

The Beaver of UNDERC

BIOS 596 - Practicum in Aquatic Biology

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Abstract:

The North American beaver (*Castor canadensis*) is one of the most important species of animal on the continent. It is considered by most ecologists to be a keystone species, and the presence of just a few beaver on a property can have a huge impact on the ecological community. My study involved conducting a survey of all the beaver lodges on the UNDERC property, and then to analyze what they were cutting and compare the results by habitat; streams, lakes and bogs/ponds. The survey consisted of visiting every probable beaver habitat in UNDERC and recording all active lodges. The tree survey consisted of fifteen plots at each of three sites in each of the three habitats. A total of 48 lodges were counted on property, giving a density of 0.016 lodges/hectare. When combined with the average number of beaver per lodge as reported by Muller-Schwarze and Sun (2003) this gives roughly 245 individuals. Analysis of the trees being cut showed that there is a significant linear relationship between the percentage of trees cut and the distance from the shore. There is also a linear relationship between the total number of trees and the number of trees cut. The percentage of trees cut was statistically the same between the three habitats, even though the total number of trees differed. Finally, a preference index of all the tree species was compiled and it was found that yellow birch is the most favored tree species to cut, followed by red maple and alder. This result differs from those of other experiments that have shown that aspen is the most preferred species cut by beaver. Aspen are not preferred by the beaver of UNDERC.

Introduction:

The North American beaver (*Castor canadensis*) is one of the most important species of animal in the environments of the continent. *C. canadensis* is the largest rodent in North America, reaching as long as 120cm and 31.5 kg in weight, and is one of the two species belonging to the genus *Castor*. The historical range of the beaver reaches from near the Arctic Ocean throughout Canada and the United States and along the rivers of northern Mexico, and includes every kind of ecosystem except for dry, arid deserts such as those in Arizona and southern California (Muller-Schwarze and Sun, 2003).

Beavers eat aquatic plants, leaves and bark, and they cut down trees both for food and for use in building lodges and dams during course of their extensive modification of their environment. Beavers all live near a body of water, such as a lake or pond, because they are more mobile in the water and they use it to cover the entrance of their lodges and as defense against predators. They will build lodges along the edges of lakes or large streams, but will actively dam up smaller, faster flowing streams to create a pond of suitable size for their needs (Muller-Schwarze and Sun, 2003).

Because beavers alter their environment so drastically, they are an important species to study to gain an insight of the health of the ecosystem, but they can also be characterized as nuisance animals by human populations. Because of this potential to be either a greatly desired animal or a pest, beavers are a large management challenge (Hill, 1982). The beaver at UNDERC have typically been frequently removed from the property under the excuse that their modification of the environment disrupts experiments or threatens the infrastructure, but in the last few years this attitude has changed and beavers have been slowly allowed to grow in population.

It is important to get an idea of the populations of beavers on the property because beavers are considered by ecologists to be a keystone species. The presence of just a few numbers of beaver in an area will greatly affect the ecological community of the area. Beavers accomplish this mainly by creating wetlands, and by selectively cutting trees. This selectivity in their diet is another important effect beavers have on their community, because by cutting only preferred tree species they allow other species to thrive in areas where they would normally be out competed. This affinity for certain types of trees is also important in defining, at least loosely, the preferable habitats that beavers will choose to live in.

My experiment will consist of two questions. The first question is how many beaver are present on the UNDERC property. The second question asks which trees the beaver are cutting and if these trees differ between three habitats; streams, lakes and ponds/marshes, and also how the patterns of tree cutting differ within these habitats. I hypothesize that there will be roughly equivalent to one beaver lodge per lake and bog on property. I believe this is the case because some areas of suitable habitat will not be occupied by beavers, and these will be compensated for by the larger lakes that will support more than one habitat. I also hypothesize that the number of trees the beaver cut will differ between the three habitats, and that the beaver will cut a larger percentage of trees that are closer to the shore line than those that are farther inland away from shore.

Materials and Methods:

Conducting the survey of the lodges on property involved a stepwise procedure over the weeks of this course. First, various maps of the property were analyzed,

including a map of all the significant lakes, bogs and large streams, and a topographical map that had included wetland/marsh areas and other ideal beaver habitats such as lowlands. After analysis, I systematically visited all probable beaver habitats, including all lakes, bogs and the 3 major streams, with the exception of Plum and Inkpot lakes. I then hiked through the property looking for areas highlighted on the topographical map that were large enough to contain possible beaver habitats. Finally, when I came across either an active lodge or a dam, I indicated the approximate location on a map of the property. Active lodges were determined by the presence of newly cut material incorporated into it, evidence of upkeep and repair with logs or mud, and the lack of any large holes or breaks in the roof or walls. Only active lodges were indicated on the map and included in my survey.

