2018 New York Central Park Squirrel Census Analysis Report

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Background

In this research project, we investigated the correlation between squirrel activity and surrounding environmental factors, including the presence of other animals, hectare conditions (busyness level), and time of day in Central Park, New York.

The data utilized in this study was sourced from the Squirrel Census Project, an interdisciplinary endeavor encompassing science, design, and storytelling, with a primary focus on the Eastern gray squirrel (Sciurus carolinensis). Through systematic squirrel counts and public dissemination of their findings, the project aims to provide insights into squirrel populations. Datasets from the Squirrel Census Project are based on volunteers and their reports of squirrel sightings. For each submission, volunteers can report additional information on the surroundings at the time of the sighting, such as the presence of other animals and/or trash, the fur and highlight color of squirrels, and the activity of the squirrel. The squirrel dataset used for our research project is sourced from volunteers' observations between October 8th and October 20th, 2018.

Data Cleaning

We used three datasets in this analysis: Squirrel dataset, Hectare dataset, and Hectare Grid dataset.

Original Data Overview

The Squirrel dataset contains all the information the volunteers observed about the squirrels - squirrel location, their fur color, their activities, and the date and time they were being observed. The squirrel census team divided Central Park into 378 hectares (42 rows and 9 columns). The Hectare dataset contains information about each hectare in the Central Park - Hectare ID, hectare conditions, shift (time of the day), the number of squirrels being observed in that hectare, weather conditions, and other animals present. The Hectare Grid dataset contains the geographical coordinates of all hectares.

First, we removed any rows with missing observations for any of the factors used in the analysis. Age, Fur Color, and Hectare Condition were modified during this process. Next, we categorized the Hectare Condition into three categories: calm, moderate, and busy. We merged all descriptions other than "calm" and "busy" ("moderate", "medium", and "calm/busy") into "moderate" to reduce the complexity of the covariate. Then we left-joined the Squirrel dataset with the Hectare dataset using the "Date", "Shift", and "Hectare ID".

Squirrel Distribution Analysis

In this section, we focused on the distribution of all squirrels across Central Park.

Squirrel Distribution Map
We decided to create a map of squirrels for each date using the geographical coordinates provided in the Squirrel dataset.

First, using the library “sf”, we convert the geographical information of the squirrel locations stored in the Hectare Grid dataset into a shapefile format. Then, we used the ColorFactor function to produce a color palette that generates different colors for each squirrel fur color (Black, Cinnamon, and Grey). Next, to visualize each squirrel in detail on the distribution map, we created a name card for each squirrel by extracting the information of each squirrel (ID, Color, Age, and Hectare) and writing it into a new matrix. With all these elements, we created a squirrel distribution map for each date and also an overview of all dates combined using library “leaflet” and based on a provider map “CartoDB.VoyagerLabelsUnder”.

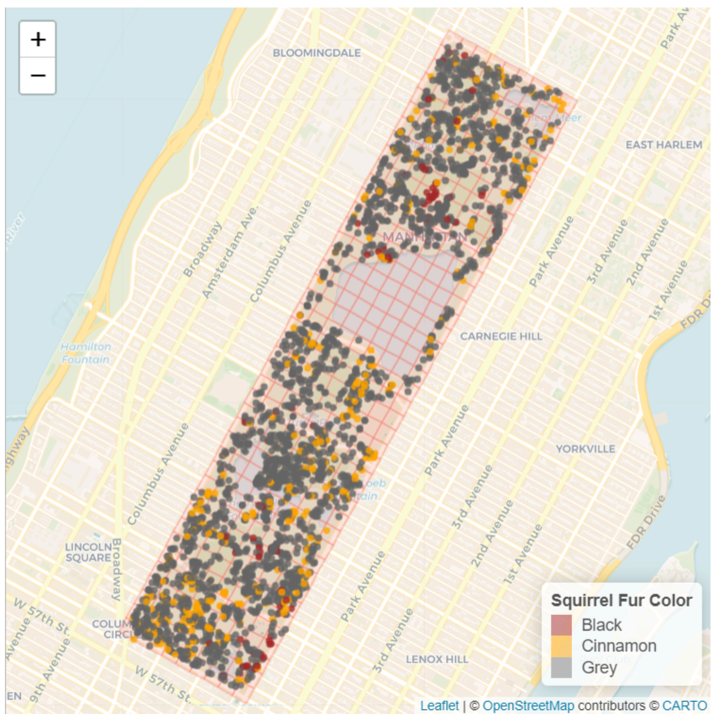


Figure 1. Squirrel Distribution Map (all dates combined)

Squirrel Distribution Based on Hectare
We then focused on the number of squirrels in each hectare to explore the distribution of squirrels. As noted previously, Central Park is divided into a 42×9 grid. In the following analysis, we combined every two rows into one group and named it from 01-21 starting from the bottom. According to the boxplot generated (Figure 2.), there are fewer squirrels in the middle of Central Park, ranging from groups 10-14. This is due to the natural landform of Central Park - a lake lies in the center of the park, thus the volunteers observed fewer squirrels in those groups. Other than those middle hectares, the squirrels are distributed uniformly across all the hectares.

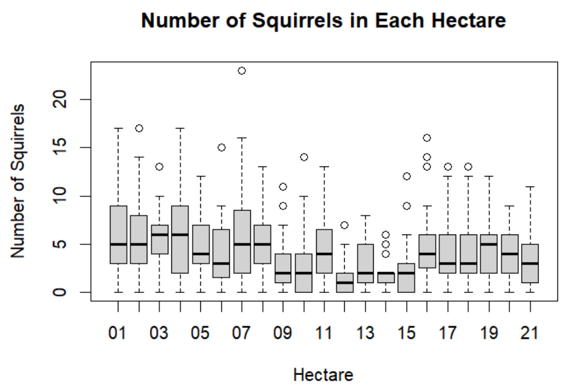


Figure 2. Number of Squirrels in Each Hectare Boxplot

We then focused on the distribution of each squirrel fur color across the hectares on different dates. We explored whether squirrel fur color correlates with the distribution of squirrels in Central Park. Then we create a stacked bar graph, counting the number of squirrels from each fur color in each grid every day. However, a caveat is that not every hectare is included in the graph - only the ones with observed squirrels are included. We can observe from Figure 3 that a significantly higher number of gray squirrels in Central Park than in any other colors (cinnamon and black) and fewer squirrels in the middle hectares – as a result of the lake in the middle of the park. The number of squirrels in nearby hectares tends to be very similar, which is also pictured in the map where there are clusters of squirrels across hectares. Throughout the days, the number of squirrels in each hectare changes and there doesn't seem to be a pattern that describes this change. The squirrels are scattered across Central Park randomly.

