Forage Quality and Biodiversity Under a Delayed Cutting Regime in the Fields of Belleisle, Nova Scotia: A Comparison of Late Cultivar and Conventional Hayfields

Submitted: June 26th, 2008

Submitted By: Sean LeMoine

Supervisors: Dr. Soren Bondrup-Nielsen, Dr. Kenna Mackenzie, and Glen Parsons

Table of Contents

List of Figures

List of Tables

Acknowledgements

I would like to thank the Nova Scotia Department of Natural Reseouces Habitat Conservation Fund for supporting this study. I would also like to thank my supervisor Soren Bondrup-Nielsen as well as, Glen Parsons and Randy Milton, NS DNR and Kenna MacKenzie, Agriculture Canada and finally I would like to thank Ken Neil and Katherine Dugas who helped me in the field.

Abstract

For this study, newly (2-3 years old) planted late cultivar hayfields at Belleisle Marsh provided improved forage quality in comparison to adjacent, older conventional hayfields (10+ years old). A significant drop in late cultivar forage quality in 2006 and the difference in field age imply that more research is required. No difference was found in grassland bird abundance nor Lepidoptera species richness and abundance, however carabid species richness was found to be greater in conventional hayfields. This difference was related to higher vegetation richness rather than field type. More specifically, species richness of plant-eating carabids (herbivore) was positively associated with greater vegetation richness.

1. Introduction

Since the Earth Summit in Rio de Janeiro in 1992, there has been an increased focus on studies looking at species diversity. This is especially apparent in agro-ecosystems as modern agriculture is recognized as one of the greatest current threats to worldwide biological diversity , of which species diversity is a component. An example of the negative impact that modern agriculture is having on species diversity is the recent, severe decline of North American grassland bird populations . Grassland birds readily nest in hayfields. The average harvest date of hayfields, which has become progressively earlier, is believed to be an important contributing factor to these population declines because these species are unable to fledge their young before the fields are harvested. One option to address this problem is to cut conventional hayfields at a later date. Though it has been demonstrated in Nova Scotia that grassland bird fledgling success can significantly improve for fields cut after the first week of July , forage quality of hay fields cut later in the season does not necessarily meet the nutrient requirements for beef cattle at specific growth stages such as levels required for calves and pregnant females (Nocera *et al.* 2005). A possible solution to this dilemma is to plant a late maturing hay cultivar. Such a cultivar could potentially meet the nutritional forage requirements for livestock, even when harvested later in the season. The objectives of this study were to determine:

1. If forage from fields planted with a late cultivar, under a delayed cut regime would be of similar or higher quality than forage from conventional hayfields cut at an earlier date,
2. If grassland bird and invertebrate communities differ between field types, and
3. How vegetation of the field types influenced invertebrate diversity.

To address these questions, we investigated the nutritional quality, grassland bird abundance, invertebrate diversity, and vegetation composition of recently planted late cultivar hayfields (2-3 years old) as well as adjacent, established conventional hayfields (10-20 years old) in the Belleisle Wildlife Management Area (BWMA), Annapolis County, Nova Scotia. The three species of grassland birds we considered for this study were the savannah sparrow (*Passerculus sandwichensis*), bobolink (*Dolichonyx* *oryzivorus*), and Nelson's sharp-tailed sparrow (*Ammodramus caudacutus*). All three of these species were frequently known to nest in Nova Scotia hayfields. The two groups of invertebrates we considered were ground beetles (Carabidae: Coleoptera), and the larvae of butterflies/moths (Lepidoptera). Coleoptera and Lepidoptera larvae are considered two of the most important invertebrate food sources for grassland birds and their young during the breeding and nesting season . In addition, ground beetles are considered beneficial due to their potential as biological pest control agents , while the majority of moth/butterfly larvae found in forage fields are recognized as agronomic pests.

2. Site Description

The study took place at the Belleisle Marsh Wildlife Management Area (hereafter "Belleisle"; 326 ha) in western Annapolis Valley, Nova Scotia, Canada (Fig.1). The predominantly government-owned Belleisle is managed for both wildlife and agricultural benefits in a multifunctional approach integrating wildlife habitat and human land use. Agricultural land in Belleisle is licensed to farmers through a periodic tender system, with licensees being required to adhere to a management strategy that includes delayed hay cutting (currently post 1 July) and pesticide restrictions. Belleisle currently supports several small beef-cattle operations and was seeded for hay (in the late 1980's, early 1990's; 120 ha) with mixtures of timothy (*Phleum pratense* L.), various bluegrass species (*Poa* spp.), and reed canary grass (*Phalaris arundinacea* L.). In the winter of 2003, three hayfields totaling 20 ha were planted with Comtal ® timothy (a late maturing variety of timothy grass), and in the spring of 2004 those same fields were also frost-seeded with Altaswede ® red clover. The three late cultivar fields, along with three adjacent, older, conventional hayfields, represented the fields for this study, which was conducted in 2005 and 2006. Two of the study fields, one conventional and one late cultivar field, were privately owned and were prepared, planted, and harvested by the landowner. The remaining four fields were prepared and planted by a contractor and harvested by local farmers. In 2005 fertilizer was applied in late July after the first cut, whereas fertilizer application in 2006 occurred in early June. In 2005, fertilizer (13N: 32P: 18K) was applied to all six of the study fields at the rate of 250 lbs/acre and in 2006 it was again applied (17N: 17P:17K) at 300 lbs/acre. Historically, fertility management has been accomplished by periodic (ca. every 10 years) applications of lime, at approximately 270 kg/ha per field.

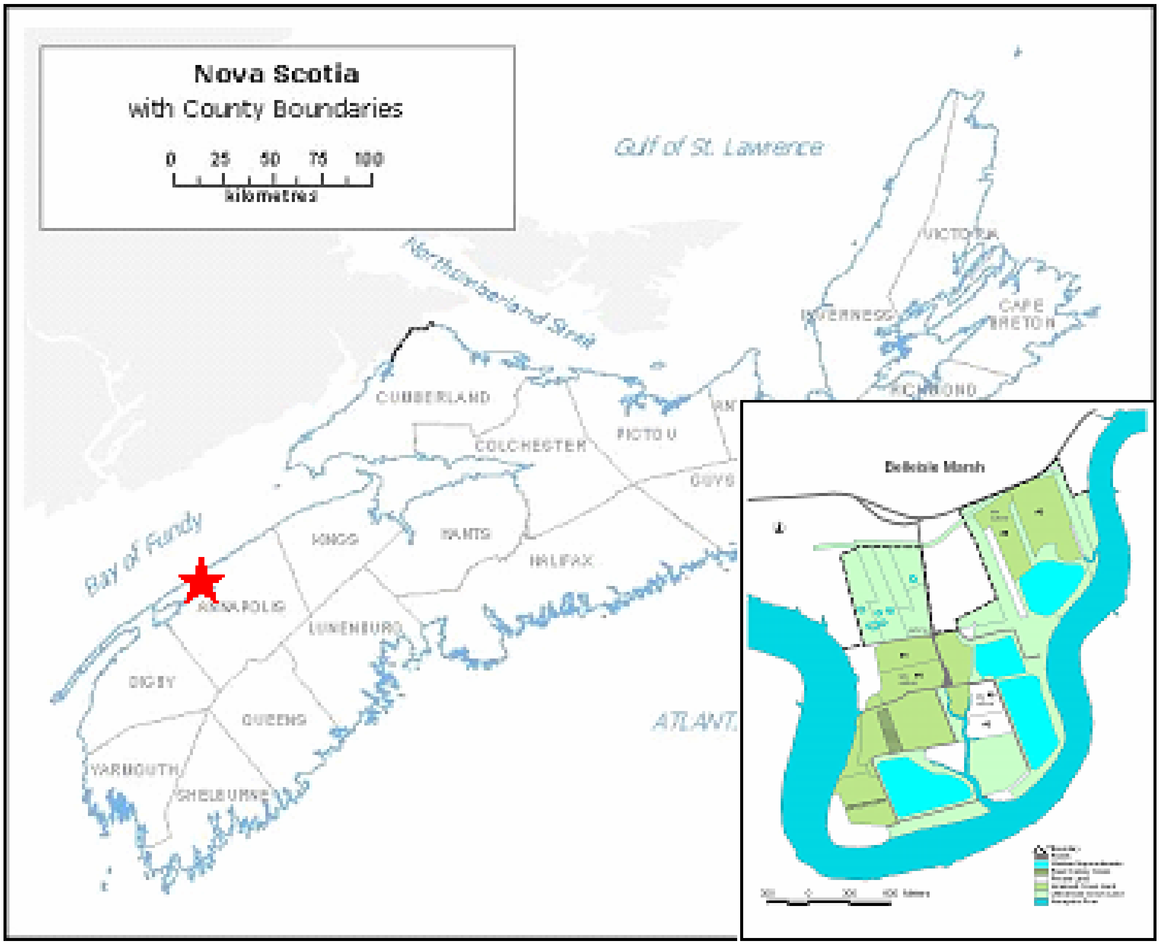

Figure 1 Map of the Belleisle Marsh Wildlife Management Area including the late cultivar fields (Field #4-6) and the adjacent conventional hayfields (Field #1-3).

3. Methods

Sampling for vegetation, forage, and invertebrates was performed in sample plots using a random grid/plot design. In 2005, grassland birds were sampled at 10 points (five in each field type) pre-determined from previous point counts conducted at Belleisle (Nocera *et al.* 2005). In 2006, five additional points were added as control points in Belleisle fields in which no forage or invertebrate sampling was being conducted. In 2005, twenty sample plots were identified within each of the six hayfields (three fields of each field type) for vegetation and invertebrate sampling. Plots were determined by dividing each field into 25m by 25m plots and numbering each plot. Twenty plots were then randomly chosen from the total number of plots for each field using a random numbers table, thus identifying each sample plot location. In 2006, only 15 sample plots/field were used. Otherwise, plots were determined as above.

3.1 Vegetation

Fields were sampled for vegetation composition using a 0.1m^2 (0.2m*0.5m) quadrat following the Daubenmire canopy coverage method . Each species identified in the quadrat was assigned a cover class based on a six point scale (Table 1 & Fig.2). The midpoint for each cover class (Table 1) was used to give a percent cover value. In addition, species were grouped into vegetation types (grasses, legumes, and forbs) for which a total percent cover was also determined. The vegetation type "Grasses" included grasses, sedges and rushes. "Legumes" included clovers, alfalfa, and vetches. "Forbs" consisted of all other remaining broadleaf plants.

