The Effects of Human Activity on Pine Cobble Trail

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ES102 Independent Project
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Introduction

Many forms of human activity alter the natural environment. However, one form of activity that we would probably not think of as having an impact upon the environment is hiking. While we consider hiking an opportunity to enjoy nature in a somewhat undisturbed form, this form of recreation does have its consequences. Anna Groskin and I decided to investigate the environmental effects of hiking by looking at Pine Cobble Trail. We wondered how much the trail might cause erosion or fragmentation of ecosystems. Pine Cobble is the site of a rather recent housing development that includes access roads and a proposed 72 building lots, and as a result, the lower portion of the trail has been relocated so that it will avoid the new roads and development sites. This new section of the trail has been in use for approximately five years. We chose to examine the area where the new trail meets the abandoned trail so that we could compare trail segments impacted by differing degrees of human activity. By examining vegetation and properties of soil including texture, density, moisture, and organic matter at locations on and off each trail, we found that the amount of trail use definitely does alter the composition and properties of soil and vegetation.

Materials and Methods

Our project involved several trips up to Pine Cobble for data collection. The map in Figure 1 shows the area we studied in relation to the Pine Cobble Development site and to Williamstown. We began by determining a location for observations and sampling. We wanted an area that would minimize variables that would alter soil and vegetation such as elevation and slope aspect. In this way we could say more legitimately that variations in results might be caused more by levels of human activity than by natural factors. Thus, we chose an area that was almost all quite flat, having a constant elevation of approximately 385m, and which included the new, relocated trail, the abandoned trail, and the old trail which continues North from the junction of the new and abandoned trails. The rough map in Figure 2 shows the location of our site in relation to the water tank. We chose spots on each trail, marked them with flagging, and created transects roughly perpendicular to the trails. We then flagged locations approximately 15-20m to either side of each trail segment, measuring the distances with a tape measure. With this length of transect, we had a large enough distance from which to choose sampling locations for vegetation and soil. The map in Figure 3 shows the sampling locations as well as the notation we used to label each site. We dug a variety of soil pits, usually about 40 cm deep, observed and measured depths of the soil horizons, and took samples from two to three layers including always the OA and B layers. We dug soil pits at the middle and fringe of each trail and at several locations off of the trails. We tried to choose locations for the off-trail pits which seemed fairly representative of the forest as a whole based on vegetation, slope, and light. At the pit locations, we also took smaller samples of the OA layers for density measurements by cutting out squares from the ground surface approximately 7x7x2 cm. We then measured the exact size (volume) and mass of the wet soil blocks. We took all of the density samples on the same day in order to minimize differences that might be caused by moisture. In order to analyze vegetation, we marked off 1/2 m^2 plots at locations at the middle, fringe, and off of the trails. As with the soil pits, we chose off-trail locations along our transects that seemed to give the best representation of the herbaceous vegetation in the area. We did not want sites with abnormally high or low amounts of plant growth. In each plot, we tried to determine species composition, quantity, and percent of the plot covered with each type of vegetation.

We continued our project by performing several tests on our dried soil samples. First we sieved each sample in a plastic sieve with -1Ø scale in order to take out larger rocks and organic matter and leave only sand, silt, and clay. We then sieved samples from the B layers and some of the OA layers in the ROTAP, using sieve sizes of -1, 0, 1, 2, 3, and 3.5 Ø. We could not find a 4Ø sieve, so we had to use the closest size, 3.5. (Michele Kloppes has soil & Rota through it!) We then calculated the percent by weight of each particle size division from the sieves. Since the sieve sizes we used only measured divisions among different sizes of sand particles, we also tried to determine the amounts of silt and clay by measuring the texture of B layer samples hydrogravimetrically in settling columns or Bouyoucos hydrometers. We also determined the amount of moisture and organic matter in the OA layers by using measurements of Loss-On-Ignition.

Data and Discussion

Use subheadings in this long section

-trail morphology: Our results include a combination of quantitative aspects gained from the tests we performed along with many features which we discovered merely through observation. In fact, our direct observations probably told us nearly as much as our quantitative data. Since we were able to directly compare trails of three differing degrees of use, we could easily notice the variations. The new trail created only a small depression in the land while the old trail and abandoned trail left large depressions in the topography. On the abandoned trail, this sunken area was filling up with vegetation and organic matter. That, in fact, created another of the striking differences among the trails. The abandoned trail had a thick grass and leaf cover while there

Good to point this out

were few leaves on the new and old trails. This may be the result of either foot traffic or erosion factors. While the grass cover prevented us from seeing much of the ground surface on the abandoned trail, the new and old trails were free of vegetation, so we could see a striking difference between their colors. The new trail was significantly darker than the old, possibly because more of the dark OA soil layer still remains than on the old trail where more extensive use has worn away much of this dark layer.

Soils:

Our soil pits told us even more about the locational variations in the soil. The soil in all areas was rather strongly colored with black OA layers and yellow-orange to greenish B layers. Most had a transitional greyish layer in-between the OA and B horizons, but this was not usually a well enough defined layer for us to take samples from it. We found that the new trail lacked a well defined OA horizon, probably because the creation of the trail greatly disturbed the soil which has not yet had time to become compacted. Instead, it was very loose and crumbly, making the new trail the most difficult location for taking density samples. The old trail also had a very small OA layer, but in contrast to the new trail, this layer was much more well defined and compacted due to a greater degree of use. In fact, we found a series of very small layers of brown, black and gray soils near the surface of the old trail center. These layers had been greatly compressed, and they broke apart into solid almost rock-like pieces. They could have been the result of organic matter and fine particles washing onto the trail periodically since the land slopes upward slightly to the South of the trail. We checked in several areas on the old trail to see if these laminated layers were unique to the site of our soil pit, but everywhere we checked, we found the same type of layering. The OA layer on the abandoned trail did not have this compact layering, but it did show evidence that at one time it experienced extensive traffic. For example, I found several small pieces of broken glass buried several centimeters down into the OA layer which itself was definitely larger and more well defined than in the new trail, probably because it had had more time to develop without disturbance. The many tangled grass roots in the OA horizon also held the soil together, so it did not crumble much.

We can see a more quantitative comparison of the OA horizons in Figure 4 which shows the thicknesses of the layers at each location. The values shown may deviate +/- 1cm, since the layers tended to have slight variations in thickness, and the transition to the B horizon was not always sharply defined. The ~~depth~~ thickness of the OA layers is largest in areas off the trail where the soil has not been greatly disturbed, eroded, or compacted. It is also greater on the abandoned trail than on the new and old trails because of the smaller amount of disturbance. The thickness is smallest on the old trail, showing that a greater amount of trampling erodes away some of the soil while also compressing it. We can see evidence of this compaction in Figure 5 which shows the densities of soil in the OA horizons at each location. The possibility for error in the density measurements was quite high, and we estimated that it might be as much as 50% of the total value. We did take all samples on the same day to account for variations in moisture, but it was not always easy to take a solid block of soil without large rocks inside and with an easily measurable size. Especially on the trails, where there was little organic matter to hold the soil together, the blocks tended to crumble, making measurements difficult. Nonetheless, the values we obtained display some notable results. The density is greatest in the middle of the trails, and the largest value is for the most highly used and compacted old trail. Figure 6 shows a moderate negative correlation between density and depth of the OA layers, indicating that since smaller layers tend to be more dense, they are probably also more compressed.

