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A Survey of the Ratio of Melanistic to Gray Squirrels (Sciurus Carolinensis) on Five Midwestern College Campuses

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A SURVEY OF THE RATIO OF MELANISTIC TO GRAY SQUIRRELS (*Sciurus carolinensis*) ON 5 MIDWESTERN COLLEGE CAMPUSES

By

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Abstract

This experiment was an observational field study on 5 college campuses across western Indiana and western Illinois. The purpose of this experiment was to find the ratio of melanistic to gray squirrels on each campus and see if the ratio changed geographically. Gray squirrels (*Sciurus carolinensis*) have melanistic color variants in their populations that have not been documented across their distribution in the United States. Melanistic variants were introduced in the eastern United States and seem to be moving westward. Data was collected for all 4 seasons for Olivet Nazarene University, St. Joseph's College and Illinois State University. Due to time constraints, University of Notre Dame and Augustana College were not observed in the winter. Olivet Nazarene University and Augustana College were the only campuses where black squirrels were present. Augustana College consistently had a higher ratio of black to gray squirrels than Olivet Nazarene University. By observing 5 campuses at distinct geographic points (northeast, southeast, central, northwest, and southwest), it was determined that the melanistic squirrels are not necessarily traveling from their initial point of introduction. The squirrels may instead have found alternate routes of moving across and into the United States. According to the results, the ratio of melanistic to gray squirrels is not decreasing moving east to west.

Key words: melanistic, *Sciurus carolinensis*, Midwest

INTRODUCTION

The purpose of this project was to determine if the ratio of melanistic to gray squirrels (*Sciurus carolinensis*) changes moving from western Indiana towards western Illinois. The ratio of genetic variants is important to study in any population and species as variation in species drives speciation and evolution. If certain populations are distinct enough, eventually they will evolve into a new species. Geographic distribution is one cause of speciation as geographically separated populations adapt to different environmental stresses. The adaptations can in turn lead to speciation.

As melanistic squirrels were introduced in the east, I hypothesized that the ratio of melanistic to gray squirrels would be highest in the easternmost campus, University of Notre Dame, and would decrease moving west. This means that Olivet Nazarene University would have the most intermediate ratio, while Augustana College would have the lowest ratio of black to gray squirrels. This hypothesis was made under the assumption that the ratio of black to gray squirrels would be higher closer to the point of origin.

REVIEW OF LITERATURE

Overview of Sciurus carolinensis

Gray squirrels are members of the order Rodentia and family Sciuridae. Rodentia is the most varied order of North American mammals, both in terms of habitat and physical adaptations. The defining characteristic of this order is their teeth. All rodents are equipped with paired, constantly-growing incisors, which are used to grasp, hold, cut, pierce, and gnaw food (Melham, 1998). The name rodent comes from the Latin “rodere” which means to gnaw. The gray squirrel eats acorns, hickory nuts, walnuts and beechnuts, plus other berries. Their intelligence can be seen in foraging habits: squirrels have developed a way to counteract the development of buried acorns into seedlings by removing the embryo from the acorn before

burying it. Burying the acorn also aids in leeching out high levels of tannin which is unpalatable and interferes with digestion (Halliday, 1994).

Gray squirrels are characterized as tree squirrels. They are diurnal, usually solitary and territorial, with the largest brain size relative to body size of all small mammals (Forsyth 2006). Typically they appear as medium in size with bushy tails, prominent ears, relatively long hind feet, with gray dorsal coloration and white on their ventral side (Hoffmeister 1989; Forsyth 2006). Color variations are present including melanistic, meaning black.

Predation is an important factor in shaping rodent evolution. Fecundity rates are high in gray squirrels to offset the index of predation. Other adaptations to predators include morphological adaptations such as eyes placed on the side of the head to allow maximum peripheral vision, elongated tails for balance, stability, and steering during arboreal leaps, and complex communication to indicate various risks in proximity (Melham, 1998; Friend, 2004). Gray squirrels live in nests and dens; males' home ranges overlap those of several females. The males will become territorial over their ranges while females are territorial over their nests (Forsyth, 2006). They breed in late winter or early spring, have a gestation period of about 44 days, and yield litters of about 4 or 5 pups (Fergus, 1991). Pups are born altricial (not fully developed and requiring parental care) and because of this, will stay in the nest to nurse for up to 8 weeks (Forsyth, 2006; Hoffmeister, 1989).

Climate is one determining factor in how active squirrels are. They tend to avoid water while it is raining and are less active in feeding and foraging. Because of their high metabolism and small bodies, squirrels are not able to put on enough fat to hibernate in winter; instead, they become lethargic and will sleep for extended periods of time (Forsyth, 2006; Hoffmeister, 1989). Territoriality also declines in winter, and individuals may even share nests to keep warm.

Biology of the black squirrel

Melanism is a phenomenon where a population of a species has an abnormally high ratio of melanistic alleles to alleles that code for other pigments. The process of melanization is complex and involves a series of chemical reactions that are mediated by enzymes and hormones and must be triggered in precise stages (Majerus, 1998). Melanistic squirrels are a genetic variant of the gray squirrel (*Sciurus carolinensis*) and not a separate species. There are 3 coat color variants on the phenotype of the gray squirrel: gray (wild-type), jet-black, and brown black; the 3 color morphs are due to varying distributions of the pigments eumelanin and phaeomelanin in the squirrels' hairs (McRobie et.al, 2009). Melanism may have evolved as an advantage to temperature variations in habitat, especially during the winter season. The melanistic squirrels may have an energetic advantage because their black pigments absorb more light and aid in keeping warm, instead of spending energy to produce body heat (Barrett & Barrett, 2011). Black coloration is also a barrier against UV light, which when penetrating, can cause future mutations and genetic problems (Kettlewell, 1973).

History of the black squirrel

Black squirrels were sent to the National Zoo in Washington, D.C. from scientists at the Rondeau Provincial Park in Morpeth, Ontario, Canada in 1902. They were eventually released into surrounding neighborhoods (a practice that would be very unlikely today, seeing the risks for possible invasive species) and have been moving westward since (Coleman, 2006). Other locations where black squirrels have been documented since their introduction to the United States include: Council Bluffs, Iowa, Kent, Ohio, Princeton, New Jersey, Albion, Michigan, College Park, Maryland, Bronx, New York, and Manhattan, New York (Coleman, 2006). Before 2008, melanistic squirrels had not been seen south of Virginia. The melanistic squirrels were first seen September 2008 in Athens-Clarke County, Georgia (Barrett & Barrett, 2011). Melanistic squirrel sightings are still rare in the southern part of the United States. Forsyth (2006) notes

that the melanistic form is more common in the north, but the term “north” is not specifically defined.

As is evident from above, research has been done on the biology of melanistic squirrels. There are very few, however, if any studies focusing on the distribution of melanistic *S. carolinensis*. This experiment was completed to determine if the ratio of melanistic to gray squirrels changes moving from western Indiana through western Illinois. More specifically, I hypothesized the ratio would be highest in the easternmost campus and decrease moving west.

MATERIALS AND METHODS

Five college campuses were chosen to conduct this study, the first being Olivet Nazarene University which acted as a base point to choose the other campuses. College campuses were chosen as study sites because they offer continuity between sites. All campuses will have the same environment over the whole time frame as opposed to parks or neighborhoods which would have less activity with colder weather. Figure 1 pinpoints the campuses that show their geographic locations in relation to one another.

Figure 1. Campuses' locations in relation to one another across western Indiana towards western Illinois.

The campuses were chosen because they offer enough distance to allow for spatial analysis, but are also close enough to conduct research during the school year. The two northern campuses, Augustana College located in Rock Island, Illinois and University of Notre Dame located in South Bend, Indiana were chosen because they are in the northwest and northeast directions respectively. The two southern campuses, Illinois State University and St. Joseph's College located in Normal, Illinois and Rensselear, Indiana were chosen because they are in the southwest and southeast directions respectively. Maps of the campuses were printed from each school's website (see Appendix); the main portions of each campus were gridded out with plots 20mx20m. Twenty plots were randomly chosen to study on each campus. The total area studied on each campus per season was 8000m^2. In the event a building covered the entire plot, another one was chosen at random.

At the first observation on each campus, a perimeter of the main portions of the campuses was drawn on a Juno Trimble GPS unit by walking the perimeter while the GPS recorded the perimeter. The perimeter maps can be viewed in the Appendix. Data for the campuses of Olivet Nazarene University, Illinois State University, and St. Joseph's College was collected for all four seasons. Data for the campuses of Augustana College and University of Notre Dame was collected for all seasons except winter which was due to time constraints. Data was collected at each plot including meteorological conditions, number of trees in the plot, and number of squirrel nests in the plot. Fifteen minutes were spent observing at each plot; a squirrel was considered to be in the plot if it was on the ground or in a tree. If a tree's branches extended out of the perimeter of the plot, it was still counted as in the plot. Squirrels not in study plot were taken note of as extraneous data. If a squirrel(s) was observed in a study plot, the GPS of the middle of the plot was recorded in the Juno Trimble GPS unit.

After all plots were observed, the total number for gray squirrels and black squirrels was recorded and ratios determined. Summer data was collected between the dates of July 5, 2013-July 22, 2013. Fall data was collected between the dates of October 6, 2013-November 2, 2013. Winter data was collected between the dates of January 13, 2014-January 19, 2014. Spring data was collected between the dates of March 22, 2014-April 1, 2014. The same procedure described above was used for each season.

