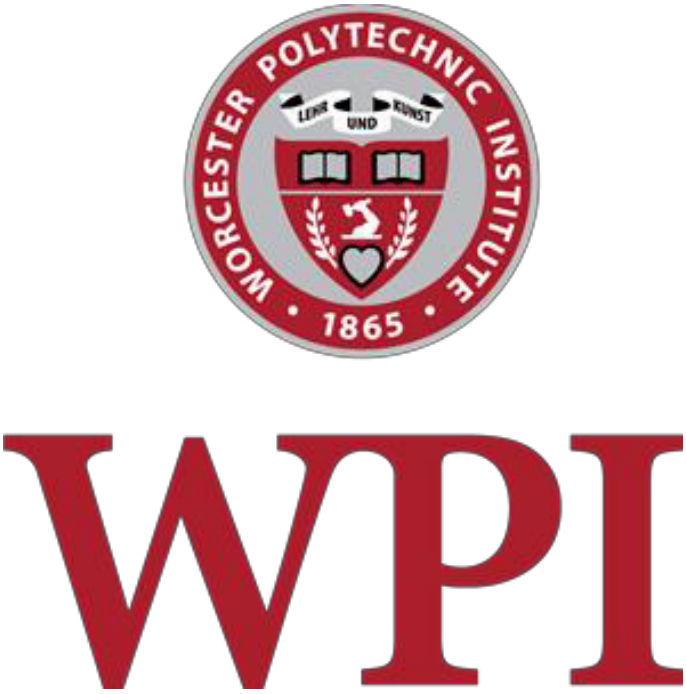
A Plan to Strategically Locate The Best Potential Partners And Locations in Massachusetts To Build New Telemetry Stations for Motus Wildlife Tracking System



Juan Martin Hinostroza
Worcester Polytechnic Institute

A Plan to Strategically Localize The Best Potential Partners And Locations in Massachusetts To Build New Telemetry Stations for Motus Wildlife Tracking System

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By

Juan Martin Hinostroza

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Professor Marja Bakermans,
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ABSTRACT

New Hampshire Audubon along with other organizations are developing a proposal to get a grant from the U.S. Fish & Wildlife Service to expand the Motus Wildlife Tracking System network in the northeastern states. This paper documents my efforts to identify the best potential sites for the implementation of new telemetry stations for this network with the ultimate purpose to contribute to the conservation of birds in North America. Information was collected through interviews and literary research, and then analyzed using online mapping tools. It was suggested to create a fence of seven new receiving stations running from southeast to northwest Massachusetts connecting to already existing stations using mostly 9-element Yagi antennas. At the same time, some areas were layered in maps where potential sites exist. It was recommended to continue reviewing the topography of the suggested areas, and to add approximately three other receiving stations were Motus studies are dedicated.

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1. INTRODUCTION

Conservation of birds in North America has been supported for over century due to notable population declines that threaten the ecosystem that will ultimately affect communities. Therefore, since the 20th Century, concerned citizens have created organizations such as Audubon, the North American Bird Conservation Initiative (NABCI), and Motus that join resources to fight for the conservation of birds in North America. In order to understand the reasons for these population declines, it is important to analyze bird activity in long distances such as migration drives, and in short distances such as stopover, breeding, and other diel activities. Therefore, GPS tracking technology has been used over the last 50 years to track the movements of birds and other animals such as bats, amphibians, small reptiles, and large insects. It consists of tracking devices placed on captured animals and receiving stations like radio towers or satellites. Although this technology started off with issues involving exceeded weight of tags and poor positional and temporary accuracy, it has been improving over time. Motus presents the latest and most efficient technology in animal tracking which has been widely used since 2012.

The Motus Wildlife Tracking System works with automated-radio-telemetry stations placed along strategic places in 11 countries and miniature tags attached to various species that provide a relatively high accuracy in spatial data. This has improved the quality of the overall data collected by scientists that can be better analyzed, leading to more accurate conclusions for a better understanding of the reasons for which the populations decline. Once this information is gathered, the previously mentioned organizations and many others can work together for the conservation of the different species of these animals. There are now more than 300 working stations around the world; however, the more strategically placed stations there exist, the better this development works. Therefore, it is important for the mission to gather as many partners as possible globally. The Audubon Society of New Hampshire is currently working on a plan to increase the number of Motus radio stations in New England to help the purpose.

This project aims to identify the most strategic places in the state of Massachusetts for the implementation of Motus automated-radio-telemetry stations as well as most adequate potential partners that could collaborate with Motus. For this purpose, it is critical to identify regions of high elevations in the area and recognizing potential partners within those regions to strategically place these receiving stations. In order to accomplish this objective, I will analyze topographic maps of Massachusetts, distinguish key aspects of the most appropriate types of antennas for the different stations depending on different purposes, and examine the characteristics of the organizations that have the potential to become collaborators. This project connects science, engineering, technology, to the society of Massachusetts to assist in the conservation of birds in North America. Additionally, it could assist the Audubon Society of New Hampshire to accomplish their mission to build more Motus receiving station in New England.

Data will be primarily collected from the Motus Wildlife Tracking System official website and from interviews to the key members of the Audubon Society of New Hampshire. The data will be further analyzed in with computer programs like Microsoft Office and ArcGIS. The time frame for this scheme is projected to be approximately 7 weeks with no expected budget.

2. LITERATURE RESEARCH

Background

The problem of the significant decline in bird populations in North America has a long history. A reduced bird population can untie a series of devastating environmental impacts that can affect societies in different ways. “Bird extinctions and population reductions (5) in the 21st century may disrupt ecosystem processes and services of potential importance to society” (Sekercioglu et al. 2004). A study made in 2004 using the online databases for bird conservation pointed stated: “We project greater-than-average extinction rates for frugivores, herbivores, nectarivores, piscivores, and scavengers. Some guilds may lose up to 46% of their species. Specialists are predicted to have more extinctions than average” (Sekercioglu et al. 2004). Thus, various plant species could start decreasing at unpredicted rates which will affect many species of herbivores, and then continue up the energy pyramid which will end up affecting humans. Likewise, another study of bird populations in an island from New Zealand disclosed that “In addition to the comparison of pollination treatments at matched island and mainland sites, there is other direct evidence that fruit set was reduced because of inadequate bird visitation” (Anderson et al. 2011). Agricultural pests that are usually controlled by birds will start increasing; therefore, affecting the vegetation in countless communities. Hence, we can conclude that the decline in bird populations can have indirect and direct effects on civil communities, which is why it is crucial to take preventive measures (Sekercioglu et al. 2004). The first organization in the United Statethat was concerned about the conservation of bird species was the National Audubon Society.

The National Audubon Society was founded in 1886 by George Bird Grinnell, and named after John James Audubon, who spent most of his life drawing and studying birds. It serves the purpose of conserving animal species, but mainly focusing on birds. Then, Massachusetts Audubon Society was founded in 1896 by Harriett Hemenway and Minna, B. Hall who wanted to contribute to the cause of bird protection. However, it was not until 1898 that Audubon became state-level and opened up establishments in fifteen other states. Ten years later the Migratory Bird Treaty Act (MBTA), which still contains the most solid laws for bird protection, was approved by President Wilson. This led to the creation of the National Audubon Society which serves similar purposes, but diverged themselves from Massachusetts Audubon Society. To this day, the Audubon societies comprise one of the most resourceful databases in North America aimed at the conservation of bird species. Audubon is a powerful distributed network with an unparalleled reach. “No other conservation organization matches the size, scale, influence, diversity, and creative energy of our chapters, nature centers, volunteer leaders, and partners” (Yurtoğlu 2018). The organization is based purely on science regarding data collection and analysis, and makes a respectable job communicating any findings with its numerous partners in order to maintain a dynamic system do best towards conservation of birds.

Similarly, NABCI, originated in Canada, works sideways with Mexico and the U.S. towards the promotion of bird conservation. NABCI serves as "a forum connecting government agencies, private organizations, and bird initiatives helping partners across the continent their common bird conservation objectives" (U.S. NABCI Committee). It started in Canada back in 1996 when the Council of Commission for Environmental Cooperation (CEC) approved their plan to develop their organization in North America. They operate in a form of government with an Executive Council and a 'Legislature and Policy". Its body consists of different committees and subcommittees their three partner countries; nevertheless, they follow similar objectives in bird conservation. Recognizing the fact that birds migrate to different places disregarding any kind of physical governmental boundaries, NABCI decided to establish a new international subcommittee to maintain a better communication between partner countries in 2016. They recognize three major resources as fundamental to their contribution to bird conservation: The State of North America's Bird report, the Migratory Bird Centennial, and their own Demographics Monitoring Report (PROPOSED 2018 NABCI Work Plan). Since migration is an important area of study in animal conservation, there are other important collective organizations that focus primarily in tracking the migration of such over different periods of time.

Motus Wildlife Tracking System (MWTS)

Since geographic positioning systems (GPS) have previously exhibited limitations in the implementation of equipment and positioning precision, the data collected were inaccurate to properly analyze migrations and movement of animals. Motus is an international research network that uses automated-radio-telemetry stations and small tags to track and study small animals such as bats, birds, reptiles, amphibians, large insects, and birds. With their proposed system, the tracking of the animals' spatial position it becomes easier and more efficient due to the fact that it makes tracking more continuous and simultaneous; thus, giving the science community more data to analyze. They use 'nanotags' manufactured by Lotek Wireless, and receiving stations with mostly Yagi antennas. "Motus also coordinates, disseminates, and archives detections and associated metadata in a central repository. Combined with the ability to track many individuals simultaneously, Motus has expanded the scope and spatial scale of research questions that can be addressed using radio-telemetry from local to regional and even hemispheric scales" (Taylor PD et al. 2017). Today, Motus has expanded to approximately 11 countries within 4 continents (Figure 1). It counts with more than 350 receiving stations since 2017, and they keep adding more as they gather more collaborators (Taylor PD et al. 2017).

