Proceedings of The National Conference
On Undergraduate Research (NCUR) 2019
Kennesaw State University
Kennesaw, Georgia
April 11-13, 2019

Activity Patterns of Feeder Birds at Georgia Gwinnett College

Matthew Tatz
Environmental Science – Natural Science (Focus in Ecology)
Georgia Gwinnett College
1000 University Center Ln
Lawrenceville, Georgia 30043 USA

Faculty Advisors: Dr. Mia Malloy, Maria Fernandez, Dr. Jill Penn

Abstract

There is currently an active effort around Georgia Gwinnett College (GGC) campus to monitor avian biodiversity and survivorship by banding birds. This research project was designed to study the frequency of visits by species and time of day at three sunflower feeder locations on campus in three individual fragmented forests with potential for future banding. Above the feeding platform, thermal-imaging cameras captured pictures of visitors to the feeder, and these images were manually identified to species. Data will demonstrate bird foraging activity throughout the day as well as relative feeder-bird abundance compared to species richness. A list of feeder-bird species and their daily feeding activity patterns revealed a normal distribution foraging pattern. Activity began at sunrise, increased until noon, and then decreased until stopping at sunset. Additionally, Carolina chickadee, Tufted titmouse, and White-breasted nuthatch were significantly more abundant than the rest, showing a high species abundance. A graph was created to test for temporal resource allocation among the most abundant species to see if this was a factor contributing towards these species' coexistence. Using GIS software ArcMap, a map was created displaying pie-charts at each site which revealed distinct resource allocation among the most abundant bird species. Using these results, researchers will be able to more efficiently band birds at peak hours of activity, as well as target species of concern. Recognizing where near-threatened species like the Red-headed woodpecker are and where species are more abundant on campus allows for more informed decisions when removing habitat for infrastructure.

Keywords: Bird Foraging Patterns, Abundance versus Richness, Georgia Gwinnett College

1. Introduction

As Georgia has become increasingly populated, there has been a large increase in deforestation and overall habitat loss.[1] Construction efforts have continued without fully understanding how various avian species that rely on these particular habitats are affected. Multiple avian species of concern are currently living around the Georgia Gwinnett College (GGC) campus such as the Brown-headed nuthatch (BHNU), whose population is currently declining as old-growth pine habitat loss increases in the state.[2] Consequentially, numerous species have grown closer to endangerment. Abundance of these bird species varies in these fragmented forests due to multiple factors such as canopy height, elevation, slope and aspect.[3] Preserving these populations contributes to a greater biodiversity and overall species richness. Understanding overall abundance of bird species around GGC campus allows for an in-depth look at what types of species are present, which may influence decisions on expanding the fragmented forests surrounding campus.

Current avian monitoring efforts on GGC campus include banding through mist-netting, point counts, and RFID tag readings. Mist-netting can be problematic, as it is not ideal in cold or hot temperatures because birds caught in the net can drop below or above a healthy temperature required to maintain metabolic homeostasis, resulting in distress. Also, excessive wind contributes to less-effective catch due to increased net visibility. Wind can also ruin the mist-nets

themselves and endanger netted birds. The point counts used at GGC only detect visible and vocal individuals at a specific point for five minutes each monitored day, missing those bird that are quiet at the time of the count. Therefore, this project used camera traps that aided in 24-hour monitoring of bird activity patterns regardless of inclement weather or whether the bird is vocalizing. Most of the current bird monitoring on GGC campus traditionally occurs in the morning between 6:00 AM and 12:00 PM, with the remainder of the daylight hours unmonitored. There is currently a lack of understanding on the foraging frequencies of birds from sunrise to sunset, and it can be challenging to monitor avian activity throughout a day. To monitor bird foraging, optimal food choice for each species, location, visibility, and time of observations after sunrise are important considerations.[4] In a previous study, black oil sunflower seeds were used as feed under both open and closed canopy and activity was monitored over a two-week period via in-person observation over small time periods. The study concluded that a longer-term experiment monitoring activity would be more efficient by having more data as well as the impact of resource predictability if feeders were left for a longer period.[4] Consistently active camera traps are a more effective tool than in-person observation, eliminating the time gap in between observation times.[5] This current monitoring study was conducted for nine weeks using stationary camera traps at feeders.