Good

Great discussion and your figures are clear. Glad you report degree of correlation, too

We can see in Figure 7 that organic matter also greatly varies between locations on and off the trails. I estimated that the possible error in measuring loss-on-ignition could be +/-25% of the total value. I obtained this value based on my estimations of error in a previous soil chemistry lab in which we used the same test for organic matter. Even if the error is that high, however, we would still have some dramatic results. The soil from on the trails definitely contains much less organic matter than that from off the trails, while the new and old trails contain less than the abandoned trail. Samples from trail fringes tended to be more variable in amounts of organic matter. While on the old and abandoned trail, values for the fringe were slightly higher than for the middle, they still had close to the same percentage of organic material. On the other hand, the new trail fringe contained a significantly larger amount of organic matter than the trail center. This may be because only the center of the new trail has yet been highly disturbed and trampled while on the other trails which have at least at one time experienced more traffic, the effects of hiking reach further beyond the trail center. In addition, the amount of organic matter seems to negatively correlate with density as Figure 8 illustrates. Organic matter must be much lighter and less dense than soil, leaving more open space within the horizon since those samples with the greatest amount of organic matter were the least dense.

Another variable in the OA layers is the moisture content. Figure 9 shows that the amount of moisture at each location has a similar distribution to organic matter. In fact, Figure 10 shows that the two values have a very strong positive correlation, so organic matter must hold moisture well. As with organic matter, I estimated the possible error for moisture by using estimations from the soil chemistry lab, and found that numbers might deviate +/- 20% of the total value. Since organic matter and moisture correlate so well, logically moisture and density similarly correlate as in Figure 11 although it seems questionable that a sample with 70% moisture might have a density only slightly greater than 0.2 g/cm^3 since the density of water is 1 g/cm^3. Some of the density measurements might be exceptionally low, or some of the samples with many roots might contain a great deal of empty space. Moisture also has a moderate positive correlation with the thickness of the OA layer as shown in Figure 12. While I would expect that this would be because a larger amount of organic matter is in the thicker, more developed OA horizons, ~~depth~~ thickness and organic matter do not correlate nearly as well.

Hmmm!

The B soil layers had fewer noticeable differences by location and were less directly affected by human activity on the trail. We tried to determine if the effects of trampling extended as far down as the B soil horizon by examining the texture of these layers. We used both sieves and hydrometers in order to test the textural composition. The results we obtained with the hydrometer method were quite imprecise since they gave us only very arbitrary estimations of particle size distributions, and, not having a scale, we did not know what the particle sizes were that corresponded with the values we obtained. In addition, we did not have a precise value for the specific gravity, so our percentage results cannot be entirely accurate. Because of all of these uncertainties, we could not compare the results from the settling columns to those from the sieves; in some cases the values between the two varied as much as 30%. Nevertheless, since we performed all of our settling column tests in the same way, relative to each other, the results we obtained do reveal some interesting trends, some of which are the same as those found through the sieve analysis. Figure 13 shows the distributions of the particles at different locations based on our results from the Bouyoucos hydrometer. All of the samples seem to have a great deal of sand and silt, but little clay. There are not really very large differences among the samples, and the variations seems more based on relative location than on relation to the trail; for example, both samples on the abandoned trail have a significantly larger amount of sand than samples from other areas. The old trail has the largest amount of clay, suggesting that small particles might be washing on to the trail, a process for which we could see visible effects in the laminated layers we found in the OA horizon.

Our other, more specific method of textural analysis involved using the ROTAP. This sieve analysis only gave us gradations in sand sizes, but the results are still useful since most of our samples were fairly sandy. The particles that went through the ROTAP, however, did not always get entirely broken up, so there might really be much more clay and silt in the samples than those results indicate. We may have had some other slight errors in measurements since dust and dirt often settled on the balance we used and changed the readings. That difference, however, usually amounted to only about 3% of the total value, a negligible amount compare to the extent of possible error with the hydrometer method. The results from the ROTAP should have a good comparison relative to each other since they were all obtained in the same manner.

Figures 14 and 15 shows these comparisons in the OA and B horizons, respectively, based on the Ø scale. (for the corresponding particle sizes and Wentworth grade, see table on Reference page). Since we did not have measurements for any increments smaller than 3.5Ø, we could not make standard histograms, but we can still see the same general trend that we discovered through the hydrometer method. In the OA horizons on the new and abandoned trails, the amount of silt and clay (percent in the pan) is much greater further from the trail while there tend to be larger particles in the center of the trails. Assuming these results are correct, the smaller particles may have been washed away or eroded from the trails due to greater exposure to weathering. This same trend, however, does not hold true for the old trail. That might be because we dug the pit off the old trail near the base of a slope, which might make it subject to the same sorts of erosion effects as found on the trail. In addition, the small layering that we found in the OA layer of the middle of the old trail indicate that materials may at times be washing into the old trail as opposed to eroding away from it. That too could account for the larger amounts of silt and clay, as the added layers may consist of smaller particles since those are more likely to get washed down the slope. Further supporting this possibility, the B layers on the old trail do not exhibit the same trend as the OA layers, and they show only a slight difference in the amount of silt and clay on and off the trail. Since the B layers on and off the trail do not show the same variations as the OA layers, perhaps the extra silt in the OA layer on the center of the old trail is the result of the addition of particles from somewhere else. In fact, the B layers on the old trail have a smaller amount of silt and clay than those on the new and abandoned trails whereas the reverse is true for OA layers. On the new and abandoned trails, the B layers exhibit the same basic trends as the OA layers although the OA layers are much sandier.

Fine reasoning here.

The cumulative frequency curves in Figures 16 and 17 help to further analyze the variations in particle size distributions. In the OA horizon, location relative to the trail appears to have little impact on how well or poorly sorted the soil is. Almost all of the samples are moderately sorted. The slightly higher value for the sorting coefficient on the middle of the old trail adds further evidence that other particles have washed in since the addition of particles from some other location would probably make the soil more poorly sorted. The B layers seem to have less variation in textural composition than the OA layers which may be a good indication that trails do in fact cause some degree of erosion in soil nearer the ground surface since it is

Beautifully drawn.

yes!

more susceptible to human contact and natural impacts from weathering. If the trail caused no erosion, then the OA horizons might be as similar to one another in composition as the B horizons. However, the B layers are generally not as well sorted as the OA layers. The values for the sorting coefficients may be somewhat skewed since the B layers generally contained a larger amount of silt and clay, particles for which we could not measure further size divisions. Nonetheless, if the B layers are in fact more poorly sorted than the OA layers, exposure to weathering and human activity would not appear to have an inconsistent or random sort of impact upon the textural composition of the soil.

Remember, clay minerals of silt & clay sizes accumulate in the B-Horizon; so, you have an expected result.

VEGETATION:

The trail affects more than just soil; it has a large impact upon vegetation as well. Although in clearing a trail, large trees may be cut down, we were mainly concerned with herbaceous vegetation and small shrubs since these would reflect the impacts of the actual activity on an already created trail. When we did our vegetation measurements on Sun, 23-April, 1995, there was still only a small amount of herbaceous vegetation. Primarily, we found only one species consistently, while a few other unidentifiable shoots were beginning to emerge. Nevertheless, we still noticed some interesting differences. Since the trail creates a clear space that allows more light in, more vegetation may grow near the trail. On the abandoned trail, grass is very dense while we found no grass growing anywhere off of the trails. A thinner cover of grass is also growing along the edges of the old trail, but only a small amount has begun to grow on the fringes of the new trail. On the abandoned trail, the grass extends out to the fringe of the trail then stops where there is a thick leaf cover. The larger amount of light near the trail also seems to affect mosses which often grow on trees and fallen logs along the sides of the trail. In addition, most prominently on the old trail, we found a larger amount of small shrubs or saplings along the edges of the trail than in the rest of the forest. Probably these too are taking advantage of the light.

