THE EFFECTS OF MAMMALIAN GRAZING
ON PLANT AND ARTHROPOD COMMUNITIES

Abstract

The effects of mammalian herbivores on plant and arthropod diversity (a measure of community structure), orders of arthropods present, plant species composition, and soil compaction can be determined to contrast similar and adjacent grazed and ungrazed areas. The vegetation and arthropod communities of two areas, similar in all respects except the presence of mammalian herbivores (e.g., horses, cattle), can be examined using the Shannon-Wiener information index. Soil compaction is measured by rate of water percolation and plant and arthropod species compositions are determined qualitatively by collection. Temperature profiles and soil nutrients are also measured.

Statement of Purpose

To allow students to assess the impacts of mammalian herbivores on a plant and arthropod communities, but also to allow students first-hand experience with the measurement of species diversity.

Theoretical Background

The grazing of domestic mammals, when enclosed on a limited area of native vegetation, often brings about great changes in the species composition of the communities present. Similar changes occur in grazed ecosystems like, for example, the savannas of Africa or the prairies of North America. These include not only the reduced abundance of some plant species due to trampling and consumption, but also the introduction of many plants that are not members of the undisturbed community and/or a number of changes in the soil of the grazed area. These changes can be explored from the standpoint of species diversity...that is, to ascertain the total number of species and the relative abundance of each species in an area.

The grazing of mammalian herbivores, if maintained, creates conditions to which the plants respond. The direct effects (which do not always cause plant death) include: (1) soil compaction and enhanced water and nutrient runoff, (2) alteration of microhabitat chemistry (urination, defecation), (3) crushing and burying of plant tissue, (4) defoliation, and (5) root destruction from treading. These effects alter the (1) structure of the plant community canopy, (2) plant growth rates, (3) plant species presence, (4) intensity and nature of plant competition for space, light, and nutrients, and (5) amount of plant litter on soil surface. It seems counterintuitive but the net change in the plant community due to mammalian herbivore grazing can be an increase in the spatial heterogeneity (microhabitat relief from treading, dung patch refugia). A number of studies have concluded that mammalian herbivores create new localized habitats for their prey by the physical process of grazing. Thus, grazing does more than simply reduce competition pressure for a limited but homogeneous common selection of resources; herbivores introduce or develop existing environmental heterogeneity. This could allow the maintenance of higher plant species diversity due to the lower palatability of ingress species and the development of different zones of the environment (refugia of dung patches and urine burns).

Alternatively, mammalian herbivores can decrease plant species diversity when they avoid feeding on competitively dominant plants. Furthermore, if land is overgrazed, mammals can dramatically lower species diversity. Such overgrazing is a major contributor to the desertification of formerly productive ecosystems. The diversity and richness of arthropods may or may not follow the same pattern due to the reduction of diversity in the vertical component of the vegetation. It is common to observe a decrease in the diversity of arthropods present due to the loss of plant structural diversity.

The soil changes include those that result from compaction by the animals’ hooves. This compaction brings about a greatly reduced rate of infiltration of rain water and a consequent increase in run off.
Both grazed and ungrazed communities are considered in terms of species diversity and just what types of species are present in each community (i.e., weedy species).

**Equipment and Supplies**

Graduated cylinder, meter sticks, small quadrats, percolation cylinder, telethermometer with soil and air probes, soil nutrient test kit (e.g., Hach, LaMotte), sweep nets, insect killing jar, sample containers.

**Methods Description**

Select two adjacent study sites, one grazed and one ungrazed. They must be similar with respect to slope of the ground, exposure to the sun, and soil type.

Select a number of systematically chosen small quadrats (0.1 m x 0.1 m) in each study site. Designate each plant species in each quadrat by its name or a voucher and number if unknown. Examples of each unknown should be tagged with its number for reference throughout the study. Be certain that a species called, for example, number 1, is the same species in each quadrat. Record the number of individuals of each species in each quadrat. Keep a running graph of the cumulative number of species sampled versus number of quadrats. Sampling must continue until the curve becomes asymptotic.

