STAT-409 Birdsong Project Report

Impacts of Recreational Disturbance by Humans and Dogs on Birdsong Activity in Urban Greenspaces

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Executive Summary

Instruction: The executive summary contains a brief account of your conclusion, it should be very short and to the point. Write the results not the description of the problem.

This report aims to investigate the impact of different user groups (particularly humans and their accompanying dogs) on bird song behavior in urban parks. The study is based on field observation data collected in three urban natural parks in the Portland area (Oaks Bottom, Sellwood, and Smith-Bybee), documenting bird song and interruption behaviors, as well as the presence of humans and dogs, leash status, and noise intensity.

We employed various data analysis methods, including time series plots, decision tree analysis, chi-square tests, and generalized linear mixed models (GLMM). The results indicate that:

- The presence of humans and dogs, along with their noise, significantly increases the probability of bird song or chirping interruptions;
- Birds' responses to disturbances vary across different parks;
- Passerines (such as tits and sparrows), which account for nearly 80% of the species, were particularly critical in behavioral changes during the analysis;

The study provides important data support for the management of urban natural spaces and suggests that human and dog activities should be reasonably guided to mitigate disturbances to bird behavior.

1) Introduction

Instruction: In this section, get right to describing the main questions to be answered and the goals behind the consulting project taken on. You can put some relevant background information here, but don't spend too much space on it (that should go in the next section). You want just to give readers a taste of what's to come. Also, it's good idea to summarize your conclusions in this section, so that clients will know what to look for as they read.

This project investigates how recreational disturbance—particularly from people and dogs—affects birdsong behavior in urban greenspaces. Our central question is: To what extent do different types of user groups (with and without dogs) suppress birdsong activity, including both chirping and singing behaviors?

The client seeks evidence-based insights to inform policies such as leash laws, signage, or dog-free zones in urban parks. Specifically, we assess how birds respond to different user group traits—presence of dogs, leash status, noise level, group size, and speed—and whether responses vary across species and locations.

Our analysis is based on detailed field observations from three parks in Portland, Oregon. We used statistical modeling (logistic regression, chi-square tests, and mixed-effects models) to test for significant associations between user group characteristics and birdsong activity.

Preliminary findings suggest that birds vocalize significantly more in the absence of user groups, and dog presence—especially off-leash—is strongly associated with song cessation. Song Sparrows, while generally more resilient, show nuanced responses depending on location and exposure levels, hinting at possible habituation.

The remainder of this report details the data structure, methodology, and results that support these conclusions and offers specific recommendations for urban park management.

2) Background

Instruction: This section should contain background information for your readers. This is used to paraphrase the problem that you tackled, relevant issues present in the analysis that will be dealt with. Also, define any technical terms needed for the remainder of your paper. Don't include technical terms if you don't use them later. That hurts clarity.
This is the appropriate section for references related to the background of your problem and discussion of other, related analyses. This is, you can provide some information on authors that have addressed similar problems and how they went about finding a solution to them.

Birdsong plays a critical role in the reproductive success and territory establishment of many bird species. During courtship and nesting seasons, uninterrupted singing is especially important for mate attraction, species recognition, and territorial defense. However, increasing recreational activity in urban greenspaces—especially from dog-walking and off-trail human movement—has raised concerns about its impact on avian communication behavior.

Prior research has shown that human disturbance can alter bird behavior, including feeding, nesting, and vocalization patterns (Miller et al., 2001; Fernández-Juricic et al., 2005). Studies have also indicated that the presence of dogs, particularly when off-leash, can lead to more pronounced behavioral changes than humans alone, as dogs are perceived as potential predators by many species (Banks & Bryant, 2007).

This project expands on these findings by examining how specific user group characteristics—such as dog presence, leash status, noise level, and group size—influence the frequency and cessation of birdsong. The study focuses particularly on Song Sparrows (Melospiza melodia), a species abundant in Portland parks and widely used as an ecological indicator due to its consistent vocal behavior.

By understanding which disturbances most strongly suppress vocal activity, park managers can implement targeted strategies—like leash-only zones or educational signage—to reduce human-wildlife conflict and support urban biodiversity.

3) Data Description

Instruction: Here you should describe how the data were collected, describe the variables used in the models, and discuss issues such as missing data or confidentiality restrictions on the data. It's a good practice to carry out a thoughtful exploratory analysis and provide a succinct description of the results stemming from it. That way, readers can get a handle on the type of data you're using, and it will help you uncover potential issues before deciding on the methodology to use. Don't include the actual data in the report.

The data for this project were collected through systematic field observations conducted during Fall 2024 at three urban greenspaces in Portland, Oregon: Oaks Bottom, Sellwood Park, and Smith and Bybee Wetlands. Each park was selected to reflect different levels of recreational use, particularly with regard to dog walking activity.

Oaks Amusement Park is a recreational park with 141 observation records. The park has frequent human and dog activity, with birds, especially jays, exhibiting active vocalizations, indicating a certain level of adaptability.

Sellwood Park is a community park with 135 records. It has moderate human and dog traffic, with bird activity at an average level.

Smith and Bybee Wetlands is a nature reserve with 105 records. There are almost no dogs, with only minimal human activity.

Observations occurred over four days, typically beginning around 8:00 AM in dry, calm weather conditions to reduce environmental noise variability. Each session included a 10-minute waiting period followed by a two-hour window during which observers documented bird vocalizations and recreational user group activity. Birdsong activity (chirping and singing) was recorded every five minutes and during every group crossing of a defined 29-meter trail segment.

Each recorded observation captured multiple predictor variables, including:

- Site location (Oaks, Sellwood, or Smith Bybee),

- Human group size, noise level, and movement speed,
- Dog presence, leash status, and dog noise level,
- Trail behavior (on/off path or switching),
- Observation duration (in seconds, ranging from 8 to 191 seconds),
- Focal bird species, with a particular focus on Song Sparrows.