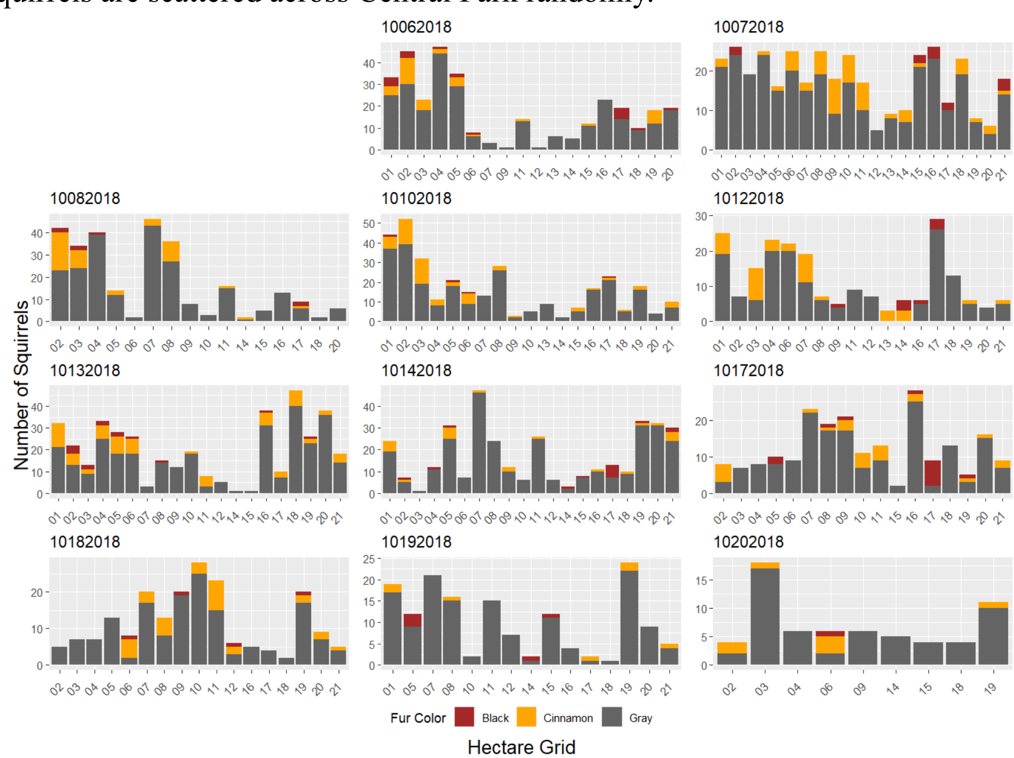


Figure 3. Number of Squirrels with fur colors in each hectare each day

Squirrel Distribution Based on Hectare Condition and Shift

Then we examined whether the condition of the hectare and when the observation took place (Shift) correlates with the number of squirrels being spotted. The condition of the hectare, which describes the amount of noise and human activity, has three categories: calm, moderate, or busy. The time of the observation is either AM and PM, indicating whether the observation was conducted during the morning or afternoon.

To test if these two variables influence the number of squirrels being observed, we created an ANOVA test between the intercept model (Y ~ 1) and the full model (Y ~ Condition + Shift), where Y represents the number of squirrels. The null hypothesis is that none of the variables, Condition or Shift, influence predicting the number of squirrels, while the alternative hypothesis states that at least one of the variables is useful in the prediction. The p-value of this model is 0.00638, which is significantly smaller than 0.05, so we reject the null hypothesis. Therefore, at least one of the variables, conditions and shift, is useful in predicting the number of squirrels.

Then we proceeded to test if both of the variables have an impact on the number of squirrels being observed. Using an ANOVA test on the model (Population ~ Condition + Shift), we have found that the p-value of "Conditions" is 0.659140 and the p-value of "Shift" is 0.000705. Therefore, according to the p-values, the Condition of the hectare is not significant in predicting the number of squirrels being observed. On the other hand, the "Shift" is useful in predicting the number of squirrels.

To better understand the relationship between the Condition and Shift and the number of squirrels, we constructed a boxplot using these three variables (Figure 4.). As shown below, the number of squirrels doesn't have a significant change whether the condition is busy, calm, or moderate. However, the number of squirrels increases when the shift is "PM" compared to "AM". More squirrels are being observed in the afternoon. From the test results, it seems that the squirrels are more active during afternoons, thus they are more easily observed.

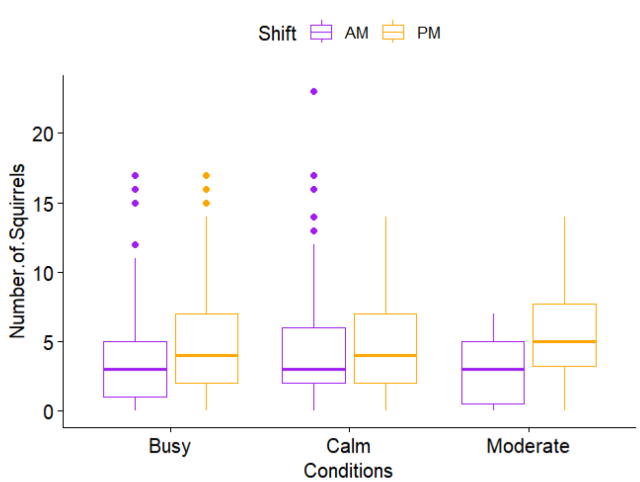


Figure 4. Boxplot of Number of Squirrels ~ Conditions + Shift

Squirrel Activities Analysis

In this section, we focus on the relationship between squirrels' daily activities and the environment.

