports of fox(es) observed in the evening(s) or night(s), 35 sightings were reports of fox(es) observed in the morning(s), seven sightings were reports of fox(es) observed midday, and 21 sightings were reports of fox(es) seen at dawn and dusk.

From the fox sightings posted on our page, eight posts (including three videos) from six residents mentioned or implied that they were supplementing the foxes' diet or that the fox(es) were eating leftover cat or dog food. Of these eight posts, one was a private message on our page. We took a neutral stance and did not respond to these participants about their actions; Facebook viewers seemed to model our behavior and did not engage with the posts as well (Table 5).

**Table 5.** Locations in and around Baton Rouge where foxes were directly or indirectly been given supplementary feeding by residents as reported between 31 August 2015 and 30 April 2016.

| Areas where Foxes are Receiving Supplementary Feeding from Residents | | |
|---|---|---|
| **Location** | **Estimate no. of Foxes** | **Commentary** |
| Highland Rd. and Kenilworth Pkwy area: Copperfield Ct. | 7 | Supplemented daily before dawn |
| BREC Bluebonnet Swamp | Many | Captured on remote camera; cat food used as bait |
| Ponchatoula, LA | 4 | "I'm pretty sure they eat cat food every night" |
| University Lakes: E. Lakeshore Dr. near Standford Ave. | 3 | Baby foxes "eat our cats leftover food every night" |
| St. Francisville, LA | 3 | 2 Videos foxes sharing food with cats |
| Port Allen: Along N. River Rd. | 3 | Video showing foxes eating from bowl |
| LSU Bird Refuge | 5 | Resident leaving pet food |

### 3.3 Urban Fox Ecology

Given the 180 fox sightings (including 61 photographs and eight videos) through citizen contributions on social media, about 140 foxes in Baton Rouge and eight surrounding areas were successfully mapped onto an online ArcGIS story map shortlist at http://coastandenvironment.lsu.edu/hooper-bui/disaster-ecology/index.html. Some participants needed to be asked to provide more specific locations or the nearest cross-streets of the foxes they sighted in order to map the location more precisely. Four major locations of foxes were identified, as well as three other common locations of foxes (Table 6). This can be observed from the online story map below (Figure 7). All of the locations were analyzed and found to be adjacent to a water source (Table 7).

**Table 6.** Common locations of urban foxes in Baton Rouge (according to reports between 31 August 2015 and 30 April 2016).

| Common Locations of Local Foxes | |
|---|---|
| **Location** | **Estimated no. of Foxes** |
| Highland Rd. and Kenilworth Pkwy area[1] | 20 |
| University Lake and City Park Lake | 14 |
| Mid-City (east of City Park) | 10 |
| University Acres subdivision[1] | 10 |
| Broadmoor Schools zone[3] | 7 |
| Goodwood Blvd and Lobdell Ave. area[2] | 5 |
| BREC Bluebonnet Swamp | Several |

