

THE EFFECT OF DISTANCE FROM EDGE ON THE DENSITY AND DIVERSITY OF
GRASSHOPPER COMMUNITIES IN A LOCALLY FRAGMENTED HABITAT



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INTRODUCTION

Biodiversity is the variety of life in an ecosystem (Wilson, 2007). An ecosystem with more biodiversity is more likely to survive drastic habitat changes, such as natural disasters. It is important that ecosystems thrive because all life depends on the ecosystems for everyday resources such as food, lumber, and plants that provide people with medicines. Biodiversity can be measured by looking at the diversity and density of the ecosystem. Diversity consists of the different species that are represented in an ecosystem. For example, a tropical rainforest is more diverse than a temperate forest because it consists of a greater variety of wildlife. Diversity is often broken down into species richness, which is the number of different species in an area, and evenness, which is the distribution of the species in an area (Krebs, p. 411-445, 1999). Density is the number of individual organisms present in an ecosystem.

There are many threats to biodiversity. Some threats are even serious enough to cause species extinction. Examples of threats include population increase, pollution, over-harvesting, and invasive species (Wilson, 2007). However, the threat that some scientists have deemed the most hurtful to biodiversity is habitat destruction. Habitat destruction harms biodiversity by hurting the habitat that the wildlife lived in. The wildlife then either move away, or died, which limits the diversity of the ecosystem. With a lower diversity, the ecosystem is weaker than before, thus making the species in the area more vulnerable to extinction. There are many man-made causes of habitat destruction such as industrialization, logging, mining, and agriculture. There are also various natural forms of habitat destruction such as wildfires, hurricanes, earthquakes, and other natural disasters. Both of these types of habitat destruction often lead to the fragmentation of a habitat (Wilcove, Mclellan, and Dopson, p.237-241, 1986).

Fragmentation is when one habitat is broken up into two or more different habitats. There are two ways this fragmentation can occur, inherent or induced. On the one hand, there is

inherent fragmentation, which is caused by nature, and usually has no human influence; wildfires, mudslides, or volcanic eruptions would be examples of inherent fragmentation. On the other hand, there is induced fragmentation. Induced fragmentation is caused by humans and happens in various ways such as logging, mining, or rural development (Bolen & Robinson 1984 p. 109).

In addition, there are three specific parts of a fragmented habitat: the edge, the ecotone, and the core. When a habitat is fragmented, the boundary that has been formed between the two different habitats is called an edge. The edge is not always a defined line between the two habitats, but it is usually easy to see where one habitat stops and another one begins. For example, the boundary between woodlands and grasslands shows a gradual change as the woods stop and the grass begins; however, you can obviously tell the difference between shady and cool woodlands and hot sunny grasslands. Another important part of the fragmented habitat is the ecotone. The ecotone is the area that straddles the edge, incorporating wildlife and resources from both sides of the edge. The range of the ecotone varies among locations, but has been estimated around 10- 30 meters from the edge into both habitats (Wilclove, McLellan, & Dobson 1986 p. 249).

The last major part of the fragmented habitat is the core. The core is the area that does not incorporate wildlife and resources from both sides of the edge, only the resources specific to which side it is on. One important thing to know about the core is that animals in the core tend to have specific diets, which is why they do not tend to venture out into the more varied areas such as the ecotone. Another important fact is that the core is not always present. The presence of the core depends on the shape of the habitat and the range of the ecotone. For example, if the habitat

is a perfect square, it is more likely to have a core than a habitat that has an elongated shape because the range of the ecotone would not cover as much of the square habitat.

A phenomenon known as edge effect can be observed in the ecotone. The edge effect is the statistically noticeable increase of life when approaching the boundary of where two habitats adjoin. Density and diversity are ways to examine the extent of the edge effect; a decrease in these moving away from the edge indicates that a core area exists. The edge effect is an essential tool in determining how great a threat fragmentation is to a habitat and to biodiversity as well. An example of the edge effect being a threat to biodiversity is the introduction of a predator to a new habitat. The predator preys on new species that have no natural defenses. This is a problem because one species can throw an entire ecosystem out of balance. Therefore, it is important that scientists study the impact that the edge effect has on a fragmented habitat.

Previous studies concerning the edge effect examined the effects of edge on biodiversity using birds as study subjects. These studies wanted to see if the biodiversity of the bird population changed due to proximity to the edge. To determine the effects on biodiversity, they measured density and diversity. Generally these results showed that the birds preferred the edge, but the results were not always clear. Therefore, existing literature on edge effect suggests using other study subjects, including ones that are more abundant and easy to store. Using other study subjects would also help give a well rounded picture of the effects of edge on biodiversity (Wilcove, McLellan, & Dobson, 1986, p. 249).

