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THE EFFECTS OF TRAFFIC DENSITY ON BIODIVERSITY IN BLACK ROCK FOREST

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TABLE OF CONTENTS

ABSTRACT

The purpose of this project is to test the influence of traffic density on biodiversity levels in the immediate roadside environments. Three different sites were used where one had heavy traffic, one had light traffic, and the last had almost no traffic. Using water traps, I caught invertebrates and counted the number of species and individuals at each condition. Surprisingly, the results showed a positive correlation between traffic density and number of species caught at each site. Amount of trash on the side of the road might explain this phenomenon. Possible solutions to negative effects of traffic density and biodiversity could be the use of culverts, or limiting heavy traffic flows to specific areas.

INTRODUCTION

With an increase in public awareness, there has arisen much concern over the extinction of many organisms from all different geographical niches around the world. For example, increases in deforestation of tropical regions have changed habitat loss for many organisms. These species suffer a loss of food, shelter, and protection from predatory species. Various groups of people have increased public awareness in order to apply pressure to slow and eventually stop the rate of environmental destruction and biodiversity loss.

A loss of even one species in an ecosystem has been seen to have a huge impact on the other organisms present. Some effects are so extreme that the entire ecosystem can collapse causing major biodiversity loss. Baskin (1997) reports on organisms that have been labeled keystone species. Like the keystone of an arch, these species hold entire ecosystems together; the disappearance of one of these species results in a complete collapse of a biological community. An example of a keystone species is a starfish. When they were removed from an area of shoreline, the mussels around began to multiply uncontrollably. Eventually, the mussels crowded out limpets, barnacles, and other marine organisms. By the end of the experiment, the number of species living on the rocks had dropped by half (Baskin, 1997).

Scientists around the world have stressed the importance of slowing habitat destruction so that previously unfound species can be discovered, classified, and understood by systematists. Many organisms have the potential to be beneficial to human society. Many plants burned in the path of tropical forest logging have potential medicinal uses that could help treat diseases such as cancer. Also, animals provide a large proportion of the food that indigenous people consume; with extinction comes an increase in hunger for these people.

The increase in public awareness has helped decrease the environmental damage occurring around the world due to logging, poaching, pollution, etc. But, by emphasizing popular large-scale dangers like tropical forest destruction, the public and the scientific community often ignore small threats that inflict large negative effects on biodiversity. For example, much of the public would not consider small roads as potential environmental destruction agents. Even small roads may contribute a large part of habitat demolition for many different types of organisms. There have been several studies done that show traffic on roads has major environmental influences. Fahrig et al. (1995) performed a study on the effects of roads on amphibian density in areas adjacent to the roads in question. 5,480,000 reptiles and frogs are killed annually by traffic in Australia, and the authors wanted to quantify the number and measure the relative densities of frogs and toads on roads ranging in traffic volume in Ottawa, Canada. They found that the effect of traffic was negative, i.e. the number of frogs and toads decreased with increasing traffic intensity. In addition, they found that the effect of traffic density on the proportion of dead frogs and toads was positively correlated. As the amount of traffic increased, so did the amount of dead frogs and toads on the roads.

In another study, Canaday (1997) found that insectivorous birds are greatly influenced by agriculture colonization, petroleum and mining operations, hunting and capture of wild animals, and timber extraction. All of these activities are concentrated along roads. Moving closer to the interior forest and away from the habitat edges created by roads, a large increase was seen in total species and number of individuals for each species captured. This demonstrates that roads have a direct effect on the level of biodiversity in their immediate surroundings.

Reijnen et al. (1996) looked at different levels of traffic density and their effects on breeding birds in Dutch agricultural grasslands. They used noise as their independent variable because noise is positively correlated with number, size, and speed of vehicles. Seven of the twelve species studied showed significant negative relationships between noise level and density. They found that noise had the largest influence on decreasing density, but that visual stimuli also had immediate effects on species living within seeing distance of the roads.

The effects roads have on biodiversity do not necessarily have to be directly related to road traffic. In Cameroon, logging roads have opened up previously pristine forests to hunters and trappers from nearby villages. In remote forest where indigenous people used to hunt and trap sustainably, market hunters are now snaring and shooting every creature that walks, crawls, or flies. The expanding network of logging roads also allows easy access to virgin hunting grounds and a convenient way to get meat to a market (McRae, 1997). This is one example of the indirect effects roads can have on biodiversity levels in areas previously rich in species. Other factors, such as lead runoff into the soil and air pollution from the exhaust of cars, can also have negative indirect effects on the level of species biodiversity.

In order to continue investigating the effects roads have on biodiversity, I investigated the subject around a small forest in southern New York. Black Rock Forest is a reserve that has very little traffic traveling on its roads. The forest is not open to public transportation, and therefore can be used to show how traffic intensity on roads effects biodiversity in the area. Because of time limitations and resources, I had to use species diversity as my dependent variable. Traffic intensity was my independent variable. I hypothesize after reading previous studies that as traffic intensity increases biodiversity will decrease.

METHODS

. I used three different sites in the forest and the surrounding area to investigate the effects of traffic on biodiversity. All of the roads were relatively the same width, and were surrounded by pristine forest. The first site was chosen outside of the forest boundaries because it had a high traffic flow. The second site was a well traveled road in the forest without the heavy traffic flow of the first site, and the third site was a road in the forest that had almost no traffic on it. To measure biodiversity, I used water traps set up around different areas to collect invertebrates. To perform this experiment, I had to acquire some supplies. To set up the water traps, I needed trays to fill with water, laundry detergent, and salt. I first filled the trays with a water depth of approximately one-inch. Next, I placed a tablespoon of salt into each trap. The salt acts as a preserving agent for the organisms caught in the traps. After adding the salt, I coated the traps with a very thin layer of laundry detergent. I used the laundry detergent to reduce the surface tension of the water. With a reduced surface tension, the animals that land on the water are unable to support themselves like they would with a normal surface tension.

I found it easiest to set up the traps on the site rather than setting up the traps in the lab and transporting them to the site. To do this I used two five-gallon containers to carry the water to the experiment locations. Next, I had to choose the locations to perform my experiment. Using a map of the forest and surrounding area, I chose three locations where I knew the traffic intensity ranged from high to low. Site 1 had a high traffic intensity. Site 2 had a medium traffic intensity, and site 3 had no traffic (see map 1).

After I had chosen my three sites, I went to each one and set up six water traps, three on each side to the road, at each location. I marked the areas where I performed my experiment with marking ribbon and let the traps sit for twenty-four hours before I extracted the animals caught in them. To collect the animals, I poured each trap through a fishnet to allow the water to pass through but not the dead animals. I then placed the animals on a paper towel in each empty tray from which they were caught, and took the trays back to the lab. Here, I picked each animal from the paper towel with forceps and placed them in film containers filled with 95% ethyl alcohol to preserve them. I then identified each organism to species type and recorded the total number of species caught at each site. I also recorded the number of individuals caught for each species. I compiled a list of numbers 1-52 and assigned a species to each number. With this list, I used the numbers to refer to the species instead of the names. Also, I took photographs of each species found in each tray. In the photographs, the number on the left of each animal is the species number from the list, and the number to the right is the number of individuals of the species caught in each tray (see pictures 1-3).