Following all observations per season, results were entered into Microsoft Excel and analyzed using T-tests, and One Way Analysis of Variance both at a p value of p= .05. ArcGIS software was used to overlay the perimeter maps with the points squirrels were seen which are shown in Figures 2 and 3. Appropriate graphs and tables are represented in the Results below.

RESULTS

Calculating the number of squirrels observed per season, it is shown that the Fall had the highest number of squirrels, and the winter the least. The numbers of squirrels per season at each campus are represented in Figures 4-8. Figures 9-12 show seasonal totals of squirrels.

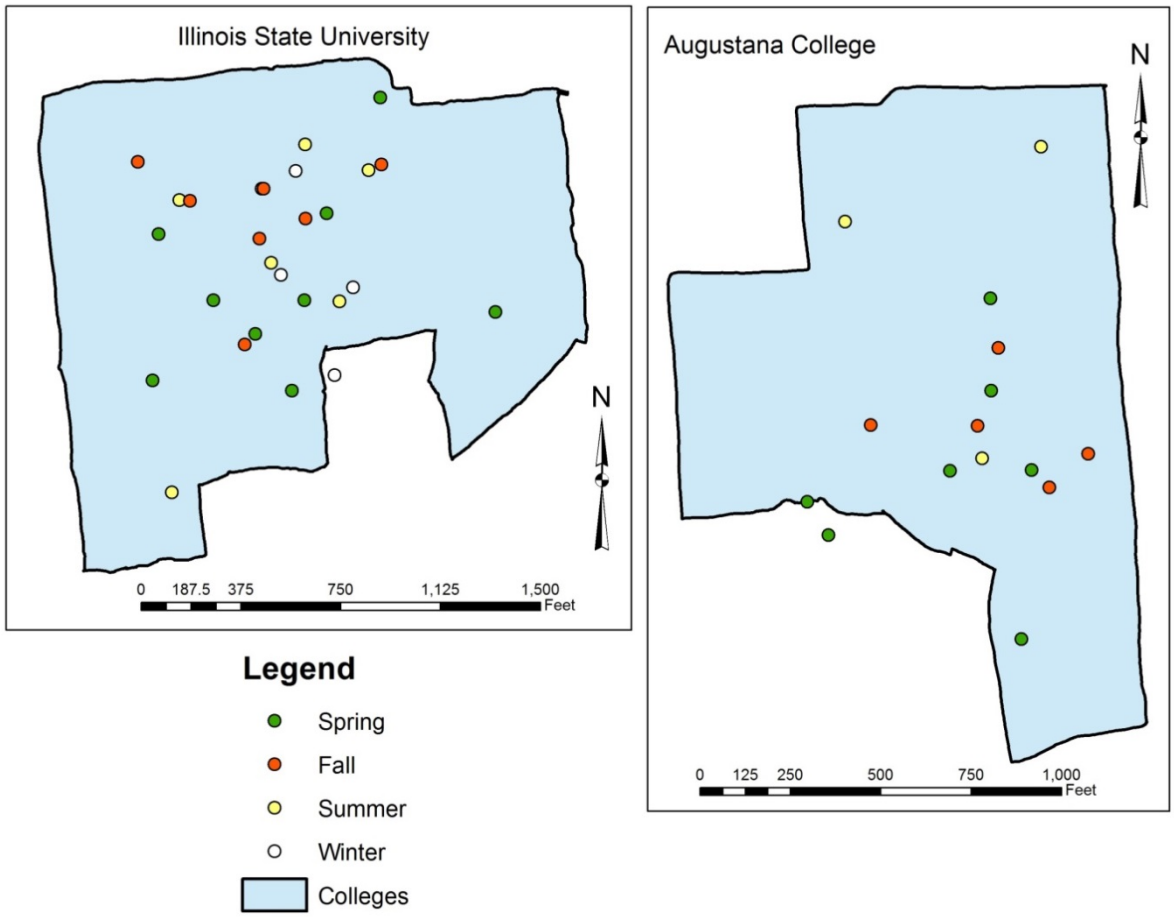

Figure 2.Data points where squirrels were observed at Illinois State University and Augustana College.

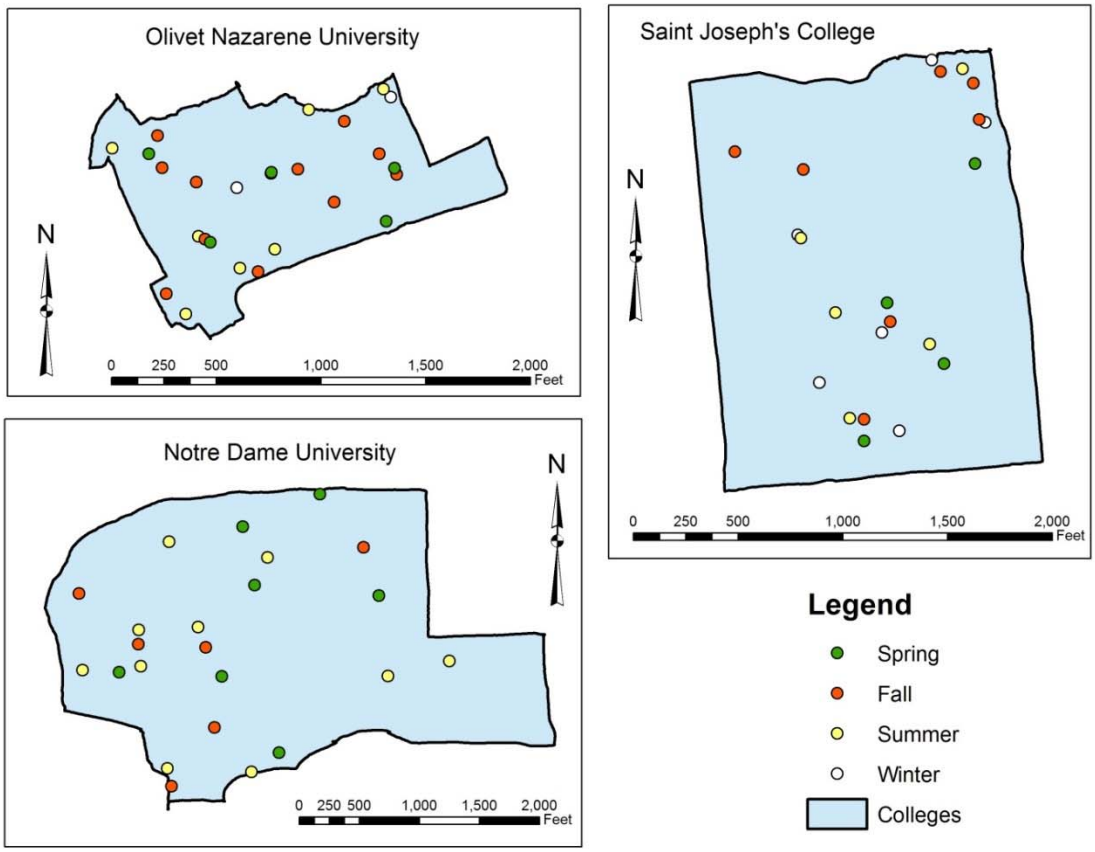

Figure 3. Data points where squirrels were observed at Olivet Nazarene University, Saint Joseph's College, and Notre Dame University.

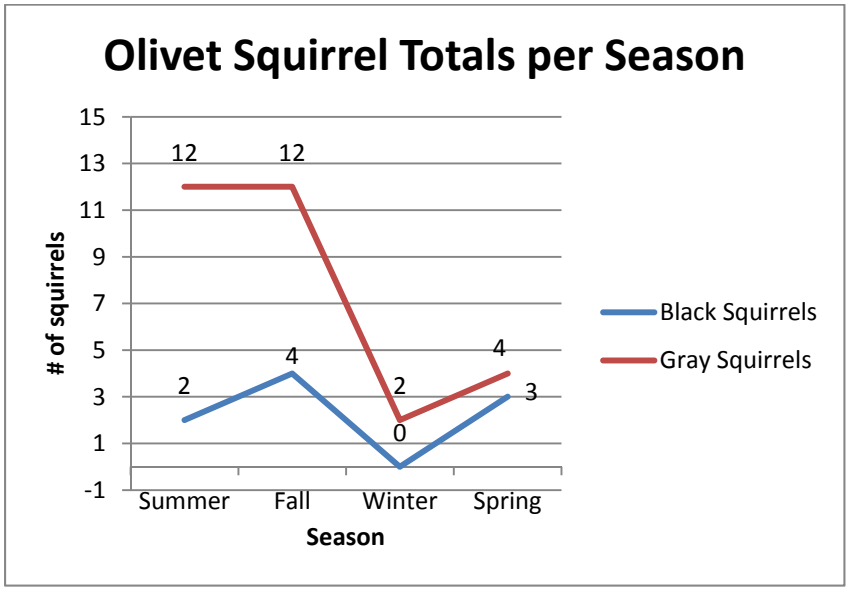

Figure 4. The number of gray and black squirrels observed at Olivet per season.