Although the increased amount of light seems to allow several larger, more hardy species to grow, at least at the time when we took observations, we found that the actual number of plants, regardless of size, increased the further we went from the trail as shown in Figure 18. While on the trail, we found only grass and mosses, off the trail we found ferns, different types of mosses and fungi, small shrubs, small herbaceous plants with bright red berries, and several others beginning to emerge. Figure 19 shows these locational variations in species diversity. I would speculate that as the Spring progresses, we would find a much greater density and diversity in species of herbaceous vegetation in areas off the trails although on the trails there would probably be less of a change. With the small amount of vegetation that we did have to work with, however, it was difficult to come up with much quantitative data. What we did discover, however, was that this vegetation varied a great deal depending on moisture and light, yet even in clearings in the forests where there was much more light, we did not find grass. Grass seems to be unique to the trail. The trail seems to foster the growth of species that would not normally grow in the rest of the forest. Perhaps these species are transported from other areas by people, or perhaps they are better able to grow in the altered OA soil layers which are thinner and more compact than the soil in which the bulk of the vegetation seems to be growing. The values for organic matter in the OA layers of the abandoned trail (Fig. 3) suggest that the grass growing on the trail is gradually restoring organic matter to the soil. We can see, however, by looking at the abandoned trail, that future growth is not doomed once a trail is created. The forest gradually seems to return to a natural state of equilibrium.

Conclusions

Although Pine Cobble Trail certainly does not have as much of an effect on the environment as other factors such as the housing development, we have found that it definitely has altered vegetation and soil. Even micro-level changes on a trail have noticeable impacts. Although we tried to minimize as many natural variables as possible, knowing that soil and vegetation are sensitive to all sorts of environmental factors, we know that we could not be positive that all of our results come from activity on the trail. Nonetheless, we can make some strong conclusions. For example, the abandoned trail has already had over five years without human traffic (except for a few people such as Anna and myself) to begin to reintegrate with the surrounding forest, yet most of our results show that in its vegetation and soil composition, it is still much more comparable to the existing trails than to the areas off the trails. Trails, then, can have a lasting impact upon the ecosystem, altering the species composition and soil profile, but at least that impact tends to concentrate on a rather narrow path instead of spreading to surrounding areas.

Stephanie,
Apart from the comments written, I can only say you did a great job... a wonderful discussion section, excellently illustrated. Those cumulative frequency curves really worked!

PAPER A/A+ → 96

POSTER (B second only)

ORAL B
CONTENT A
GRAPHICS A

POSTER OVERALL A- → 92

References

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2. Noss, Reed F. "Do We Really Want Diversity?" Learning to Listen to the Land. Washington D.C.: Island Press, 1991, pp. 41-45

3. Methods of Soil Analysis, Part 1, Physical and Mineralogical Methods. Madison, Wisconsin: American Society of Agronomy, 1986.

4. Krumbein, W.C./Pettijohn, F.J. Manual of Sedimentary Petrography. New York: D. Appleton-Century Company, 1938.

**I worked extensively on this project with Anna Groskin. We also had assistance from instructors Dave DeSimone, Gretchen Meyer, and Jay Thoman; from TA's Jim Heyes and Deb Zucker; from writing workshop tutor, Justin Wright; and finally, Sandy Brown helped with our organic matter and moisture analysis

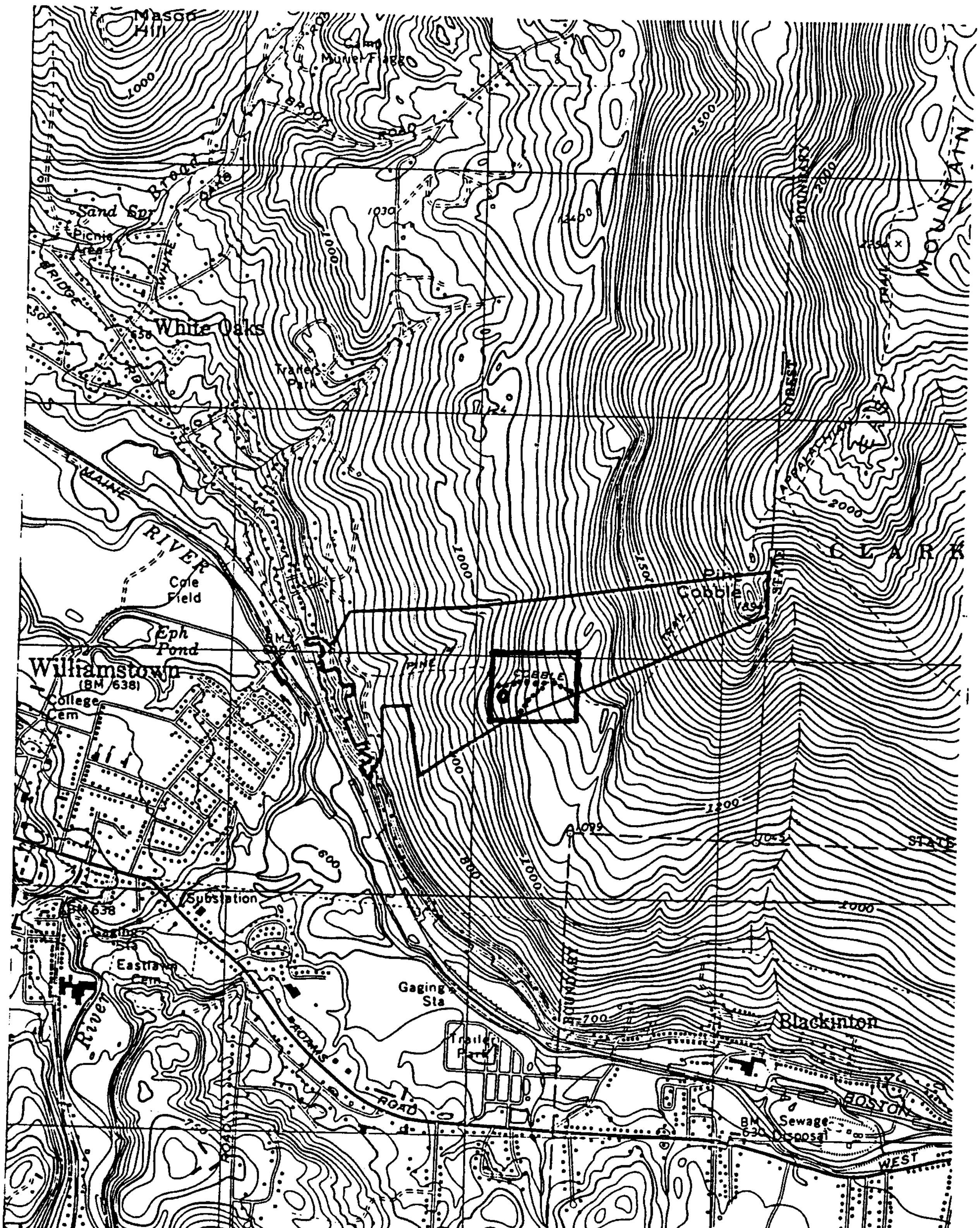
Notation on Graphs

AT = Abandoned Trail
NT = new, relocated section of trail
OT = oldest, most used trail; continues from junction of AT and NT
mid = middle of trail
fr = fringe of trail
off = off of the trail
NAT = between NT and AT

Particle Size Conversions

Ø	Wentworth Grade (approximate)	Grade Limit (mm)
-1	very coarse sand	2
0	coarse sand	1
1	medium sand	0.5
2	fine sand	0.25
3	very fine sand	0.125
3.5	coarse silt	0.088

FIGURE 1 WILLIAMSTOWN AND PINE COBBLE



o water tank

PINE COBBLE
PROJECT LOCATION
U.S.G.S WILLIAMSTOWN
QUADRANGLE 1973
——— APPROXIMATE PROPERTY LINE

sampling site - area shown in detail in Fig. 2

Job No. 8-1789.00 Fig.