(a)

(b)

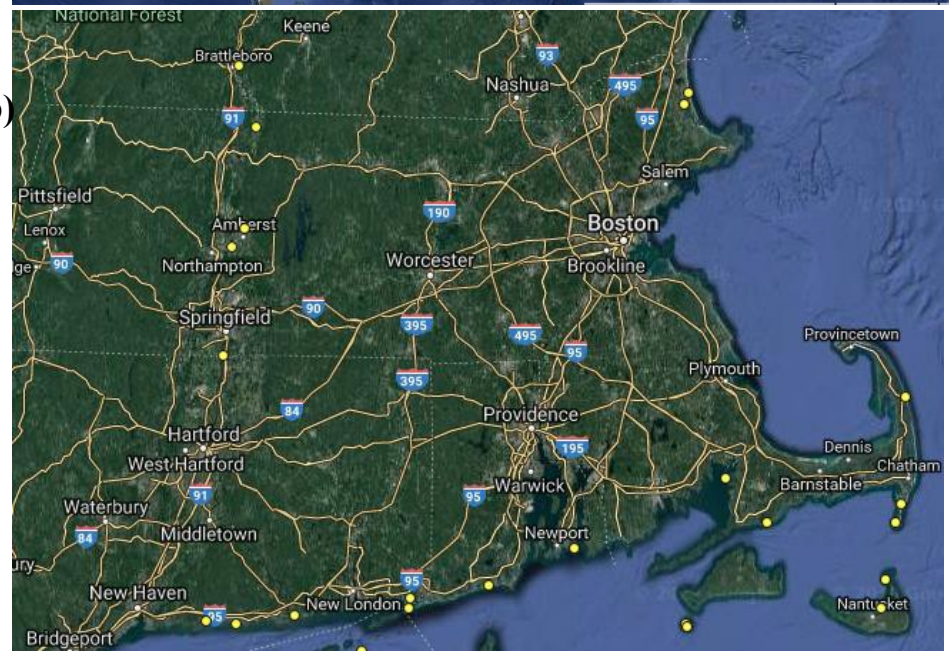


Figure 1. (a) World Map revealing all the locations of Motus receiving stations **(b)** Massachusetts map revealing existing receiving stations. Retrieved from: https://motus.org/data/receiversMap?lang=en

In Figure 1 (a) we can count 14 receiving stations located in Massachusetts from which 11 are located near the coasts and only 3 are located inland. Hence, it is appropriate to build more receiving stations inland since not all bird species travel along the coasts. The Motus receiver stations vary as each may carry different number of Yagi antennas that can cover different ranges, and most of them run uninterrupted throughout the year. They use two receivers that have different tasks: the Sensorgnome, which monitors the antennas; and the Lotek, which rotates the efficiency of detection between antennas. The antennas are categorized in 3 main groups based on their coverage range as seen in Table 1.

Table 1. Types of antennas used in Motus automated-radio-telemetry receiving stations.

Relative Tracking Distance	Relative Range	Beam	When are they used?	Direction	Range
Close	Short – Medium	Broad	When birds are in long-distance flights	Omnidirectional (360^{o}) or	~ 500 m
				Directional 3-5 element	2-3 km
Long	Large	NA	When birds are in low-distance flights	Directional 9 element	~ 15 km

Furthermore, the stations can be powered either by solar-powered batteries or by a direct connection to a power source; nonetheless, a direct connection could be preferable since it has a lower cost and maintenance. In addition, they allow for a direct connection to the internet (either Ethernet or cellular network) which provides live locations at any time. However, in order to lower costs stations could be disconnected. Either way, the data collected in the hard drive will be stored until a staff member deletes it.

Motus researchers divide the areas in the map into "grids" which are, as the name implies, squared areas where receiving stations are strategically located (typically along the coast side). Grids with higher station densities are better for collecting data for stopovers period, departure duration, and daily movement. Meanwhile the ones with lower station densities are superior for larger bird migration crossings. Within these grids, there are different arrangements in which stations are configured in order to serve different purposes as shown in Table 2. An example of a turnstile configuration can be seen in the lower part of the map in Figure 1, as the receiving stations are situated linearly from New Haven to Newport. Similarly, an example of two stations lying in a point-to-point configuration is seen near north of Salem.

Table 2. Types of arrays of receiving stations within grids and their purposes.

Array	Configuration	Purpose	Examples
Turnstile/Fence	line	The detection of migrants passing through latitude **or** longitude.	Birds Migrating in geographical bottlenecks ➢ The Panama Canal ➢ Gulf of Mexico
Point-to-point	Strategically placed individual stations, or groups of such	Activity detection in known areas of ➢ Breeding ➢ Wintering	

		➢ Stopover ➢ Key migratory locations	

As mentioned before, all the information collected in the stations is immediately saved in each station. This database consists of all tag detection data and its station's metadata which needs to be manually submitted by each user to the Motus research platform where it will be automatically saved in the centralized database at Bird Studies Canada's national data center. The tag detection data occurs when the stations identify different radio signals and then filter for the frequencies related to the tag frequencies registered in the system. Users are able to filter their data, and along with their metadata they can disregard any discrepancies in order to achieve the best possible data quality for a better analysis. Therefore, with the accuracy of this information provided by Motus "Projects to date have logged over 250 million detections at over 560 receiving stations (Fig. 1) and, for many projects, a large portion of tagged animals (sometimes exceeding 80%) are detected at stations beyond the original tagging site. This wealth of data has led to comprehensive and diverse applications in the study of breeding and post-breeding dispersal, stopover and migration behavior, and overwintering ecology" (Taylor PD et al. 2017). Nevertheless, since this ongoing project needs various of receiving stations in order to serve best, it requires to cover certain expenses at each station which may vary depending on some geographical factors.

The major costs that a project that installs towers demands is the implementation of the automated-radio-telemetry stations which may vary in costs depending on the setup (see Figure 2); however, their estimated cost range from $3,000 to $10,000 (CAD). Similarly, the cost of maintenance depends on regularity in which they connect to the internet, their power operation, and location. Their yearly cost of maintenance is estimated to range between $100 and $5,000 (CAD) (The Motus Wildlife Tracking System). The partners that build the stations usually cover the cost of its implantation and maintenance. Nonetheless, even if these prices may seem too high for some collaborators, there is always the possibility of getting partial or complete funding from other collaborators. Motus has also funding partners that help with some of the costs; in addition, they have an open donation webpage on the official website for other smaller contributions to the project. Once a tower is built anyone can access its recorded information through the official Motus webpage.

Equipment	Quantity	Cost	Total (typical station)
Receiver	1	~$1500	**$1500**
Tower/Mast	1	~$800 – pop-up mast ~$1-2,000 bracketed tower	**$800**
Antenna and Cables	1-6 per station	~$600 per antenna (*price will vary depending on length of cable*)	**$1,200**
Solar Power	1, 100W solar panel 1, 110 amp/hr battery 1, charge controller 1, wiring and fuses	~$750-1,000	**$1,000**
Miscellaneous parts	Waterproofing, hardware, cables, fasteners, storage box, rebar.	~$500	**$500**
Total			**$5,000**
Approximate procurement and setup cost ~ $2,000			*$2,000*
Approximate annual Maintenance cost ~ $500			*$500*
Total			*$7,500*

Procurement, setup, and annual maintenance costs can vary substantially depending on the specifics of each installation.

Figure 2. "Average cost of Motus station components, setup, and maintenance" Extracted from https://motus.org/wp-content/uploads/2017/08/Motus_LandownerInformation_April2017.pdf.

Moreover, there have been several publications that were published using the MWTS as a tool. For example, there was a study in southern Ontario, Canada in which four ornithologists studied the effects of the conditions and time of fledging in songbirds. After the completion of their research, they were able to conclude that the relative time in the season in which songbirds start fledging is not a significant factor in survival during the post-fledging period, while the fledging conditions represent a more significant factor for the survival during such period (Evans et al. 2019). Likewise, another study from 2014 studied the movement decisions of three bird species when facing critical ecological barriers. To collect data, 350 km of Motus network from southwest Nova Scotia to southern Maine were used. They found that initial fat score and tailwind assistance represented a factor in migratory departure probability among other factors (Woodworth et al. 2014). Similar to the publications, there are hundreds of other ongoing projects that are possible due to the network. A particular species of interest in the Northeast is the Eastern Whip-Poor-Will, which has three ongoing projects. This bird species along with common Nighthawks have populations across the eastside that are "declining precipitously";

thus, research is being conducted to identify the ecological trap they face throughout the year and develop effective strategies for their conservation (Grahame 2018).

Interviews and Skills

Research conducted in 2001 identifies three important phases when conducting a phone interview; these include information collected before and during the interview, as well as the analysis after it takes place "the points discussed in this paper are critical, especially for the novice researcher, to be aware of and to proactively address before initiating data collection" (Burke & Miller 2001). Before the interview, it is important to first develop a list of potential candidates which will be the subjects of the interviews. Once these are properly identified, one can proceed to develop interview protocols and start communicating with those participants in order to schedule the interviews. The interview questions developed for the interview protocol should be communicated to the subject in advance because he/she might need time to think through the answers and be properly prepared for the interview. In addition, it would be necessary to establish a method for recording the information collected during the interview; some examples include tape recorders and phone call recorders. When the interview is about to start it is essential to cover these six aspects: "introduce yourself (prestigious titles help), identify the sponsor of your study, give the general topic of the study, relay the confidentiality of their responses, explain how the information will be used, and give an estimate of the interview's length" (Burke and Miller 2001). In addition, the interviewer should ask for the consent to record the interview in case a recording is necessary.

During the interview, it is also relevant to take notes on the interviewee's responses as there might be some issues with the communication platform. In any case, it is better to have both methods of data collection. When talking to the subject, "the interviewer's style should be friendly, courteous, conversational, and unbiased. As such, interviewers should read questions in a conversational tone and avoid awkward pauses between questions" (Burke and Miller 2001). At the same time, it is beneficial to make the subject keep talking by asking he subject to explain the answers, and verify the interviewer's understanding of these by briefly rephrasing their responses and then asking for confirmation. In order to keep the subject engaged in the conversation, it would be ideal to occasionally comment on his/her responses with "'Uh-huh, this is the kind of information we want' or 'Thanks, we appreciate your frankness'" (Burke and Miller 2001). In case of receiving a vague answer, one might rephrase the question after briefly apologizing for any lack of clarity. Additionally, if the subject appears to avoid providing a clear and close-ended response to a forward question, the interviewer should ask for a generalization or for the subject's opinion. Once the interviews are terminated, it is time to analyze the data collected in each of them. For this, it is important to establish a data analysis method depending on the number of interviews and variety of subject types. The interviewer should send a copy of the minutes taken and the interview's recording (if any) to the subject to keep him/her informed of what information is going to be analyzed.

When more detailed information is required from subjects, there exist in-depth interviews which are specifically explained in a guide developed in 2006 by Carolyn Boyce and Palena Neale. This type of interviews offers a more thorough picture of the topic that is subject to research. Another benefit that it offers is that it can make the interviewee feel more comfortable. However, it could also have the downside of generating bias in the subject's responses in some cases. "Responses from community members and program participants could also be biased due to their stake in the program or for a number of other reasons. Every effort should be made to design a data collection effort, create instruments, and conduct interviews to allow for minimal bias" (Boyce and Neale 2006). Furthermore, the guide explains that in depth interviews should be presented in 5 sections, which include: introduction and justification, methodology, results, conclusion and recommendations, and appendices.

There are also challenges that interviewers have to face during and after the interview when these skills are not sufficiently developed. A study published in 2003 concluded that there are 4 major challenges that interviewers encounter during the process. For example, 'unexpected participant behaviors' might be present during the interview. This involve interruptions, communication issues, and other unfortunate behaviors that the participant might carry throughout the interview. Similarly, the interviewer could also have to deal with sensitive issues where the participant exhibits emotional break downs when touching sensitive topics in the conversation. This could affect the validity of the participant's answers as it may create bias. On the other hand, the interviewer could take mistaken actions and subjectivities which may carry consequences. Thus, the interviewer could forget to explains sections of the procedure to the participant (such as the fact that it is going to be a recording and/or notes of the session), or that he/she might unconsciously try to lead the participant towards a specific answer. The last challenge identified during this research, is 'phrasing and negotiating questions', which include issues with the phrasing of questions, difficulties in keeping the main topic of the study, and being questioned by participants. These may lead to confusing answers, ambiguity, and deviations from the main topic (deMarrais et al. 2003).

