THE EFFECT OF ANTHROPOGENIC NOISE ON VEERY SINGING BEHAVIOR

OLIVIA SANTANA
Calvin College, Grand Rapids, MI 49546USA

MENTOR SCIENTISTS: DRS. KARA BELINSKY AND KEN SCHMIDT
Texas Tech University, Lubbock, TX 79409 USA

Abstract. Acoustic competition occurs when one sound causes a break in communication between two organisms. There are many noises that cause interference and multiple organisms can be affected. For birds, their song is a vital source of communication for mating, protecting their territory, and alerting others of danger. In this study, we examined competition in Veery (*Catharus fuscescens*) songs due to anthropogenic noises such as traffic. We hypothesized that traffic would shorten song length and affect song frequency. Songs were recorded near 3 different categories of noise: traffic areas, a natural creek and quieter woodland areas. The files were analyzed and the best files were chosen based on song quality and amount of data. Trends indicated that the Veery song length could be affected by traffic noise. With these findings, preservation efforts, such as buffer zones, could reduce impacts of acoustic competition in Veeries and other species.

INTRODUCTION

In 2007, over 254 million cars traveled the roadways of the United States and the numbers only continue to increase. Road systems are a major part of our country and although people may think the amount of time they drive leaves no effects, all areas of roadway, from major cities to rural suburban areas suffer a consequence of these actions. One of the results of so many vehicles traveling is an increase in noise. Roads may vary in the amount of noise and the consistency of the noise depending on the number of vehicles traveling over a certain area of road. If these roads are located close to natural areas, the noise levels can cause acoustic competition affecting the communication of organisms. Acoustic competition occurs when one sound interferes with another sound being heard, causing a break in communication.

Communication is a vital ability for all organisms. It is the basis for many interactions between animals (Brumm 2009). Just like humans, animals use sounds to send and receive information from each other. This information may involve finding a food source, alert about a nearby predator, attracting a mate, or defining territory. If these interactions are interfered with and can no longer be sent, the receiver of the information suffers the consequence. If attracting a mate is the intended message but that message never gets to the female, her sexual productivity could decrease creating an effect on the population size overall.

Sometimes communication is interrupted by interference from other noise. This dilemma is referred to by Bee (2008) as the "Cocktail party problem" - described as the problem of communicating in a loud setting, such as a party, and trying to hear what one person is saying over all the other background noise. This situation is difficult due to the fact that different organisms' signals overlap in frequency and in time causing acoustic interference and masking which can alter the signals being sent. Many animals that live in noisy environments face these same problems (Bee 2008). The sound of water running along a creek, or of birds chirping, or squirrels chattering in the yard are just a few of the many noises that regularly reach our ears. However, there are many noises that humans create, both consciously and unconsciously. Whistling to hail a taxi in the city attracts the attention of the driver, but may interfere with the conversation of people around you. Anthropogenic noises, especially traffic noise, affects how other organisms such as birds and frogs are able to communicate (Cunnington 2010). In the same way a person will pause a conversation when walking past a rumbling train, other organisms also avoid situations where communication is difficult (Klump).

Birds use their songs in order to defend territories and attract mates (Halfwerk 2010). Traffic noise can create acoustical interference impacting reproductive success. Halfwerk (2010) found that female Great Tits laid smaller size clutches and had fewer fledged chicks in noisier areas. One explanation given for this result is females choosing lower quality males due to interference with song-based assessment of traits. Slabbekoorn (2007) found lower species diversity and lower breeding densities of birds along highways. This could be due to the behavioral alterations birds make in noisy environments, such as looking up more to guard against predators which comes at a cost to the amount of time spent feeding. When a message is sent from one organism, other noise can make it lose some of its quality and it could be misinterpreted by the recipient (Luther 2007, Slabbekoorn 2007).

The Veery (*Catharus fuscescens*) is a species of Neotropical migrant that travels from Brazil to the north and northeast regions of the United States for their breeding season from May until September. Over half of the Neotropical bird populations have decreased due to a number of factors (Kociolek 2011). Roads can be threats to bird survival. Although roads tend to increase availability of nesting sites and food sources by providing edge territory for birds to nest in and extra sources of nutrients and food types with a variety of habitats present, they can also be a source of habitat loss and mortality due to collisions with vehicles. This is especially true during seasons of breeding and migration (Kociolek 2011). This causes a decrease in biodiversity (Slabbekoorn 2007, Verzijden 2010, Goodwin 2010). The Veery population is on a slight decline (Kociolek 2011); conservation efforts to protect declining species from disappearing need to be taken. When noise from another source interferes with the Veeries singing their song, communications cannot occur, leading to no mating.