I used diversity indices to analyze data and to determine if traffic had an effect on biodiversity. The first analysis I performed was a measure of the Shannon index. This index gives an average degree of uncertainty of predicting the species of an individual picked at random from the community. The next analysis was the Simpson index. This index is of the chance of selecting the same species from two different communities in a randomly sampled pair. I also calculated the Hill's diversity estimate. This gives an estimate of the number of species in the community. I also found the variance of the Shannon index, which shows the variation with in each sample taken. I counted and compared the number of species present at each site, and the total number of organisms caught in each sample. I then found the average Shannon index, the average Simpson index, the average Hill's measure of diversity, the average number of individuals caught, and the average number of species caught for each of the sites and graphed these values for each of the three conditions. To further my analysis, I performed a t-test between the first and second site, the first and third site, and the second and third site. My final analysis was the Jaccard and Sorenson measure of community similarity.

RESULTS

To analyze my results, I decided on two types of comparisons: an intrasample and interconditional comparison. I first wanted to compare the data I got between the different samples within each of the three sites where I performed my experiment. For this comparison, I used the Shannon index, Simpson index, Hill's measure of diversity, Shannon index variance, and the number of individuals caught per sample. The second comparison I performed was between the different sites. For this comparison, I treated the six samples from each site as one grouped sample; so, I examined my data as if I had taken one sample from each of the three sites. For this analysis, I used the t-test between the different condition, the Jaccard and Sorenson measure of community similarity and the graphed averages of the Shannon index, Simpson index, Hill's measure of diversity, number of species present, and number of individuals caught.

The following are values that I obtained for my different measuring indexes between the samples in each site. From my data I see that some samples in the first site had a large number of species but others had a low number. My calculated Shannon index values for the six samples from the first site ranged from .5623 to 2.5483. This is a very large range for the Shannon index. For the Shannon index, a community with only 1 species would have a value of 0 and a community with a large number of species would have a much higher value. Over all, the Shannon index for the first site is higher than the Shannon index for the second, whose values range from 0 to 1.3863. The values for the third site show that a small number of species are present. These values ranged form 0-1.6094, with four out of the six samples having a value of 0. This analysis shows that variation within the sites decreased as traffic flow decreased

The Simpson index shows the opposite trend as the Shannon index. The values are smaller with a higher traffic flow. The first site has a range of .1-.625, the second site has a range of .25-1, and the third site has a range of 0-1. Hill's diversity measure also shows that the different sites have different levels of biodiversity and that the different samples within each site have a large variation. The first site ranges in values from 1.7548-12.7858, the second site has a range from 1-3.7798, and the third site has a range from 0-5.

The variance of the Shannon index also shows differences between the conditions. The first site ranges from .0350-.0878, the second site ranges from 0-.1111, and the third site ranges form 0-.125. But, the most obvious result that shows that the different sites have different levels of biodiversity are the species count and individual counts in each sample. In the first condition there was a sample that caught 18 species and a sample that only caught 2. The second and third sites had a smaller variation between samples than the first site. The second site only ranged from 1-4 species per sample, and the third site ranged from 0-5 species caught per sample. From these results, I found that there was a lot of variation in the samples taken from the same condition, but there also was a lot of variation between the three conditions.

For my next comparison, I used a t-test of the Shannon index, the Jaccard and Sorenson community similarity test, and the graphs of the average values for the different indexes for each condition. All of analyses allowed me to perform a conditional comparison rather than a sample comparison. In order to use the t-test, I had to perform three different tests. The t-test measures the probability that two conditions have equal values for whatever index I used. The t-test would not allow me to perform a test of all three conditions at once, so I had to perform three distinct tests between two conditions. Thus, I had a test run for the first and second site, the first and third site, and the second and third site. For the first test, the probability was 3.19E-06, for the second test the probability was 3.57E-04, and for the third test the probability was .393. If the probability is lower than .05, a significant difference exists between the two conditions. From my results I see that there is a significant difference in biodiversity between the first and second and the first and third sites, but there is not a significant difference between the second and third sites. Possibly because the second and third site were both located in the interior of the forest while the first site was located in a residential area.

I next used the Jaccard index to test for community similarity. This test also was limited to a two-condition comparison. So, I had to perform three tests in the same manner as the t-test. The comparison between the first and second site had a value of

.148, the first and the third sites had a value of .089, and the second and third sites had a value of .200. This index varies from 0 with no species in common to 2 for a community with all species in common. From my results, I see that my values for all three tests are very low. This implies that my different conditions have very few species in common.

This conclusion is further supported by the values obtained for the Sorenson index. The Sorenson index varies from 0 for communities with no species in common to 1 for communities with all species in common. My values for the three different tests were .138, .085, and .182 respectively. These values are very low and show, like the Jaccard index, that the different conditions have few species in common.

I modified the Jaccard and Sorenson equations to compare all three conditions. These values, although not very reliable, show that there are few species in common between the different conditions. The Jaccard index values for sites one, two, and three is .034, and for the Sorenson index it is .033.

All of the values for the calculations performed thus far are summarized in table 1. The table lists the site and sample number and the subsequent Shannon index value (H'), the Simpson index value (D), the Hill's diversity value (N1), the variance for the Shannon index (Var H'), and the number of species (N) for each sample. The table also shows the degrees of freedom (DOF), the t-value (t), and the probability (p) for the three different t-tests performed (1 vs. 2, 1 vs. 3, and 2 vs. 3). The values of the Jaccard index and the Sorenson index are in the table for the three different conditional tests below the probability of the t-test. The final calculation shown in the table is the Jaccard and Sorenson index values for the comparison of all three conditions at once.

To continue my analysis of my data, I graphed the average value for the Shannon index, the Simpson index, Hill's diversity, the number of species, and the number of individuals caught for each condition. These are shown in graphs 1-5 respectively. Graph 1, graph 3, graph 4, and graph 5 all show the greatest values for each index occurring for the first site, the next greatest for the second site, and the least for the third site. Graph 2, the Simpson index, shows that the greatest value is for condition three, the next largest is at the second site, and the smallest is at the first site.

From both of my comparisons, between samples within a site and between sites, the idices used to measure the diversity level for each site show a significant difference between the sites. From the first analysis, I found that much variation occurred between the samples within a site. And, for my second analysis, I found that significant differences existed between the different conditions in which the site with a high traffic flow (site 1) had the most diversity, the site with a medium traffic flow (site 2) had a lower diversity level, and the site with almost no traffic flow (site 3) had the lowest diversity level.

