MANAGING HAZARDOUS SPECIES BY MANIPULATING THE ACOUSTIC ENVIRONMENT OF TARGET HABITATS: APPLYING THE "SONIC NET" TO HUMAN WILDLIFE CONFLICT MITIGATION.

Amanda Werrell, [1] John Swaddle, [1] and Page Klug[2]

[1]Institute for Integrative Bird Behavior Studies, College of William and Mary, Williamsburg, Virginia 23187-8795 USA

[2]U.S. Department of Agriculture APHIS, Wildlife Services, National Wildlife Research Center, North Dakota Field Station, NDSU Biological Sciences Dept. 2715, P.O. Box 6050, Fargo, ND, 58108, USA

Abstract: Bird-aircraft strikes in the USA are estimated to cost between $155 million to upwards of $1.2 billion each year. A number of different landscape features on or near airfields are responsible for attracting birds and other hazardous wildlife, generally sources of food, water, or cover. My research explores the use of sound that is designed to mask communication among birds (termed a "sonic net") to deter Red-winged Blackbirds (*Agelaius phoeniceus*) from a key attractant type, sunflower fields (food). The "sonic net" works by masking communication of a target species producing "pink noise" overlapping the frequencies in which a species communicates. If birds can't listen for predators or conspecific warning calls they are predicted to leave the area. Working with local sunflower producers in North Dakota, we set up experimental sites in five sunflower fields that were being actively used by large flocks of blackbirds. Overall we saw 64% less additional damage, or approximately 42.9 cm^2 reduction in additional area damaged per flower as a result of the "sonic net" treatment. The "sonic net" was effective in reducing flock use of a treated patch.

Introduction

Aircraft collisions with wildlife are a serious concern to the aviation industry in terms of both safety and economics. Bird strikes make up 97% of reported wildlife strikes, and 23 of the 25 species deemed most hazardous to aircraft by the FAA are avian.[1] A number of different landscape features on or near airfields are responsible for attracting birds and other hazardous wildlife, generally sources of food, water, or cover.[1] These attractants are often difficult or impossible to remove completely, thus alternative forms of management are critical to reduce the risk they pose to aircraft safety.[1] In our research we tested the effectiveness of an upcoming deterrent technology, the "sonic net" in sunflower fields, a highly attractive food source.

The "sonic net" technology uses directional speakers to produce wide frequencies of sound. These frequencies can be adjusted to overlap the range of frequencies used in the vocal communication of a target species.[2,3] Application of a "sonic net" reduces the ability of birds to gather acoustic information from their environment, such as conspecific alarms calls or other auditory cues.[3,4] This acoustic degradation of habitat has been shown to cause up to an 82% reduction in bird abundance in a treated area, when tested in an airfield setting.[2]

"Sonic net" technology is distinguished from other control methods because birds have not shown habituation to the treatment, and it is a potentially environmentally friendly alternative to more destructive management methods. Current acoustic deterrents include broadcasting sounds such as alarm calls, predator calls, anthropogenic noise, or sudden loud noises from cannons or pyrotechnics.[5] These scare tactics exhibit reduced effectiveness after several weeks of application due to habituation.[6] Previous studies on the "sonic net" have shown no decrease in sensitivity to the treatment, and we predict that the acoustic environment produced by the "sonic net" will lead to an actual increase in predation risk, reinforcing avoidance behavior and preventing habituation.[2] In addition, the "sonic net" has the potential to degrade habitat quality, without causing any lasting damage to the structure or function of that habitat. Rather than lethal or destructive methods of control, the "sonic net" is predicted to have a smaller environmental impact, deteriorating habitat quality acoustically. The "sonic net" can be turned on and off to target specific times of day or year, and the frequencies produced can be manipulated to specifically target the vocal communication range of a particular species and thus, minimize the impacts on species communicating in different ranges.[2, 4, 7]

