# Sound Pollution and it's Impact on Bird Behavior

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Sound Pollution and Its Impact on Bird Behavior

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**Abstract**

One effect of urbanization is a drastic increase in sound pollution, but very little field research has been conducted to determine the impact of sound pollution on wild organisms. Sound pollution is expected to impact organisms that rely heavily on vocalizations, such as birds. We investigated how sound pollution impacts bird behavior. To observe how behavior is affected by sound pollution, we utilized a local forest patch bordered on one side by a highway and on the opposite side by a typical suburban neighborhood. We established one bird feeder by the highway (high disturbance: HD), where sound pressure levels exceeded 80 decibels, and a second feeder on the neighborhood side (low disturbance: LD), where the average noise level was 57 decibels. Both sites were monitored for approximately two hours every morning for 10 weeks. Birds were identified by species through analysis of video taken during the two hours. A total of 247 bird visits were observed, with 230 occurring at the low disturbance (LD) feeder and 17 at the high disturbance (HD) feeder. At the LD feeder, 12 species visited while only 4 species visited the HD feeder. There was a significant relationship between level of disturbance and behavior. Future analysis will further characterize the impact of sound pollution on specific bird behaviors.



**Part 1**

The acceleration of urbanization has important consequences for native wildlife populations. A primary effect of urbanization is the increase in road construction. Currently in the United States, there are approximately 4.12 million miles of roads

(https://www.artba.org/about/faq/) and in Pennsylvania there are about 120,527 miles of highway (PA Highway Statistics, 2017). Although there are many impacts of roads on natural populations, one aspect that extends beyond the edges of the roadside is noise pollution. Depending on the type of surface and the vehicle used sound pollution can vary (Table 1). Hard surfaces, such as macadam produce greater levels of sound pollution (The Pennsylvania CODE).

Table 1. Vehicle type and decibels produced depending on surface and speed (The Pennsylvania CODE).

| | Soft Site | | Hard Site | |
|---|---|---|---|---|
| Vehicle Type | 35 mph or less | Above 35 mph | 35 mph or less | Above 35 mph |
| 6,000 lbs or more | 86 | 90 | 88 | 92 |
| Motorcycle | 82 | 86 | 84 | 88 |
| Any other vehicle | 76 | 82 | 78 | 84 |

There is also noise produced naturally. This natural noise can come from creeks, wind, and animals. In Berks County the natural sound pressure is approximately 37-40 decibels (Brilliant Maps: Figure 1). The Occupational Safety and Health Administration (OSHA) permits workers to be exposed to 90 dBA for 8 hours and 105 dBA for 1 hour (OSHA: Permissible Noise Exposures). These exposer levels are based on the sound pressure humans can be exposed to over a certain period of time before hearing loss and damage occurs. Because there are a variety of factors that go into the creation of sound pollution, some research has studied sound pollution as a gradient.