Horizontal Scale in Feet 1" : 2000'

FIGURE 2

PINE COBBLE TRAIL : JUNCTION OF NEW AND ABANDONED TRAILS

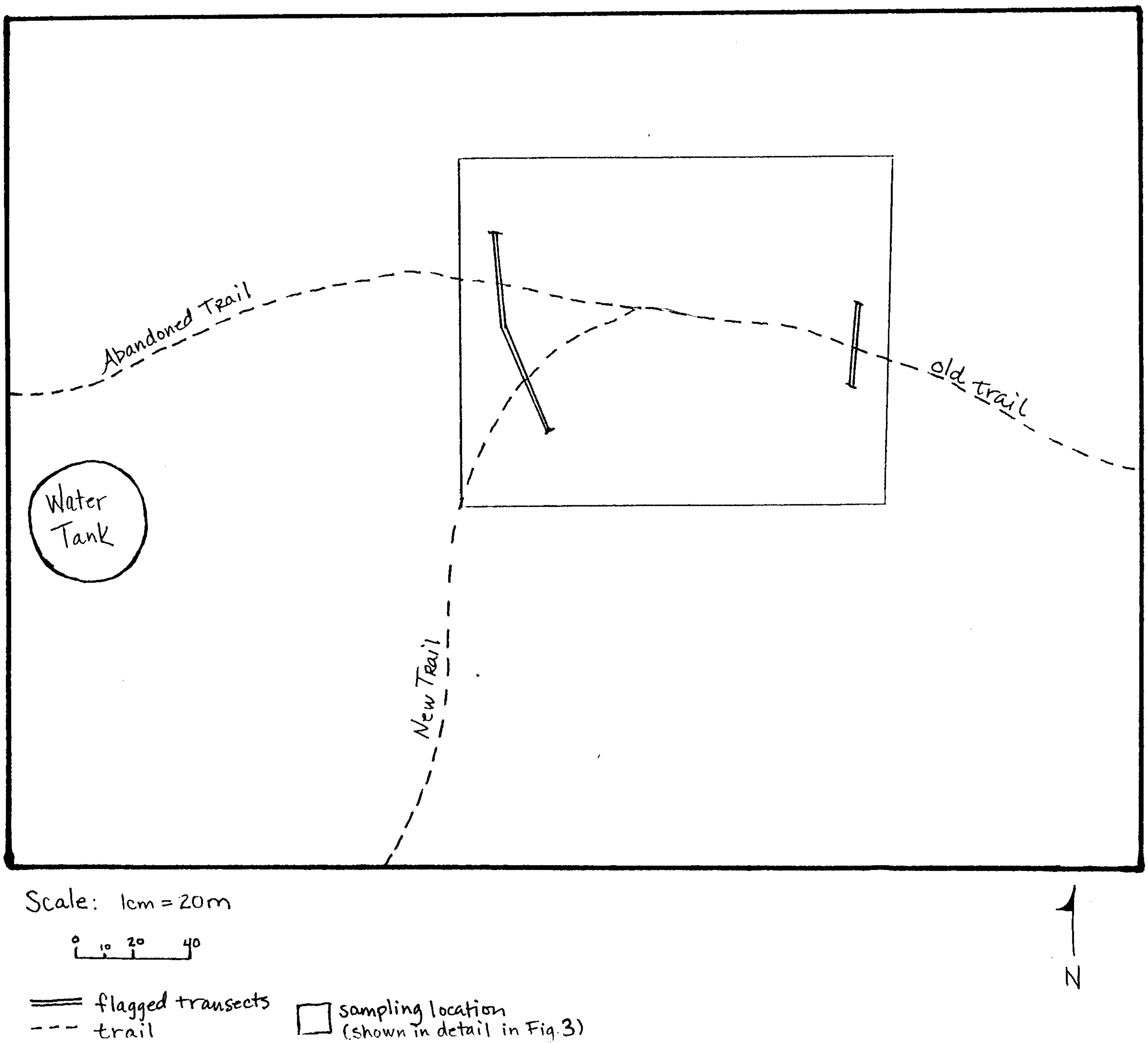
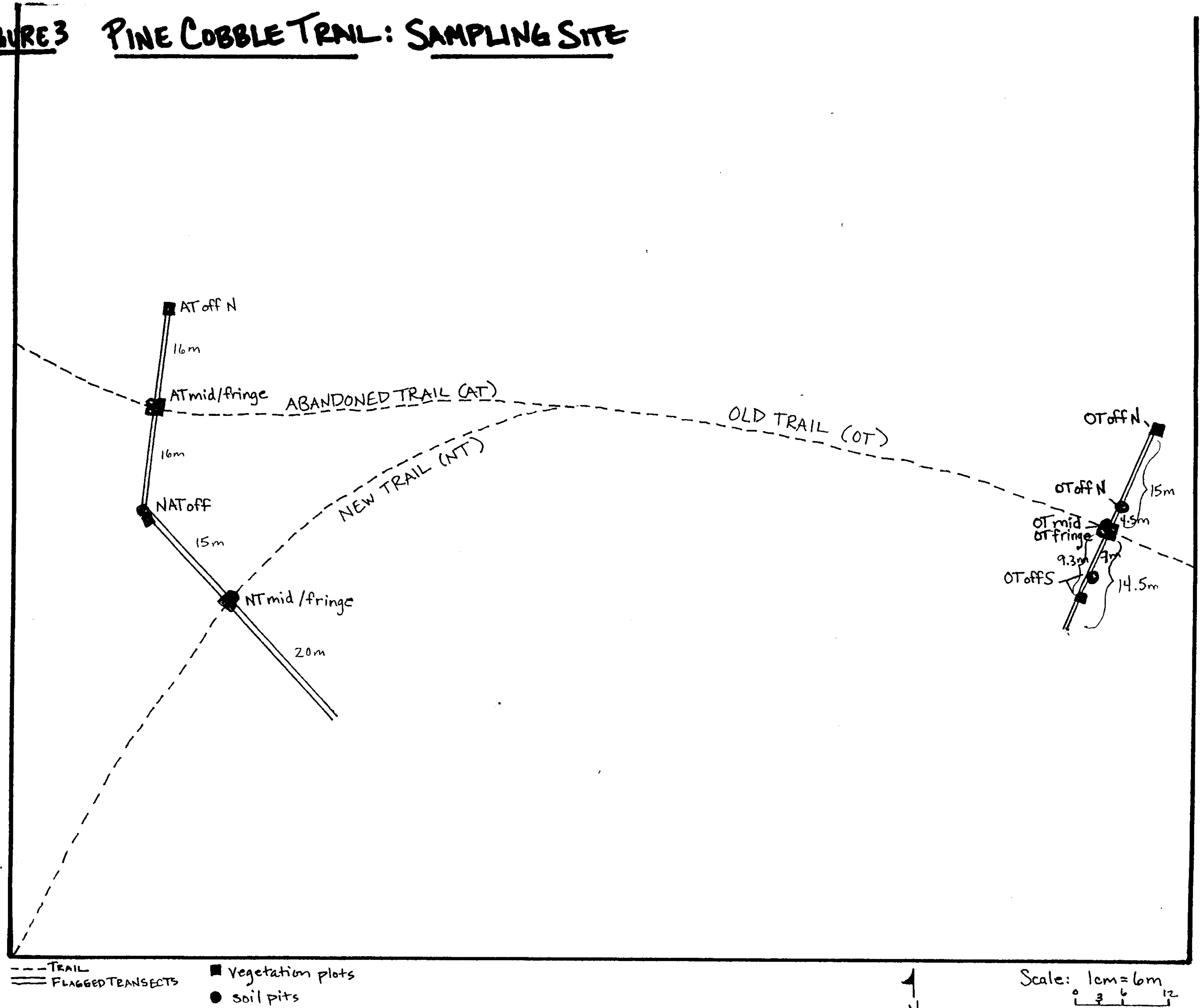