Study System

Red-winged Blackbirds (*Agelaius phoeniceus*) and their relatives are infamous for the huge, often mixed-species, flocks that they form in the non-breeding season.[5] These massive flocks can be quite destructive to both agriculture and aviation. In aviation, blackbirds have caused some of the most damaging and fatal bird strike incidences in the United States.[9] In an agricultural setting, blackbird flocks are known to cause severe damage to crop fields, especially sunflower and corn. [10,11,12] In this study we will be focusing on "sonic net" deterrence of blackbird flocks from a highly attractive food source, sunflower fields. Agricultural fields are not uncommon features on or near airport properties, and are known to attract many high-risk species.[1,5]

This study builds upon previous work to test and extend the application of a "sonic net" to a highly attractive habitat type. Our research will help to determine if the "sonic net" may be an effective method to reduce wildlife hazards associated with these attractants. Specifically, is a "sonic net" effective in reducing the use of a highly attractive food source by Red-winged Blackbirds?

Methods

We identified five sunflower fields with active blackbird flocks in Burleigh County, North Dakota. Within each of these five fields, two square, half-acre plots were established with a minimum of 172 meters between the center points, or roughly 2 square acres between the edges of each plot. These distances were established based on estimated coverage area for a "sonic net" device. Each set of plots was established to be equidistant from the field edges, visible wetlands, or any other deterrent device present upon set up. Once center coordinates were established, one plot was randomly selected as a treatment site while the other was assigned as control. In our treatment plots a "sonic net" device was set up at the center, and attached to solar panels a minimum of 31 meters away. In control sites a decoy speaker was set up in the center of the plot to control for any visual effects of the "sonic net" speakers. Within each of the plots three 45-meter transects were established, one along the center of the plot and two parallel transects approximately 11 meters out from the center transect. We individually identified and marked 21 flowers equally spaced along each transect for a total of 63 flowers per plot. Each of these 63 flowers was measured for diameter to calculate the entire area and an initial estimate of area damage to establish the baseline damage for each plant prior to the onset of the experiment. Once initial damage estimates were collected from each plot the experiment was initiated. In our treatment plots the "sonic net" sound treatment was applied during all daylight hours, when birds may be foraging, from 30 minutes prior to sunset to 30 minutes after sunset, every day for 20 days. In the control plots, the decoy "sonic net" was present for the same 20-day period, but no sound treatment was applied. At the end of the 20-day treatment window, we measured the total area damaged on the same 63 flowers from each plot to calculate the change in damage across each individual.

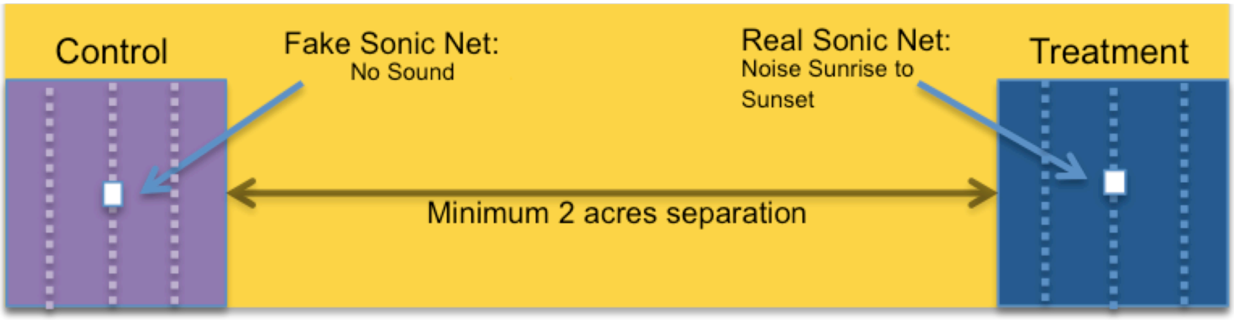

Figure 1. Diagram of Sunflower experimental set up. Five experimental sites were selected in fields with active blackbird flocks, and control and treatment plots were established. Damage estimates were recorded for 63 individually marked flowers per plot. In treatment patches a "sonic net" played "pink noise" from sunrise to sunset, no sound was played in control plots. After 20 days each individual flower was re-measured for additional damage.