Based on suggestions from previous studies and literature, we chose insects as our study subjects for an examination of edge effect in a fragmented habitat because they are abundant, small and easy to store (Lattin, p. 232, 1976). The particular insect we chose was grasshoppers because they are easy to distinguish from other insects and from one another (Capernia, Scott, &

Walker, p. 7, 2004). To differentiate the grasshoppers from other species we looked at antennae length. Grasshoppers have relatively shorter antennae compared to other insects, usually measuring half their body length (Capernia, Scott, & Walker, p. 7, 2004). In addition, grasshoppers live in grasslands and are most active during the day (Capernia, Scott, & Walker, p. 7, 2004). The diet of a grasshopper is very general, meaning they eat a variety of plant species. Since grasshoppers are not selective eaters, they are more likely to be found at the edge of a habitat, but they also be found in the core (Craig, Bock, Bennett, Bock, 1999). Knowing that grasshoppers can be found at both the core and edge, we wanted to determine if the density and diversity of grasshopper communities are affected by distance from edge, moving from the ecotone to the potential core, in a fragmented habitat.

To answer our research question, we chose a locally available fragmented grassland area to sample. In order to get as accurate a sample as possible, we marked six sets of five transects (which are invisible lines that mark a path), each transect measuring one hundred meters. Each set was marked by a number 1-6, and each transect was labeled A-E. For example, 1A referred to set 1, transect A. The first transect was placed ten meters away from the edge and parallel to the edge; each transect that followed was placed fifteen meters apart, remaining parallel to the edge, as Figures 1 and 2 show. We started at ten meters from the edge because that is where previous literature suggested the ecotone starts (Wilcove, McLellan, and Dobson, p. 249, 1986). We placed each transect parallel to the edge in order to collect grasshoppers at different distances from the edge; this helped us to see where the edge effect would start. We used the sweeping method to collect grasshoppers along each transect, sweeping two high and two low. The sweeping method was used because a previous study showed that it was inexpensive, efficient, accurate, and easy to do (Larson, O'Neill, & Kemp, 1999, p. 213). We swept two high so that we

could catch any grasshoppers that jumped or lived in the upper part of the grass; we swept two low so that we could catch the grasshoppers that prefer the lower part of the grass.

In the lab, we then separated grasshoppers by set number and by transect letter and identified them in order to calculate the species richness, density index, diversity index, and evenness. We chose these four measures because they gave us a more complete picture of how distance from edge affected the grasshopper communities at our study site, than any individual calculation could provide. We used a density index because it is an estimation of the total density, and it was unrealistic to collect every grasshopper in our site in order to calculate the total density. This is the same reason why we used the Shannon-Weiner Diversity Index, which estimates diversity by incorporating species richness and evenness and asking the predictability of the next sampled individual (Simis, 2011). The index ranges from 0-5, with zero being the most predictable, meaning the population has only one species (Krebs, 1999).

To evaluate our research question and determine the density and diversity of the grasshopper communities at our study site, we developed four hypotheses. We assessed these individually because each of these calculations yields separate parts that all add up to help us get the most complete view of biodiversity in our field. The alternative hypotheses (H_A) and null hypotheses (H_0) for our study are as follows: H_0 - The distance from the edge has no effect on the species richness of grasshopper communities. H_A - The distance from the edge has an effect on the species richness of grasshopper communities. H_0 - The distance from the edge has no effect on the density index of grasshopper communities. H_A - The distance from the edge has an effect on the density index of grasshopper communities. In order to help find a solution to our question we also looked at Shannon-Weiner Diversity Index and the evenness.

METHODS

The experiment took place at a grassy field bordered by woods on Old Legislative Road, Allegheny County, Maryland. The study site was set up on July 6, 2011. We collected the grasshoppers between 10:30AM-12:00PM on July 7, 2011. We set up six sets of transects and labeled them 1 through 6 (see Figure 1).