FIGURE 3 PINE COBBLE TRAIL: SAMPLING SITE



Thickness

Figure 4
~~Depths~~ of OA Soil Horizons by Location

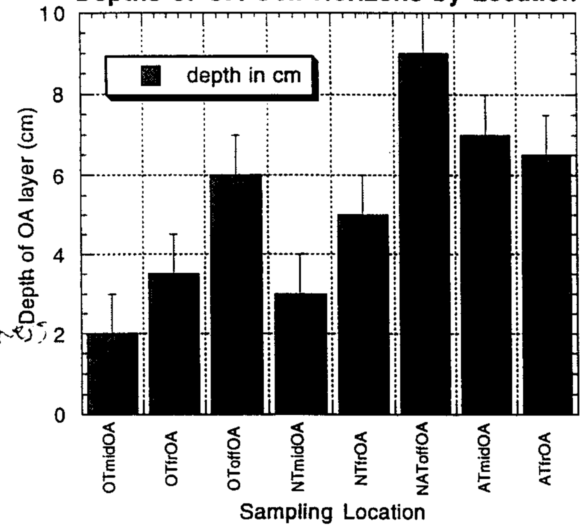


Figure 5
Densities of OA Soil Horizons by Location

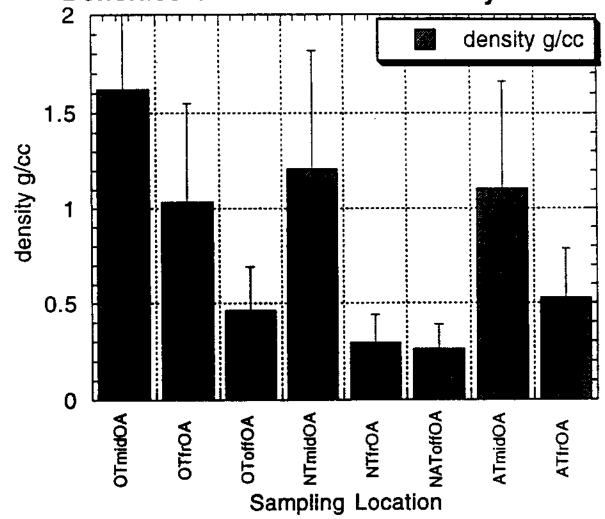


Figure 6
Density vs ~~Depth~~ of OA Horizon
Thickness

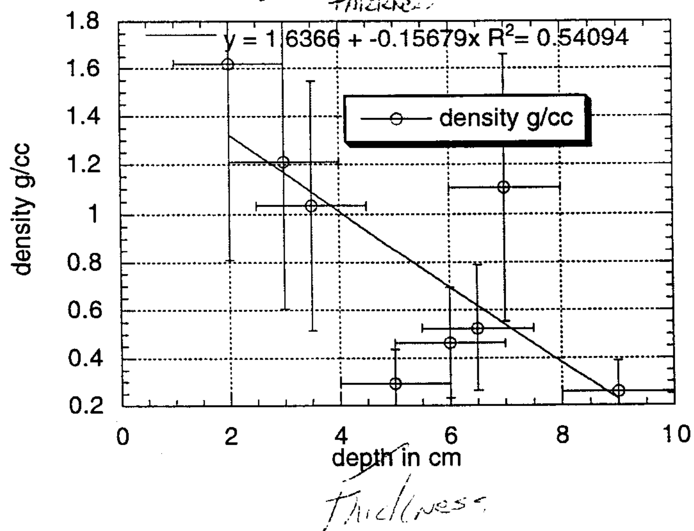


Figure 7
Organic Matter Content
of OA Soil Horizons by Location

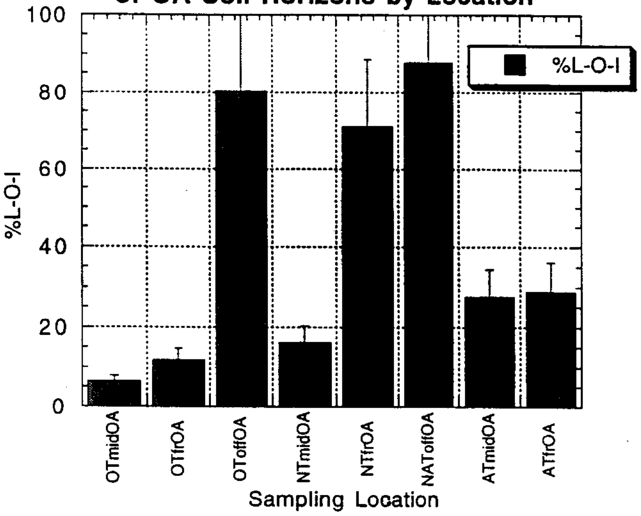


Figure 8
Organic Matter vs Density of OA Soil Horizon

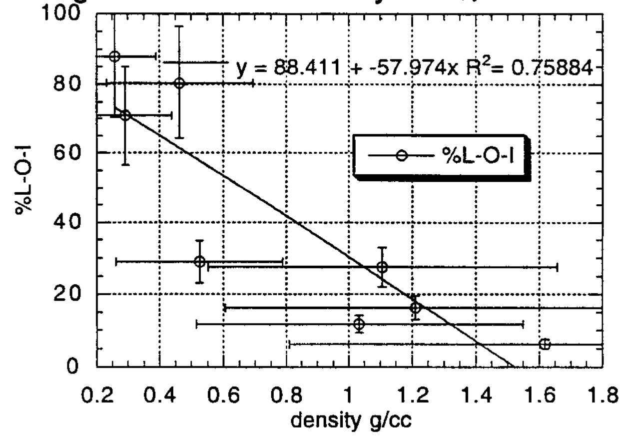


Figure 9
Moisture Content of OA Soil Horizons by Location

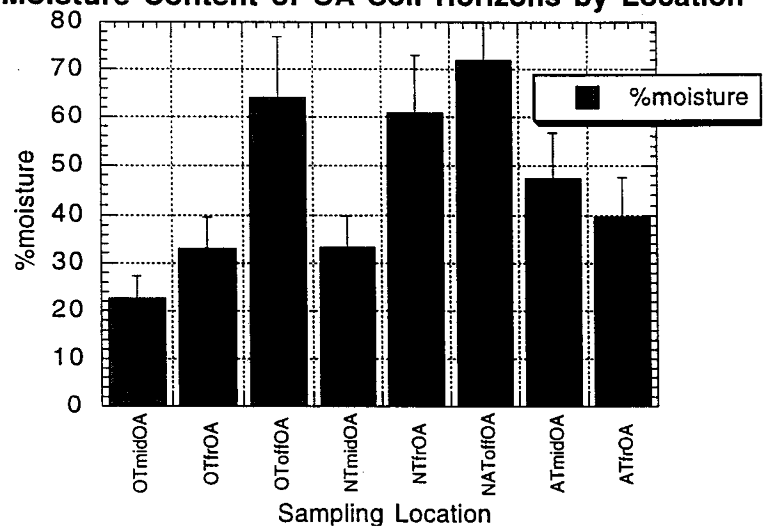


Figure 10
Moisture Content vs Organic Matter

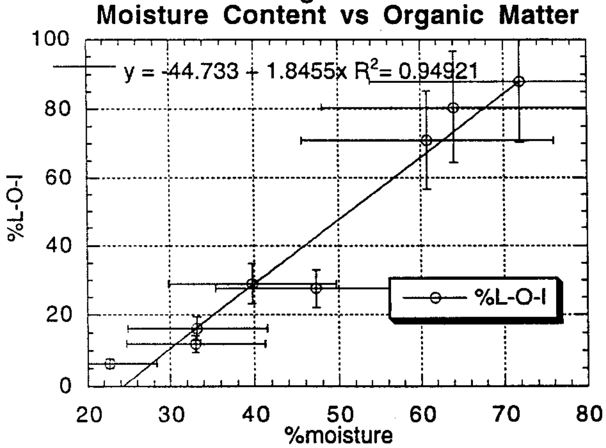


Figure 11
Moisture Content vs Density of OA Soil Horizon

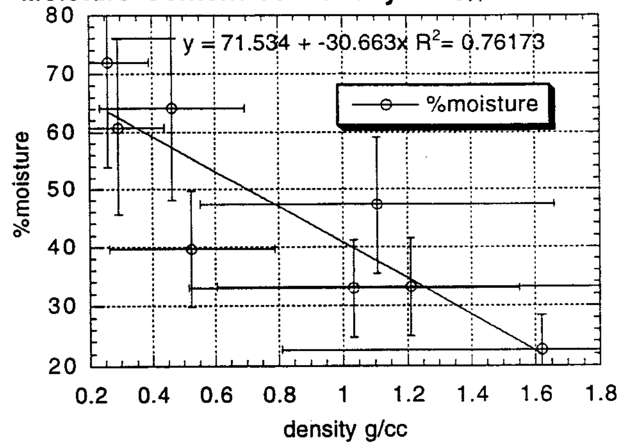


Figure 12
Moisture Content vs Thickness of OA Layer

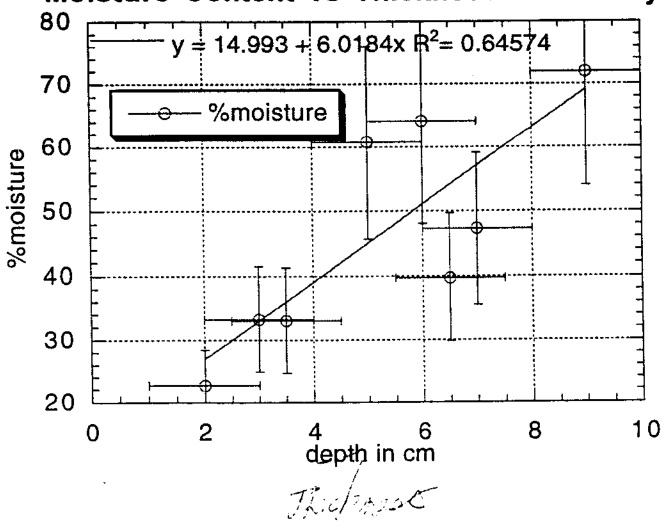


Figure 13
Soil Texture in B Horizons by Location
(Based on tests with the Bouyoucos Hydrometer Method)

