Final Abstract

Final Report Approved on February 14, 2025

M.L. 2021 Project Abstract

For the Period Ending June 30, 2024

Project Title: Behavioral Response of Bald Eagles to Acoustic Stimuli

Project Manager: Christopher Feist

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Funding Source:

Fiscal Year:

Legal Citation: M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 07d

Appropriation Amount: $261,000

Amount Spent: $261,000

Amount Remaining: -

Sound bite of Project Outcomes and Results

Our project tested noise-based deterrence signals aimed to reduce bald eagle fatalities at wind farms. During tethered flight trials, we found that bald eagles did not respond to the noise signals, suggesting that alternative methods may be needed to protect these birds from wind turbine collisions.

Overall Project Outcome and Results

As wind energy expands globally, bird collisions with turbine blades have become an increasing concern. This project aimed to evaluate the effectiveness of acoustic deterrents in reducing bald eagle collisions, contributing to wildlife conservation and compliance with the Bald and Golden Eagle Protection Act.

The first phase of the project tested eight bald eagles' behavioral responses to different sound stimuli. Natural (i.e. eagle scream) and synthetic (i.e. sirens) were among the signal types tested. Natural, broadband signals elicited the strongest reactions, while habituation to the sounds was minimal.

In the second phase, 16 bald eagles completed over 130 tethered flight tests to assess whether deterrent sounds altered

their flight paths. Results showed no significant changes - eagles frequently flew directly toward the speaker playing the deterrent sounds, indicating the tested acoustic deterrent was ineffective.

Key Outcomes:

- Wildlife Conservation: Results provide critical data on bald eagle responses to acoustic deterrents.
- Research Findings: Natural, broadband sounds triggered the most responses, but did not significantly alter flight paths.
- Future Applications: Findings suggest current acoustic deterrent methods may not effectively prevent bald eagle collisions at wind farms, highlighting the need for alternative mitigation strategies.

Project Significance:
These results inform wildlife managers and policymakers about the limitations of acoustic deterrents for eagle conservation. While the study contributes to understanding bald eagle behavior in response to sound, additional research is needed to develop more effective strategies for reducing bald eagle collisions and balancing renewable energy expansion with wildlife protection.

Project Results Use and Dissemination

The team has communicated the results of the work to colleagues in Xcel Energy's Renewable Energy Research group and with colleagues at Western Ecosystem Technology Inc (WEST)., an environmental consulting firm.

The project work was presented at the Acoustical Society of America May 2023 meeting and published in the corresponding journal (J. Acoust. Soc. Am. 153, A186 (2023)).

The final report as submitted to LCCMR is planned to be worked into a St Anthony Falls Laboratory (SAFL) project report. The project report will be highlighted on SAFL's website and will be searchable via internet search engines.

Environment and Natural Resources Trust Fund

M.L. 2021 Approved Final Report

General Information

Date: February 18, 2025

ID Number: 2021-294

Staff Lead: Mike Campana

Project Title: Behavioral Response of Bald Eagles to Acoustic Stimuli

Project Budget: $261,000

Project Manager Information

Name: Christopher Feist

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Project Reporting

Final Report Approved: February 14, 2025

Reporting Status: Project Completed

Date of Last Action: February 14, 2025

Project Completion: June 30, 2024

Legal Information

Legal Citation: M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 07d

Appropriation Language: $261,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota, St. Anthony Falls Laboratory, to protect wildlife by designing and implementing an acoustic deterrence protocol to discourage bald eagles from entering hazardous air space near wind energy installations.

Appropriation End Date: June 30, 2024

Narrative

Project Summary: The goal of the work is to design and implement an acoustic deterrence protocol that will discourage bald eagles from entering hazardous air space near wind energy installations.