CONCLUSIONS

After performing all of my analyses, I found that the road traffic and biodiversity level was positively correlated. With this conclusion, I reject my original hypothesis that the road with the most traffic would have the smallest biodiversity level and the road that had very little traffic would have the greatest amount of biodiversity. Although my research of other case studies suggested opposite results from mine, some case studies I found suggested that specific animals thrived in areas with a large human disturbance.

Martinez (1994) found that the little bustard, *Tetrax tetrax*, was not influenced by proximity to buildings, villages, or roads. This species seems to have developed a high tolerance to human impacts in its environment. The abundance and the spatial distribution of the species was unaffected by the human factors listed above. This shows not all species that live in environments with high human interaction are affected in a negative way. The little bustard actually thrived more in this environment because some of its competitors and predators were not able to adapt to the changes and were driven out of the area.

Although, I don't believe the above situation is responsible for the results that I obtained, I do believe that the species that I caught in my traps were highly resistant to human influence and even survive more with human influence than in their natural environment. I based this conclusion on the amount of trash present on the roads. The majority of species that I caught were flies, wasps, and bees. The increase in trash on the side of the road gives these insects medium to feed on and to have a greater reproductive success than in an area that does not have trash. My first site was located out of the forest and had a substantial amount of trash on the side of the road. Very little trash was in the second site and no observable trash was in the third site. These two sites did not have any dead animals in the area, which might have resulted in a greater abundance of different species. The majority of the insects caught were parasitic and need either a high level of trash or dead animals to thrive. With the absence of both of these in the two sites, it is not surprising that the species diversity was not high in either the second or the third site.

If I had taken more samples and performed this experiment over a period of many weeks, I would expect to have obtained different results. Between my samples within each site a large variation occurred. This does not surprise me given that I only sampled the three different populations once. With multiple samples, I might have had a more even distribution throughout the different trays at each site. By only sampling once, I have greatly reduced the reliability of my results. An increase in sample number would have given me more accurate results.

Although I did not get the results I had expected to see, I still feel that human influences like roads have a large impact on biodiversity around these disturbed areas. This has been presented in other case studies, which I mentioned in this report. With these case studies, some researchers proposed possible solutions to the effect humans have on biodiversity level. Yanes et al. (1995) performed a study on the effectiveness of culverts in facilitating animal movement across roads. They found that culverts did help in facilitating animal movement across roads that usually acted as barriers for animal. But, some characteristics of the different culverts caused more animals to use them. For example, the width and height of the culvert had to be large enough for large mammals to pass through. At the same time, small mammals did not use culverts that were too large because they would be easy targets in the culverts for larger mammals.

In their study on amphibian density around roads, Fahrig et al. (1995) list possible solutions to decrease the effect roads have on animal diversity. They also list culverts with specific characteristics as possible pathways for the animals to use to get around the man made obstacles. They also propose to increase traffic volume on a few already existing roads rather than building new ones. This solution would have to be carefully studied in order to make sure the increase in traffic volume did not have more serious effects on the environment surrounding the roads than with less traffic.

I believe that the culvert solution has definite possibilities if special considerations can be made. For example, make multiple size culverts in the same area to allow smaller animals to move under the road without the fear of predation. As I mentioned before, public awareness exists about large-scale environmental destruction, but the information given to the public is limited. Few people around the world can change their daily routine to save the rain forest in South America, but everyone can do something to help eliminate some human impacts on the environment where they live. For example, if more people car-pooled together, then traffic on the roads would drastically decrease, and hopefully the impact on the biodiversity around the roads would decrease also. Human influence is prevalent all over the world, and it is up to us to make sure that our actions reduce the negative influence we can cause on biodiversity.

ACKNOWLEDGMENTS

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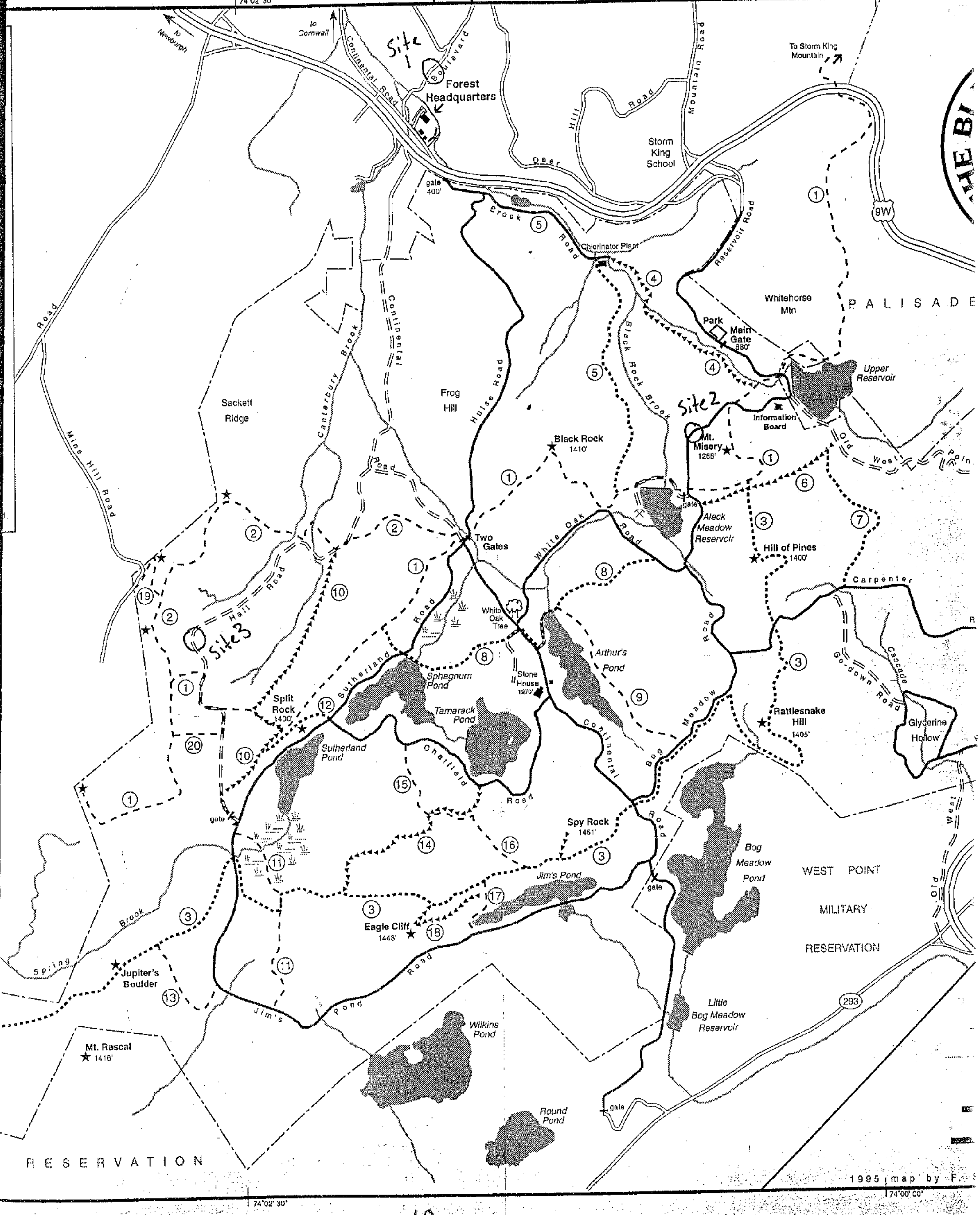
Map 1