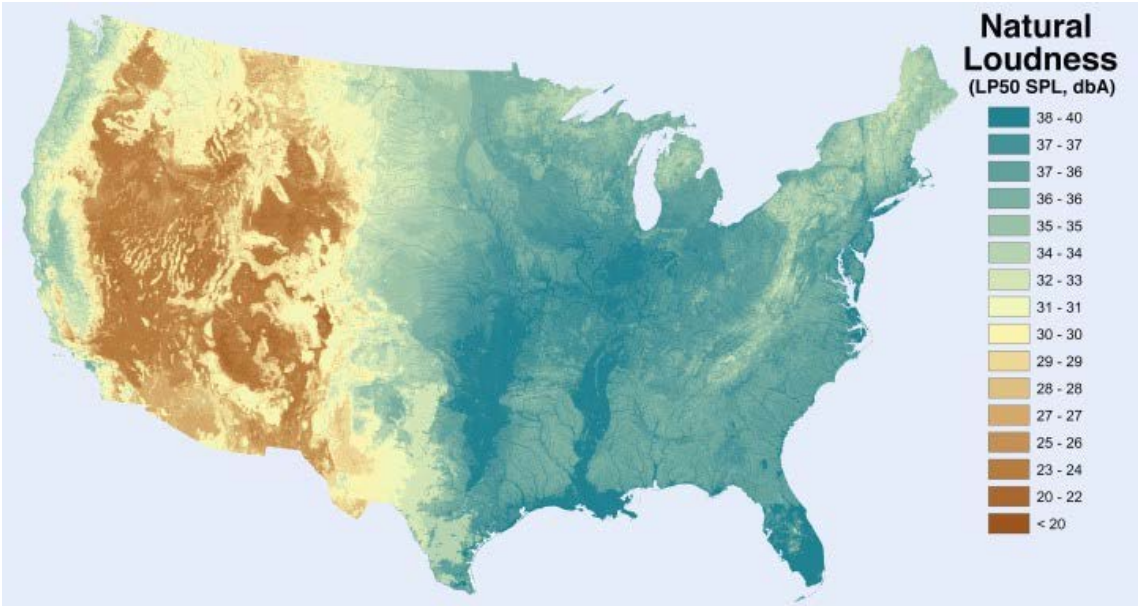


Figure 1. Map of the United States color coded based on the natural loudness (Brilliant Maps).

Utilization of gradients to study sound pollution has been conduction frequently when observing how sound pollution impacts vocalizations of birds. This is because birds use sound to attract mates, claim territory, and sound alarms. Birds are a good indicator species because they react to environmental pressures easily and their presence or absence can indicate habitat quality. They are also good indicators because specimen collections can be noninvasive through the collection of eggs, feathers or blood (Guigueno and Fernie, 2017). Birds can also be found in a majority of different habitats which make them a good study subject in observational studies.



Primarily, studies focus on the rural-to-urban gradients and how they influence bird song. One hypothesis that has been tested is, that increased ambient noise is advantageous to birds that learn their songs relative to birds with innate songs. Species that exhibit song plasticity have a better advantage in urban habitats because they are able to adjust their song frequencies so that their songs are not masked by traffic (Ríos-Chelen *et. al*, 2012). Song plasticity is where birds have the capability to change their songs. Birds that have songs higher in pitch frequency

compared to traffic are less susceptible to noise pollution (Rheindt 2003). Additionally, species that produce songs with intermediate frequencies are better able to increase the frequency of their song more than those species with low or high frequencies (Hu and Cardoso, 2010). This is beneficial to these species because they are better able to communicate which allows them to inhabit a habitat that is not necessarily ideal (such as urban areas as well as those near high trafficked areas). Another adaptation some birds exhibit is increasing the amount of vocal activity in response to anthropogenic noise. Serins (*Serinus serinus*) increase the amount of time spent singing as sound pollution increases, however when sound pressure levels exceed 70 decibels they stop singing (Díaz *et. al*, 2011). This indicates that at some point the costs of singing out weight the benefits. This could be due to the fact that while singing is important for claiming territory, attracting mates and alerting others to danger, singing is also metabolically costly. When birds have to compete with sound pollution to send these signals, it becomes energetically expensive to do so and so they will stop singing when it exceeds a certain sound pressure level. In European Starlings (*Sturnus vulgaris*) a 16 decibel increase in sound pressure was found to cause an increase in the rate of oxygen consumption by 1.16 times (Oberweger and Goller, 2001). Some birds also adjust when they are singing their songs so as to avoid singing during times were there is greater amounts of noise pollution. Birds that lived closer to airports started singing their songs much earlier than those that did not live near airports (Gil *et. al*, 2015). This mechanism to avoid anthropogenic noise can be both beneficial and harmful to those individuals. It can be beneficial because they might be better heard but it can also harm them because they are active longer so there are energy costs associated.



While senders are able to adjust the frequency, or time of their vocalizations the ability of the receivers to understand the call is also important. In a study by Luther and Magnotti (2014),

male northern cardinals (*Cardinalis cardinalis*) responses to normal frequencies were stronger than those with shifted frequencies. Because of the preference for songs of normal frequency and the stronger response to them, the altered songs used to avoid sound pollution can alter the community composition and impact survival rates. These altered songs can change the community composition by causing males to be less vigilant defending their territory when a bird with a shifted frequency is present and could impact reproductive success. A study on mammals found that forager vigilance was positively impacted by traffic noise (Kern and Radford, 2016). While this study looked at mammals, the behavior of foraging occurs in birds as well and therefore it is possible that birds would also experience this effect.