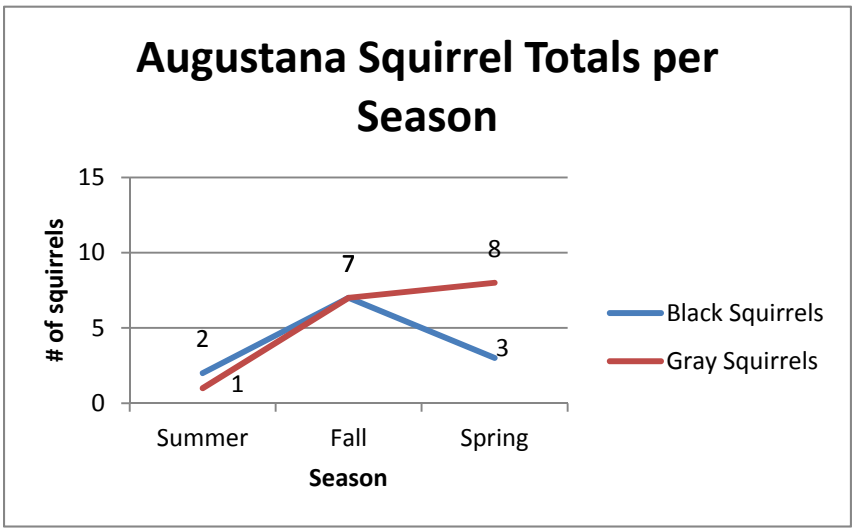

Figure 5. The number of gray and black squirrels observed at Augustana per season

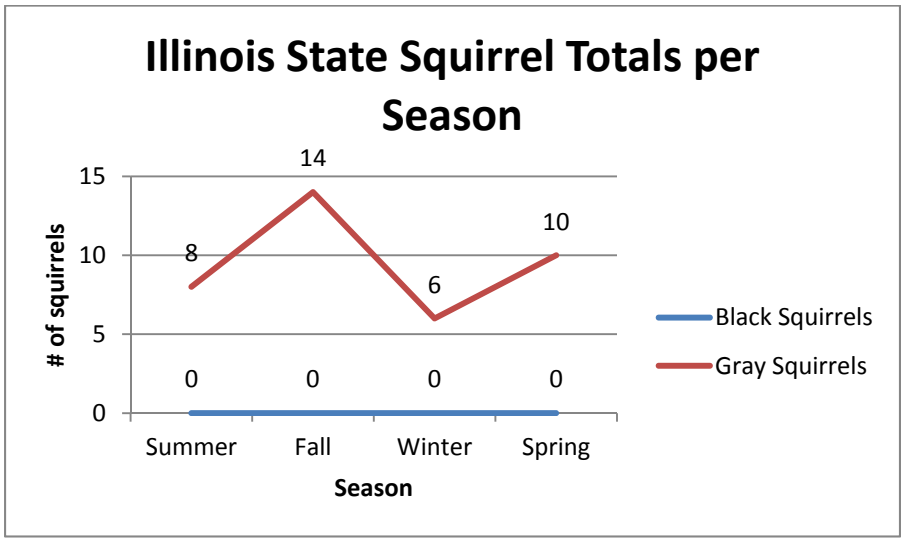

Figure 6. The number of gray and black squirrels observed at Illinois State per season.

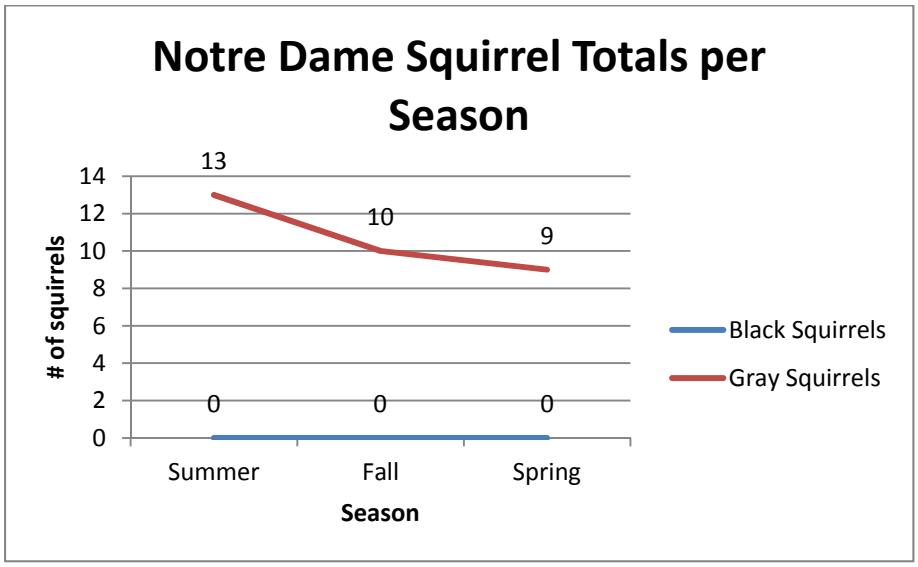

Figure 7. The number of gray and black squirrels observed at Notre Dame per season.

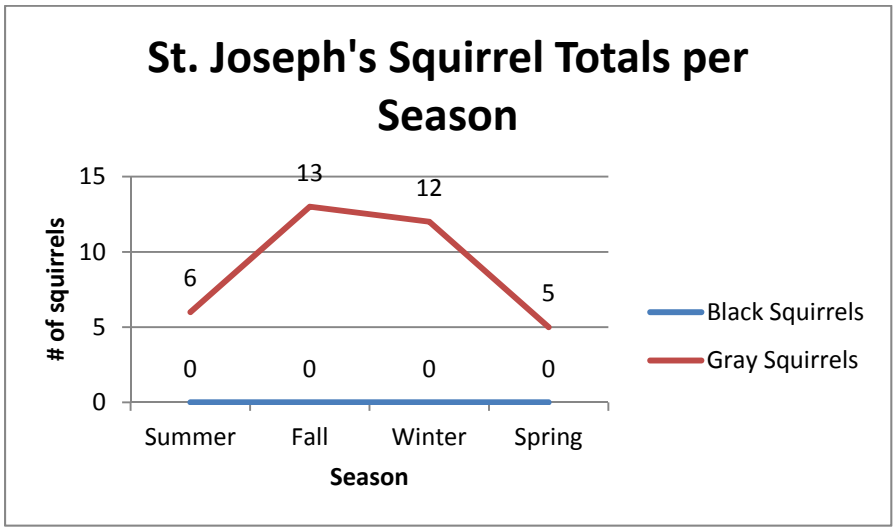

Figure 8. The number of gray and black squirrels observed at St. Joseph's per season.

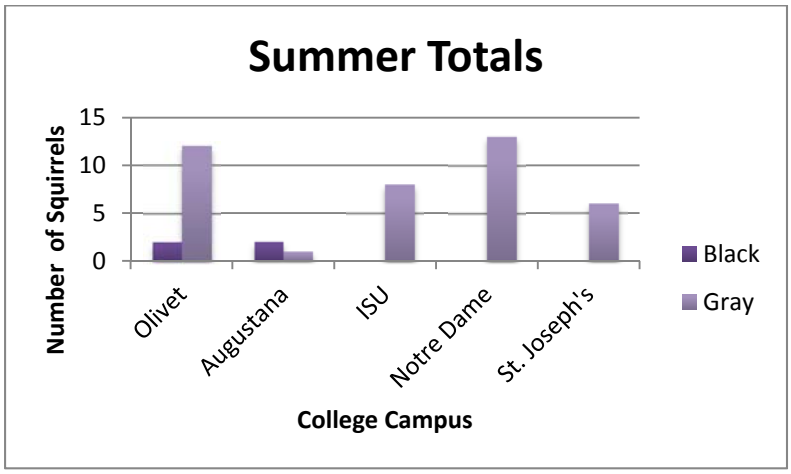

Figure 9. Summer totals of gray and black squirrels.

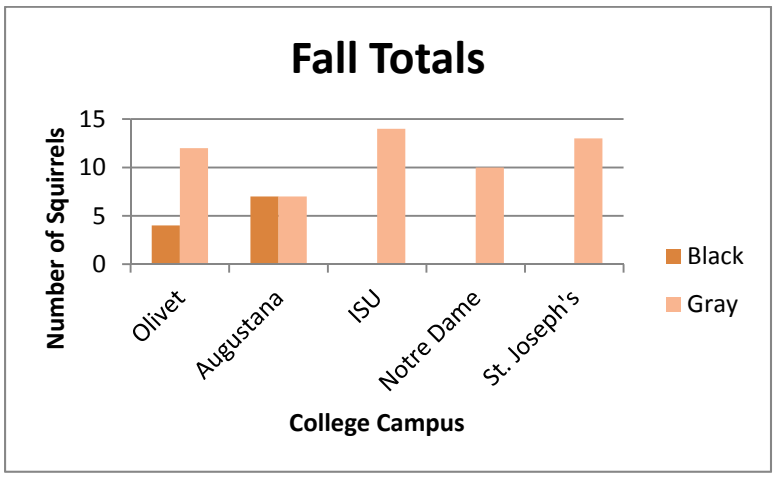

Figure 10. Fall totals of gray and black squirrels.