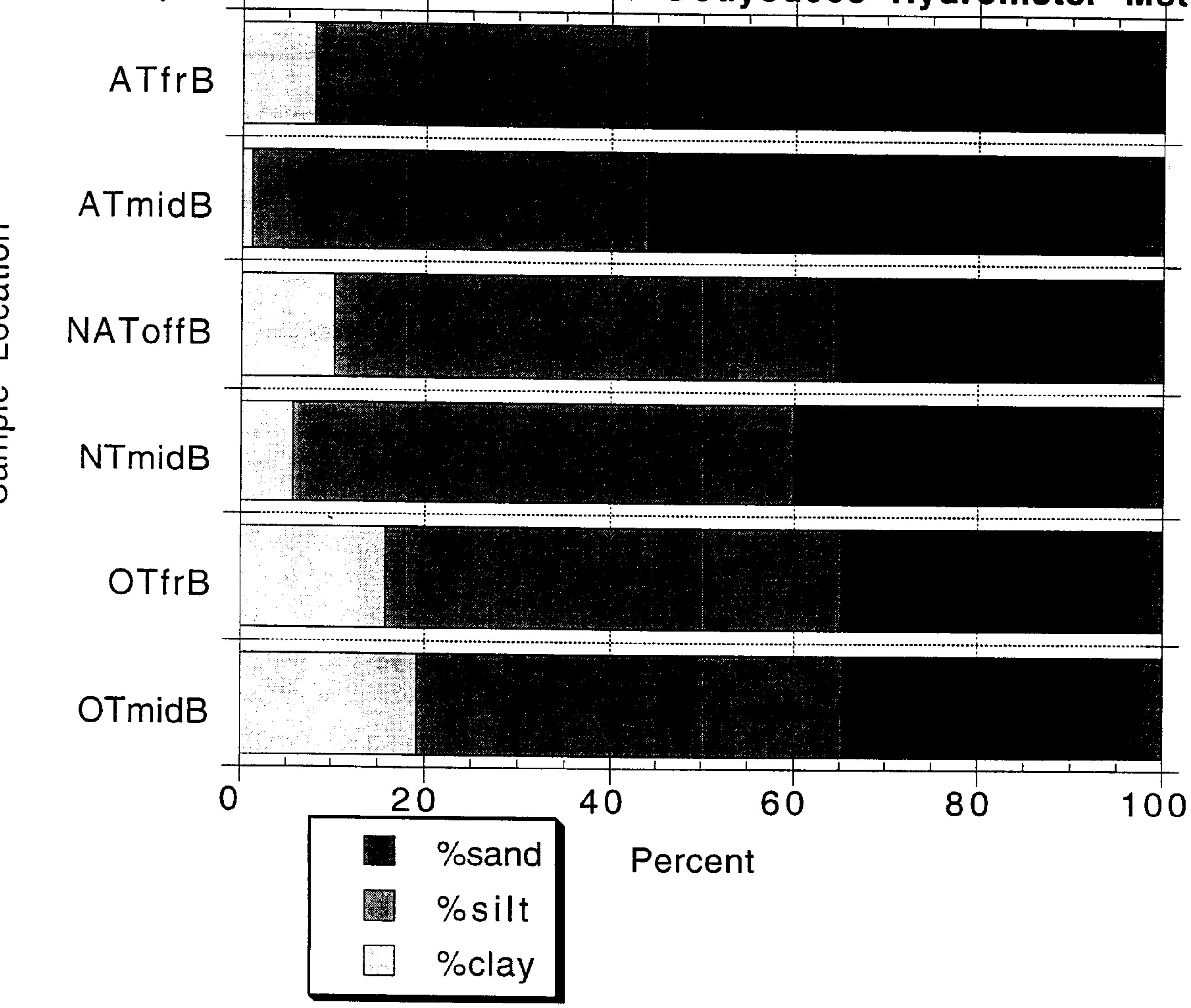


FIGURE 14

PARTICLE SIZE DISTRIBUTIONS IN OA LAYERS

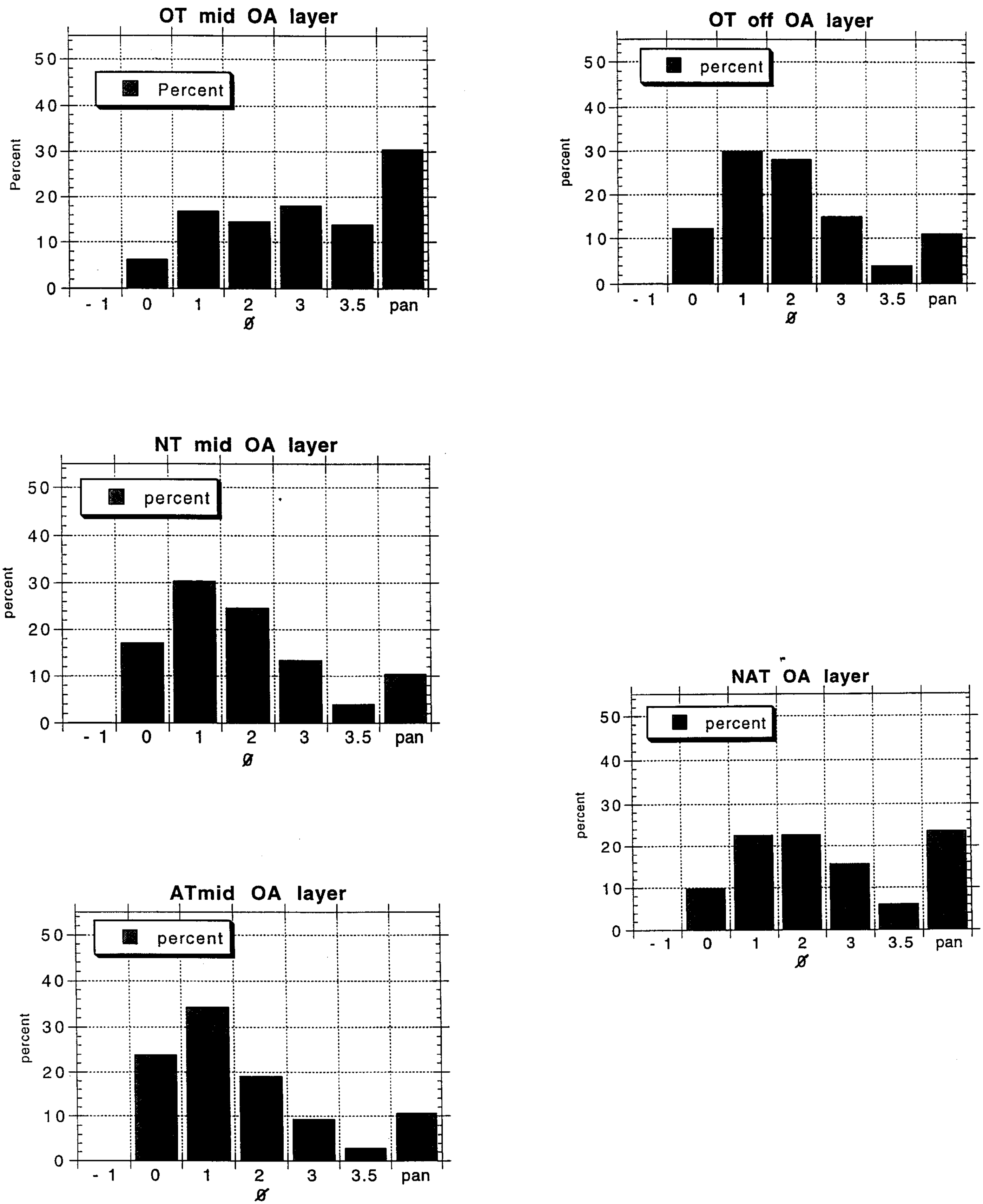