In this study, we investigated whether Veery singing behavior was affected by acoustic competition. We measured the length of Veery songs and the rate of singing in areas where acoustic interference from anthropogenic noises, specifically traffic noises, were present. These areas were then compared to areas of natural woodland noise and areas with noise from creeks. Predictions were made for each of the following three noise categories.

We hypothesized that shorter songs sung more often to be heard in areas with traffic noise. This predicts that where traffic noise is present, Veeries will increase the amount of energy used to communicate and thus habitats near traffic noise areas would not be prime habitats for Veeries. The roads studied have a fair amount of traffic, but not as much as a highway or city roads do. A highway will have a low constant hum of traffic where as less traveled roads contain a sporadic zoom of traffic. This sporadic traffic flow creates a Doppler Effect as each car passes by. This Doppler Effect creates spaces of silence between traffic noise intervals. If Veeries sing shorter songs in between the cars, the percentage of songs successfully communicated to the receiver will increase due to less interference than on a busier road.

Creek noise is predicted to have the same length songs as the woodland areas, but songs will be sung at a higher frequency. This change in frequency could be seen in one of two ways. First, it could be a change in the overall frequency in the song, meaning the birds shift the pitch at which they sing the entire song in order to avoid interference. Alternatively, Veeries could raise just the high or low frequency of their song in order to avoid overlap with certain acoustic competition while staying partly within their normal range. Water has a broad range of frequencies while traffic produces a low frequency noise (Goodwin 2010). Thus it will be more likely for the frequencies of the bird’s song and the water noise to naturally overlap and thus need to be slightly altered for better communication.

In areas of woodland noise, we predicted songs to be sung at a longer length but less often than songs sung in the traffic areas recordings. The least amount of noise is present in woodland areas, presenting the most opportunities for the Veery to have successful communication with the first attempt. Each song that is sung requires an energy sacrifice, fulfilling a vital communication need but at a cost. If a slightly longer song sung once can be communicated efficiently without needing to be repeated, the Veery would be able to conserve energy to invest in reproduction or foraging.

METHODS

Field Sites

Research occurred at the Cary Institute of Ecosystem Studies in Dutchess County, Millbrook, New York, USA. The approximately 325 ha of Cary Institute property is dominated by a second-growth oak and maple forest with paths, trails, and ephemeral wetlands throughout. We recorded Veeries naturally singing at three categories of locations: areas near traffic, areas near a water source, and areas of natural woodland noise. The sources of traffic used were the Taconic State Parkway, Route 82, and Route 44 which surround the property. On average, 9528 cars per day drive on the segment of the Taconic State parkway surrounding the Cary Institute property while 4999 cars travel along the Route 82 segment and 10407 drive along the Route 44 segment. The water sources used were various locations along Wappingers Creek, which runs through the Cary property and Knapp Road Creek. The woodland noise was recorded in natural forest area not located near any major roads or water sources. See Figure 1.

Experimental Design

Song Recordings

We recorded from May 19 – June 30, 2011 during the morning, which included the hours of 5am – 11am. Each recording was 2-3 minutes in length. Recordings were taken using a Telinga parabolic reflector, a Sennheiser MKH 62 microphone, and a Marantz MPD 660 digital recorder (sampling rate of 44.1 kHz, bit rate of 705.5 kbps). During recording, the gain settings ranged from 4 to 6. A focus on good quality recordings taken close to the bird was emphasized, but was a challenge to accomplish due to the cryptic and shy nature of the subjects. We took a GPS point at each location using a Garmin eTrex Legend C. Seventeen of the best recordings were selected based on highest song quality as shown on a sonogram and the number of songs the file contained (minimum = 8, maximum = 29). Using screen shots of the songs and the GPS points, we made comparisons between files to ensure that each was of a separate Veery male. All of the traffic recordings were taken 83 to 591 meters from the traffic source. All of the water recordings were taken 33 to 92 meters away from the water source. The total sample size equaled 17: 6 birds located in traffic areas, 5 birds located in water areas, and 6 birds located in woodland areas. Although this is a small number of replicates, this was a preliminary study, allowing for the limitations presented.