[1] Across Bayou Fountain
[2] Mid-eastern portion of Ward Creek
[3] Jones Creek

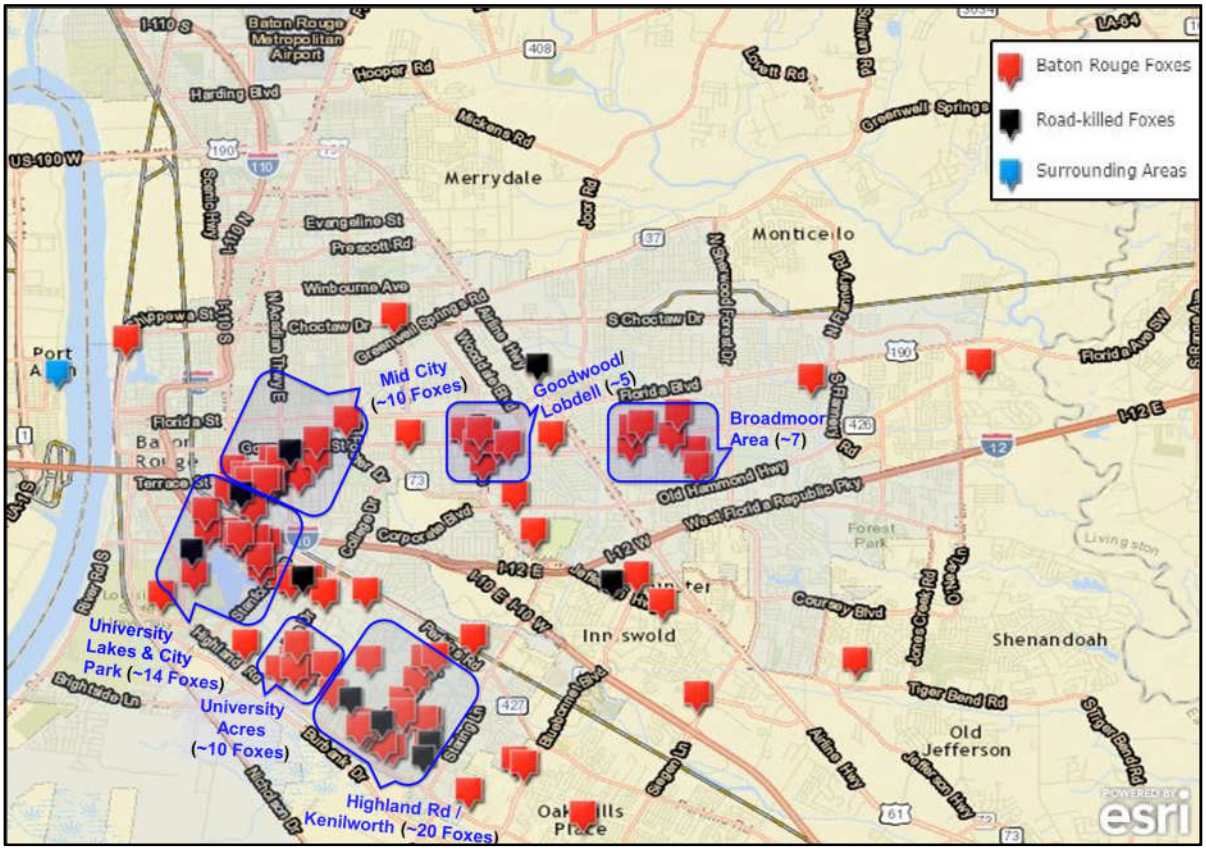


**Figure 7.** A snapshot of the online ArcGIS story map with the common local fox locations, as reported by participants between 31 August 2015 and 30 April 2016 on Facebook, Twitter, Instagram, or Nextdoor.[1]
The city area of Baton Rouge is highlighted in light blue in the background.
[1] Powered by Esri

**Table 7.** Mean distance of the foxes from the nearest water source for each common location from 31 August 2015 to 30 April 2016.[1]

| Distance of the Foxes or Group of Foxes Sighted from the Nearest Water Source (miles) | | | | | |
|---|---|---|---|---|---|
| | **University Lakes, City Park, and Mid City** | **University Acres** | **Highland Rd. and Kenilworth Pkwy area** | **Goodwood Blvd. and Lobdell Ave. area** | **Broadmoor Schools zone** |
| | University Lake | Bayou Fountain | Bayou Fountain | Ward Creek | Jones Creek |
| Mean | 0.13s | 0.32 | 0.21 | 0.23 | 0.49 |
| Standard Deviation | ±0.14 | ±0.11 | ±0.13 | ±0.18 | ±0.17 |

[1] The raw data for this is in Table A1.

It is important to note that many of the reported locations of the local foxes, hence their spot on the map and their distances from a water source, are estimates because many participants usually provided the nearest cross-streets (not a specific location point), and 35 sightings included foxes that were seen regularly at the reported locations.

From the additional information provided by participants' observations, 14 foxes have been reported as being road-killed at seven different locations in Baton Rouge (Table 8). All foxes reported as road-killed were from Baton Rouge. In addition, several participants have noted that about 15 foxes are using or living in storm culvert/drainage tunnels in seven locations in or around the city of Baton Rouge (Table 9). Furthermore, five locations in Baton Rouge where fox dens were found have been reported (Table 10).

**Table 8.** Locations where foxes were reported or seen to have been road-killed between 31 August 2015 and 30 April 2016.

| Local Foxes Reported or Observed as being Road-killed | |
|---|---|
| **Location** | **Estimated number of Foxes** |
| Highland Rd. and Kenilworth Pkwy area | 6 |
| Starring Ln (between Highland Rd. and Burbank Dr.) | 1 |
| University Lake: Standford Ave. | 1 |
| University Lake: West Lakeshore and S. Campus Dr. | 1 |
| University Lake: Near LSU Bird Refuge | 1 |
| Mid City: Belmont Ave. | 1 |
| Florida Blvd and Airline Hwy ramp | 1 |
| Southdown subdivision: Robert E. Lee High School | 1 |
| Bluebonnet Blvd and Jefferson Hwy area | 1 |
| **Total** | **14** |

**Table 9.** Locations where foxes were living around storm culverts as reported or seen between 31 August 2015 and 30 April 2016.