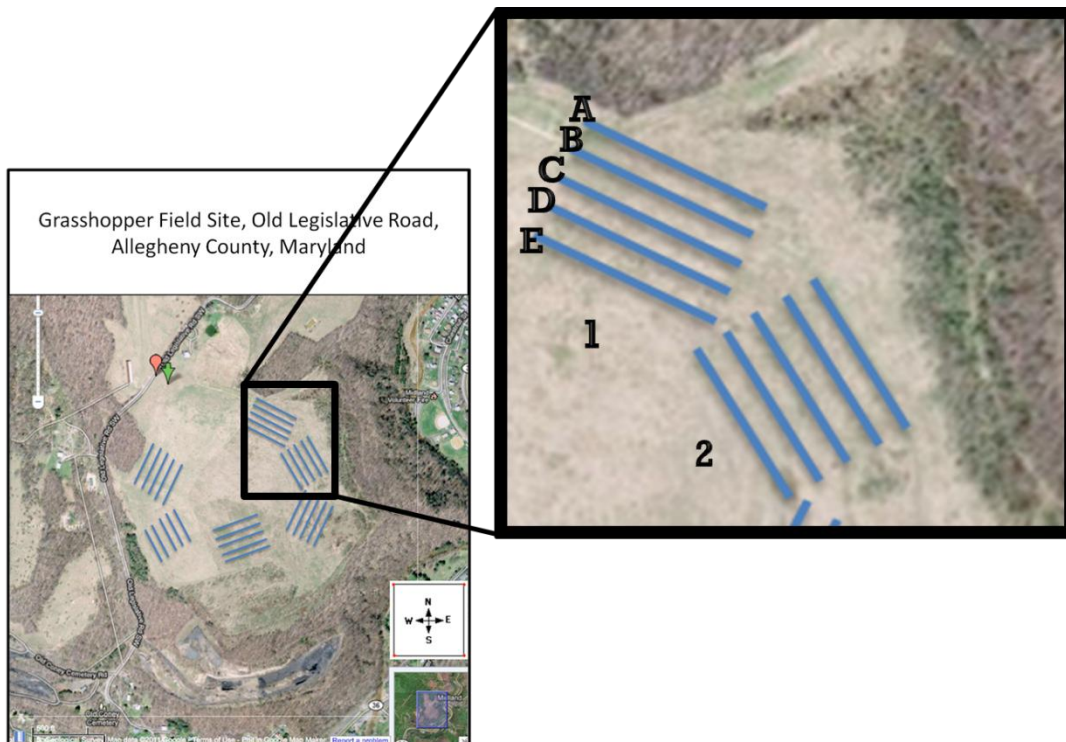


Fig. 1. – This figure shows a satellite picture of the layout of our study site. Each group of blue lines represents a different set of transects.

Each set had five transects labeled A through E depending on distance from the edge. All of the A transects were closest to the edge, while all of the E transects were furthest from the edge (see Figure 2).