3. METHODOLOGY

The purpose of this project is to contribute to the conservation of birds by assisting NH Audubon to find the best locations to implement new Motus telemetry stations in Massachusetts. This would benefit the scientific understanding of bird population declines, which would assist in finding solutions. My goal is concise and has 2 main areas of focus. I will evaluate which are the best locations for these stations and identify the best potential collaborators to help with their implementation. My research focuses on the following question: What are the best locations that match the best potential collaborators of the Motus Wildlife Tracking System in Massachusetts? To address this question, I developed a series of objectives in an attempt to better organize this project. These are:

1. Identify the characteristics of an ideal site for new Motus receiving stations
2. Identify which station array would be the best fit for local bird studies, and find the distances at which they should be placed from each other.
3. Identify educational centers and public sectors within those highly-elevated regions that fit the distance parameters
4. Identify high elevation regions in Massachusetts that match the potential array
5. Identify other Motus projects in Massachusetts

I will use literature research, online mapping platforms, and interviews to collect data that will be useful in the analysis of the identification of best places to locate new Motus receiving stations that match the best potential collaborators as shown in Figure 3 below:

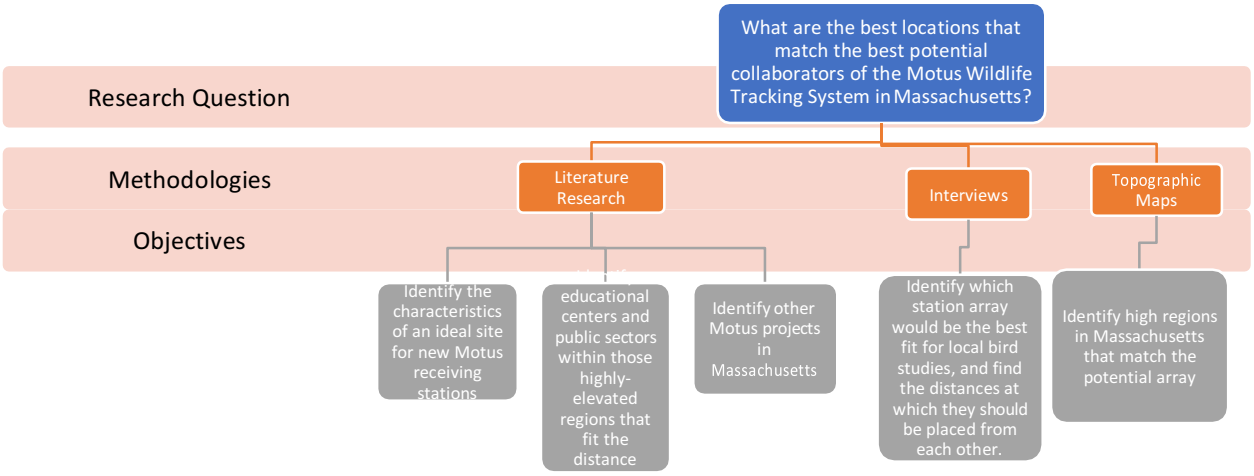


Figure 3. General research approach

Using Literature Research

I will conduct a literature research on the best ways to conduct interviews and in order to acquire the most valuable pieces of information that will allow me to continue with my project. The resources used will include research papers, educational website and other publications. This is important because it will provide me with enough background information on how to gather as much information from a person without being disrespectful or making the interviewee uncomfortable in any possible way. This phase involves learning about interpersonal and communication skills that will be useful in the next step of the methodology. In addition, there will be another literature research focused on the Motus receiving stations and the characteristics of the different antennas used. I would further this study by identifying the educational centers and public sectors in Massachusetts that would help find the best potential collaborators of MWTS. In order to find locations to develop for more specific studies dealing with shorter animal activities, I will conduct research on ongoing projects in specific areas in Massachusetts and possibly in some other extents where particular species are being studied.

Conducting Interviews

Through secondary research I will identify members of the wide community working for the conservation of birds that may have information that can assist in the identification of the best locations to implement the Motus receiving stations. Therefore, in order to actually gather background information on the type of bird studies that are relevant in Massachusetts and what are the purposes and resources of NH Audubon, I will reach out to key individuals from the Audubon Society of New Hampshire and the Motus Wildlife Tracking System (MWTS) using emails. Once a basic relationship has been established based upon common purposes, interviews will be conducted through a convenient telecommunications platform that specializes in offering video chat through the internet. For this, I plan to organize a meeting with the interviewee in time and platform that is most convenient for them. I will personally record and take minutes of the proceedings. However, before the interview begins, I will ask the interviewee for permission to record the meeting. If permission is not granted, I will proceed taking minutes. The questions I ask will be personalized to the knowledge, expertise, and job position of each interviewee. Once, the interview is terminated, I will make sure to ask the interviewees for recommendations on other key people who might be able to provide me with other or more specific information. Appendices A and B show the interview consent form and a sample interview transcript to be used in the project.

Analyzing Topographic Maps

Birds migrate at certain altitudes and directions throughout the year; therefore, the antennas that track the migrations of birds should be located at high grounds and strategic places in order to improve their spatial accuracy. I will use topographic maps of Massachusetts to properly identify key locations where Motus receiving stations can be built. One of the best tools for topography and mapping is ArcGIS, which is a desktop and online application that allows for people and

organizations to analyze areas in a topographic map; it assists “to create, manage, share, and analyze spatial data” (arcgis.com). This useful tool will allow me to create layers in a map of Massachusetts with proper elevations, and other characteristic features that would be identified during the interviews and the literature research. Moreover, it is crucial for the efficiency of the antennas that there are no obstructions within the range. Google maps or personal visitations will ensure that these locations will serve best to the data collected by the Motus receiving stations.

4. RESULTS

Interviews

Dr. Carol Foss

I performed a phone interview with Dr. Carol Foss, Senior Advisor for Science and Policy at NH Audubon on April 16th, 2019. Over her career, she obtained a B.A in Biology, a M.S. in Zoology, and a Ph.D. in Wildlife Ecology; in addition, she has more than thirty years in working experience with NH Audubon. During the interview process, there were times the communication was compromised by noise; however, since Dr. Foss gave me her consent to record the interview, it allowed for a better collection of data. During the interview, she mentioned that the MWTS provides an opportunity for organizations and people working for bird conservation to understand different migration pathways. This is helpful especially for determining "migratory connectivity for some of our populations of declining species". Moreover, MWTS enables the process of locating stopover areas during migration, which can be relevant subjects of study. In addition, it revolutionized the previous method to track birds since before they needed to deploy a bigger tag on a bird and then try to recapture it next year in order to collect the data. This was a gamble since there are numerous birds that do not survive migration, so plenty of the data would get lost.

Dr. Foss also expanded on the history behind the idea of expanding the Motus network in the northeast. It was a project initiated in Pennsylvania, and designed as proposal to get a grant from the U.S. Fish & Wildlife Service to implement more Motus receiving stations in the states of Pennsylvania, Maryland, New Jersey, Delaware, and New York (Group 1). Then, NH Audubon along with the collaboration of several organizations (most of which are in Pennsylvania) decided to design another additional proposal to that existing one in 2017 in which they aimed to expand it even more to the states of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut (Group 2). Even though she mentioned possible inaccuracy in the approximation of this numbers, Dr. Foss estimated to receive a funding between $750,000 and $1,000,000 from the grant "which would include installation of the infrastructure as well as the bat project, the monarch project, the m --- arc project, and also the type of project that is going to test the effectiveness of different antenna arrays". This means that the funding will not only be focused on birds, but also for other species that can be tracked using the MWTS. However, this is an ongoing process were the proposal will keep on being developed for months.

On the other hand, there were was also questioning about the logistics of the implementation of such receiving stations. Dr. Foss revealed that they are hoping to be able to implement between 40 to 60 stations inland in the states of Group 2; hence, they will "probably target kind of one fence across Connecticut and Rhode Island, a fence across Massachusetts, and then probably two fences across the North New Hampshire and Maine. It was also stated that in Pennsylvania they used between 20 km to 30 km of separation between stations, and that the area in which they are located should be at a high elevation compared to the surroundings and with a fairly open area in order to avoid potential interference from any natural or architectural

structure. Additionally, the station hosts should own/manage the properties with the appropriate topography and ideally have already structures with suitable height within them. Stations hosts should be able to monitor the station, download, and submit the data collected at least four times a year; besides, the host will be requested to cover the costs of maintenance. Nevertheless, there is a number of receiving stations that will be solar-powered which will significantly reduce these costs.

At the end of the interview, Dr. Foss mentioned that the greatest challenge that she and NH Audubon are going to face during the project of the implementation stations is going to be "Locating appropriate sites for receiving stations and dealing with all of the administrative tasks associated with that". Therefore, she showed appreciation for the initiative of my project as well as the collaborative effort to assist their project of the Grant Proposal, and suggested that I leave out a layered map in GIS for other students to continue my project in the future.

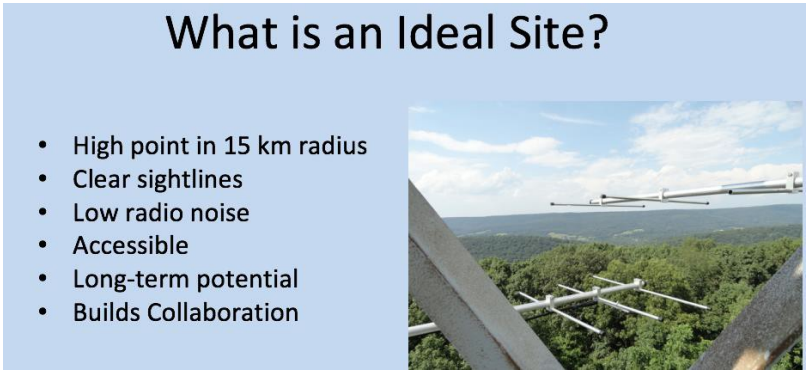
Alison Fetterman

Alison Fetterman was another key collaborator of the MWTS and subject to a phone interview. Her education consists of Bachelor of Arts in Biology, Ecology and Evolution, and a Master of Environmental Studies. Fetterman works for the Willistown Conservation Trust and is the Project Manager for MWTS for the process of expanding the Motus network in the Northeast, which means she is in charge of locating the best places for the implementation of new Motus stations. Therefore, the questions asked during her interview were more oriented towards ways and challenges to identify these places. In addition, she provided a presentation she uses to explain the process she uses to identify said places. Fetterman emphasized that the purpose of expanding the network inland in the mid-Atlantic area is to cover the large gap where important information about bird migration, stopover areas as well as movement patterns of other species of animals tagged using the MWTS.