Data Preparation:

There were two new variables used in this section of the analysis: temperature and presence.

The temperature variable is a numeric variable for daily temperature in Fahrenheit extracted from the Sighter.Observed.Weather.Data column using the library "stringr".

The dog_presence variable is a binary variable, extracted through using the keywords "(dog|Dogs|Dog|dogs)" in the column Other. Activities, Other.Interactions, Other.Animal.Sightings where the previous two are observation notes and the last is for recording animal sightings. A 1 indicates that there was a mention of dogs in either of these columns and 0 for no mention of dogs anywhere in the row of observation.

Squirrel Activities and Time:

Squirrels are diurnal creatures, which means they are primarily active during daylight hours. We want to investigate the correlation between squirrel activity and the time of the day. We have a 1:1 ratio for observation counts in the AMs and in the PMs.

To model this correlation, a logistic regression with class= "binomial" was applied. Since all the labels (XRunning, XChasing etc.) are all binary, using binomial distribution scales all probabilities accordingly. The model produces the following coefficients.

Coefficients for glm (Shift ~ XRunning, XChasing, XClimbing, XEating, XForaging):

	Estimate	Std.Error	T value	Pr(>|t|)
XRunning	-0.025566	0.022621	-1.130	0.25849
XChasing	0.004146	0.033144	0.125	0.90047
XClimbing	0.060102	0.024124	2.491	0.01278 *
XEating	-0.069854	0.021904	-3.189	0.00144 **
XForaging	-0.042657	0.020676	-2.063	0.03920 *

For the sake of analysis, we only consider variables with significant p values lower than 0.05, and where we can reject the null hypothesis that the two variables are uncorrelated. It seems that Climbing has a positive association with the AMs, tending to appear in the morning hours $e^{0.06}$ times more commonly. For Eating and Foraging activities, they tend to happen less in the morning hours, with $e^{-0.06}$ as likely. This may imply that squirrels tend to be more active in the trees in the morning hours, and more focused on food during afternoon hours. However, the "AM" and "PM" in this data set don't specify the specific time of the observation, and can only broadly symbolize “before noon” and “afternoon” hours. Perhaps that is why there isn’t a strong correlation between time shift and squirrel activities, since most of the observation occurred during daylight hours.

Thus, we proceeded to analyze the co-relationship between squirrel activity and the condition of the hectare during AMs and PM shown as two separate mosaic plots with the shades as Pearson residuals (Figure 5). From the graph, we can see that:

- No matter the time shift, running activity is more strongly positively correlated with busy hectare conditions compared to moderate and calm hectares.
- No matter the time shift, foraging activity is more strongly positively correlated with calm or moderate hectare conditions compared to busy hectares.
- Compared to PMs, running and chasing activities seems to be more strongly positively correlated with AM hours.

These observations may suggest that squirrel activities are correlated with the environment, where busy hectares may startle squirrels into running and climbing, where calmer conditions allow squirrels to salvage for food without fear of predators or other competitors. As for the correlation between running and chasing in AM hours, this may be due to the fact that there are more busy hectares observed in PM shifts. For AM shifts, the ratio of busy and calm conditions is approximately 1:1. But for PMs, busy and calm observations have a ratio of 2:1, which means that the majority of the PM shifts are more busy, and thus have a stronger negative correlation with the running activity.