Results

"Sonic net" treatment significantly decreased the additional damage measured in treatment plots as compared to our control sites ($P < 0.001$). Overall we saw 64% less additional damage, or approximately 42.9 cm^2 reduction in additional area damaged as a result of the "sonic net" treatment. These data were analyzed using a linear mixed effects model where damage was predicted by patch type (control or treatment), time of estimate (before or after 20-day trial) with site and individual flower as random effects. There was no significant effect of patch type (control v. treatment) on baseline damage between plots.

We also find a significant interaction between damage estimate period and patch type, with an effect size of 42.9 cm^2 less damage in our treatment sites than control sites in damage estimates after 20 days. This equates to a 64% reduction in additional damage after 20 days as a result of the "sonic net" treatment. The magnitude of the effect also differed noticeably between sites. Site one had the highest amount of additional damage done to both the control (207.7 cm^2) and treatment (132.1 cm^2) patches, but on average 36% less additional damage was seen in the treatment patch. Site two had the second highest average damage dealt to the control patch (116 cm^2), and damage was functionally prevented in the control patch with an average of -7.7cm^2. In site three there was functionally no additional damage dealt to either the control (-0.9 cm^2) or the treatment (-5.8 cm^2). The same is true in site 4 with -3.0 cm^2 in the control and -1.8 cm^2 in the treatment. In site five, damage was again fully prevented in the control patch, with an average of 7.9cm^2 additional damage to the control site, but -1.9cm^2 damage in the treatment patch.