To conduct the survey of the trees that the beavers are cutting, I first took the map with all the lodges on property and randomly selected lodges by a random number table and grid. I continued selecting lodges until I had obtained three lodges from each of the habitats I wished to compare; streams, lakes and bogs/ponds. Five transects were then set up perpendicular to the shore. One transect began at the lodge, two transects were set 25m along the shore in each direction from the first, and two more were set up 50m from the first in each direction. Each transect contained three plots, one on the shore line, one 10m away from the shore and one 25m from the shore. For the bogs sampled where the lodge was not on the actual shore line, the first transect was placed on the shore line so that plot one was the shortest distance from the lodge to the shore, the distance to the lodge was recorded, and the remaining plots and transects were set up as described before. This gave a total of 15 plots per site. Within the plots, all trees present that were

at least chest height were counted by species, since beavers will rarely cut very small saplings, and all cut trees were counted and identified as close as possible to species. Standing trees that were dead were not counted, but fallen over trees that showed signs of beaver cutting at the stem were counted as cut trees. This was only necessary for two plots in the entire survey.

Results:

I. Lodge Survey results:

A total of 48 active lodges were counted on the UNDERC property and indicated on the map in figure 1. In addition, there were 6 significant beaver dams counted, half of which were located along the length of Brown Creek. The approximate locations of the dams and the approximate boundary of new wetlands found which contain lodges are also indicated on the map in figure 1. Additionally, a large number of non active lodges were found, but they were not indicated on the map nor counted in the total.

II. Tree survey results: within habitats

To perform an ANCOVA analysis using a general linear model of the percent of trees cut versus the transect number and the habitat, first an arcsine transform was done on the percent trees cut data. The ANCOVA results showed not only that there is a significant relationship between distance from shore and the percent of the trees cut, but also that this is independent of the habitat (table 1). A linear regression analysis of percent trees cut versus transect confirmed the strong relationship with a p value of .001 (table 2), and the correlation can be seen in figure 2. As a check, an analysis of the total trees cut versus distance is also significant to the same p value. However, the residuals

were heavily weighted to the positive side, which indicated that perhaps the relationship was less linear and more logarithmic (fig. 3). To test this, graphs were created that logged transect, percentage, and both. These graphs, however, did not seem to show any more distinctive linear relationship than the standard linear graph (fig. 2 and 4). Linear regression analysis was performed on these new cases, and the residuals were again examined (fig 5), however, the residuals were no better or worse than those of the original.

A linear regression analysis of the total trees cut versus the total abundance also shows a p value of .001, indicating there is a significant relationship between the total trees present and the total trees that are being cut for each habitat (table 3). This is shown in figure 6.

III. Tree survey results between habitats:

An ANOVA analysis of the total trees cut versus the three habitats showed that the number of trees cut differs significantly between all habitats. This is shown in figure 7. An ANOVA using both habitat and transect as factors against the total number of trees cut showed there was no interaction between transect and habitat (table 4). Additionally, an ANOVA analysis shows that the total number of trees present differs significantly between the three habitats, with a p value of .002 as indicated in figure 8.

However, an ANOVA analysis of the percent of trees cut versus the habitat shows no significant difference between the habitats (table 5) with a p value of .74. An ANCOVA of the percent trees cut compared to the habitat type and the total trees present indicates that the habitat type and total trees differ in the slope of the resulting line (table

6) and therefore no further analysis was attempted because the lines of the habitat and the transect were not parallel and therefore cannot be compared.

IV. Preference Index by species:

To determine which species of trees are preferred by the beaver on the UNDERC property, a preference index was constructed for each species by the formula

$$preference = \frac{\% \text{ trees cut}}{\% \text{ trees available}}$$
 of each species. A value of less than 1 indicates the

species is not preferred while a value of greater than one indicates that the species is largely preferred. The preference index is shown in figure 9, and indicated that the most preferred species on the UNDERC property is yellow birch, followed by red maple and alder.

Discussion

I. Lodge survey:

There were a total of 48 lodges counted on the UNDERC property, 6 large dams, over half of which were on Brown Creek, and significant areas of marshlands not indicated on the map. There are many statistics cited for the ideal population density of beavers, but the one that is cited by Muller-Schwarze and Sun (2003) is 1.2 lodges per km of stream habitat. This statistic does not really apply to the property, since there were only 3 streams where beaver were found and a vast majority of the lodges were located on lakes. Therefore, a better indication of population density on this property is 0.016 lodges/hectare. The statistic cited by Muller-Schwarze and Sun (2003) as the average number of beavers per lodge in Michigan is 5.1 beavers per lodge. This average can be

applied to the index of lodges to get an approximate population of beavers on property as 245 individuals.