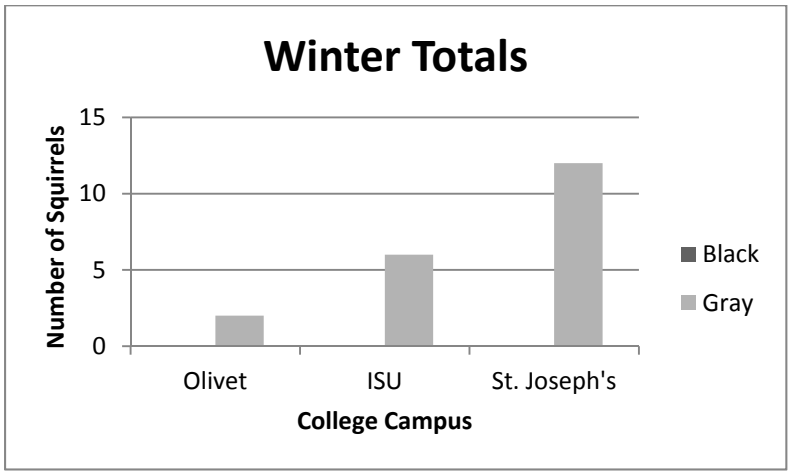

Figure 11. Winter totals of gray and black squirrels. Augustana and Notre Dame were not observation sites for the winter season. No black squirrels were observed in the winter counts.

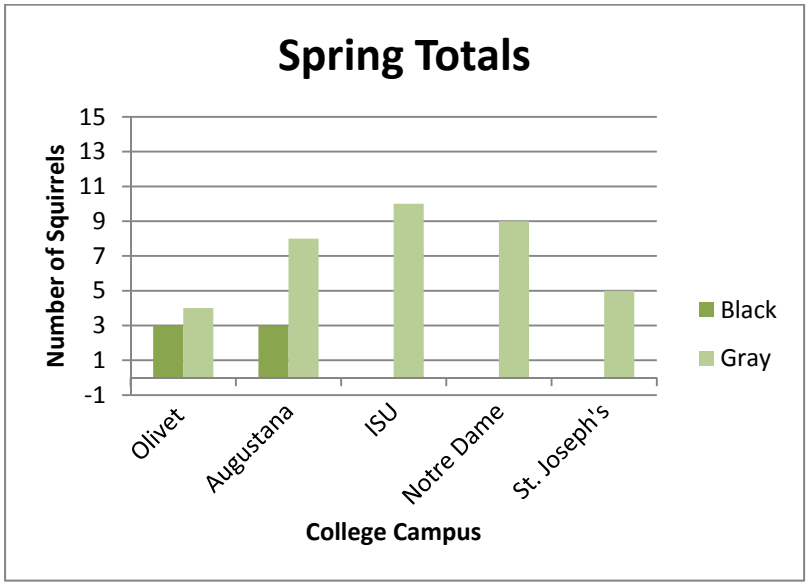

Figure 12. Spring totals of gray and black squirrels.

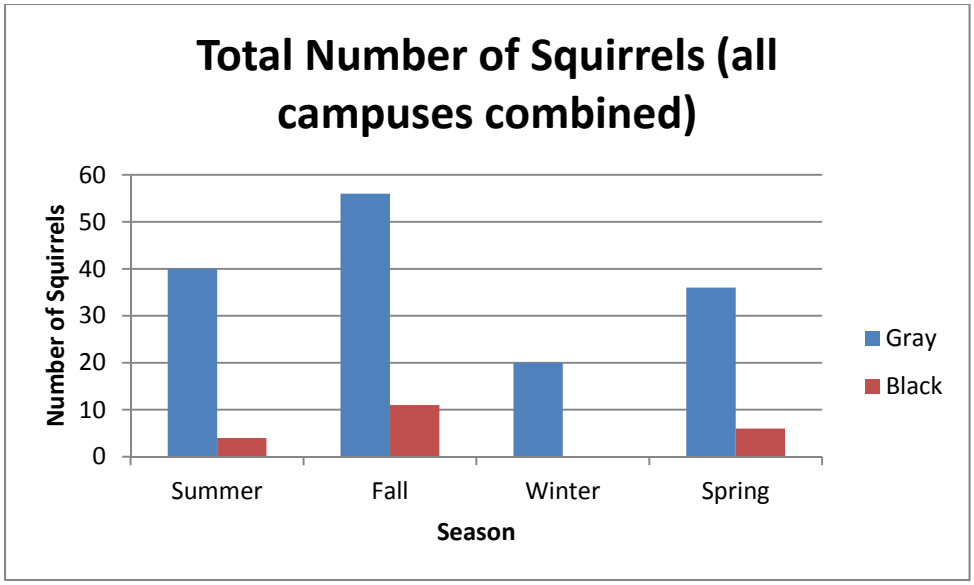

Figure 13. Combined numbers of gray and black squirrels of all campuses per season.

Statistical analysis was performed for this study using the one-way analysis of variance (ANOVA) to compare all 5 campuses. T-test distribution was performed between the black squirrel populations at Olivet and Augustana since they were the only campuses with black

squirrels. Both of these statistical tests are used to compare data from multiple locations and see if there are statistical significant differences between them. Table 1 shows that the only season with statistically significant population differences of black squirrels is the Fall. According to ANOVA's perimeters, to have statistical significance, the Calculated F value has to be greater than the Tabulated F value.

Analysis of Variance	
Summer	
Tabulated F	2.467
Calculated F	1.583
Fall	
Tabulated F	2.467
Calculated F	4.735
Winter	
Tabulated F	3.159
Calculated F	0
Spring	
Tabulated F	2.467
Calculated F	1.06

Table 1. The analysis of variance statistical results calculated with a p value of .05.

Table 2 shows that there were no seasons with statistically significant differences in black squirrel populations between Augustana and Olivet. Similarly to ANOVA, to have statistical significance, the Calculated t value has to be greater than the Tabulated t value in t-tests.

t-tests between Augustana and Olivet	
Summer	
Tabulated t	2.032
Calculated t	0
Fall	
Tabulated t	2.032
Calculated t	0.736789
Spring	
Tabulated t	2.032
Calculated t	0

Table 2. The t-tests statistical results calculated with a p value of .05.

The ratios of each campus's population of black to gray squirrels was found per season and is represented in Table 3 below. Illinois State, Notre Dame, and St. Joseph's did not have black squirrels so their ratios are always 0. Olivet and Augustana had inconsistent ratios of black to gray squirrels across seasons as can be seen in the following table.

Summer:		**Fall**		**Winter**		**Spring**	
Olivet	1:6	Olivet	1:3	Olivet	0	Olivet	1.3:1
Augustana	2:1	Augustana	1:1	Augustana	(not observed)	Augustana	1:2.6
ISU	0	ISU	0	ISU	0	ISU	0
St. Joseph's	0	St. Joseph's	0	St. Joseph's	0	St. Joseph's	0
Notre Dame	0	Notre Dame	0	Notre Dame	(not observed)	Notre Dame	0

Table 3. Ratios of black to gray squirrels per campus across seasons. (Black:Gray)

DISCUSSION

As is evident in the above results, the hypothesis posed at the beginning of this study that stated the ratio of black to gray squirrels would decrease moving from east to west is rejected. Olivet Nazarene University and Augustana College were the only campuses where black squirrels were present. Furthermore, Olivet did not have higher ratios of melanistic to gray squirrels than Augustana except in the Spring, leading to the premise that melanistic squirrels did not move straight from east to west or had alternate routes. Augustana's population of squirrels was overall more equally divided between melanistic forms and gray forms than Olivet's as well. This could be due to a combination of the number of melanistic alleles in the populations and the presence of predators on each population. Olivet's population of squirrels is prey to a red-tail hawk and a pair of cooper's hawks that may select the black squirrels; Augustana's population of squirrels is prey to its own host of hawk predators also. Hawks may prey on black squirrels in higher quantities simply because the black squirrels are easier to see, compared to their gray counterparts which camouflage on trees.

The statistical analysis that treated this data, including the ANOVA and t-tests show that the only significant difference in melanistic squirrel populations between all campuses was in the fall. A total of 11 black squirrels were seen between Olivet's and Augustana's campuses. The other seasons, in contrast to the fall, had 6 or fewer black squirrels observed. The t-test analyses show that the population of black squirrels between Olivet and Augustana is not statistically significant during any season.

Meteorological conditions which are reported in the Appendix could have affected this study, especially the winter and spring, due to the severity of the winter season. As previously mentioned, these squirrels breed in late winter into early spring, so breeding may have taken place later than normal. If this was the case, pups would not have had time to fully develop and leave the nest before the spring data was collected. The spring data collection took place at the beginning of the season, which could have skewed the results as well, since other data was collected mid-season. It is important to see that no melanistic squirrels were observed at Olivet in the winter, as opposed to the other seasons. Although amount of space available to inhabit is one factor in determining population size, it is also evident this is not the determining factor. The smaller campuses observed at (Olivet Nazarene University and St. Joseph's College) had the same number, if not more squirrels present comparing across seasons.

Numbers of nests in each plot, along with numbers of trees per plot are reported in the Appendix. These variables did not have an apparent effect in number of squirrels in each plot. Some plots had multiple trees but no squirrels. Some plots had no nests but did have squirrels. Any combination of nests and trees, no nests with trees and so on did not have an apparent correlation with the number of squirrels present in the plot. This can be attributed to the fact that squirrels' home ranges vary in size but are larger than a 20 X 20m plot. The squirrels would not be confined to foraging in the plot where there nest is present.

Possible improvements to this study would include an increased number of observations and expanding to more campuses, which could be possible with further funding and time. As with any scientific study, increased numbers of data sets help to verify and support the accuracy of the data found. Consistent observation times are another possible improvement; for instance, most observations took place between the hours of 9:00AM and 4:00PM but a few observations took place before and after that time frame. Since squirrels are diurnal, their activity levels would have been low during crepuscular hours.

