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RESEARCH FACTS
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Does pasture management affect the environment?

Project Title:

Carbon sequestration, methane production and nitrous oxide emissions from cattle grazing native prairie

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Background

Carbon dioxide is the most famous greenhouse gas, but the “global warming potential” of methane is 25 times stronger (and nitrous oxide is 300 times stronger) than carbon dioxide. Forage plants sequester carbon dioxide, while cattle produce methane and nitrous oxide. The net impact of forage and beef production on greenhouse gases will depend on the relative production, storage and release of these various greenhouse gases by plants, animals and soil.

Plant root growth naturally sequesters carbon dioxide as organic matter in the soil. This stored carbon is released when soil is cultivated, which helps to explain why organic matter levels decline under summerfallow. Perennial forages require less tillage and develop a more extensive root system than annual crops, so forages increase the amount of carbon sequestered in the soil. Carbon is also stored in the stems and leaves of plants. Some of this carbon returns to the soil surface as plant litter and some is eaten, digested, absorbed and incorporated into the animal’s body, returned to the soil surface as manure, or exhaled as carbon dioxide or methane.

Legumes such as alfalfa and sainfoin can capture nitrogen from the atmosphere and store it as ammonia in the soil. Nitrogen is also stored as crude protein in the forage. Some crude protein is retained in the animal consuming the forage (e.g. muscles, skin, and hair contain protein), while some is lost in the urine and manure. Some urinary nitrogen is in the form of nitrous oxide which can move from the soil to the atmosphere, especially under warm, wet conditions.

Moisture availability and topography (e.g. low spots vs. hilltops) will also influence the degree to which forages grow and sequester carbon and nitrogen in the soil. Grazing management may also affect long term forage productivity and greenhouse gas sequestration, as well as the amount of methane and nitrous oxide produced by grazing cattle. As a result, the forage species grown, topography and grazing management may all influence the net environmental impact of forage-based beef production.

Objectives

To assess changes in soil organic carbon concentration in native range that has been grazed continuously (season long) or in a short-duration rotational manner, and to evaluate the potential greenhouse gas emissions from grazed forages.

What they did

These researchers conducted two experiments near Swift Current, Saskatchewan. Experiment 1 involved a native mixed grass prairie pasture on sandy loam soil with rolling topography that had been used in a 14 year grazing trial. Hilltops were primarily crested wheatgrass, slopes contained needle and thread, blue grama, and Northern and Western wheat grasses, and low spots had snowberry and bromegrass. The pasture was sub-divided so that each paddock contained hilltops, slopes and depressions. Some paddocks were grazed continuously (end of May through early July), and others were grazed in a deferred-rotational manner (turnout dates of mid-May, late-June, mid-May and late September). Pastures were grazed to a height of 3 to 5 cm. Soil carbon was measured from hilltops, slopes and low spots at the end of the 14 year study.

In Experiment 2, pastures containing either sainfoin (Nova) or a mix of alfalfa (Spredor) and hybrid brome grass (AC Knowles) were established and grazed in July for three seasons. Soil carbon, nitrous oxide loss from urine spots, and methane production by grazing steers were measured.

What they learned

In Experiment 1, soil organic carbon levels were the same in both the continuously and rotationally grazed pastures. However, differences in moisture levels, forage species, or both mean that carbon levels were higher in low spots than on the slopes or hilltops.

After adjusting for the level of forage intake, the amount of methane produced by cattle did not differ between the sainfoin vs. alfalfa-grass pastures in Experiment 2. Growing conditions that favored high forage productivity and digestibility appeared to reduce methane production by the animals. Some methane was absorbed by the soil, but did not differ between the sainfoin vs. alfalfa-grass pastures.

Although these pastures contained legumes, soil nitrous oxide emissions were low and very similar to ‘background’ emissions observed in short-grass prairie. Emissions did not differ between the sainfoin vs. alfalfa-grass pastures. Even though nitrous oxide emissions from urine spots were higher, the results of this research suggest that the Intergovernmental Panel on Climate Change may be vastly over-estimating urinary nitrogen loss by cattle on pasture (IPCC estimates may be 4 to 27 times too high).

When urinary and background nitrous oxide emissions were balanced with soil methane absorption, both the sainfoin and alfalfa-grass pastures produced similar amounts of greenhouse gas. However, the amount of greenhouse gas produced by these sources is likely dwarfed by the amount of carbon sequestered in the soil organic matter by the roots of these forages.

What it means

Within reason, ranchers can use continuous and deferred grazing systems on native range without altering soil carbon sequestration. Topography needs to be considered when soil carbon sequestration is estimated. Methane production by grazing cattle is lower when forage productivity and digestibility are improved. Nitrous oxide losses did not appear to be affected by legume type, but were considerably lower than IPCC estimates.

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