All of the lakes were actively colonized by beavers, but one result of this survey was that, with the notable exception of Bolger Bog and Reddington Bog, not a single bog was home to a beaver lodge. Bolger Bog had quite a sizable lodge, and included at least two large beavers that were active during daylight while the lodge on Reddington was average size. Every other bog on property lacked beavers even when lakes of similar size did have beaver. Looking through the literature, this seems to be a very unique situation, or if it is not it has never been thoroughly researched, because there were no indications that beaver do not colonize bogs. I hypothesize that the reason for this has nothing to do with the bog itself, but is a function of the vegetation surrounding it. The species of trees that typically colonize bogs are those early successional species that thrive on wet habitat, species such as tamarack, black spruce, and balsam fir, and these are among the least favored by beaver (fig 6). If this is the case, then presumably the vegetation at Bolger and Reddington bogs should be different than those of the other bogs on property, perhaps containing a greater abundance of the beaver's preferred food. I have no data on the relative vegetation of Bolger Bog or the other bogs, however, because they were not among the habitats sampled. This result should receive further study.

Another important finding of my survey was the large abundance of non active lodges and abandoned dams. Although these were not marked on the map and therefore I do not have an exact number recorded, their abundance was evident at all stages of the survey and all over the property. One of the most notable examples of this was a system of no less than 5 large (greater than 10m long) dams crossing a small stream between Bog

Pot and Tenderfoot Creek. All of the dams were in disrepair and the stream flowed through them, and there was no pond or active lodge. It was obvious, though, that beaver were a very important feature of this area, which is prime beaver habitat, in the recent past. The only explanation that I have for the large abundance of abandoned lodges and habitats is the recent history of trapping and removing “nuisance” beavers from the property. This practice has only recently been drastically decreased, but evidence of the severity of it is apparent throughout the property.

There are a few places on the property that I believe merit further exploration and surveying. The first is the area directly north of the road to north gate and to the east of Reddington Bog. This area is full of wetlands and has the potential to contain at least a few lodges, however I was not able to find any. This area is impossible to get a canoe into which was the standard survey technique I used, so to survey this area I had to walk through the woods and intermittently emerge onto the shores of the wetlands and look for lodges. I believe that with more people and more time it would be possible to find more lodges in this area since it is very suitable habitat for beavers. The second area I would wish to survey in more detail is the area to the extreme west of the property, from Cranberry Bog to Trout Pond. Although I surveyed both Cranberry Bog and Trout Pond and found no beaver, the area in between is much like that of the north of the property. Again, it was impossible to get a canoe in and often the approach involved steep banks that are difficult to traverse in waders.

In conclusion, I believe that this property can support a somewhat larger population of beavers. The number of suitable habitats that contain no beaver colonies is substantial, as are formally colonized habitats that have been abandoned, most likely due

to overambitious trapping in the past. As the population of beaver increases over the next few years I hypothesize that we will see more and more beaver moving into these suitable, if somewhat less ideal, habitats, and also re colonizing many of the abandoned lodges and dams.

II. Tree survey

There is a statistically significant linear relationship between the distance from the shore line and the percentage of trees cut, although it is unclear if this relationship is more linear or logarithmic from the analysis. This shows that, as the beavers move further away from the shore they cut a smaller percentage of trees. Beavers use the water for such vitally important things as transportation, flotation, and protection, and they are very awkward on land and therefore should seek to spend less time on dry land away from water, thus this result is completely consistent with what is known about beaver behavior. This relationship has been shown by many other studies (Muller-Schwarze and Sun, 2003; Hill, 1982).

Although the total number of trees present and the total number of trees cut differed significantly between habitats, the percentage of trees cut was the same for the three habitats. This means that the beavers are cutting the same percentage of trees, and so if a habitat contains larger numbers of trees the beavers are cutting more of them, and this percentage is the same no matter the habitat. This indicates a large regularity in beaver behavior, because this percentage is the same despite differences in the types of trees at each habitat and in the total abundance of trees. Although regularity in beaver behavior is not surprising, and has been demonstrated before for a variety of different

behaviors such as damn building, preferential cutting and dispersal, regular behavior in the percentage of trees cut down even among different habitats was not mentioned in the literature read. These habitats differed in every variable I tested, including total number of trees, tree composition by species, and percentage of coniferous trees. The only common variable that I could think of is that, in this area the climate is the same, and so aspects of the environment such as the length of the winter and summer are the same that could potentially affect the percentage of trees harvested. It would be interesting to see if this regularity is observed in habitats with diverse climates, such as between and Iowa, or in habitats that have greater diversity than the ones I studies, such as mountain peaks and swamps.

