2004 Annual Report

Grassland Section

Dickinson Research Extension Center
1089 State Avenue
Dickinson, ND 58601

Click Here for Printer Friendly version

Biologically Effective Grazing Management Can Enhance Biogeochemical Cycles and Improve Soil Structure of Rangeland Ecosystems

Llewellyn L. Manske PhD
Range Scientist
North Dakota State University
Dickinson Research Extension Center

Grass plants, grazing mammals, and grassland ecosystem processes have evolved together. During the long period of coevolution, grass plants developed defoliation resistance mechanisms--biological processes that help the plants withstand and recover from grazing. A complex system consisting of soil organisms and having numerous trophic levels is located in the rhizosphere. These symbiotic organisms developed in conjunction with the evolution of plants and interact with grass plants through the roots. The activity of rhizosphere organisms is critical for ecosystem functions and for energy and nutrient flow through the ecosystem. The details of the intricate relationships among the grass plants, the soil organisms in the rhizosphere, and the grazing mammals are not completely understood, but current knowledge has allowed development of biologically effective grazing management practices that beneficially stimulate these biological and ecological processes and improve the performance levels of the components of grassland ecosystems.

The mutually beneficial relationship between rhizosphere soil organisms and the roots of the grass plant can be enhanced by properly timed grazing. The rhizosphere--the narrow zone of soil around the roots of perennial grassland plants--contains bacteria, protozoa, nematodes, mites, springtails, and endomycorrhizal fungi. The grass plant's roots release carbon compounds, including simple sugars, to these organisms, and the rhizosphere organisms release mineral nitrogen that the plant's roots absorb. Grassland soils contain abundant quantities of nitrogen, but most of it is in the organic form and unavailable for direct use by plants. Soil microorganisms convert organic nitrogen to mineral nitrogen, the form that plants can use. Activity of the soil microorganisms increases with the availability of carbon compounds in the rhizosphere, and elevated microorganism activity results in increased mineral nitrogen available to the grass plant. The endomycorrhizal fungi also provide phosphorus, other mineral nutrients, and water that the plant needs for growth.

Grazing lead tillers between the third-leaf stage and the flowering stage can increase the amount of carbon compounds the defoliated plant releases into the rhizosphere. The increase in mineral nitrogen made available by elevated rates of microorganism activity allows the plant to accelerate growth and recover more quickly from defoliation. This beneficial activity does not seem to occur when grazing is conducted during the middle and late growth stages of the grass plant.

Activity of ectomycorrhizal fungi, a second type of beneficial soil fungi, can be stimulated by biologically effective grazing management. These fungi improve soil structure. Ectomycorrhizal fungi previously unknown in the mixed grass prairie were recently found in association with roots of grass plants managed with the twice-over rotation grazing system, which coordinates grazing periods with grass growth stages when defoliation resistance mechanisms are stimulated. The slow-growing ectomycorrhizal fungi develop a sheath around perennial grass roots and do not enter the tissue of the host plant as endomycorrhizal fungi do.

The ability of ectomycorrhizal fungi to improve soil quality results from their excretion of large amounts of insoluble polysaccharides with adhesive qualities. These substances stabilize soil particles and bind them into water-stable aggregates that range from about the size of air rifle pellets to the size of large marbles. An increase in water-stable aggregates increases soil pore size and distribution. The changes in soil quality improve soil oxygenation, water infiltration, and root distribution and decrease erodibility.

The rooting depth of rangeland soils at the location where ectomycorrhizal fungi were first discovered increased from 2-3 inches to 18-24 inches after seven years of management with the twice-over rotation system. The activity levels of ectomycorrhizal fungi are greater on pastures managed with the twice-over rotation system than on pastures under other grazing management because of the enhanced symbiotic relationship between the rhizosphere and healthy rangeland grasses.

The twice-over rotation grazing management system is biologically effective and applies defoliation treatment to grass plants at the appropriate phenological growth stages to stimulate the defoliation resistance mechanisms. A small amount of leaf material is removed by grazing animals when grasses are between the third-leaf stage and the flowering stage. This timed defoliation promotes the active passage of greater quantities of carbon compounds through the grass plant roots into the rhizosphere and stimulates soil organism activity. The increased activity of rhizosphere organisms, including endomycorrhizal fungi and ectomycorrhizal fungi, speeds the recovery of plants from grazing, improves soil structure, and accelerates the biogeochemical cycles within the grassland ecosystem.

Acknowledgment

I am grateful to Amy M. Kraus for assistance in preparation of this manuscript. I am grateful to Sheri Schneider for assistance in production of this manuscript.