Arthropod type diversity could also be examined at the two study sites to determine if arthropods follow a pattern similar or dissimilar to plant species (see Root, 1973, for discussion). Arthropods can be sampled by sweep netting or if time allows—via pit trapping. The Shannon-Wiener Index is again applied to these data and the two study sites are compared.

An estimate the compaction of the soil can be made using a small cylinder with no ends. Insert the cylinder approximately five cm into the soil. Pour water (50 ml in clay soil, 150 ml in sandy soil) into the cylinder and record the length of time required for the water to enter the soil. (Do several replicates in both sites and average).

Measure temperatures of the soil at 10 cm below surface, surface, and at 50 cm intervals from the ground's surface to 2 meters with a telethermometer. Do this for both sites with replicates. Plot temperature on the X axis against height/depth on the Y axis to generate a temperature profile for both sites. Collect at least 10 subsamples of soil at each site from 0 to a 10 cm depth. Combine these and mix well. Determine nutrient availability for NO3, NH4, P, K, Ca, and Mg using a suitable test kit.

Also examine areas of particular compaction caused by excessive trampling. Notice any patterns in the vegetation which grows there (i.e. around a hoof print).

Examine the grazed and ungrazed areas as to plant species composition. Identify as many of the species as is possible. Which species are most common?

**Analysis of Data**

Plant species diversity and arthropod type diversity for each of the two sites can be computed using the Shannon-Wiener information index:

\[
H' = - \sum_{i=1}^{s} p_i \ln p_i \quad \text{(Note: } \ln = \text{natural logarithm)}
\]

where: \( p_i \) is the number of individuals of one species divided by the total number of all individuals in the sample and \( \ln \) is the natural logarithm.

Also calculate the species richness (S), which is equal to the total number of unique species or morphotypes at each site. Does plant species and arthropod type diversity increase or decrease with
grazing? Does the arthropod type diversity follow a pattern similar or dissimilar to the plant species diversity?

Disturbances of almost any kind, including those which enrich communities, tend to reduce species diversity and alter the relative abundance of species and trophic structure. How can you reconcile that a disturbance such as grazing by mammalian herbivores can increase or decrease plant species diversity?

Plot the temperature data generating a temperature profile with temperature on the abscissa and depth/height on the ordinate. How does the presence or absence of canopy affect the active surface? Present the soil percolation and soil nutrient data in tabular form. What differences are noted between the two sites? Do these differences correlate with the activity of mammalian herbivores?

**Specific Site Information**

Our projects will be conducted on Carl and Claire Brown dairy farm, 1858 Old Schoolhouse Road, Lewisburg, PA. The Brown Farm is located on Old School House Road, just south of Pheasant Ridge Drive. Turtle Creek, a small tributary of the Susquehanna River, winds through our study area.

Soil at our study sites, both grazed and ungrazed, is Holly silt loam. This floodplain soil is nearly level (slopes range from 0 to 3 %), is very deep, and is poorly drained to very poorly drained. The study area is frequently flooded during times of high precipitation or rapid spring snow melt.

Typically, the surface layer is dark grayish brown silt loam about 28 cm thick. The subsoil is mottled, gray silt loam and light gray silty clay loam 80 cm thick. The substratum is gray gravelly loamy sand to a depth of 150 cm or more.

The permeability of Holly soil is moderately slow or moderate, and the available water capacity is high. Runoff is slow because of the level nature of the landscape. Rooting is restricted by a high water table between the surface and a depth of about 15 cm during the winter and spring.

Most areas where this soil occurs are in pasture or woodland, although some areas are used for cultivated crops. The prevention of overgrazing or grazing when the soil is wet is an important pasture management concern. If the pasture is grazed when the soil is wet, the surface layer becomes compacted and plants are excessively trampled. Use of proper stocking rates, deferred grazing, rotational grazing, and nutrients help maintain desirable plant species.

**References**