Background Recordings

Due to the range in gain used above, on a later date, we also recorded a standard background sample at each of the locations of the analyzed files. The standard background recording was taken in order to have a standardized sample of what a constant level background noise with no bird songs present sounded like. For each recording, the gain was set at 5 and a 2-minute sample, the approximate length of the birdsong recordings, was taken.

Transect Recordings

We recorded transects on July 21-23, 2011 from 7am – 11am. A 2-minute sample of the background noise was collected starting at the source and moving into the forest in 10 meter increments. We recorded samples to 260 meters. Areas chosen were relatively flat and similar in topography; however, a few small hills were present in both transects. All hills started after the 50 meter mark.

Each transect started at the source of the noise (i.e. the road and the creek) and moved inward into quieter forested areas. As the distance increased traveling away from the noise source, the level of noise present decreased, showing that the farther into the forest you moved, the quieter it was. Using the data collected, a buffer zone was calculated. This buffer zone can be used for environmental protection purposes, as it tells the area in which there is a higher level of noise than the control of the quieter woodland forest.

Data Analysis

We analyzed files as sonograms using Raven Pro 1.4 (Cornell Lab of Ornithology). Data measurements included: begin and end time (s), delta time (s), high and low frequency (Hz), delta frequency (Hz), and average power (dB). All calculations were done using Microsoft Excel.

Song Recordings

Within each file, a box was drawn around each song. After each box was drawn the measurements selected were made and data was entered into a selection table. After all the songs from that file were committed, each selection table's contents were copied into an excel spreadsheet and saved. This was done for all the files.

Background Recordings

The background sound was analyzed in two ways.

First, the song files were used. For each song that had already been boxed, an identical box of equal size was created directly after each song. If there was not enough room following the song before the next song started, the box was made directly in front of the song instead. The selection table was copied into a different excel sheet for later use. This was done for all the files.

Second, the background files which had been recorded at a later date were analyzed using the same measuring scheme as the transect recordings. This scheme was used on each recording.

Transect Recordings

For each file in both the creek and the traffic transects the following scheme was used to box data. Boxes were drawn 1.7 seconds in length, the length of the average Veery song. They were drawn from a height of 0-16 kHz. From the end of one box to the beginning of the next box there was a 4-second gap. There were 16 boxes made in each sound file. The first box typically began at two seconds unless a spoken introduction with background information on location was still occurring on the file. Then boxes began at the first second after the vocal instructions.

Statistical Analysis

For each file, the data was averaged. The data for all the song files within each category was then averaged. These averages were used to calculate statistical significance. Statistics were first calculated in Excel using the ANOVA test. We used JMP 5.0 software for MAC (SAS Institute) to run two-tailed t-tests and non-parametric Kruskal-Wallis tests.

RESULTS

The 17 Veery song files had an average length of 1.7 seconds per song. The song length did not differ between the three categories of noise (ANOVA one-factor: df = 2,14, f-ratio = 1.32, p-value = .30). Trends are present (Figure 2) that the Veery song length in traffic areas was slightly shorter than in woodland areas; the difference is not statistically significant, but there could be a correlation (T-test: df = 10, f-ratio = 2.23, p-value = .17).

To ensure that the three categories were designated without a bias in each, the background song samples were tested for significance within each category. This ensured there were no misfit files that would have caused skewed data within each of the categories. Tests run on the files within each category showed no statistical significance (ANOVA: Single Factor - Traffic: df = 15, 80, f-ratio = .22, p-value = 1.0; Water: df = 15, 64, f-ratio = .65, p-value = .82; Woodland: df = 15, 80, f-ratio = .53, p-value = .91). Statistical tests comparing the three categories showed statistical significance (ANOVA: Single Factor: df = 2,14, f-ratio = 16.48, p-value > .001). Thus showing that the each category of noise lacked outliers and that the traffic, creek, and woodland areas where files were collected were distinctly different and should be distinguished as separate categories.