Another improvement is that the perimeter maps plotted with data points only convey what plots squirrels were seen in. They do not show the number of squirrels seen in each plot or if the individuals were gray or black. A source of error when plotting the data points is that the Juno Trimble GPS unit's accuracy varies with how many satellites it is receiving. The accuracy of the GPS reading would vary between 4 meters and 12 meters. This is why some of the data point maps in the Appendix are outside of the perimeter. Further analysis needs to be done in order to gain a clearer understanding of why there is no evident pattern to the distribution of melanistic squirrels.

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APPENDIX

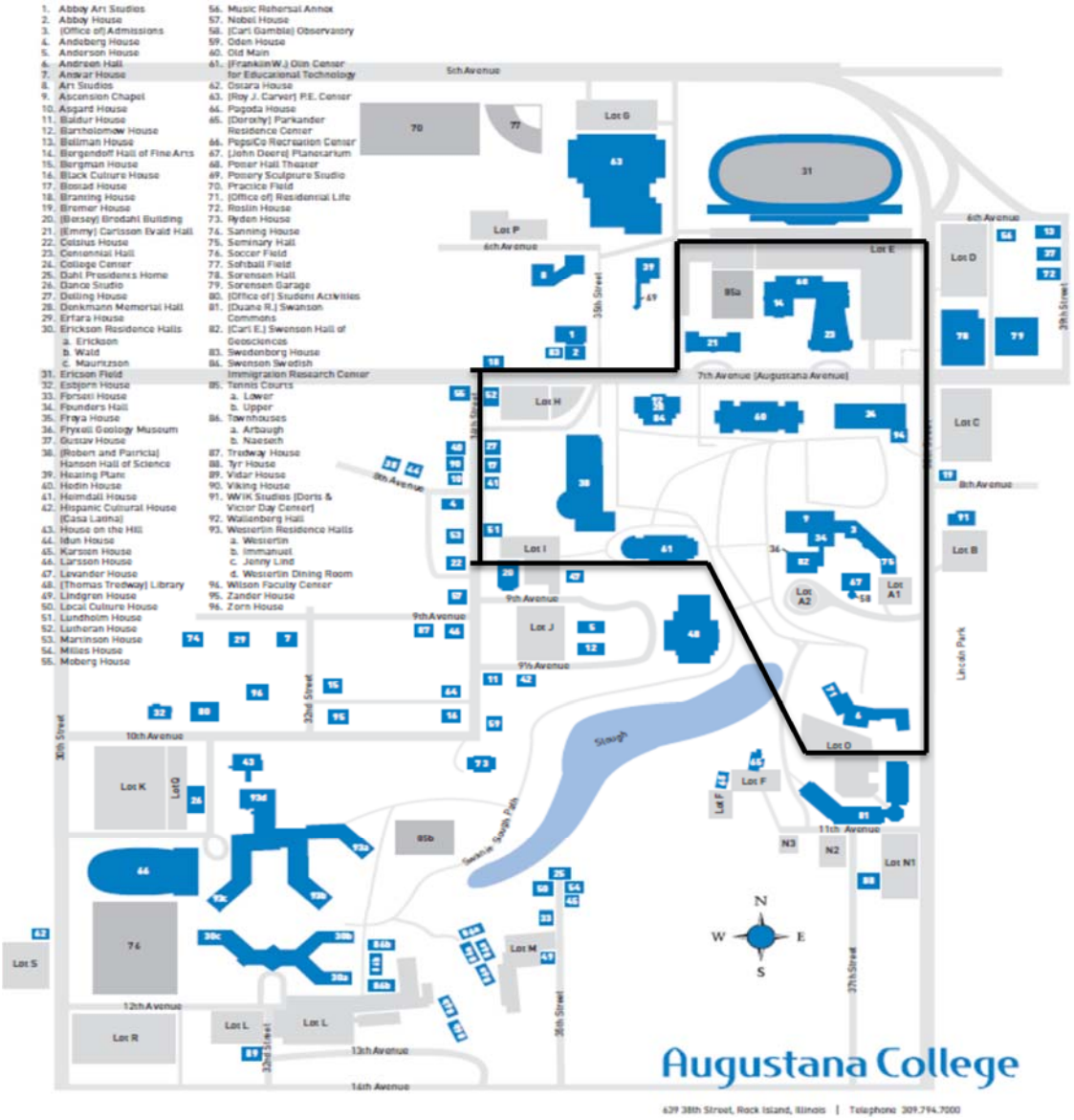

Figure A1. Augustana College perimeter map. Main portion of campus is outlined in black and was used for this study.

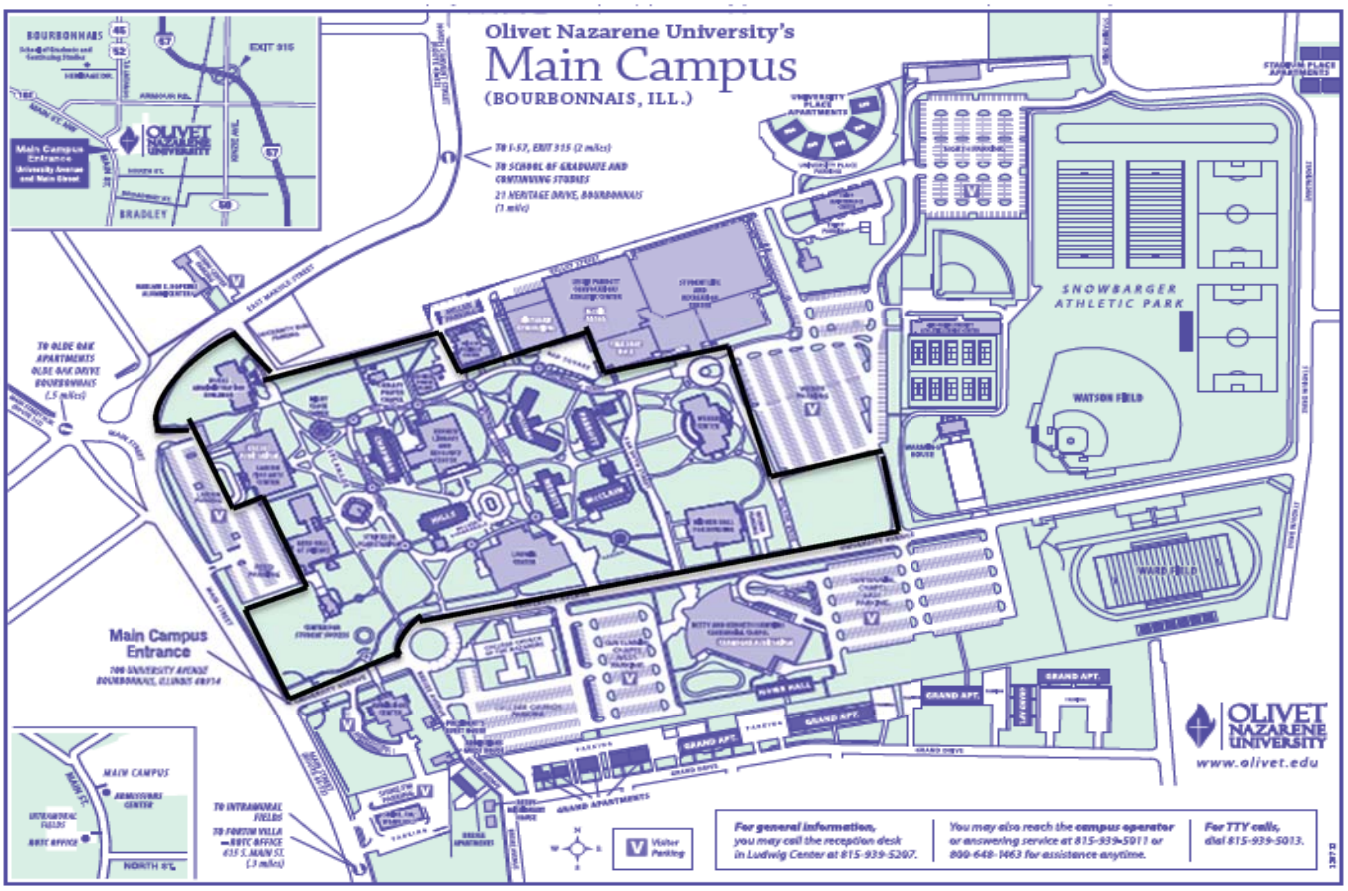

Figure A2. Olivet Nazarene University perimeter map. Main portion of campus is outlined in black and was used for this study.