Sound pollution also impacts other types of behaviors that bird's exhibit. While some birds do not necessarily alter their vigilance or roosting behavior, fewer predators have been observed near anthropogenic noise, which provides protection (Yorzinski and Hermann, 2016). Other studies indicate that traffic noise can impact diversity and community composition, decreasing species richness and diversity (Rheindt, 2003, Herrera-Montes and Aide, 2011). Establishment of a phantom road, where noise playbacks were utilized by a migration route, caused a decrease in abundance in approximately a quarter of the species along the phantom road, and two species completely avoided it (McClure *et. al*, 2013). This is important because it shows that roads influence the distribution of some bird species.



Avoiding predators is a major component of survival. If anthropogenic noise decreases the ability to perform antipredator behavior then survival rates would decrease. As noise increases, individuals of some species decrease the distance between themselves and their neighbor. This increases density, and this behavior is similar to those expressed in high-risk situations, such as when a predator is nearby (Owens *et. al*, 2012). In house sparrows (*Passer*

*domesticus*), flushing response increased when birds were exposed to noise pollution (Meillere, *et. al*, 2015). These types of behaviors could be due to increased vigilance caused by the decreased ability to detect actual predators due to anthropogenic noise.

Another impact of anthropogenic noise, is a reduction in reproductive success. Some birds, such as ovenbirds (*Seiurus aurocapilla*) have experienced decreased pairing success due to sound pollution. In part this is due to females choosing better quality territory over higher quality mates (Habib *et. al*, 2007). This can be harmful for the species and can led to decreased overall fitness. Other studies have found that traffic noise decreases the ability of parents to identify when nestlings are hungry and nestlings also fail to recognize when a parent has returned to the nest (Lucass *et. al*, 2016). This causes nestlings to be smaller and have higher oxidative stress compared to normal. Chicks also took a longer time to fledge but success did not seem to be affected (Injaian *et. al*, 2017). In nestling exposed to greater amplitudes of noise, telomere attrition was greater (Injaian *et. al*, 2018). This negatively impacts survival due to premature senescence and can have severe consequences for the population. Because noise pollution increases developmental stress this could cause problems later on for birds. One such problem is the ability to learn songs, when birds experience greater developmental stress they do not develop the ability to perform the correct songs. This influences their ability to attract mates later on in life (Spencer *et. al*, 2004). However, while there are many negative repercussions of noise pollution there are some positive attributes that anthropogenic noise can have on bird communities.



Because noise decreases the amount of species richness, it allows for varying avian communities to arise that would otherwise not be present (Francis *et. al*, 2009). Noise pollution from roads can also provide a different type of foraging habitat and decreases predation. Some

species can utilize roads as a heat source to conserve energy. Predatory birds can use structures along roads as perches to scout for prey and some species can use human structures for nesting sites (Morelli *et. al*, 2014). While these are all examples of how roads can be beneficial to birds there have been very few studies to test the potential benefits of roads and whether some species have adapted to utilizing human structures for their benefit. If some bird species have adapted to using human structures, it is important to understand how they utilize the structures and identify how these species are different from those that have not adapted.

While the majority of studies have looked at the impact of sound pollution on vocalizations or reproductive success, it is also important to understand how noise pollution impacts or influences behavior. The proximate cause of increased sound pollution might be changes in vocalizations and decrease in reproductive success, however the ultimate cause is likely liked to changes in behavior in response to increased noise. By understanding how anthropogenic noise alters behavior in birds we can better understand how excess noise impacts humans. Studies focusing on the impact of noise on humans have mainly looked at the health consequences. Noise has been found to be a stressor which impacts the automatic nervous system and the endocrine system (Geravandi *et. al* 2015). However not many studies have look at how these physical symptoms caused by sound pollution impact behavior. By using birds as indicator organisms, we can draw connections as to how human behaviors might be altered by excess and increased noise.



**Part 2**

**Project Introduction**

Urbanization causes increased sound, light, air, and water pollution. Most research has focused on how air and water pollution impact organisms, but there has been very little research regarding the impact of sound and light pollution on wild populations. Most of the research that has been conducted has been in experimental settings, because it is difficult to isolate noise or light as a single testable variable in nature but results of these studies show that both light pollution and sound pollution impact the reproductive success and behavior of those organisms tested (Ortega, 2012). By understanding how disturbance impacts species interactions, management plans can be better designed and can influence conservation efforts.

