CHAPTER 48

Non-confined Winter Feeding in Frozen Regions: Benefits and Risks

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Cattle and forage production provides many economic and ecological amenities including high quality food for consumers, economic activity for rural communities, wildlife habitat, protection from soil erosion and sequestration of carbon. In the Canadian prairies, conventional grazing on pasture is not generally possible in winter and supplemental feed must be provided. Over the last decade, an adverse economic climate has led many producers to explore low-cost alternatives for overwintering cattle, based on grazing of stockpiled forage, standing or swathed corn, swathed cereal grains or hay bales.

The economic advantages of these systems have been demonstrated in several studies (Karn et al. 2005; Kelln et al. 2011; McCartney et al. 2004). In Saskatechewan, costs for extensive feeding systems (swath, bale and straw-chaff grazing systems) had 18% lower total systems costs compared to a drylot system (Kelln et al. 2011). Similarly, trials conducted in Alberta have demonstrated that swath grazing reduced feeding costs by 40–46% compared to a more traditional diet of straw and barley silage fed daily or every second day (McCartney et al. 2004).

In addition to reducing feeding costs, overwintering cattle management must consider animal productivity and health (e.g. calving rate, weight gain); forage crop productivity and persistence; soil productivity; and environmental factors such as water quality contamination by pathogens and nutrients, and net greenhouse gas emissions. This chapter describes current knowledge on cattle overwintered in non-confined feeding systems.

Animal productivity

Several studies have been conducted to examine the effects of winter feeding systems on beef cow performance and reproductive efficiency. In a three-year study conducted in central Alberta, swath grazing reduced weight gain in cows compared to those fed barley-silage:straw diets in confinement, but there were no differences between systems in calving interval, length of calving span and birth or conception rates (McCartney et al. 2004). Another study in the Prairie region (Kelln et al. 2011) reported weight loss over a 78-day period in cattle overwintered in a bale graze (-7.5 kg) or straw chaff (-6.4 kg) grazing system, while animals in the dry lot realized gains of 9.1 kg. Greatest losses (-23.7 kg) occurred in cattle that were grazed in the swath grazed system. However, the following year, cattle in all systems gained weight with the greatest gains realized by dry lot cows (+32.9 kg), followed by swath grazed (+28.1 kg) and bale grazed cows (+14.6 kg). Observed differences in weight loss/gain may be related to a reduction in feed quality and inaccessibility of the feed associated with adverse weather (Baron et al. 2006). Factors which impact daily grazing time in the Northern Great Plains, which has been shown to range from 0.5 to 11 h/day, include cow age, presence of snow cover, wind velocity and minimum daily temperature (Adams et al. 1986).

Crop/soil productivity

Increasingly rigorous regulations for mechanical application of manure has raised concern about the environmental implications of extensive cattle overwintering systems. Several studies have been conducted and/or are underway in western Canada to determine the impact of overwintering practices on soil nutrient profiles, including nitrogen (N) and phosphorus (P), as well as plant productivity of annual and perennial stands produced on the overwintering site during the subsequent growing season.

Winter feeding baled or processed bales of hay and straw fed on a Russian wild ryegrass pasture (stocking density of 2080 cow days/ha) was compared to conventional feeding in a drylot pen and mechanically spreading of manure (67 t/ha) or compost (22 t/ha) on pasture (Jungnitsch et al. 2011). Soil inorganic nitrogen (0–15 cm) from the overwintering site, although highly variable, was 3–3.7 times (117 kg N/ha) greater than the unfertilized control treatment. In contrast, soil inorganic N was similar for unfertilized control pastures and for pastures receiving the raw or composted manure. Forage dry matter yields were 3.3–4.7 times greater for winter feeding pastures and 1.4–1.7 times greater for pastures receiving raw manure or compost compared to controls. Of the feed imported to the field, 30–40% of N and 20–30%, of P was recovered in the subsequent forage crop. In contrast, only 1% of feed N and 3% of feed P was recovered in the forage fertilized with manure from the confined system. These data suggests that the overwintering systems support greater efficiency in recycling winter feed nutrients into pasture forage growth compared to confined feeding.

Productivity and nutrient distribution have been explored on growth of annual crops. The effects of bale, swath and straw-chaff grazing on amounts and distribution of soil N and P and on growth of barley planted the following spring indicated that nitrate nitrogen in the 0 - 15 cm depth was 53% higher on the bale grazing site compared to the straw-chaff site due to an accumulation of feed/feed nutrients in the bale graze system (Kelln et al. 2012). Available P was 34% higher in the bale grazing site compared to the other two systems. The distribution of nutrients was highly variable for bale and straw-chaff grazing treatments. Soil density was 21% greater in the bale grazing system compared to grazed straw–chaff piles, indicating compaction. Soil density decreased on compost and raw manure sites compared to those where no manure was applied, demonstrating the benefit of manure on soil structure. Total crop biomass from the bale grazed sites was 15% greater compared to the other two sites. Soil nutrient and crop biomass distribution was most uniform in the straw-chaff system and least uniform in the bale grazed system.