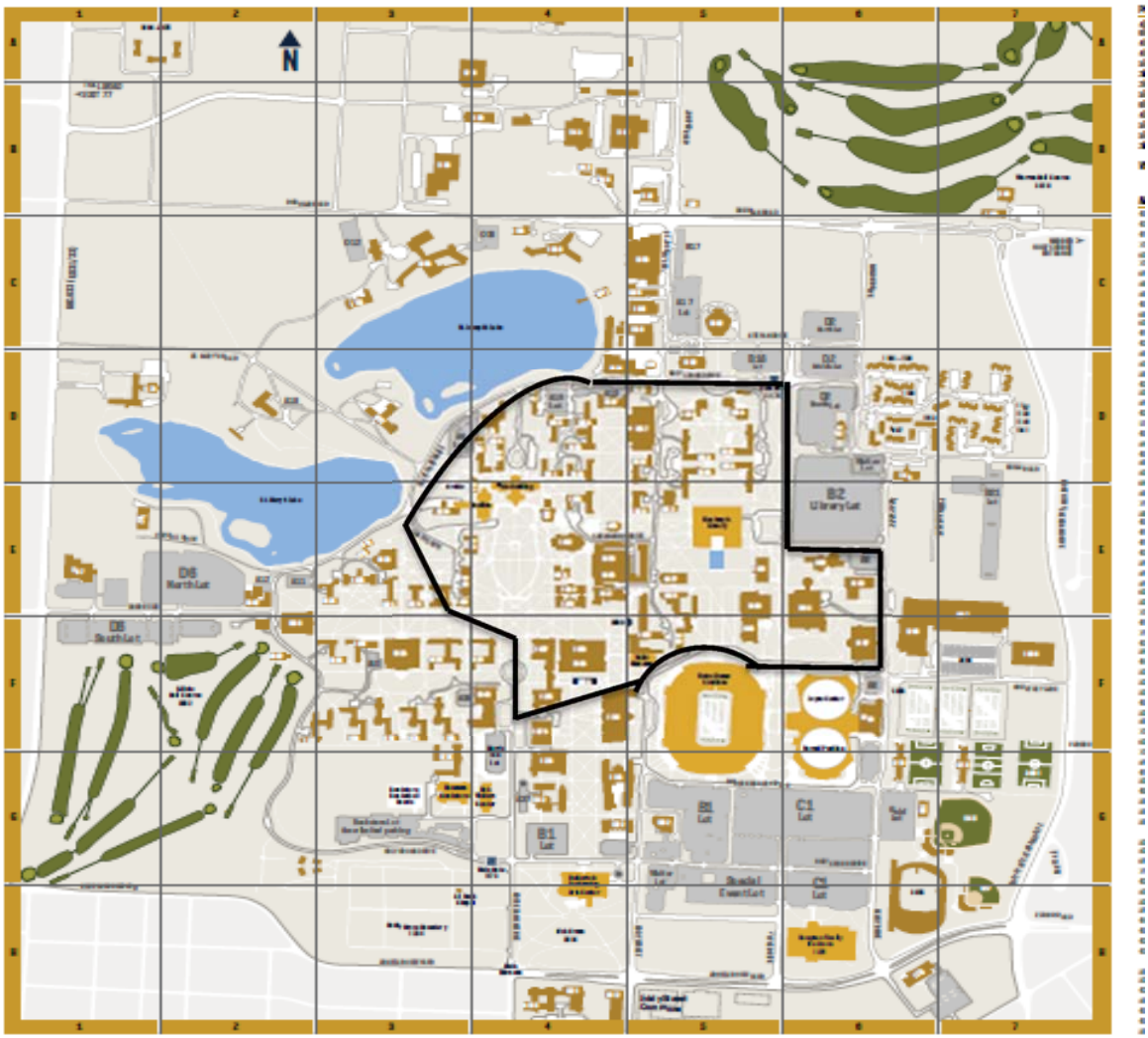

Figure A3. University of Notre Dame perimeter map. Main portion of campus is outlined in black and was used for this study.

Figure A4. Illinois State University perimeter map. Main portion of campus is outlined in black and was used for this study.

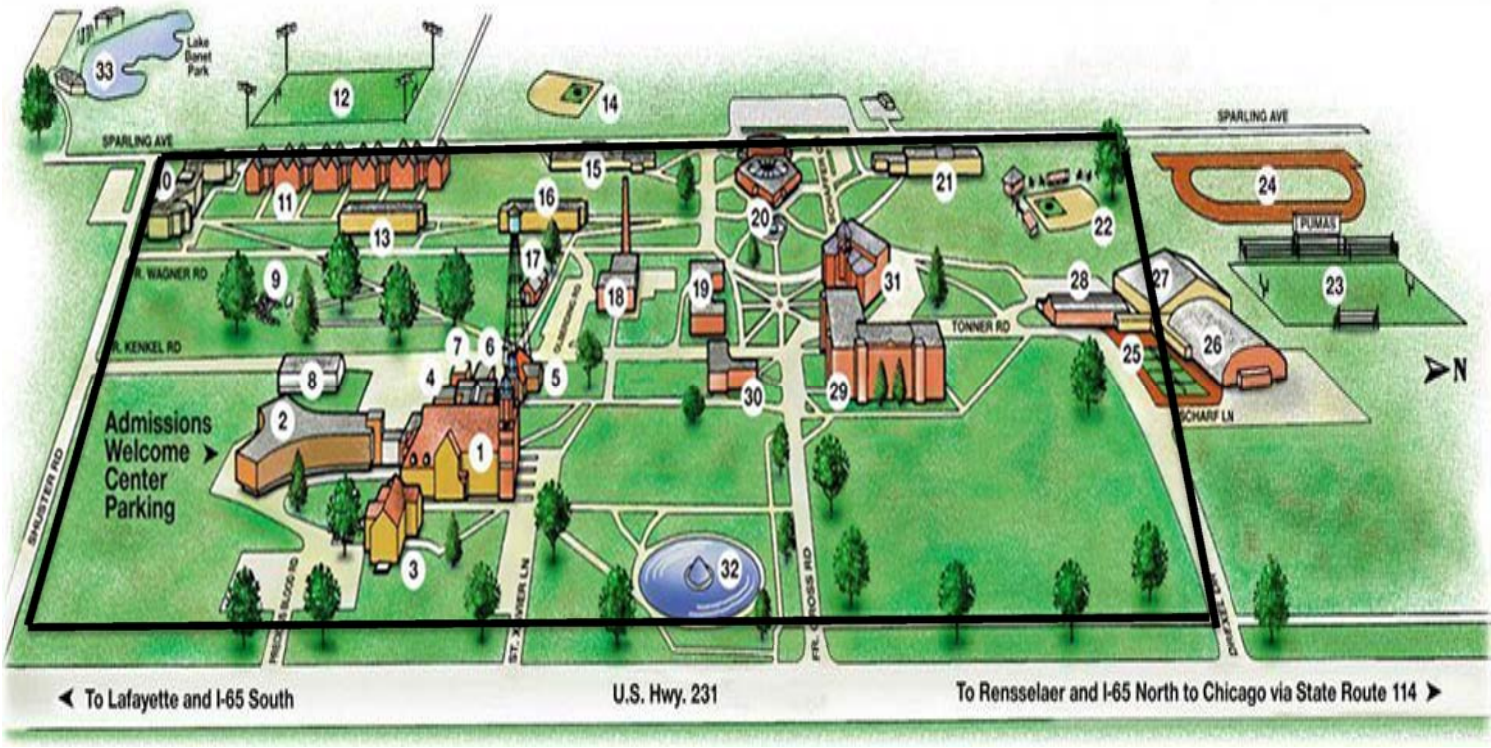

Figure A5. St. Joseph's College perimeter map. Main portion of campus is outlined in black and was used for this study.

Olivet Summer Totals						
Date	Temp (°F)	# Trees	# Nests	Plot	Gray	Black
7/5/2013	71	6	1	1	3	0
7/5/2013	73	6	0	2	1	0
7/5/2013	74	3	0	3	2	0
7/5/2013	76	1	0	4	0	0
7/5/2013	77	2	1	5	0	0
7/5/2013	75	2	2	6	0	0
7/5/2013	77	4	0	7	0	0
7/5/2013	78	5	0	8	0	0
7/5/2013	78	2	0	9	0	0
7/5/2013	78	0	0	10	1	0
7/9/2013	86	6	1	11	1	0
7/9/2013	86	0	0	12	0	0
7/9/2013	86	4	1	13	0	0
7/9/2013	86	5	0	14	1	1
7/9/2013	87	3	0	15	0	0
7/9/2013	87	4	0	16	0	0
7/9/2013	88	5	0	17	0	0
7/9/2013	88	4	1	18	0	0
7/9/2013	88	1	0	19	0	0
7/9/2013	88	4	2	20	3	1
Avg. Temp	81.35			Totals:	12	2
				Average	0.6	0.1

Table A1. Olivet Summer Data with numbers of trees and nests included.

Augustana Summer Totals						
Date	Temp (°F)	# Trees	# Nests	Plot	Gray	Black
7/7/2013	84	4	1	1	0	1
7/7/2013	84	7	0	2	0	0
7/7/2013	84	5	1	3	0	1
7/7/2013	85	4	1	4	0	0
7/7/2013	85	11	0	5	0	0
7/7/2013	84	3	0	6	0	0
7/7/2013	83	3	0	7	0	0
7/7/2013	83	4	0	8	0	0
7/7/2013	82	3	1	9	0	0
7/8/2013	73	6	1	10	0	0
7/8/2013	73	4	0	11	0	0
7/8/2013	73	4	1	12	0	0
7/8/2013	73	9	0	13	0	0
7/8/2013	73	8	0	14	0	0
7/8/2013	73	8	0	15	0	0
7/8/2013	74	3	3	16	1	0
7/8/2013	76	6	1	17	0	0
7/8/2013	77	4	1	18	0	0
7/8/2013	80	6	1	19	0	0
7/8/2013	82	4	0	20	0	0
Avg temp	79.05			Totals:	1	2
				Average	0.05	0.1

Table A2. Augustana Summer Data with numbers of trees and nests included.

