# Managing Dairy Cattle Pasture for Biodiversity

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## Introduction

Viewing agriculture as a modified ecosystem generates the need to also view biodiversity as essential and potentially beneficial.

Biodiversity increases the resilience and stability of agricultural production in the face of pests, diseases, variable weather and climate, and economic fluctuations.

Biodiversity is also important for its own sake and for the well-being of the wild biota.

Biodiversity is enhanced by complexity in habitats at scales ranging from landscapes, within fields, among plants, down to the soil fabric.

The focus of this research is milk production or the dairy production system, at the core of which exists a grassland area producing forage that normally provides 40 to 90 percent of the feed energy for the cows.

**The objective** is to promote pasture in the landscape, and to develop habitat complexity within pasture fields to encourage greater biodiversity.

## 1. Pasturing Dairy Cows Reduces Environmental Impact

### Introduction

Where feasible use of pasture for lactating cows can improve profitability of a dairy farm.

Also, we hypothesize that, when all inputs are considered, the environmental impact of confining dairy cows is higher than that of employing pasture for 7 months of the year.

### Method

A Life-cycle assessment using SimaPro-v.6 was conducted to compare environmental costs of producing 1 Mg of milk in confinement systems to those that pastured cows for up to 7 months /year in Atlantic Canada. All direct and embedded costs of all inputs including growing grain, facilities and machinery, transportation, housing, and land use were included (Fig. 3).

### Results

Relative Environmental Impact = Pastured - Confined

| | (%) | | (%) |
|---|---|---|---|
| Acidification | -19 | Terrestrial ecotoxicity | minor |
| Ozone layer depletion | -15 | Photochemical oxidation | minor |
| Freshwater aquatic ecotoxicity | -13 | Global warming | minor |
| Human toxicity | -11 | Eutrophication | minor |
| Marine aquatic ecotoxicity | minor | Abiotic depletion | minor |
| Land use | minor | | |

### Conclusions

The reduction in environmental impact of pasturing dairy cows relates to lower use of grain and fuel.

**Figure 1:** Mower and chain harrow used for intensive pasture management

**Figure 2:** Managing pasture for biodiversity; conventional (foreground) and lax (right) grazing treatments. The treatments are repeated again in the background.

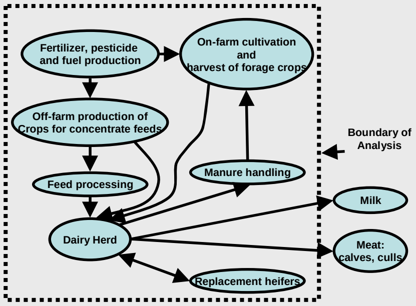




**Figure 3:** LCA milk production analysis inputs, outputs, and system boundaries

## 2. Grazing Management to Create Habitat Complexity

### Objective

Use grazing frequency to create different heights of pasture.

### Hypothesis

By varying grazing intensity we can create different habitats in the pasture, each favoring different groups of organisms.

### Methods

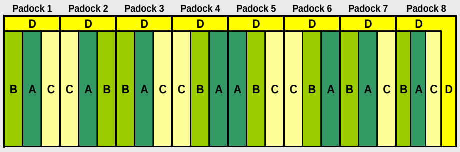
Since 2004, rotational grazing was used to create four levels of management intensity replicated in eight paddocks:

**A) Intensive management:** grazed every rotation, then mowed and chain harrowed (Figure 1)

**B) Conventional management:** grazed every rotation, mowed only once in June (Figure 2).

**C) Lax management:** grazed every second rotation

**D) Stockpiled:** grazed once at the end of July.





## 2.1. Pasture Quality and Cow Performance

Plants under lax-grazing (C) were more mature when grazing, so their nutritional quality of the forage was lower the A and B treatments (i.e., higher NDF, lower CP).

There was no detrimental effect in having one third of the pasture as lax-grazed (C) sward on cow performance: milk yield, protein and fat content, and cow body condition. Cows were able to selectively graze the more nutritious components out of the C-sward.

From the perspective of a grazing dairy herd, the C treatment results in half the forage being uneaten so we can't recommend that it occupy a large portion of the pasture landscape. The C treatment will have to be justified for some other reason such as providing habitat for above-ground insects and birds, and the input of organic matter into the soil.

## 2.2. Botanical Diversity

In general, botanical diversity was deceased by lax grazing

There was a management intensity-by-productivity interaction: When productivity was high, botanical diversity was increased by intensive management — probably because it reduced plant competition. When soil productivity was low, pasture management has little effect on botanical diversity.

For more details see Poster 654, Session 270, Wednesday, November 7

## 2.3. Above-Ground Arthropods

The initial objective is to document the diversity of beetles, both predaceous (e.g. Carabidae and Coccinellidae) (Figure 5) and herbivorous (e.g. Curculionidae and Chrysomelidae.