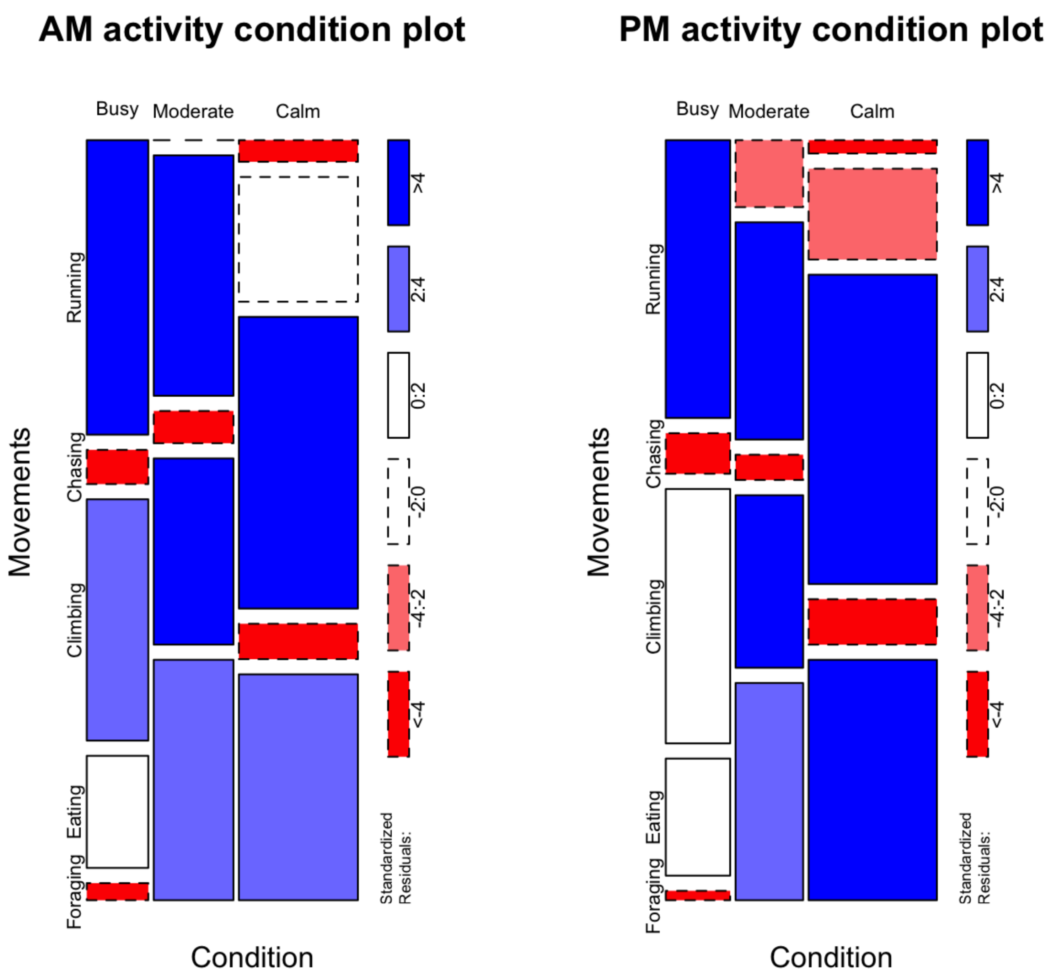


Figure 5. Count of Squirrel Activity ~Hectare Conditions + Shift time

Squirrel Activities and Dog Presence:
Furthering on the idea that environment may affect squirrel activities, we investigated one particular animal that seems to influence squirrel activity on a great level. From the observation notes, we noticed that there were many comments concerning the dogs in central park, such as : "threatened by approaching dog", "chased by a dog and climbed up a tree, carried a nut up there and started eating".

To model this correlation, a linear model was applied. The model supplied the following coefficients.

Coefficients for lm(Dog_presence ~ XRunning, XChasing, XClimbing, XEating, XForaging):

	Estimate	Std.Error	T value	Pr(>|t|)
XRunning	0.023210	0.019709	1.178	0.2391
XChasing	0.001205	0.028922	0.042	0.9668
XClimbing	0.045745	0.021049	2.173	0.0298 *
XEating	0.046207	0.019069	2.423	0.0155 *
XForaging	-0.018234	0.018006	-1.013	0.3113

For the sake of analysis, we only consider variables with significant p values lower than 0.05, and where we can reject the null hypothesis that the two variables are uncorrelated. It seems that Climbing has a positive association with the dog presence, tending to happen when dogs are present 5% more commonly, which aligns with the observation note presented earlier where squirrels are chased up trees by the dogs. For Eating activities, they tend to happen more in the case of dog presence also, being 5% more likely. The probability of these two activities happening when a dog is present is very similar, and may imply that they happen sequentially as the notes suggest: a dog will chase a squirrel up a tree, and there it will start eating its food safe from the dog down below. However, since dog presence also indicates human presence in many cases, this correlation might also be because of people bringing food or feeding the squirrels.

Thus, we proceeded to analyze the co-relationship between squirrel activity and the condition of the hectare during dog presence and dog absence shown as two separate mosaic plots (Figure 6). From the mosaic plots, the pattern for squirrel activities with and without dog presence is very similar. Since Central Park is a dog park, 75% of the observations have a dog present, so there might not be enough data to observe a different pattern for when dogs are absent. Also, the observation for moderate hectares is around only 10% of the overall observations, thus, the boxes for the correlation are very small compared to the other two conditions.

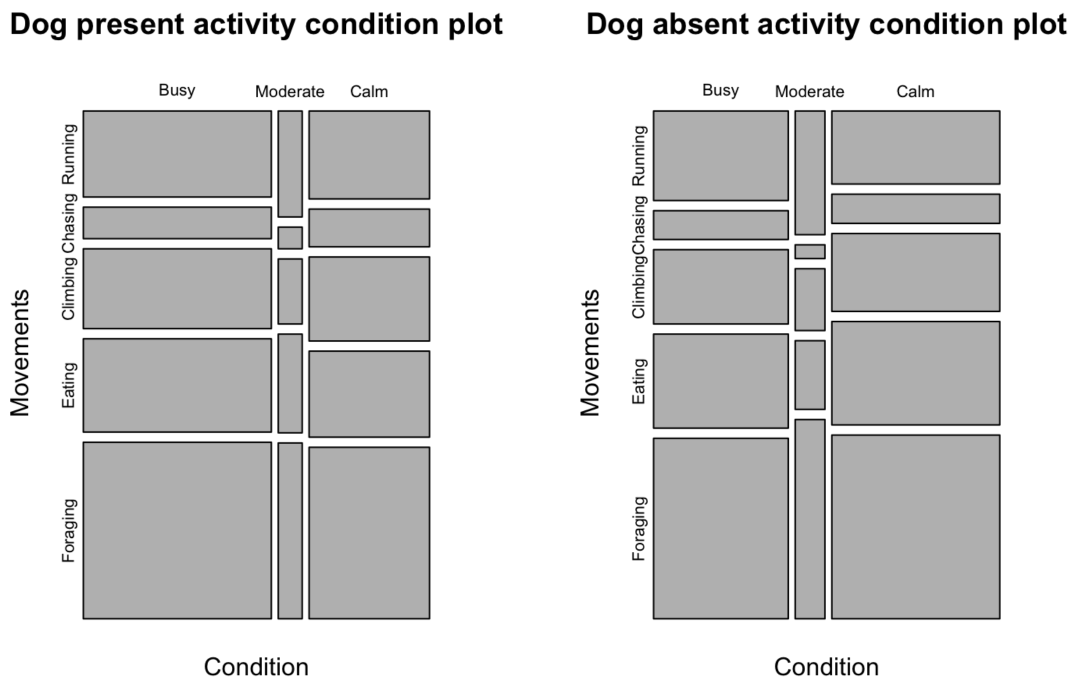


Figure 6. Count of Squirrel Activity ~Hectare Conditions + Dog Presence

Squirrel Activities and Environment Combined:
Next, we proceed to summarize our analysis, incorporating both the already discussed variables dog presence and shift, into a larger decision tree that conditions squirrel activities. For other possible factors that may influence squirrel activity, the variables temperature, litter, and location were added. Litter is the amount of litter found in the hectare at the time of the observation, which is categorized into three categories: abundant, some, and none. Location is just the location of the hectare where the squirrels are observed, separated into three categories: High, Mid, and Low. We created a decision tree to display how these variables contribute to the change in squirrel activities.