Table 1 Daubenmire coverage classes with corresponding percent area of coverage and coverage range midpoint

Coverage Class	Area of Coverage (%)	Midpoint (%)
1	1-5	2.5
2	6-25	15.0
3	26-50	37.5
4	51-75	62.5
5	76-95	85.0
6	96-100	97.5

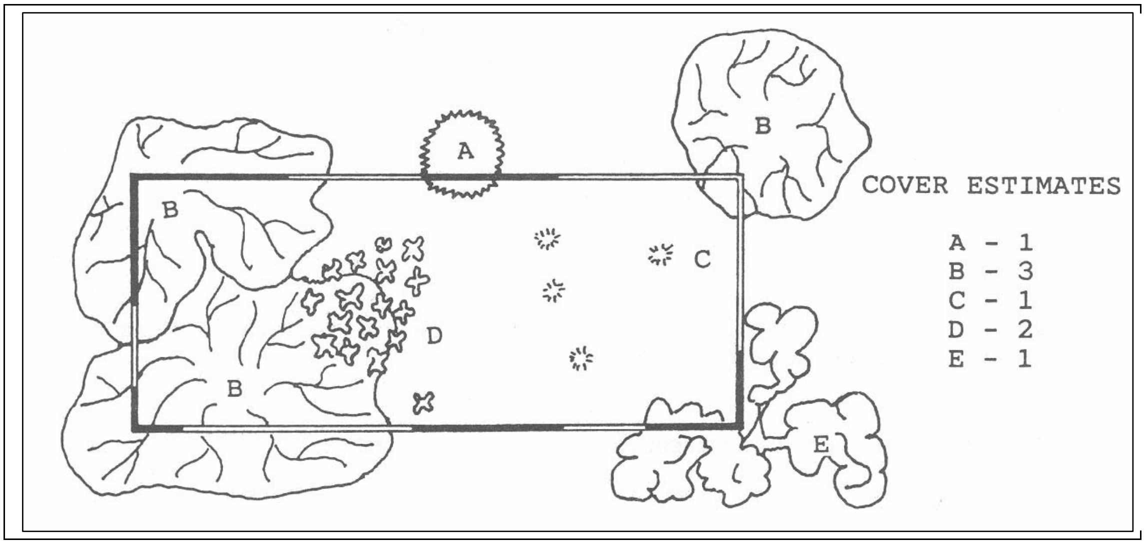

Figure 2 An example of estimating cover in a single quadrat with the Daubenmire canopy coverage method .

For both years, vegetation sampling occurred during the last week of June. During this time, the majority of the species found in the fields had bloomed and were easier to identify. In 2005, 20 plots were sampled in each field, each with a single quadrat (60 samples per field type) which was place five meters to the east or west (alternated between plots) of each plot center. In 2006, only 15 plots were sampled in each field, however, two quadrats were sampled per plot, one five meters to the east and one to the west of the plot center. The results of the two squares were then averaged to provide a percent cover (45 samples per field type).

Forage quality was sampled weekly for a six week period from mid June to late July. This period covered both the time in which local farmers generally cut their fields for hay (~June 20th) and the fledging period of nesting grassland birds (<July 7th). For both years, samples were collected from five of the previously described plots within each of the six fields, resulting in 15 samples/field type. At each sample point, one would walk ~16 metres from the centre and then proceed to circle the sampling area, reaching down and cutting a group (8-12) of stems at the front of the lead foot every ten steps. This was repeated until the starting point was reached. The end result was a sample weighing between 200 and 300 grams. Stems were cut 8-10 cm above the ground to replicate the height at which hay is harvested. Each sample was then dried for 48 hours at 60°C, then

ground with a Wiley Mill (1mm sieve). A five gram sub-sample of each ground forage sample was then sent to the Nova Scotia Department of Agriculture and Fisheries-Feed Quality Evaluation Division in Truro for nutrient analysis. The samples were analysed for a number of variables including crude protein (%CP), acid detergent fiber (%ADF), calcium (%Ca), and phosphorus (%P). Variables were compared to recommended levels for beef cattle .

3.2 Invertebrates

Carabidae or ground beetles were sampled using pitfall traps. Pitfalls consisted of a 15cm deep plastic cup buried flush to the soil surface. Each pitfall contained ~3cm of water, two salt tablets to help preserve captured specimens, and liquid soap to break the surface tension and prevent captured beetles from languishing on the surface of the water. Each pitfall was also covered by a 4” by 4” plywood top (supported by wire legs) to keep out rain and reduce incidental capture on non target organisms such as small mammals and frogs. Active periods for the traps varied between the two years (see below), however, when not active (not collecting specimens), each trap was fitted with a plastic cover to prevent accidental captures. All traps were located at least 10m from a field edge to reduce the presence of edge/hedgerow associated species and at least 25m from other traps to reduce depletion effects . Specimens were removed and placed in a zip lock bag containing 70% ethanol. In the lab, individuals were keyed to species with Lindroth . Examples of each species were pinned and labelled following the methods outlined by Wheeler *et al.* (2001) . Individuals which were difficult to identify or rare were sent to the Agriculture and Agri-Food Canada office in Ottawa for identification by Dr. Henri Goulet. From this collection, a voucher collection was provided to the national museum and reference specimens have been made available for provincial and federal institutions.

In 2005, one pitfall was placed in the centre of each plot. Traps were set during the third week of each month and sampled the following week (starting May 19th ~ end of July), resulting in three, one-week sampling periods. In 2006, two pitfall traps were placed in each plot, five metres north and south of the centre of each plot. Traps were set during the second week of May, sampled biweekly until the end of July, and remained open (active) every other week. This resulted in two one week samples for each month or six sampling periods. The reason traps were only active every other week was to ensure the quantity of ground beetles captured was manageable in relation to handling time and identification, as well as to reduce the chance of over sampling the population. Once harvesting started, fields or even sections of fields were harvested at different dates. This made it difficult to compare invertebrate sampling once harvesting started. Due to the difficulty in separating the effects of July hay harvesting on capture rates, only specimens captured in May and June are included in this report.

Lepidoptera larvae were collected with sweep nets from May to July for 2005 and 2006. A cool spring and insufficient sampling effort (once/month) appeared to have resulted in only a few specimens (<15 individuals) from 2005. Due to a small number of individuals collected from 2005, only those collected in 2006 are included in this report. For 2006, sweep netting began on May 24th and was conducted every second week, weather permitting. Two sweep transects were conducted at each sample point. A transect consisted of 10 sweeps or passes of a canvas sweep net through the upper third of the vegetation while walking 10 steps (~15m). During a single sample period transects were walked in a southwest and northeast direction from the sample point. For the following sample period, sweeps were conducted in a southeast and northwest direction, after which this rotation was repeated. This resulted in any portion of sampled vegetation having the potential of being swept only once a month. Once each transect was swept, the net contents were searched and all Lepidoptera larvae were removed, recorded, and placed, along with potential food vegetation in separate, covered plastic containers. Containers were checked and cleaned every other day. Checks included determining if the larvae had pupated, perished, or needed more food. Larvae which had pupated were set aside and checked weekly to determine if the adult had emerged. Before larvae pupated, photos were taken with a digital camera to establish a catalogue of larvae and adult images. These images were used to assist in identifying other photographed larvae (at least to genus) which did not pupate. Identification was completed through the assistance of Dr. Ken Neil and Government of Canada .

3.3 Grassland Birds

Point counts were conducted in both field types for 2005 and 2006. In 2006, additional control sites outside of the six study fields were sampled for comparison to those in the study fields to ensure the additional anthropogenic activity from invertebrate and forage sampling was not influencing the point count results. Each point count was conducted for five minutes, during which time the number of individuals for each focus species (savannah sparrow, bobolink, and Nelson's sharp-tailed sparrow) were recorded based on visual and audial observation up to 100m. In the case of bobolinks, whether the bird was male or female was also recorded. Point counts were only conducted in the morning between 30 minutes past sunrise and 10am. In addition, they were not conducted if it was raining, if fog interfered with visibility, or if winds were greater than 25km/h. Point count locations were reached during each survey using a GPS. Upon arriving at each point count location, the observer was required to wait for three minutes before starting the count to allow any birds that were initially startled by the presence of the observer time to settle down. Point counts were conducted weekly from late May until mid July. The highest count during the summer for each species at each point was used to summarize the point count results for each point. The highest count, sum of all counts at a point over the sampling period, or the average are all considered appropriate methods in measuring and analyzing relative abundance . For the purpose of analysis, only point counts starting when the first Nelson's sharp-tailed sparrow was recorded, up to four weeks following, were used for data summary. This reduced bias associated with an absence of Nelson's sharp-tailed sparrows from earlier counts as they are the last of the three species to arrive, as well as bias associated with male bobolinks grouping together in preparation for migration in later counts.

4. Statistical Analyses

All statistical tests were conducted with R version 2.6.1 .

4.1 Vegetation

Percent cover and species richness (for plots) for the two field types were compared using the non-parametric Wilcoxon Rank-Sum Test, also know as the Mann-Whitney Test. Litter depth (square root transformed) and species richness (for fields) were compared with a Student T-Test.

Forage quality between fields was analysed at specific sampling periods and as an average of the entire (six week) sampling period. The specific sampling periods were those closest to the earliest date in which cutting could occur (July 1st) and the date which encompassed the peak grassland bird fledgling period (July 7th). In 2005 these dates were June 28th and July 5th while in 2006 they were June 29th and July 6th. For each variable, data were checked for normality. When data were non-normal, they were log-transformed. Welch's Student T-Test was used to tests for differences in means (two-tailed) between field types and for comparison to recommended values (one-tailed). For the entire sampling period, averaged variables were compared (Welch's Student T-Test) between forage types for a given year and between years for a given forage type.

4.2 Invertebrates

Carabid species richness and abundance for plots (within fields) were compared between field types using Wilcoxon Rank-Sum Test. Species richness was made comparable by rarefaction curves based on individuals sampled, rather than sampling effort. This took into account the variability of catch sizes influenced by structural characteristics of habitat, differences in mobility between species, and even gender within a species. Rarefaction curves (Figure 13 & 14) were based on the Coleman curve and were calculated using the statistical free software Estimate S . Field carabid richness and abundance were compared using Welch's Student T-Test (two-sided). Total carabid richness, as well as herbivore richness and carnivore richness were each separately modeled by Analysis of Covariance (ANCOVA) with poisson errors (count data has a poisson distribution). The explanatory variables used in each model were: vegetation richness, grass richness, forb richness, legume richness, and field type. Analysis for omnivore carabid richness and abundance was not conducted due to the small number of omnivorous ground beetles collected.

Lepidoptera species richness and total abundance were compared between field types using the Wilcoxon Rank-Sum Test.

4.3 Grassland Birds

Welch's Student T-Test was used to tests for differences in mean abundance (two-tailed) between field types. Grassland bird count data was log-transformed (log+1) when found to be non-normal. Data for 2006 were analyzed with an ANOVA due to the addition of a third category ("control") in the variable "Field Type".