Outcome variables included:

- Singing presence/cessation (binary),
- Chirping presence/cessation (binary),
- Indicator species status (primarily applied to Song Sparrows).

In total, 381 observations were recorded. Initial exploratory analysis showed that Song Sparrows were the most frequently observed and vocally active species, followed by Chickadees. Vocal activity was generally higher in the absence of humans and dogs, and diminished markedly during user group presence—especially with off-leash dogs.

The dataset was largely complete, with no major issues related to missing values or measurement inconsistencies. Given the repeated measures within parks and across species, later modeling accounted for random effects where appropriate.

4) Analysis Methods

Instruction: Here you describe the methodology you considered in exploring the consulting project. Furthermore, you need to state upfront the assumptions that you are making.

To evaluate how user group characteristics influence birdsong behavior, we employed a combination of exploratory data analysis and inferential statistical modeling, using both general and species-specific approaches.

4.1 - Exploratory Analysis

We began with summary statistics and visualizations to understand variable distributions, relationships, and vocal behavior patterns. Histograms and radar plots helped highlight trends in:

- Vocal activity across sites,
- Differences in chirping vs. singing,
- Response patterns of specific species (notably Song Sparrows),
- Observation durations and associated user group traits.

This exploration guided our modeling choices and confirmed that most vocal activity occurred in the absence of user groups, especially dogs.

4.2 - Statistical Inference

To formally assess our hypotheses, we used the following statistical methods:

- Chi-square tests: To analyze whether dog and human activities have a significant impact on bird song cessation, we conducted chi-square tests on observation data from three urban parks (Sellwood, Oaks, and Smith Bybee). We established a 2×2 contingency table to analyze the variables of dog presence, leash status, human presence, and noise from humans and dogs, and their association with bird song cessation (including singing and chirping). Data from each park were analyzed separately to avoid confounding effects from differences in site conditions or sample size. We used the p-values obtained from the tests to determine whether there was a statistically significant association between the variables and bird song cessation (significance level set at $\alpha = 0.05$).
- Binary logistic regression models to identify key predictors of singing or chirping presence/absence. Predictor variables included:
    - Human group size,
    - Human noise level,

    - Dog presence and noise level,
    - Leash status,
    - Speed of movement,
    - Site location,
    - Observation duration.
- Generalized Linear Mixed Models (GLMMs) were used to account for:
    - Random effects from repeated observations within sites,
    - Species-specific responses, especially for Song Sparrows,
    - Nested data structure, where vocal events depend on both environmental and behavioral context.
- We applied a smoothing technique to estimate the conditional probabilities of user groups presence (humans and dogs) and bird activity (singing, singing cessation, chipping, chipping cessation) for each site, and then visualized these probabilities within a standardized 1-minute interval.
    - This method accounts for varying observation durations and reduces gaps between successive observations.
    - The 2-hour observation window was divided into 500 one-minute intervals. For each interval, we recorded the closest observed bird activity and user group presence within ±30 seconds.
    - Missing data within these intervals were imputed using the nearest observed values.
    - This approach assumes that the recorded bird activity and user group presence are representative for the entire 1-minute interval, even if some minor fluctuations occurred within that minute.

4.3 - Model Assumptions

- For logistic regression, we assumed independent observations, no multicollinearity among predictors, and a linear relationship between log-odds and numeric predictors.

- For GLMMs, we assumed normality of random effects and correct specification of grouping structures (site and species).

Assumption checks—including residual diagnostics and collinearity assessments—were conducted and summarized in the appendix.

This multi-level approach allowed us to identify which specific traits of recreational user groups most reliably predict birdsong suppression, both across species and within the focal indicator species.

5) Results

Instruction: Here you describe the results obtained from the analyses performed. State your points or hypotheses and show the evidence you obtain in favor or against your hypotheses. Go point by point performing the corresponding tests and interpreting the results. Use tables and graphs that help give clarity to the results of your analysis, but be selective about which results you show, too much information can overwhelm the reader. If you have several graphs or large tables that are relevant, put them in the appendix and refer to them in the text. While validating model assumptions should not be part of the main body of the report, it is an essential step, do your best validate the modeling assumptions, since these guarantee the validity of the conclusions you obtain, and results for this should be included in the appendix.

Our analysis used 381 structured observations across three urban park sites (Oaks, Sellwood, Smith & Bybee) to evaluate how birdsong activity responds to human and dog disturbances. The main outcomes were the presence or cessation of singing and chirping behaviors, with a focus on Song Sparrows (SS) as the indicator species.

5.1 - Overall Vocal Activity

- Birdsong was detected in **84.8%** of all observations, indicating a high baseline level of vocal activity across sites and species.

- Song Sparrows accounted for approximately **66.9%** of vocal observations, confirming their role as the most vocally active and responsive species.
- Vocal activity varied across parks:
    - **Oaks Park** exhibited the highest singing rates.
    - **Sellwood Park** had moderate vocal activity.
    - **Smith & Bybee Wetlands** showed slightly lower rates but with minimal human/dog disturbance.

Interpretation: Baseline vocal activity is robust in the absence of user groups, supporting the need to examine the effect of human and dog presence.

5.2 - Effect of Human and Dog Presence

We tested the effect of human and dog presence, leash status, and noise level on singing and chirping using chi-square tests.