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

Wind energy is a cost competitive, clean energy source that offers benefits for Minnesota. However, there are some undesirable environmental impacts of wind energy installations; one of primary interest here is federally protected bald eagle collisions with wind turbines resulting in fatalities. A promising method designed to reduce eagle collisions is the installation of acoustic deterrent devices at wind energy installations. In recent years, several studies have attempted to estimate the efficacy of acoustic deterrent systems, but these studies have been conducted in uncontrolled environments with limited data, resulting in a wide range of effectiveness estimates; i.e. estimates of effectiveness on altering flight paths of raptors away from wind turbines range from 7% to 88%. Further, the acoustic stimuli used were developed in the absence of knowledge relating to the hearing attributes of bald eagles. For these devices to be useful as a reliable raptor collision mitigation method, acoustic deterrence developers must have confidence in their effectiveness. This project aims to answer this question under controlled experimental conditions.

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

In experiments designed to develop the most effective acoustic deterrent, behavioral responses of bald eagles to a battery of natural and synthetic stimuli will be acquired and analyzed to establish a clear understanding of which stimulus types bald and golden eagles are most responsive to and habituate to the least. A set of prospective deterrence signals will be engineered using the most effective stimuli identified in the behavioral response tests referenced above. Those signals will be used to determine if tethered, but otherwise free-flying birds, respond to deterrence signals by altering customary flight paths. Additional experiments will be conducted by associating prospective sound-based deterrent signals with a visual object to determine if the eagles associate objects with acoustic cues and that those cues might enhance the avoidance behaviors that mitigate the taking of birds at wind energy facilities.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

This project will provide scientifically rigorous data addressing the effectiveness of acoustic deterrence signals to alter the flight path of eagles and therefore mitigate the fatality rate associated with wind turbine collisions. The project will identify and design acoustic deterrence signals that have been tested under controlled experimental conditions with bald eagles. Findings from this study will provide system designers and developers alike a solid foundation upon which to implement acoustic deterrence technologies.

Project Location

What is the best scale for describing where your work will take place?

Statewide

What is the best scale to describe the area impacted by your work?

Region(s): Central, NW, SW, NE,

When will the work impact occur?

In the Future

Activities and Milestones

Activity 1: Behavioral testing of perched bald eagles to potential acoustic deterrence signals

Activity Budget: $120,000

Activity Description:
In this activity, the team will build on work recently concluded as part of a U.S. Department of Energy (DOE) funded project. In phase one of that study, the auditory attributes of bald and golden eagles were investigated. In a second study, a subset of calls from the vocal repertoire of bald and golden eagles were acoustically analyzed, and in a third preliminary data associated with behavioral responses of 3 bald eagles to a collection of natural and synthetic acoustic stimuli in a laboratory setting were acquired and analyzed.

In the first activity of the proposed study, our goal is to expand the small sample sizes used in the preliminary study to include 10 bald eagles in an effort to identify the most effective alerting acoustic stimuli and to which there is little, if any, habituation. Using this information, acoustic deterrence signals will be developed and used in tests specified in activities 2 and 3. Bald eagles will be tested at the University of Minnesota Raptor Center.

Activity Milestones:

Description	Approximate Completion Date
Engineer prospective acoustic deterrent stimuli for activities 2 and 3	October 31, 2021
Complete bald eagle behavioral response testing	November 30, 2021
Complete analysis of bald eagle behavioral responses to acoustic stimuli	December 31, 2021

Activity 2: Phase 1 behavioral testing of bald eagles to potential acoustic deterrent signals during tethered flight

Activity Budget: $65,000

Activity Description:
The objective of activity 2 is to measure the effectiveness of acoustic deterrence signals developed in activity 1 to alter the flight path of eagles during tethered flight. Testing in this phase of the project will take place with wild bald eagles that are being rehabilitated at The University of Minnesota Raptor Center. To evaluate the effectiveness of acoustic deterrence signals to alter the flight path of eagles, 10 individuals will be evaluated during this phase of the investigation. Individual eagles will be evaluated multiple times on different days to assess habituation tendencies. By the end of the project, as many as 1200 flights, or more, will have been logged. Half of these flights will have included an acoustic deterrence element and half will not. Analyzing data collected during these flights using tracking sensors (GPS tags) attached to the birds will permit the objective assessment of the acoustic deterrence strategy.