74°02' 30"
74°00'00"
to Newburgh
to Cornwall
Continental Road
Boulevard
Site 1
Forest Headquarters
Hill Road
Mountain Road
To Storm King Mountain
Storm King School
Deer
gate 400'
Brook Road
Chlorinator Plant
Reservoir Road
9W
Whitehorse Mtn
P A L I S A D E
Park
Main Gate 880'
Upper Reservoir
Information Board
Site 2
Mt. Misery 1268'
Old West Point
Black Rock Brook
Black Rock 1410'
Frog Hill
Hulse Road
Continental Road
Canterbury Brook
Sackett Ridge
Mine Hill Road
Road
Two Gates
White Oak Road
Aleck Meadow Reservoir
gate
Hill of Pines 1400'
Carpenter
Hall Road
Site 3
White Oak Tree
Stone House 1270'
Arthur's Pond
Go-down Road
Cascade
Glycerine Hollow
Sutherland Road
Sphagnum Pond
Tamarack Pond
Split Rock 1400'
Rattlesnake Hill 1405'
Bog Meadow Road
Sutherland Pond
Chatfield Road
Continental Road
gate
Spy Rock 1461'
Bog Meadow Pond
WEST POINT MILITARY RESERVATION
Jim's Pond
gate
Eagle Cliff 1443'
Spring Brook
Jupiter's Boulder
Jim's Pond Road
Little Bog Meadow Reservoir
293
Mt. Rascal 1416'
Wilkins Pond
Round Pond
gate
R E S E R V A T I O N
1995 map by F.
74°02' 30"
74°00' 00"

SPECIES LIST

01. Muscomorpha 1
02. Cecidomyidae
03. Pentatomidae
04. Troginae 1
05. Syrphidae 1
06. Nabidae
07. Muscomorpha 2
08. Halictidae 1
09. Halictidae 2
10. Halictidae 3
11. Halictidae 4
12. Andrenidae 1
13. Colletidae 1
14. Andrenidae 2
15. Colletidae 2
16. Ichneumonidae
17. Sphecidae
18. Phormicinae
19. Tipulidae 1
20. Halictidae 5
21. Apiphorm
22. Muscomorpha 3
23. Anthiomyiidae 1
24. Anthiomyiidae 2
25. Nematocera 1
26. Noctuidae
27. Nematocera 2
28. Andrenidae 3
29. Anthiomyiidae 3
30. Anthoimyiidae 4
31. Muscomorpha 4
32. Muscomorpha 5
33. Andrenidae 4
34. Muscomorpha 6
35. Nematocera 3
36. Halictidae 6
37. Halictidae 7
38. Sphecidae 2
39. Anthiomyiidae 5
40. Tipulidae 2
41. Spider
42. Black Fly
43. Syrphidae 2
44. Colletidae 3
45. Nematocera 4
46. Nematocera 5
47. Andrenidae 5
48. Troginae 2
49. Bombidae
50. Halictidae 8
51. Anthiomyiidae 6
52. Tipulidae 3

SPECIES CAPTURED PER SITE (# of individuals captured)

SITE 1

Tray A
Muscomorpha 1 (1)
Cecidomyidae (3)

Tray B
Pentatomidae (1)
Troginae 1 (1)
Syrphidae 2 (1)
Nabidae (1)
Muscomorpha 2 (1)
Halictidae 1 (1)
Halictidae 2 (1)
Halictidae 3 (1)
Halictidae 4 (1)
Andrenidae 1 (8)
Colletidae 1 (1)
Andrenidae 2 (5)
Colletidae 2 (2)
Ichneumonidae (1)
Sphecidae 1 (1)
Phormicinae (1)
Tipulidae 1 (1)
Muscomorpha 1 (2)

Tray C
Andrenidae 1 (1)
Halictidae 5 (1)
Colletidae1 (1)
Apiphorm (1)
Andrenidae 1 (1)
Muscomorpha 1 (1)
Muscomorpha 3 (1)
Anthiomyiidae 1 (1)
Anthiomyiidae 2 (1)
Nematocera 1 (1)

Tray D
Noctuidae (1)
Nematocera 2 (1)
Anthiomyiidae 1 (1)
Andrenidae 3 (1)
Anthiomyiidae 3 (2)
Anthiomyiidae 4 (1)

Tray E
Muscomorpha 4 (1)
Muscomorpha 5 (1)
Andrenidae 4 (1)
Muscomorpha 6 (2)

Tray F
Muscomorpha 5 (1)
Nematocera 3 (1)
Halictidae 6 (1)
Halictidae 7 (2)
Sphecisae 2 (1)

SITE 2

Tray A
Anthiomyiidae 5 (3)

Tray B
Anthiomyiidae 5 (1)
Tipulidae 2 (1)
Muscomorpha 5 (1)

Tray C
Muscomorpha 5 (1)
Anthiomyiidae 1 (1)
Spider (1)
Black Fly (1)

Tray D
Syrphidae 2 (1)
Anthiomyiidae 4 (2)

Tray E
Colletidae 3 (1)
Nematocera 4 (1)
Nematocera 5 (2)
Andrenidae 5 (2)

Tray F
Nematocera 1 (1)

SITE 3

Tray A
Colletidae 1 (1)
Troginae 2 (1)
Nematocera 5 (1)
Nematocera 4 (1)
Anthiomyiidae 4 (1)

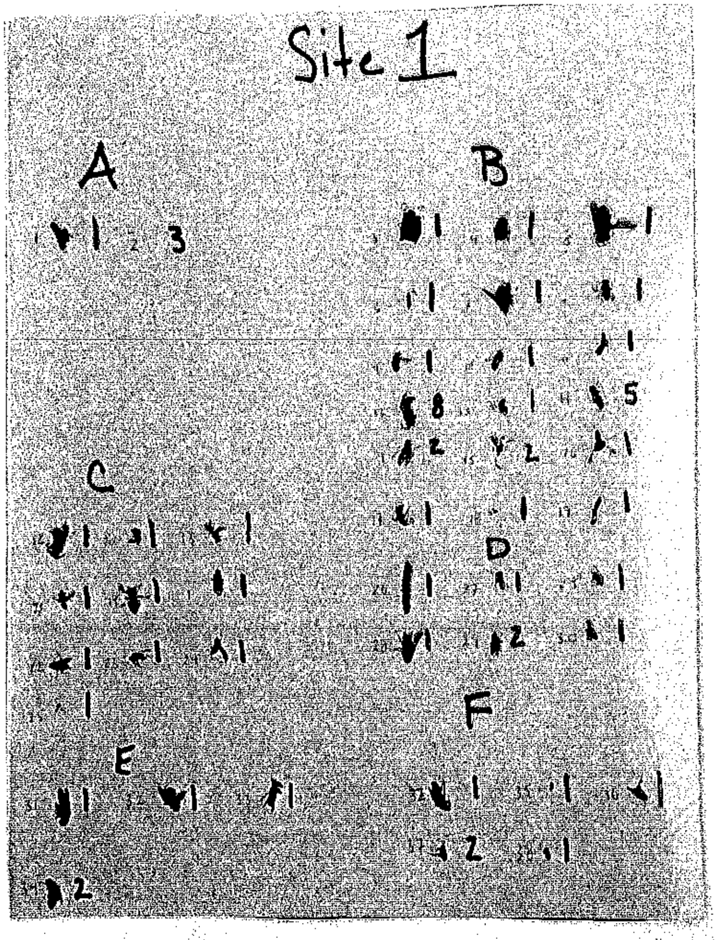
Tray B
Bombidae (1)