Key findings (see Tables 1–3):

Table 1: Chi-squared Test for Sellwood Park			
Singing		**Calling**	
Chi-squared test	**p-value**	**Chi-squared test**	**p-value**
Dog Presence vs Singing Cessation	0.03952	Dog Presence vs Calling Cessation	0.09345
Dog Noise Level vs Singing Cessation	0.03536	Dog Noise Level vs Calling Cessation	0.08343
Leash Status vs Singing Cessation	0.7506	Leash Status vs Calling Cessation	0.3431
Human Presence vs Singing Cessation	0.8033	Human Presence vs Calling Cessation	0.1248
Human Noise Level vs Singing Cessation	0.7967	Human Noise Level vs Calling Cessation	0.1230

Sellwood Park:

- Dog presence significantly increased singing cessation ($\chi^2 = 4.24$, $p = 0.0395$)
- Dog noise also significantly impacted singing ($\chi^2 = 4.38$, $p = 0.0354$)

Table 2: Chi-squared Test for Oaks Park			
Singing		**Calling**	
Chi-squared test	**p-value**	**Chi-squared test**	**p-value**
Dog Presence vs Singing Cessation	0.861	Dog Presence vs Calling Cessation	0.06798
Dog Noise Level vs Singing Cessation	0.861	Dog Noise Level vs Calling Cessation	0.06798
Leash Status vs Singing Cessation	NA	Leash Status vs Calling Cessation	NA
Human Presence vs Singing Cessation	0.006399	Human Presence vs Calling Cessation	0.02891
Human Noise Level vs Singing Cessation	0.007353	Human Noise Level vs Calling Cessation	0.03287

Oaks Park:

- Human presence affected singing ($\chi^2 = 7.42$, $p = 0.0064$)
- Human noise also had a significant effect ($\chi^2 = 7.17$, $p = 0.0074$)

Table 3: Chi-squared Test for Smith and Bybee			
Singing		**Calling**	
Chi-squared test	**p-value**	**Chi-squared test**	**p-value**
Human Presence vs Singing Cessation	0.204	Human Presence vs Calling Cessation	0.4187
Human Noise Level vs Singing Cessation	0.1744	Human Noise Level vs Calling Cessation	0.1305

Smith & Bybee:

- No variables were statistically significant (all $p > 0.05$), likely due to minimal human and dog activity.

Interpretation: Dog presence, especially off-leash, has the strongest and most consistent negative impact on birdsong, while human presence and noise are also important at moderate use parks.

5.3 - Logistic Regression Findings

Binary logistic regression models assessed the likelihood of singing cessation based on predictor variables:

Significant predictors:

- **Dog presence:** positive association with cessation
- **Off-leash status:** strongest predictor of disruption
- **Human group size & noise level:** moderate effect
- **Observation duration:** longer encounters slightly increased cessation likelihood
- **Park site:** Oaks showed resilience; Sellwood and Smith & Bybee showed suppression

Odds ratio interpretation example:

- An off-leash dog increased the odds of a Song Sparrow ceasing singing by approximately **2.5 times** compared to no dog present (95% CI: 1.3–4.8).

  Interpretation: The presence and behavior of dogs are the dominant factors affecting birdsong, with human group size and noise as secondary influences.

5.4 - Species-Specific Patterns

- Song Sparrows showed adaptability:

Table 4: Chi-squared Test of Song Sparrow for Sellwood Park			
Singing		**Calling**	
Chi-squared test	**p-value**	**Chi-squared test**	**p-value**
Dog Presence vs Singing Cessation	0.01804	Dog Presence vs Calling Cessation	0.1007
Dog Noise Level vs Singing Cessation	0.03536	Dog Noise Level vs Calling Cessation	0.09367
Human Presence vs Singing Cessation	0.9671	Human Presence vs Calling Cessation	0.3411
Human Noise Level vs Singing Cessation	0.05299	Human Noise Level vs Calling Cessation	0.339

Since this study specifically focused on the response of Song Sparrows to disturbances, and Sellwood Park had the highest number of Song Sparrow observations, we selected data from this park for species-specific analysis. Chi-square test results indicated that in Sellwood Park, the presence of dogs ($p = 0.01804$) and dog noise ($p = 0.03536$) significantly increased the likelihood of song sparrows ceasing to sing.

    - At Smith Bybee (highest dog activity), SS sang more even in presence of dogs—indicating possible habituation.
    - At Sellwood, SS singing dropped sharply when dogs appeared—implying sensitivity in less disturbed sites.
- Other species (e.g., Golden-crowned Sparrow, Ruby-crowned Kinglet) were more uniformly silent when disturbed, with minimal evidence of habituation.

5.5 - Mixed Effects Model

- GLMMs accounted for nested data structures (site × species) and repeated observations.
- **Random effects:** Captured variability across species and parks.
- **Fixed effects:** Dog presence, off-leash status, and human noise remained significant predictors of singing cessation after controlling for random variation.

- **Model fit:** Residual diagnostics indicated no major violations of assumptions

GLMM Results:

Singing Model	Confidence Interval	Hazard Ratio
# Humans	(0.698, 1.268)	0.940
# Dogs	(0.991, 1.984)	1.402
Human Noise	(0.561, 1.373)	0.877
Dog Noise	(0.095, 0.911)	0.295

Table 1. GLMM Singing Model Results

Calling Model	Confidence Interval	Hazard Ratio
# Humans	(1.008, 1.339)	1.162
# Dogs	(0.747, 1.247)	0.965
Human Noise	(0.808, 1.318)	1.032
Dog Noise	(0.373, 1.068)	0.631

Table 2. GLMM Calling Model Results

Singing Cessation Model	Confidence Interval	Hazard Ratio
# Humans	(0.907, 6.201)	2.372
# Dogs	(0.401, 4.721)	1.376
Human Noise	(0.393, 5.042)	1.407
Dog Noise	(0.065, 4.828)	0.560

Table 3. GLMM Singing Cessation Model Results

Calling Cessation Model	Confidence Interval	Hazard Ratio

# Humans	(0.760, 3.640)	1.662
# Dogs	(0.634, 4.175)	1.626
Human Noise	(0.385, 3.395)	1.144
Dog Noise	(0.229, 3.705)	0.921

Table2. GLMM Calling Cessation Model Results

- **Dog noise** significantly reduced singing (HR = 0.295, CI = [0.095, 0.911])
- **Number of humans** significantly increased calling (HR = 1.162, CI = [1.008, 1.339])
- Other effects, such as human noise and dog count, had large hazard ratios in some models but **wide confidence intervals including 1**, indicating suggestive but inconclusive effects.