5. Results

5.1 Vegetation

In 2005, a total of 30 plant species were identified, of which 14 were present in the late cultivar fields and 27 were present in the conventional fields. Due to difficulty in distinguishing between blue grass species (*Poa* spp.), they were grouped as one species. This was also done for aster species (*Aster* spp.) as they were not flowering at the time fields were sampled and were there for difficult to identify to species. For the conventional hayfields, Field #1 had the lowest total grass cover but the highest timothy cover (Table 2). It also had the lowest forbs cover and the highest species richness (Fig. 3). Field #2 had the lowest legume cover as well as the highest forbs cover, and Field #3 had the greatest total grass and red clover cover but also had the lowest timothy cover. In the late cultivar fields, Field #4 had the lowest total grass cover. Field #5 had the greatest % total grass and timothy cover, as well as the lowest red clover cover. Field #6 had the lowest total grass and timothy cover and the highest total legume and red clover cover. Field #6 also had the greatest species richness of the three late cultivar fields.

Table 2 Mean Field Vegetation Composition 2005

Field	Field Type	*%Grass	%Timothy	%Legume	%Red Clover	%Forbs
1	conventional	35.8	13.0	22.4	4.3	6.2
2	conventional	52.7	10.5	2.9	1.6	13.9
3	conventional	53.2	10.4	13.3	5.0	11.7
4	late	49.8	49.4	25.1	25.0	0
5	late	63.3	57.0	20.6	20.6	0.1
6	late	55	42.9	37.1	31.9	4.8

*Grasses include sedges & rushes

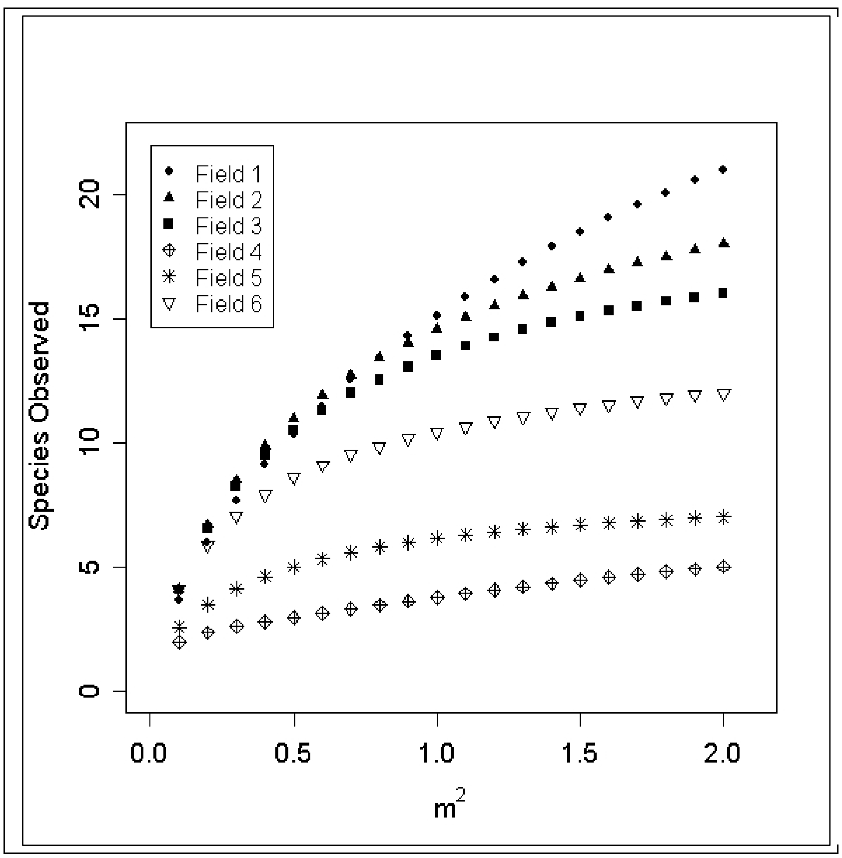

Figure 3 2005 area-based plant species rarefaction curves for conventional hayfields (Fields 1, 2, & 3) and late cultivar fields (Fields 4, 5, & 6).

Total plot vegetation species richness and richness for each vegetation type were all significantly greater in the conventional fields (Table 3). Except for % total grasses, there was a significant difference in % cover between field types for each of the vegetation types and for red clover.

Table 3 Plot (within field) Species and Vegetation Composition Analysis 2005

Variable	Mean Values by Field Type: late cultivar	conventional	w	*p*-value
total richness	2.9	3.9	1003	<0.001
grass richness	1.7	2.4	1131.5	<0.001
legume richness	0.7	1.0	2211	0.017
forb richness	0.2	0.8	957.5	<0.001
* % grasses	56.0	47.3	2149.5	0.066
% timothy	49.8	11.1	3267.0	<0.001
% total legumes	27.6	12.5	2461.0	<0.001
% red clover	25.8	3.6	2889.5	<0.001
% total forbs	1.6	10.7	953.0	<0.001

* Grasses include sedges & rushes

Litter depth ranged from 0cm to 9.8cm for late cultivar fields, while litter depth within conventional fields ranged from 0.0cm to 10.6cm. Although mean litter depth for the late cultivar fields was higher, no significant difference in litter depth was found between the two field types (late: mean=3.5cm ±2.4 and early: 2.8cm ±2.5; t=1.307, p=0.194 (two-tailed), d.f.=116). A comparison of species richness at the field level (rather then between plots) showed that the plant species richness for the conventional hayfields (mean=18.3 ±2.5) was significantly greater than for the late cultivar fields (mean=8.0 ±3.6; t=4.071, *p*=0.015 (2-tailed), d.f.=4).

Crude protein (%CP) for both field types responded in a similar manner with a decline throughout the sampling period except for a slight increase in the second week of July (Fig.4). Crude protein for both June 28th and July 5th were greater by 1% or more in the late cultivar fields than in the conventional fields (Table 4), however only on June 28th was the %CP significantly higher.

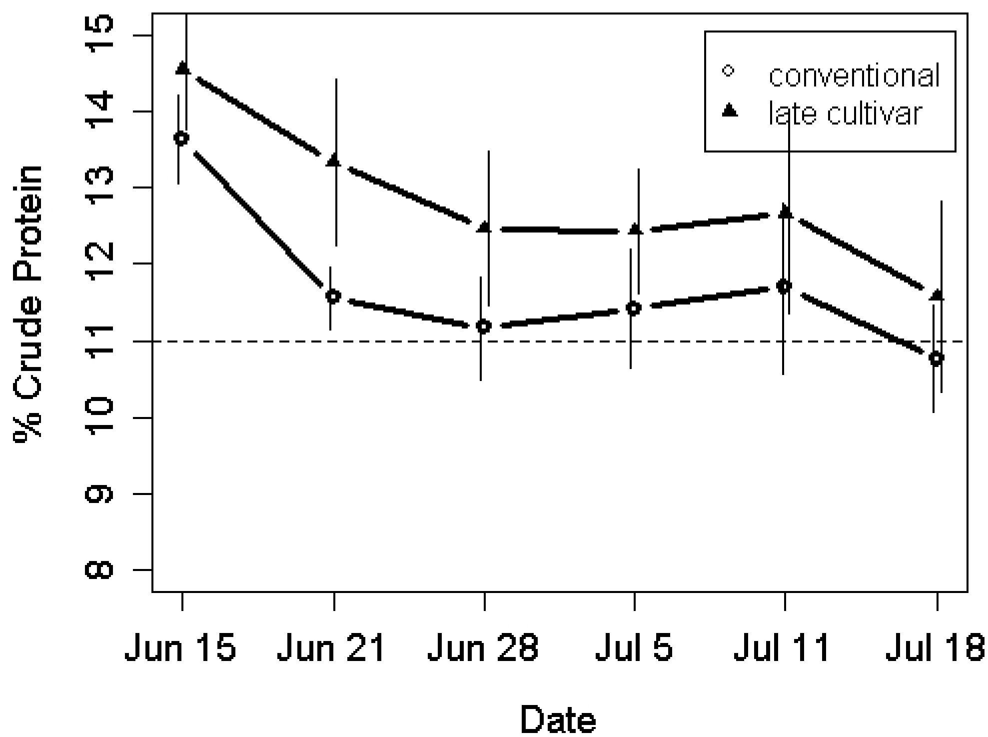

Figure 4 2005 % crude protein for both field types during six week sampling period with comparison to the minimum recommended level (dotted line) for calves and pregnant females (NRC 1996).

Acid detergent fiber (%ADF) for both field types decreased between June 15th and June 21st but then increased for the remainder of the sampling period (Fig.5). No difference was found between field types for June 28th and July 5th (Table 4).

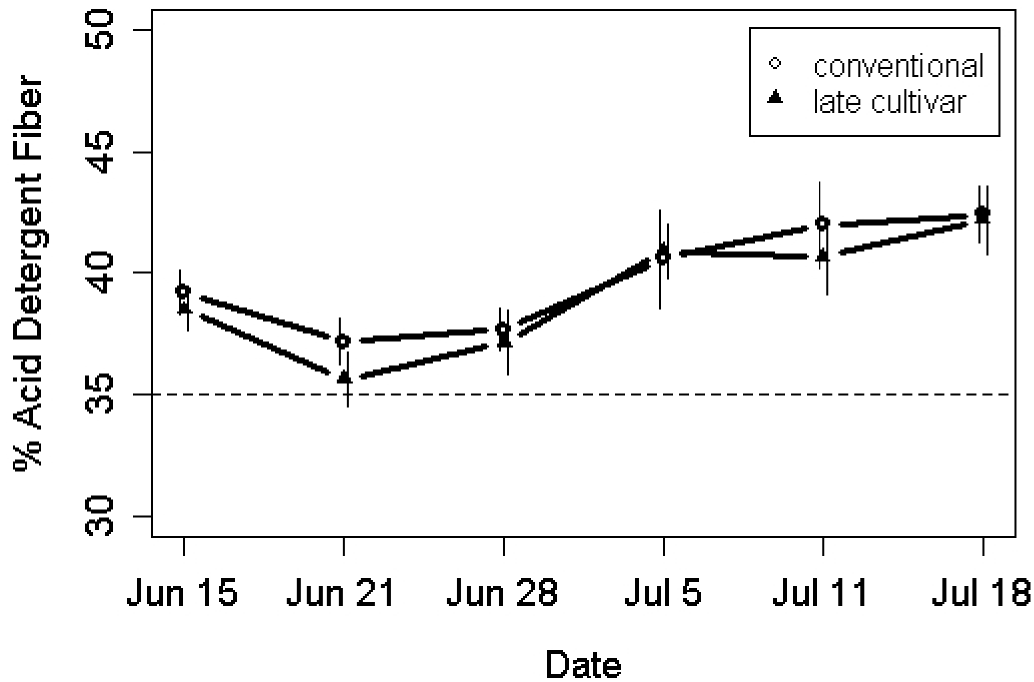

Figure 5 2005 % acid detergent fiber for both field types during six week sampling period with comparison to the maximum recommended level (dotted line) for beef cattle (Rayburn 1994).