Many factors can dictate diurnal bird foraging activity, including predatory risk and energy balance. Previous studies have found activity to follow a bell-shaped trend, peaking mid-day, but this curve may change with seasonality and weather patterns.[6,7,8] Pitera et al. notes that in order to ensure overnight survival, small birds must accumulate sufficient energy reserves throughout the day with a higher portion of foraging occurring in the morning to make up for depleted energy reserves lost overnight.[7] Seasonality did seem to alter foraging activity, but there was still a general bell-shaped trend. Brandt et al. found foraging activities resulted in an inverted bell-shaped trend, where foraging was highest in the morning and in the evening, regardless of predation patterns.[9] As both trends suggest foraging activity is highest in the morning, it was hypothesized that bird foraging activity in the fragmented forests surrounded GGC campus will be greatest from sunrise to noon, peaking shortly after sunrise, and decreasing from noon to sunset.

Forest fragmentation is currently a concern as it has contributed to a loss in biodiversity and increased species extinction due to factors such as decreased pollination, seed dispersal and nutrient recycling.[10] Ecological theory supports the notion that loss of biodiversity at the base of an ecosystem leads to a negative bottom-up effect to dependent species like feeder birds.[11] Didham et al.'s research supports the notion that fragmented forests results in a decline in species richness as well as abundance.[10] Knowing this, it is likely specialist species like the BHNU would perform worse in fragmented forests with less resource availability. Therefore, it was hypothesized that there are a few (two to three) generalist bird species with significantly greater abundance around campus, which may be due to continuous forests. The other possibility is that the abundance for each species would not be significantly different than any other species around campus, indicating a higher species richness. The objectives of this study are to observe a trend in feeder bird foraging activities, find relative abundance of feeder bird species, and to discern if three replicate habitats with identical feeders have similar relative species abundance.

2. Methodology

Three bird feeders were created using 1.5 meters steel rod with a 25 x 20 cm wooden plank attached. A mesh cage with 1 x 1 cm holes was fixed to the base with aluminum wire. Attached to the back of the plank, a 40 x 10 cm plank stands vertically with a Tasco 8MP game camera facing downwards towards the wire cage full of seed. The camera was set to take three pictures every five seconds. Six 8 MB SD cards were used, two per camera. While one card was in use, the other would be analyzed to ensure consistent monitoring of bird activity. The feeders were placed in areas with open underbrush and lower canopy in relatively undisturbed areas on Georgia Gwinnett Campus (GGC) and identified as locations A, B, & C. Biweekly, and over a ten-week non-breeding season (8/24/18 – 11/2/18), the SD cards were rotated, and the black oil sunflower seeds were replenished. Captured photos were analyzed for foraging time. Visitations were counted once every five seconds per species unless two or more individuals of the same species were present (each additional individual of the same species would count as a visit) to reduce double-counting the same individual. If any individual left and came back within those five seconds, that would not be counted as a visit. For species abundance, a post hoc Tukey test was created to find significant differences for the top ten rating in rank abundance. For the three most abundant species, Carolina chickadee (CACH), Tufted titmouse (TUTI) and White-breasted nuthatch (WBNU), independent statistical analyses were run to find mean values plotted on a scatter plot graph against the mean visits per time period of all species. The overall abundance of each species per location was then visualized by creating three pie charts overlaying a satellite image of GGC campus with markers showing where the feeders were placed.

3. Results

The data was compiled for the three separate feeders, and total species visits were compared to time of day and a bar graph was created to illustrate the trend (Figure 1). To find general species abundance in terms of visits to the feeders, total visitation per species was compiled and compared to one another for significant differences using a post-hoc Tukey Test. (Figure 2). The three most abundant species were compared to each other and to the compiled visits of all species combined in order to see if there was any temporal resource allocation happening between them by creating a comparative bar graph (Table 1, Figure 3). Finally, species abundance was plotted onto a GIS map of the GGC campus in the form of three separate pie charts respective to each feeder in order to see if there were any trends in relative species abundance per location and to track species territory based on population size (Figure 4).