The movement of squirrels was separated into two categories: movement and eat, where the first categories indicate whether a squirrel was running/ climbing/chasing, and the second indicates whether it was engaging in activities about food, which includes eating or foraging for food.

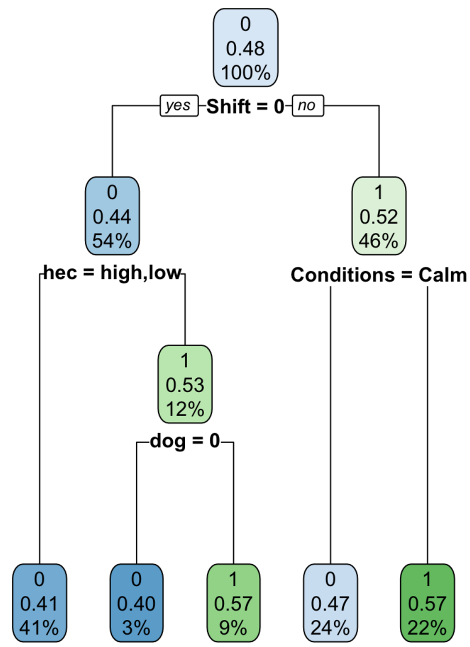


Figure 7.1. Decision Tree for Movement (Running, Chasing, Climbing)~ (hectare) Condition, Hectare (location), Shift, Dog (presence), Temperature, Litter

The decision tree for movement (Figure 7.1) has a test accuracy of about 70% percent, where it correctly classified the squirrel movement activities based on the other conditions. For the first layer of the tree, we can see that the squirrels are more likely to be active during PM hours, with a probability of 52% compared to 54% of AMs. We can also see that for high and low hectares, the squirrels have a 59% probability of action compared to those in mid hectares with a probability of 53%. However, only 12% of data is captured in the mid hectares, which may explain why the decision tree created a new node with dog presence to further categorize the data. Overall, there isn't much difference in the probability of squirrel activity across the different conditions, as all probabilities are around 50% or so, just a little bit better than chance.

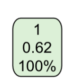


Figure 7.2. Decision Tree for Food (Running, Chasing, Climbing)~ (hectare) Condition, Hectare (location), Shift, Dog (presence), Temperature, Litter

The decision tree for food activities (Figure 7.2) has a test accuracy of 63.3% percent, where it correctly classifies squirrel food activities given other conditions. There is only 1 single node, indicating that squirrels have a 63% probability of engaging in food activities regardless of the circumstances. As squirrels need food to survive daily, it is reasonable that they have to search for and eat food everyday given any circumstance, no matter if there were dogs, or the hectare is bustling with people, or it's a cold dreary day. Food activities ensure that squirrels will survive on a day to day basis, and are thus independent of other factors.

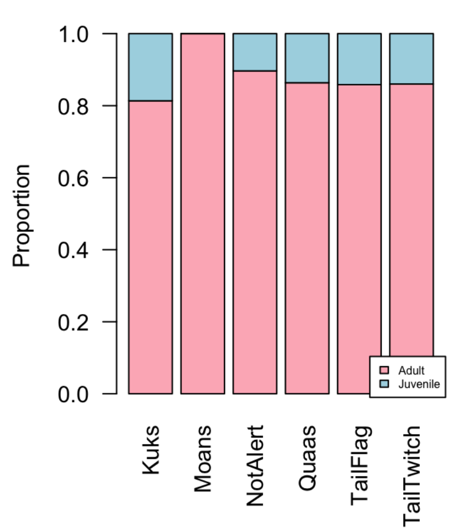
Squirrel Alertness Analysis

As with many other animals, squirrels use sounds and motion to communicate with one another. In particular, squirrels use kuks, moans, and quaas to communicate alertness and relay information about the level of danger. For instance, when squirrels see immediate danger or have urgent information they want to convey to peers, they produce a kuk sound and elongate the kuk sound to a quaa sound when danger is not as pressing (Kelly 2012).

Before conducting any analysis, it's important to note that there are overlaps in sound observations; a squirrel entry may have true values for both kuk and quaa. Since these entries cannot be categorized due to the lack of context, all entries with more than one sound or more than one tail motion were removed. This resulted in the removal of 29 entries, leaving 2680 entries for analysis. However, in this analysis, sound and tail alertness will be examined separately. Therefore, squirrels with one sound and one tail motion will not be removed from the data. Additionally, after cleaning the data, only one observation of moans remained. This may result in possible NaNs in our models and results.

Analysis: Correlation with Age

In our initial analysis, we aim to investigate the correlation between age and alertness. Specifically, we want to determine if experience with predators leads to a higher level of alertness. The Squirrel Census partitions squirrels into 2 categories: juvenile and adult.



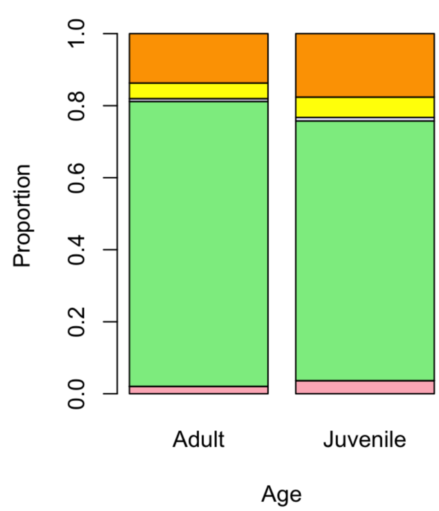


Figure 8. *Left* Stacked proportional bar graph of the age proportions for each alert response.
Figure 9. *Right* Stacked proportional bar graph of alert reactions for each age group.

