

The effects of plant succession and ant nest on soil organic matter and soil moisture

Independent Research Project: Summer 2002

Author: Ronald Rizo; San Diego State University

Research Mentor: John Harte; University of California, Berkeley

Abstract:

An earthflow that occurred in Gunnison County, Colorado created a natural laboratory to study plant succession. Plant succession and ants can effect the soil composition of grounds left bare and depleted of organic matter by the landslide. This study was conducted to examine if the described successional pathway and ant nests changed soil composition in the landslide. The study revealed that the described successional pathway increased soil organic content if it begins from bare ground and ends with possible climax community. Pioneer species did not initially contribute to a significant change on soil organic content. Ant nests, on the other hand, do increase soil organic content. Moisture results reveal that all sites differ in soil moisture and soil moisture retention. Observe interactions between ants and pioneer species has also raised question on the importance of insect and plant interaction during succession.

Introduction

How plant species come back after a disturbance is of great importance in the field of restoration ecology. For restoration ecologists, natural succession processes need to be studied in detail before any attempts can be made at mimicking them with restoration efforts. An earth flow, which occurred in Gunnison County, Colorado around 1923, (Langenhien, 1956) is a perfect model to study the processes of succession that have been at work for the past 80 years.

In some areas of the earth flow, the plant community and top soil were completely washed out leaving large areas of bare ground (Langenhiem, 1956). Biologists have been studying plant succession at the earth flow and have identified three successional pathways. The principal successional pathway was determined to consist of dusty maiden (*Chaenactis alpina*), the intermediate community as perennial forbs, and the possible climax characterized as Sagebrush (*Artemisia tridentata*)(Langenheim, 1956).

Soil composition influences plant community structure (Warskinson, 1998). When the earth flow washed away the topsoil, *Chaenactis alpina* was established first because it was able to grow in the poor soils. Studies on plant succession at other sites show that pioneer species can facilitate the growth of the next successional stage by improving soil composition (Cambell, 1946). Past studies at the Gothic earthflow did not examine if this successional pathway brought changes in soil composition that could have facilitated plant growth. We also do not know if *Chaenactis alpina* was essential in facilitating the initial change on the bare soil.

We can measure differences in soil composition from the different successional stages by looking at the amount of soil organic matter and moisture. Organic matter helps soil retain moisture and provides resources for microbes that decompose the organic material into available plant nutrients (Harte, personal communication). Thus, soil organic matter can be used as estimate of facilitation because foliage from plants that fall into the ground is what contributes to soil organic matter.

I ask three related questions in this study:

1. Does this successional pathway contribute to soil organic matter?
2. Do successional communities differ in soil moisture?
3. Does *Chaenactis alpina* facilitate growth for the next successional community by initially contributing soil organic matter to the bare soil?

Besides studying the effect of plant on soil composition, I will also test the effects of ant nests on soil composition. Insect activity in an ecosystem has proved to be important because of the ecological functions they carry out. Besides direct interaction with the plant community as pollinators, insects also carry out other functions that are vital to ecosystems. For example, ant nests soils may have higher organic matter in the vicinity of the nest because of the debris, stored food, and waste product ants accumulate

from foraging (Wagner et al, 1997). Ant nests also aerate, mix, and enrich topsoil because of the constant maintenance and tunnel building (Zim and Cottam, 1987). Therefor, since the soil in ant nests is so rich in these properties, when ant colonies die, they provide fertile ground for plants to grow (Wagner et al, 1997).

From field observations, several ant nests were discovered in the pioneer community. Since we know that pioneer species inhabit poor soils, ant nests in this area may alter soil composition. Therefore, I am going to test if ant nests soils are higher in organic content than are bare soils.

Materials And Methods

The Gothic earth flow is located south of the Rocky Mountain Biological Laboratory (RMBL) in Gunnison cCounty, Colorado. The flow is approximately two km long and one km wide.

Five ground types were used to test for soil organic matter and moisture:

1. Bare ground; serving as a control group and as an indicator of soil organic matter before succession.
2. Ground from ant nests.
3. Ground from pioneer species; *Chaenactis alpina*.
4. Ground from intermediate community, characterized by perennial forbs.
5. Ground from possible climax community; *Artemisia tudentata*.

