Interaction of western harvester ants with southeastern Montana soils and vegetation
by Jeffrey Lawrence Birkby

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Botany
Montana State University

Abstract:
Mounds of the western harvester ant (Pogonomyrmex occidentalis) located on rangeland in southeastern Montana were examined to determine the possibles causes of a ring of lush vegetation that surrounded the denuded mound disc. Nutrient and soil water content samples were collected along a transect from the center of the mounds to a control area three meters distant. Significantly high values of nitrate, phosphorus, sulfate and soil water were found in the denuded disc area. Root biomass data indicated that some roots penetrated the denuded disc area, providing a means for transporting available nutrients and soil water to the edge-vegetation. A change in species composition was also noted. While Bouteloua gracilis dominates in the study area, Stipa comata dominated in the edge-vegetation. The change in species composition and the increased availability of nutrients and soil water resulted in a high production of the edge-vegetation that more than compensated for the denudation of the mound by the ants.

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APPROVAL

of a thesis submitted by

Jeffrey Lawrence Birkby

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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INTRODUCTION

Alteration of ecosystems by burrowing animals has been studied for more than a century (Darwin, 1882). Soil modification and corresponding changes in production and species composition of the surrounding vegetation are documented for pocket gophers (Thomomys talpoides, McDonough, 1974; Laycock, 1958), woodchucks (Marmota monax monax, Merriam and Merriam, 1965), moles and voles (Talpa europaea and Microtus arvalis, Gozczynska and Goszyzynski, 1977), and other mammals. Ecosystem modifications by several ant species have also been examined, including Lasius flavus (King, 1977), Myrmica spp. (Czerwinski et al, 1969), Formica obscuripes (Beattie and Culver, 1977), Formica exsectoides (Salem and Hole, 1968), Formica cinerea (Baxter and Hole, 1968), Pogonomyrmex badius (Gentry and Stiritz, 1972), and Pogonomyrmex occidentalis (Rogers and Lavigne, 1974). The western harvester ant, Pogonomyrmex occidentalis, was chosen as the subject of this study.

Range managers consider _P. occidentalis_ colonies destructive because they denude large areas around their dome-shaped mounds, seemingly reducing available livestock forage. The diameters of these denuded areas vary from less than one meter in heavily vegetated areas to nine meters or more in sparsely vegetated grasslands of Oklahoma (Wight and Nichols, 1966). Hull and Killough (1951) estimated that 33,500 hectares had been denuded by _P. occidentalis_ in the Big Horn Basin of Wyoming, while Scott (1951) calculated that over six million mounds exist in the Wind River Basin.

A ring of lush vegetation has been observed around the disc denuded by _P. occidentalis_ (Rogers and Lavigne, 1974; Wight and Nichols, 1966). Based on these observations, as well as my own, I hypothesized that the vigor of the edge-vegetation may compensate for the absence of plant prduction within the denuded disc areas. To test this hypothesis, root and shoot production were examined along a transect from the center of each denuded disc to a control area three meters distant. In addition, species composition, soil nutrient concentration and soil water content were analyzed along the same transects to determine what factors might be responsible for the observed changes in plant productivity.

STUDY AREA

I conducted my research at the USDA Livestock and Range Research Station in southeastern Montana, ten kilometers south of Miles City near the Tongue River ($46^{o}17'30''N$, $105^{o}45'00''W$). Soil Conservation Service personnel (Nichols, 1978) classified the study site an Ustic Torriorthent (fine-loamy, frigid, calcareous), sloping less than one percent on an alluvial terrace. A calcium rich C_{ca} horizon occurred twenty centimeters below the surface. Annual precipitation at Miles City averaged 36 cm, with 26 cm falling between April and September. Temperatures averaged $23^{o}C$ in July and $9^{o}C$ in January (USDC, 1979). *Bouteloua gracilis*, *Buchloe dactyloides* and *Stipa comata* dominated the site, which lies within Kuchler's (1964) *Bouteloua-Stipa-Agropyron* vegetation zone (Type 64). Cattle grazed the study area periodically until a year prior to my observations, when a fence was erected around the site to exclude them.