| Local Foxes Reported or Observed as Using or Living in Drainage Tunnels/Storm Culverts | |
|---|---|
| **Location** | **Estimated number of Foxes** |
| Highland Park area | Some |
| Highland Rd. and Kenilworth Pkwy area | 8 |
| BR Center for Visual and Performing Arts | Few |
| Ponchatoula, LA | 4 |
| Hundred Oaks and Arlington Ave. | 2 |
| Baker, LA | 1 |
| Tunnels under Arline Hwy | - |

**Table 10.** Areas where local fox dens were reported or observed

| Location | Date |
|---|---|
| Kenilworth: Louray and Chandler Dr. (in empty lot) | 2014 |
| Southdown subdivision | 2015 |
| University Lakes (20 dens) | March 2015, 2016 |
| Highland Rd. and Kenilworth Pkwy area | 2016 |
| University Acres subdivision | Over last 10 years |

From the trail cameras and our evening/morning observations, we observed that the foxes have become habituated to living around resident's homes and mostly use storm culverts or openings under the roots of oak trees as dens, switch to spare dens nearby when disturbed or when more convenient, are mostly active after dusk to dawn but can sometimes be seen midday, do not seem to have mange, exhibit upright wrestling and caching behavior, and commonly eat rats, mice, insects, birds, and also squirrels. Reports from several participants and our observations of some local foxes also indicated that these urban canids are still timid animals, although they are somewhat likely to watch people and cats/dogs from afar or even play with them. In fact, 15 people stated that the fox(es) co-existed well with nearby cats or dogs. Five of the 15 people have stated that the fox(es) stayed away from or was chased by a dog.

After two residents notified us in the spring of 2016 about the foxes living under a house and in the neighborhood storm culvert, respectively, we were able to set up trail cameras on their property (two cameras in each of the locations) to closely monitor the two fox families as case studies. Both residents mentioned that foxes have been living nearby their house for several years.

The first family had been living under the house close to a bird refuge by University Lake, and we started to monitor them on 21 March 2016 through trail cameras and on-site observations from a distance. The family consisted of three adults (two parents and one first-year helper vixen who was more of a juvenile) and five fox kits that appeared to be about four to five weeks old at that time, given that they were venturing outside their den nearby and had brown fur. Typically, the kits developed reddish coats two to three weeks afterwards and started experimenting with solid food. They co-existed well, even with the presence of the homeowner's domestic cat and dog. The lake fox family was very active, mostly around 7:30 pm to 7 am local time, and the kits ventured out more often and further from the den with each passing week. They exhibited typical fox behavior such as upright wrestling and establishing a sibling hierarchy; they chased and pounced on each other to develop their hunting and fighting skills. The parents modeled hunting lessons for their kits by catching and bringing in prey, and there were instances where a squirrel tail or fur was found near their den or a wing was observed being removed from the den. Interestingly, the foxes also acquired and brought to their den empty cat food cans and newspapers found nearby. According to the cameras and residents, the parent foxes ventured nearby during the mornings or sometimes midday to hunt for food for their kits, and the vixen checked back often, especially when the kits were young. We observed on several occasions that the foxes tend not to be too cautious around city streets and did not usually abstain from being on the street until passing vehicles or bicycle riders were close. In fact, one of the kits was found

road-killed on 2 April 2016, and the mother had carried him near the den where she and the siblings nudged the deceased kit. The fox family switched back and forth between two spare dens nearby, one being at a bird refuge, and they would not be active around the resident's house sometimes for a week or few weeks, possibly when they were feeling extra wary or when their current den became flooded due to rainfall.

The second fox family was brought to our attention on 18 April 2016 by a local resident. The fox family of three adults and eight kits has been living in the ditch of a storm culvert, situated between a homeowner's front yard and the low-traffic street near the Highland Road and Kenilworth Parkway area. The kits appeared to be about six to seven weeks old. They also co-existed well even with the presence of the homeowner's large dog. The presence of two younger kits (four to five weeks old) suggests that those kits may be the offspring of the helper vixen or that the male has two females that chose to raise the kits together. Their behavior was very similar to the fox family by the lake, and they were active around the same period of time. The male parent has also been a frequent visitor to another resident's backyard, located beyond the empty field across the street, for four years. The parents gave warning calls when people approached or were passing by their kits or the den. However, these foxes were also barely wary of the construction happening on the empty field (they were drawn to the logs and dirt piles) or the oncoming vehicles, as they frequently ran, played, or caught insects on the street after dark. Incidentally, there were a few reports of one of the male kits being road-killed by a vehicle on 23 April 2016. The fox family also switched back and forth between two or more spare dens nearby sometimes for about a week, possibly when they felt disturbed or when their den became flooded after heavy rainfall. Whereas some of the spare dens were located under bushy or wooded areas nearby, they used the hole on the bottom of an oak tree located right alongside the high traffic Highland Road as another spare den. This den was used more frequently towards the end of April 2016.