The delta frequency (Figure 3) at which the songs were sung did not differ between the three categories of noise (Anova: Single Factor: df = 2,14, f-ratio = .42, p-value = .67). In comparing the high frequency and low frequency among the traffic, creek, and woodland noise, we detected no statistically significant difference between the three categories (Low Frequency = ANOVA one factor: df = 2,14, f-ratio = 1.19, p-value = .33; High Frequency = ANOVA one factor: df = 2,14, f-ratio = 1.28, p-value = .31).

The transect files (Figure 5) showed a significant trend in the data. A regression test showed a correlation between distance from the sound source and the amount of noise heard (Regression ANOVA: df = 1, 25, f-ratio = 61.46, p-value = 3.4E-08).

DISCUSSION

Trends in our data showed that Veery song length may shorten in traffic noise areas. This supports our hypothesis that traffic noise would affect the Veery song length, making it shorter. The hypothesis that the frequency of the Veery song would be higher in areas of traffic or woodland noise was not supported. The declining Veery population could be detrimental to the balance of the ecosystem as Veeries are insect eaters and disperse seeds.

At our study site, we found that trends suggest there may be a correlation between traffic noise and the length of the Veery song. Due to a relatively low sample size, this trend was not statistically significant. However, this trend could be biologically significant in affecting the mating signals and, ultimately, mating success of Veeries. Further research could show other aspects of biological significance and help to make further correlations.

In looking at the frequency of the songs (Figure 3), there was no statistical significance found between the noise near traffic, water, or in natural woodland. This could be due to the fact that the frequency range in which the Veery sings does not overlap very much, if at all, with the frequency of the traffic noise. The delta frequency for the creek noise was lower than for the traffic noise or the woodland noise (see Figure 2). This could be due to the fact that water has a broader range of frequency than woodland or traffic noise. Traffic noise has a low frequency band and natural woodland noise has a higher band while stream noise has a wide band that would overlap both. In comparing the high and low frequencies between the traffic noise, creek noise, and woodland noise (Figure 4), there was no significant change. This indicates that Veeries do not change their frequency in order to increase their communication with other species.

The song length data shows trends suggesting that the louder a noise is in an area, the shorter the song length. These trends are seen in figure 2 as the bars indicating the length of the song increase from left to right. There was no statistical significance present; one possible explanation for this was starting recording toward the end of the season resulting in only a small sample size to be collected. With a larger sample size and more analysis it is possible that the significance would be different.

Another factor in the length of the Veery song is the type of traffic noise. The roads studied have a medium amount of cars traveling on them; however, they are not as busy as a highway or city roads. Therefore, a low constant rumbling of traffic is not heard, but a more sporadic noise level is created due to the Doppler Effect, which occurs when a noise increases as an object gets closer and fades as it moves away. The breaks between cars traveling on the road allow birds the opportunity to sing opposite the anthropogenic noise and thus increase the odds of their songs being communicated efficiently.

Since the Veery, and many other bird species found in this area are migratory birds, the noise level of the forest is variable depending on the time of the year and the stage of the breeding cycle. The transect and background noise recordings were taken at a later time than the bird recordings and the forest had gotten quieter in between as birds had ended breeding and thus stopped singing. Singing takes energy for a bird and if they are no longer breeding there is no need to attract a mate, so that energy can be spent more efficiently on other activities such as foraging and parental care.

However, in looking at the background noises of the birdsong files and of the standard background files taken a few weeks later both show that there was a statistical difference between the three categories of noise. Also, there was no statistical significance among the different roads of the traffic category or the different creeks of the stream category. This confirms that the categories used were not biased and that the sounds within were grouped together correctly and that there were real differences in the amount of background noise among the categories.

The transect data confirmed that as an object gets farther away from the source of the sound, the more indistinct the sound becomes. This is shown by the decreasing trend line in Figure 5 and has a strong correlation. These data suggest that buffer zones may be an efficient way to limit the effect of human actions on the natural environment. Using the average background noise in the woodland area as a standard, it was calculated that a 30 meter buffer zone is needed. (See Figure 6). In other words, from the source of the traffic to 30 meters into the woods there is a higher average power than the natural standard in the woodland areas. After 30 meters, the decibel level in the traffic area is the equal to or less than the decibel level in the natural woodland noise. Thirty meters is not a very large area; however for birds that are edge nesters it could still have an effect. Creating buffer zones might help keep human interference from affecting bird and other animal communication. It is important for humans to consider how their actions affect other species besides their own.