Calcium (%Ca) for both field types also responded in a similar manner, with a gradual increase beginning at the end of June (Fig.6). Calcium was significantly higher for the late cultivar on both June 28th and July 5th (Table 4)

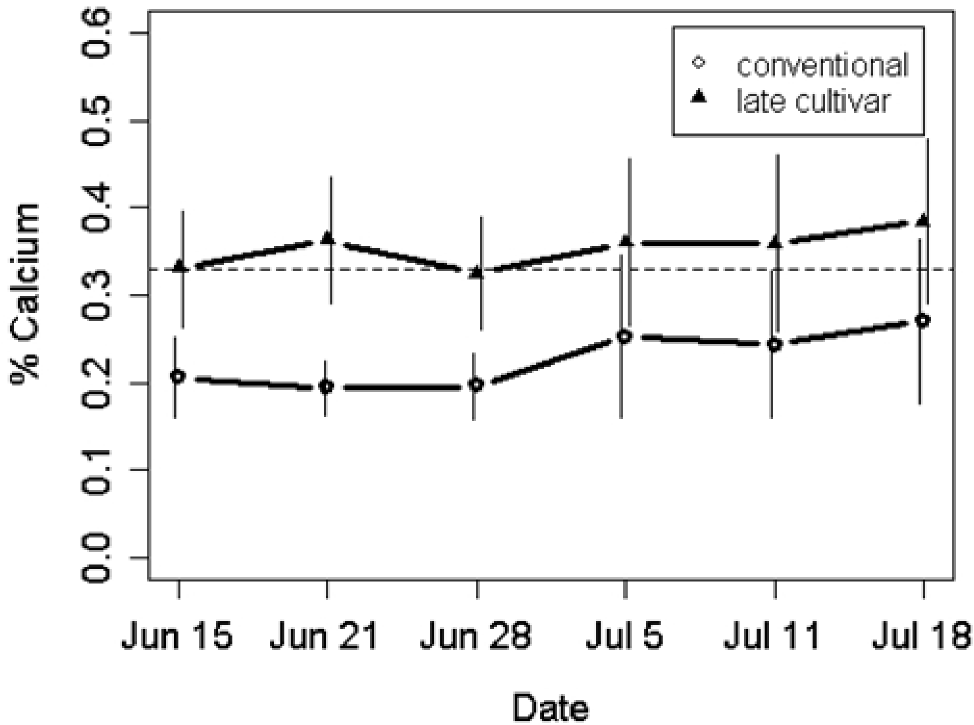

Figure 6 2005 % Calcium for both field types during six week sampling period with comparison to the minimum recommended level (dotted line) for pregnant and lactating beef cows (NRC 1996).

Phosphorus (%P) for both field types decreased throughout the entire six week sampling period (Fig.7). Phosphorus was only significantly higher for the late cultivar on June 28th. Ca/P ratio was significantly higher for both June 28th and July 5th (Table 4).

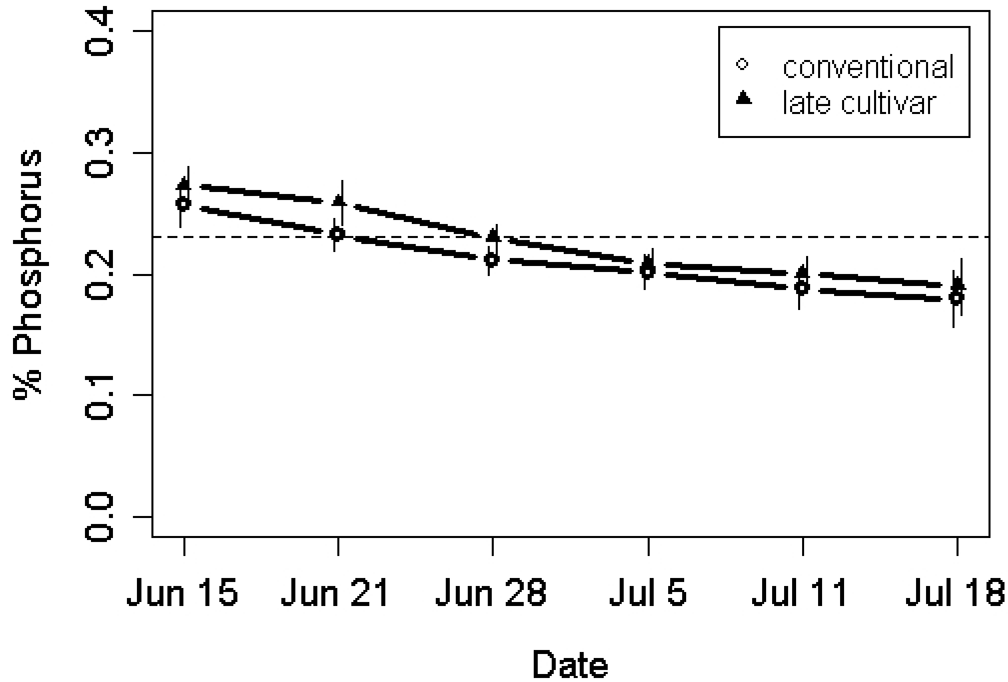

Figure 7 2005 % Phosphorus for both field types during six week sampling period with comparison to the minimum recommended level (dotted line) for pregnant and lactating beef cows (NRC 1996).

Table 4 June 28th and July 5th Forage Analysis 2005

		Mean Values by Field Type				
Date	Variable	Late Cultivar	Conventional	d.f.	t-value	*p*-value
June 28th	% CP	12.46	11.16	28	2.307	0.029
July 5th	% CP	12.44	11.42	27	1.935	0.064
June 28th	% ADF	37.16	37.68	28	-0.718	0.479
July 5th	% ADF	40.89	40.61	27	0.270	0.789
June 28th	% Ca	0.33	0.20	28	4.127	<0.001*
July 5th	% Ca	0.36	0.22	27	2.108	0.044*
June 28th	% P	0.23	0.21	28	2.357	0.026*
July 5th	% P	0.21	0.20	27	0.857	0.399
June 28th	Ca:P Ratio	1.40	0.95	28	3.342	0.002*
July 5th	Ca:P Ratio	1.70	1.11	26	1.861	0.013*

* based on log-transformed data

In 2006, a total of 36 plant species were identified, of which 23 were present in the late cultivar fields and 33 were present in the conventional fields. As in 2005, blue grass species (*Poa* spp.) were grouped as one species, as were asters (*Aster* spp.). As in 2005, Field #1 had the greatest timothy cover of the conventional hayfields (Table 5). It also had the lowest forbs cover. Field #2 again had the lowest legume cover. Field #3 had the greatest legume, red clover, and forb cover, as well as the greatest species richness (Fig. 8). In the late cultivar fields, Field #5 again had the greatest grass and timothy cover, as well as the lowest legume and red clover cover. Field #4 had the lowest total grass and highest legume and red clover cover, while Field #6 had the lowest timothy cover as well as the lowest species richness.

Table 5 Mean Vegetation Composition and Litter Depth 2006

Field	Field Type	*% Grass	% Timothy	% Legume	%Red Clover	% Forbs	**Plant Richness
1	conventional	74.8	27.0	16.2	2.9	11.9	19 (16)
2	conventional	82.9	2.4	2.9	1.2	12.1	19 (17)
3	conventional	69.5	19.2	16.6	6.1	15.4	24 (21)
4	late	67.2	62.8	24.3	22.8	3.4	13 (11)
5	late	89.7	74.3	11	10.9	1.4	14 (11)
6	late	78.8	57.3	19.9	17.1	3.8	11 (11)

*Grasses include sedges & rushes
**Parentheses based on sampled area of $2.0m^2$

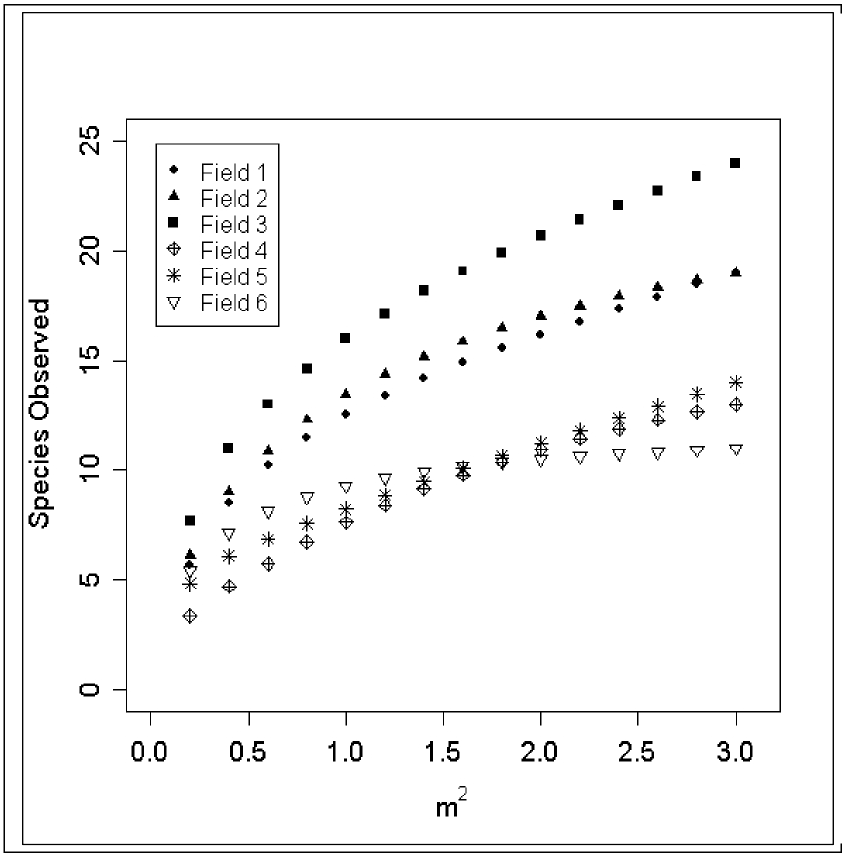

Figure 8 2006 area-based plant species rarefaction curves for conventional hayfields (Fields 1, 2, & 3) and late cultivar fields (Fields 4, 5, & 6).

Total plot vegetation species richness and richness for grass and forbs were significantly greater in the conventional fields (Table 6), however legume richness was not different between field types. As in 2005, there was a significant difference in point % cover between field types for each of the vegetation types except for % total grasses.