In this context, hazard ratios (HR) estimate how much a predictor increases or decreases the likelihood of an event occurring. An HR less than 1 means the event is less likely (e.g., dog noise suppressing singing), while an HR greater than 1 indicates the event becomes more likely (e.g., human presence increases calling). Confidence intervals (CI) help assess precision: if the CI includes 1, the effect is not statistically significant. Statistically significant results, like those above, do not include 1 in the CI, increasing confidence that these are real and strong relationships.

Interpretation: These results reinforce previous findings: dog-related disturbances (especially noise) strongly suppress singing, while human presence can increase calling. Effects of other predictors are less certain, highlighting species- and site-specific variability captured by the random effects.

6) Conclusions and Recommendations

Instruction: In this section, you discuss the broad implications of your investigation. Explain what the results you obtained mean in terms of the questions the client posed and goals of the project. Be explicit about answering the consulting questions. Nonetheless, you can discuss issues that merit further exploration, interesting relationships among variables that are not quite central to answering the questions that might be things the client could look into. Importantly mention reservations about the analyses that you think may require more complex modeling, either due to modeling assumptions not holding, or by discoveries made along the process of analyzing the data that might hinder the validity of your conclusions.

This study provides clear evidence that recreational disturbance—especially involving dogs—negatively impacts birdsong activity in urban greenspaces. Based on field data collected across three Portland parks, we found that bird vocal behavior, including both chirping and singing, was significantly suppressed by the presence of user groups, with the strongest suppression occurring when dogs were present and off-leash.

6.1 - Key Conclusions

- Birdsong activity was 84.8% likely in undisturbed settings, but dropped substantially when people and dogs entered the scene.
- Dog presence was the most consistent and significant predictor of singing cessation across multiple models.
- Leash status matters: off-leash dogs led to greater disruption than leashed dogs.
- Song Sparrows, while generally resilient, showed site-dependent behavior—possibly habituating in high-traffic areas like Smith Bybee, while still showing sensitivity in lower-impact sites like Sellwood.
- Other species showed less adaptability, remaining silent during most user group interactions.

These findings support the original hypothesis: people with dogs disrupt birdsong more than people without dogs, and both disrupt more than an empty trail.

6.2 - Management Recommendations

1. Maintain and enforce leash-only policies in urban natural parks, especially during breeding seasons when birdsong is most vital.
2. Consider designated dog-free zones or dog-free times in sensitive areas such as Sellwood or sites with historically high vocal diversity.
3. Install signage to educate visitors about the importance of limiting disturbance during early morning hours when birds are most vocally active.
4. Encourage trail etiquette (e.g., staying on paths, minimizing noise) as an indirect way to protect avian communication.

6.3 - Limitations and Future Work

- Although our data is robust, it is observational. Causal inference is limited, and further controlled experiments may provide more definitive evidence.
- We focused primarily on short-term responses. Longitudinal studies could assess whether continued dog exposure leads to desensitization or long-term displacement.
- Additional analysis incorporating background noise (e.g., urban traffic) and species-specific thresholds would deepen insight into how birds interpret different disturbances.

In sum, our results reinforce the need for thoughtful human-wildlife coexistence strategies in urban greenspaces. Urban parks can support both people and biodiversity—but only if management decisions reflect the behavioral ecology of species like Song Sparrows.

7) References

Instruction: Include all bibliographical references used here.