Since it was determined that the habitats each contained a different number of trees but the percentage cut was the same, it was interesting to see what relationship there was between the total abundance of trees and the total cut (fig. 6). The first thing this showed is that there is a difference between the numbers of trees in each habitat and the total number cut, as already stated. The significant linear relationship is strongly positive, and shows that as the total abundance of trees increases the percentage of cut trees increases as well. This holds true in between habitats but also within the same habitat. Figure 10 shows a graph of the total cut trees versus the total abundance, but grouped by transect, and clearly the total abundance of trees is greater in transect one, near the water, which also has the highest number of cut trees, and the highest percentage of cut trees (figure 2). This clear linear relationship between the total cut trees and the total abundance of trees in an area has been demonstrated by other studies (Muller-Schwartz and Sun, 2003).

III. Preference index.

It has been shown that beaver almost invariably prefer to cut aspen and willow than any other trees, and they are followed by alder and birch and maple. Last of all are the coniferous trees, which are often ignored due to their high resin content (Muller-Schwartz and Sun, 2003). According to the data collected, however, on UNDERC aspen was one of the least preferred species cut (figure 6). The explanation of this, I believe, is two fold. First large areas of aspen are not often found near substantial bodies of water, and therefore would not necessarily fall within the area I surveyed. Although the formula for calculating the preference index was meant to normalize the data to compensate for a relative lack of a particular species (for example, there were not many yellow birch found, but they are still the most preferred species), if the majority of large aspen stand were outside of the survey range, say 100 to 200 meters away from the lodge, we would get a result that was not necessarily indicative of what the beavers are actually eating. The other factor was that all of the aspen trees that actually were counted were very large, with DBH of 6 inches or more. It is rare, although not unheard of, that beavers cut such large trees; therefore they were perhaps neglecting these large aspens in favor of smaller trees that are easy to handle. Most likely then, I simply miss counted the number of small aspen that were cut, either because I did not recognize them as aspen or because they did not fall into the plots. I believe that by increasing my sample size at each site and increasing the number of sampled sites, the net result would be a substantial increase in the area sampled and a more reasonable result could be found.

Aside from the lack of preference of aspen and the affinity for yellow birch, the feeding habitats are consistent with what has been observed (Muller-Schwarze and Sun, 2003). The beaver of UNDERC have a preference towards alder and maple, and a near complete aversion to coniferous trees. Sites in which beaver were eating firs and cedars corresponded to places where there was a high density of these trees and a near lack of other species.

Acknowledgments

I would like to thank Dr. Belovsky for all of his help in researching and analyzing the beaver on UNDERC and the guidance he gave me when I was in need, Dr. Karen Franci for providing the organizational support needed to get me going on my project in a timely and organized fashion, and the Bernard J. Hank Family Endowment for the monetary funds necessary to make such an amazing course possible.

Works Cited

Hill, Edward P. 1982. Beaver. In J.A. Chapman and G.A. Feldhamer (eds). Wild Mammals of North America. John Hopkins University Press, Baltimore.

Muller-Schwarze, Dietland and Lixing Sun. 2003. The Beaver. Cornell University Press, New York.