Table 6 Vegetation Type and Species Analysis (Wilcoxon Ranked Sum Test) 2006

Variable	Mean Values by Field Type late cultivar	conventional	w	*p*-value
Species richness	4.5	6.5	566.5	<0.001
Grass richness	2.8	3.8	567.5	<0.001
legume richness	1.2	1.0	1117.5	0.337
forb richness	0.6	1.6	607	<0.001
* % total grasses	78.6	75.4	1101.5	0.475
% timothy	64.9	16.2	1923.5	<0.001
% total legumes	18.4	11.9	1262.5	0.043
% red clover	16.9	3.4	1658	<0.001
% total forbs	2.9	13.2	600	<0.001

* Grasses include sedges & rushes

Litter depth ranged from 0cm to 3.0cm for samples from late cultivar fields, while samples from conventional fields ranged from 1.3cm to 6.3cm. Litter depth was greater in the conventional fields (mean=3.1cm ±1.19) than in the late cultivar fields (mean=1.1cm ±0.65; t=10.616, p=<0.001 (two-tailed), d.f.=88). A comparison of species richness at the field level (rather then plots) showed that the plant species richness for the conventional hayfields (mean=20.7 ±2.9) was significantly greater than for the late cultivar fields (mean=12.7 ±1.5; t=4.243, p=0.013 (2-tailed), d.f.=4). 2006 species richness based on a sampled area of 2.0m^2 (area sampled in 2005) was practically the same species richness as in 2005 for the conventional hayfields (Fig.3 & 8). Though species richness for the 2006 late cultivar fields was still greater, the difference was less pronounced.

As in 2005, %CP for both field types decreased throughout the sampling period except for a slight increase in the second week of July (Fig.9). Unlike in 2005, there was no significant difference in %CP between field types for the last sample period in June (June 29th) and the first in July (July 6th) (Table 7).

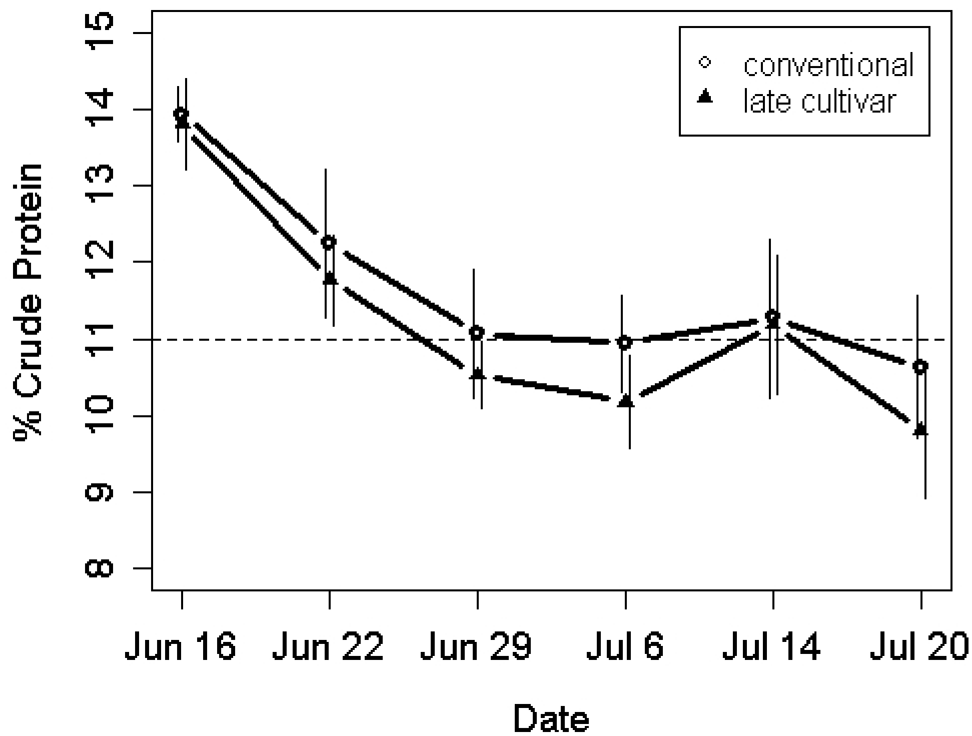

Figure 9 2006 % crude protein for both field types during six week sampling period with comparison to the minimum recommended level (dotted line) for calves and pregnant females (NRC 1996).

Unlike in 2005, there was no initial decrease in %ADF however %ADF for both field types did increase throughout the sampling period in a similar manner (Fig.10). %ADF on June 29th for the late cultivar was significantly higher than for the conventional hayfields but there was no difference in % ADF on July 6th.

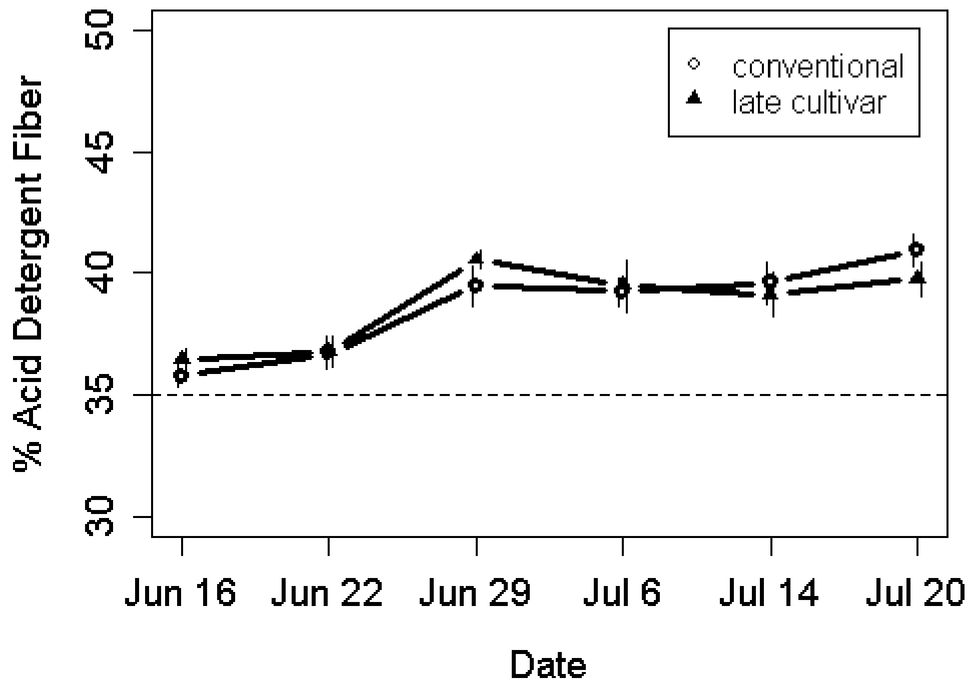

Figure 10 2006 % acid detergent fiber for both field types during six week sampling period with comparison to the maximum recommended level (dotted line) for beef cattle (Rayburn 1994).

As in 2005, %Ca for both field types experienced a gradual increase beginning at the end of June (Fig.11). %Ca for both June 29th and July 6th were significantly higher for the late cultivar.

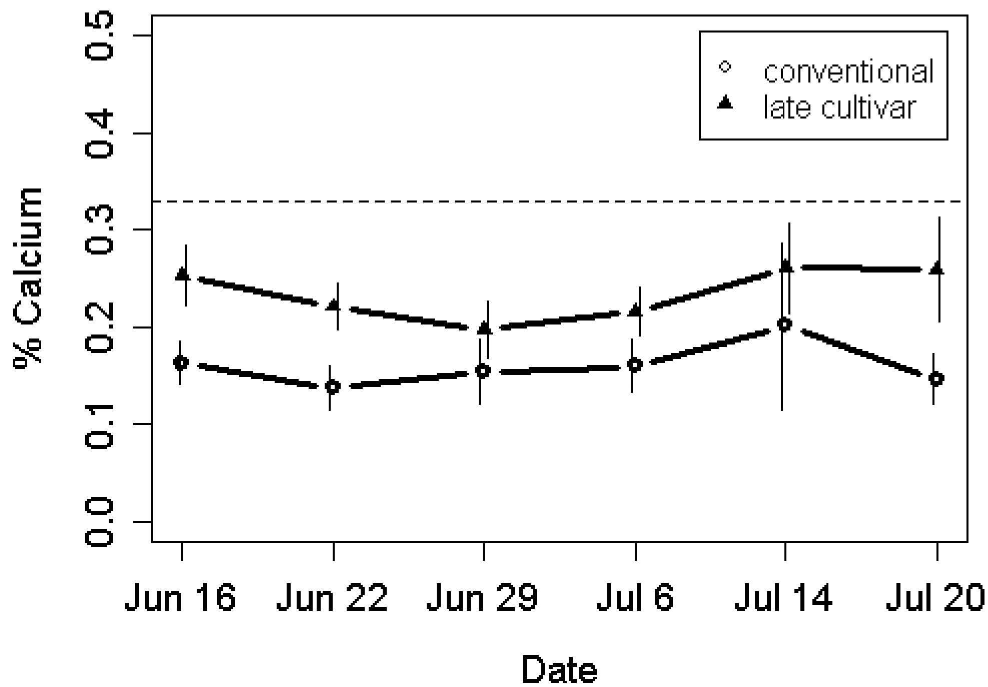

Figure 11 2006 % Calcium for both field types during six week sampling period with comparison to the minimum recommended level (dotted line) for pregnant and lactating beef cows (NRC 1996).

As in 2005, %P declined throughout the entire sampling period (Fig.12). %P was not significantly different on June 29th, but on July 6th the %P for the conventional hayfields was significantly higher than for the late cultivar fields. Similar to 2005, Ca/P ratio was also significantly higher for the late cultivar for both sample dates.

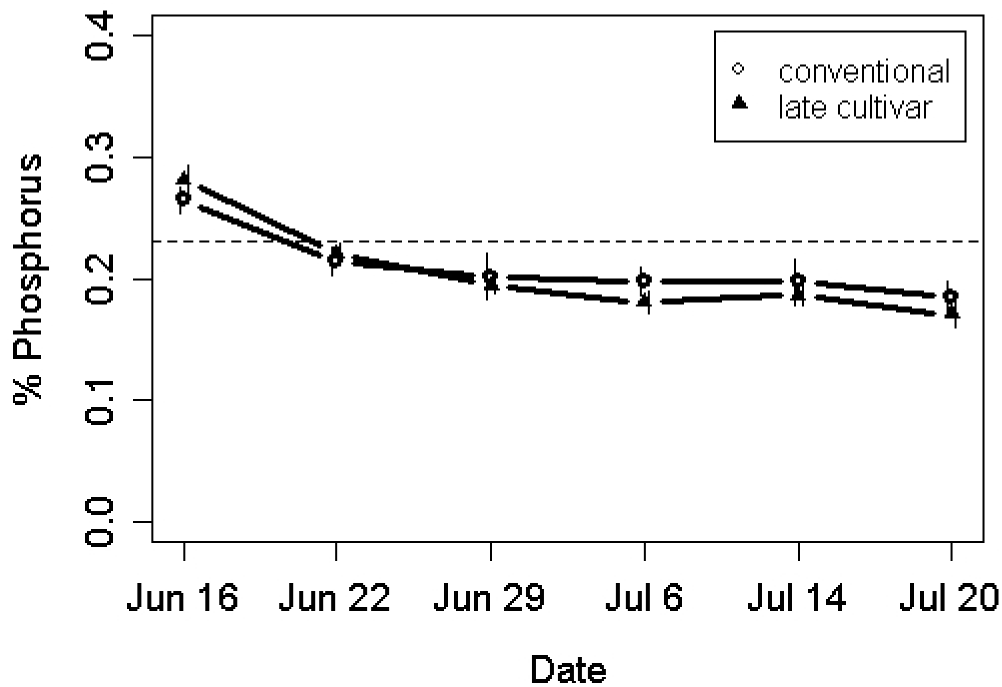

Figure 12 2006 % Phosphorus for both field types during six week sampling period with comparison to the minimum recommended level (dotted line) for pregnant and lactating beef cows (NRC 1996).