3.1. Foraging Activity Patterns

To determine whether there was a foraging pattern throughout the day, photos were individually analyzed for independent bird species "visits" from 6:00 AM – 8:00 PM, divided into half-hours. An individual would only be counted as one visit regardless of the time present on the feeder and would be counted as soon as the individual landed on the feeding platform. All visits were added per thirty-minute time period and then totaled for all locations. A single-factor ANOVA was created for each analysis to determine whether there was a trend in foraging time (Figure 1). This analysis yielded a bell-shaped curve with significant differences in feeder visits between each neighboring 30-minute interval ($p < 0.001$). There were significant differences between all time periods with a p-value < 0.0001. Standard error bars in figure one reveal there are multiple significant differences among groups, namely between the morning to mid-day, and mid-day to evening.

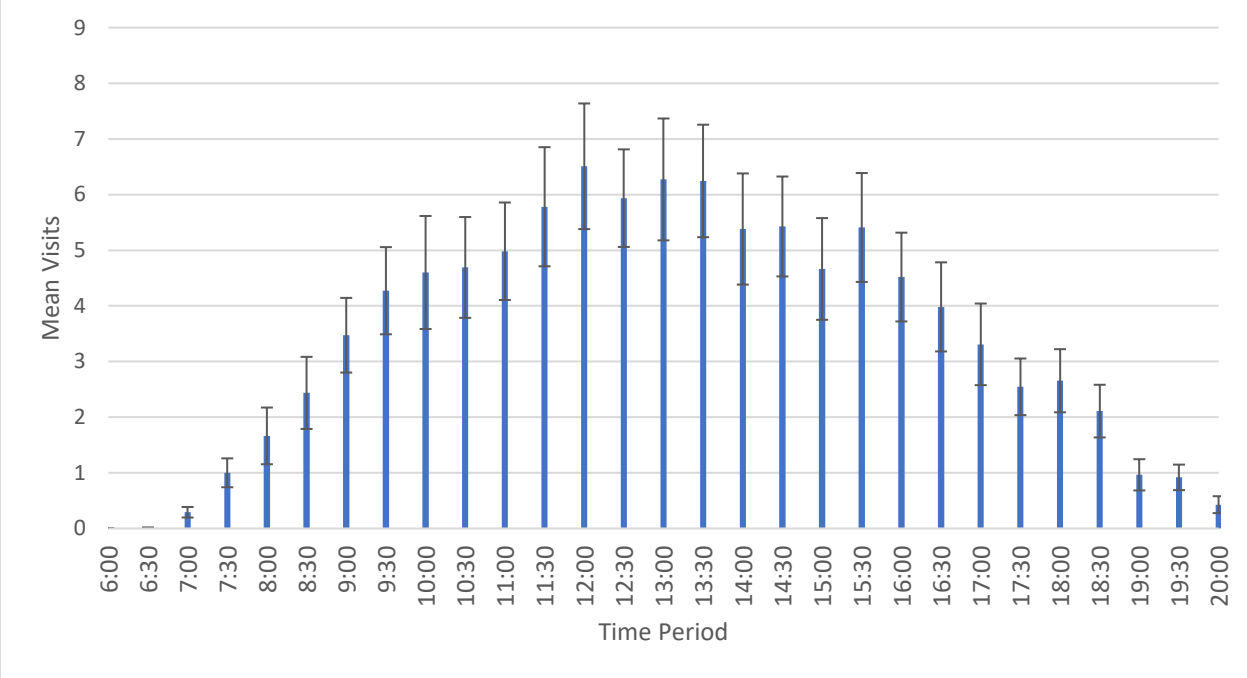

Figure 1. Relationship between the mean value of combined number of visits of all bird species and time period from sunrise to sunset.

Figure 1 reveals the bell-shaped curve trend in bird foraging through a day's period by comparing the mean number of visits recorded throughout the thirty-minute time increments at all three locations. The peak number of visits was at 12:00 PM while the fewest recorded visits was at 6:00 AM. Visits remained relatively abundant from 9:30 AM – 4:30 PM.

3.2. Abundance Versus Richness

All visits per species were also totaled for all locations to determine the most abundant feeder birds (Figure 2). For the three most abundant species, Carolina chickadee (CACH), Tufted titmouse (TUTI) and White-breasted nuthatch (WBNU), independent statistical analyses were used to find mean values plotted on a scatter plot graph against the mean visits per time period of all species (Table 1, Figure 3). All trends showed the same bell-shaped curve, with similar and consistent foraging times from 9:00 AM – 4:00 PM. With lower rates of abundance, the species seem to have less drastic changes in foraging activity throughout the day, with CACH having the largest shifts. Both the TUTI & WBNU peaked thirty minutes ahead of the average (Figure 3).