METHODS AND MATERIALS

Seven mounds of similar diameter were subjectively selected for intensive sampling. The mounds averaged 55 cm in width, with each surrounded by a denuded disc averaging 250 cm in diameter. Immediately outside of the disc was a ring of lush vegetation that contrasted strikingly with adjacent vegetation.

Vegetation and soils were sampled in August 1978 from the center of the mound, from the edge-vegetation area, 20 cm on either side of the edge-vegetation, 65 cm on either side of the edge, and from an area 3 m from the mound center, which served as a control (Fig. 1). Soil nutrient, soil water and root samples were collected from the sampling areas with a soil coring tube 2.05 cm in diameter. Vertical distribution of nutrients, soil water and roots was studied by partitioning soil cores into 0-10, 10-30, 30-50, and 50-100 cm fractions.

Data from three transects radial to each mound for each position and depth were pooled to reduce the variance of the soil nutrient, soil water, and the root

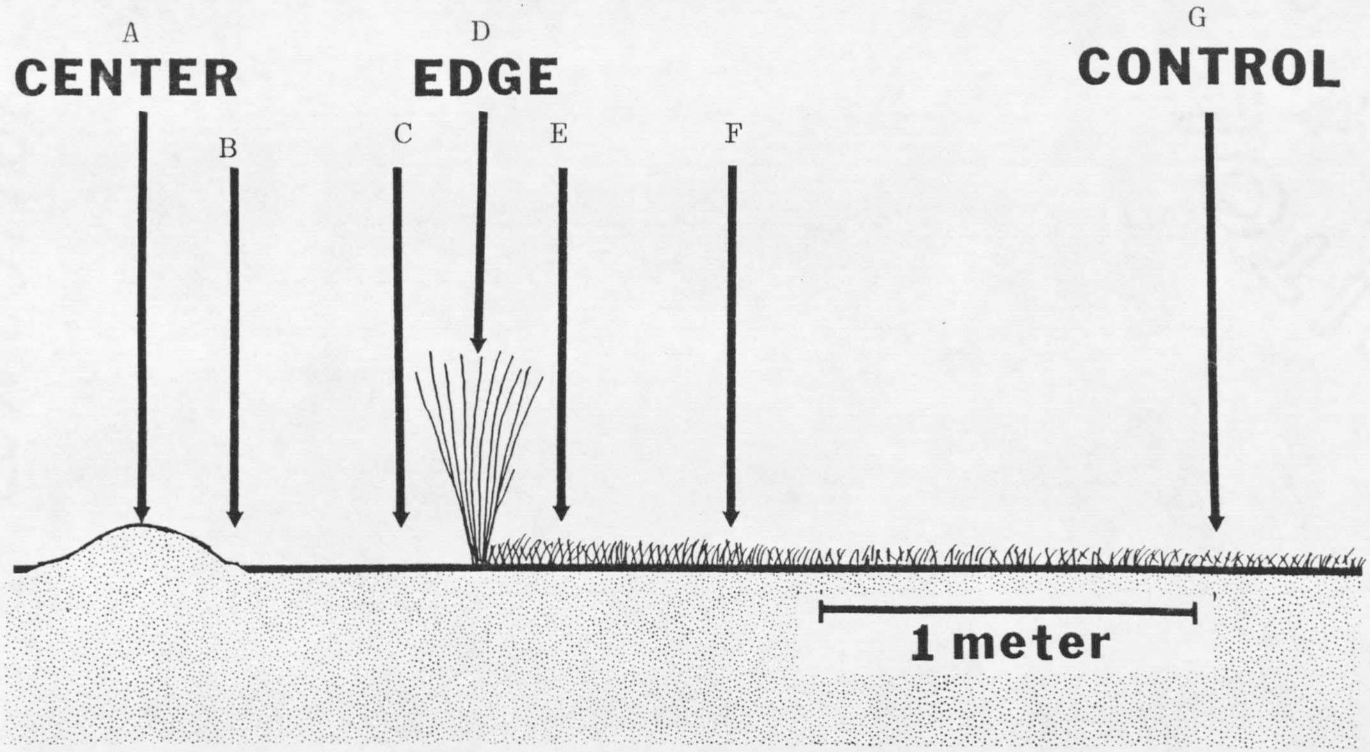

Figure 1. Sampling points along the ant mound transect. Arrows indicate samples taken from A) mound center, B) 65 cm in from disc edge, C) 20 cm in from disc edge, D) edge-vegetation, E) 20 cm out from edge-vegetation, F) 65 cm out from edge-vegetation, and G) a control area 300 cm from the mound center.

data. Soil water and root biomass were sampled from all seven mounds. Due to the high cost of nutrient analyses, soils of only three mounds could be analyzed for nutrients in the 0-10 cm layer, and only two mounds were analyzed for nutrients in the 10-30, 30-50, and 50-100 cm layers. These samples were pooled in the same manner as the root biomass and soil water samples.

Soil nutrient cores were dried at 60°C for 48 hours immediately after collecting, and were then analyzed by the Montana State University Soil Testing Laboratory. Nitrate content was determined by the phenoldisulfonic acid technique (Snell and Snell, 1936); phosphorus was measured by a modified Bray method (Olsen and Dean, 1965); potassium, magnesium, calcium and sodium were extracted with a 1M solution of ammonium acetate and then analyzed with an atomic absorption spectrophotometer; ammonium was determined by microKjeldahl distillation (Bremmer, 1965); sulfate sulfur