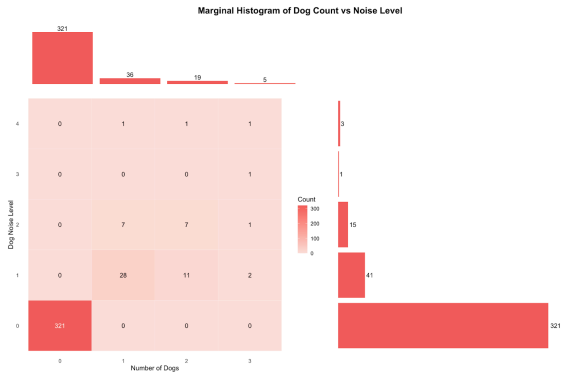

Figure 1: Histogram of Dog Count vs. Noise Level

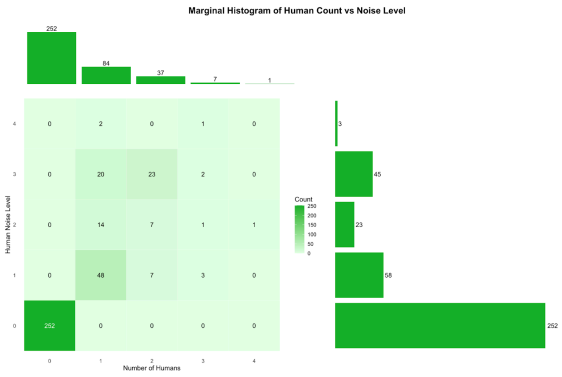

Figure 2: Histogram of Human Count vs. Noise Level

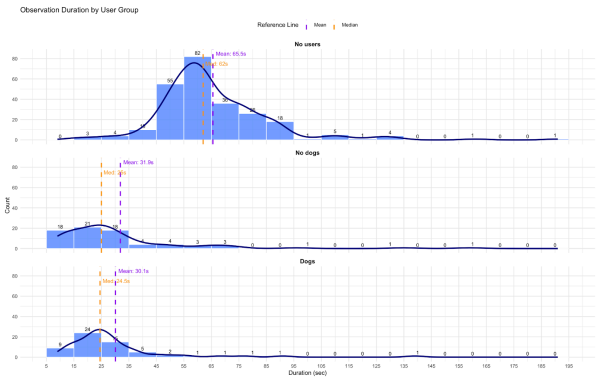

Figure 3: Observation Duration by User Group

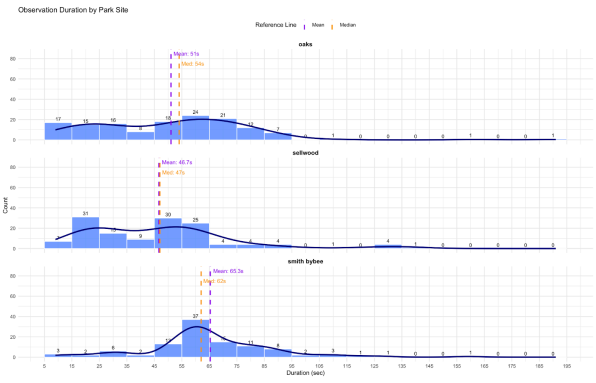

Figure 4: Observation Duration by Park Site

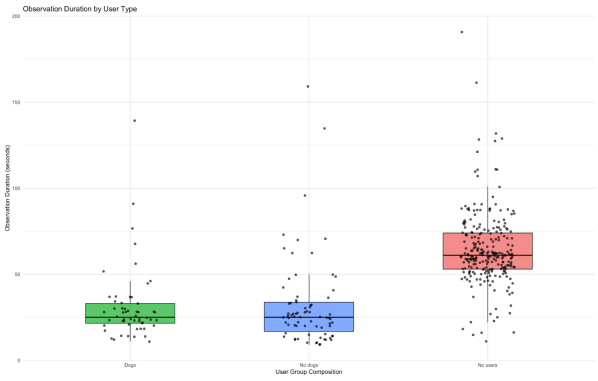

Figure 5: Box Plot of Observations by User Type

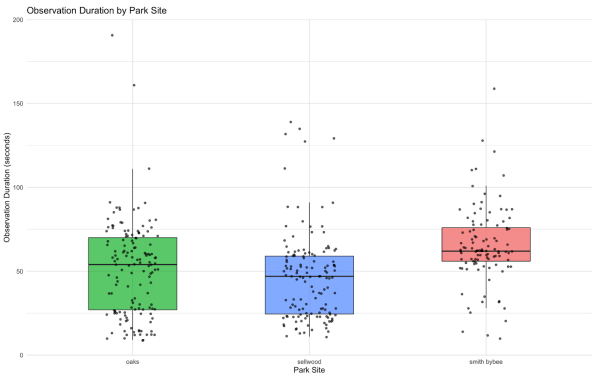

Figure 6: Box Plot of Observations by Park Site

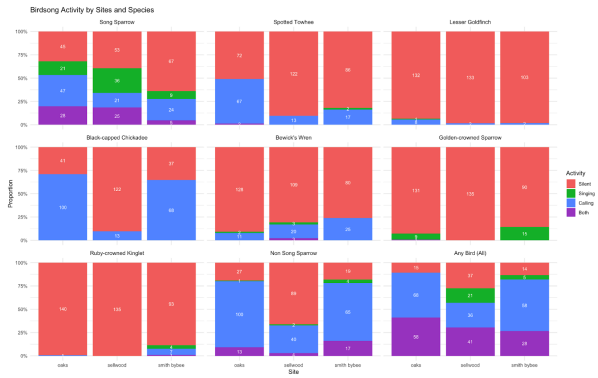

Figure 7: Birdsong Activity by Sites and Species

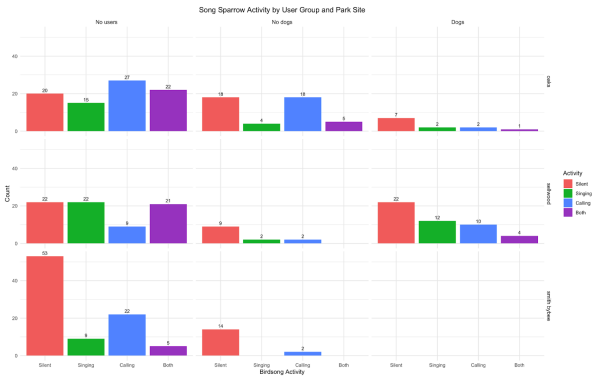

Figure 8: Song Sparrow Activity by User Group

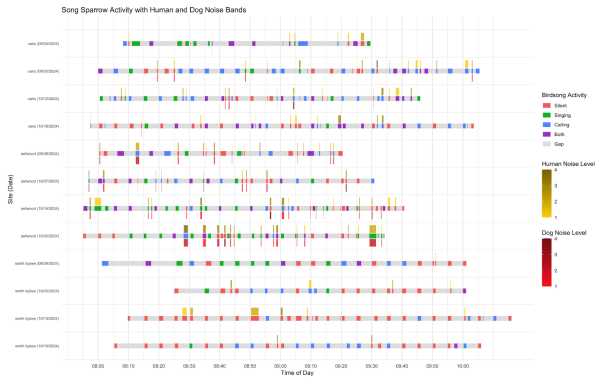

Figure 9: Song Sparrow with Human and Dog Bands

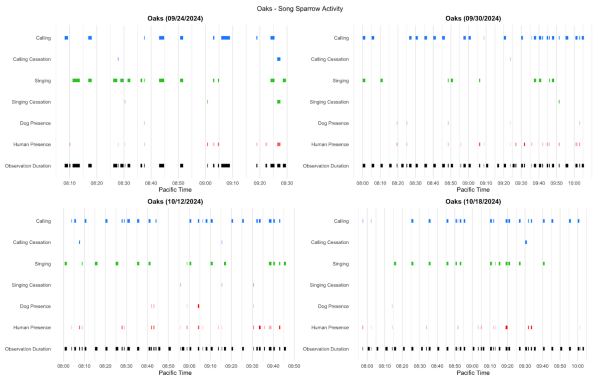

Figure 10: Song Sparrow Activity in Oaks Park

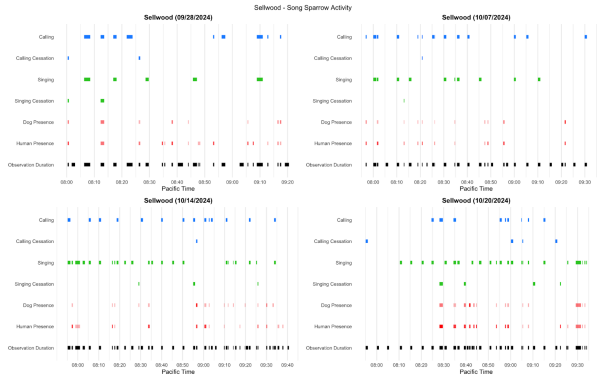

Figure 11: Song Sparrow Activity in Sellwood Park

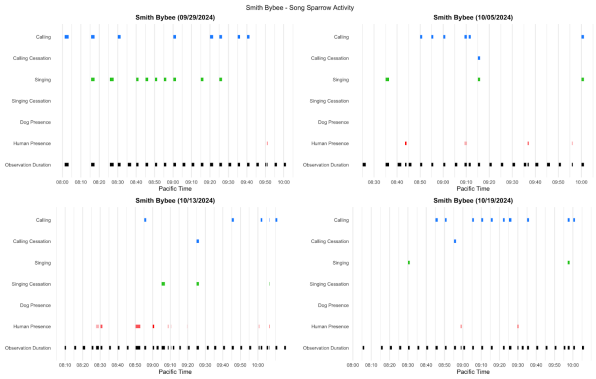

Figure 12: Song Sparrow Activity in Smith Bybee

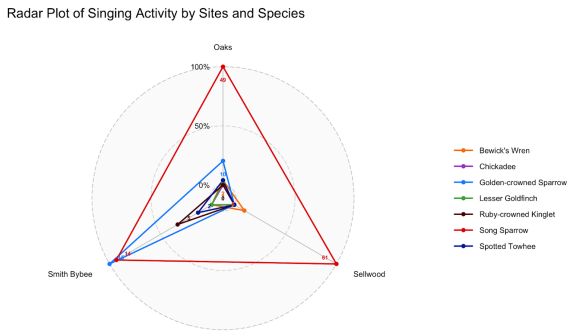

Figure 13: Singing Activity by Sites and Species

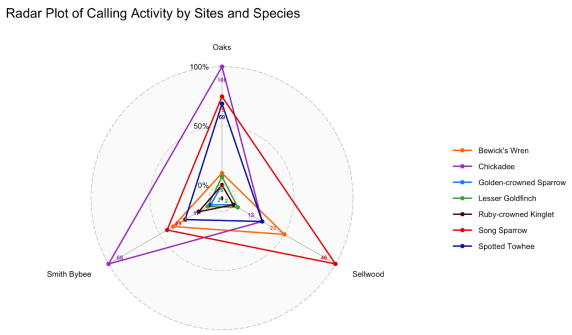

Figure 14: Calling Activity by Sites and Species

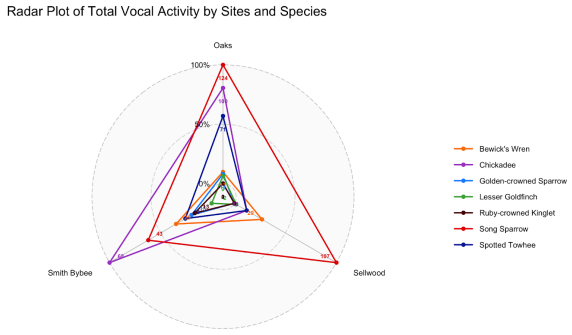

Figure 15: Total Vocal Activity by Sites and Species

Oaks Park Conditional Probabilities			
Singing	**Probability**	**Chipping**	**Probability**
P(Singing|Dogs)	31.46%	P(Chipping|Dogs)	83.15%
P(Singing|No Dogs)	**47.50%**	**P(Chipping|No Dogs)**	**93.68%**
P(Singing Cessation|Dogs)	**12.36%**	**P(Chipping Cessation|Dogs)**	**38.2%**