Regarding the identification of the best locations for the implementation of Motus, Fetterman provided a presentation she uses to explain the process she follows. Some of the main points are presented below.

(a)

(b)



(c)

(d)

Figure 4. Three important slides from Alison Fetterman's presentation "Motus Receiver Stations: Site selection, Evaluation, & Permission": **(a)** main steps for selecting an appropriate site for Motus receiving stations **(b)** characteristics of an ideal site for Motus receiving stations **(c)** Ways to identify these sites in a digital topographic map **(d)** Images of Motus receiving stations. The antenna on the left is standing alone, while the others are standing on previously existing structures.

As we can see in Figure 4 (a), there are many areas in the process of "Site Selection, Evaluation, & Permission" that are similar to those presented in my project. Fetterman and Dr. Foss mentioned that the main goal of the project is to expand the Motus network inland and also to

target identified stopover areas. Nevertheless, Fetterman states that once the goal and the topography have been established examined, one can proceed to visit the site to make sure that there is a clear sight within a 15-km radius and check there is little to no possible sources of noise in the approximation. The last step is to outreach the landowner(s) and settle an agreement for the implementation. When focusing on the site selection section, there are six important points shown in Figure 4(b). The last and the first two of these points can be addressed using ArcGIS by developing layers in the digital map due to the fact they have to do with the elevations and the sightline, and it allows to see the collaboration it builds with other existing stations. The third and fourth points are more approachable with physical visitations since some maps may be outdated, and the sources of noise may be easier to identify by straight sight and physical evaluation.

Mapping

Using the locations found in Appendix D & E, I was able to pin point the locations of the educational centers in a map of the state of Massachusetts as seen in Figure 5 below.

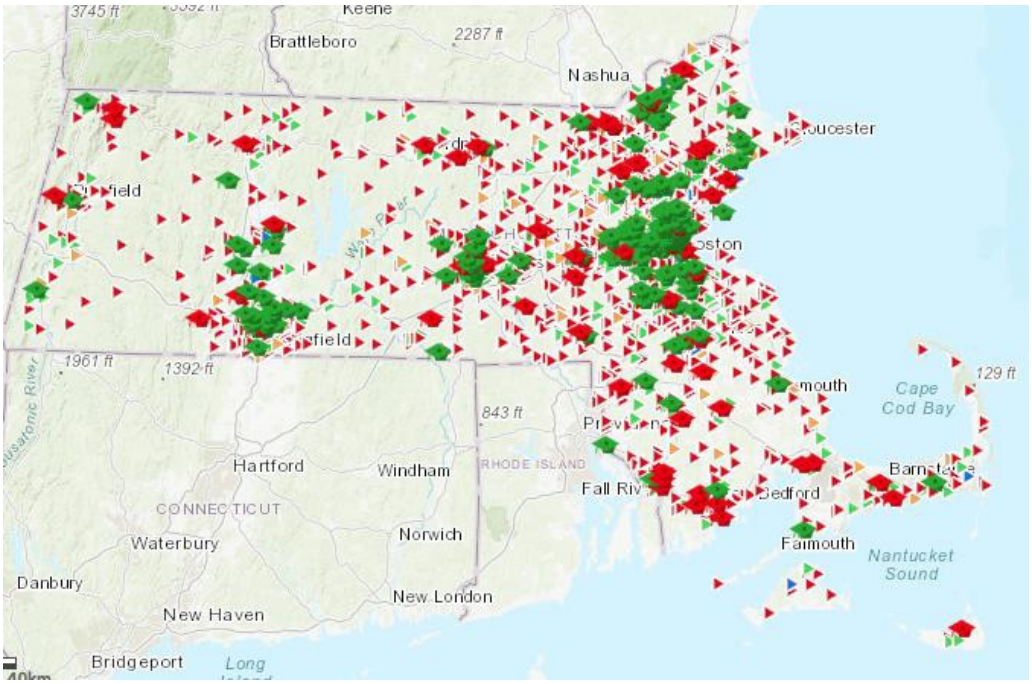


Figure 5. Educational centers in Massachusetts. The triangles represent schools going from Pre-K to 12th grade listed in Appendix E while the mortarboards represent colleges/universities. Similarly, the red stands for public, the green stands for private, the blue stands for charter education, and the yellow stands for special education. ArcGIS was the tool used for the creation of this figure.

As mentioned by Fetterman, most Motus stations should be placed on public areas due to the fact that the grant will come from the government's funding. Therefore, another important additional feature for the map is a layer of areas of public access. Therefore, in Figure 5 we can see this

layer added on top of the ones with the educational centers, as well as a close approximation to Massachusetts's perimeter. The two figures were separated for purposes regarding visual clarity. In addition, since Fetterman stated that it is also important to find locations that connect to the already existing Motus stations, I have included their precise locations represented in big grey dots. Their exact locations are specified in Table 3 with a brief description of the location and antennas used; the information was obtained from the MWTS website.

Table 3. List of specific locations of existing Motus receiving stations in Massachusetts.

LOCATION	LONGITUDE	LATITUDE	DATE CREATED	STATUS	TYPE
Chilmark	-70.8134°	41.2531°	5/31/2018	Active	1 antenna, 9-element Yagi
Chilmark	-70.8152°	41.2613°	4/25/2016	Active	6 antennas, 9-element Yagi
Falmouth	-70.5068°	41.5518°	10/1/2017	Active	3 antennas, 5-element Yagi
Nantucket	-70.0637°	41.3073°	9/19/2017	Active	3 antennas, 5-element Yagi
Wauwinet	-70.0493°	41.3906°	9/19/2017	Active	3 antennas, 5-element Yagi
Chatham	-70.01°	41.5526°	10/11/2017	Active	3 antennas, 5-element Yagi
Chatham	-69.9869°	41.6088°	10/12/2017	Active	3 antennas, 5-element Yagi
Wellfeet	-69.9724°	41.9147°	9/30/2017	Active	3 antennas, 5-element Yagi
Bourne	-70.66154°	41.68068°	6/6/2016	Active	2 antennas, 6-elemnt Yagi
Plum Island	-70.82496°	42.7466°	9/1/2016	Active	3 antennas, 9-element Yagi
Plum Island	-70.8084°	42.7804°	8/1/2017	Active	N/A
Longmeadow	-72.6°	42.032°	9/14/2018	Active	3 antennas, 9-element Yagi
Hadley	-72.566°	42.3412°	3/18/2016	Active	3 antennas, 9-element Yagi
Amherst	-72.5174°	42.396°	5/7/2018	Active	3 antennas, 6-elemnt Yagi

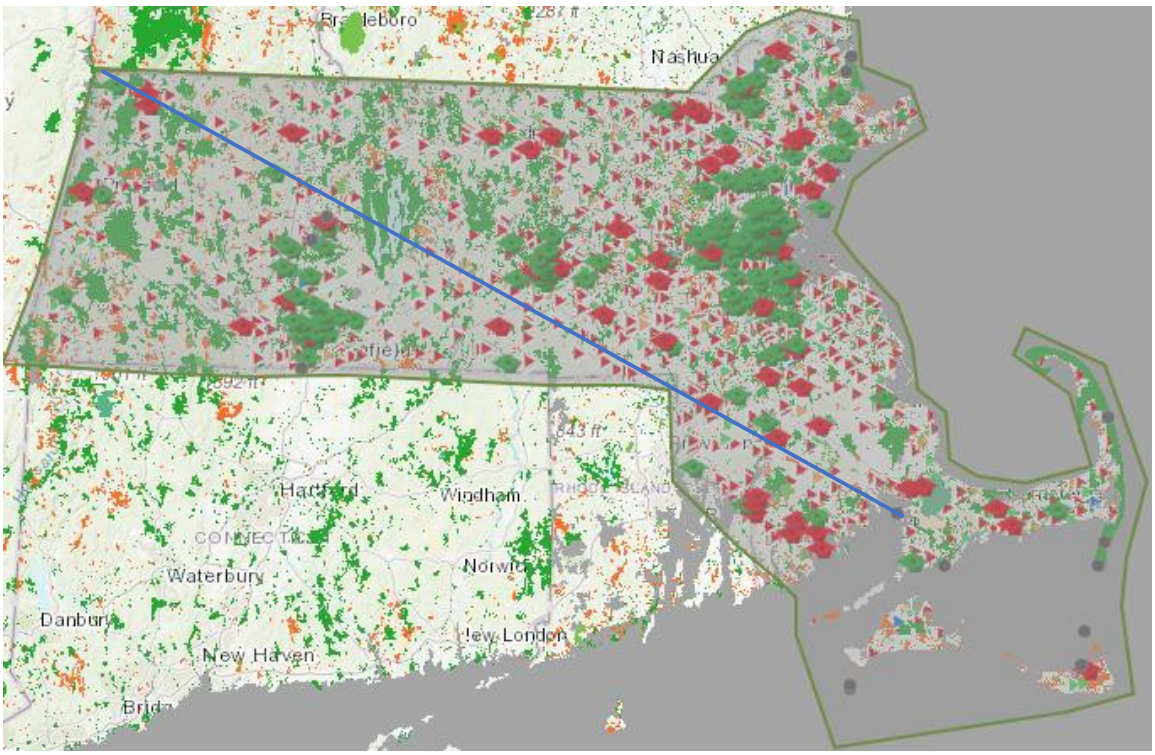


Figure 6. Educational centers specified in Figure 5, plus public areas shown in green, private areas shown in orange, locations of already existing Motus receiving stations represented in grey dots, and a close approximation of Massachusetts's perimeter. The blue line across the diagonal represents a possible path for a fence across Massachusetts. ArcGIS was the tool used for the creation of this figure.

Once the first round of potential sites was layered in ArcGIS, the other online tool GmapGIS was used to identify the high elevations that match with the potential sites shown in Figure 6.

Figure 7: GmapGIS relief profile in Massachusetts. This tool was analyzed to review the topography of the potential sites near the fence path traced in Figure 6.

Table 4. List of universities/colleges in Massachusetts that are potential hosts for Motus receiving stations based on their positioning and relative elevation.

COLLEGE	ADDRESS	CITY
Rob Roy Academy	1872 Acushnet Avenue	Bristol County
Bristol Community College	188 Union Street	New Bedford
Massasoit Community College	1 Massasoit Boulevard	Brockton
Wheaton College	26 East Main Street	Norton
Southeastern Technical Institute	250 Foundry Street	Easton
Bridgewater State University	131 Summer Street	Bridgewater
Dean College	99 Main Street	Franklin
Tri County Regional Vocational Technical High School Adult Education	147 Pond Street	Franklin
Blackstone Valley Vocational Regional School Post-Secondary Nursing Program	65 Pleasant Street	Upton
Bancroft School of Massage Therapy	333 Shrewsbury Street	Worcester
Massachusetts College of Pharmacy and Health Science	19 Foster Street	Worcester
New England School of Acupuncture at MCPHS	19 Norwich Street	Middlesex County
Worcester Polytechnic Institute	100 Institute Road	Worcester
Rob Roy Academy	150 Pleasant Sreett	Worcester

Anna Maria College	50 Sunset Lane	Paxton
Williams College	880 Main Street	Williamstown

Table 5. List of ongoing Motus projects in Massachusetts. Information was obtained from the official MWTS website.