During the month of April, the parents were observed fetching mice for the kits, and the kits had started to hunt insects. Some carcasses of mice, birds, and squirrels were also found near their dens around this time, as well as some shredded newspaper. Additionally, we observed the parents and a few kits running around the neighbors' porches soon after sunrise. Furthermore, footage from the camera showed the mother nursing her kits alongside the den in homeowner's front yard at 4 pm local time. These field studies demonstrated how skillful the foxes can be in becoming habituated to the urban environment and that they may play an important ecological role.

The evidence from the field studies was used to reassure residents that foxes do not pose a real threat to domestic cats and dogs. We were able to raise awareness to address other issues related to the local urban foxes. This included advising residents to secure their chickens just before dusk and to let them out of the henhouse after daylight. A vixen in the Southdowns subdivision was seen by a member of the research team to take away two backyard chickens as prey early on 2 April 2016. We also reminded residents to drive carefully around the areas where foxes were commonly found via Facebook posts.

# CHAPTER 4. DISCUSSION

## 4.1 Social Media as a Tool of Scientific Engagement

Facebook is the most effective social media platform today for its highly extensive global reach (King, O'Rourke & DeLongis, 2014). Another advantageous technology is the wide use of smartphones through which social media become even more accessible and through which photographs can be easily taken and posted to any social medium within minutes. Social media, especially Facebook Pages, also present a very quick, user-friendly, and interactive platform where scientists and the public can communicate closely and directly (and personally via Facebook Page emails). Thus, this project demonstrates that social media, especially Facebook, can efficiently be used to collect and document ecological data on wildlife that would otherwise be very costly and time consuming. Our Fourier analysis and our Facebook Insights results demonstrated that broadcast of the project on news media has also been successful for connecting citizens to the page and the science, although ascertainment bias existed in areas where the news sources or social media do not typically reach.

Our Facebook Page's performance shows Fox Finders of Baton Rouge has become a successful campaign, receiving 1132 Facebook likes in eight months between 31 August 2015 to 30 April 2016, with an average Daily Total Reach of 393 people and average Daily Engaged Users of 38 people, although these two metrics varied greatly, depending on the type of post and the frequency of posts we published. Given the Facebook Page's Insights tool, the main metrics for our page's performance and user engagement, specifically the page's Daily Total Reach and average engagement rate, indicated that our project was effective. Reach is a more accurate measure of our Facebook Page's audience than Total Page Likes because many users who do see posts may not have liked the page, and not all the people who like the page see each post. Thus, a noteworthy protocol of Facebook is that although posts published or shared by a Facebook Page's administrators should theoretically reach everyone who liked the page via their news feed, this may often not be the case, depending on Facebook's algorithm and that particular fan's engagement with the page. The more a fan is engaged with a page, especially its posts, the more of the page's posts will appear on the fan's news feed. In addition, our average Page Engagement Rate of 14% and average Post Engagement Rate of 11% with a page of 1132 fans demonstrate relatively good social media performance. It is important to note that as the number of page fans grow, Engagement Rate is likely to decrease because more people will need to engage with the page or posts to close the gap between Total Reach and Engaged Users.

Metrics for our posts, especially Lifetime Post Total Reach and Lifetime Engaged Users, provide a clearer concept of our page's connection with the audience who seem to be most interested in videos and photographs of foxes submitted by other residents or from our trail cameras. Furthermore, the overwhelming positive and supportive comments from participants, many of whom provided information beyond the requested data, show that they are interested in and involved in being citizen scientists. Therefore, this project proved to be an effective model that easily promoted citizen science by connecting many residents of Baton Rouge and surrounding areas to the wildlife around their local environment in a compelling and interactive way, as well as by raising interest and engagement of people from many different places in the nation and in several other countries. One of the highlights of this research is that our Facebook Page reached

and led to engagement from users associated with over 16 countries and 384 cities, demonstrating that this model can be initiated anywhere worldwide with access to the Internet. This is very likely to soon lead the community to become more involved in science, increase their understanding and appreciation of the wildlife and nature around their environment, and teach them how to respond to a wild animal such as a fox.

This research also demonstrated that the fox is an umbrella species. In this context, an umbrella species is a species that acts to cause people to begin to have more overall care for their surrounding environment because they care about that particular species. For example, their awareness of the fact that foxes live in storm culverts, storm drains, and other areas may offer opportunities for city dwellers to become more aware of what goes down their drains.