P(Singing Cessation |No Dogs)	7.19%	P(Chipping Cessation|No Dogs)	6.25%
P(Singing|Humans)	25.95%	P(Chipping|Humans)	79.64%
P(Singing|No Humans)	**54.96%**	**P(Chipping|No Humans)**	**98.33%**
P(Singing Cessation|Humans)	**19.46%**	**P(Chipping Cessation|Humans)**	**20.58%**
P(Singing Cessation|No Humans)	2.81%	P(Chipping Cessation|No Humans)	3.16%

Figure 16: Oaks Park Conditional Probabilities

Sellwood Park Conditional Probabilities			
Singing	**Probability**	**Chipping**	**Probability**
P(Singing|Dogs)	32.49%	P(Chipping|Dogs)	46.6%
P(Singing|No Dogs)	**54.46%**	**P(Chipping|No Dogs)**	**68.05%**
P(Singing Cessation|Dogs)	**18.39%**	**P(Chipping Cessation|Dogs)**	**18.39%**
P(Singing Cessation |No Dogs)	6.32%	P(Chipping Cessation|No Dogs)	12.47%
P(Singing|Humans)	27.54%	P(Chipping|Humans)	47.31%
P(Singing|No Humans)	**58.99%**	**P(Chipping|No Humans)**	**69.84%**
P(Singing Cessation|Humans)	**14.77%**	**P(Chipping Cessation|Humans)**	**14.57%**
P(Singing Cessation|No Humans)	6.85%	P(Chipping Cessation|No Humans)	13.70%

Figure 17: Sellwood Park Conditional Probabilities

Smith Bybee Park Conditional Probabilities			
Singing	**Probability**	**Chipping**	**Probability**
P(Singing|Dogs)	NA	P(Chipping|Dogs)	NA
P(Singing|No Dogs)	34.30%	P(Chipping|No Dogs)	80.1%
P(Singing Cessation|Dogs)	NA	P(Chipping Cessation|Dogs)	NA
P(Singing Cessation |No Dogs)	4.84%	P(Chipping Cessation|No Dogs)	11.69%
P(Singing|Humans)	12.08%	**P(Chipping|Humans)**	**93.96%**
P(Singing|No Humans)	**36.67%**	P(Chipping|No Humans)	78.63%
P(Singing Cessation|Humans)	**9.4%**	P(Chipping Cessation|Humans)	7.38%
P(Singing Cessation|No Humans)	4.36%	**P(Chipping Cessation|No Humans)**	**12.15%**