CONCLUSIONS

In this study, trends suggest that Veery song length may be short in areas that contain louder noise levels due to traffic or other anthropogenic noises. This could occur in order for the songs to fit in between cars driving along the roads. Singing in between cars increases the chance that a song will successfully be communicated to the intended recipient without distortion due to extra interference from car noises. The 30 meter buffer zone could help limit how much influence anthropogenic noise has in a natural area by protecting the area from certain unnatural levels of noise. Due to the amount of use the major roads around the Cary Institute get, a 30 meter buffer zone would be sufficient. Different sized zones would be needed in different areas depending on the amount of traffic present on those roads.

The data collected comparing the song frequency between the traffic, creek, and woodland noise was not statistically significant. Nor was the data comparing the song length between traffic, creek, and woodland noise. Due to the small song sample size that was collected, further research on song length and frequency in various traffic areas needs to be done to confirm and show other trends present in these areas. Human influence is present everywhere; how it affects other species and individuals should be studied and considered when making environmental decisions.

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APPENDIX

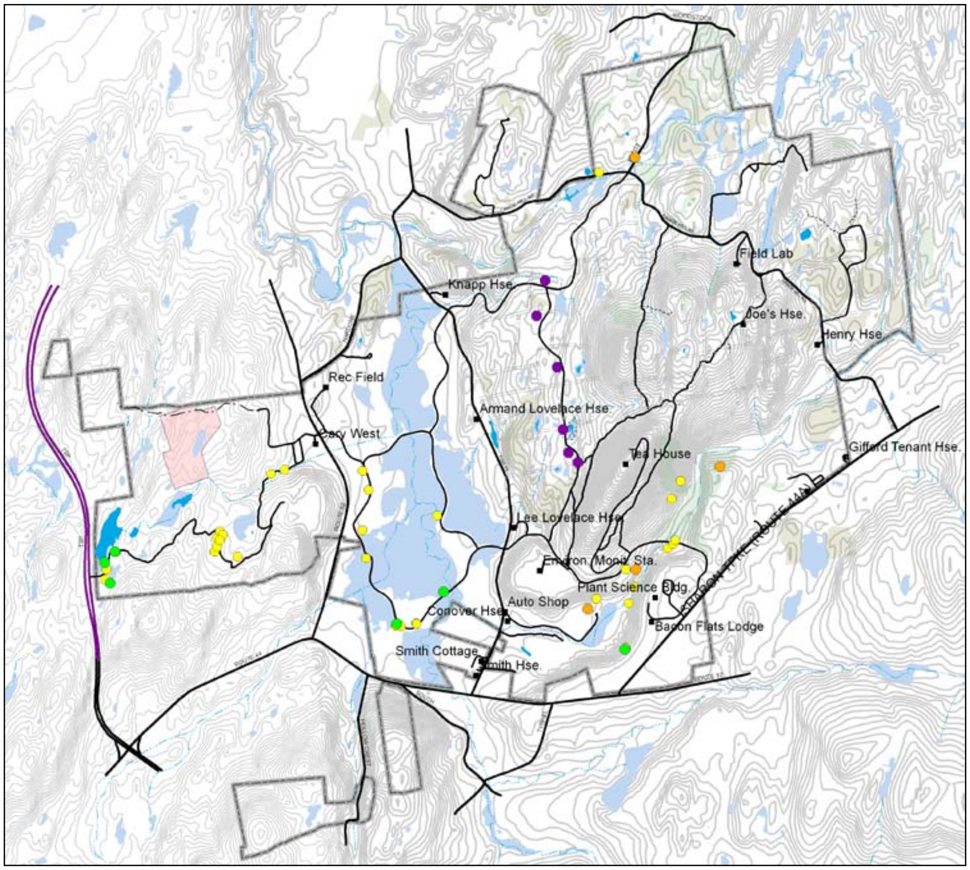

FIGURE 1. Data Collection Sites. Three categories of noise samplings were collected from sites on the Cary Institute property Yellow dots indicate the locations at which all the files were recorded. Files from 17 of these locations (Yellow dots) were used in data analysis: Purple dots are natural woodland noise; Green dots are traffic noise; and Orange dots are stream noise.