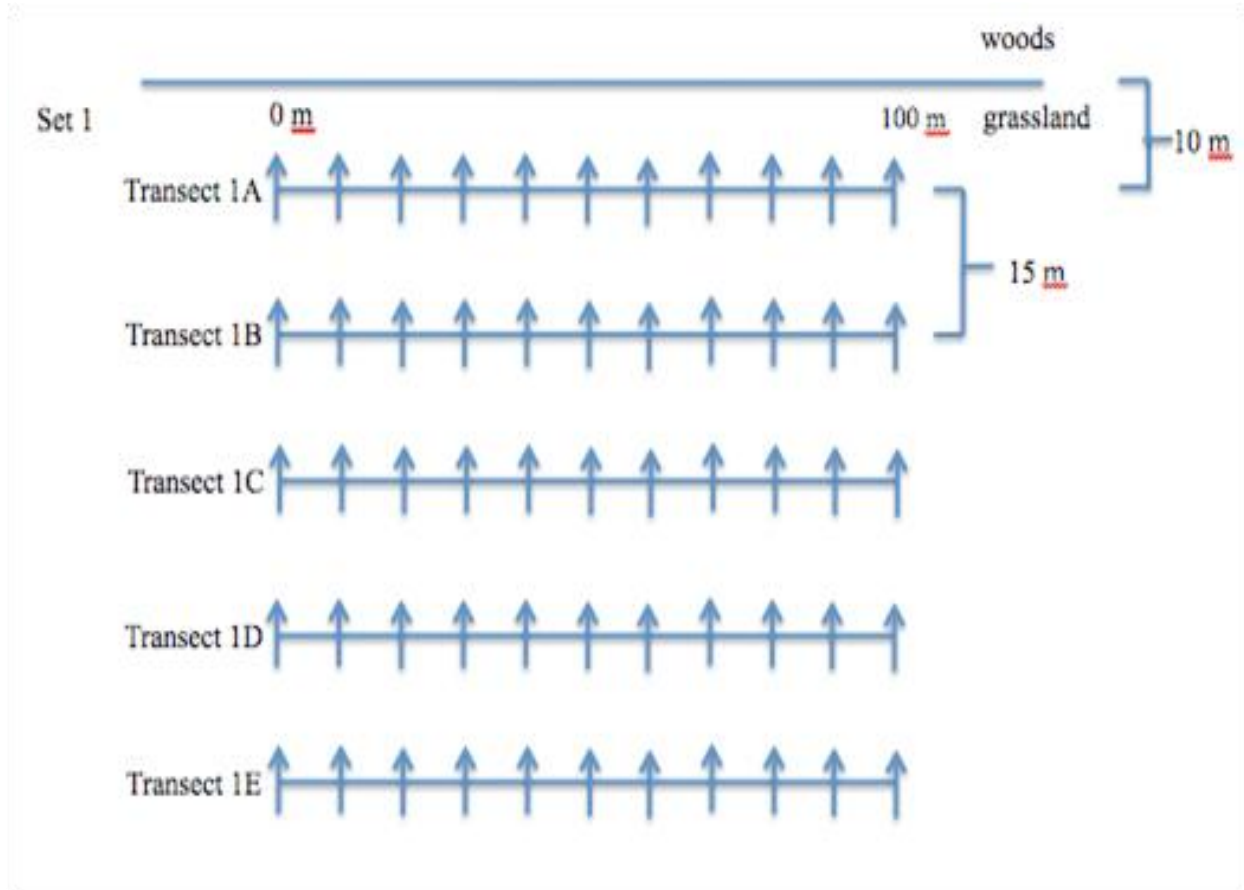


Fig. 2.-This figure illustrates the setup of each set. The first line represents the edge which separates the grassland and woods. The arrows represent the flags we used to mark our ten meter distance.

The first transect, A, began 10 meters from the edge that separated the woodland from the grassland, and each of the following transects were placed 15 meters from one another. Each transect was measured to 100 meters in length, and a flag was placed every 10 meters to mark the path for collection through each transect. This was repeated for each transect in the study site.

We used standard sized sweeping nets to collect the data. We swept between each flag 40 times, totaling 400 times a transect; for example, at transect 1A we swept 400 times. As we walked, we swept two ½ meter sweeps below the waist, and two ½ meter sweeps level with the waist. We emptied the contents of the net into the bag specific to the transect at each flag.

In the lab, the grasshoppers were frozen to prepare them for observation. After they were frozen, we separated the grasshoppers from other insects that we collected in the field. Next, we

used a microscope to help classify the grasshoppers into the subfamilies, which included stridulating slant faced, spur throated, and banded winged. Then, we used a field guide as a reference to help us separate them by species.

We then determined species richness, diversity index, density index, and species evenness. We determined the species richness of each individual transect by counting how many species were present. We then calculated the average species richness for each row of transects (A-D). For example, row A included each transect labeled “A” from each set in the study site. We calculated the average species richness for each row. We also calculated the density index for each transect by dividing the total number of individual grasshoppers by the area of the transect. We calculated the area of each transect by multiplying the length of the transect (100 m) by the width of the sweep (0.5 m). We then calculated the average density index for each row. Using our raw data, we also calculated the Shannon-Weiner Diversity Index. The formula that we used was

$$H' = -\sum_{i=1}^S (p_i \ln p_i)$$

The components of this formula are species richness (S) and relative species abundance (p_i).

With the diversity index, evenness can be determined. This is calculated by $J = \frac{H'}{H}$, where H' is the Shannon-Weiner Diversity Index and H is the maximum diversity. Maximum diversity of an area is the most diverse that an area can be given a certain species richness.

A t-test was conducted on the species richness and the density index. The sample mean of the species richness and the density index was determined. When the t-test value is calculated, the mean of one row is compared to another row. For example, the mean of species richness and density index from Row A was compared to the means of Row B, Row C, and Row D. If the

value is greater than an alpha of 0.05, then there is no different in the samples of species of grasshoppers collected among rows.

The graphs for species richness and density have a 95 percent confidence interval. This means that we are 95 percent confident that the means of the actual population from which we collected our samples will be within that interval. The graphs for the Shannon-Weiner Diversity Index and evenness do not have confidence intervals because we cannot have confidence intervals for data that we cannot do a statistical test on. We cannot do t-tests on data that is representative. The values for the Shannon-Wiener Index and evenness are representative, not numeric. A value of "0" for the Shannon-Weiner Index does not mean that there is no diversity; it means that there is only one species present in an area. An evenness of "1" does not mean that there is one evenness; it means that there are an equal number of individuals in each species. We could do t-tests on species richness and density because the values are numeric.