Project Name	Short Description	Location
Semipalmated Sandpiper stopover in Plymouth, MA (#58)	A joint project between Manomet and MassWildlife will be deploying nanotags on SESAs in Plymouth Bay to learn more about their local stopover ecology.	Plymouth Bay, MA
CT River Valley Migratory Songbird Study (#74)	Migratory passerine use of the Connecticut river valley in Massachusetts, Vermont, and New Hampshire	Through Connecticut River passing through Massachusetts
Parker River/Great Bay Refuge (#9)	bat, shorebird, and saltmarsh sparrows nanotag projects in northeast MA and southern NH. 3 towers at Parker River, 2 at Great Bay	Northeast, MA
Monomoy - Steph Koch (#88)	Nanotags are being placed on Red Knots on Cape Cod, MA, with the goal of learning more about important stopover sites and migration pathways.	Cape Cod, MA
Western MA Tree Swallows (#162)	To be entered by PI	Western MA

5. DISCUSSION

The literature research, as well as the information gathered throughout the interview process revealed valuable information about the characteristics of the layers that need to be added in ArcGIS to successfully identify potential locations for the implementation of the New Motus receiving stations. Even though it was declared that public spaces are the most adequate places for implementing Motus stations, private educational centers may also be potential collaborators due to their strong connection to education and scientific studies. Therefore, it may be relevant to avoid disregarding these private centers from the 'potential collaborator' list to be developed in the future. It was also discussed that it could be of interest to make a fence array diagonally across Massachusetts. A diagonal line was drawn in ArcGIS running from the southeast receiving station at Bourne to the northwest of Massachusetts. Even though it is most expected that it will not be a completely straight line, it is important to know an approximation of the distance spreading through this line. The line was measured to be approximately 245 km, which gives this an approximation of 9 stations potentially forming the fence. Due to the fact that this was strategically placed to connect with the existing station at Bourne and Amherst, there will only need to be 7 stations needed to be implemented for the completion of this particular fence. On the other hand, since it was found that there are 5 ongoing Motus projects focusing on stopover places in Massachusetts presented in Table 5. From these, only project #162 has no Motus receiving stations in the region of study. Project #73 would be missing only one other receiving station to the North of Amherst since that is where the Connecticut River extends to. Therefore, it is calculated that only around 10 receiving stations would need to be implemented in the state of Massachusetts alone. It was discovered that they expect to implement approximately 50 receiving stations in the states of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut. Considering the fact that Massachusetts is the second longest of these (from east to west) and that Rhode Island is a short state extending only ~55 km (east to west) with already two Motus stations along that distance, it is understandable that 1/5 of the stations to be built are placed here. It was also mentioned in the interviews and seen in Table 3 that the 9- element Yagi are the most used antennas and efficient since they cover more area.

When filtering the potential sites for these stations, I looked at all the public sectors in as well as all the schools and colleges/universities in Massachusetts. Due some technical issues with the ArcGIS 10.6 program, it was not possible to edit the bookmarks for the map. Therefore, it was not possible to filter out the colleges and schools that where located within the 15-km range of the existing Motus stations in the map. However, Appendix D shows the list of universities without the 18 that where within this radius of the stations. The issues with the programs made it difficult to get exact evaluations of the universities lying near the potential fence; nevertheless, a raw list of the ones lying at relative high elevations and near the potential fence are listed in Table 4. It was decided that schools do not have much potential to be station hosts due to the fact that most of school buildings are low, and that schools have rarely been part of the collaborations to Motus stations as seen in the Motus website. In addition, a publication in Mass Audubon identified five places in Massachusetts that are "Great Bird Migration Spots":

- Mt. Auburn Cemetery, Cambridge and Watertown
- Parker River National Wildlife Refuge, Newbury and Newburyport
- Daniel Webster Wildlife Sanctuary, Marshfield
- Scusset Beach State Reservation, Sandwich
- Canoe Meadows Wildlife Sanctuary, Pittsfield

During spring migration, these places are contain numerous species of birds as these move north (Hillary 2013). These identified stopover sites along with the ones in the listed in Table 5 are other potential sites for point-to-point receiving stations placed around Massachusetts. Similarly, Dr. Foss suggested the specific study of the monarch butterfly. This species lives all the way from southern Canada to Argentina, and "aggregations are most regularly seen along the coast as well as in association with other leading lines such as river valleys and ridgelines" (Walton n.d). Due to the fact that most of the already existing stations are already located in the coastline, other sites along the main biggest rivers in Massachusetts may also be considered as points of interest.

In further attempts to identify potential sites after analyzing the map shown in Figure 6, I created a list of the cities in Massachusetts in which the potential fence lies:

- Lakeville
- Norton
- East Whitinsville
- Prospect Hill
- West Brookfield
- Ashfield
- North Adams

All of these cities are less than 30 km long (across the line traced by the potential fence), and the table shows. Amherst was disregarded from the list since it already counts with a receiving station. Continued work on this project could use this information to develop a list of tall buildings within those cities to assist in the completion of the fence across Massachusetts. As this is an ongoing project that attempts to help the grant proposal of the New England states projected by NH Audubon, there will be future work focused on the continuation of this project. Nevertheless, it is important to mention that due to an inconvenient lack of licenses from the online tool ArcGIS 10.6, it was of significant difficulty to create an elevation profile of the areas of Massachusetts which would point out the high elevations that are needed for the stations.

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APPENDICES

Appendix A: Singed Informed Consent Agreements for Participation in a Research Study

Investigator: Juan Martin Hinostroza
Contact Information: Mobile: +1(508) 847-8727, e-mail: jmhinostrozatama@wpi.edu
Title of Research Study: A Plan to Strategically Locate The Best Potential Partners And Locations in Massachusetts To Build New Telemetry Stations for Motus Wildlife Tracking System
Sponsor: Worcester Polytechnic Institute
Introduction : You are being asked to participate in a research study. Before you agree, however, you must be fully informed about the purpose of the study, the procedures to be followed, and any benefits, risks or discomfort that you may experience as a result of your participation. This form presents information about the study so that you may make a fully informed decision regarding your participation.

Purpose of the study: The purpose of this study is to identify key locations in the state of Massachusetts to strategically locate new Motus telemetry stations as an effort to assist the Audubon Society of New Hampshire with their bird conservation purposes, as well as to recognize the best potential collaborators that could assist in the implementation of these stations.

Procedures to be followed: I would like to take approximately 15 to 30 minutes of your time to ask you a series of questions regarding your organization, and your expertise on the Motus Wildlife Tracking System. I will ask for you're the subject's consent to record the meeting, introduce the project, and start asking questions.

Risks to study participants: This research study does not present any reasonably foreseeable risks or discomforts to the subject.

Benefits to research participants and others: From this research, the Audubon Society of New Hampshire and the Motus Wildlife Tracking System will be directly benefitted as it directly addresses their need to implement more telemetry stations. Similarly, there will be more data for the scientific community focusing on bird studies and the reasons for their population decline. Members of the community of Massachusetts may also be indirectly affected since findings on the solutions for bird population decline could lead to higher vegetation in the area.

Record keeping and confidentiality: Records of your participation in this study will be held confidential so far as permitted by law. However, the study investigators and, under certain circumstances, the Worcester Polytechnic Institute Institutional Review Board (WPI IRB) will be able to inspect and have access to confidential data that identify you by name. Any publication or presentation of the data will not identify you.

Compensation or treatment in the event of injury: Since this investigation does not involve more than minimal harm, there is no compensation associated in the event of injury. However, please acknowledge that you do not give up any of your legal rights by signing this statement.

For more information about this research or about the rights of research participants, or in case of research-related injury, contact me using the information listed at the beginning of the page, the IRB Chair (Professor Kent Rissmiller, Tel. 508- 831-5019, Email: kjr@wpi.edu) or/and the Human Protection Administrator (Gabriel Johnson, Tel. 508-831-4989, Email: gjohnson@wpi.edu).

Your participation in this research is voluntary. Your refusal to participate will not result in any penalty to you or any loss of benefits to which you may otherwise be entitled. You may decide to stop participating in the research at any time without penalty or loss of other benefits. The project investigator retains the right to cancel or postpone the experimental procedures at any time they see fit.

By signing below, you acknowledge that you have been informed about and consent to be a participant in the study described above. Make sure that your questions are answered to your satisfaction before signing. You are entitled to retain a copy of this consent agreement.

Carol R. Foss
Study Participant Signature

Date: 4/15/2019

CAROL R. FOSS
Study Participant Name (Please print)

Signature of Person who explained this study

Date: 4/15/2019

For more information about this research or about the rights of research participants, or in case of research-related injury, contact me using the information listed at the beginning of the page, the IRB Chair (Professor Kent Rissmiller, Tel. 508- 831-5019, Email: kjr@wpi.edu) or/and the Human Protection Administrator (Gabriel Johnson, Tel. 508-831-4989, Email: gjohnson@wpi.edu).

Your participation in this research is voluntary. Your refusal to participate will not result in any penalty to you or any loss of benefits to which you may otherwise be entitled. You may decide to stop participating in the research at any time without penalty or loss of other benefits. The project investigator retains the right to cancel or postpone the experimental procedures at any time they see fit.

By signing below, you acknowledge that you have been informed about and consent to be a participant in the study described above. Make sure that your questions are answered to your satisfaction before signing. You are entitled to retain a copy of this consent agreement.

Study Participant Signature — Date: 4/17/19

Alison Fetherman
Study Participant Name (Please print)

Signature of Person who explained this study — Date: 4/17/19

Appendix B: Sample Interview Script (To Dr. Carol Foss)

Opening

My name is Juan Martin Hinostroza. I am a student at Worcester Polytechnic Institute and I am conducting research on the best locations to build new telemetry stations for the Motus Wildlife Tracking System in Massachusetts. I would like to ask you a series of questions regarding your organization, and your expertise on the Motus Wildlife Tracking System. My goal is to use this information toward identifying the number and the location of telemetry stations to be built in Massachusetts, as well as the best potential collaborators that could assist in their implementation. As stated in the interview consent form, this interview will take approximately 15 – 30 minutes. Are you prepared to answer some questions now?