Illinois State University Summer Totals						
Date	Temp (°F)	# Trees	# Nests	Plot	Gray	Black
7/15/2013	84	3	0	1	1	0
7/15/2013	84	4	1	2	1	0
7/15/2013	84	6	2	3	0	0
7/15/2013	84	tntc	1	4	0	0
7/15/2013	86	12	0	5	0	0
7/15/2013	85	5	0	6	0	0
7/15/2013	86	6	0	7	0	0
7/15/2013	87	4	0	8	0	0
7/15/2013	88	6	5	9	1	0
7/15/2013	88	5	2	10	0	0
7/15/2013	88	4	1	11	2	0
7/15/2013	88	6	0	12	0	0
7/15/2013	88	3	1	13	1	0
7/15/2013	88	4	0	14	0	0
7/15/2013	88	4	1	15	0	0
7/15/2013	88	0	0	16	0	0
7/15/2013	89	4	1	17	0	0
7/15/2013	89	4	0	18	0	0
7/15/2013	89	7	1	19	1	0
7/15/2013	89	5	0	20	1	0
Avg temp	87			Totals:	8	0
				Average	0.4	0

Table A3. Illinois State University Summer Data with numbers of trees and nests included.

Notre Dame University Summer Totals						
Date	Temp (°F)	# Trees	# Nests	Plot	Gray	Black
7/20/2013	84	11	0	1	0	0
7/20/2013	85	6	0	2	0	0
7/20/2013	86	7	1	3	2	0
7/20/2013	86	10	0	4	0	0
7/20/2013	86	8	0	5	2	0
7/20/2013	86	5	1	6	1	0
7/20/2013	87	4	0	7	1	0
7/20/2013	87	11	0	8	1	0
7/20/2013	87	11	0	9	1	0
7/20/2013	87	6	0	10	1	0
7/20/2013	86	8	0	11	1	0
7/20/2013	86	0	0	12	0	0
7/20/2013	86	4	0	13	0	0
7/20/2013	85	9	0	14	1	0
7/20/2013	85	6	0	15	0	0
7/21/2013	77	12	0	16	2	0
7/21/2013	77	7	1	17	0	0
7/21/2013	78	4	0	18	0	0
7/21/2013	80	4	0	19	0	0
7/21/2013	80	7	0	20	0	0
Avg temp	84.05			Totals:	13	0
				Average	0.65	0

Table A4. Notre Dame University summer data with numbers of trees and nests included.

St. Joseph's College Summer Totals						
Date	Temp (°F)	# Trees	# Nests	Plot	Gray	Black
7/22/2013	80	0	0	1	0	0
7/22/2013	80	7	1	2	0	0
7/22/2013	80	2	0	3	0	0
7/22/2013	81	11	3	4	1	0
7/22/2013	81	11	0	5	0	0
7/22/2013	83	8	0	6	0	0
7/22/2013	83	6	0	7	0	0
7/22/2013	83	5	0	8	0	0
7/22/2013	84	1	0	9	0	0
7/22/2013	84	2	0	10	0	0
7/22/2013	85	3	0	11	0	0
7/22/2013	85	5	0	12	2	0
7/22/2013	85	6	0	13	0	0
7/22/2013	85	7	1	14	1	0
7/22/2013	85	0	0	15	0	0
7/22/2013	84	12	1	16	1	0
7/22/2013	84	5	0	17	0	0
7/22/2013	84	10	2	18	1	0
7/22/2013	83	5	0	19	0	0
7/22/2013	83	2	0	20	0	0
Avg temp	83.1			Totals:	6	0
				Average	0.3	0

Table A5. St. Joseph's Summer data with numbers of trees and nests included.

ISU Fall Totals						
Date	Temp (°F)	# Trees	# Nests	Plot	Gray	Black
10/6/2013	52	4	0	1	0	0
10/6/2013	52	2	0	2	0	0
10/6/2013	53	7	0	3	0	0
10/6/2013	53	4	0	4	0	0
10/6/2013	53	8	0	5	0	0
10/6/2013	53	5	0	6	0	0
10/6/2013	54	4	0	7	0	0
10/6/2013	54	4	0	8	1	0
10/6/2013	54	3	2	9	0	0
10/6/2013	54	4	1	10	2	0
10/6/2013	55	3	3	11	4	0
10/6/2013	56	6	0	12	3	0
10/6/2013	57	4	0	13	2	0
10/6/2013	59	7	3	14	0	0
10/6/2013	59	5	2	15	1	0
10/6/2013	59	3	2	16	1	0
10/6/2013	59	3	0	17	0	0
10/6/2013	60	2	0	18	0	0
10/6/2013	60	0	0	19	0	0
10/6/2013	60	4	0	20	0	0
Avg temp	55.8				Total: 14	Total: 0
				Average	0.7	0

Table A6. Illinois State Fall Data with numbers of trees and nests included.

St. Joseph's Fall Totals						
Date	Temp (°F)	# Trees	# Nests	Plot	Gray	Black
10/11/2013	58	3	0	1	0	0
10/11/2013	60	1	0	2	0	0
10/11/2013	60	2	4	3	2	0
10/11/2013	60	4	0	4	1	0
10/11/2013	60	2	0	5	0	0
10/11/2013	62	1	0	6	0	0
10/11/2013	62	5	0	7	0	0
10/11/2013	62	tntc	0	8	2	0
10/11/2013	62	tntc	3	9	0	0
10/11/2013	62	tntc	2	10	2	0
10/11/2013	63	2	0	11	0	0
10/11/2013	63	3	0	12	0	0
10/11/2013	63	1	0	13	0	0
10/11/2013	63	0	0	14	0	0
10/11/2013	63	5	0	15	0	0
10/11/2013	63	0	0	16	0	0
10/11/2013	63	tntc	2	17	2	0
10/11/2013	64	8	1	18	1	0
10/11/2013	64	4	1	19	0	0
10/11/2013	64	tntc	2	20	3	0
Avg temp	62.05			Totals	13	0
				Average	0.65	0

Table A7. St. Joseph's Fall Data with number of trees and nests included.

Augustana Fall Totals						
Date	Temp (°F)	# Trees	# Nests	Plot	Gray	Black
10/19/2013	40	8	0	1	0	0
10/19/2013	40	tntc	0	2	0	0
10/19/2013	40	4	0	3	0	0
10/19/2013	41	6	2	4	1	0
10/19/2013	42	tntc	0	5	2	3
10/19/2013	42	4	2	6	1	0
10/19/2013	42	10	0	7	0	2
10/19/2013	42	5	0	8	1	0
10/19/2013	43	4	0	9	0	0
10/19/2013	43	5	3	10	0	1
10/19/2013	44	2	0	11	0	0
10/19/2013	45	tntc	1	12	1	1
10/19/2013	46	7	1	13	0	0
10/19/2013	46	tntc	0	14	1	0
10/19/2013	48	1	0	15	0	0
10/19/2013	48	5	0	16	0	0
10/19/2013	49	6	0	17	0	0
10/19/2013	50	3	0	18	0	0
10/19/2013	50	6	0	19	0	0
10/19/2013	51	7	0	20	0	0
Avg temp	44.6			Totals	7	7
				Average	0.35	0.35

Table A8. Augustana Fall Data with numbers of trees and nests included.

Notre Dame Fall Totals						
Date	Temp (°F)	# Trees	# Nests	Plot	Gray	Black
10/26/2013	39	4	0	1	0	0
10/26/2013	40	0	0	2	0	0
10/26/2013	42	5	0	3	0	0
10/26/2013	42	5	1	4	0	0
10/26/2013	43	7	0	5	0	0
10/26/2013	43	10	0	6	0	0
10/26/2013	43	3	0	7	1	0
10/26/2013	43	4	0	8	1	0
10/26/2013	43	5	0	9	0	0
10/26/2013	43	6	0	10	0	0
10/26/2013	43	9	0	11	0	0
10/26/2013	43	tntc	0	12	3	0
10/26/2013	43	tntc	0	13	2	0
10/26/2013	43	6	0	14	0	0
10/26/2013	43	tntc	0	15	0	0
10/26/2013	43	tntc	0	16	0	0
10/26/2013	44	tntc	0	17	1	0
10/26/2013	44	tntc	0	18	0	0
10/26/2013	44	5	2	19	0	0
10/26/2013	44	5	0	20	2	0
Avg temp	42.75			Totals	10	0
				Average	0.5	0

Table A9. Notre Dame Fall Data with numbers of trees and nests included.

Olivet Fall Totals						
Date	Temp (°F)	# Trees	# Nests	Plot	Gray	Black
11/2/2013	43	4	0	1	2	0
11/2/2013	43	3	0	2	0	0
11/2/2013	43	3	0	3	1	0
11/2/2013	44	4	0	4	1	1
11/2/2013	44	3	1	5	2	0
11/2/2013	45	7	2	6	1	0
11/2/2013	45	3	1	7	0	0
11/2/2013	45	2	0	8	1	0
11/2/2013	46	2	0	9	0	0
11/2/2013	46	5	1	10	1	0
11/2/2013	46	0	0	11	0	0
11/2/2013	47	5	0	12	0	1
11/2/2013	48	2	0	13	0	1
11/2/2013	48	4	2	14	1	0
11/2/2013	48	4	1	15	0	0
11/2/2013	48	3	2	16	1	1
11/2/2013	48	3	2	17	1	0
11/2/2013	49	0	0	18	0	0
11/2/2013	49	4	3	19	0	0
11/2/2013	49	5	0	20	0	0
Avg temp	46.2			Totals	12	4
				Average	0.6	0.2

Table A10. Olivet Fall Data with numbers of trees and nests included.