Activity Milestones:

Description	Approximate Completion Date
Develop data acquisition system	October 31, 2021
Complete analysis of tethered flight trial data	May 31, 2022
Complete bald eagle tethered flight trials	May 31, 2022

Activity 3: Phase 2 behavioral testing of bald eagles to potential acoustic deterrent signals during tethered flight

Activity Budget: $76,000

Activity Description:
Activity 3 will expand tethered flight testing into a second season. Tethered flight exercise associated with the Center's rehabilitation program typically occurs during the months of October through December in preparation for the bird's release into the wintering population of wild eagles. A second phase of testing will allow refinement of the testing procedure and concentration on acoustic stimuli shown in the earlier phases of this study to be most effective. We will also assess the combined influence of the presence of a structure and the broadcast of deterrence signals, as well as the influence of each element in isolation. Field testing of acoustic deterrence systems at wind farms have indicated some positive association between the noise deterrent and wind turbines.

Activity Milestones:

Description	Approximate Completion Date
Modify tethered flight procedure and acoustic stimuli	August 31, 2022
Complete tethered flight trials	December 31, 2022
Complete analysis of flight response data	March 31, 2023
Final project report	June 30, 2023

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Peggy Nelson	Speech-Language-Hearing Science, University of Minnesota	Peggy will serve as a co-investigator and assist in the design of behavioral response testing.	Yes
Jeffrey Marr	St. Anthony Falls Laboratory, University of Minnesota	Jeff Marr will serve as a co-investigator and assist with project management and research dissemination.	Yes
Christopher Milliren	St. Anthony Falls Laboratory, University of Minnesota	Chris Milliren will provide technical support and develop the sensor systems used in the behavioral response and tethered flight testing.	Yes
Edward Walsh	VA Loma Linda Healthcare System	Ed will serve as a lead research scientist on the project with responsibilities including developing acoustic stimuli, design of laboratory testing, and analysis of behavioral response test data.	Yes
JoAnn McGee	VA Loma Linda Healthcare System	JoAnn will serve as a lead research scientist on the project with responsibilities including developing acoustic stimuli, design of laboratory testing, and analysis of behavioral response test data.	Yes
Lori Arent	The Raptor Center, University of Minnesota	Lori Arent will assist in the design of laboratory testing, be responsible for access to test subjects, animal care protocols and permitting requirements, and lead tethered flights of bald eagles.	Yes
Julia Ponder	The Raptor Center, University of Minnesota	Julia Ponder will serve as a co-investigator and provide expertise on raptor behavior, design of laboratory testing, animal care protocols, and permitting requirements.	Yes

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.
Results of the project will be communicated with the wind industry and other stakeholders via conferences, journal articles, reports, and direct communication with wind industry partners. Acknowledgement of the Environment and Natural Resources Trust Fund will be done through the use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and other communications as per the ENTRF acknowledgement guidelines. The impact of this project will influence strategic planning activities of primary wind energy stakeholders as they develop the next generation of environment friendly technologies.

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?
Results of the project will be communicated with the wind industry and other stakeholders via conferences, journal articles, reports, and direct communication with wind industry partners. The impact of this project will influence