Figures

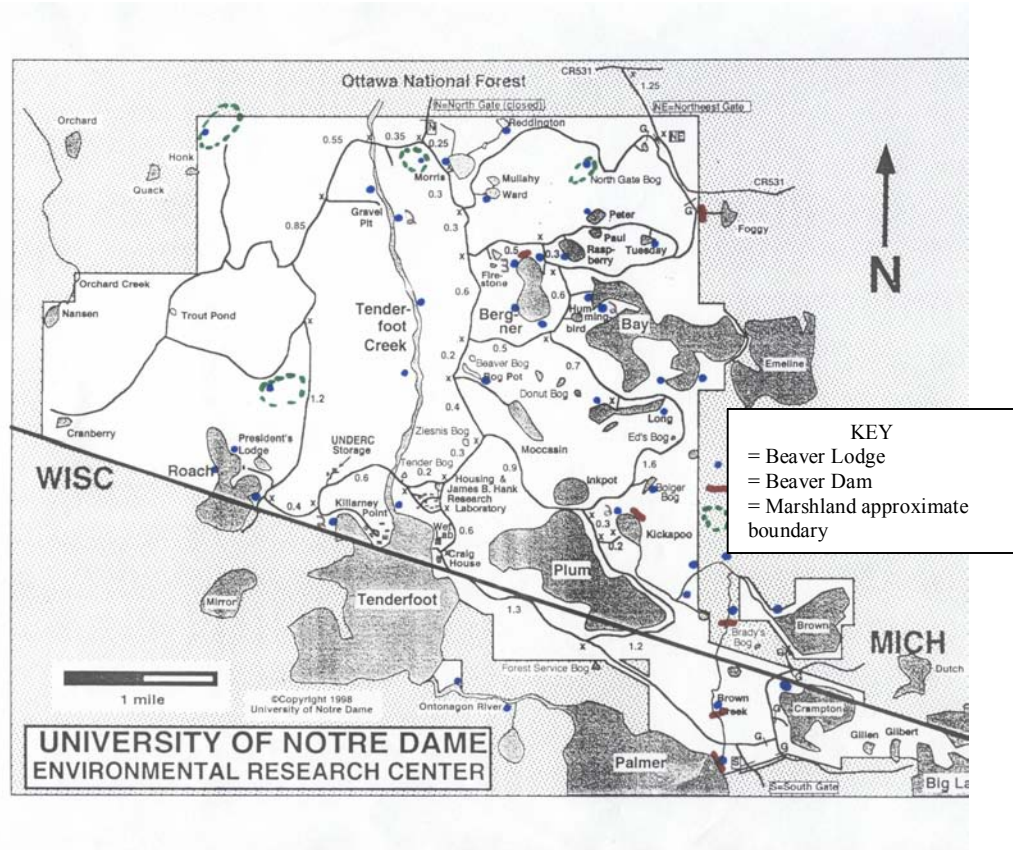


Figure 1: Map of UNDERC property with beaver lodges, dams and marshlands indicated.

Total of 48 lodges and 6 significant dams.

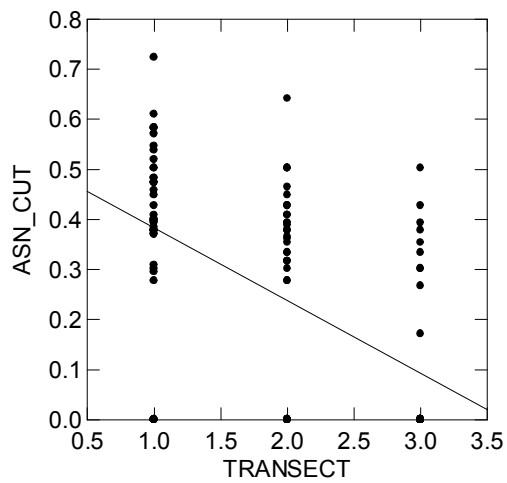


Figure 2: Plot of percent trees cut vs. distance. $p = .001$

Plot of Residuals against Predicted Values

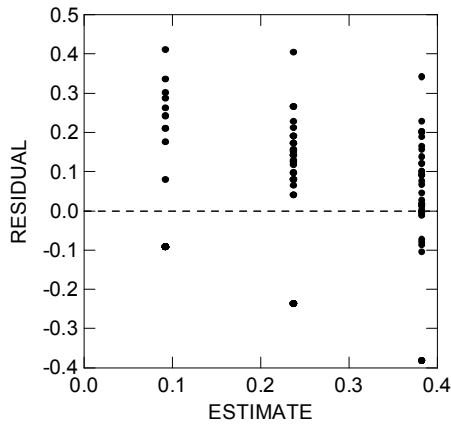


Figure 3: Plot of the residuals after a linear regression analysis of % trees cut vs. transect. Note residuals disproportionately high.