Tray C

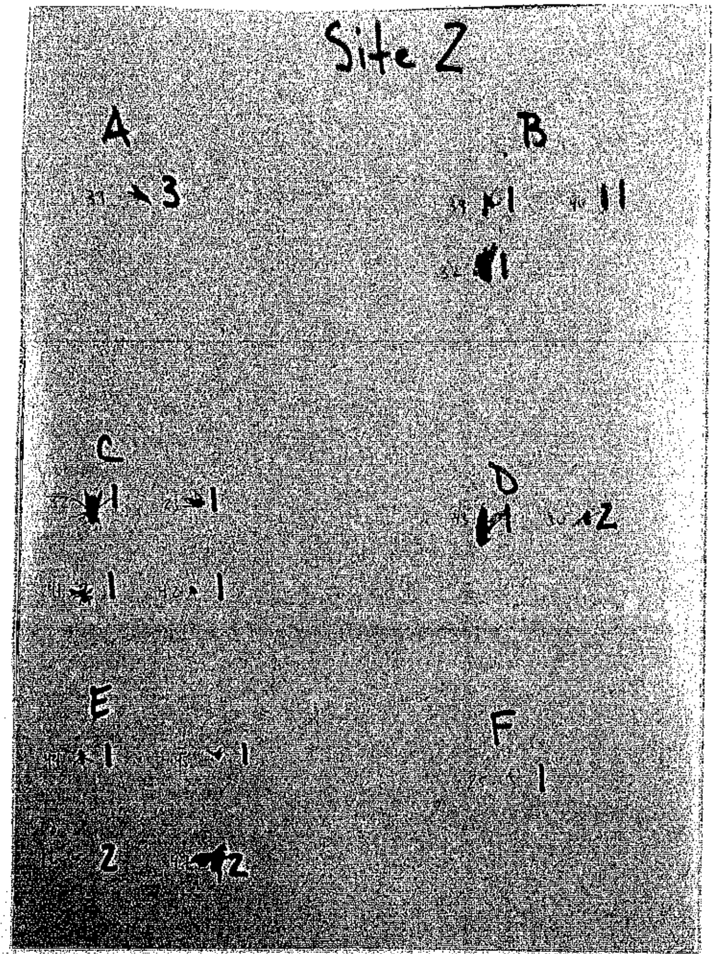
Tray D
Halictidae 8 (1)

Tray E
Anthiomyiidae 6 (1)
Tipulidae 3 (1)