RESULTS

We calculated the species richness per row; along with doing this, we calculated 95% confidence intervals. In Figure 3, graphically row A appears to have the greatest species richness and row B has the least species richness. However, Figure 3 does not depict any statistical trend in the species richness between the rows of transects because the confidence intervals overlap, which suggests that there is no difference on the average species richness per row. After performing our t-test we confirmed that there was no significant difference between any of the rows for species richness of grasshoppers. Therefore our data shows that distance from edge has no effect on average species richness.

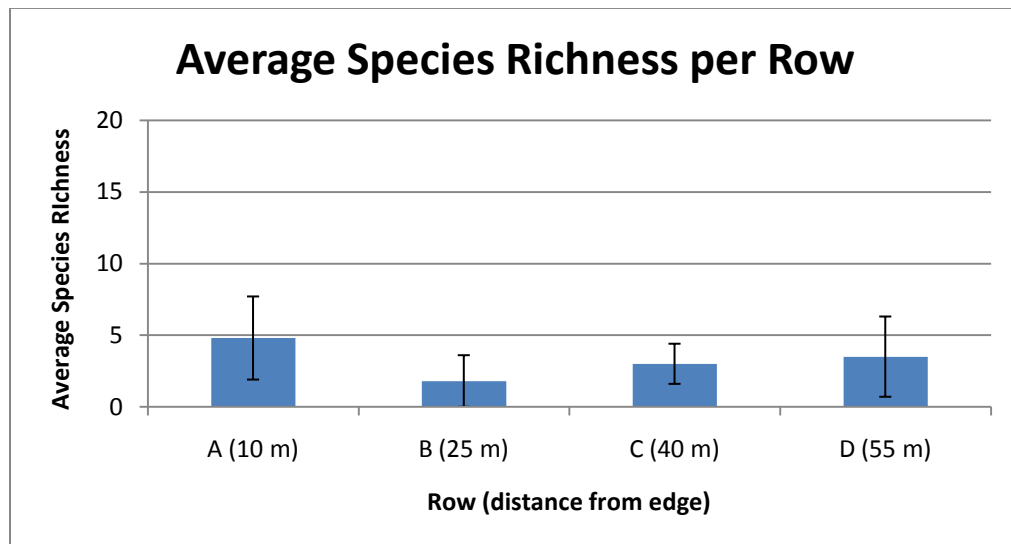


Fig. 3- This graph shows the species richness for each row of transects with a 95% confidence intervals.

Figure 4 represents the results we obtained by calculating the density index of the grasshoppers at our study site for each row. Graphically row A appears to have the greatest density, and row B appears to have the lowest. However the confidence intervals are again overlapping, which suggests that there is no difference on the density index per row. After performing a t-test we determined that there was again no significant difference between the

average densities per row. Thus our data shows that distance from edge has no effect on average species richness.

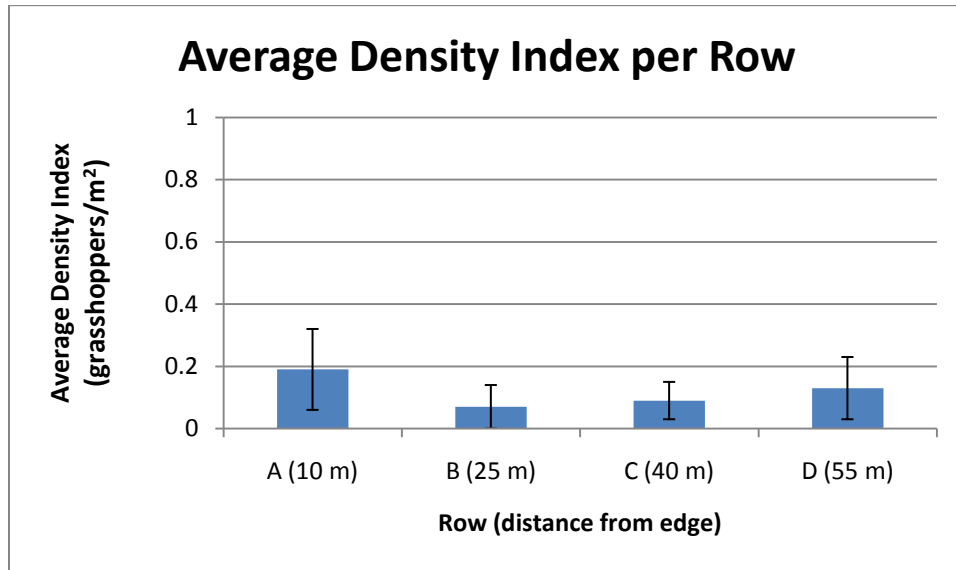


Fig. 4- This graph displays the density index for each row of transects with a 95% confidence intervals.