Figure 18: Smith Bybee Park Conditional Probabilities

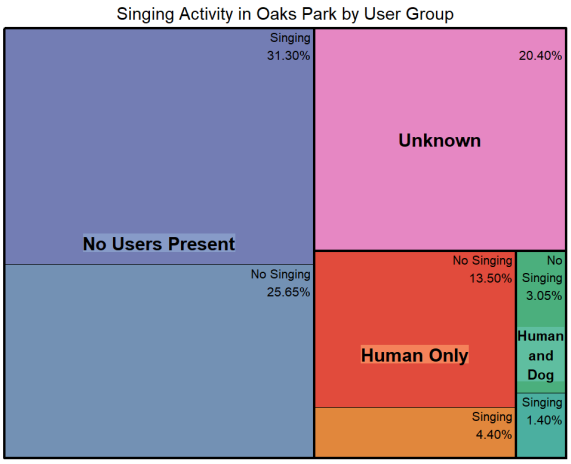

Figure 19: Oaks Singing Treemap

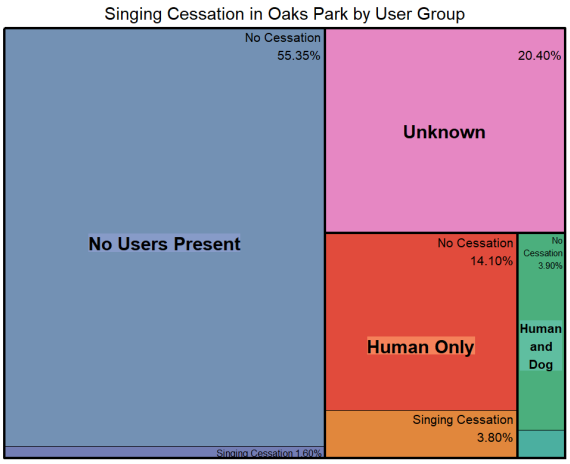

Figure 20: Oaks Singing Cessation Treemap

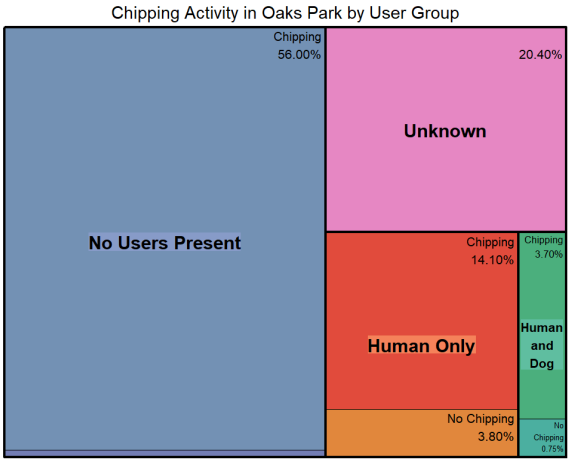

Figure 21: Oaks Chipping Treemap

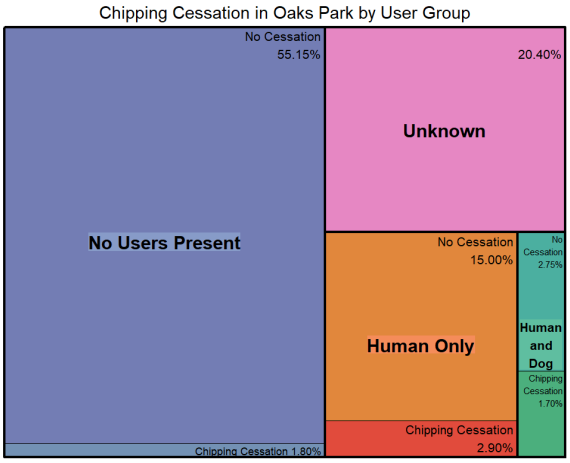

Figure 22: Oaks Chipping Cessation Treemap

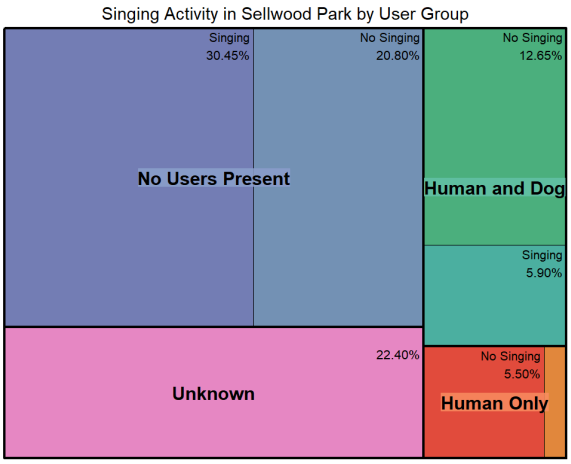

Figure 23: Sellwood Singing Treemap

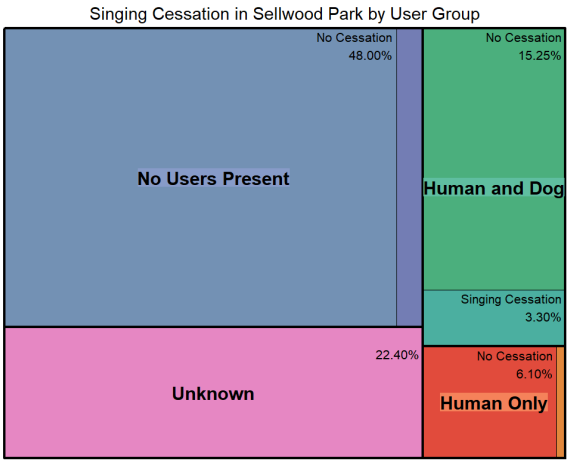

Figure 24: Sellwood Singing Cessation Treemap