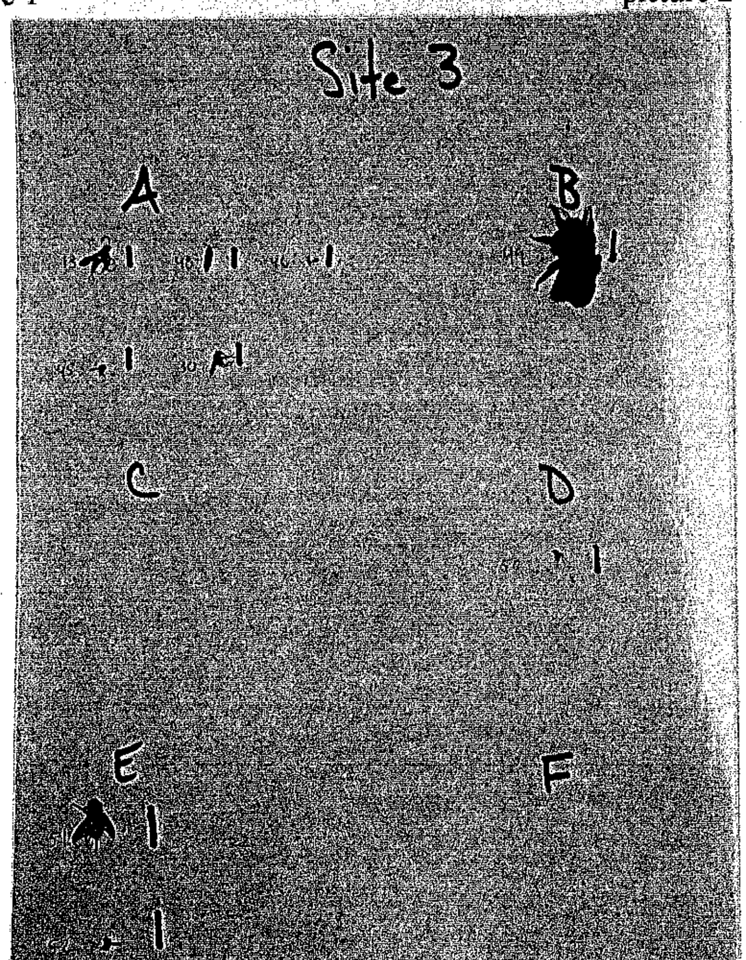
Tray F



picture 1



picture 2

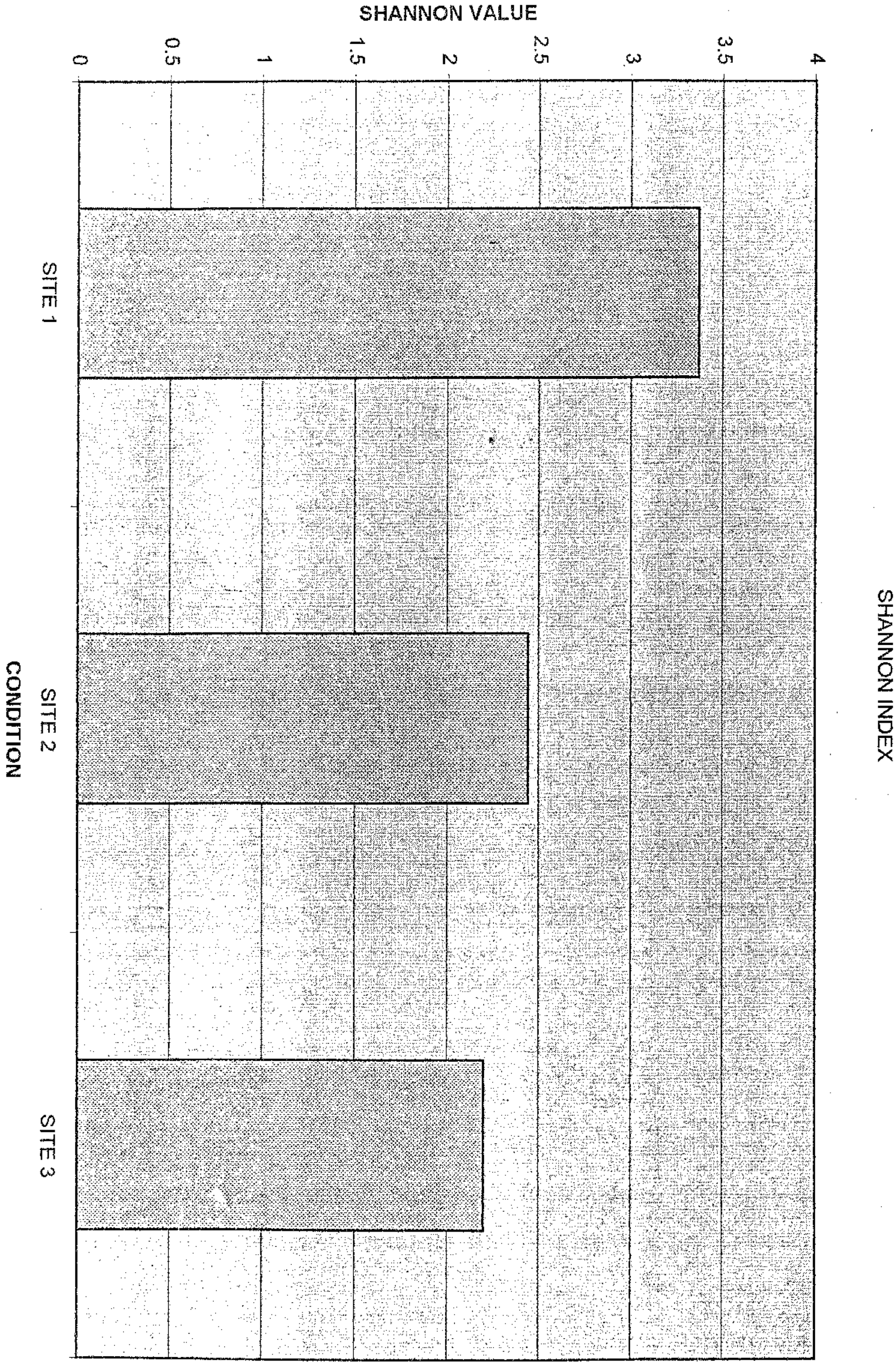


picture 3

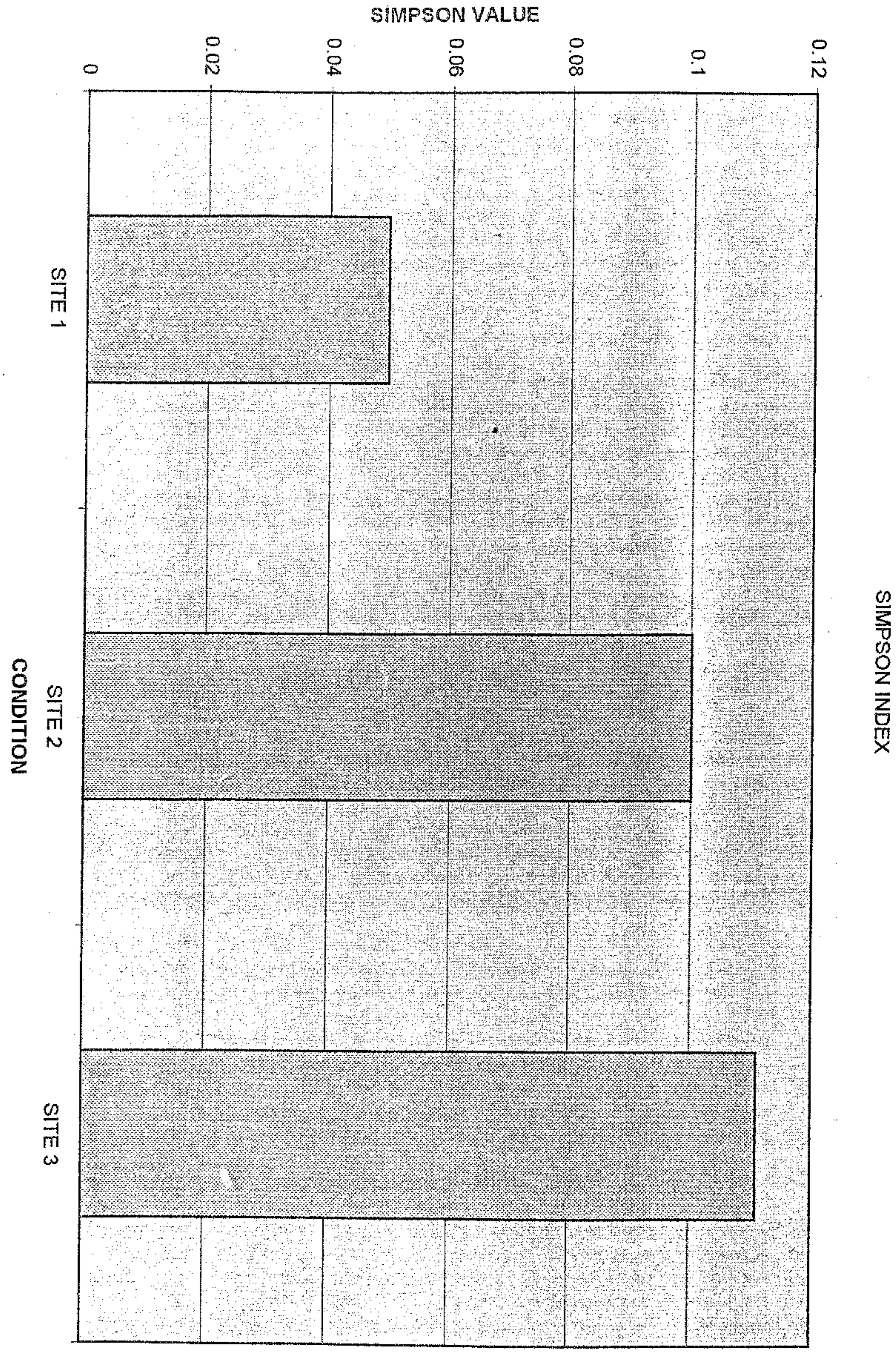
table 1

Site	H'	D	N1	Var H'	N	
1a	0.5623	0.625	1.754765	0.08782573	2	
1b	2.548332	0.115505	12.78576	0.03501555	18	
1c	2.302585	0.1	10	0.045	10	
1d	1.747868	0.183673	5.742347	0.06502779	6	
1e	1.332179	0.28	3.789291	0.08306175	4	
1f	1.56071	0.222222	4.762203	0.07335011	5	
2a	0	1	1	0	1	
2b	1.098612	0.333333	3	0.11111111	3	
2c	1.386294	0.25	4	0.09375	4	
2d	0.636514	0.555556	1.889882	0.09114467	2	
2e	1.329661	0.277778	3.779763	0.05946122	4	
2f	0	1	1	0	1	
3a	1.609438	0.2	5	0.08	5	
3b	0	1	1	0	1	
3c	0	0	0	0	0	
3d	0	1	1	0	1	
3e	0.693147	0.5	2	0.125	2	
3f	0	0	0	0	0	
t-test	1 vs. 2	1 vs. 3	2 vs. 3		jaccard 1,2,3	0.033898
DOF	43.42992	15.26548	19.45276		sorenson 1,2,3	0.033333
t	5.350384	4.586024	0.874635			
p	3.19E-06	0.000357	0.392694			
jaccard ind (j)	0.148148	0.088889	0.2			
sorenson ind (s)	0.137931	0.085106	0.181818			