strategic planning activities of primary wind energy stakeholders as they develop the next generation of environment friendly technologies. The US Department of Energy and the American Wind Wildlife Institute are committed to reducing the environmental impacts of wind energy and fund research aimed at this goal. Proposals for funding additional work can be submitted to these sources, as well as by establishing partnerships with private energy companies.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount	$ Amount Spent	$ Amount Remaining
Personnel										
Technician		Veterinarian Technician - Animal Care			24%	0.18		$8,042	-	-
Lori Arent		Scientist - Bird Handling			27%	0.24		$21,257	-	-
Julia Ponder		Co PI			27%	0.06		$11,438	-	-
Peggy Nelson		Co PI			27%	0.04		$6,784	-	-
Benjamin Erickson		Scientist			24%	0.16		$11,062	-	-
Christopher Milliren		Engineer			24%	0.48		$29,447	-	-
Jeffrey Marr		Co PI			27%	0.02		$3,165	-	-
Christopher Feist		PI			27%	0.4		$30,649	-	-
							Sub Total	**$121,844**	**$121,844**	**-**
Contracts and Services										
Ed Walsh and JoAnn McGee	Professional or Technical Service Contract	Ed and JoAnn will serve as lead researchers on the project. They bring expertise in experimental design, data analysis, and animal bio-acoustics.		X		1		$128,000	$128,000	-
							Sub Total	**$128,000**	**$128,000**	**-**
Equipment, Tools, and Supplies										
	Equipment	Audio Equipment	Amplifiers and signal generators for use in the tethered flight testing					$2,000	$2,000	-
	Equipment	Speakers	Speakers used in tethered flight testing to emit acoustic stimuli					$4,000	$4,000	-
	Equipment	Tethered flight materials	Equipment used in tethered flights of bald eagles such as harness, gauntlets, creance line, etc.					$1,675	$1,675	-

	Equipment	RTK GPS tracking	Tracking device system to measure the flight path of bald eagles during tethered flights					$3,000	$3,000	-
							Sub Total	**$10,675**	**$10,675**	**-**
Capital Expenditures										
							Sub Total	**-**	**-**	**-**
Acquisitions and Stewardship										
							Sub Total	**-**	**-**	**-**
Travel In Minnesota										
	Miles/ Meals/ Lodging	Travel rate set at $0.54 per mile for personal vehicles. Total miles of 297 for three individuals.	Reimbursement for travel to the eagle tethered flight location and the raptor center.					$481	$481	-
							Sub Total	**$481**	**$481**	**-**
Travel Outside Minnesota										
							Sub Total	**-**	**-**	**-**
Printing and Publication										
							Sub Total	**-**	**-**	**-**
Other Expenses										
							Sub Total	**-**	**-**	**-**
							Grand Total	**$261,000**	**$261,000**	**-**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Contracts and Services - Ed Walsh and JoAnn McGee	Professional or Technical Service Contract	Ed and JoAnn will serve as lead researchers on the project. They bring expertise in experimental design, data analysis, and animal bio-acoustics.	Ed and JoAnn are critical partners to the success of this project. They served as lead researchers on the previous work completed by this team that is directly leading to the project proposed here. Ed and JoAnn were responsible for much of the experimental design, acoustic signal design, and data processing from our previous project where bald and golden eagle hearing were mapped as well as a pilot behavioral response experiment. Ed and JoAnn will be largely responsible for acoustic signal development, experimental design, and data processing in the project proposed here. Without Ed and JoAnn on the team this proposal would not have been submitted. There are no other researchers with their experience working with bald eagle hearing. Because of this, the single source contract is needed. Ed Walsh and JoAnn McGee are researchers with the VA Loma Linda Healthcare System. They have previously held affiliated research positions at the University of Minnesota in the Speech, Language, and Hearing Sciences department. They are being included on this proposal as a professional service contract as this was deemed the easiest way of including them on the proposal. Ed Walsh and JoAnn McGee each have a rate of $100/hour. It was estimated their involvement on the project would total 640 hours.

Non ENRTF Funds

Category	Specific Source	Use	Status	$ Amount	$ Amount Spent	$ Amount Remaining
State						
			State Sub Total	**-**	**-**	**-**
Non-State						
In-Kind	Unrecovered F&A	Support of SAFL facilities where research will be conducted.	Secured	$143,550	$143,550	-
			Non State Sub Total	**$143,550**	**$143,550**	**-**
			Funds Total	**$143,550**	**$143,550**	**-**

Attachments

Required Attachments

Visual Component

File: 4f8fffc1-b7b.pdf

Alternate Text for Visual Component

The visual shows two of the experimental setups planned for the project. One figure shows a bald eagle in an indoor pen at the Raptor Center where behavioral testing to acoustic stimuli is occurring, image is from a previous DOE funded study. Speakers are located on either side of the eagle and researchers are monitoring/controlling the test from a remote location using video. The second figure shows an experimental setup with a bald eagle flying down a corridor with speakers on either side. ...