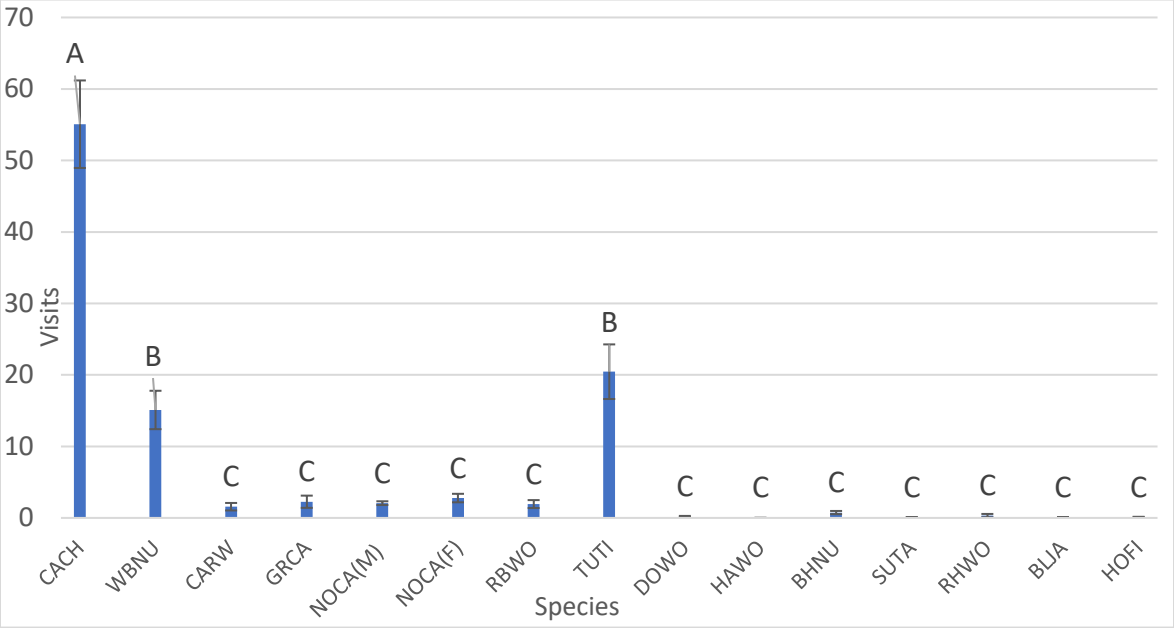

Figure 2. Overall abundance per species determined via total number of visits at all three locations

The abbreviations used denote the following species from left to right: Carolina chickadee (CACH), White-breasted nuthatch (WBNU), Carolina wren (CARW), Grey catbird (GRCA), Northern cardinal (male) (NOCA(M)), Northern cardinal (female) (NOCA(F)), Red-bellied woodpecker (RBWO), Tufted titmouse (TUTI), Downy woodpecker (DOWO), Hairy woodpecker (HAWO), Brown-headed nuthatch (BHNU), Summer tanager (SUTA), Red-headed woodpecker (RHWO), Blue jay (BLJA), and House finch (HOFI).

Figure 2 represents the overall abundance of each species at the three feeder locations. The CACH is the most abundant species, significantly different than all other species (A vs B and A vs C) with a p-value of $p < 0.01$. Second most abundant, TUTI was significantly different than all species with $p < 0.01$ except for WBNU ranking third most abundant and also different than all other species with $p < 0.01$ except for the TUTI (B vs A and B vs C).

Table 1: Statistical comparison of the three most abundant species

Species Comparison	F Value	df	p- Value
CACH vs WBNU	35.79	1	0.0001
CACH vs TUTI	23.04	1	0.0001
WBNU vs TUTI	1.31	1	0.25

Table 1 shows the statistical differences amongst the three most abundance species. CACH is significantly different from both WBNU and TUTI with both p-values < 0.01. WBNU and TUTI were not significantly different from each other with a p- value of 0.25.