Table 7 June 29th and July 6th Forage Analysis 2006

		Mean Values by Field Type				
Date	Variable	Late Cultivar	Conventional	d.f.	t-value	*p*-value
June 29th	% CP	10.52	11.07	28	-1.236	0.227
July 6th	% CP	10.18	10.94	28	-1.878	0.071
June 29th	% ADF	40.55	39.49	28	2.541	0.017
July 6th	% ADF	39.49	39.25	28	0.42	0.676
June 29th	% Ca	0.20	0.15	28	2.481*	0.019*
July 6th	% Ca	0.22	0.16	28	3.237	0.003
June 29th	% P	0.19	0.20	28	-0.700	0.490
July 6th	% P	0.18	0.20	28	-2.555*	0.016*
June 29th	Ca:P Ratio	1.01	0.78	28	2.514	0.018
July 6th	Ca:P Ratio	1.20	0.82	28	4.258	<0.001

* based on log-transformed data

Comparison of average %CP from late cultivar hayfields between the two years showed a significant difference, with 2005 being higher than 2006 (Table 8). A comparison in %CP of conventional hayfields showed no difference between years (Table 9). Only in the conventional fields was a difference seen in %ADF between years, while there was a decrease for both forage types in %Ca between years. %P was significantly lower in 2006 in the late cultivar, but not in the conventional hayfields.

Table 8 Analysis of Averaged Late Cultivar Forage Variables

	Mean Values by Year				
Variable	2005	2006	d.f.	t-value	*p*-value
%CP	13.09	11.49	148	5.476	<0.001*
%ADF	38.57	38.48	148	0.217	0.829
%Ca	0.34	0.23	147	6.647	<0.001*
%P	0.23	0.21	148	3.634	<0.001*
Ca:P Ratio	1.49	1.10	148	5.096	<0.001*

Table 9 Analysis of Averaged Conventional Hayfield Forage Variables

	Mean Values by Year				
Variable	2005	2006	d.f.	t-value	*p*-value
%CP	11.91	11.91	143	0.111	0.912
%ADF	39.24	38.13	143	2.600	0.010*
%Ca	0.2	0.15	138	4.881	<0.001*
%P	0.22	0.22	143	6.000	0.550
Ca:P Ratio	0.96	0.74	140	3.691	<0.001*

5.2 Invertebrates

In 2005, a total of 835 ground beetles, representing 17 species, were caught during the months of May and June in 2005 (Table 10). Of the species identified, seven are considered carnivores (C), five herbivores (H), three omnivores (O), and two have unknown (U) eating habitats. The most common carnivorous species in the late cultivar fields was *Pterostichus melanarius*, while *Poecilus lucublandus lucublandus* was more common in the conventional hayfields. The most common herbivore in the late cultivar fields was *Harpalus rufipes* while *Amara communis* was the most common herbivore in the conventional hayfields. *Harpalus affinis* was the most common omnivore species in both field types.

Table 10 Carabid Species, Abundance, and Eating Habits 2005

Species	Activity Abundance Conventional	Late	Total	Accumulated Percent	*Feeding Habit
Poecilus lucublandus lucublandus (Say)	126	96	222	26.59	C
Pterostichus melanarius (Illiger)	62	130	192	49.58	C
Harpalus rufipes (DeGeer)	59	108	167	69.58	H
Amara communis (Panzer)	86	35	121	84.07	H
Clivina fossor (Linné)	31	11	42	89.10	C
Carabus granulatus hibernicus (Lindroth)	10	14	24	91.98	C
Bembidion properans (Stephens)	1	12	13	93.53	C
Amara laevipennis (Kirby)	11	2	13	95.09	U
Amara aenea (DeGeer)	11	1	12	96.53	H
Harpalus affinis (Schrank)	2	7	9	97.60	O
Agonum muelleri (Herbst)	1	5	6	98.32	C
Amara familiaris (Duftschmid)	4	1	5	98.92	H
Amara aulica (Panzer)	3	1	4	99.40	H
Amara littoralis (Mannerheim)	2	0	2	99.64	O
Anisodactylus kirbyi (Lindroth)	1	0	1	99.76	C
Amara cupreolata (Putzeys)	0	1	1	99.88	O
Amara impuncticollis	1	0	1	100.00	U
Total	411	424	835		

* C = carnivore, H = herbivore, and O = omnivore; Based on Larochelle, A. 1990; Larochelle and lariviere 2003

Based on the total number of individuals caught, Field #1 (conventional hayfield) had the highest total carabid richness (Fig.13) and Field #4 (late cultivar) had the lowest total carabid richness. When standardized based on captured individuals, Field #5 had the highest total carabid species richness (Table 11). In addition both privately owned fields (Field #2 & 5) had the lowest carabid abundance of the six fields.

Table 11 Carabid Species Richness and Abundance 2005

		*Species Richness			Abundance		
Field	Field Type	Total	Carnivore	Herbivore	Total	Carnivore	Herbivore
1	conventional	10	4	4	147	78	64
2	conventional	9	4	3	103	44	52
3	conventional	8	4	2	161	110	47
4	late	6	3	2	160	78	79
5	late	11	5	4	65	42	19
6	late	8	5	2	199	148	48

*standardized to 65 (Total), 42 (Carnivore), and 19 (Herbivore) individuals

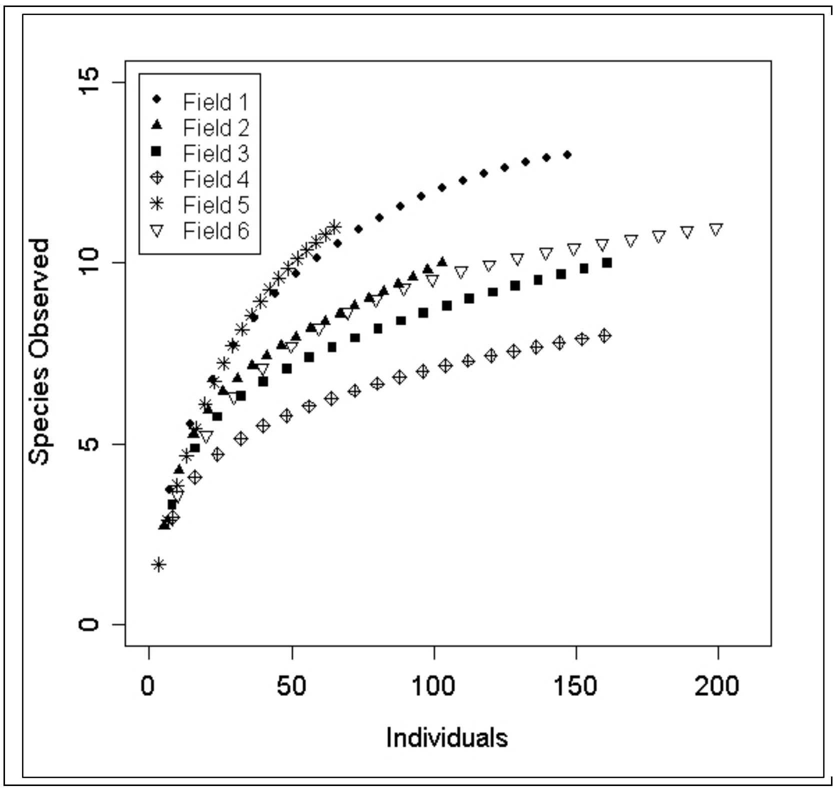

Figure 13 2005 individual-based carabid species rarefaction curve for conventional hayfields (Fields 1, 2, & 3) and late cultivar fields (Fields 4, 5, & 6).

In comparing plot carabid richness and abundance, only herbivore richness was significantly different (Table 12). Comparison of the field species richness and abundance variables (Student T-Test instead of Wilcoxon's Ranked Sum Test) resulted in no significant differences between field types with p-values ranging from 0.692 (total richness) to 0.925 (total abundance).

Table 12 Plot Carabid Richness and Abundance Analysis 2005

	Mean Values by Field Type			
Variable	Late Cultivar	Conventional	w	*p*-value
total richness	2.7	3.2	1466.5	0.073
total abundance	7.1	6.9	1739.5	0.752
carnivore richness	1.6	1.6	1743.5	0.758
carnivore abundance	4.5	3.9	1915	0.544
herbivore richness	0.9	1.4	1355	0.013
herbivore abundance	2.4	2.7	1562	0.205

In 2006, a total of 7842 ground beetles, representing 37 species, were collected during the months of May and June 2006 (Table 13). Of the species identified, 21 were considered carnivores, nine herbivores, five omnivores, and two had unknown eating habitats. As in 2005, *P. melanarius* was the most common carnivore in the late cultivar fields and *P. lucublandus lucublandus* was the most common carnivore in the conventional hayfields. *H. rufipes* was the most common herbivore for both field types and *H. affinis* (Schrank) was the most common omnivore for both field types.

Table 13 Carabid Species, Abundance, and Eating Habits 2006

	Activity/Abundance			Total Accumulated	*Feeding
Species	Conventional	Late	Total	Percent	Habit
Pterostichus melanarius (Illiger)	1120	2222	3342	42.62	C
Poecilus lucublandus lucublandus (Say)	1198	901	2099	69.38	C
Harpalus rufipes	614	515	1129	83.78	H

(DeGeer)					
Clivina fossor (Linné)	252	228	480	89.90	C
Amara communis (Panzer)	194	50	244	93.01	H
Carabus granulatus hibernicus (Lindroth)	67	51	118	94.52	C
Harpalus affinis (Schrank)	70	33	103	95.83	O
Amara aenea (DeGeer)	50	8	58	96.57	H
Agonum muelleri (Herbst)	15	38	53	97.25	C
Bembidion properans (Stephens)	12	30	42	97.78	C
Amara lunicollis (Schiodte)	22	4	26	98.11	O
Amara familiaris (Duftschmid)	14	4	18	98.34	H
Blemus discus (Fabricius)	15	1	16	98.55	C
Amara laevipennis (Kirby)	9	5	14	98.72	U
Pterostichus luctuosus (Dejean)	11	3	14	98.90	C
Agonum thoreyi thoreyi (Dejean)	1	9	10	99.03	O
Amara aulica (Panzer)	9	1	10	99.16	H
Agonum melanarium (Dejean)	7	1	8	99.26	C
Harpalus somnulentus (Dejean)	9	0	9	99.38	H
Anisodactylus kirbyi (Lindroth)	5	3	8	99.48	C
Agonum trigeminum (Lindroth)	4	3	7	99.57	U
Anisodactylus nigrita (Dejean)	5	1	6	99.64	C
Agonum tenue (LeConte)	2	2	4	99.69	C
Amara littoralis (Mannerheim)	2	1	3	99.73	O
Harpalus rubripes (DeGeer)	1	2	3	99.77	H
Anisodactylus harrisii (LeConte)	2	0	2	99.80	H
Anisodactylus sanctaecrucis	2	0	2	99.82	H