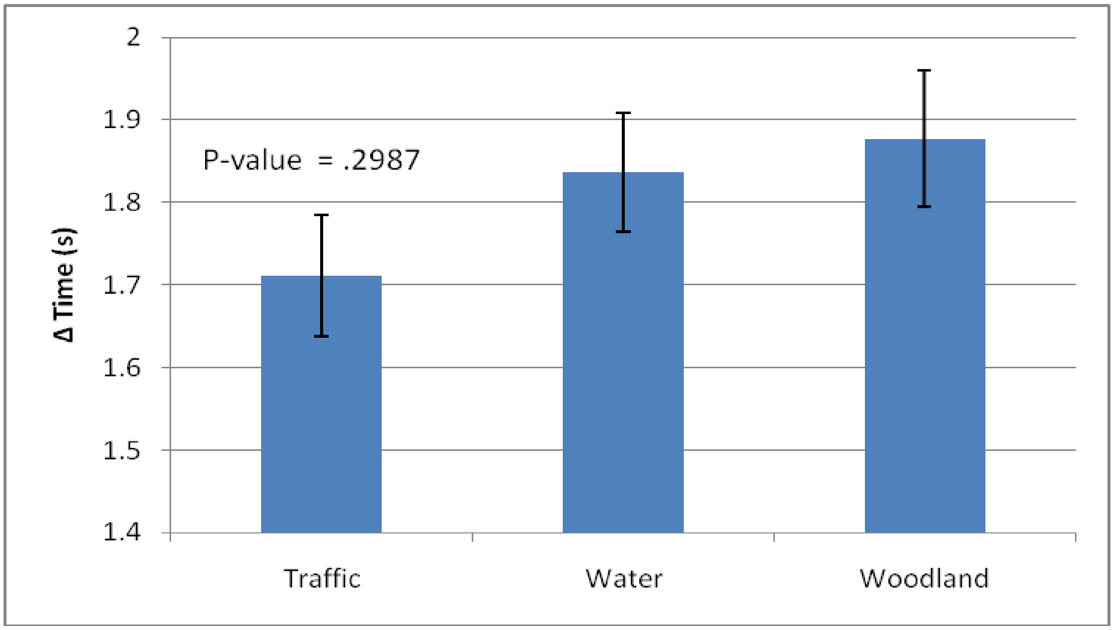

FIGURE 2. Comparison of Song Length Between Noise Categories. There is a trend that song length shortens the noisier an area gets. A larger data sample could confirm this.

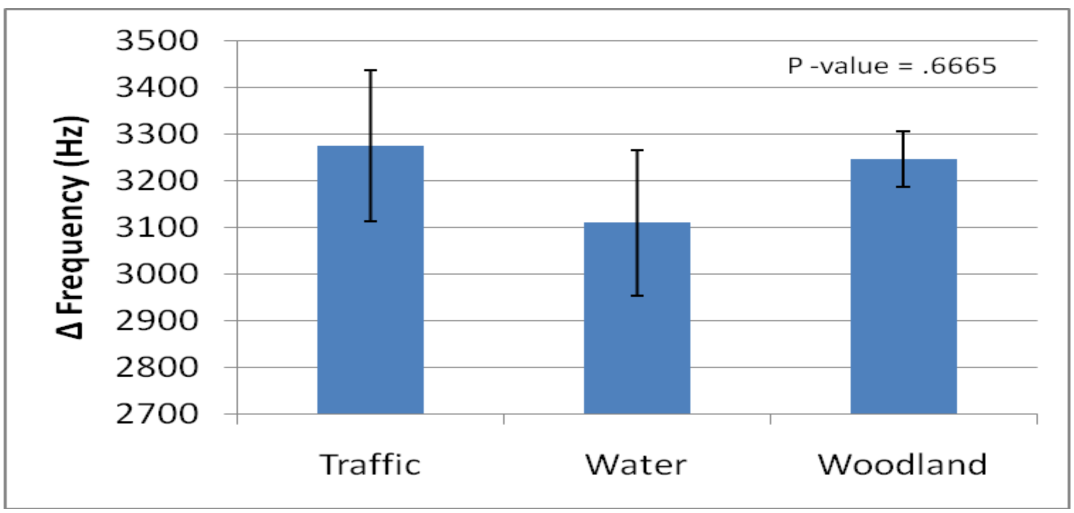

FIGURE 3. Comparison of Change in Song Frequency as a Function of Areas of Noise. The frequency of water changes less in comparison to traffic and woodland noise. Water has a broader frequency range in which sound will occur. This implies that it will have a higher probability of overlapping with either traffic or woodland. A broader frequency band also could cause the potential for more masking of noises to occur within its broader range.