### 4.2 Studying Urban Foxes

The red fox is globally the most widespread wild terrestrial carnivore, and its habitat clearly includes the urban landscape. Urbanization can lead to fragmentation and degradation of natural habitats, typically resulting in negative effects on biodiversity and on species like carnivores or canids. Our study showed that red foxes may benefit from urbanization because they can exploit urban habitats and resources. Thus, they become well integrated into the human environment, in the midst of people, cats, dogs, and cars, and do not seem to be causing any apparent problems. Furthermore, contact with nature and wildlife can have positive benefits for humans, and urban residents are usually eager to observe the wildlife such as foxes around them. Foxes also provide ecosystem services such as pest and population control and do not seem to overpopulate themselves. Assessment of urban wildlife populations is thus important for monitoring their benefits, and for possible conflict and resolution. (Scott et al., 2014).

It is possible that humans provide a service to the foxes; humans provide cover for the foxes and tend to discourage coyotes. Additionally, in the area where we did our study, we suspect that there is a high level of compliance with heartworm treatment in captive canines. This, in turn, may suppress heartworm in the wild fox populations, because the local mosquito population titer would be lower, allowing the urban foxes to thrive. A fox confiscated from a homeowner by Louisiana Department of Wildlife and Fisheries was found to have died of heartworm while it was rehabilitating for release.

The fox also represents an umbrella species that can engage people in urban environmental science. This can lead to more education and can direct people's attention to their impact on the urban environment. Therefore, social media can be the most effective tool to further inform the public about the science, clear misconceptions, and educate residents about how to successfully interact with the surrounding wildlife, in turn leading to improved conservation efforts. The idea that foxes are a problem from the standpoint of rabies has been a misconception that was addressed on our Facebook Page. In fact, there has not been any incident of rabies in foxes in Louisiana since 1970 (Kliebert, 2014). Addressing many residents' misconception that foxes might be a threat has been one of the most helpful outcomes, given the reports from many participants and our observation of many local foxes indicating that foxes are actually timid

animals, co-exist well, and do not prey on cats or dogs. In fact, our camera evidence, as well as some of the residents' comments on our Facebook Page, suggest that they sometimes play with cats or dogs.

Overwhelming reports from residents' comments and input as well as our own observations support the conclusion that urban foxes are generally timid, especially around domestic animals, have a high tendency to be active after dusk to dawn, live near a water source and also in drainage tunnels, and are subject to fatality from vehicles on the road. Although they are drawn to a water source, they likely concentrate around anthropogenic food resources, particularly if they are receiving supplementary feeding, although they do not need humans to provide them with dietary resources. In fact, supplementary feeding can be used as a method to lead to increased conservation of these or other animals (Steyaert et al., 2014), especially to prevent them from being road-killed. In addition, our results show these urban foxes are similar to rural foxes in many ways such as still being timid around humans and cats/dogs (although not as much in the city), establishing dens and spare dens around trees, and consuming basically the same diet (mice, insects, squirrels, and birds with instances of fruit and pet food). Therefore, studying the fox population and behavior can lead to a better understanding of the role these animals play in our urban ecosystem, particularly foxes who are consuming rodents and insects as pest-control, and how to best respond to these animals that are naturally an integral part of our urban ecosystem. In turn, this information can be immediately and effectively shared with the public through social media to inform and engage them with the natural sciences.

Although quantifying the fox population in Baton Rouge and enumerating the population from sighting density was not directly our objective, this was a difficult task, especially because we do not plan to tag or collar the foxes to avoid disturbing them. Some of the different sightings by residents could be of the same fox, and/or the same fox could be sighted at a different location at another time. Several participants have noted observing the same fox at different times or also observing the same fox another participant had sighted. These incidents have been accounted for in the data. Regardless, we were able to make a reasonable estimate of the number of foxes in the city of Baton Rouge and surrounding areas from social media sightings.

### 4.3 Limitations and Further Research

The main challenge of the project was not being able to receive clear fox photographs, especially because all photographs are likely taken with a smartphone, which can lack the quality of a typical camera. We initially required the photographs because we thought people might mistake cats and dogs for foxes, but it became immediately clear the public was very adept at identifying foxes. Many participants themselves have mentioned this as a setback. At this point, no photographs that erroneously identify foxes have been submitted. However, there is a possible limitation of the research, which was not being able to further verify sightings submitted without any photographs.