(Fabricius)					
Agonum cupripenne (Say)	0	1	1	99.83	C
Amara cupreolata (Putzeys)	1	0	1	99.85	O
Bradycellus nigrinus (Dejean)	0	1	1	99.86	C
Carabus nemoralis (O.F. Müller)	1	0	1	99.87	C
Chlaenius emarginatus (Say)	1	0	1	99.89	C
Chlaenius niger (Randall)	1	0	1	99.90	C
Xestonotus lugubris (Dejean)	1	0	1	99.91	C
Dyschirius integer (Say)	0	1	1	99.92	C
Pseudamara arenaria (LeConte)	1	0	1	99.94	C
Bradycellus rupestris (Say)	1	0	1	99.95	C
Unknown Amara sp	4	0	4	100.00	
Total	**3723**	**4119**	**7842**		

* C = carnivore, H = herbivore, and O = omnivore; Based on Larochelle, A. 1990; Larochelle and lariviere 2003

Based on the total number of individuals caught, Field #3 (conventional hayfield) had the highest total carabid richness (Fig.14) and Field #4 (late cultivar) had the lowest total carabid richness. When standardized by individuals caught, Field #5 again had the highest carabid richness (Table 14). As in 2005, both privately-owned fields also had the lowest carabid abundance of the six fields.

Table 14 Carabid Species Richness and Abundance 2006

		Species Richness			Abundance		
Field #	Field Type	*Total	*Carnivore	*Herbivore	Total	Carnivore	Herbivore
1	conventional	17	8	5	1280	813	400
2	conventional	15	6	6	569	341	210
3	conventional	18	8	6	1874	1549	297
4	late	10	5	3	1789	1494	272
5	late	24	10	7	575	419	141
6	late	10	6	2	1755	1541	197

*standardized to 569 (Total), 341 (Carnivore), and 141 (Herbivore) individuals.

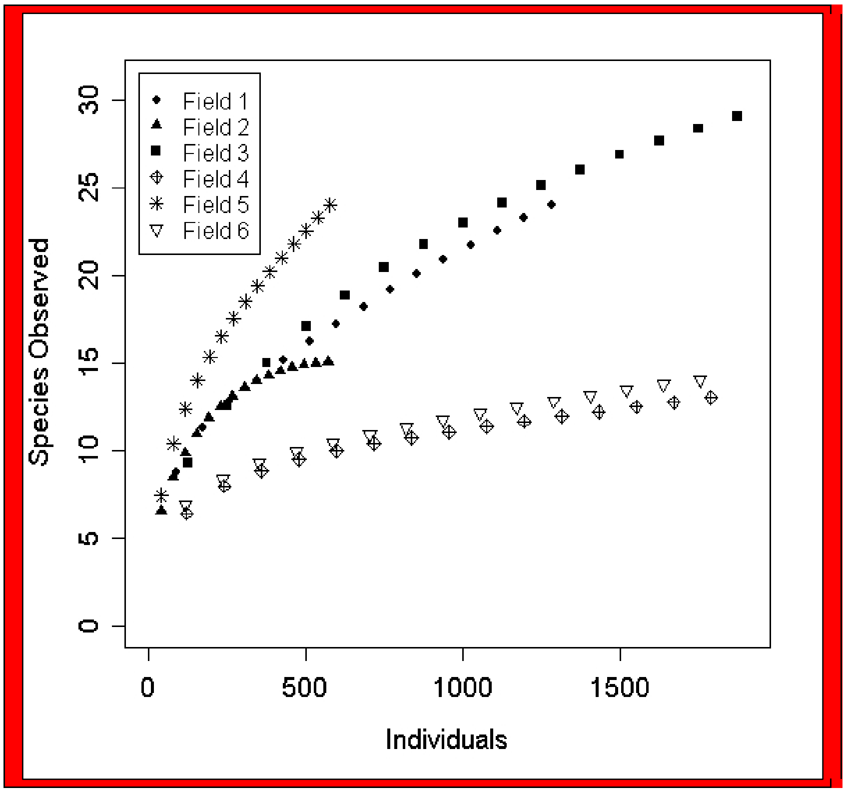

Figure 14 2006 individual-based carabid species rarefaction curve for conventional hayfields (Fields 1, 2, & 3) and late cultivar fields (Fields 4, 5, & 6).

In comparing plot carabid species richness, both total richness and herbivore richness of the conventional hayfields were found to be significantly higher than in the late cultivar fields (Table 15). Herbivore abundance was also significantly greater in the conventional hayfields. Comparison of the richness and abundance variables at the field level (Student T-Test instead of Wilcoxon's Ranked Sum Test) again resulted in no significant differences between field types with p-values ranging from 0.212 (herbivore abundance) to 0.851 (carnivore richness).

Table 15 Carabid Richness and Abundance Analysis 2006

	Mean Values by Field Type			
Variable	Late Cultivar	Conventional	w	*p*-value
total richness	6.9	8.1	664	0.004
total abundance	91.5	82.6	1075	0.617
carnivore richness	4.1	4.2	1009.5	0.983
carnivore abundance	76.8	60.1	1181	0.175
herbivore richness	2	2.8	546	<0.001
herbivore abundance	13.6	20.2	703	0.013

Total carabid richness as well as carnivore and herbivore richness was individually modeled with vegetation richness variables (total vegetation, grass, legume, and forb richness) and field type to determine which contributed to abundance and species richness. Neither total carabid nor carnivore richness were significantly related to any of the explanatory variables, however, herbivore richness was positively associated with vegetation richness (Table 16) and negatively associated with legume richness.

Table 16 Analysis of Covariance Summary for Herbivore Richness

Variable	Estimate	Std. Error	z-value	*p*-value
intercept	0.67439	0.19091	3.533	<0.001
vegetation richness	0.08222	0.03270	2.514	0.012
legume richness	-0.25099	0.11010	-2.280	0.023

Also in 2006, a total of 4,800 sweeps or passes of the sweep net (20/sample point for each sample period) were conducted from May 24th to July 19th. From these sweeps, a total of 154 Lepidoptera larvae were collected, of which 43 were reared to adult and identified to species, two were identified to species as larvae, and 47 were identified to genus. The most common species collected in the late cultivar fields was *Mythimna unipuncta* (Family: Noctuidae), commonly known as the armyworm. The most common species collected in the conventional hayfields was *Thymelicus lineola,* also known as the European skipper. Over half of the specimens which could be identified to genus or species belonged to the Family Noctuidae.

Table 17 Lepidoptera Larvae (Species and Genus) by Field Type 2006

			Field Type		
Group	Name	Family	Conventional	Late	Total
Species	*Mythimna unipuncta*	Noctuidae	8	12	20
	Thymelicus lineola	Hesperiidae	9	5	14
	Xylena nupera	Arctiidae	1	1	2
	Orgia leucostigma	Lymantriidae	0	2	2
	Hypena scabra	Noctuidae	1	1	2
	Plusia contexta	Noctuidae	1	1	2
	Caenurgina crassiuscula	Noctuidae	0	1	1
	Cisseps fulvicolis	Arctiidae	1	0	1
	Glaucopsyche lygdamus couperi	Lycaenidae	1	0	1
Genus	*Mythimna sp.*	Noctuidae	9	12	21
	Xylena sp.	Arctiidae	9	3	12
	Thymelicus sp.	Hesperiidae	7	3	10
	Plusia sp.	Noctuidae	2	1	3
	Colias sp.	Pieridae	1	0	1
Unknown	Unk 1		1	0	1
	Unk 2		1	0	1
	Unk 3		0	1	1
	Unknown		34	25	59
	TOTAL		**86**	**68**	**154**

Field #6 had the highest species richness and abundance, while field #5 had the lowest richness and abundance (Table 18).

Table 18 Field Lepidoptera Richness and Abundance

Field #	Field Type	Species Richness	Total Abundance
1	conventional	5	34
2	conventional	5	34
3	conventional	6	18
4	late	6	22
5	late	3	10
6	late	6	36

Lepidoptera species richness between field types was not different at both the plot and field level (Table 19).

Table 19 Point and Field Lepidoptera Richness and Abundance Analysis

Variable	Sample	Late Cultivar	Conventional	w	*p*-value
Lepidoptera richness	point	0.5	0.5	988	0.824
Lepidoptera abundance	point	1.5	1.9	891	0.316
Lepidoptera richness	field	5.0	5.3	5	1
Lepidoptera abundance	field	22.7	28.7	4	1

5.3 Grassland Birds

In 2005, bobolinks were the most frequently observed species while Nelson's sharp-tailed sparrows were the least observed. Comparison between field types in 2005 found savannah sparrow's numbers were significantly higher in the conventional hayfields than in late cultivar fields (Table 20). No significant difference was found between field types for either of the other species or for the combined total abundance.

Table 20 Grassland Bird Point Count Analysis 2005

Species	Mean Abundance Conventional	Late	d.f.	t-value	*p*-value
male bobolink	3	3.8	8	-0.560	0.591
female bobolink	1	1	8	0.000	1.000
Total bobolink	4	4.8	8	-0.502	0.629
savannah sparrow	3.8	2.2	8	3.024	0.016
Nelson's sharp-tailed sparrow	0.8	0.8	8	0.000	1.000
Total	8.6	7.8	8	0.487	0.639

In 2006, savannah sparrows were the most common species observed and the Nelson's sharp-tailed sparrow was the least observed (Table 21). No significant difference was found between field types in 2006 for any of the three focus species (Table 22), for total abundance, nor was there a difference observed between either of the two field types (conventional and late cultivar) and the control points.