Birds are a good indicator species because they can be found in a majority of different habitats. In Pennsylvania there are currently 429 species of birds that are considered class 1, meaning that the species have been documented as being present in Pennsylvanian through an identified specimen (Pennsylvania Ornithological Records Committee). In areas that were disturbed by either grazing or logging there was a significant decrease in the abundance of birds and species richness (Dahal *et al*., 2014). This is comparable to what happens when urban sprawl overtakes nature, and these ecological changes were observed without any other anthropogenic changes such as increased light or sound. Loud natural sounds such as streams, waterfall, and wind have always been part of the environment, but noise pollution in urbanized areas has escalated over the past few decades, disturbing the integrity of natural ecosystems (Ortega, 2012). In Puerto Rico anuran and bird communities near roads had lower levels of species richness and varied in community composition (Herrera-Montes and Aide, 2011). The effect was most pronounced in birds, which were much more vocal during the day and during high traffic times (Herrera-Montes and Aide, 2011). The decrease in community composition and species richness is likely due to the increased metabolic cost necessary for birds to compete with

anthropogenic noise (Oberweger and Goller, 2001). Rather than compete with the noise, birds are more likely to avoid those areas. These changes in behavior can have negative repercussions such as decreased reproductive success and decreased ability to perform antipredator behaviors. However these changes in behavior in birds can also cause negative impacts on other species such as mammals and plants. For example, when birds were introduced to human foods, the introduced food altered the birds' behavior and decreased the amount of native plant species and the dispersal of their seeds (Vasconcellos-Neto *et al.*, 2015). This indicates that not only does urbanization influence behaviors of bird species, but it also impacts the native plant populations.

**Goals and Hypothesis**

We believe that sound pollution will cause birds to become less aggressive and alter their social structure due to their decreased ability to identify one another based on song. We also hypothesized that birds at the low disturbance site on average would spend a longer amount of time on the feeder, due to their ability to better distinguish sounds.

**Material and Methods**

Study Area



The study was conducted on Albright College property. We were interested in observing activity localized around two feeders, located in similar habitats differentiated largely by ambient noise. The "high disturbance" (HD) feeder was located at the northern edge of Albright's campus, along the hedge line that separated the Albright Woods apartments from Route 12. The "low disturbance" (LD) feeder was located in the norther hedge line in the backyard of one of Albright's affinity houses, which separates the yard from Albright woods (Figure 2). Feeders

were approximately 400 meters apart and had similar vegetation due to previously being a part of the same wooded area.


Figure 2. Map of feeder locations in relation to the Albright Campus (HD- high disturbance, LD- low disturbance).



Data Collection and Video Analysis

Every morning around 06:00 video cameras were set up and feeders were recorded for about an hour. Extech Instrument Digital Sound Level Meters were hung underneath the feeders and recorded minimum and maximum sound level pressures during the video. Trail cameras, placed on posts approximately 5 meters from the feeders, were used to record movement around the feeders to determine if there were times of the day where activity might be greater. Videos were viewed using VLC media player and bird species that landed on the feeders were identified

using Sibley (2014), and sex was determined if species were sexually dimorphic. Because we could not distinguish if they same birds were coming to the feeders multiple times we counted the number of visits rather than the number of birds.

Categorization of Behavior

Behavior was analyzed while watching the videos. The primary behaviors we identified were avoidance, which was when a bird on the feeder would leave due to being disturbed by another bird fly by or landing on the feeder. Calling, we classified as anytime a bird on the feeder made a vocalization. Feeding, was anytime a bird picked up feed in their beak. Perching was anytime a bird landed on the feeder and stood there for a second or more and scouting was when a bird would hop around the feeder looking around. Other behaviors noted, such as begging, preening, crop sharing (adults feeding juveniles), mating behaviors and aggression were grouped into the category 'other'. We also recorded how long each bird stayed on the feeder.

**Results**

At the high disturbance site, sound pressure levels exceeded 80 decibels at times and at the low disturbance site the average noise level was 57 decibels. We had a total of 230 visits at our low disturbance feeder and 17 visits at our high disturbance feeder. The majority of visits to both feeders were *Carpodacus mexicanus* (House Finch). The low disturbance feeder had a total of 12 species visit and the high disturbance feeder had only 4 species visit (Table 2). Species that visited the high disturbance feeder were also present at the low disturbance site. Disturbance and behavior have a relationship ($df = 1$, $p = 0.00885$; Figure 2). Species and behavior also have a relationship, however species and disturbance have no relationship. Birds spent an average of 4 minutes 25 seconds at the HD feeder and 3 minutes and 49 seconds at the low disturbance feeder.