Figure 9 shows the proportion of behaviors of alertness within each age group. To our surprise, the proportion of “not alert” for juvenile squirrels is less than that of adult squirrels. There is also a higher proportion of tail motion for juveniles than adults. With this observation, we constructed two multinomial logistic regression with the response variables being sound and tail motion with the covariate of age.

$$ln(\frac{P(Sound_i)}{P(NoSound)}) = \beta_{age} * X_{age} \qquad ln(\frac{P(Tail_i)}{P(NoTailMotion)}) = \beta_{age} * X_{age}$$

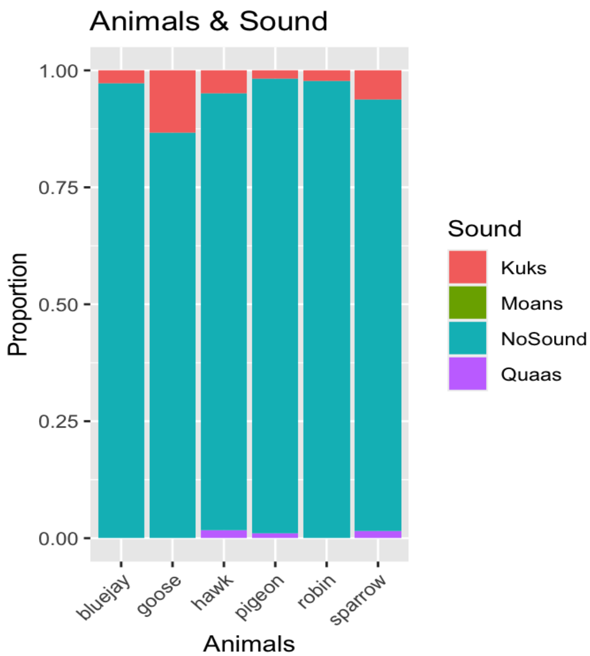
> Since it is a multinomial logistic regression, it compares each possible level of the response with the reference level. In the instance of the tail motion model, the response variable is the tail motion variable with the reference level of no tail motion and the model analyzes the correlation of the age covariate (binary) and the log odds of tail twitch as opposed to no tail motion and the correlation of the age covariate and the log odds of tail flag as opposed to no tail motion.

However, all the p-values for both models were above 0.05 and thus were insignificant on the 0.05 level. This could be explained by the disproportionate representation of juveniles as shown in Figure 8.

Although the covariates did not reach statistical significance at the 0.05 significance level, the multinomial logistic model that modeled tail motion against age still reflects the trends observed in Figure 9. The multinomial logistic model indicates that juvenile squirrels are approximately 1.39 times more likely to exhibit tail twitching compared to adult squirrels, although this result is marginally significant (p-value = 0.05305).

Analysis: Correlation with the Presence of Other Animals

Following our analysis of the correlation between age and alertness, we were interested in understanding how the presence of birds in the area affects squirrels. As previously noted, squirrels typically respond to perceived threats with sounds and tail motions, including those caused by predatory birds such as hawks and owls. In our dataset, volunteers also provided information on other animals present when a squirrel was observed. After analyzing the data to identify the most frequently encountered birds, we selected pigeons, hawks, robins, bluejays, sparrows, and geese for our analysis.



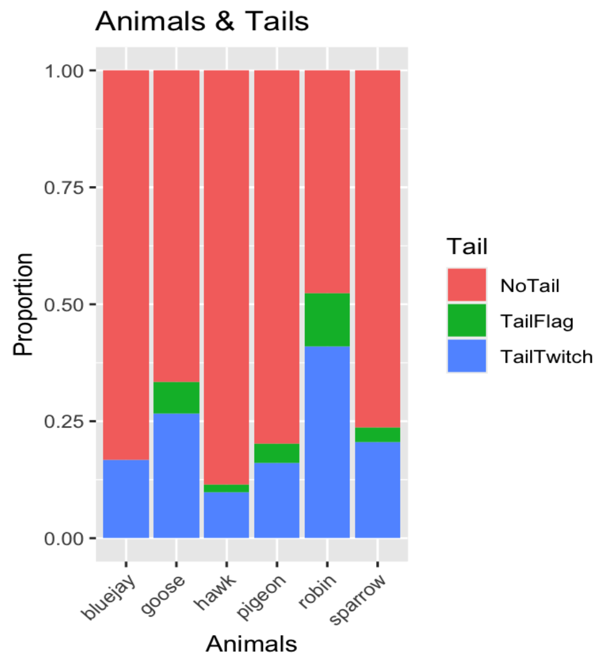


Figure 10. *Left* Stacked proportion of sounds observed when each animal is present.
Figure 11. *Right* Stacked proportion of tail motions observed when each animal is present.

The figures above show a higher proportion of Kuks observed when a goose is present and a possible correlation between the presence of goose and robins and tail motion observations. These findings from the stacked charts motivated the creation of our two multinomial logistic regressions analyzing the relationship between the presence of birds found in Central Park and the alertness behavior of squirrels.

The full display of all parameter estimates for both models can be found in the appendix file named Squirrel_Alertness_YingLinZhao, but for the sake of conciseness, we will only look to include the statistically significant values and the values for the hawk (a predator that hunts squirrels) covariate in our discussion of squirrel alertness.

<u>The Sound Model:</u>

$$ln(\frac{P(Sound_i)}{P(NoSound)}) = \beta_{hawk}X_{hawk} + \beta_{goose}X_{goose} + \beta_{pigeon}X_{pigeon} + \beta_{robin}X_{robin} + \beta_{sparrow} * X_{sparrow} + \beta_{bluejay} * X_{bluejay}$$

In the sound alertness model, the table below presents predictor estimates for the kuk level, specifically for sparrows, geese, and hawks. It's worth noting that the remaining levels of the sound variable lack significant predictors, possibly attributed to the limited occurrences of moans and quaas in the presence of animals.