Table 21 Grassland Bird Abundance Summary 2006

	Mean Abundance					
Field Type	♂ Bobolink	♀ Bobolink	Total Bobolink	Savannah Sparrow	Nelson's Sharp-tailed Sparrow	Total
conventional	2.4	1.4	3.8	4.4	1.8	10.0
Late	2.6	1.4	4.0	4.0	1.6	9.6
Control	3.4	0.8	4.2	4.0	2.0	10.2

Table 22 Grassland Bird Point Count Analysis 2006

Species	Source	d.f.	Sum of squares	Mean square	*F*-ratio	*p*-value
male bobolink	Field Type	2	2.80	1.40	0.656	0.537
	Residuals	12	25.60	2.13		
female bobolink	Field Type	2	1.20	0.60	0.783	0.479
	Residuals	12	9.20	0.77		
Total bobolink	Field Type	2	0.40	0.20	0.064	0.939
	Residuals	12	37.60	3.13		
savannah sparrow	Field Type	2	0.53	0.27	0.118	0.890
	Residuals	12	27.20	2.27		
Nelson's sharp-tailed sparrow	Field Type	2	0.40	0.20	0.200	0.821
	Residuals	12	12.00	1.00		
Total	Field Type	2	0.93	0.47	0.147	0.865
	Residuals	12	38.00	3.17		

6. Discussion

6.1 Vegetation

As the late cultivar fields were planted with red clover and timothy, a difference between field types for these two species was expected. The difference in legumes was mainly the product of the high red clover content in the late cultivar fields. The greater %cover of forbs and species richness in the conventional fields would be expected for older fields due to succession, as was the case for Bazzaz and Southwood *et al.* . Although the late cultivar fields were planted with only two species in 2003, 14 species were already present in the cultivar fields by 2006. Potential sources for these species include the soil seed bank, seed from adjacent fields and field edges, as well as remaining root fragments from plants such as Canada thistle (*Cirsium arvense*), that were present in the fields previous to being planted. A large difference in % grass and timothy cover was seen between years. A potential explanation for this could have been temporarily inflated estimates due to the flattening of grass vegetation by heavy rain which occurred previous to the vegetation sampling in 2006. Precipitation records for the area show that 2006 precipitation levels for the combined months of May and June were the highest recorded for the previous 50 years Due to the high rain event, large portions of vegetation in all six fields (and adjacent fields) remained horizontal right up to harvest in July (personal obs.), potentially inflating cover estimates as the horizontal (flattened) grass would appear to cover more area than when it was vertical. If this did influence cover estimates of grass species, it did not seem to have a similar impact on broad leaf plants (both legumes and forbs) as there was no significant difference in forbs between years for either field type, nor was there a difference in legume and red clover cover for the conventional hayfields. There was a difference in legume and red clover for the late cultivar, however red clover is considered a short-lived perennial which tends to die off in fields in the second or third year . As 2006 was the third year since the late cultivar was planted, a reduction in red clover could have been anticipated.

Forage quality in 2005 for the late cultivar was of greater quality in % CP and mineral content for both individual sample periods (ex: July 5th) and for the entire averaged sample period. In comparison to recommended levels, the percent crude protein (%CP) for both field types on July 5th (late: 12.44 & conventional: 11.42) was found to be adequate for calves and pregnant females (>11%; NRC 1996). Acid detergent fiber (%ADF) for both field types was found to be higher (late: 40.89% & conventional: 40.61%) than recommended levels (≤34-35%; Rayburn 1994). Percent calcium (%Ca) for the late cultivar was comparable to recommended levels for pregnant and lactating beef cows (0.33%; NRC 1996) for June 28th and July 5th. Calcium in the conventional fields was only adequate for pregnant and lactating cows during July 5th. Phosphorus (%P) was not adequate for pregnant and lactating beef cows (0.23%; NRC 1996) for the conventional hayfields on June 28th nor for both field types on July 5th (late: 0.209% & conventional: 0.201%). Ca/P ratios in the late cultivar fields were adequate for all types of beef cattle (1.5-2/1; NRC 1996). Overall, forage from the late cultivar fields was of higher quality.

Forage quality in 2006 was similar between field types for % CP and phosphorus, but was still of greater quality for calcium in the late cultivar fields. In comparison to recommended levels, %CP for the late cultivar was lower than 11% for both June 29th (10.52%) and July 6th (10.18%) and therefore would not support the higher maintenance demands of calves and pregnant females (>11%; NRC 1996). Crude protein in conventional fields for both dates was comparable to, but not greater than 11% so it too would not be adequate for calves and pregnant females. As in 2005, %ADF for both dates was found to be higher than recommended levels (≤34-35%; Rayburn 1994). Both calcium and phosphorus for both dates was also insufficient for supporting pregnant and lactating beef cows (Ca: 0.33% & P: 0.23%; NRC 1996). Nor were Ca/P ratio for both field types adequate for supporting beef cattle (1.5-2/1; NRC 1996).

Although both field types showed a decline in quality from 2005 to 2006, the decline in overall forage quality for the late cultivar was much more pronounced. The decline in red clover in the late cultivar would account for some of this decline but the fact that the late cultivar fields still had significantly greater quantities of red clover in 2006 (late: 16.8% & conventional: 3.4%) suggests that other contributing factors were involved. Collins and Fritz list three primary factors that affect forage quality in most cases; these are forage species, maturity stage, and harvesting conditions. Secondary factors are listed as temperature and soil moisture during growth, soil fertility, and cultivar type. Although known forage species, harvest conditions, and the proximity of the fields to one another assists in partially ruling out some of these variables, the difference in overall plant composition, age of the fields, and how these variables influence a field's response to the previously mentioned factors, made understanding and explaining the 2006 decline in forage quality difficult for this particular study.

6.2 Invertebrates

As for the vegetation, Carabid sampling effort for 2005 provided some insight into how the carabid richness differed between field types but otherwise was inadequate. None of the species accumulation curves (Fig.4) seemed to near their respective asymptotes, suggesting the sample did not sufficiently represent the populations present in the six fields. However, data from 2005 did support general trends such as the contribution that herbivores made to overall carabid richness in the conventional hayfields (as was in the case of 2006). Results from 2005 also suggested trends that were confirmed from 2006 results, such as the high carabid richness that was associated with Field #5 and low abundance associated with both privately-owned fields (Field #2 & #5). Field accumulation curves for 2006 indicate that some fields were sampled sufficiently (Fig.5), however, others such as Field #5, still appeared to be unrepresentative of the overall field species richness. Difference in 2006 total carabid richness between field types was mainly attributed to difference in herbivore richness which was associated positively with total vegetation richness (log) and negatively with legume richness. The positive relationship with vegetation richness is supported by other research which relates invertebrate richness with vegetation richness and in turn, community succession . The privately-owned late cultivar field (Field #5) was an exception to this and suggests that factors other than vegetation richness can strongly influence field carabid richness. Other variables known to influence carabid richness within a field include soil type and soil moisture , adjacent habitat such as hedge rows , and farming practices . Although there are thought to be pest control benefits associated with carabid beetles, most of these are based on laboratory feeding tests and there for require further field testing. Certain species belonging to the *Harpalus* and *Amara* genus which have seed eating habits (herbivorous), are thought to have some potential as biological weed control agents . For this study, eight out of nine herbivore species (six of which were *Harpalus* or *Amara*) were more abundant in the conventional fields which possessed a greater abundance and richness of forbs or “weeds”.

Lepidoptera sampling in 2006 resulted in 1.28 individuals per sampling point (based on biweekly sampling for two months). This seems comparable to the 2.2 mean number of caterpillars reported by Nocera *et al.* . The number of individuals and even species could potentially be increased by including additional sampling methods, such as soil collection or vegetation beating and by sampling during the evening. The European skipper (Family: Hesperiidae) and most noctuids (Family: Noctuidae) are active during the evening. Although the European skipper takes cover in folded grass blades during the day, many noctuid larvae retreat into the soil litter during the daytime, thus limiting the effectiveness of sweep netting alone. All species caught in 2006 are considered pests, except for *Glaucopsyche lygdamus couperi* (silvery blue butterfly), which larvae feeds upon vetch and alfalfa. *Mythimna unipuncta* or the armyworm, which was the most abundant larvae collected, is of the greatest concern as it is considered a serious pest of forage grasses in North America .

6.3 Grassland Birds

Results support that there is no difference between the two studied field types in total and individual species grassland bird abundance, when both are under a delayed cutting regime, although it is important to clarify this is based on a relatively small sample size. Although field size has been shown to influence bobolink abundance , the study fields for each field type collectively represent the minimum in field size Herkert suggested for bobolink presence, therefore the influence of the project's field size on bobolink abundance is likely negligible. Past research also suggests that any difference in grassland bird richness or abundance would most likely be associated with field age, however the close proximity of the study fields, their small size, and the small sample size, makes identify a difference difficult.

7. Conclusion

The objectives of this study were to determine:

1. If forage from fields planted with a late cultivar, under a delayed cut regime would be of higher quality than forage from conventional hayfields,
2. If grassland bird and invertebrate communities differ between field types, and
3. How vegetation of the field types influenced invertebrate diversity.

The forage quality for the new, late cultivar fields in this study clearly provided better quality forage in comparison to adjacent, older, conventional hayfields. Even in 2006 when %CP, %ADF, and %P were not found to be different between the two field types, %Ca was still higher in the late cultivar. As red clover has a higher protein content than grass and is short-lived (~3-4 years), one would expect new fields to initially decline in %CP as their clover composition declined. The comparison of older conventional fields to new late cultivar fields made it difficult in determining how much of the differences in forage quality were related to cultivar type or to the age of the fields.

Grassland bird abundance was not different between the two field types, nor was Lepidoptera richness and abundance. Mean carabid richness was found to be greater in conventional hayfields (within fields), however this was related to higher herbivore carabid richness which was in turn mainly associated with greater total vegetation richness. Accounting for invertebrate trophic levels contributed to a better understanding of the relationship between vegetation composition and invertebrate diversity within the study fields. No references were found that address or suggested cultivar types varied in their influence on field fauna diversity, however results from this study further support existing literature that suggest the age of the field does.

It should be noted that results from the privately owned fields differed from the other fields in a number of areas, including lower legume cover (Field #5), lowest carabid abundance (Field #2 & #5), and highest carabid richness (Field #5). Although these results are based on a small number of fields, the consistency of differences throughout the study related to the privately owned fields suggests a need to better understand why these results differed.

8. Recommendations

A number of recommendations aimed at maintaining forage quality and increasing wildlife diversity in hayfields can be derived from the results of this project.

Recommendations:

1. The use of late cultivars, in conjunction with delayed cutting should be considered as a viable approach to improving hayfield wildlife diversity while reducing the negative impact the delayed cut has on forage quality.

2. It is strongly encouraged that additional research be pursued and supported to address, in more detail, how cultivar types influence forage quality. A study consisting of paired plots or fields planted with different cultivars at the same time would greatly assist in clarifying the influence cultivars have on forage quality. Such a study should be conducted for a minimum of four years to account for the gradual reduction of clover content and extreme weather conditions, as believed to have occurred in 2006, which would potentially influence a single growing season. It should also include measurements of forage biomass to provide information on forage quantity.
3. The factors contributing to the high carabid richness in the privately owned late cultivar field should be reviewed. If the high carabid richness was related to management practises, a better understanding of why the carabid richness is so high in this field could assist in maintaining higher carabid richness in newly planted hayfields. Soil characteristics such as composition, moisture, as well as adjacent habitat, field preparation, and harvesting practices should all be considered.
4. Finally, studies looking at the relationship between grassland birds and invertebrate prey should be encouraged. Studies have demonstrated that birds can prevent invertebrate pest outbreaks in forests and reduce pests in cash crops such as corn . A better understanding of how, and if birds control forage pests would contribute greatly to supporting grassland bird conservation in the agricultural landscape.

9. References