was extracted with ammonium acetate, precipitated with barium chloride ($BaCl_2$) and read spectroscopically (Black,1965); soil organic matter was measured colorimetrically after dichromate oxidation (Sims and Haby, 1970); pH was determined using a 1:2 soil-water paste and a soil pH meter (Black, 1965); and percent soil water was determined gravimetrically (Black, 1965).

Root biomass cores were dried for 24 hours at 60°C immediately after collecting. The samples were then soaked overnight in a sodium hexametaphosphate (Calgon) solution to loosen the roots from the soil particles. A 1 mm screen was used to separate the wet samples from the softened soil particles. Sand was removed by soaking the washed and sieved samples in water and then decanting the organic material. Visual estimates were then made of the percentage of roots in each sieved sample. Root samples were dried at 60°C, weighed, and ashed at 600°C to correct for the weight of the inorganic contaminants (Weaver, 1977).

Species composition of the vegetation surrounding the disc was measured using the canopy-coverage method of Daubenmire (1959). Frames measuring 20 by 50 cm were placed at 120° intervals in the edge-vegetation of the seven mounds, and canopy-coverage classes of 0-5%, 5-25%, 25-50%, 50-75%, 75-95% and 95-100% were recorded.

The midpoints for each class were used to calculate the means and standard errors. Canopy-coverage was also measured at 120° intervals 20 cm, 65 cm and 2 m outside the edge of the disc. After determining the canopy coverage of each plot, the shoot material was clipped at ground level, dried at $60^{\circ}C$ for 24 hours, and weighed. Quantitative differences between depths and sampling positions for all factors were examined by paired-t tests (Snedecor and Cochran, 1967).

RESULTS

The distribution of soil water, phosphates, nitrates, sulfur and soil organic matter, as well as the above- and below-ground biomasses are shown in Fig. 2.

Soil moisture was significantly greater in the center of the mound at all four sampling depths than in the control location ($p<.05$). Soil moisture content was greatest 50-100 cm below the mound, averaging 11% as compared to 7% at the same depth in the control area. Soil moisture decreased in the shallower soil horizons, with the driest soils (4% soil moisture)