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
Proposal endorsement - UMN	bfa95df9-195.pdf
Peer Review Research Addendum	a6971368-350.docx
Background Check Form	31e142ec-15d.pdf
ASA conference presentation May 2023	61c0290e-c05.pptx
Final Report	23e17fec-62a.pdf
Status Report Update	06b62206-3c3.docx

Media Links

Title	Link
Star Tribune Article (9/23/21)	https://www.startribune.com/university-of-minnesota-researchers-protect-eagles-wind-farms-airspace/600100175/
CSE SAFL Article (September 2021)	https://cse.umn.edu/safl/news/safls-innovative-eagle-project-highlighted-star-tribune
ASA conference 1 page summary	https://acoustics.org/behaviors-produced-by-a-variety-of-sounds-among-eagles-a-study-with-survival-implications/
ASA conference abstract	https://pubs.aip.org/asa/jasa/article/153/3_supplement/A186/2885950/Behavioral-responses-of-bald-eagles-Haliaeetus

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

To reduce the project budget to the recommenced funding amount, some of the project scope was removed. Specifically, our plan to travel to Cyril, OK to test golden eagle behavioral response as part of Activity 1 was removed. As MN has a low population of golden eagles, this part of the scope had the least significant impact to MN natural resources. Additionally, results from bald eagle behavioral response testing will have relevance to an acoustic deterrence system that would also work for golden eagles. The project title was changed to reflect the removal of behavioral response testing of golden eagles.

Additional Acknowledgements and Conditions:

The following are acknowledgements and conditions beyond those already included in the above workplan:

Do you understand and acknowledge the ENRTF repayment requirements if the use of capital equipment changes?

N/A

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I understand the UMN Policy on travel applies.

Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?

No

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

N/A

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Work Plan Amendments

Amendment ID	Request Type	Changes made on the following pages	Explanation & justification for Amendment Request (word limit 75)	Date Submitted	Approved	Date of LCCMR Action
1	Completion Date	Previous Completion Date: 07/31/2023 New Completion Date: 06/30/2024	We have had multiple delays on the project and are requesting to change the end date to June 30th, 2024 extending the project by approximately 1 year. Project delays include an outbreak of avian influenza preventing the team from getting access to rehabilitating bald eagles for testing, contract delays at the start of the project of 2+ months, PI illness delaying progress, and delays due to covid19.	August 10, 2022	Yes	August 10, 2022

Status Update Reporting

Final Status Update August 14, 2024

Date Submitted: January 23, 2025

Date Approved: January 24, 2025

Overall Update

In the first phase of the project, the behavioral responses of bald eagles to acoustic based stimuli were observed. In total 8 bald eagles were assessed and behavioral results were analyzed for proportion of positive response, response strength, and habituation for each stimulus. Broadly speaking, natural, broadband, signals more often generated responses of bald eagles and should be the focus of any signal used as a deterrence. Response habituation was also considered and the overall takeaway is that habituation does occur, but the decline in responsivity is marginal at best.

In the second phase of the project, signals from the behavioral response testing were used to determine if tethered, but otherwise free-flying birds, respond to deterrence signals by altering their flight paths. In total, 16 bald eagles were tested over 130 flights. Of flights with a deterrence signal, there were no signs of flight path alteration with eagles often flying directly to the speaker which played the sound. The conditions during the tethered flight tests do not fully represent what occurs in the field, i.e. free flying eagles at a wind farm, however, for the testing done here we can conclude the acoustic deterrent was not effective.