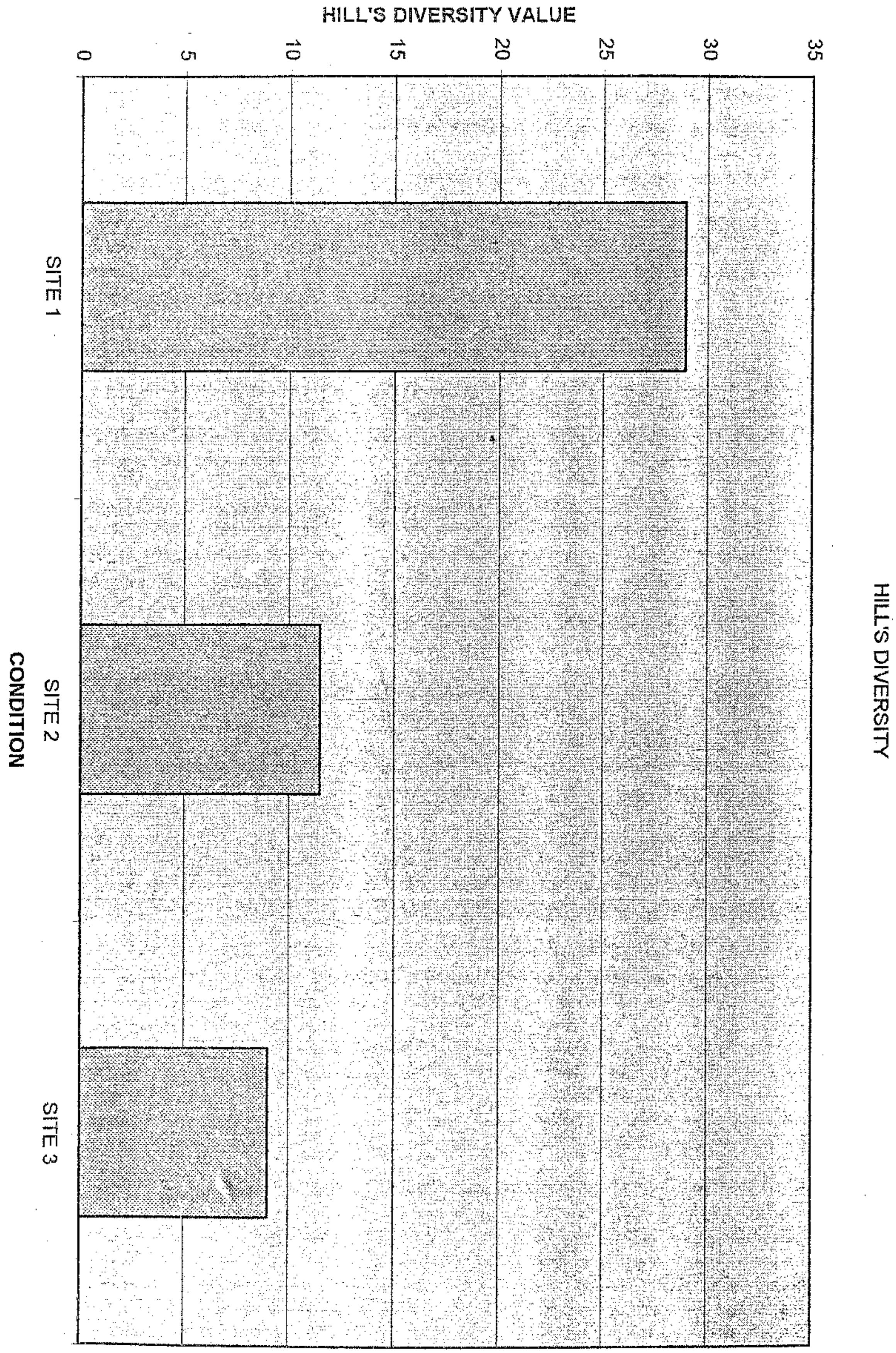
graph 1


SHANNON INDEX
SHANNON VALUE
0
0.5
1
1.5
2
2.5
3
3.5
4
SITE 1
SITE 2
SITE 3
CONDITION

graph 2

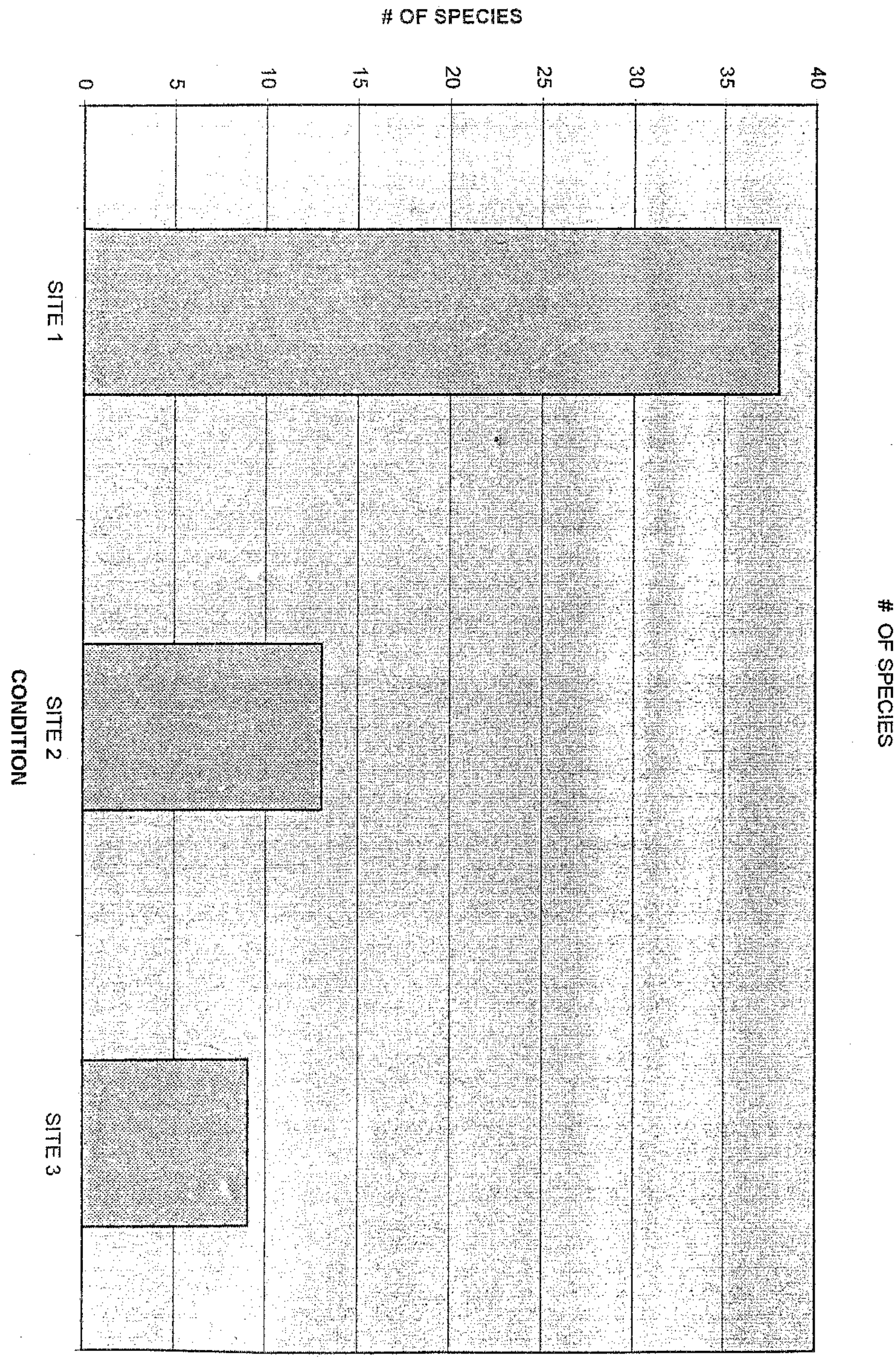

SIMPSON INDEX
SIMPSON VALUE
0
0.02
0.04
0.06
0.08
0.1
0.12
SITE 1
SITE 2
SITE 3
CONDITION

graph 3