Sound Model		Coefficient	Standard Error	P-Value
Kuks	Sparrows	1.1545	0.6410	0.0087

	Goose	1.9659	0.7981	0.01377
	Hawk	0.8931	0.6410	0.1636

Based on the model, we have that

- Assuming all else equal, if sparrows are present, the odds of squirrel producing a kuk sound are approximately 3.1724 $(e^{1.1545})$ times the odds when no sparrow is present.
- Assuming all else equal, if geese are present, the odds of the squirrel producing a kuk sound are approximately 7.1413 $(e^{1.9659})$ times the odds when no goose is present.
- Assuming all else equal, if hawks are present, the odds of a squirrel producing a kuk sound are approximately 2.4427 $(e^{0.8931})$ times the odds when no hawk is present. However, this is not statistically significant on a 0.05 level.

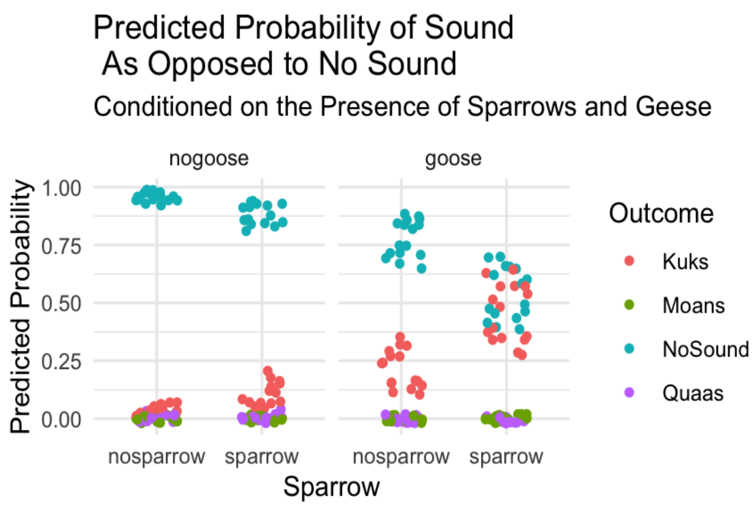


Figure 12. Predicted probability of observing each sound conditioned on the presence of sparrows and geese.

Figure 12 shows a similar pattern. Compared to when geese and sparrows are not observed, we can see the average predicted probability of observing a kuk sound when there is a goose increases from approximately 5% to approximately 25%. Although geese are not natural predators of squirrels, the abrupt loud noise can startle a squirrel and cause it to become alert. Although there is no clear indication in the other animal notes field about whether the goose was honking or not, squirrels' kuks may be a result of loud honks of geese in the surrounding area. In a similar manner, when sparrows are observed, the average predicted probability of hearing a kuk sound increases by approximately 5% compared to when sparrows are not observed. The correlation between the presence of sparrows and squirrel kuks is interesting because sparrows are not predators of squirrels. Upon further investigation, we found evidence suggesting that squirrels frequently eavesdrop on birds' conversations to gather information about their surroundings

(Newman 2019). Consequently, the observed correlation between the presence of sparrows and squirrel kuks likely stems from the potential danger that squirrels overheard from sparrow conversations. Furthermore, the correlation between the presence of sparrows and geese with kuks of squirrels is significantly strengthened when both animals are present. This is evidenced by a sharp rise in the predicted probability of hearing kuks when both geese and sparrows are present, in contrast to their absence. We hypothesize that this may be a result of the diet overlap between the three animals– since all three animals' diets consist of seeds, grains left on the grass by park visitors, and fruits (Wildlife Online 2014; Geese Relief; Sparrow Daughter 2023).

Interested in the presence of hawks – a predator of squirrels and sparrows – , the presence of sparrows – a bird that squirrels likely eavesdrop on for danger alerts– , and its relationship with sounds observed, we also created Figure 13, which displays the predicted probability conditioned on the presence of sparrows and hawks.

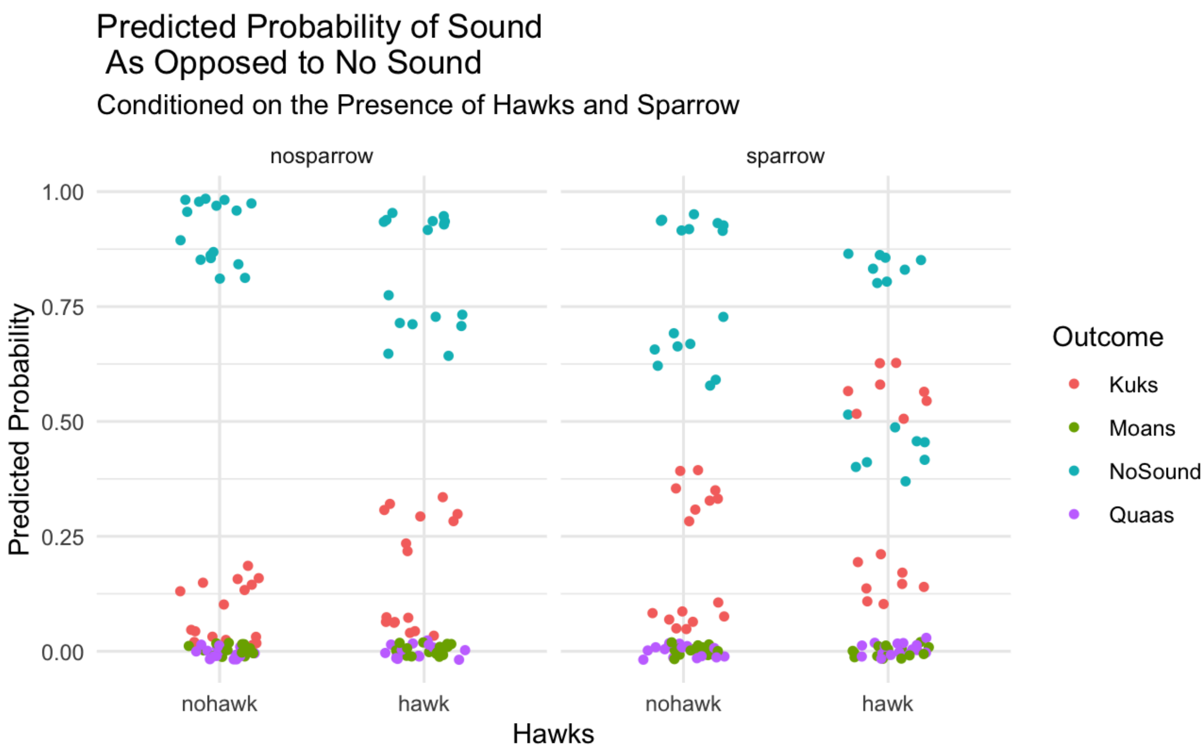


Figure 13. Predicted probability of observing each sound conditioned on the presence of hawks and sparrows.