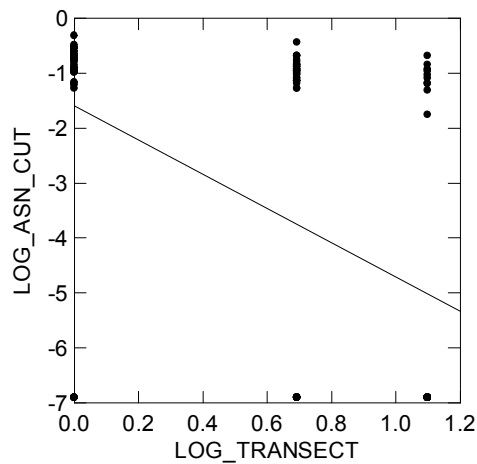
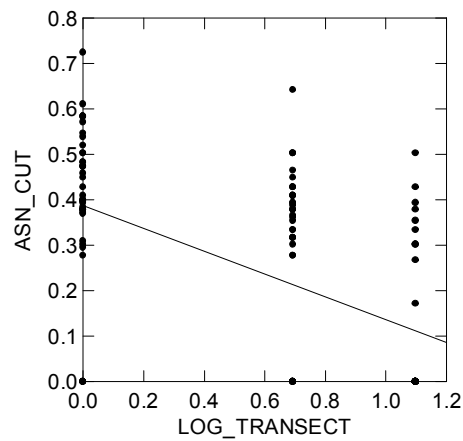
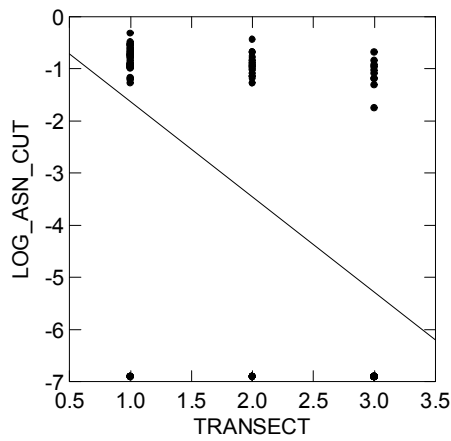
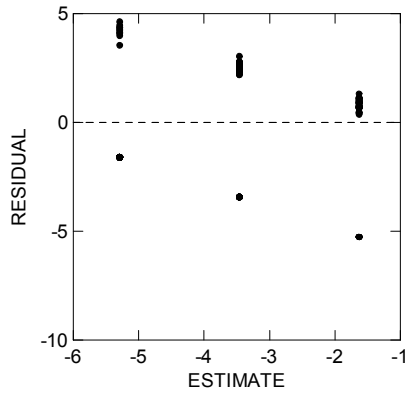
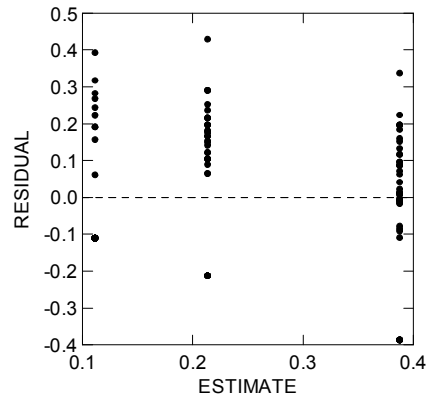


Figure 4: Graphs of the log transformed % cut vs. distance, the % cut vs. log transformed distance, and the log transformed % cut vs. log transformed distance respectively. All graphs grouped by habitat.

Plot of Residuals against Predicted Values



Plot of Residuals against Predicted Values



Plot of Residuals against Predicted Values

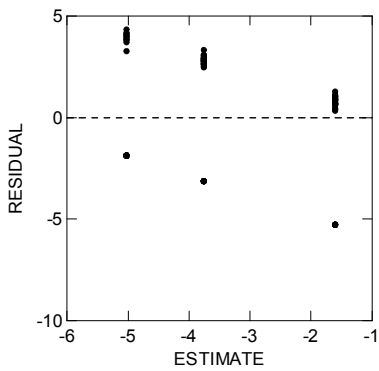


Figure 5: Plot of residuals after a linear analysis of log transformed % cut vs. distance, % cut vs. log transformed distance, and log transformed % cut vs. log transformed distance respectively.

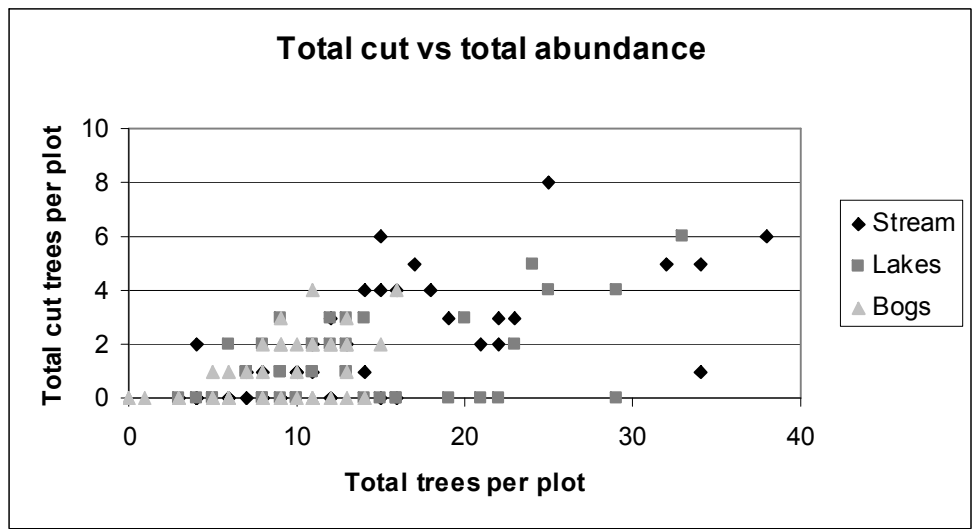


Figure 6: Total trees cut graphed against total abundance of trees. $P = .001$

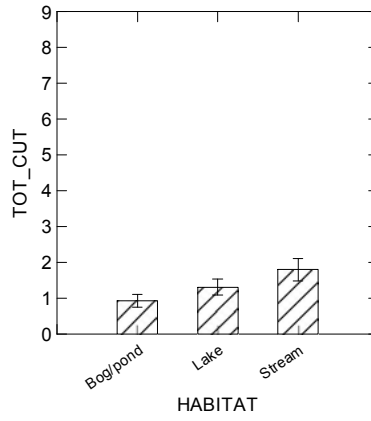


Figure 7: Total trees cut per habitat.