It is apparent that both annual and perennial systems can benefit from the recycled nutrients available from feed/manure generated from cattle overwintering systems. However, it is important to note that nutrient distribution in these systems may be highly variable and in some circumstances, may increase the risk of nutrient accumulation particularly when feed is imported into the system, as is the case with bale grazing.

Other environmental considerations

Pathogen presence/persistence

Grazing livestock can affect water quality if they are not appropriately managed. Although there have been reported increases in coliform concentrations in nearby water courses, little is known about the bacterial concentrations near winter feeding sites. There is little data from western Canada where frequent freeze-thaw cycles may occur over winter. However, winter grazing sites located in Kansas and Washington had elevated fecal bacteria concentrations over the winter feeding period with greatest numbers near the round-bale feeders. Whereas fecal *E. coli* concentrations returned to those in the pre-feeding period after three months, fecal *Streptococci* concentrations remained high (Lenehan et al. 2005).

Water quality

The potential impact of nutrients and pathogens associated with winter feeding sites on water quality is an important public concern. It has been demonstrated that most of the runoff on the Prairies occurs during snowmelt, accounting for 79% of annual runoff in south-central Manitoba (Glozier et al. 2006); 85% in southern Saskatchewan watersheds (Nicholaichuk 1967); >90% averaged across 8 watersheds in Alberta (Little et al. 2007); and ~0–76% in Crowfoot Creek, Alberta (Ontkean and Chanasyk 2005).

The consequence of a snowmelt-dominated runoff system is that the majority of nutrient and pathogen loading into Prairie streams, rivers and lakes occurs in early spring. New information suggests that the processes of nutrient losses in snowmelt dominated runoff differ from those in rainfall-dominated runoff. As a consequence, beneficial management practices may differ from those recommended for rainfall-dominated runoff. Rainfall runoff generates significant amounts of erosion and causes substantial losses of nutrients in particulate forms. In contrast, snowmelt runoff occurs relatively slowly over frozen soils and often favours larger losses of dissolved than particulate forms of nutrients. Vegetative buffer strips, when examined in Vermont, were not effective in intercepting P, N or suspended solids in runoff from a livestock yard during the winter and snowmelt period (Schellinger and Clausen 1992). The dissolved nutrients are very difficult to intercept during early spring when vegetation is dead or dormant. Also, recent research in Manitoba has shown that vegetated buffer strips are less effective than expected for intercepting N and P (Sheppard et al. 2006).

Given the high proportion of runoff that comes from snowmelt, manure application on frozen soil or snow is a poor agronomic and environmental practice (Srinivisan et al. 2006; Klausner 1976; Young and Mutchler 1976). In Manitoba, mechanical application of manure during winter is banned for large livestock operations and will be banned for all livestock operations in 2013. Fortunately, only 3% of mechanically applied manure is applied in winter.

However, there are also concerns about runoff contamination from feces and urine deposited directly onto snow and frozen soil by non-confined overwintering cattle, as well as the substantial amount of wasted feed that is often left behind. Bale grazing, in particular, has attracted the most concern, since this system often results in large imports of nutrients into the overwintering area. For example, if 550 kg bales of hay are fed at the recommended spacing of 12 m apart, the gross loadings of N and P are often greater than 500 and 80 kg/ha, respectively. As a result, N and P loadings usually exceed plant uptake and increase risk of runoff and leaching losses. In bale grazing investigations in southern Manitoba, for example, concentrations of nitrate-N in soil were as large as 500 kg/ha in the top 120 cm, while Olsen-extractable P concentrations were as large as 200 kg/ha in the top 15 cm (Picard, pers. comm.).


Waste feed and manure are still visible amidst the spring forage growth in the second year following bale grazing.

These concerns have prompted several studies in the Canadian Prairie provinces to examine nutrient losses to surface runoff after bale grazing. Although none of these studies are fully complete, preliminary results demonstrate that these concerns are justified. In the South Tobacco Creek Watershed Evaluation of Beneficial Management Practices project in southern Manitoba, annual N losses from a bale grazing area were as large as 40 kg/ha, more than ten times larger than from the adjacent control area (Elliott, pers. comm.). Preliminary results from a winter bale grazing research project in southwestern Saskatchewan show similar trends for substantial losses of P in the runoff (Cade-Menun, pers. comm.). Therefore, bale grazing sites should be located where the risk of runoff reaching significant water courses or water bodies is low.

Greenhouse gas emissions

Gaseous emissions from non-confined winter feeding of beef cattle include ammonia and the greenhouse gases nitrous oxide (N_2O), methane and carbon dioxide. Nutrient loss from the system is detrimental not only in terms of the environmental implications but also in terms of the need to import additional nutrients to maintain forage/crop productivity. Gaseous emissions can originate from two main sources: i) enteric methane from cattle associated with microbial fermentation of feedstuffs in the rumen and ii) microbial activity in soil and manure. Therefore, these emissions can be affected by management decisions involving cattle productivity during the winter feeding period and crop/forage management of the land following winter feeding. However, little peer-reviewed research has been published to date regarding gaseous emissions from these systems.