Activity 1

All work for activity 1 has been completed. Since our last update, we have completed response habituation analysis, and the overall takeaway is that habituation does occur, but the decline in responsivity is marginal at best. We have also completed writing the final report. See the final report attachment and the June 2023 update for further details and summary of the results.
(This activity marked as complete as of this status update)

Activity 2

All work for activity 2 has been completed. A first season of testing flying bald eagles and how they would respond to acoustic based deterrents was performed. Initial testing occurred during the fall of 2022 and then actual testing was performed during the winter of 2022-2023. The results have been analyzed. Since our last update, we have completed writing the final report, including the creation of flight path figures using GPS data taken during the experiments. See final report attachment and the June 2023 update for further details and summary of the results.
(This activity marked as complete as of this status update)

Activity 3

All work for activity 3 has been completed. This work expanded efforts from activity 2 and refined the testing protocol, with several changes over what was used in activity 2 testing. Primarily, the deterrence signal was reduced to only 1 signal, the speaker positions were placed to the left and right of a forced flight direction, and the deterrence was played from either the “left” or “right” speakers. Please see the final report for details on the experimental setup. These changes were developed during the summer and fall of 2023. Seven bald eagles were tested during activity 3 with the new experimental setup (winter 2023-24). Following the tests, results were analyzed and discussed with the project team. The team concluded there were no signs of flight path alteration due to the deterrence signal. Eagles regularly flew directly to the speaker which played the deterrent stimuli. Please see the final report which presents the results in more detail including figures of the eagle flight paths during testing."
(This activity marked as complete as of this status update)

Dissemination

The project PI has communicated the results of the work to colleagues in Xcel Energy's Renewable Energy Research group. This group investigates new technologies developed for use in wind energy. The project PI has communicated results with colleagues at Western Ecosystem Technology Inc. (WEST), an environmental consulting firm. WEST specializes in working with industry, government, and private organizations on environmental impact issues, specifically wind energy's impact on bat and avian populations. The project work was presented at the Acoustical Society of America May 2023 meeting and published in the corresponding journal (J. Acoust. Soc. Am. 153, A186 (2023)). The final report as submitted to LCCMR is planned to be worked into a St Anthony Falls Laboratory (SAFL) project report. The project report will be highlighted on SAFL's website and will be searchable via internet search engines and accessed through the University of Minnesota Library system.

Status Update Reporting

Status Update December 1, 2023

Date Submitted: January 23, 2025

Date Approved: January 24, 2025

Overall Update
Work on activity 1 and 2 have been completed. Activity 3 is currently finishing field testing, tether flight trials with bald eagles, and will process the results during the first half of 2024.

Activity 1
All work for activity 1 has been completed. Indoor behavioral response testing to acoustic stimuli was performed on 8 bald eagles. The results for this testing have been analyzed and will be summarized in a final report at the end of the project.
(This activity marked as complete as of this status update)

Activity 2
All work for activity 2 has been completed. A first season of testing flying bald eagles and how they would respond to acoustic based deterrents was performed. Initial testing occurred during the fall of 2022 and then actual testing was performed during the winter of 2022-2023. The results have been analyzed and will be summarized in a final report.
(This activity marked as complete as of this status update)

Activity 3
Activity 3 work is currently underway. Tethered flight testing with bald eagles will occur during this winter season and results will be analyzed in the first half of 2024.

Dissemination
No update

Status Update Reporting

Status Update June 1, 2023

Date Submitted: June 12, 2023

Date Approved: June 30, 2023

Overall Update

Progress during the period of December 1, 2022 through June 1, 2023 was made on Activities 1, 2, and 3.
Activity 1 has largely been completed with results from the indoor behavioral response testing having been processed and presented at a conference. The team will continue to refine the analysis moving forward with the plan of publishing a paper.
Activity 2 tethered flight testing made significant progress with the team testing 8 birds so far. Analysis so far shows the eagles rarely responding to the stimulus during flight confirming in situ opinions during the testing. Following these results the team is working to change our testing approach.
Activity 3 is a continuation of activity 2 and the team is actively preparing for this phase of the project. Some of the planned changes so far include a different speaker configuration, stimulus, and stimulus length.
Team members attended the Acoustical Society of America conference in May, 2023 and presented on results from activity 1. The presentation given at the conference is included on the attachments page.