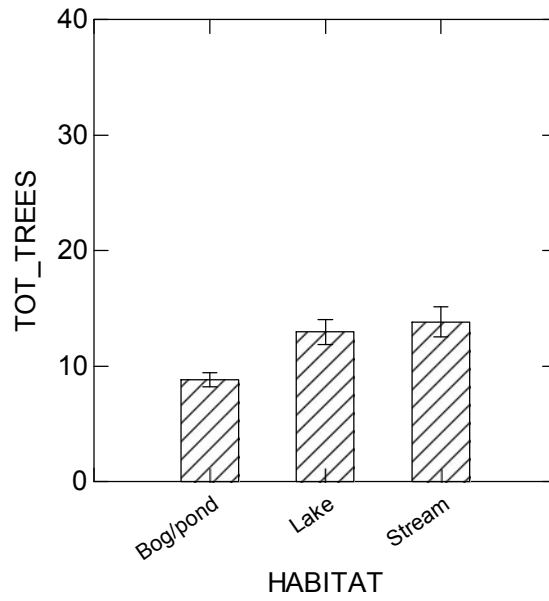


Figure 8: Total tree abundance per habitat.

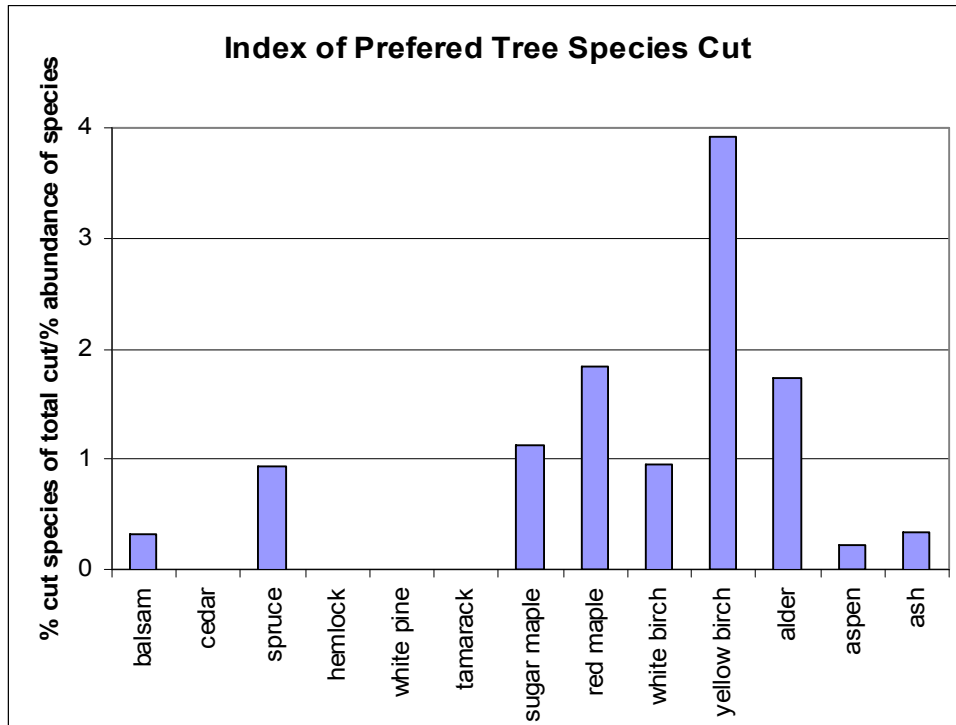
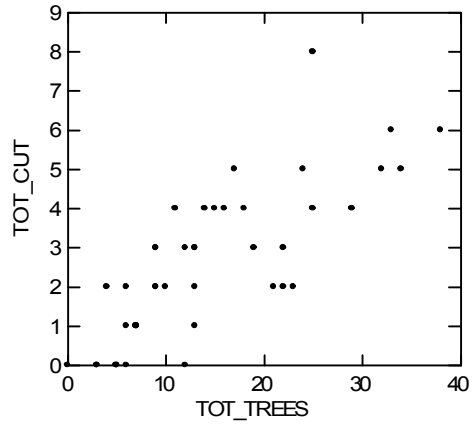
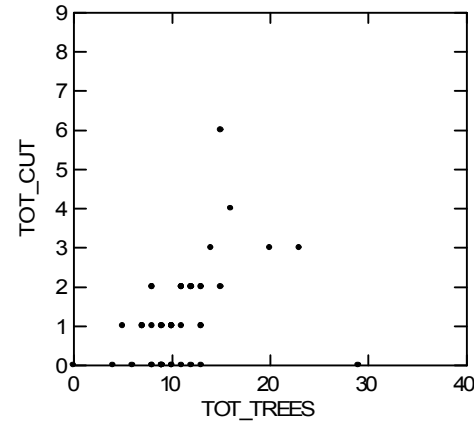


Figure 9: Preference index of tree species eaten by beavers. Index greater than 1 shows species is highly preferred. Index less than 1 shows species is highly not preferred. Yellow birch is most preferred, followed by red maple and alder. Sugar maple is the only other species with an index greater than 1.