Figure 5 shows that there is not a specific trend for the Shannon-Weiner values due to the relative closeness of the data for each row. Again in Figure 5 row B appears to have the lowest value. We did not run a t-test.

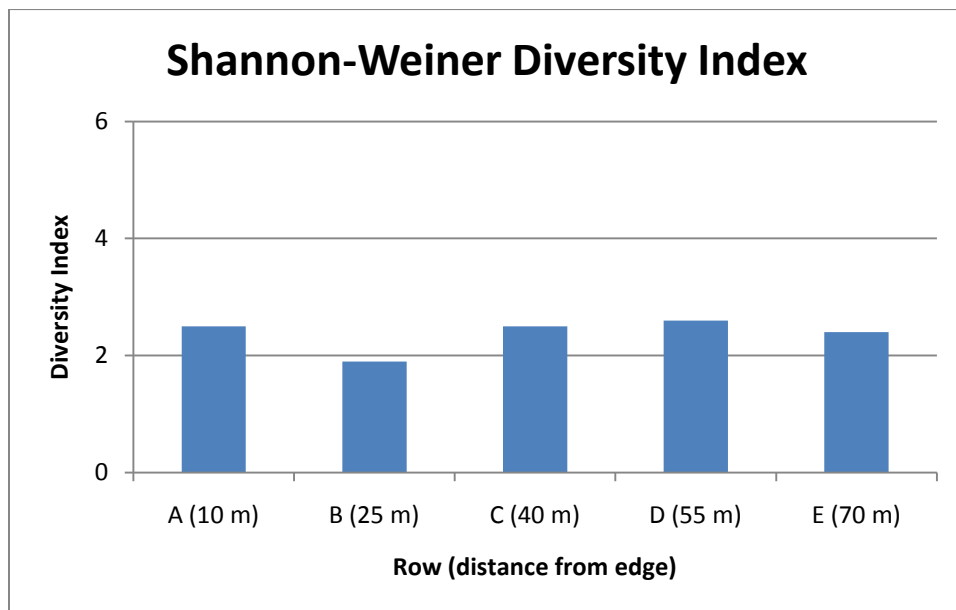


Fig. 5- This graph evaluates the diversity index for each row of transects.

Figure 6 displays the evenness values for each row of transects. All of the rows have relatively the same evenness. The range of the values for all of the rows is within a tenth of a decimal. We did not perform a t-test.

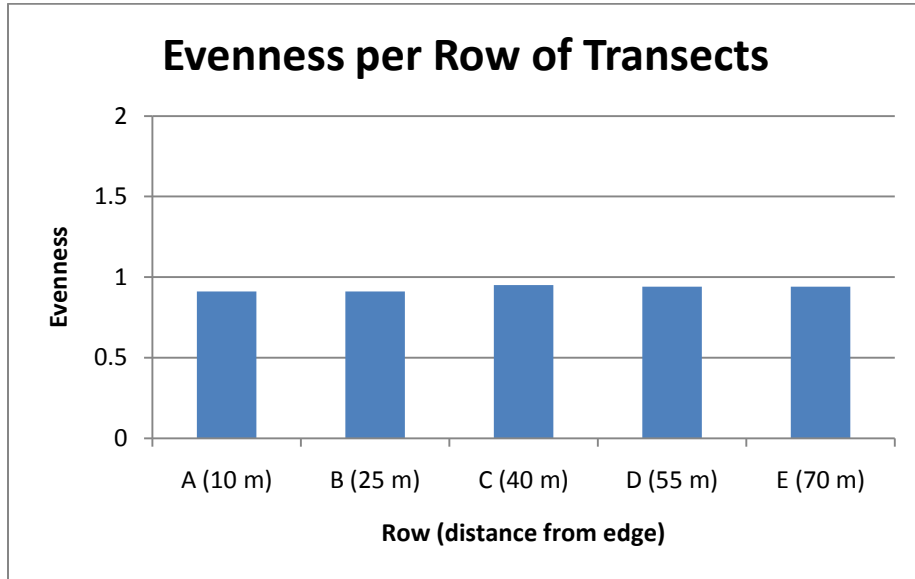


Fig. 6- This graph presents the evenness values for each row of transects.