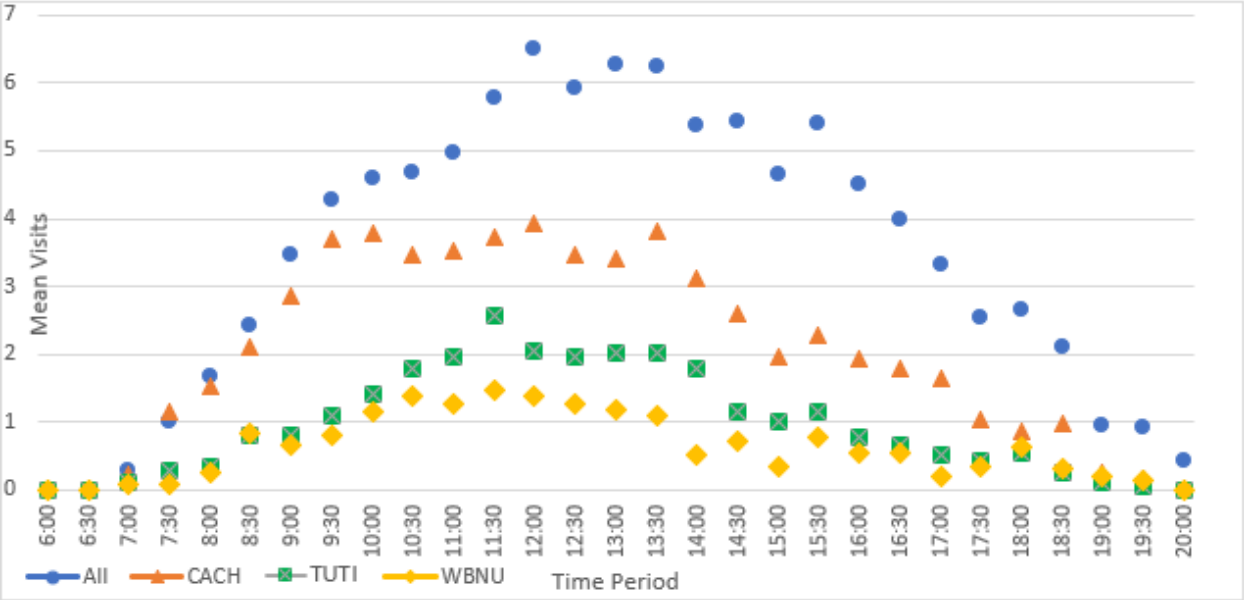

Figure 3. Comparison between All Species, CACH, TUTI & WBNU in mean visits throughout thirty-minute increment time periods

Figure 3 shows mean species visits for the top three abundant species CACH, TUTI & WBNU over the various time periods. All trends show the same bell-shaped curve, with similar active consistent foraging times from 9:00 AM – 4:00 PM.

3.3. Relative Species Abundance

The overall abundance of each species per location was visualized by creating three pie charts overlaying a satellite image of Georgia Gwinnett College (GGC) campus with markers showing where the feeders were placed (Figure 4). Created using Arc Map, a GIS application software, and the visitation data collected, three pie charts were created to show the difference species abundance at each respective feeder location in order to compare relative abundance at each location. Each feeder was situated in a fragmented forest with comparable habitat features including similar elevation, plant diversity, and canopy height. Figure 4 shows that CACH was most abundant at all locations, WBNU was the second most abundant at location C (third for A & B), while TUTI was second most abundant at locations A & B (third at C). This map also shows the relative geographical locations of the three feeders on GGC campus.