The first four ground types were within the landslide. Ground of possible climax community was just outside the landslide. Ten soil samples from the five types of ground were collected twice: two days after rain and nine days after rain.

Successional communities and bare ground were first identified. Ten 1×1 meter quadrants were then haphazardly placed over them. Each quadrat was divided into 25 (20×20cm) squares. Using a cylinder of 2 centimeter diameter, 10 centimeters of soil were extracted from one randomly chosen square within the quadrat. Percent ground cover of the successional communities was also estimated from the 1×1 meter quadrats.

To examine the effects of ant nests, five ant nests were picked in the pioneer community. At the base of each ant nests, two soil samples were collected.

Rocks and roots were sieved from the soil samples. Then all soil samples were taken through a series of drying and heating process in the lab. The first step was to dry

out all the moisture in at 120° for 24 hours. Next, soil organic matter was burned at 430° oven for 5 minutes. The differences in weight before and after each step were the weight of moisture and soil organic matter from the samples.

To test if this successional pathway contributes organic matter to the bare soils, a linear regression of percent cover from each community with percent organic matter from each community was performed. To test for difference between bare grounds and pioneer ground; bare grounds and ant nests, a two tailed t-test was used. Differences in the amount of moisture from the five ground types and day since rain was done using a two-way ANOVA.

Results

The linear regression of the four ground types show that soil organic matter increases as percent ground cover increases for this successional pathway ($R^2=0.81$, $n=39$, $p<0.0001$, fig. 1). Organic matter in pioneer and bare ground do not differ ($t=1.163$, $df=18$, $p=0.259$, fig. 2). Organic matter in ant nests and bare ground do differ ($t=2.671$, $df=10$, $p=0.023$, fig. 3). Soils also differ in their ability to retain moisture (table 1, fig. 4).

Discussion

Langenheim (1953) determined that the successional pathway most likely to happen was *Chaenactis alpina*, perennial forbs, and sagebrush. My study, shows that the described successional pathway contributes to soil organic matter, if it begins from bare soil and ends with possible climax community (fig 1). Figure one shows that the highest increase of percent organic matter in the soils comes from the last stage of succession. Pioneer and intermediate community increases in soil organic matter were slight, but not significant. Each step in succession though, whether small or large, is important because it progressively leads to higher organic matter in the soil. This then raises two important questions. First, how much soil organic matter is necessary to be ecological significant? Second, how much of an increase in soil organic matter is necessary to possibly facilitate plant succession?

For example, there are no differences between pioneer soils and bare ground soils, even though the whole pathway does show a pattern (fig. 2). Organic matter went from 1.157 ± 0.443 (Mean $\pm$ 1 SE) in bare ground to 1.505 ± 0.454 in pioneer ground. Therefore,

Chaenactis alpina, probably the first species to appear after disturbance, does not facilitate the next successional community by significantly improving soil organic matter. Other factors may be involved for successional growth for perennial forbs, such as moisture. *Chaenactis alpina* may be improving soil composition in other ways besides contributing to soil organic matter. Moisture results show that pioneer ground hold more moisture and longer than bare ground does (Fig 4 & table 2). Growth of intermediate community may be facilitated by this increased moisture and moisture holding ability.

Ant nests soils had high organic content than control soils (Fig 3). Therefore, ants in the landslide are improve soil organic matter. Ants, through their daily activity, alter soil organic matter more than does *Chaenactis alpina*.

From field observation in the landslide, there seems to be interaction between ants and *Chaenactis alpina* mediated by aphids. Aphids often depend on a mutualistic interaction with ants (Wimp and Whitham, 2001). Aphids provide ants honeydew (Way, 1963), which they excrete from their bodies. In return, ants provide aphids with protection from predators (Tilles and Woods, 1982). Ant tending has also been shown to increase aphid honeydew production up to 50% (Bank and Nixon, 1958).

Since aphids provide a food source for ants, it may be that the food supply increases the population and activity of ant colonies, which in turn alters soil composition. Since *Chaenactis alpina* directly provides a resource for aphids, which in turn provides a resource for nearby ants, *Chaenactis alpina* may indirectly effect the nearby soil composition.