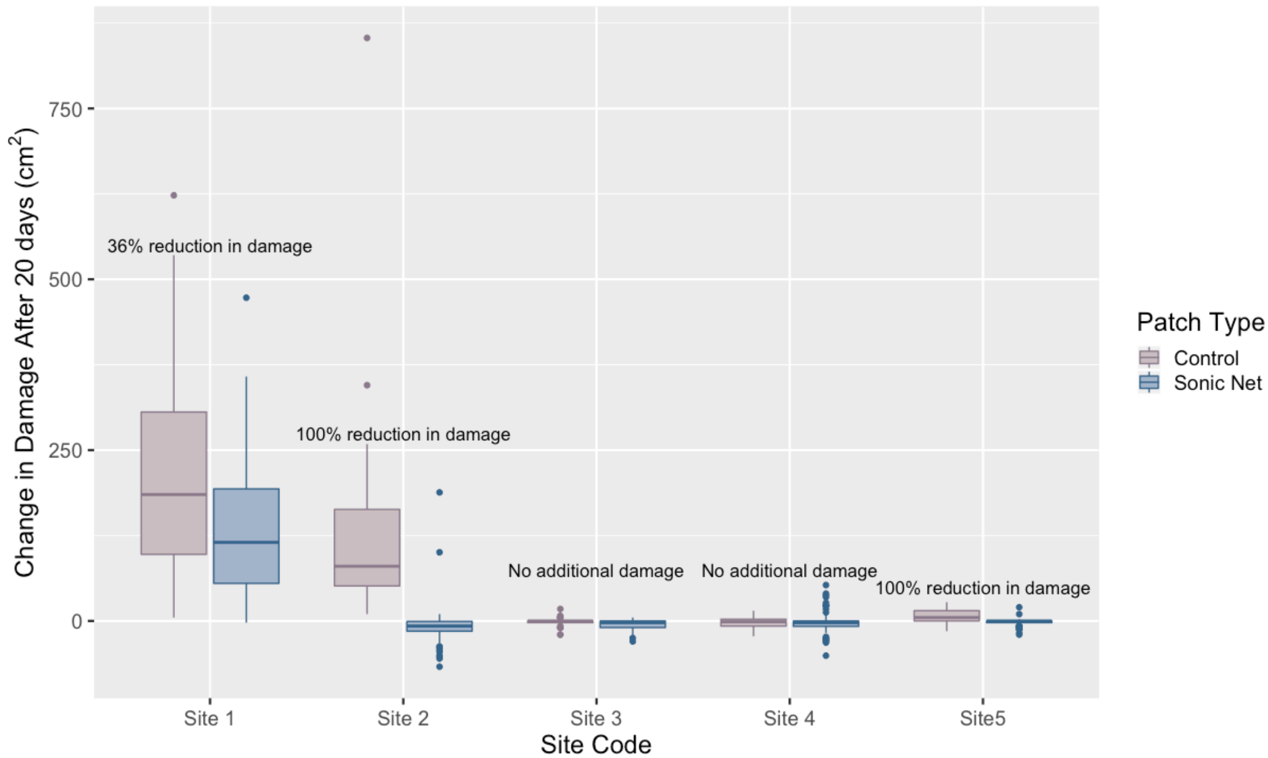

Figure 2. Effects of the "sonic net" across five sunflower fields. Data were collected from five different fields in North Dakota between August 25 and October 23. In each field, damage estimates were collected before and after a 20-day treatment window, during this time "pink noise" was played in treatment sites and no sound was introduced in control sites. The change in damage (damage after – damage before) is shown.

Discussion

Our results show that the introduction of communication masking noise produced by a "sonic net" is effective at preventing or reducing bird foraging in that area. Using additional damage as a proxy for bird abundance, we can presume that this effect also denotes a reduction in flock size or the amount of time individual birds were using these foraging patches. This is supported by observations in the field. We witnessed a black bird flock attempting to enter one of our treated sunflower patches, but upon descent the birds were deterred, hovering above the field before the flock split and settled into two sunflower patches outside of the half-acre treatment range. We believe that these results show strong support for the effectiveness of a "sonic net" in deterring species even from highly attractive habitat types.

It is also important to note that the magnitude of the effect of the "sonic net" differed greatly between fields. While flock size estimates were not explicitly recorded and thus, not able to be included in our model, we believe that this factor is important in interpreting some of the variation between sites, and should be included in further work. For the purposes of this analysis, we will discuss rough, relative estimates of flock size.

Site one had by far the largest flock size of any of our sites. Flock sizes in the local area were estimated to be well into the tens of thousands. In this site we saw our largest reduction in total damage between control and treatment patches, with $75cm^2$ less damage to the sunflower or approximately a 34%

reduction in damage. Birds continued to forage within the treatment patch despite our sound treatment, but at a reduced rate compared to our control site.

In the remaining 4 sites (2-5) flock sizes could be described roughly as "mid-sized" flocks, based on our observations. In site 2 and site 5, we saw low (7.9 cm^2) to intermediate (116cm^2) levels of additional damage to the control plots in these sites and no discernable additional damage to our treatment sites. However, in site 3 and site 4 no discernable additional damage was found in either control or treatment plots of these sites. There are a few possible explanations for this result. Sites 3 and 4 were the final sites of the season, and the experiments there in were run in October when sunflower are nearly ready for harvest and blackbird numbers in the region are starting to decline due to southward migration. The timing of these experiments may have contributed to these results. We know from previous work that blackbirds prefer to forage on sunflower in the soft seed stage, earlier in the seed ripening, and while the sunflower head is still green.[13] In both of these fields the sunflower seeds were very late in development and the heads were brown at the onset of experimentation. Both fields were harvested within hours or days of the conclusion of our experiment. It is also possible that the differences in the effect sites between all 4 of these sites (2-5) are due primarily to foraging patterns of flocks. We know that blackbird damage to sunflower fields is not uniform, but rather tends to be clumped and uneven.[12,14] Thus it is possible that these flocks were damaging other parts of these fields during all of these 20-day experimental windows, but by chance this damage did not occur in our control plots, making it difficult to discern if the "sonic net" would have had an effect. Overall, with no discernable additional damage in 4 of our 5 sites and a 34% reduction in damage in the remaining site we are confident in concluding that the "sonic net" is effective in reducing if not preventing bird use of a highly attractive food source, sunflower.