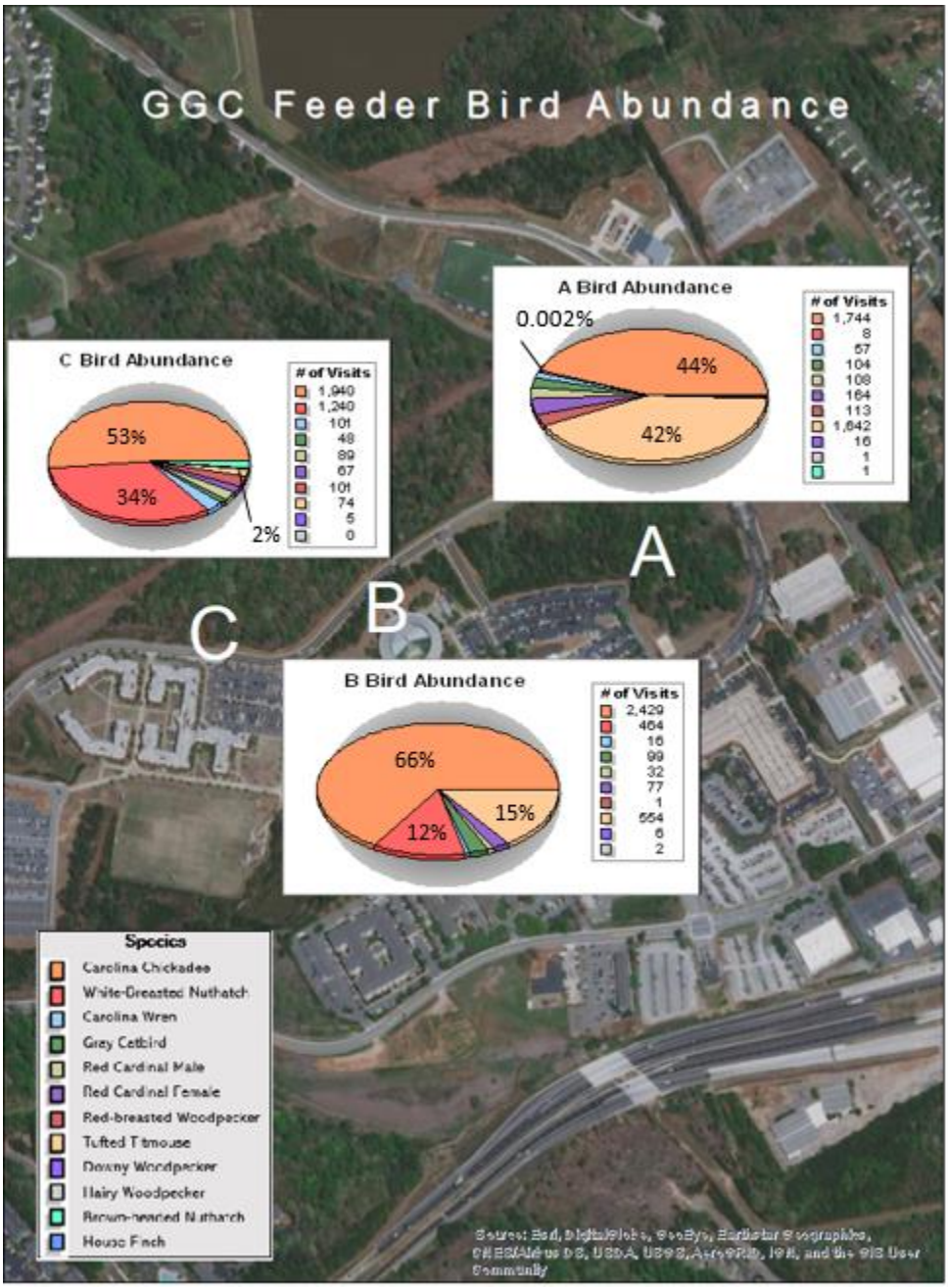

Figure 4. Map of GGC campus containing pie charts representing overall abundance per each species at locations A, B & C.

Figure 4 displays relative species abundance for each of the three feeder locations, including percentages for the three most abundant species. This visualization shows that CACH was most abundant at all locations, WBNU was the second most abundant at location C (third for A & B), while TUTI was second most abundant at locations A & B (third at C). This map also shows the relative geographical coordinates on GGC campus the three feeders were located.

4. Discussion

Due to suburbanization in the past decades, deforestation is at an all-time high in Georgia. This has led to the decline in specialist species populations such as the red-cockaded woodpecker which rely on old-growth pine trees for nesting. When a forest becomes fragmented, various biological processes which maintain biodiversity suffer, such as pollination, seed dispersal and nutrient recycling, which leads to a less diverse ecosystem.[1] Additionally, decreased patch size, increased edge length and isolation decrease species richness.[3] As such, a decline in total area of continuous forest and an increase in the number of fragmented forests causes a decrease in total species richness which leads to a lower biodiversity and thus less diverse ecosystem.[1] By finding species abundance in the bird populations on GGC campus, we are able to investigate whether the fragmented forests of GGC support the notion that species abundance is greater than species richness in these ecosystems.