As portrayed by the story map of the fox sightings, another limitation for gathering data was that only a few foxes were reported from northern Baton Rouge (north of Government Street); therefore, ascertainment bias was present in our data. This might be due to the limitation of the broadcasting of our fox project seemingly not reaching areas in north Baton Rouge, which is a

more rural/lower income area where more people may not have access to the internet, DIG magazine, or cable news. Thus, it's most likely that the residents in this area are more concerned about survival than participating in citizen science, and further personal or direct outreach might be required to engage these residents in such community projects. It is also possible that foxes may not be present, or barely present, in north Baton Rouge.

The few trail cameras we deployed are limited in what they can show. We cannot track the foxes for an extended time, especially when they start leaving their den in the fall and mostly stay out of the sight of cameras. However, trail cameras provide much qualitative data with insight to the fox population's behavior and ecology, especially during the spring and summer times when they are active around their den sites.

To apply this research model to study wildlife in a more populated area or where higher citizen participation is expected, a researcher could re-direct participants to an online form to report a sighting, with the link provided on the social media page, rather than citizens directly entering the data as text or as comments on social media. This would be a more efficient system, as conducted by the UW-Madison Urban Canid Project (Gaines, 2015).

Citizen science has become increasingly important for its ability to engage large numbers of volunteers to generate observations at scales that can be very difficult to achieve by individual researchers. Developments in information technology during the last few decades have created new opportunities for citizen science to engage ever larger audiences of volunteers to help address some of ecology's most pressing issues in general, such as global environmental change. Using online tools and social media, volunteers can find projects that match their interests and learn the skills and easily learned the required to develop questions, collect data, submit data, and help process and analyze data online. As a coupled natural and human approach, citizen science can also help researchers access local knowledge, exchange broad feedback with the public, and implement conservation efforts that might be otherwise unattainable (Kobori, 2016).

# CHAPTER 5. CONCLUSION

This project incorporated the public in the process of data gathering and in portions of the analysis, engaging citizens in answering many questions. In turn, they can understand and appreciate the creatures they share their backyards with and thus promote conservation of these fascinating animals. The most promising aspect of this model is that it can be applied to research about many types of animals within different types of fields or across different regions.

From the feedback we've been receiving on our Facebook page since last year, this idea is continuing to benefit the community in connecting local residents to the nature and wildlife around them. Because smart phones (which include cameras to capture the science) and social media have become a common part of daily life, they provide a platform for the public to easily get involved in science around them while engaging with our team and other residents. Thus, this model facilitates an interactive and close communication between scientists and the public and allows the different groups to exchange important feedback. Facebook has become an efficient medium for outreach and education, such as addressing many of the residents' concerns and misconceptions about foxes: how the local foxes haven't been reported to have rabies in 46 years, are quite timid, and do not pose a real threat, especially towards domestic cats or dogs with whom they co-existed very well. These connections can further lead to personally engaging with citizens in the science in person when they are asked or they volunteer to welcome us researchers into their property to set up trail cameras to discover the wildlife around them together.

This project serves as an effective model for engagingly and efficiently studying other animals (such as coyotes, raccoons, bears, etc.) in different parts of the world in general, because using only traditional methods like surveying and tagging the animals would be costly, time-consuming, and disruptive to their natural state. In addition, using trail cameras can be limited in scope if it is the only method used for survey. This project shows that using social media as the major research tool, which has become a regular part of communication and networking, is an effective way for gathering data and outreach/education via citizen science where communities can easily be involved. Studying animal populations and behavior can also lead to a better understanding of the role these animals play in our urban ecosystem.