Body

- *For the record, please state your name and position at (organization name).*
- *In your words, what is (organization name)'s mission/purpose?*
    i. *Could you explain in detail the actions your organization takes to accomplish its mission?*
    ii. *How are the purposes of your organization related to those of the Motus Wildlife Tracking System?*
  - *Since when has the Audubon Society of New Hampshire been trying to implement more Motus receiving station in New England?*
  - *What are the main reasons for which the Audubon Society of New Hampshire wants to implement more Motus receiving station in New England?*
  - *What are the main bird species that are targeted in this region? Is it just birds or other animals as well?*
  - *For these bird studies, which station configuration(s) do you think will work best (fence or point-to-point)?*
  - *Does the Audubon Society of New Hampshire has a budget for these receiving stations? If not, have you targeted any potential partners yet?*
  - *How many more Motus receiving stations do you think will be ideal to implement in New England? In Massachusetts?*
  - *Why do you think is important to build more Motus receiving stations inland?*
  - *Do you know if there are any other bird conservation organizations in New England that would like to contribute to the implementation of these Motus receiving stations?*
  - *What do you consider to be important characteristics of a potential collaborator?*
  - *What do you think are the greatest challenges that you and the Audubon Society of New Hampshire are going to face in the project of implementation of stations?*
  - *How important do you think that the Motus Wildlife Tracking System for the conservation of birds? Why?*
  - *Is there research or a specific topic that you would like me to focus on this project to better serve the purpose of the implementation of new Motus stations in New England? Please keep in mind that I will have to finish the project by the end of this month; however, I could leave some parts of this projects opened for other students.*
  - *Do you think that my project of identifying key locations and potential collaborators for the implementation of Motus receiving stations will support the purpose of your organization?*

Closing

I appreciate your time and insight you were able to provide me regarding your organization and knowledge. Is there anything else you would like to add before we close this interview?

- *If yes, allow for interviewee to share and follow additional questioning if needed. Then, close the interview when finished.*
- *If no, thank the interviewee and proceed with closing up the interview.*

Appendix C: Raw Interview Notes From Interviews

Interviews

Dr. Carol Foss

- *Do I have your consent to record this interview?*

Yes

- *For the record, please state your name and position at NH Audubon.*

I am Carol Foss and I am Senior Advisor for Science and Policy at New Hampshire Audubon

- *In your words, what is NH Audubon's mission/purpose?*

Our mission is to protect New Hampshire's environment for wildlife and for people.

i. *Could you explain in detail the actions your organization takes to accomplish its mission?*

We have active programs and environmental education in conservation biology and environmental advocacy and in protection and management.

ii. *How are the purposes of your organization related to those of the Motus Wildlife Tracking System?*

Motus provides an opportunity to understand migration pathways particularly of species of conservation concern and hopefully they will enable us to determine migratory connectivity for some of our populations of declining species. It also can be useful in locating stopover areas that could then be targets for land 'subjection*' to provide 'forging'* areas for species during migration.

- *Since when has the Audubon Society of New Hampshire been trying to implement more Motus receiving stations in New England?*

We are actually collaborating with a number of organizations primarily in Pennsylvania who developed this vision for expanding the Motus network in the Northeast. And we became involved in 2017 when we organized a regional meeting here at our officesin Concord and invited academic state-agency folks, some governmental organization folks from all the New England states who have a potential interest in the Motus network to kind of explain to them how we might move this forward. That meeting led to a competitive State wildlife grant application to U.S Fish & Wildlife Service last May, I guess it was, which was funded. And that grant provides for increasing the network in Pennsylvania, Maryland, New Jersey, Delaware, and New York states. This year, the New England states will be collaborating on a partner proposal to expand the network in Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut. The notice of 'such*' an opportunity is expected to be out, I think at the end of this week (the last I heard), and then we will have 90 days to put the full proposal together.

- *What are the main bird species that are targeted in this region? Is it just birds or other animals as well?*

Well, kind of a complicated question, so several grant preproposals include not only expanding the infrastructure of the network, but also some field projects that would utilize the infrastructure. So for the mid-Atlantic states proposal, there are several New England field projects being funded. Including ----- --. I can't remember all of the New England projects that are involved with the mid-Atlantic proposal. With the proposals that we are preparing for the New England states, Massachusetts Audubon is interested in doing an eastern------ project. We are also planning to include a bat project, and we are also planning to include a monarch butterfly project with a collaborator in Canada.

- *For these bird studies, which station configuration(s) do you think will work best (fence or point-to-point)?*

In Pennsylvania they put up a fence with stations between 20-30 km apart which hopefully will detect anything with a nanotag moving north to south across the State of Pennsylvania. The Motus network, originally, was set up to monitor in short bird migration so the original network was focused on the Atlantic Coast and the north and south shores of the Great Lake. So that's great for short bird, but for pothering monarch butterflies and birds that are migrating across more inland areas the Northeast was kind of a black hole, and that is why the folks in Pennsylvania developed this vision of expanding the network through the inland northeast.

- *Does the Audubon Society of New Hampshire has a budget for these receiving stations? If not, have you targeted any potential partners yet?*

Not yet, we are just beginning to work on that. Depending on how many of the new England states opts to be directly involved in this project, that will determine how much money we can request through this competitive Fish & Wildlife program, so we are figuring probably somewhere between the $750,000 to a $1,000,000 range which would include installation of the infrastructure as well as the bat project, the monarch project, the m ---arc project, and also the type of project that is going to test the effectiveness of different antenna arrays.

- *How many more Motus receiving stations do you think will be ideal to implement in New England? In Massachusetts?*

Well, it depends on the scale of data that you are trying to collect or enable researchers to collect. We won't be in a position to establish an entire grid by the way, but our intent is to run several fences across New England. In Pennsylvania, the land form is very much oriented East to West, whereas here they are more oriented North to South, so we will probably target kind of one fence across Connecticut and Rhode Island, a fence across Massachusetts, and then probably two fences across the North New Hampshire and Maine. And with this initial effort we are hoping to do something in the order of 40 to 60 receiving stations across the region.

- *Do you know if there are any other bird conservation organizations in New England that would like to contribute to the implementation of these Motus receiving stations?*
  GIS Analysis to look for the appropiate topography, and then once potential sites are located, people will have to go out on the ground and then double check to make sure the site is appropriate, and we will need willing land owners who are willing to give permission for a receiving station on their property. So, it is a much longer process to figure out where receiving stations can go than it is to actually install them once you have the site located. So that is a long process, that would be part of the Grant project.
- *What do you consider to be important characteristics of a station host?*
  i. They would need to own or manage properties that have the appropriate ---- of a station characteristics of the station height
  ii. Ideally, they will be able to keep an eye on the receiving stations, make sure it is operating properly a minimum of 4 times a year, and download & submit it 4 times a year.
  iii. They will be requested to cover the expenses of maintenance, if it is a building with electricity and Wi-Fi. However, some of these stations will likely be free standing and operating with solar power, so in that case the solar panel will be provided as part of the installation.
- *What do you think are the greatest challenges that you and the Audubon Society of New Hampshire are going to face in the project of the implementation of stations?*
  Locating appropriate sites for receiving stations and dealing with all of the administrative tasks associated with that. And a collaborative agreement with the landowner, because it is federal money we will have to do compliance with historical and cultural resources in each State or each site, and also endangered species compliance for each site. So that will be a big job.
- *How important do you think that the Motus Wildlife Tracking System for the conservation of birds? Why?*
  The biggest service that Motus provides is a way to track songbirds. Before Motus, the only option available required deploying a device on a bird, hoping it will come back the next year, and then recapturing to take the device and collect the data. So, given that lot of birds do not survive migration in one direction you have to deploy a lot of devices in order to get a few back. With Motus anytime a tagged bird passes a receiving station there will be a detection, so even if the individual doesn't make it all the way back the following year you would still be able to collect some information about where it has been.
- *What are the characteristics of potential locations for receiving stations?*
  High elevation compared to the surrounding area is good, and a fairly open area so that trees aren't interfering with potential signals. So if you can get the antennas well up above the surrounding area either by getting them up on a high roof or like a tall utility post, or in the top of a hill where you can have a large

expand of open air that is going to give you the largest area of reception. You don't need to have Wi-Fi or an internet connection that just makes things easier. Antennas need to be up above the canopy.

- *Is there research or a specific topic that you would like me to focus on this project to better serve the purpose of the implementation of new Motus stations in New England? Please keep in mind that I will have to finish the project by the end of this month; however, I could leave some parts of this projects opened for other students.*
- *Do you think that my project of identifying key locations and potential collaborators for the implementation of Motus receiving stations will support the purpose of your organization?*

  It would be very very helpful as we move this project forward, it would also be good to connect with someone at Mass Audubon. The other piece of this is if there are places where we know birds are stopping over during migration. Trying to site a receiving station in that area will be helpful, and I am particularly interested in a big wetland in Eastern Massachusetts in windfield. That's a major stopover area for black birds, but we don't know if any of the birds from our breeding populations are using that stopover site, so I'm hoping that a receiving station can be located somewhere that would cover that wetland.

Alison Fetterman

- Do I have your consent to record this interview?

Yes

- For the record, please state your name and position.
  My name is Alison Fetterman, I work for Willistown Conervation Trust and in regards to Motus I am the project coordinator. Bird Conservation Associate

- In your words, what is the purpose of implementing more Motus stations in New England?

  In New England the purpose of placing more Motus receiving stations is to fill in the inland gap of the Motus receiving network in the northeast. There aren't many receiving stations to pick up information inland.

  i. Could you explain the actions that the collaborative organizations are taking to serve this project?

  I know of NH Audubon are trying to apply for a grant to implement more stations and I know there are trying to make other partnerships.
- How many more Motus receiving stations do you think will be ideal to implement in New England? In Massachusetts?

  We typically look at is the maximum range of a 9-element Yagi antenna is 15 km so we place them 30 km from each other so with the maximum range we connect them across.

We estimated 46 stations in 5 states. We are looking at Pennsylvania, New York, Delaware, Maryland, and New Jersey that come from this Grant and New England is sitting there waiting to ad on to the grant.
Lines going from east to west along the border

- Why do you think is important to build more Motus receiving stations inland?
  Our goal to go inland is because that is where receiving stations are lacking, and to maximize these Nano tags and put them on songbird species that we know are inland migrants or even shorebirds we are not sure might be inland migrants, we want to be able to detect more of their movements, and be more informed.
- What do you consider to be important characteristics of a potential collaborator?
  It is easier to use building they use for education. There is a handful of stations that are on top of buildings. I started a lot with public lands since we have the support of the government in states. Buildings need to be very strategic since they need to be at the highest point in a 15-km radius. The most wonderful structures for that are fire towers.
- What do you think are the greatest challenges are faced during the implementation of stations?
  - It is finding the right spot is the hardest part. No private lands. The hardest part is to convince buildings. Knowing how to approach people. Avoid using the word 'tower'.
- What are the characteristics in terms of dimension, topography, space, and view, that the receiving stations need to have in order to work efficiently?
  - Ideally you want to be able to cover at least 4 directions and have a clear line of sight.

Appendix D: List of colleges and universities in Massachusetts. 19 colleges/universities were filtered out because they were within the 15-km radius of the existing stations in Massachusetts. Obtained from https://www.arcgis.com/home/item.html?id=7b9f09149b1f47768047da2e1afdb4cf.