While these results are quite promising for application both in agriculture and aeronautics there are still many aspects of this research that warrant further study. A primary concern has to do with the scale of this experiment. In future work it will be important to determine if the effects seen in this study will hold true if this treatment is applied at a larger scale. In this research we looked only at half-acre plots that were nested within larger fields. Thus, the cost of relocating would be quite low for these individual blackbirds as there was an abundance of additional food just outside of the "sonic net" treated patch. We do not know if individuals will respond differently if the entire local food source were covered with the "sonic net" treatment, but we would predict that the response would be different in this scenario.

Another avenue for follow-up study in this research is an economic analysis for the application of this technology. This would require a cost and benefits analysis of the costs of implementing this technology at a site against the potential to prevent damage. In agriculture this will require an analysis of the value of damage prevented, the likelihood of blackbird flocks in the area, and the cost of set up and maintenance for producers. For example, this may be cost effective for producers that regularly grow crops in areas that put them at high risk for severe damage from blackbird flocks, but not in cases where flock presence is inconsistent between years or local flock sizes are small. We believe this analysis will be more straight forward in the aeronautic industry as the cost of bird-aircraft strikes can be astronomical with estimates ranging from $155 million annually in direct repair costs to upwards of $1.2 billion when considering indirect costs of delays and cancellations.[15,16] Thus, strategic application "sonic nets", especially to attractants that are difficult or impossible to remove, may be a feasible application for this technology and supplement other wildlife control methods already in place to reduce risks to airport safety.

Literature cited:

[1] Federal Aviation Administration 2007. Hazardous wildlife attractants on or near airports. Advisory Circular. 150. 5200-33B.

[2] JP Swaddle et al 2016. A sonic net excludes birds from an airfield: implications for reducing bird strike and crop losses. Ecological Applications. 26, 339–345.

[3] G Mahjoub et al 2015. Using a "sonic net" to deter pest bird species: Excluding European starlings from food sources by disrupting their acoustic communication. Wildlife Society Bulletin. 39, 326–333.

[4] B Lorh et al 2003. Detection and discrimination of natural calls in masking noise by birds: estimating the active space of a signal. Animal Behavior. 65, 763-777.

[5] TL DeVault et al 2017. Wildlife at Airports. WDM Technical Series. 1-19.

[6] AT Baxter and AP Robinson 2007. A comparison of scavenging bird deterrence techniques at UK landfill sites. International Journal of Pest Management. 53, 347-356.

[7] JWC Sun and PM Narins 2004. Anthropogenic sounds differentially affect amphibian call rate. Biological Conservation. 121, 419-427.

[8] K Yasukawa and WA Searcy 1995. Red-winged Blackbird (*Agelaius phoeniceus*). The Birds of North America. (available at https://birdsna.org/)

[9] SC Barras et al 2003. Blackbird and Starling strikes to civil aircraft in the United States 1990-2001. Proceedings of a special symposium of the Wildlife Society Annual Conference. 9, 91-96

[10] JA Leitch et al 1997. Economics of cattail (*Typha spp.*) control to reduce blackbird damage to sunflower. Agriculture, Ecosystems and Environment. 65, 141-149.

[11] DL Otis and CM Kilburn 1988. Influence of environmental factors on blackbird damage to sunflower. Fish and Wildlife Technical Report. 16. 1-9.

[12] RA Dolbeer 1981. Cost-benefit determination of blackbird damage control for cornfields. Wildlife Society Bulletin. 9. 44-51.

[13] JL Cummings et al. 1989. Chronology of Blackbird Damage to Sunflowers. Wildlife Society Bulletin. 17, 15-52

[14] ME Klosterman et al. 2013. Comparisons between blackbird damage to corn and sunflower in North Dakota. Crop Protection. 53, 1-5.

[15] RA Dolbeer 2013. The history of wildlife strikes and management at airports. Wildlife in airport environments: preventing animal-aircraft collisions through science-based management. John Hopkins University Press. 181-188

[16] JR Allan and AP Orosz 2001. The costs of birdstrike to commercial aviation. 2001 Bird Strike Committee-USA/Canada. 3, 218-226.