There was no significant difference between site and time spent on the feeder ($p = 0.5679$, $t = 0.5805$; Figure 4).

Table 2. Species list of all of the birds that visited the feeders, with number of visits of each species and percent of visits identified.

| Species | Low | % visiting LD feeder | High | % visiting HD feeder |
|---|---|---|---|---|
| *Carpodacus mexicanus* (House Finch) | 176 | 76.52 | 11 | 64.71 |
| *Molothrus ater* (Brown headed cowbird) | 17 | 7.39 | 4 | 23.53 |
| *Melospiza melodia* (Song Sparrow) | 14 | 6.09 | | |
| *Dumetella carolinenis* (Gray Catbird) | 8 | 3.48 | 1 | 5.88 |
| *Cyanocitta cristata* (Blue Jay) | 2 | 0.87 | | |
| *Thryothorus ludovicianus* (Carolina Wren) | 2 | 0.87 | 1 | 5.88 |
| *Passerina cyanea* (Indigo Bunting) | 2 | 0.87 | | |
| *Carinalis cardinalis* (Northern Cardinal) | 3 | 1.3 | | |
| *Poecile atricapilla* (Black-capped Chickadee) | 2 | 0.87 | | |
| *Carduelis tristis* (American Goldfinch) | 2 | 0.87 | | |
| *Troglodytes aedon* (House Wren) | 1 | 0.43 | | |
| *Passer domesticus* (House Sparrow) | 1 | 0.43 | | |
| Total | 230 | | 17 | |

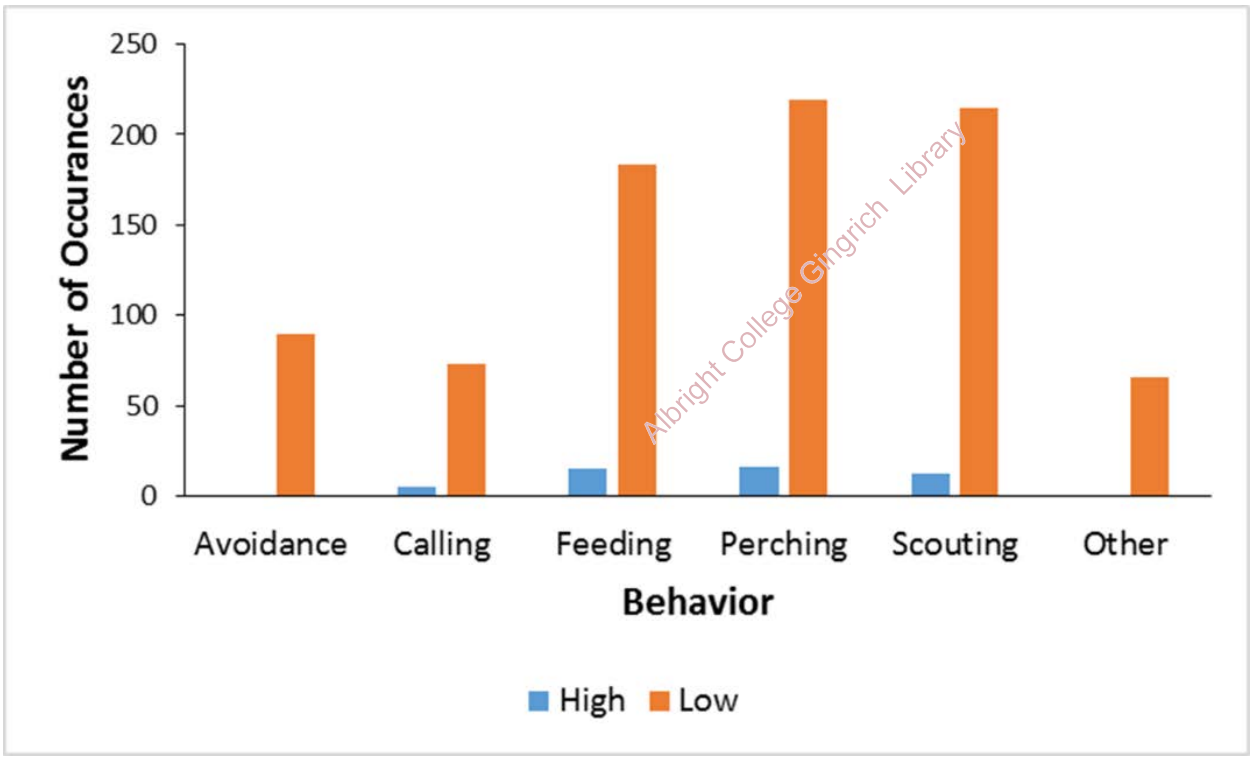

Figure 3. Relationship between behavior and disturbance.