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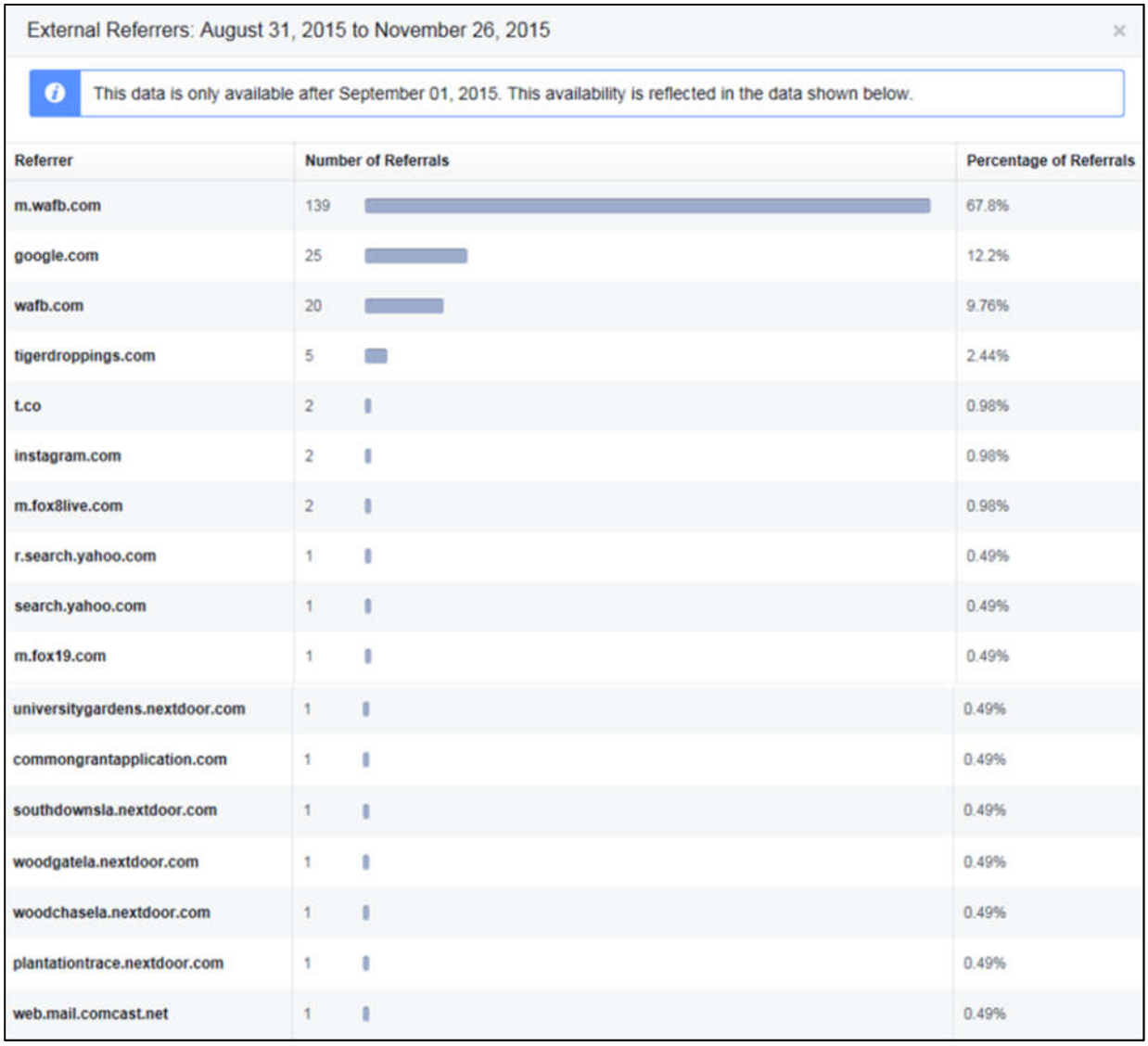
# APPENDIX A: SUPPLEMENTAL DATA


External Referrers: August 31, 2015 to November 26, 2015

This data is only available after September 01, 2015. This availability is reflected in the data shown below.

| Referrer | Number of Referrals | Percentage of Referrals |
|---|---|---|
| m.wafb.com | 139 | 67.8% |
| google.com | 25 | 12.2% |
| wafb.com | 20 | 9.76% |
| tigerdroppings.com | 5 | 2.44% |
| t.co | 2 | 0.98% |
| instagram.com | 2 | 0.98% |
| m.fox8live.com | 2 | 0.98% |
| r.search.yahoo.com | 1 | 0.49% |
| search.yahoo.com | 1 | 0.49% |
| m.fox19.com | 1 | 0.49% |
| universitygardens.nextdoor.com | 1 | 0.49% |
| commongrantapplication.com | 1 | 0.49% |
| southdownsla.nextdoor.com | 1 | 0.49% |
| woodgatela.nextdoor.com | 1 | 0.49% |
| woodchasela.nextdoor.com | 1 | 0.49% |
| plantationtrace.nextdoor.com | 1 | 0.49% |
| web.mail.comcast.net | 1 | 0.49% |

**Figure A1.** The number of people who viewed our Facebook Page due to a referral from an external website for the first 88 days of data collection, from 31 August 2015 to 26 November 2015.