Activity 1

In this phase of the investigation, the behavioral responses of bald eagles to a collection of natural and synthetic acoustic stimuli were analyzed in an effort to identify effective acoustic deterrent signals. Tests were conducted in an acoustically damped room and a high-resolution video camera was used to capture the behavior of the subject during experimental trials consisting of ten blocks of randomized acoustic stimuli, along with silent or catch trials. Eight untrained eagles, six juveniles, three males and three females, along with two four-year olds, one male and one female, were included in the study. A jury of judges was asked to determine whether the eagle responded, and if so, to identify the nature of the response and response strength. Findings indicate that subjects responded to stimuli between 95% and 45% on average depending upon signal type. Responses to natural stimuli were observed on average 75% of the time compared to 53% when synthetic signals were presented. Subjects also responded to broadband signals 70% of the time, compared to 47% for narrowband signals. In addition, female subjects tended to be more responsive on average than male subjects. Response habituation was also considered during this reporting period.

Activity 2

The response of bald eagles during tethered flight to acoustic stimuli were studied to identify the impact, if any, on the flight path. Tests were conducted outdoors at a park used by The Raptor Center for exercising raptors prior to release back into the wild. Four speakers were setup up at NE, SE, SW, and NW locations approximately 70 m from a central bird release point. An acoustic stimuli for one of the speakers was manually triggered based on flight direction for each of the flights. Each bird underwent 6-10 flights based on the health of the bird. A GPS tracker was attached to the bald eagles to measure the flight path. Time syncing between the stimulus trigger and the GPS tracker provided information on when the stimulus was played during the flight. 8 birds in total have been tested with 5 birds tested with the full data acquisition system (stimuli + GPS). For the 5 birds tested with the full system, no obvious change in flight path to the acoustic stimuli were observed. The team has decided to alter the test methodology to further investigate the use of acoustic stimuli as an alerting/deterring method.

Activity 3

The majority of activity 3 is planned to start in the fall of 2023 when The Raptor Center typically has the most bald eagles. It is expected there will be more birds available for testing this year compared to last year as the avian influenza has not been present in the wild population.

Dissemination

Project team members attended the Acoustical Society of America conference on May 8, 2023 and presented results from Activity 1. The presentation included a PowerPoint, abstract, and a 1 page summary of the work.

Status Update Reporting

Status Update December 1, 2022

Date Submitted: December 7, 2022

Date Approved: December 20, 2022

Overall Update
Progress during the period of June 1, 2022 through December 1, 2022 was made on Activities 1 and 2. The project end date was also extended to June 30, 2024 allowing for additional time to complete tethered flight testing. Out of the control of the project team, avian influenza has drastically reduced the number of bald eagles being treated at the Raptor Center and thus limiting the number of test subjects for tethered flight trials.

Activity 1 progress focused on completing the editing of video footage taken during indoor behavioral response testing of bald eagles and compiling the judge's responses to the behavioral responses.

Activity 2 progress focused on finalizing the data acquisition system for field tethered flights with bald eagles and testing a few eagles. The speaker system used for playing the acoustic stimuli has been completed, tested, and deployed during bald eagle tethered flights. Additionally, sensors used for tacking eagles during flight has been developed, tested, and deployed during tethered flights. Due to avian influenza, very few bald eagles (currently 1) are being treated at the Raptor Center which has delayed further progress on this Activity.

Activity 1
In Activity 1, twelve acoustic deterrent stimuli were developed for testing in an indoor laboratory setting. These twelve alerting acoustic stimuli were then tested on nine bald eagles at the University of Minnesota Raptor Center. During the testing, the team identified which alerting stimuli were most effective. However, more detailed analysis still needs to be performed on the results from judging the behavioral response of the bald eagles during the testing. We are anticipating to make substantial progress on compiling results during December 2022.