4.1. Foraging Activity Patterns

Prior research proposes that diurnal bird activity patterns are directly correlated to the light-dark cycle.[7,8] Feeders were consistently filled with sunflower seeds which allowed for consistent activity throughout the day. As Figure 1 shows a bell-shaped curve, there is no support for our hypothesis that bird foraging patterns via visits would be highest during morning hours (sunrise to noon). Instead, this study indicates foraging activity increases until 10:00 AM as birds become active and remains consistently active until 4:00 PM before dropping off as birds prepare for torpor. The trend increases until noon may be due to the delay it takes for birds to wake up and take time to travel to the feeders. Activity decreases later in the day as birds may begin to return for rest. The bell-shaped curve supports Pitera et al.'s similar bell-shaped trend observing foraging routines of chickadees.[7]

4.2. Abundance Versus Richness

We accept our second hypothesis that there would be a few species with higher abundance rather than a greater species richness and evenness as shown through Figure 2. CACH, WBNU and TUTI all have significantly higher abundance compared to the other species. This is likely due to the habitats in which these birds were observed, as species abundance tends to be higher than species richness in fragmented forests, and there is often a general loss in biodiversity as forests become more fragmented.[3] CACH was the most abundant species of all three. The three most abundant species on campus was not a new observation. Over the past fifty years, CACH, TUTI, WBNU & BHNU have all continued flocking together, with CACH and TUTI remaining most abundant in population size.[12] This is supported by the abundance pie charts shown in Figure 4, where the species were all found cohabitating (location B). Interestingly, the charts help show where the most abundant species' ranges were located. The CACH were found at all sites in high abundance, but the WBNU were found primarily at location C (west campus) and the TUTI were primarily found at location A (east campus). In between the two locations (location B), both the WBNU and the TUTI shared the territory.

4.3. Relative Species Abundance

All three locations were comparable in terms of having similar elevation, plant diversity, and canopy height. Although each may be considered fragmented forests, location B was of much smaller patch size in relation to A and C. Smaller patch size creates more edge habitat which often leads to altered patterns in bird communities.[3] As CACH is most abundant at location B (66%), it may be best accustomed to these fragmented conditions compared to the other species. Doherty and Grubb found that survivorship of CACH was greater than both TUTI and WBNU under food-supplemented conditions.[13] This difference is well-represented in Figure 4, as CACH was most abundant at all three locations where feeders were consistently filled with food. Between the three most abundant species, it was found that probability of survival increases for both CACH and WBNU as woodlot area increases, while TUTI remains unchanged.[13] Figure 4 does not support these findings, as CACH remained most abundant at all three locations regardless of patch size, while WBNU and TUTI were both more successful in larger patch sizes. While patch size may not be a strong indicator of abundance in this scenario, it is possible that behavior can explain why WBNU is more abundant at location C than A (34% vs. 0.002%) and TUTI is more abundant at location A than C (42% vs. 2%). Morse observed that the WBNU was the most hostile species in mixed flocks.[12] At location B, both WBNU and TUTI were present, but their abundance was reduced compared to sites A and C where they were not commonly co-

habituating, shown in Figure 4. This may be a representation of interspecific competition between the two species. Future research observing behavior between WBNU and TUTI could help clarify this phenomenon.

5. Conclusion

Notably, The BHNU was monitored significantly less than the other species. This may be a direct effect of the rapid deforestation of old-growth longleaf pine forests in the southeast.[1] The BHNU is the only specialist species of the four, particularly relying on this pine habitat and is the only species which has dropped significantly in abundance as there was only one recorded individual found at location C throughout the survey period. This lack in sample size makes further assumptions about the BHNU unreliable. As for the three most abundant species, their activity patterns were graphed and compared to each other and to the mean of all species' visits. Because there were no significant differences in activity, Figure 3 suggests the three most abundant species are able to effectively forage at the same times without having to form any temporal resource partitioning. It is notable that food supply was not limited; therefore, future research could test to see if limiting food could lead to resource partitioning amongst the species. Additionally, research following bird foraging patterns in continuous forests could further explain the impacts forest fragmentation has on diversity. If the continuous forest is also an old-growth forest, it is possible that there may also be more abundance in specialist species. As proposed by Znidersic, we support the notion that camera traps are a reliable method to identify species presence and abundance.[5] When individual researchers cannot physically be present in the field throughout the day or if unideal weather conditions are present, camera traps ensure data is being collected continuously relative to field activity.