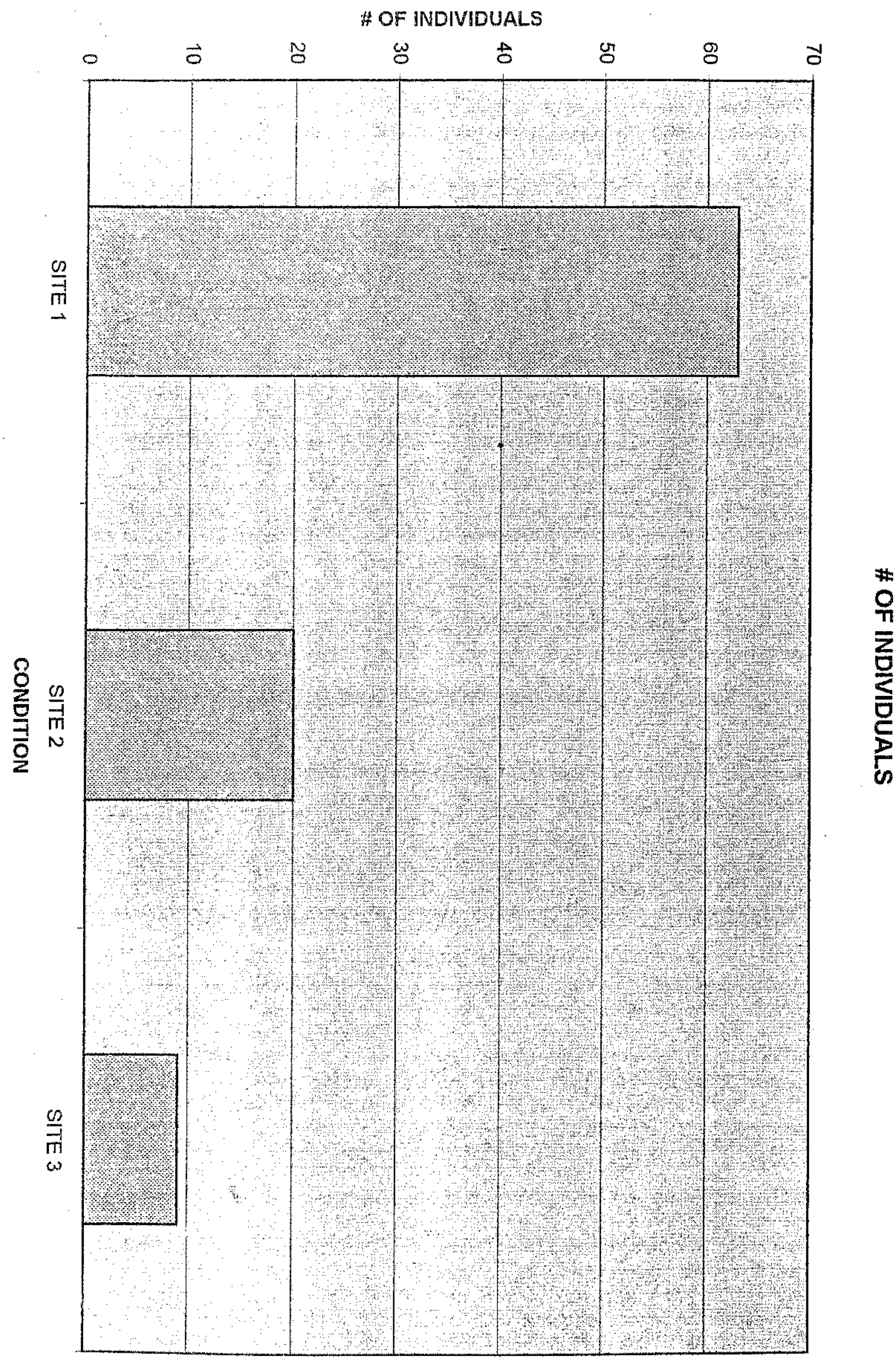


HILL'S DIVERSITY
HILL'S DIVERSITY VALUE
0
5
10
15
20
25
30
35
SITE 1
SITE 2
SITE 3
CONDITION

graph 4


OF SPECIES
0
5
10
15
20
25
30
35
40
SITE 1
SITE 2
SITE 3
CONDITION
OF SPECIES

graph 5



OF INDIVIDUALS
0
10
20
30
40
50
60
70
SITE 1
SITE 2
SITE 3
CONDITION
OF INDIVIDUALS