**Table A1.** Mean distance of the foxes from the nearest water source for each common location from 31 August 2015 to 30 April 2016.

| Distance of the Foxes or Group of Foxes Sighted from the Nearest Water Source (miles) | | | | | |
|---|---|---|---|---|---|
| | **University Lakes and City Park area** | **University Acres** | **Highland Rd. and Kenilworth Pkwy area** | **Goodwood Blvd. and Lobdell Ave. area** | **Broadmoor Schools zone** |
| | University Lake | Bayou Fountain | Bayou Fountain | Ward Creek | Jones Creek |
| | 0.02 | 0.09 | 0.06 | 0.02 | 0.31 |
| | 0.02 | 0.15 | 0.07 | 0.05 | 0.33 |
| | 0.02 | 0.26 | 0.07 | 0.10 | 0.52 |
| | 0.04 | 0.27 | 0.08 | 0.20 | 0.60 |
| | 0.04 | 0.31 | 0.10 | 0.20 | 0.70 |
| | 0.05 | 0.32 | 0.11 | 0.32 | |
| | 0.05 | 0.34 | 0.12 | 0.33 | |
| | 0.06 | 0.34 | 0.19 | 0.58 | |
| | 0.08 | 0.34 | 0.20 | | |
| | 0.10 | 0.35 | 0.22 | | |
| | 0.14 | 0.37 | 0.22 | | |
| | 0.22 | 0.48 | 0.22 | | |
| | | 0.52 | 0.22 | | |
| | | | 0.44 | | |
| | Dawson Creek | | Dawson Creek | | |
| | 0.04 | | 0.23 | | |
| | 0.06 | | 0.33 | | |
| | 0.14 | | 0.45 | | |
| | 0.23 | | 0.48 | | |
| | 0.24 | | | | |
| | 0.30 | | | | |
| | 0.58 | | | | |
| Mean | 0.13 | 0.32 | 0.21 | 0.23 | 0.49 |
| Standard Deviation | ±0.14 | ±0.11 | ±0.13 | ±0.18 | ±0.17 |

# APPENDIX B: IRB EXEMPTION FORM

The following is a copy of the form stating that the exemption request to engage with local residents while studying the urban foxes was approved by the Louisiana State University's International Review Board (IRB).

**ACTION ON EXEMPTION APPROVAL REQUEST**

LSU

**TO:** Linda Hooper-Bui
Environmental Sciences

**FROM:** Dennis Landin
Chair, Institutional Review Board

Institutional Review Board
Dr. Dennis Landin, Chair
130 David Boyd Hall
Baton Rouge, LA 70803
P: 225.578.8692
F: 225.578.5983
irb@lsu.edu | lsu.edu/irb

**DATE:** August 31, 2016

**RE:** **IRB#** E10014

**TITLE:** Mapping and Studying the Red Fox Population in Baton Rouge, LA using Social Media

**New Protocol/Modification/Continuation:** New Protocol

**Review Date:** 8/31/2016

**Approved** X **Disapproved**

**Approval Date:** 8/31/2016 **Approval Expiration Date:** 8/30/2019

**Exemption Category/Paragraph:** 2b

**Signed Consent Waived?:** Yes

**Re-review frequency:** (three years unless otherwise stated)

**LSU Proposal Number** (if applicable):

**Protocol Matches Scope of Work in Grant proposal:** (if applicable)

**By**: Dennis Landin, Chairman DLandin

**PRINCIPAL INVESTIGATOR: PLEASE READ THE FOLLOWING –**
**Continuing approval is CONDITIONAL on:**

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report, and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects*
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
3. Obtaining renewed approval (or submittal of a termination report), prior to the approval expiration date, upon request by the IRB office (irrespective of when the project actually begins); notification of project termination.
4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.
5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants, including notification of new information that might affect consent.
6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.
7. Notification of the IRB of a serious compliance failure.
8. **SPECIAL NOTE: When emailing more than one recipient, make sure you use bcc. Approvals will automatically be closed by the IRB on the expiration date unless the PI requests a continuation.**

**All investigators and support staff have access to copies of the Belmont Report, LSU's Assurance with DHHS, DHHS (45 CFR 46) and FDA regulations governing use of human subjects, and other relevant documents in print in this office or on our World Wide Web site at http://www.lsu.edu/irb*

# APPENDIX C: PROOF OF COPYRIGHT

Most portions of this thesis, which has previously appeared on the online journal PeerJ at https://peerj.com/preprints/2623/. The following is a contract acknowledging the author of this article (and this thesis) as the copyright holder.

# VITA

Ahsennur Soysal was born in 1991 in the city of Ankara Turkey. She moved to Baton Rouge, Louisiana in 2000 and has been residing in this city until present. She received her Bachelor's degree with a major in Coastal Environmental Sciences with a minor in biology from Louisiana State University (LSU). As her interest in environmental sciences and issues grew, she decided to further her studies by continuing her education to obtain a Master's degree in Environmental Sciences from the College of the Coast and Environment at LSU. She also volunteered to co-mentor a high school student for an academic year as part of the EnvironMentors program sponsored by the college. She anticipates to graduate from this Master's program in December 2017.