Beetles were collected with pitfall traps and by sweeping through the summers of 2004 and 2005.

In the 7,345 individuals collected, 137 species are represented. Several significant records are included, *Ceutorhynchus oregonensis* (Curculionidae) first record for Atlantic Canada, *Notiophilus novemstriatus* (Carabidae), second record for Canada, and *Lathrobium armatum*, *Oxypoda brachyptera* (Staphylinidae) and *Ceutorhynchus neglectus* (Curculionidae) new records for Nova Scotia. The four most speciose families all have more than 20 species and among them contained more than 70% of all species: weevils, Curculionidae (34), rove beetles, Staphylinidae (30), ground beetles, Carabidae (23) and leaf beetles, Chrysomelidae (21).

Most species in these four families are not native to North America, with most arriving in North America through unintentional introductions. All of the 15 most abundant species are not native to North America. All of these 15 species were found in all four treatments.

Reduced intensity of grazing did not increase species richness after two years, because the most abundant species were found in all four treatments. Ten species were collected more frequently than expected in certain treatments, including 5 in the most intensively grazed and 3 in the least intensively grazed.

## 2.4. Soil Biota

1. What is the effect of changing above-ground biodiversity (plants, insects, other micro-invertebrates) on below-ground diversity (protists, fungi, micro-invertebrates) (Figure 6)?
2. What is the effect of above-ground management intensity on below-ground diversity?
3. Do changes in above-ground diversity and management affect below-ground diversity and food web structure immediately, or over several years?

We found that above-ground biodiversity does not necessarily correlate with below-ground biodiversity.

We also found that community structure changes below-ground and above-ground may be occurring at different time scales. Overall, plant diversity peaks with semi-intensive field management, as predicted by theory. Below-ground biota respond more slowly, and bio-indicator organisms are affected differently. For example, whereas bacteria responded to treatment (by ECOLOG assay) within 2 years, the protozoa response was marginally significant statistically in year 3, but becoming significant in year 4.

A detailed analysis of nematode functional diversity showed an increase in fungivores with time in management intensive grazing, similar to our treatment C. This is a very positive sign of a healthy food web establishing and maintaining itself in the soil, under this kind of grazing management.

**Figure 4:** Suction lysimeter and pump to extract soil solution at a depth of 60 cm.

**Figure 5:** Example of a Carabid ground beetle, Amara aenea.

**Figure 6:** Example of below-ground biota; collembola and mites.

**Figure 7:** Plots containing various combinations of 4 domesticated grasses.

## 2.5. Soil Nitrate Leaching

Soil nitrate leaching under the grazing treatments was measured with suction cups buried 60 cm deep in the soil (Figure 4)

Unfertilized pasture relying primarily on $N_2$ fixed by *Trifolium repens* L. is very conservative of N. Three quarters of all nitrate nitrogen values were low (below 2.5 mg/l) in 2005 and 2006

On average, the nitrate content of the soil solution increased slightly as the intensity of grazing management increased.

The maximum nitrate values were measured during sward regrowth of the second rotation in each of two experimental years.

## 2.6. Conclusions

1. Milk from pastured dairy cattle costs less to produce and has a lower environmental impact than milk from confined dairy herds.
2. Pasture can be managed to create diverse habitats without reducing cow performance or healthy.
3. Different groups of organisms are favored by different intensities of grazing. In particular:
   1. Botanical diversity was enhanced by moderate grazing, but reduced by lax grazing.
   2. Above ground arthropods prefer tall, lax-grazed swards.
   3. Soil bacteria are favored by intense grazing, while fungi are favored by lax grazing

## 3. Do Grass Mixtures Yield More than Monocultures?

**Objective**

Can biodiversity in grass mixtures improve total pasture yield, and the consistency of yield over the growing season?

Grasses differ in growth habit and growth over the season, so may complement each other in mixtures. Different combinations of grass species may yield better under rotational vs. stockpile grazing, or in dry vs. wet growing seasons.

**Method**

Combinations of timothy (*Phleum pratense*), Kentucky bluegrass (*Poa pratensis*), meadow fescue (*Festuca pratensis*), and reed canarygrass (*Phalaris arrundinace*) are being grown under (a) rotational or stockpiling grazing (b) rotational grazing with varying nitrogen fertilizer (Figure 7).

**Preliminary Results**

Under rotational grazing, simple binary mixtures containing Kentucky bluegrass have the most consistent yield. Timothy yielded well in the spring, but poorly later in the season

The benefit of complex mixtures of grasses may not be in yield at the 0.1 m² scale, but in supplying a range of grasses for different micro environments. However, what establishes and what is best adapted may be different species.