COLLEGE	ADDRESS	TYPE
Ailano School of Cosmetology	541 West Street	< 2-year, Private for-profit
Alexander Academy	55 Massachusetts Avenue	< 2-year, Private for-profit
Ali May Academy	1459 Hancock Street	< 2-year, Private for-profit
American Academy of Personal Training	561 Boylston Street	< 2-year, Private for-profit
Andover Newton Theological School	210 Herrick Road	4-year, Private not-for-profit
Anna Maria College	50 Sunset Lane	4-year, Private not-for-profit
Assabet After Dark	215 Fitchburg Street	< 2-year, Public

Assumption College	500 Salisbury Street	4-year, Private not-for-profit
Babson College	231 Forest Street, Babson Park	4-year, Private not-for-profit
Bancroft School of Massage Therapy	333 Shrewsbury Street	< 2-year, Private for-profit
Bard College - Holyoke Microcollege	247 Cabot Street	2-year, Private not-for-profit
Bard College at Simon's Rock	84 Alford Road	4-year, primarily associate's, Private not-for-profit
Bay Path Adult Evening School	57 Old Muggett Hill Rd	< 2-year, Public
Bay State College	122 Commonwealth Avenue	4-year, Private for-profit
Bay State School of Technology	225 Turnpike Street	< 2-year, Private for-profit
Becker College	61 Sever Street	4-year, Private not-for-profit
Becker College	964 Main Street	4-year, Private not-for-profit
Benjamin Franklin Institute of Technology	41 Berkeley Street	4-year, primarily associate's, Private not-for-profit
Bentley University	175 Forest Street	4-year, Private not-for-profit
Berklee College of Music	1140 Boylston Street	4-year, Private not-for-profit
Berkshire Community College	1350 West Street	2-year, Public
Blackstone Valley Vocational Regional School Post-Secondary Nursing Program	65 Pleasant Street	< 2-year, Public
Blessed John Xxiii National Seminary	558 South Avenue	4-year, Private not-for-profit
Blessing Channels Nail Academy	76 Winn Street, #1C	< 2-year, Private for-profit
Blue Hills Regional Technical School Practical Nursing Program	800 Randolph Street	< 2-year, Public
Boston Architectural College	320 Newbury Street	4-year, Private not-for-profit
Boston Baptist College	950 Metropolitan Avenue	4-year, Private not-for-profit
Boston Career Institute	320 Washington Street	< 2-year, Private not-for-profit
Boston Career Institute	422 Main Street	< 2-year, Private not-for-profit
Boston College	140 Commonwealth Avenue	4-year, Private not-for-profit

Boston College	885 Centre Street	4-year, Private not-for-profit
Boston College	129 Lake Street	4-year, Private not-for-profit
Boston Graduate School of Psychoanalysis Inc	1581 Beacon Street	4-year, Private not-for-profit
Boston University	1 Silber Way	4-year, Private not-for-profit
Boston University School of Medicine	72 E Concord Street	4-year, Private not-for-profit
Brandeis University	415 South Street	4-year, Private not-for-profit
Branford Hall Career Institute	112 Industry Avenue	< 2-year, Private for-profit
Branford Hall Career Institute	189 Brookdale Drive	< 2-year, Private for-profit
Bridgewater State University	131 Summer Street	4-year, Public
Bristol Community College	188 Union Street	2-year, Public
Bristol Community College	777 Elsbree Street	2-year, Public
Bristol Community College	2 Galleria Mall Drive	2-year, Public
Bristol Community College	11 Field Road	2-year, Public
Brockton Hospital School of Nursing	680 Centre Street	2-year, Private not-for-profit
Bunker Hill Community College	250 New Rutherford Avenue	2-year, Public
Cambridge College	1000 Massachusetts Avenue	4-year, Private not-for-profit
Cambridge College	360 Merrimack Street	4-year, Private not-for-profit
Cambridge College School of Management and Education	17 Monsignor O'Brien Highway	4-year, Private not-for-profit
Cape Cod Community College	540 Main Street	2-year, Public
Cape Cod Community College	2240 Iyanough Road	2-year, Public
Cape Cod Electrical School	9 New Venture Drive	< 2-year, Private for-profit
Catherine Hinds Institute of Esthetics	300 Wildwood Avenue	< 2-year, Private for-profit
Charles H Mccann Technical School Adult Education	70 Hodges Cross Rd	< 2-year, Public
Clark University	950 Main Street	4-year, Private not-for-profit
College of Our Lady of the Elms	291 Springfield Street	4-year, Private not-for-profit
College of the Holy Cross	1 College Street	4-year, Private not-for-profit
Curry College	1071 Blue Hill Avenue	4-year, Private not-for-profit
David Nicholas International	18 Park Street	< 2-year, Private for-profit

Dean College	99 Main Street	4-year, primarily associate's, Private not-for-profit
DiGrigoli School of Cosmetology	1578 Riverdale Street	< 2-year, Private for-profit
Diman Regional Technical Institute Division of Continuing Education	251 Stonehaven Road	< 2-year, Public
East Boston Beauty Academy	4 Neptune Road	< 2-year, Private for-profit
Eastern Nazarene College	23 East Elm Avenue	4-year, Private not-for-profit
Electrology Institute of New England, Inc	1501 Main Sreett	< 2-year, Private for-profit
Elizabeth Grady School of Esthetics and Massage Therapy	222 Boston Avenue	< 2-year, Private for-profit
Emerson College	120 Boylston Street	4-year, Private not-for-profit
Emmanuel College	400 The Fenway	4-year, Private not-for-profit
Empire Beauty School	624 Worcester Road	< 2-year, Private for-profit
Empire Beauty School	30 West Street	< 2-year, Private for-profit
Empire Beauty School	347 Pleasant Street	< 2-year, Private for-profit
Endicott College	376 Hale Street	4-year, Private not-for-profit
Face Forward, Inc	83 Pine Street, Unit B	< 2-year, Private for-profit
Fine Mortuary College	150 Kerry Place	2-year, Private for-profit
Fisher College	118 Beacon Street	4-year, Private not-for-profit
Fitchburg State University	160 Pearl Street	4-year, Public
Flavia Leal Beauty Creator's Academy	20 Chelsea Street	< 2-year, Private for-profit
Flavia Leal Institute of Aesthetics and Nail Academy	600 West Cummings Park, Suite 1000	< 2-year, Private for-profit
Framingham State University	100 State Street	4-year, Public
Franklin W. Olin College of Engineering	1000 Olin Way	4-year, Private not-for-profit
Gordon College	255 Grapevine Road	4-year, Private not-for-profit
Gordon-Conwell Theological Seminary	90 Warren Street	4-year, Private not-for-profit
Gordon-Conwell Theological Seminary	130 Essex Street	4-year, Private not-for-profit
Gould Construction Institute	100 Unicorn Park Drive, Suite 2	< 2-year, Private for-profit
Greater Lowell Technical School Adult Education	250 Pawtucket Boulevard	< 2-year, Public
Greenfield Community College	1 College Drive	2-year, Public
Hair's How	99 Preston Street	< 2-year, Private for-profit

Harvard College	8 Garden Street/Radcliffe Yard	4-year, Private not-for-profit
Harvard University	677 Huntington Ave	4-year, Private not-for-profit
Harvard University	25 Shattuck Street	4-year, Private not-for-profit
Harvard University	117 Western Ave/Soldiers Field	4-year, Private not-for-profit
Harvard University	79 JFK Street	4-year, Private not-for-profit
Harvard University	48 Quincy Street	4-year, Private not-for-profit
Harvard University	1585 Massachusetts Avenue	4-year, Private not-for-profit
Harvard-Smithsonian	60 Garden Street	4-year, Private not-for-profit
Hebrew College	160 Herrick Road	4-year, Private not-for-profit
Hellenic College/Holy Cross	50 Goddard Avenue	4-year, Private not-for-profit
Holyoke Community College	303 Homestead Avenue	2-year, Public
Hult International Business School	1 Education Street	4-year, Private not-for-profit
International Dermal Institute	131 Middlesex Turnpike	< 2-year, Private for-profit
JK Nails Academy	68 Millbury Street	< 2-year, Private for-profit
Jolie Hair and Beauty Academy	44 Sewall Street	< 2-year, Private for-profit
Jupiter Beauty Academy	15-17 Freeport Way	< 2-year, Private for-profit
Laboure College	303 Adams Street	4-year, primarily associate's, Private not-for-profit
Lasell College	1844 Commonwealth Avenue	4-year, Private not-for-profit
Lawrence Memorial Hospital/Regis College School of Nursing	170 Governors Avenue	2-year, Private not-for-profit
Lawrence Training School	530 Broadway Street	< 2-year, Private for-profit
Lesley University	29 Everett Street	4-year, Private not-for-profit
Lincoln Technical Institute	5 Middlesex Avenue	< 2-year, Private for-profit
Longy School of Music of Bard College	27 Garden Street	4-year, Private not-for-profit
Lowell Academy Hairstyling Institute	136 Central Street	< 2-year, Private for-profit
Mafy's Nails Academy	59 Plymouth Street	< 2-year, Private for-profit
Mansfield Beauty Schools	200 Parking Way	< 2-year, Private for-profit

Martin Electrical School	130 Kerry Place	< 2-year, Private for-profit
Massachusetts Bay Community College	250 Eliot Street	2-year, Public
Massachusetts Bay Community College	19 Flagg Drive	2-year, Public
Massachusetts Bay Community College	50 Oakland Street	2-year, Public
Massachusetts College of Art and Design	621 Huntington Avenue	4-year, Public
Massachusetts College of Liberal Arts	375 Church Street	4-year, Public
Massachusetts College of Pharmacy and Health Science	19 Foster Street	4-year, Private not-for-profit
Massachusetts College of Pharmacy and Health Science	179 Longwood Avenue	4-year, Private not-for-profit
Massachusetts General Hospital Dietetic Internship	55 Fruit Street	4-year, Private not-for-profit
Massachusetts Institute of Technology	77 Massachusetts Avenue	4-year, Private not-for-profit
Massachusetts School of Barbering	58 Ross Way	< 2-year, Private for-profit
Massachusetts School of Law	500 Federal St Woodland Park	4-year, Private not-for-profit
Massasoit Community College	49 Union Street	2-year, Public
Massasoit Community College	1 Massasoit Boulevard	2-year, Public
Massasoit Community College	900 Randolph Street	2-year, Public
Merrimack College	315 Turnpike Street	4-year, Private not-for-profit
MGH Institute of Health Professions	36 1st Avenue	4-year, Private not-for-profit
Middlesex Community College	591 Springs Road	2-year, Public
Middlesex Community College	33 Kearney Square	2-year, Public
Mildred Elley-Pittsfield	100 West Street	< 2-year, Private for-profit
Millennium Training Institute	600 West Cummings Park	< 2-year, Private for-profit
Monarch School of Cosmetology	2701 Boston Road, Suite 2	< 2-year, Private for-profit
Montachusett Regional Vocational Technical School Practical Nursing Program	1050 Westminster Street Rte 2a	< 2-year, Public
Montserrat College of Art	23 Essex Street	4-year, Private not-for-profit
Motoring Technical Training Institute	1241 Fall River Avenue	< 2-year, Private for-profit
Mount Wachusett Community College	444 Green Street	2-year, Public
National Aviation Academy New England Campus	150 Hanscom Drive	2-year, Private for-profit
New England College of Business	10 High Street	4-year, Private for-profit