In Figure 7, row A contains the greatest number of grasshoppers, and row B has the lowest. This difference reflects the overall graphic trends seen in the data for species richness, average density, and the Shannon-Weiner Diversity Index.

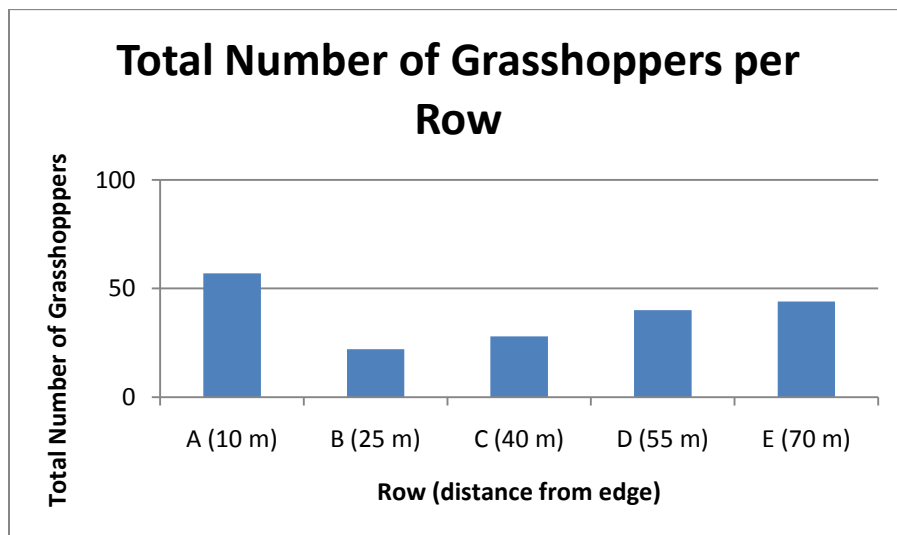


Fig. 7- This graph presents the total number of grasshoppers for each row of transects.

CONCLUSIONS AND DISCUSSION

Based on the results of our t-test, comparing the species richness of rows A and B, rows A and C, and rows A and D, we do not reject our null hypothesis that the distance from edge has no effect on the species richness of grasshopper communities. As depicted in Figure 3, the confidence intervals overlap, indicating that there is not a difference between the average species richness of each row of transects.

Furthermore, our t-test results comparing the density indices of rows A and B, rows A and C, and rows A and D indicate that there is no difference in the densities of these rows. Therefore, we do not reject our null hypothesis that the distance from edge has no effect on the density index of grasshopper communities. Figure 4's confidence intervals reveal that there is not a difference between the average density indices for each row of transects.

We also used the Shannon-Weiner Diversity Index to investigate our research question; as Figure 5 shows graphically there is not a difference for rows A, C, D, and E, but there is a difference for row B; row B appears to be lower, but it may not be. There was no statistical test run on the Shannon-Weiner Diversity Index, so there may be a difference in the rows A, B, C, D and E.

In addition to the Shannon-Weiner Diversity Index, we also used evenness to examine our research question; as Figure 6 displays, the values appear to be close for each row, so there is no trend. No statistical test was run for the difference between the averages of evenness for each row of transects. There may be a difference, but we did not have time to complete a statistical test.

The overall graphic trend for species richness, density, the Shannon-Weiner Diversity Index and total number of grasshoppers collected (see Figure 7) is that row B has the lowest amount and row A has the highest amount based on appearance graphically. Reasons behind this

may be because row B in each of the sets of transects was not like the rest of the rows. Several bushes and thorn bushes were found; also, the grass appeared to be shorter and composed of different types in set 4. Finally, in set 2, row B was on a slanted hill compared to row A and C. Statistically there is no difference in species richness and density. There may or may not be a statistical difference for the Shannon-Weiner Diversity Index and evenness.

Based on our results we do not see the edge effect occurring in this fragmented area. We expected to see statistical and graphic trends in species richness, density, diversity and evenness. The trends would have been that was a greater value of each variable closer to the edge and a lower value further away. There were no trends that indicated that edge effect occurred in our study site and this is why we have come to the conclusion that the distance from the edge does not affect the grasshopper communities in our study site.