Surprisingly, although there is an increase in the predicted probability of kuks in the presence of hawks than where there are no hawks, the increase is not as large as we expected it to be – given hawks are predators of squirrels. In addition, we can observe that the predicted probability for kuks is higher when there are hawks and sparrows than when there are only hawks. This supports our hypothesis that using information from overhearing birds' conversations, squirrels react accordingly to the presence of predators.

The Tail Model:

$$ln(\frac{P(Tail_i)}{P(NoTailMotion)}) = \beta_{hawk}X_{hawk} + \beta_{goose}X_{goose} + \beta_{pigeon}X_{pigeon} + \beta_{robin}X_{robin} + \beta_{sparrow} * X_{sparrow} + \beta_{bluejay} * X_{bluejay}$$

Moving to our analysis of tail alertness using the tail model – which analyzes the correlation between the presence of pigeons, hawks, robins, blue jays, sparrows, and geese and the tail motions of squirrels.

Tail Model		Coefficient	Standard Error	P-Value
Tail Flag	Robins	1.8216	0.5367	0.0007
	Hawks	-0.7321	1.0288	0.4767
Tail Twitch	Robins	1.6156	0.3367	0.0000016
	Hawks	-0.4272	0.4420	0.3337

Based on the model, we have that

- Assuming all else equal, if robins are present, then the odds of a squirrel doing a tail flag is approximately 6.1817 ($e^{1.8216}$) times the odds when no robins are present.
- Assuming all else equal, if hawks are present, then the odds of a squirrel doing a tail flag is approximately 0.4808 ($e^{-0.7321}$) times the odds when no hawks are present.
- Assuming all else equal, if robins are present, then the odds of the squirrel doing a tail twitch is approximately 5.0309 ($e^{1.6156}$) times the odds when no robins are present.
- Assuming all else equal, if hawks are present, then the odds of a squirrel doing a tail twitch is approximately 0.6523 ($e^{-0.4272}$) times the odds when no hawk is present. However, this is not statistically significant on a 0.05 level.

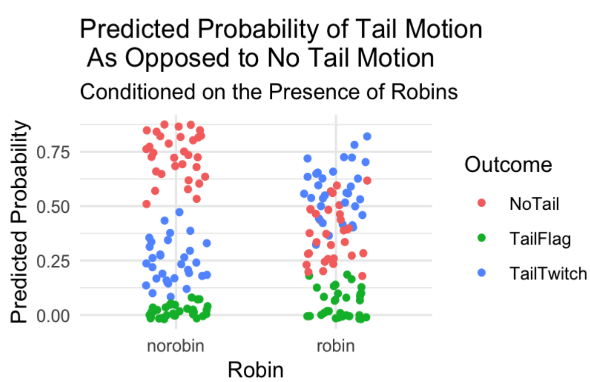


Figure 14. Predicted probability of observing each tail motion conditioned on the presence of robins.

To our surprise, both the hawk coefficient and the p-value indicate that there does not exist a strong correlation between the presence of hawks and squirrel tail motions. Focusing on the sole significant predictor, the presence of robins, and its correlation with squirrels' tail motions, we observe a noticeable distinction in both the predicted probabilities of tail flagging and tail twitching. Specifically, there is an increase in the likelihood of observing these tail motions when robins are present. Furthermore, the average predicted probability of no tail motion decreases significantly from approximately 75% to around 40% in the presence of robins.

Further investigation into the underlying reasons for squirrels' reactions to robins revealed intriguing findings. Not only do squirrels eavesdrop on birds' conversations, but they also engage in predation on baby birds and eggs, and compete with birds such as robins and sparrows for nuts, insects, and fruit (Wildlife Online, 2014). This discovery led us to hypothesize that the observed alertness in squirrels may be influenced not only by the threat of predation but also by the presence of food sources or competition for these resources.

Limitations

Due to the nature of these datasets, it is plausible that some squirrels were being observed multiple times. The Unique Squirrel IDs provided in the datasets are composed of three elements: the hectare the squirrel is in, what time or day it is, and i-th squirrel being observed in that hectare. Therefore, one squirrel may be assigned more than one “unique ID” depending on the number of times it has been sighted.

Moreover, the squirrel activities being observed may also be influenced by human activities. Firstly, the squirrel distribution map created from these datasets serves more as a snapshot of the squirrels’ daily activities rather than a tracking of their movements. Secondly, it’s essential to note that not all hectares of Central Park are being observed every day. Therefore, some clusters of squirrels observed may be correlated with the volunteers being assigned to certain areas.

Conclusion

To summarize, we can see that squirrel behaviors are, to an extent, influenced by other animals in their habitat. When dogs are present around them, squirrels do more climbing and eating activities as dogs enjoy chasing small lively animals, and squirrels will move to avoid them. When certain birds, like robins, sparrows, and geese are present, squirrels also react to their presence with unique sounds and tail motions to signal alertness. However, it is unclear whether this alertness is threat-motivated or food-motivated.

Generally, squirrels are quite random creatures, and the patterns we observe in their behavior are limited. These small creatures’ activities are influenced by many factors in their environment, and it is hard to distinguish a single contributing factor.

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Appendix:

Link to our common GitHub: https://github.com/yzhao2433/Squirrel-Analysis

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