New England College of Optometry	424 Beacon Street	4-year, Private not-for-profit
New England Conservatory of Music	290 Huntington Avenue	4-year, Private not-for-profit
New England Hair Academy	110 Florence Street	< 2-year, Private for-profit
New England Law Boston	154 Stuart Street	4-year, Private not-for-profit
New England School of Acupuncture at MCPHS	19 Norwich Street	4-year, Private not-for-profit
New England School of Photography	274 Moody Street	< 2-year, Private for-profit
New England Tractor Trailer Training School of Massachusetts	1600 Osgood Street	< 2-year, Private for-profit
Newbury College	129 Fisher Avenue	4-year, Private not-for-profit
Nichols College	129 Center Road	4-year, Private not-for-profit
North Bennet Street School	150 North Street	2-year, Private not-for-profit
North Shore Community College	300 Broad Street	2-year, Public
North Shore Community College	30 Log Bridge Road	2-year, Public
North Shore Community College	1 Ferncroft Road	2-year, Public
Northeastern University	370 Common Street	4-year, Private not-for-profit
Northeastern University	360 Huntington Avenue	4-year, Private not-for-profit
Northeastern University	89 Broad Street	4-year, Private not-for-profit
Northeastern University	430 Nahant Road	4-year, Private not-for-profit
Northeastern University	145 South Bedford Street	4-year, Private not-for-profit
Northeastern University Professional Advancement Network	360 Huntington Avenue	4-year, Private not-for-profit
Northern Essex Community College	360 Merrimack Street	2-year, Public
Northern Essex Community College	45 Franklin Street	2-year, Public
Northern Essex Community College	100 Elliott Street	2-year, Public
Northpoint Bible College	320 South Main Street	4-year, Private not-for-profit
NV My Hair Academy	296 Newton Street	< 2-year, Private for-profit
Page School of Electrical Technology	66 Westech Drive	< 2-year, Private for-profit
Peterson School	350 University Avenue	< 2-year, Private for-profit
Peterson School	184 West Boylston Street, Unit 12A	< 2-year, Private for-profit
Peterson School	25 Montvale Road	< 2-year, Private for-profit

Pine Manor College	400 Heath Street	4-year, Private not-for-profit
Porter And Chester Institute of Canton	5 Campanelli Circle	< 2-year, Private for-profit
Porter And Chester Institute of Chicopee	134 Dulong Circle	< 2-year, Private for-profit
Porter And Chester Institute of Worcester	220 Brooks Street	< 2-year, Private for-profit
Quincy College	1250 Hancock Street	2-year, Public
Quinsigamond Community College	670 West Boylston Street	2-year, Public
Regis College	235 Wellesley Street	4-year, Private not-for-profit
Rob Roy Academy	1872 Acushnet Avenue	< 2-year, Private for-profit
Rob Roy Academy	260 S Main Street	< 2-year, Private for-profit
Rob Roy Academy	1 School Street	< 2-year, Private for-profit
Rob Roy Academy	150 Pleasant Sreett	< 2-year, Private for-profit
Roxbury Community College	1234 Columbus Avenue	2-year, Public
Salem State University	352 Lafayette Street	4-year, Public
Salter College	645 Shawinigan Drive	2-year, Private for-profit
Salter College	184 West Boylston Street	2-year, Private for-profit
Salter School	2 Florence Street	< 2-year, Private for-profit
School of the Museum of Fine Arts	230 The Fenway	4-year, Private not-for-profit
Shawsheen Valley Regional Vocational Technical School Adult Education	100 Cook Street	< 2-year, Public
Simmons College	300 The Fenway	4-year, Private not-for-profit
Simmons College	321 Brookline Avenue	4-year, Private not-for-profit
Southeastern Technical Institute	250 Foundry Street	< 2-year, Public
Spa Tech Institute	227 Turnpike Road	< 2-year, Private for-profit
Springfield College School of Professional and Continuing Studies	529 Main Street, Suite 1M4	2-year, Private not-for-profit
St. John's Seminary College	127 Lake Street	4-year, Private not-for-profit
Stonehill College	320 Washington Street	4-year, Private not-for-profit
Suffolk University	8 Ashburton Place	4-year, Private not-for-profit
The Boston Conservatory at Berklee	8 The Fenway	4-year, Private not-for-profit

Toni & Guy Hairdressing Academy	727A Granite Street	< 2-year, Private for-profit
Toni & Guy Hairdressing Academy	6 Park Avenue	< 2-year, Private for-profit
Tri County Regional Vocational Technical High School Adult Education	147 Pond Street	< 2-year, Public
Tufts University	200 Westboro Road	4-year, Private not-for-profit
Tufts University	145 Harrison Avenue	4-year, Private not-for-profit
Tufts University	419 Boston Avenue	4-year, Private not-for-profit
Universal Technical Institute of Massachusetts Inc	1 Upland Road	2-year, Private for-profit
University of Massachusetts Amherst	181 Presidents Drive	4-year, Public
University of Massachusetts Boston	100 Morrissey Boulevard	4-year, Public
University of Massachusetts Dartmouth	285 Old Westport Road	4-year, Public
University of Massachusetts Dartmouth Center for Innovation and Entrepreneurship	151 Martine Street	4-year, Public
University of Massachusetts Dartmouth School for Marine Science and Technology	706 South Rodney French Boulevard	4-year, Public
University of Massachusetts Lowell	1 University Avenue	4-year, Public
University of Massachusetts School of Law	333 Faunce Corner Road	4-year, Public
University of Massachusetts Worcester Medical Center	55 Lake Avenue North	4-year, Public
University of Phoenix-Boston	19 Granite Street	4-year, Private for-profit
Urban College of Boston	178 Tremont Street	2-year, Private not-for-profit
VIP Beauty Academy	100 Water Street	< 2-year, Private for-profit
Wellesley College	106 Central Street	4-year, Private not-for-profit
Wentworth Institute of Technology	550 Huntington Avenue	4-year, Private not-for-profit
Western New England University	1215 Wilbraham Road	4-year, Private not-for-profit
Westfield State University	577 Western Avenue	4-year, Public
Wheaton College	26 East Main Street	4-year, Private not-for-profit
Wheelock College	200 The Riverway	4-year, Private not-for-profit
William James College	1 Wells Avenue	4-year, Private not-for-profit

Williams College	880 Main Street	4-year, Private not-for-profit
Woburn Electrical School	14 Orange Street	< 2-year, Private for-profit
Worcester Polytechnic Institute	100 Institute Road	4-year, Private not-for-profit
Worcester State University	486 Chandler Street	4-year, Public

Appendix E: List of schools from pre-K through 12th Grade in Massachusetts. Obtained from https://www.arcgis.com/home/item.html?id=a7ccf184af704f5fbd17d69f935554d6

Name	Address	City/Town (Mailing)	City/Town (Geographic)	ZIP Code
Paige Academy	28 Highland Avenue	Roxbury	BOSTON	2119
Our Lady of Perpetual Help Mission Grammar School	94 St Alphonsus Street	Roxbury	BOSTON	2120
Cristo Rey Boston High School	100 Savin Hill Avenue	Boston	BOSTON	2125
Community Academy of Science and Health	11 Charles Street	Dorchester	BOSTON	2122
Park Street School	67 Brimmer Street	Boston	BOSTON	2108
James Otis School	218 Marion Street	East Boston	BOSTON	2128
Shaloh House Day School	29 Chestnut Hill Avenue	Brighton	BOSTON	2135
Holy Name Elementary School	535 West Roxbury Parkway	West Roxbury	BOSTON	2132
St. Theresa of Avila Elementary School	40 Saint Theresa Avenue	West Roxbury	BOSTON	2132
St. Brendan Elementary School	29 Rita Road	Dorchester	BOSTON	2124
Brighton High School	25 Warren Street	Brighton	BOSTON	2135
Clarence R Edwards Middle School	28 Walker Street	Charlestown	BOSTON	2129
Warren Prescott K-8 School	50 School Street	Charlestown	BOSTON	2129
Lyndon School	20 Mount Vernon Street	West Roxbury	BOSTON	2132
Mozart School	236 Beech Street	Roslindale	BOSTON	2131
Dennis C Haley School	570 American Legion Highway	Roslindale	BOSTON	2131
Joseph Lee School	155 Talbot Avenue	Dorchester	BOSTON	2124
Holmes Elementary School	40 School Street	Dorchester	BOSTON	2124
Edward Everett School	71 Pleasant Street	Dorchester	BOSTON	2125
Jeremiah E Burke High School	60 Washington Street	Dorchester	BOSTON	2121
John W McCormack School	315 Mount Vernon Street	Dorchester	BOSTON	2125
Mather School	1 Parish Street	Dorchester	BOSTON	2122
Bais Yaakov of Boston School	198 Strathmore Road	Brighton	BOSTON	2135
Kingsley Montessori School	30 Fairfield Street	Boston	BOSTON	2116
The Winsor School	103 Pilgrim Road	Boston	BOSTON	2215
Orchard Gardens School	906 Albany Street	Roxbury	BOSTON	2119

St. Peter Academy School	371 West Fourth Street	South Boston	BOSTON	2127
Lilla G Frederick Middle School	270 Columbia Road	Dorchester	BOSTON	2121
Epiphany School	154 Centre Street	Dorchester	BOSTON	2124
Paul A Dever School	325 Mount Vernon Street	Dorchester	BOSTON	2125
Joseph P Tynan School	650 E. Fourth Street	South Boston	BOSTON	2127
Nathan Hale School	51 Cedar Street	Roxbury	BOSTON	2119
Rafael Hernandez School	61 School Street	Roxbury	BOSTON	2119
Hugh Roe O'Donnell School	33 Trenton Street	East Boston	BOSTON	2128
Samuel Adams School	165 Webster Street	East Boston	BOSTON	2128
Dr. William Henderson Lower School	1669 Dorchester Avenue	Dorchester	BOSTON	2122
Manassah E Bradley School	110 Beachview Road	East Boston	BOSTON	2128
James Condon Elementary School	200 D Street	South Boston	BOSTON	2127
James J Chittick School	154 Ruskindale Road	Mattapan	BOSTON	2126
William Ellery Channing School	35 Sunnyside Street	Hyde Park	BOSTON	2136
Urban Science Academy	1205 VFW Parkway	West Roxbury	BOSTON	2132
Meridian Academy	54 Brookside Avenue	Jamaica Plain	BOSTON	2130
Boston College High School	150 Morrissey Blvd	Dorchester	BOSTON	2125
Dr. William Henderson Upper School	18 Croftland Avenue	Dorchester	BOSTON	2122
Boston University Academy	1 University Road	Boston	BOSTON	2215
Boston Trinity Academy	17 Hale Street	Boston	BOSTON	2136
German International School Boston	57 Holton Street	Allston	BOSTON	2134
City on a Hill Charter Public School	58 Circuit Street	Roxbury	BOSTON	2119
Quincy Upper School	152 Arlington Street	Boston	BOSTON	2116
Fenway High School	67 Alleghany Street	Roxbury	BOSTON	221