1



2



3

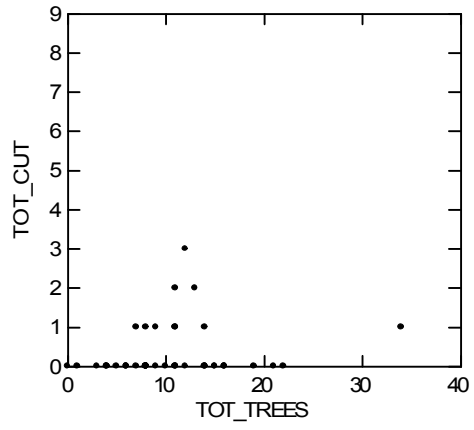


Figure 10: Total cut trees vs. total number of trees, grouped by transect.

Tables

ANCOVA results for the percent cut vs. habitat and transect

Dep Var: ASN_CUT N: 132 Multiple R: 0.560 Squared multiple R: 0.313

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
HABITAT\$	0.090	2	0.045	1.330	0.268
TRANSECT	1.829	1	1.829	54.022	0.000
HABITAT\$*TRANSECT	0.066	2	0.033	0.978	0.379
Error			4.267	126	0.034

Table 1: SYSTAT results table for ANCOVA test.

Linear regression results for percent cut vs. transect

Dep Var: ASN_CUT N: 132 Multiple R: 0.546055 Squared multiple R: 0.298176

Adjusted squared multiple R: 0.292777 Standard error of estimate: 0.183167

Effect Tail)	Coefficient	Std Error	Std Coef	Tolerance	t	P(2
CONSTANT	0.528012	0.042180	0.000000	.	12.51795	
TRANSECT	-0.145111	0.019526	-0.546055	1.000000	-7.43179	

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	1.853035	1	1.853035	55.231542	0.000000
Residual	4.361539	130	0.033550		

Table 2: SYSTAT results table for Linear Regression

Linear regression results for Total cut vs. total trees

Dep Var: TOT_CUT N: 135 Multiple R: 0.607 Squared multiple R: 0.369

Adjusted squared multiple R: 0.364 Standard error of estimate: 1.323

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	-0.317	0.220	0.000	.	-1.438	0.153
TOT_TREES	0.140	0.016	0.607	1.000	8.818	0.000

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	136.006	1	136.006	77.758	0.000
Residual	232.631	133	1.749		

*** WARNING ***

Case 2 is an outlier (Studentized Residual = 3.888)
 Case 3 has large leverage (Leverage = 0.106)

Durbin-Watson D Statistic 1.507
 First Order Autocorrelation 0.245

Table 3: SYSTAT results table for linear regression

ANOVA results for total trees cut against transect and habitat

Dep Var: TOT_CUT N: 135 Multiple R: 0.650739427 Squared multiple R: 0.423461801

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
HABITAT\$	1.69926E+01	2	8.496296296	5.037013802	0.007861479
TRANSECT	1.09970E+02	2	5.49852E+01	3.25979E+01	0.000000000
HABITAT\$*TRANSECT	2.91407E+01	4	7.285185185	4.319008783	0.002622587
Error	2.12533E+02	126	1.686772487		

Table 4: SYSTAT results for ANOVA analysis.

ANOVA results for percent of trees cut vs. habitat

Dep Var: ASN_CUT N: 132 Multiple R: 0.068 Squared multiple R: 0.005

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
HABITAT\$	0.028	2	0.014	0.296	0.744
Error	6.186	129	0.048		

Table 5: SYSTAT results table for ANOVA analysis

ANCOVA results for percent of trees cut against habitat and total trees

Dep Var: ASN_CUT N: 132 Multiple R: 0.307 Squared multiple R: 0.095

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
HABITAT\$	0.175	2	0.088	1.960	0.145
TOT_TREES	0.333	1	0.333	7.453	0.007
HABITAT\$*TOT_TREES	0.209	2	0.104	2.338	0.101
Error	5.627	126	0.045		

Analysis of Variance

Table 6: SYSTAT results table for ANCOVA analysis.