There were several limitations that we had during our experiment. The first limitation that we had was time. We had two days to set up and conduct our experiment. The timing restricted us from having a larger study site and potentially being able to collect more data. Having a larger study site would have been beneficial to our study because it would mean being able to replicate the experiment, which would make the results of our experiment more accurate. Another limitation to our experiment was the distance we measured. Since we only measured ten meters from the edge in a 100 meter transect, and no further than 70 meters away from the edge, there was a lot of unmeasured area in the field we studied. The ten-meter area between the edge and our first transect may have shown an increase of density and diversity in grasshopper population; that area could have been where the edge effect was observed. In addition, if we had measured further into the field we may have found a core area, in comparison to our results in which we did not find a core area. Something else that limited our study was that we were unable to

identify some of the species of grasshoppers; this may have lead to some unexpected results. Human error also affected our results. Sets one and two in Row E combined bags because of a mistake. This affected the density and diversity indices of our results.

We had many suggestions for improvement based on the limitations of our study. Our first suggestion was that we should have used a different range of measurements between the edge and the first transect, in order to extend the sampling area between the edge and the first transect. Another suggestion we had was to become more familiar with the different species of grasshopper in order to prevent misidentifications that could have made the data less accurate. In this case, if we had more time we could have become more familiar with the species of grasshoppers, as mentioned above. More time would have also benefitted this study by allowing us to conduct our experiment at more study sites of varying sizes, to increase the accuracy of the results. One more suggestion that we had was to conduct our experiment on other study subjects, to evaluate the effect of distance from edge on other species.

One question we developed as a result of our study is: how big of a threat is fragmentation to biodiversity? This is an important question because, according to previous sources, fragmentation is the biggest threat to biodiversity. The biodiversity of grasshoppers at our site did not seem to be affected by the distance from the edge as a result of fragmentation. However limitations may have been the cause of our results. Therefore, this question needs more studies conducted about it (Wilcove, Mc.Ellan, Dobson, 1986).

Another question we posed based on the interpretation of our results is: Does distance from edge affect other species? We based our study upon the suggestions of other studies; one of the suggestions that these other studies had was to use different study subjects in future

experiments. This is crucial in the effort to better comprehend the edge effect (Wilcove, McEllan, Dobson, 1986).

REFERENCES CITED

- Bolen, E.G., Robinson, W.L. (1999). *Wildlife Ecology and Management*. UpperSaddle River, NJ:Prentice-Hall, Inc.
- Capinera, J.L., Scott, R.D., Walker, T.J. (2004). *Grasshoppers, Katydid, and Crickets of The United States*. Ithaca, NY: Cornell University.
- Craig, D.P., Bock, C.E., Bennett, B.C., Bock, J.H. (1999). Habitat Relationships Among Grasshoppers (Orthoptera:Acrididae) at the Western Limit of the Great Plains in Colorado. *Department of Environmental, Population, and Organismic Biology*. 142(2), 314-327.
- Cunningham, W.P., Cunningham, M.A. (2000). *Principles of Environment Science Iniquity and Applications*. New York, NY: McGraw Hill Companies.
- Holl, K.D., Cairns, J. (1994). Vegetational community development on reclaimed coal surface mines in Virginia. *Bulletin of the Torrey Botanical Club*, 121(4), 327-337.
- Krebs, C.J. (1999). *Ecological Methodology Second Edition*. Menlo Park, CA: Addison Wesley Educational Publishers; Inc..
- Larson, D.P., O'Neill, K.M., Kemp, W.P. (1999). Evaluation of the Accuracy of Sweep Sampling in Determining Grasshopper (Orthoptera:Acrididae) Community Composition. *Department of Entomology*. 207-214.
- Lattin, J.D. (1976). Insect Diversity and Systematics. *The American Biology Teacher*. 231-234.
- Purves, W.K., Orians, G.H., Heller, H.C. (1992). *Life: The Science of Biology*. Sunderland, Massachusetts: Sinauer associates, Inc.

Saunders, D.A., Hobbs, K.J., Margules, C.R. (1990). *Biological Consequences of Ecosystem Fragmentation: A Review*, 4(1), 18-28.

Simis, M.J. (2011). *Biodiversity*. Frostburg State University. Frostburg, MD. Class Lecture.

Soulé, M. (1986). *Conservation Biology: The Science of Scarcity and Diversity*. Sunderland, MA: Sinauer Associates.

Wilson, E.O. (2007). *E.O. Wilson on saving life on Earth*. Retrieved from web address