FIGURE 15

PARTICLE SIZE DISTRIBUTIONS IN B LAYERS

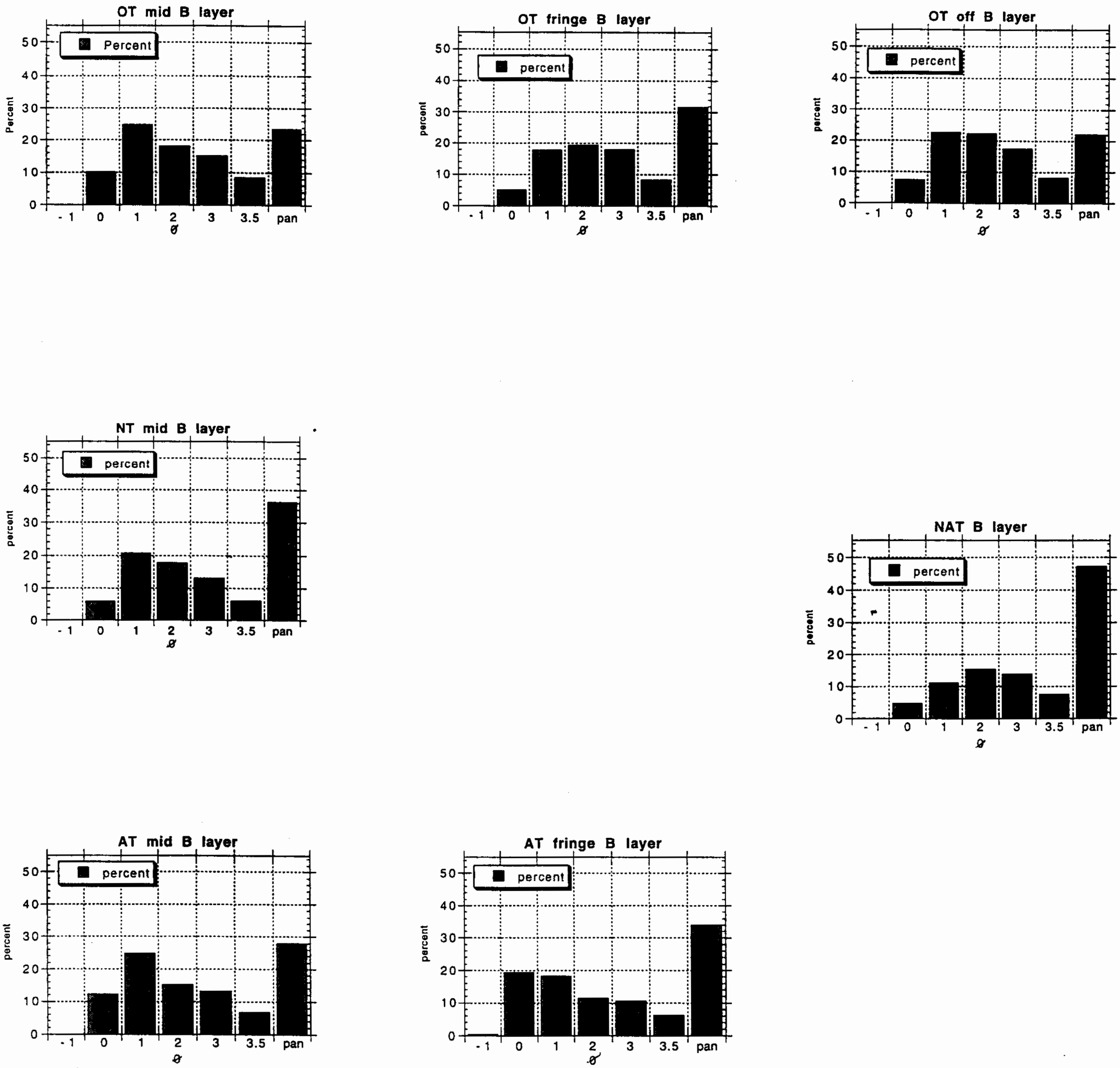
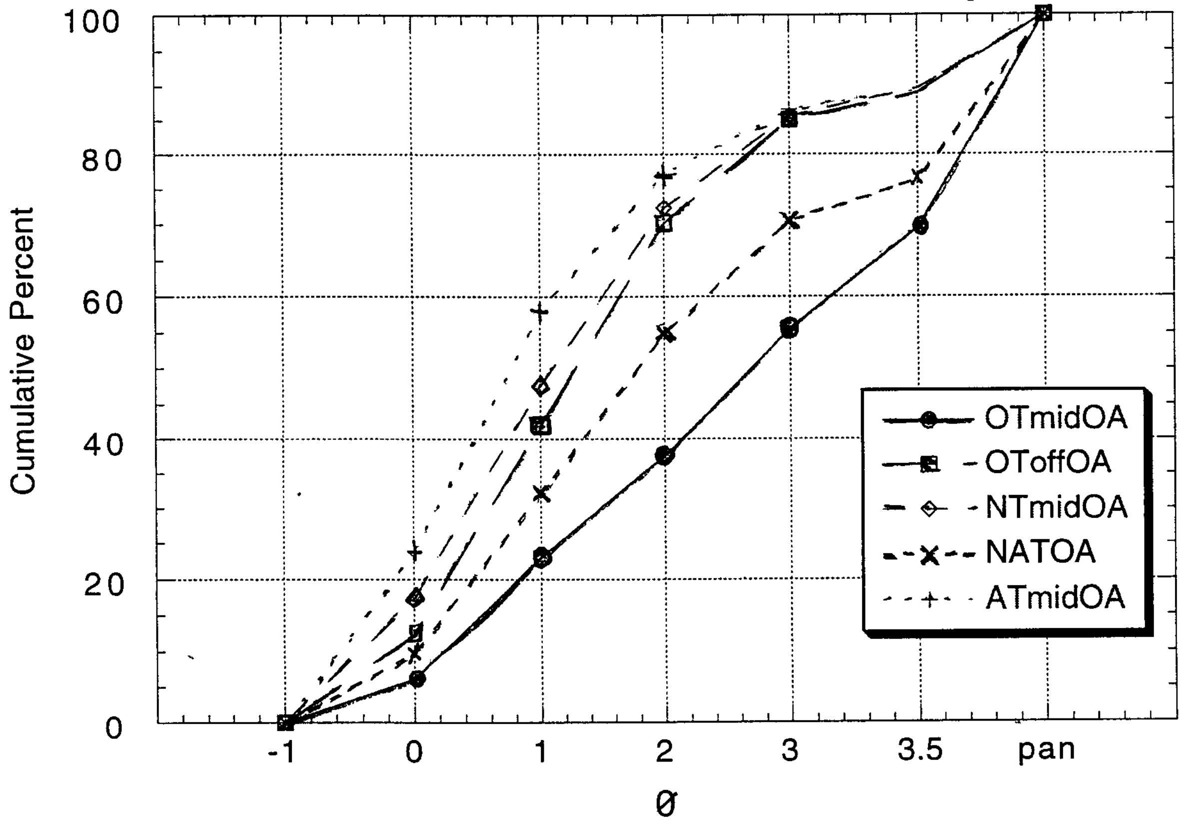