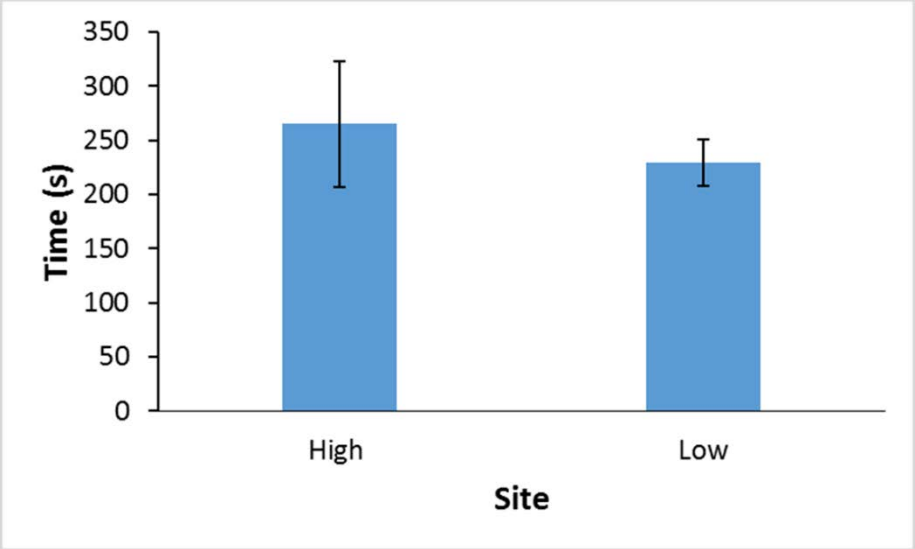


Figure 4. Average time spent of feeders at both locations (HD and LD), including standard error.

**Discussion**

While the majority of studies on birds have focused on how increased sound pollution impacts vocalizations there have been some studies that have looked at how urbanization influences reproductive success and behavior. Previous studies (Dahal *et. al* and Herrera-Montes *et. al*) have suggested that urbanization decreases bird species richness and abundance. Similarly, our results indicate that there is a greater abundance and richness of bird species which visit the low disturbance site compared to the high disturbance site. We also found a positive relationship between behavior and disturbance. This could be because at low disturbance sites birds are better able to hear what is around them and so they feel comfortable performing other behaviors, such as preening or exhibiting mating behaviors. It is also possible that at the low disturbance site, there were more birds present on the feeder at the same time and so birds exhibited more avoidance behavior due to being chased off the feeder. While birds at the high disturbance site, spent more time on average on the feeder than birds at the low disturbance site, there was no

significant difference between the two groups. These results could be due to the fact that our sample size at the high disturbance site was very low. It could also be because at the low disturbance site, more birds were present on the feeder, increasing competition and so birds were being chased off.

In summary we show that urbanization does impact the number of bird species present. Birds favored the low disturbance site, as measured by species richness and number of visits. These results are similar to those found by Herrera-Montes and Aide (2011) and Dahal *et. al* (2015), which found that roads caused decreased species richness and abundance. There was a significant difference between behavior and disturbance. This indicates that urbanization influences birds to alter their behavior to compensate for the decreased ability to hear what is around them.

**Part 3**

Analysis of Research and Literature

The majority of research on noise pollution focuses on how birds alter their vocalizations and have reduced reproductive success due to increased sound. The purpose of the study was to expand upon the limited amount of research looking at the impact of sound pollution on bird behavior. Our study looked at common behaviors that birds express and how they might vary depending on noise levels. Looking at how normal behaviors in birds are influenced by sound pollution we might be able to identify similar trends in people. This is important because if humans are impacted by noise pollution, steps should be taken to minimize the amount of sound pollution created.

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