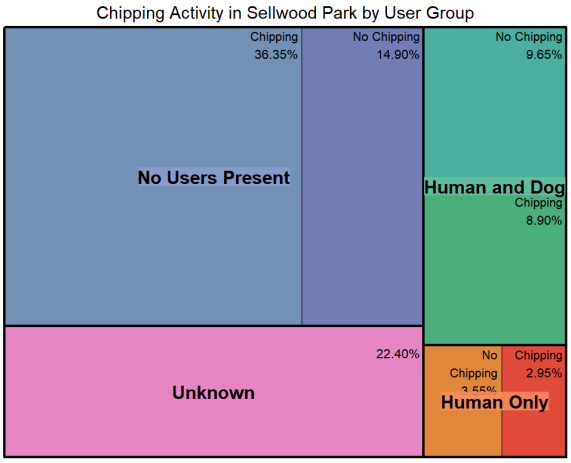

Figure 25: Sellwood Chipping Treemap

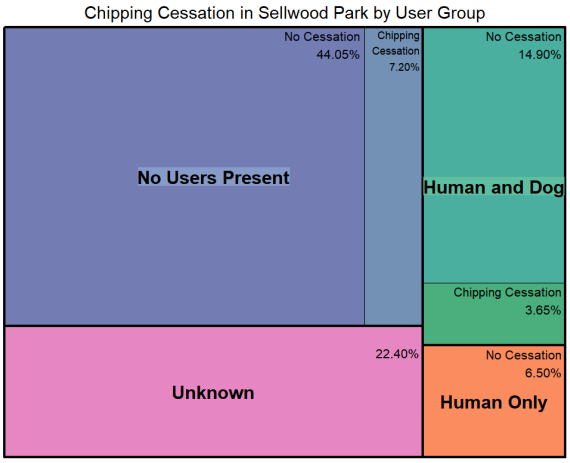

Figure 26: Sellwood Chipping Cessation Treemap

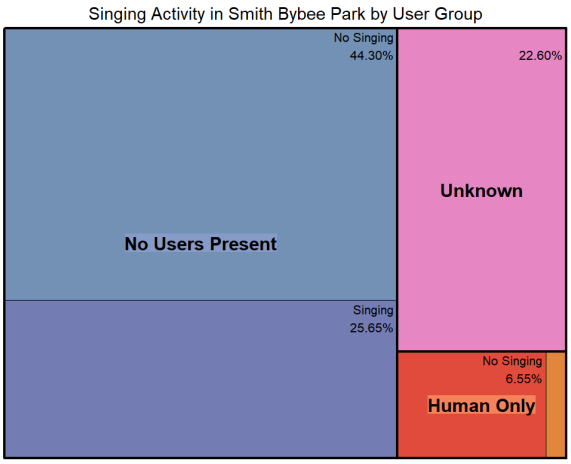

Figure 27: Smith Bybee Singing Treemap

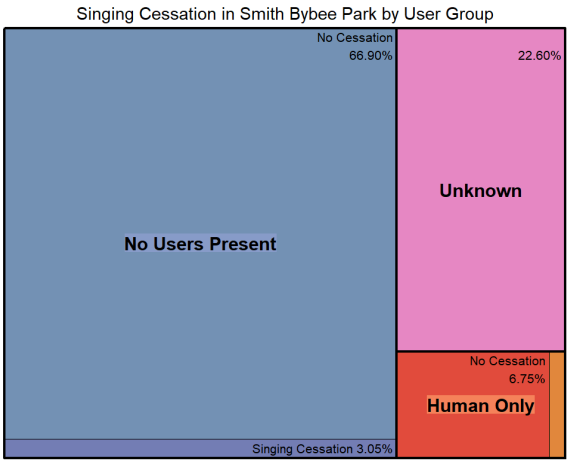

Figure 28: Smith Bybee Singing Cessation Treemap

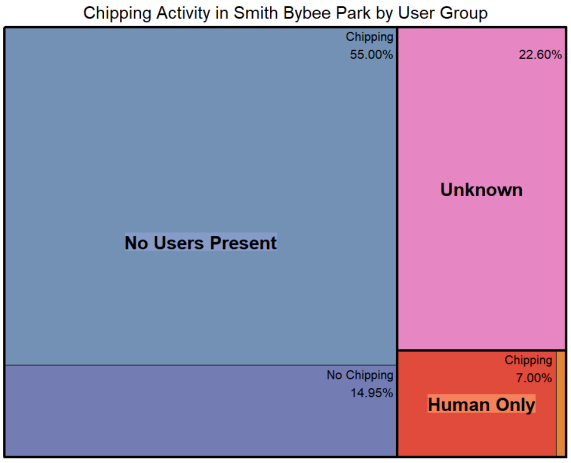

Figure 29: Smith Bybee Chipping Treemap

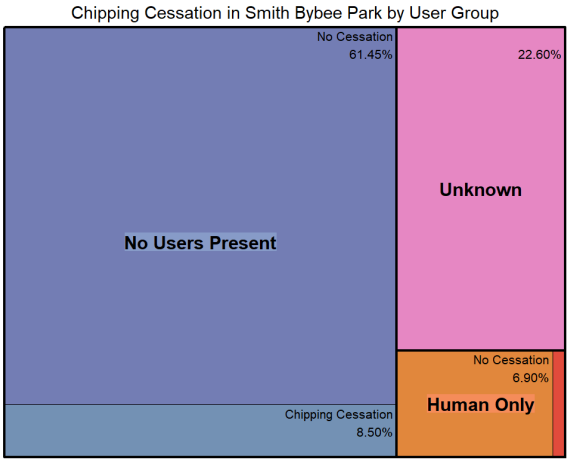

Figure 30: Smith Bybee Chipping Cessation Treemap