6. Acknowledgements

The author wishes to express his genuine gratitude to Dr. Mia Malloy in the School of Science and Technology at Georgia Gwinnett College for her guidance throughout the research and paper-editing process. He was also like to acknowledge both Maria Isabel Fernandez and Dr. Jill Penn for their suggestions and continued research at the GGC Bird Lab. Finally, he would like to show his appreciation to GGC's School of Science and Technology for providing the funding to make this research possible.

7. References

1. Pinder, J.E., T.E. Rea, and D.E. Funsch, "Deforestation, Reforestation and Forest Fragmentation on the Upper Coastal Plain of South Carolina and Georgia." *The American Midland Naturalist* 142, no. 2 (1999): 213–228, https://www.jstor.org/stable/2426774?seq=1#page_scan_tab_contents
2. BirdLife International 2016, "Sitta pusilla," The IUCN Red List of Threatened Species, 2016, https://www.iucnredlist.org/species/103881613/94282209
3. Kellner, Kenneth F., Patrick J. Ruhl, John B. Dunning, Kevin W. Barnes, Michael R. Saunders, and Robert K. Swihart, "Local-scale Habitat Components Driving Bird Abundance in Eastern Deciduous Forests." *The American Midland Naturalist* 180 (2018): 52.
4. Pecor, Keith W., Ellen C. Lake, and Matthew A. Wund, "Optimal Foraging by Birds: Experiments for Secondary & Postsecondary Students." *American Biology Teacher* 77, no. 3 (2015): 192-97.
5. Znidersic, Elizabeth, "Camera Traps are an Effective Tool for Monitoring Lewin's Rail (Lewinia pectoralis brachipus)." Waterbirds: The International Journal of Waterbird Biology 40, no. 4 (2017): 417-22.
6. Colinet, Hervé, and David Renault, "Similar Post-Stress Metabolic Trajectories in Young and Old Flies." *Experimental Gerontology* 102 (2018): 43–50.
7. Pitera, A.M., C.L. Branch, E.S. Bridge, and V.V. Pravosudov. "Daily Foraging Routines in Food-Caching Mountain Chickadees Are Associated with Variation in Environmental Harshness." *Animal Behaviour* 143 (2018): 93-104.
8. Santiago-Quesada, Francisco, José A. Masero, Sora M. Estrella, and Juan M. Sánchez-Guzmán, "Persistent Bimodal Activity Patterns in Wild and Captive Black-Tailed Godwit Limosa Limosa under Different Environmental Conditions." *Behavioral Ecology and Sociobiology* 66, no. 3 (2011): 397–405.

9. Brandt, Miriam J., and Will Cresswell, "Diurnal Foraging Routines in a Tropical Bird, the Rock Finch Lagonosticta Sanguinodorsalis: How Important Is Predation Risk?" *Journal of Avian Biology* 40 (2009): 90-94.
10. Didham, Raphael K., Jaboury Ghazoul, Nigel E. Stork, and Andrew J. Davis, "Insects in fragmented forests: A functional approach" *Trends in Ecology & Evolution* 11, no. 6 (1996): 255-60.
11. Knops, J.M.H., D. Tilman, N.M. Haddad, S. Naeem, C.E. Mitchell, J. Haarstad, M.E. Ritchie, K.M. Howe, P.B. Reich, E. Siemann, and J. Groth, "Effects of plant species richness on invasion dynamics, disease outbreaks, insect abundances and diversity." *Ecology Letters* 2, no. 5 (1999): 286-93.
12. Douglass H. Morse, "Foraging Relationships of Brown-Headed Nuthatches and Pine Warblers." *Ecology* 48, no. 1 (1967): 94-103.
13. Doherty, Paul F. Jr., and Thomas C. Grubb Jr, "Survivorship of Permanent-Resident Birds in a Fragmented Forested Landscape." *Ecology* 83, no. 3 (2002): 844-857.