Activity 2
Progress made on Activity 2 was the development of a data acquisition system for measuring the location of bald eagles during tethered flights and completing the sound system used for triggering acoustic stimuli during tethered flights. Developing and finalizing these two systems was a critical milestone for this activity and a significant effort.

The sound system includes 4 speakers that are spread out in a field where speakers are placed approximately 70 m from a central point at NW, NE, SE, and SW orientations. The speakers are controlled wirelessly from a laptop allowing quick deployment of the system.

The location tracking sensor has gone through multiple iterations and we are now settled on using a GPS tracking device that attaches to the eagle during the tethered flights. Location data of the flying eagle is synchronized with the sound system via GPS timestamping giving precise information on when an acoustic stimuli is played relative to the eagles flight path. The team plans to add a camera mounted to the flying eagle to track head movement.

To date, 3 eagles have been tested with the full acoustic deterrent system. We hope to test many more eagles in the Spring.

Activity 3
Activity 3 is scheduled to start August, 2023.

Dissemination

The PI of the project attended the Wind Wildlife Research Meeting from November 15-17 which is a biennial research meeting to share and engage on the latest research focused on understanding the risk wind energy poses to wildlife and solutions to avoid/minimize the impacts.

Status Update Reporting

Status Update June 1, 2022

Date Submitted: June 1, 2022

Date Approved: July 7, 2022

Overall Update
Progress during the period of July 1, 2021 through June 1, 2022 was made on Activities 1 and 2 which can be summarized as developing an effective acoustic deterrent and testing the acoustic deterrents in controlled environments on rehabilitating, wild bald eagles.

Twelve acoustic stimuli/deterrence signals were developed for testing the behavioral response of bald eagles. Nine bald eagles were tested to the developed stimuli in a controlled indoor setting at the University of Minnesota Raptor Center. Initial, qualitative findings based on observations during the testing indicated which signals provided more response. The primary method for analyzing behavioral response of the bald eagles is video footage taken during the testing. Editing of the approximately one-hundred videos collected is ongoing but largely complete. Judging of the behavioral response is also ongoing.

Outdoor, tethered flight testing of bald eagle response to acoustic signals (deterrence signals) began November/December of 2021 but is behind schedule. The team planned to make progress on this task during the Spring, however an outbreak of Highly Pathogenic Avian Influenza in wild birds has put this activity on pause.

Activity 1
In Activity 1, twelve acoustic deterrent stimuli were developed for testing in an indoor laboratory setting. These twelve alerting acoustic stimuli were then tested on nine bald eagles at the University of Minnesota Raptor Center. During the testing, the team identified which alerting stimuli were most effective. However, more detailed analysis still needs to be performed on the results from judging the behavioral response of the bald eagles during the testing.

The bulk of the work has been completed for activity 1 with the analysis of the bald eagle behavioral responses to the alerting signals still needing to be completed. The project start was delayed approximately 3 months due to delays in contracting.

Activity 2
Activity 2 is behind schedule but will be made up during the summer of 2022. Progress made on Activity 2 was the development of a data acquisition system for measuring the location of bald eagles during tethered flights. Several tests were performed to test the data acquisition system using a small unmanned aerial vehicle and with bald eagles.

The main reason for delay on this part of the project was the PI, Christopher Feist, had an illness which prevented him for working for a month during a critical time to prepare Activity 2. The team decided to shift the work to the Spring and Summer of 2022. However, we are currently waiting on the Highly Pathogenic Avian Influenza outbreak to subside before continuing this work.

Activity 3
Activity 3 is planned to start late summer of 2022.

Dissemination
Team members presented at the 181st Acoustical Society of America meeting in December of 2021.

Ongoing discussions with Xcel Energy on the work being performed in addition to new projects being developed from the work.

Star Tribune article on the project entitled "University of Minnesota researchers drill down on ways to protect eagles in wind farm's airspace' published on September 23, 2021.

Article on the project on the University of Minnesota College of Engineering website, September 2021.