Studies on succession can reveal the factors that are nessessary for plants, and ultimately animals, to return after a disturbance. This study, besides revealing that succession in the landslide does increase organic content in the soil, has also shown how important insect activity is in the reclamation of soil. From the observed interaction of ants and *Chaenactis alpina*, this study has also raised questions on the importance of interactions between insects and plants during succession. Future studies are necessary to determine if this observed interaction is indeed causing improvement in soil composition in bare soils.

Literature Cited

Banks, C.J. and H.L. Nixon. 1958. Effects on the ant, *Lasius niger* L., on the feeding and excretion of the bean aphid *Aphis fabae* Scop. Journal of Experimental Biology 35: 703-711

Cambell, N.A. 1946 Biology. The Benjamin/Cummings Publishing Company Inc. Pg 1134-1135

Carnevale, R. 1994 Bug it: Factoring in Insect Fauna in Ecological Restoration. RMBL Restoration Ecology student paper.

Curtin, C.G. 1994. The Gothic earthflow revisited: a chronosequence examination of colonization on a subalpine earthflow. Vegetation 111: 137-147

Harte, J. Energy and Resources Group; UC-Berkeley, CA. Jharte@socrates.Berkeley.edu

Langeheim, J.H. 1956. Plant Succession on a Subalpine earthflow in Colorado. Ecology 37: 301-317

Tilles, D.A., and D.L. wood. 1982. The influences of carpenter ant attendance on the development and survival of aphids in a giant sequia forest. Canadian Entomologist 114: 1133-1142.

Turbak, S. 1969. A study of Plant Succession on the Gothic Earhtflow. RMBL undergraduate Research Participant

Wagner et. al. 1997. Harvester ant nests, soil boita and soil chemistry. Oecologia 112:232-236

Watskinson, A.R. 1998. The Role of the soil Community in Plant population Dynamics. Trends in Ecology & Evolution 13: 171-172

Way, M.J 1963. Mutualism between ants and honeydewproducing homoptera. Annual Review of Entomoly 8: 307-344

Wimp and Whitham 2001. Biodiversity consequences of predation and host plnat hybridazation on an aphid-ant mutualism. Ecology 82(2), 2001, pp. 440-452

Zim, H.S. and Cottam. 1987. Insects: a guide to familiar American insects, rev. ed. New York: Golden Press.

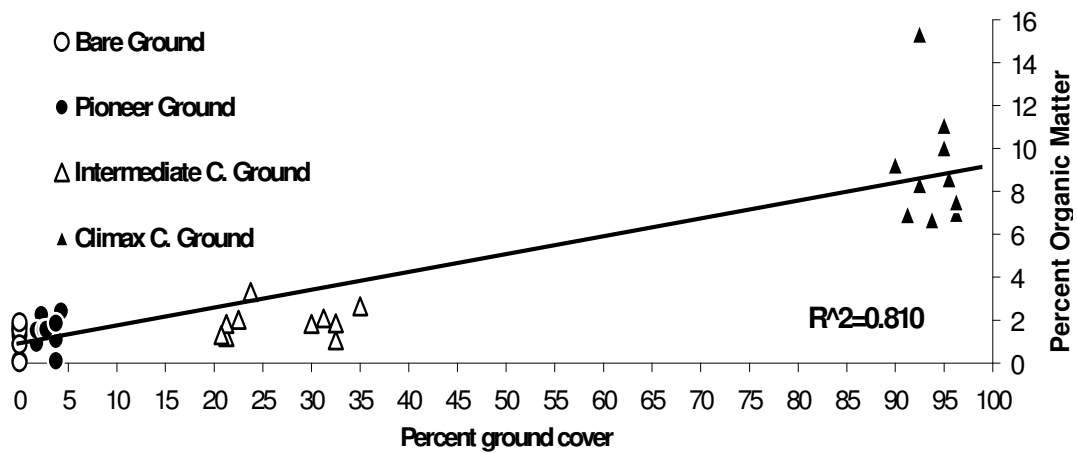


Fig 1. Percent of ground cover and soil organic matter from four ground types; 10 soil samples from each ground type are plotted. Figure shows that as percent ground cover increases, so does percent organic matter; from bare ground to possible climax community ($R^2=0.810$, $p<0.0001$). .