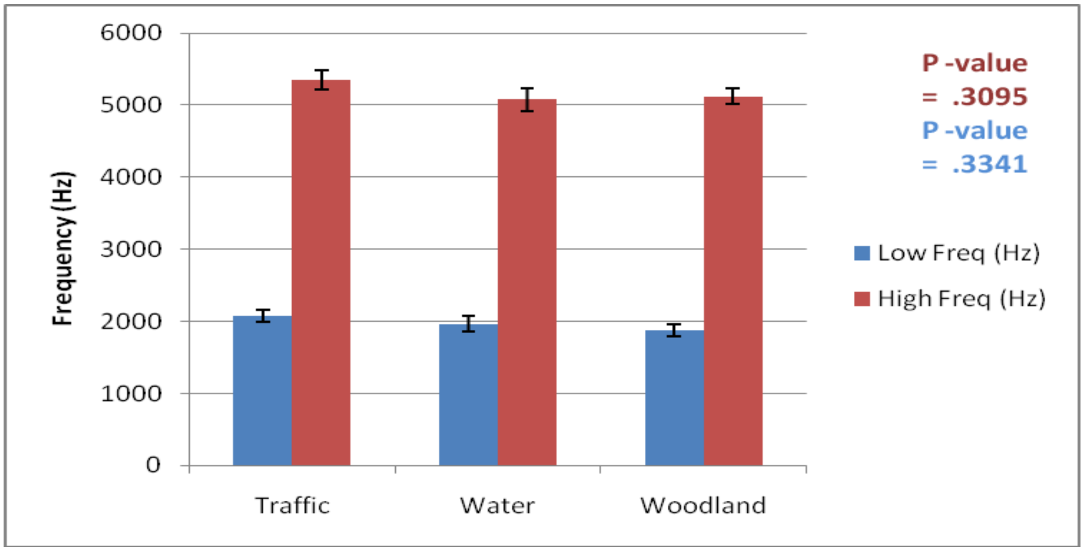

FIGURE 4. Comparison of Range in Frequencies. There was no statistical significance between the minimum and maximum frequencies in the 3 noise categories. Since the frequency in each category did not seem to change, this suggests that the Veery's ability to communicate is not improved by altering the pitch either higher or lower depending on the noise level within the area they are singing.