Figure 16
Cumulative Frequency Curves of Grain Size Distributions in OA Layers

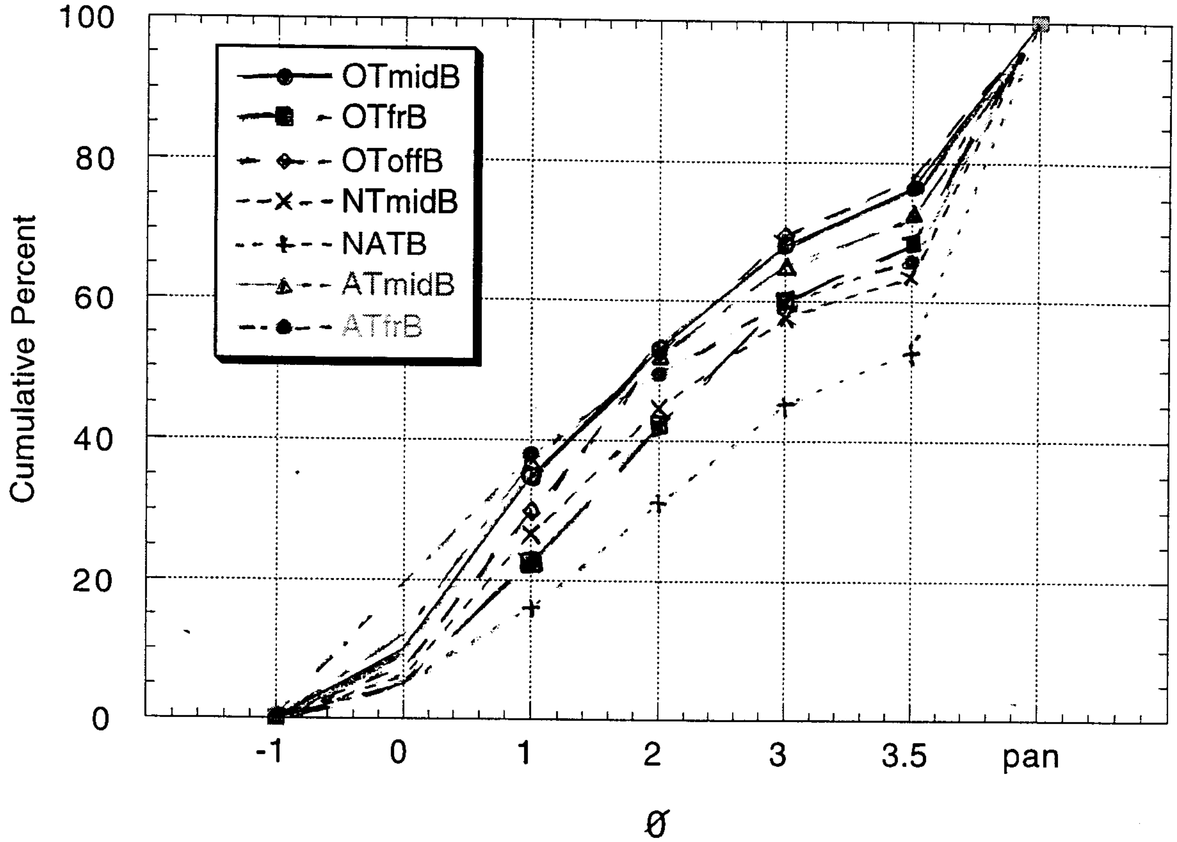


Sorting Coefficients

OTmidOA	2.64
OToffOA	2.12
NTmidOA	2.16
NATOA	2.71
ATmidOA	1.92

*Note that the graph is distorted since 3.5 Ø on the x-axis should be closer to 3 Ø. The pan includes all values greater than 3.5 Ø. See table on Reference page for particle sizes in mm corresponding to the Ø scale.

Figure 17
Cumulative Frequency Curves of Grain Size Distributions in B Layers



Sorting Coefficients

OTmidB	2.94
OTfrB	2.55
OToffB	2.75
NTmidB	2.93
NATB	2.55
ATmidB	3.25
ATfrB	3.60

***Note that the graph is distorted since 3.5 Ø on the x-axis should be closer to 3 Ø. The pan includes all values greater than 3.5 Ø. See table on Reference page for particle sizes in mm corresponding to the Ø scale.**

Figure 18
Amount of Vegetation vs Distance from Trail

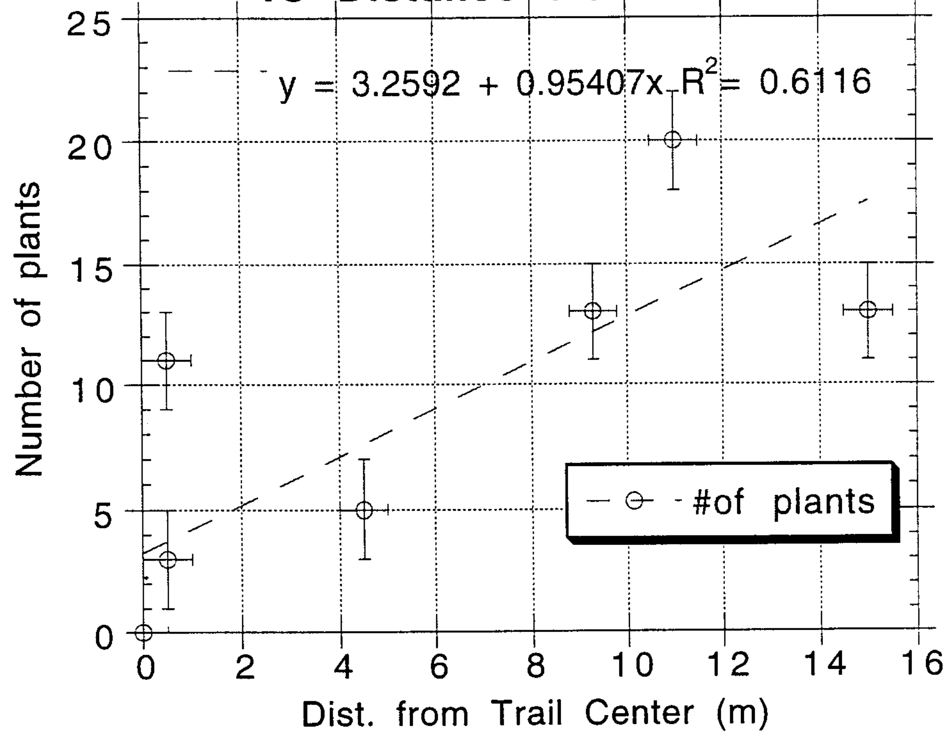


Figure 19
Diversity of Herbacious Plant Species by Location