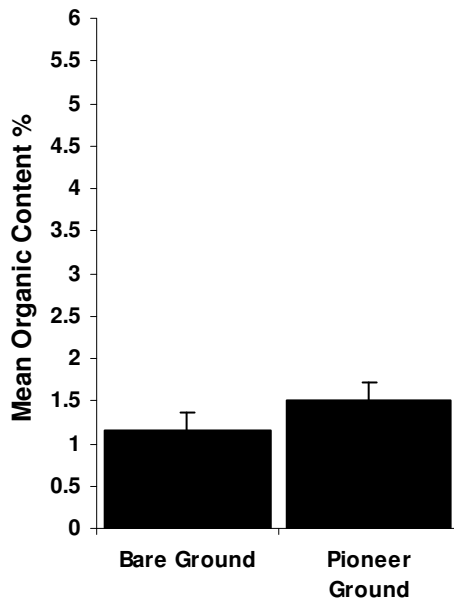


Fig 2. Bare ground and pioneer ground do not differ significantly in soil organic matter ($t=1.163$, $df=18$, $p=0.259$). Bars represent mean ± 1 SE.

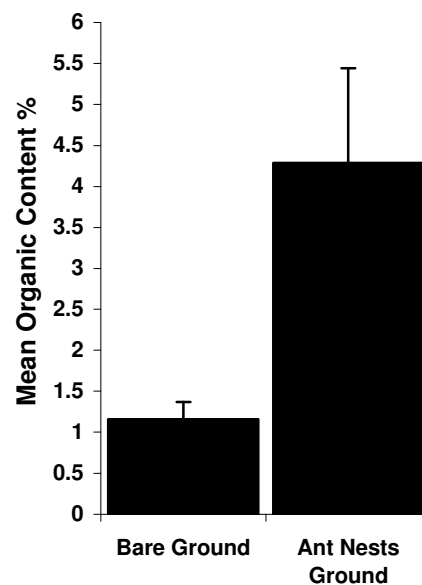


Fig 3. Ant nests have higher soil organic matter than bare grounds ($t=2.671$, $df=10$, $p=0.023$). Bars represent mean ± 1 SE.

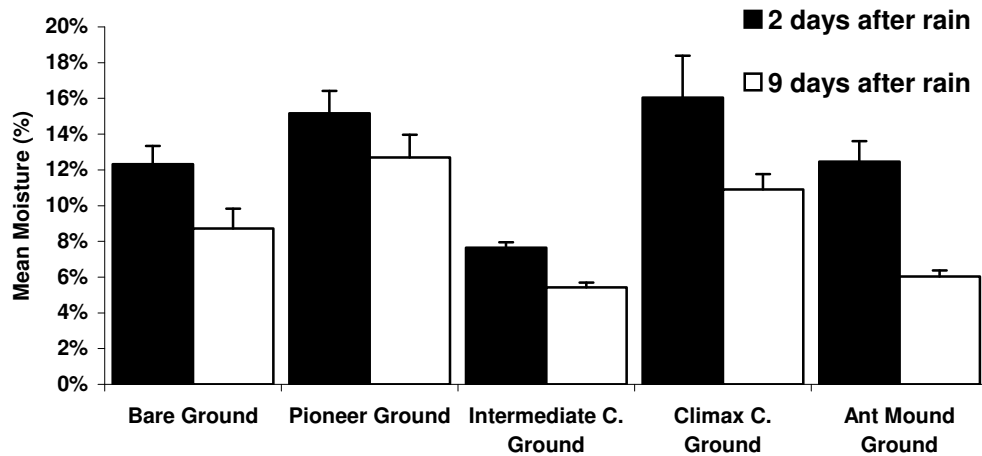


Fig 3. Percent mean soil moisture from the five ground types. Soil moisture ANOVA and Fishers PLSD on table 1 & 2.

TABLE 1: ANOVA comparing mean percent moisture among sites and days after rain.

	DF	Sum of Sq	f	p
Sites	4	751.696	14.076	<0.001
days after rain	1	394.216	29.528	<0.001

TABLE 2: Fishers PLSD of mean percent soil moisture between bare ground and sites.

	Mean diff.	Crit diff.	p
Bare ground & pioneer ground	-3.411	2.296	0.004
Bare ground & intermediate C.	3.983	2.296	0.0009
Bare ground & Climax C.	-2.955	2.296	0.012
Bare ground & ant mound	1.266	2.296	0.2762