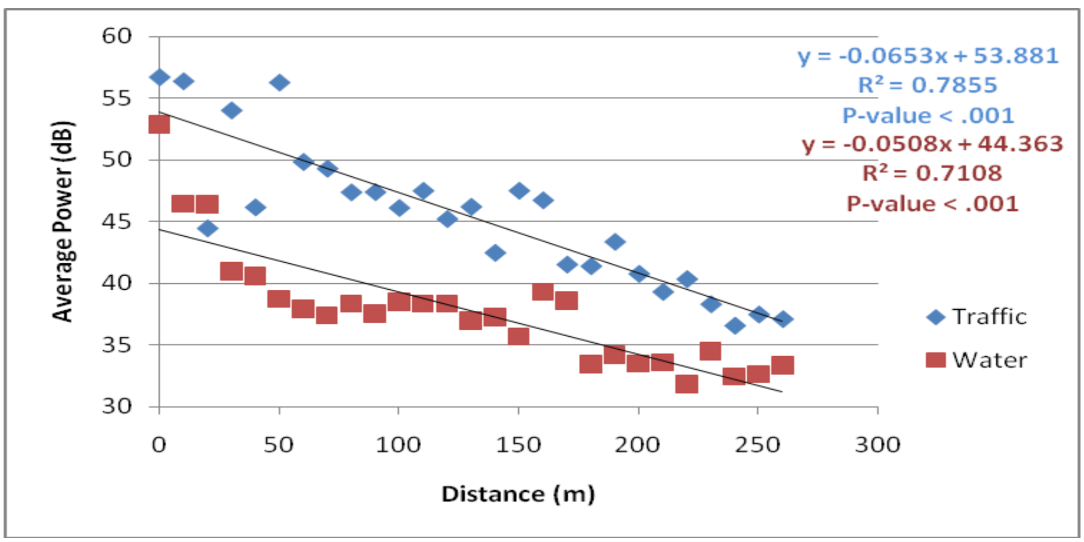

FIGURE 5. Comparison of Transect Measurements. Two-minute recordings were taken at 10 meter intervals. As expected, this shows that as the distance from the sound source increases, the ability to hear the sound decreases.

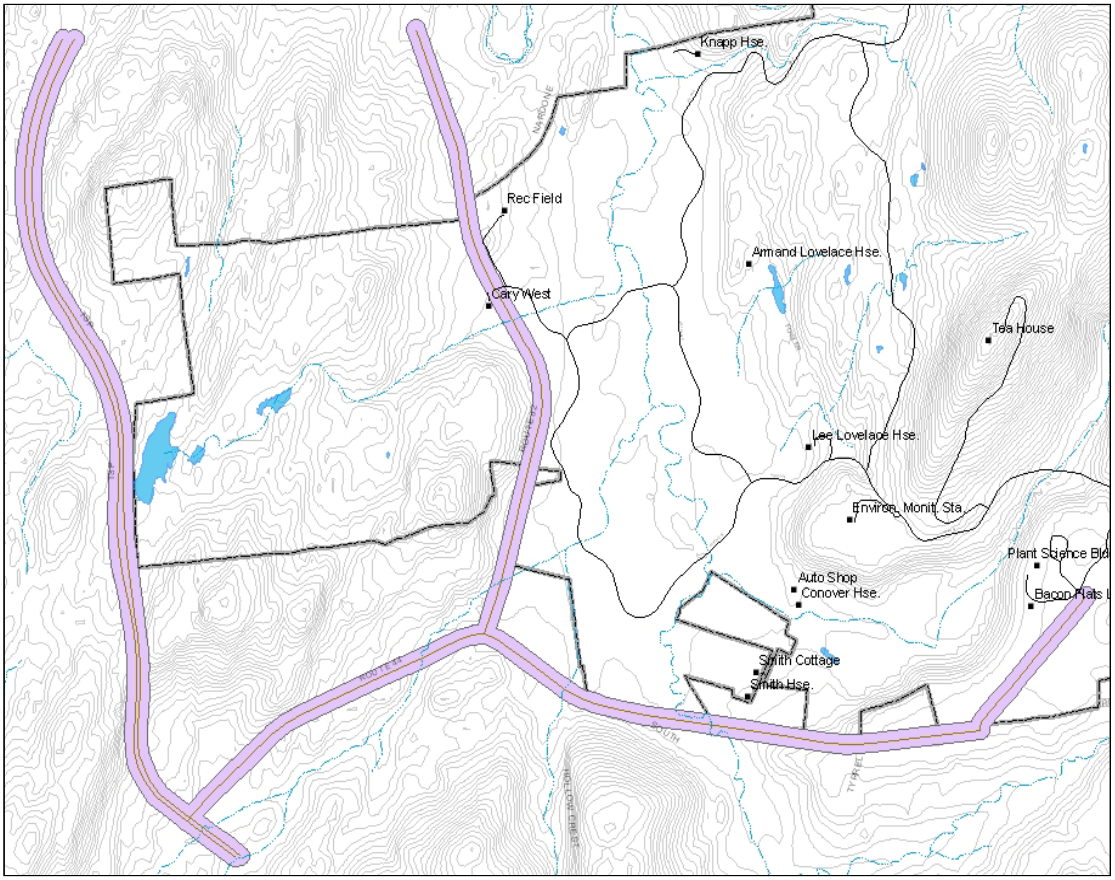

FIGURE 6. Buffer Zone Along Taconic State Parkway, Route 44, and Route 82. A buffer zone of 30 meters although the major roads shows the area in which the decibel level of noise is higher than that of the natural woodland setting. This suggests that the low amount of traffic on these roads does not affect Veery singing in this area.