Greenhouse gas emissions have been measured from beef cattle overwintered in confined feeding systems, including enteric methane from open beef cows (Bernier 2011) and enteric methane and bedding pack greenhouse gas emissions from beef steers (Boadi et al. 2004). Methane emissions, expressed as a percent of gross energy intake, were significantly decreased in open cows that were cold-stressed compared to open cows fed the same diet in thermal neutral conditions (Bernier et al. 2012). As enteric emissions from cows are the largest contributor to net greenhouse gas emissions from beef production systems in western Canada (Beauchemin et al. 2010), decreased enteric methane emissions during the winter months could be an important reduction in the net emission inventory from beef cattle production systems. Further studies are needed to measure enteric methane emissions from beef cows in non-confined winter feeding systems on the Prairies.

Measuring greenhouse gas and ammonia emissions from soil and manure in a non-confined feeding system during the overwintering period is difficult due to cold temperatures, snow pack and high variability in the distribution of nutrients over the landscape. Manure from these systems differs from manure accumulated in a confined feeding system as it is characterized by patches of feces, urine and/or waste feed, which are associated with high-traffic areas including wind shelters, watering sites and feeding areas. Deposition of feces and urine may occur directly on frozen soil and forage or on a snow pack of various depths, leading to areas of high and low nutrient accumulation. In addition to nutrient concentration, other factors which may influence gaseous emission from soil and manure in these overwintering systems include soil type, topography, depth of snow, speed of snow melt, number of freeze-thaw events, soil moisture conditions, weather and crop/forage management over the following spring and summer period.

Although there are no peer-reviewed publications examining gaseous emissions from non-confined overwintering sites in North America, nitrous oxide, methane and ammonia emissions have been measured from clay-silt soils in non-confined winter feeding systems in Sweden (Salomon and Rodhe 2011). In this study, silage bales were placed on a forage field occupied by pregnant beef heifers (71 heifers/ha). The bale grazing technique was similar to that used in North America. Cumulative nitrous oxide emissions were not different from high or low congregation areas compared to a control site for a period of 149 days after heifers were removed from the field. Differences were apparent in the timing of nitrous oxide release as the control area had the greatest losses (18 g N_2O-N/ha/d) during the spring while the low congregation area had the greatest losses (30 g N_2O-N/ha/d) in the fall and early winter period. The soil in all three locations acted as a carbon sink during the fall and early winter period, with negative methane emissions. The low congregation area, however, lost carbon in the form of methane during the spring. Ammonia emissions were low during all periods, ranging from 0.1–0.3 kg N/ha/d.

Nitrous oxide emissions during the winter months have been reported from land previously used for summer pasture in the Northern Great Plains (Liebig et al. 2010). Emissions were evident during warming periods and spring thaw. Collectively, these findings suggest that nitrous oxide may be produced in non-confined winter feeding areas during the winter months.

Form of nutrient addition to soil may also play a significant role in gaseous emissions from soil and manure (Jones et al. 2007; Donohoe 2011), and different winter feeding systems may result in different forms of nutrient additions to the soil. Annual crops grown for swath-grazing, for example, may receive added nutrients in the form of inorganic nitrogen fertilizer, whereas bale grazing and feeding processed forages on pasture will result in the addition of large quantities of organic nutrients and carbon to the soil surface as waste feed (Jungnitcsh et al. 2011). These different forms of nutrient additions may result in different soil microbial processes, leading to different patterns and quantities of gaseous emissions (Jones et al. 2007; Donohoe 2011). Observed increases in urine and fecal nitrogen and phosphorus (Bernier 2011) with higher concentrations of available nitrogen (Donohoe 2011) have been reported in cold-stressed open cows compared to thermal neutral cows fed the same diet. It may be speculated that increased concentrations of available nutrients could lead to increased emissions from soil and manure as well.

Conclusion

The economic merit of non-confined winter grazing systems has been reported anecdotally by producers and confirmed through published literature. However, much less information is available regarding potential losses in animal performance and nutrient movement associated with these overwintering sites. Although several studies have demonstrated that cattle in non-confined overwintering environments may achieve comparable gain and reproductive performance compared to cattle in confinement, reduced gains have been reported between the two systems. Extreme environmental conditions such as an abundance of snow or prolonged cold may hinder performance. These effects can be minimized by providing adequate protection though the use of wind fences, monitoring forage quality and providing supplementation when required.

Increases in both forage quantity and quality may also be realized in non-confinement feeding compared to feeding animals in a confinement with subsequent application of manure. This may be attributed to greater efficiency in recycling winter feed nutrients into pasture forage growth compared to confined feeding systems. However, the potential for nutrient run-off does exist, particularly in high slope positions. Decisions regarding site selection and stocking density are paramount to ensure the sustainability of these overwintering sites.

Given the challenges of developing beneficial management practices that are suited to the Prairies, scientists, producers and extension specialists must work together to develop, adapt and test beneficial management practices (new or old) that will address the many factors that are required for economically and environmentally sustainable cattle overwintering systems. And, while doing so, we should keep in mind the many opportunities, economic and environmental goods and services that cattle and forage systems also generate. Therefore, it is worthwhile to engage a broad range of private and public partners to work on this issue.

References available online at www.farmwest.com

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