ISU Winter Totals						
Date	Temp (°F)	# Trees	# Nests	Plot	Gray	Black
1/13/2014	40	2	0	1	0	0
1/13/2014	40	5	0	2	0	0
1/13/2014	38	4	0	3	0	0
1/13/2014	38	3	0	4	0	0
1/13/2014	38	5	0	5	1	0
1/13/2014	38	5	1	6	1	0
1/13/2014	39	6	0	7	3	0
1/13/2014	39	6	0	8	1	0
1/13/2014	39	3	0	9	0	0
1/13/2014	39	5	0	10	0	0
1/13/2014	40	6	0	11	0	0
1/13/2014	40	0	0	12	0	0
1/13/2014	41	4	0	13	0	0
1/13/2014	41	6	0	14	0	0
1/13/2014	41	3	0	15	0	0
1/13/2014	40	0	0	16	0	0
1/13/2014	40	5	1	17	0	0
1/13/2014	40	3	0	18	0	0
1/13/2014	40	3	0	19	0	0
1/13/2014	40	3	1	20	0	0
Avg temp	39.55			Total:	6	0
				Average:	0.3	0

Table A11. Illinois State winter data with numbers of trees and nests included.

St. Joseph's Winter Totals						
Date	Temp (°F)	# Trees	# Nests	Plot	Gray	Black
1/14/2013	32	1	0	1	0	0
1/14/2013	32	2	1	2	0	0
1/14/2013	33	7	2	3	2	0
1/14/2013	34	1	0	4	0	0
1/14/2013	34	4	0	5	1	0
1/14/2013	34	tntc	3	6	3	0
1/14/2013	34	4	0	7	0	0
1/14/2013	35	tntc	1	8	2	0
1/14/2013	35	1	1	9	0	0
1/14/2013	35	0	0	10	0	0
1/14/2013	36	1	0	11	0	0
1/14/2013	36	13	2	12	3	0
1/14/2013	36	0	0	13	0	0
1/14/2013	37	5	1	14	1	0
1/14/2013	37	6	0	15	0	0
1/14/2013	38	3	0	16	0	0
1/14/2013	38	4	0	17	0	0
1/14/2013	38	3	0	18	0	0
1/14/2013	38	3	0	19	0	0
1/14/2013	38	0	0	20	0	0
Avg temp	35.5			Totals:	12	0
				Average:	0.6	0

Table A12. St. Joseph’s winter data with numbers of trees and nests included.

Olivet Winter Totals						
Date	Temp (°F)	# Trees	# Nests	Plot	Gray	Black
1/19/2014	19	4	0	1	1	0
1/19/2014	19	7	0	2	0	0
1/19/2014	20	2	0	3	0	0
1/19/2014	21	3	0	4	0	0
1/19/2014	23	4	2	5	0	0
1/19/2014	23	4	0	6	0	0
1/19/2014	24	4	0	7	0	0
1/19/2014	26	3	2	8	1	0
1/19/2014	27	5	1	9	0	0
1/19/2014	27	3	0	10	0	0
1/19/2014	27	5	0	11	0	0
1/19/2014	28	4	0	12	0	0
1/19/2014	28	2	0	13	0	0
1/19/2014	28	3	0	14	0	0
1/19/2014	29	2	0	15	0	0
1/19/2014	29	3	0	16	0	0
1/19/2014	30	2	2	17	0	0
1/19/2014	30	3	0	18	0	0
1/19/2014	30	4	0	19	0	0
1/19/2014	30	2	0	20	0	0
Avg temp	25.9			Totals	2	0
				Average	0.1	0

Table A13. Olivet winter totals with numbers of trees and nests included.

ISU Spring totals						
Date	Temp (°F)	# Trees	# Nests	Plot	Gray	Black
3/22/2014	35	2	0	1	0	0
3/22/2014	35	4	0	2	1	0
3/22/2014	34	4	0	3	0	0
3/22/2014	34	0	0	4	0	0
3/22/2014	34	0	0	5	0	0
3/22/2014	34	0	0	6	0	0
3/22/2014	35	5	0	7	0	0
3/22/2014	35	2	0	8	0	0
3/22/2014	35	0	0	9	1	0
3/22/2014	36	1	0	10	0	0
3/22/2014	36	2	0	11	0	0
3/22/2014	36	1	0	12	1	0
3/22/2014	37	3	2	13	0	0
3/22/2014	37	4	0	14	1	0
3/22/2014	37	0	0	15	1	0
3/22/2014	38	3	0	16	1	0
3/22/2014	38	4	1	17	1	0
3/22/2014	38	2	0	18	0	0
3/22/2014	39	4	0	19	2	0
3/22/2014	39	2	0	20	1	0
Avg. Temp	36.1			Total:	10	0
				Average:	0.5	0

Table A14. Illinois State Spring data with number of trees and nests included.

St. Joseph's Spring totals						
Date	Temp (°F)	# Trees	# Nests	Plot	Gray	Black
3/22/2014	41	tntc	0	1	0	0
3/22/2014	41	0	0	2	0	0
3/22/2014	41	1	0	3	0	0
3/22/2014	41	1	0	4	0	0
3/22/2014	41	6	0	5	0	0
3/22/2014	41	tntc	3	6	1	0
3/22/2014	41	5	0	7	0	0
3/22/2014	41	tntc	1	8	2	0
3/22/2014	41	0	0	9	0	0
3/22/2014	40	2	0	10	0	0
3/22/2014	40	2	0	11	0	0
3/22/2014	39	4	0	12	1	0
3/22/2014	39	0	0	13	0	0
3/22/2014	39	3	0	14	0	0
3/22/2014	38	4	0	15	0	0
3/22/2014	38	3	0	16	0	0
3/22/2014	38	3	0	17	1	0
3/22/2014	37	0	0	18	0	0
3/22/2014	37	tntc	0	19	0	0
3/22/2014	37	tntc	2	20	0	0
Avg. Temp	39.55			Total	5	0
				Average	0.25	0

Table A15. St. Joseph's Spring data with number of trees and nests included.

Augustana Spring totals						
Date	Temp (°F)	# Trees	# Nests	Plot	Gray	Black
3/29/2014	37	6	1	1	0	0
3/29/2014	37	5	1	2	0	0
3/29/2014	37	6	0	3	0	0
3/29/2014	38	2	0	4	0	0
3/29/2014	39	tntc	1	5	0	0
3/29/2014	41	5	0	6	0	1
3/29/2014	41	tntc	0	7	1	1
3/29/2014	42	6	0	8	0	0
3/29/2014	43	5	0	9	0	0
3/29/2014	43	5	0	10	2	0
3/29/2014	44	7	0	11	0	0
3/29/2014	45	4	0	12	0	0
3/29/2014	45	tntc	0	13	1	0
3/29/2014	45	6	1	14	0	0
3/29/2014	46	4	0	15	0	0
3/29/2014	47	8	0	16	2	0
3/29/2014	47	5	0	17	0	0
3/29/2014	48	tntc	0	18	1	1
3/29/2014	48	7	0	19	0	0
3/29/2014	49	5	0	20	1	0
Avg. Temp	43.1			Total	8	3
				Average	0.4	0.15

Table A16. Augustana Spring data with number of trees and nests included.

Notre Dame Spring totals						
Date	Temp (°F)	# Trees	# Nests	Plot	Gray	Black
3/29/2014	38	4	0	1	0	0
3/29/2014	38	4	0	2	1	0
3/29/2014	38	5	0	3	0	0
3/29/2014	39	5	0	4	2	0
3/29/2014	39	4	0	5	2	0
3/29/2014	41	3	0	6	0	0
3/29/2014	41	tntc	0	7	0	0
3/29/2014	41	2	0	8	0	0
3/29/2014	41	3	0	9	1	0
3/29/2014	42	3	0	10	0	0
3/29/2014	41	4	0	11	1	0
3/29/2014	42	6	1	12	1	0
3/29/2014	42	0	0	13	0	0
3/29/2014	42	0	0	14	0	0
3/29/2014	42	2	0	15	0	0
3/29/2014	42	4	0	16	0	0
3/29/2014	43	2	0	17	1	0
3/29/2014	43	3	0	18	0	0
3/29/2014	43	2	1	19	0	0
3/29/2014	43	1	0	20	0	0
Avg temp	39.2			Total	9	0
				Average	0.45	0

Table A17. Notre Dame Spring data with numbers of trees and nests included.

Olivet Spring totals						
Date	Temp (°F)	# Trees	# Nests	Plot	Gray	Black
4/2/2014	46	4	0	1	0	2
4/2/2014	46	4	0	2	0	0
4/2/2014	46	3	0	3	0	0
4/2/2014	46	4	0	4	0	0
4/2/2014	47	1	0	5	0	0
4/2/2014	47	5	0	6	0	0
4/2/2014	47	4	0	7	0	0
4/2/2014	47	6	0	8	1	0
4/2/2014	47	3	0	9	0	0
4/2/2014	47	4	2	10	0	0
4/2/2014	47	3	2	11	1	0
4/2/2014	47	4	3	12	0	0
4/2/2014	47	4	1	13	0	0
4/2/2014	45	3	0	14	0	0
4/2/2014	45	6	2	15	0	0
4/2/2014	45	3	2	16	1	0
4/2/2014	45	2	0	17	0	0
4/2/2014	44	0	0	18	0	0
4/2/2014	44	3	0	19	1	1
4/2/2014	43	3	0	20	0	0
Avg. Temp	45.9			Total	4	3
				Average	0.2	0.15

Table A18. Olivet Spring data with number of trees and nests included.