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EVALUATIONS OF ALFALFA, BIRDSFOOT TREFOIL, AND SMOOTH BROMEGRASS FOR WINTER STOCKPILED FORAGE

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By

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ABSTRACT

EVALUATIONS OF ALFALFA, BIRDSFOOT TREFOIL, AND SMOOTH BROMEGRASS FOR WINTER STOCKPILED FORAGE

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Fall stockpiling may serve as an alternative to stored feeds for winter use by ruminants. This study evaluated birdsfoot trefoil, alfalfa, and smooth bromegrass by stockpiling growth from late August until sampling in early November, December, and January at three locations. Plots were subjected to three summer cutting treatments at East Lansing and KBS, and rotational grazing at Lake City. Samples were taken in early November, early December, and late December in 1994 and 1995 at East Lansing and Lake City, and in 1995 at the Kellogg Biological Station (KBS) in Southwest Michigan. Samples were analyzed for ADF, NDF, and crude protein. In 1994 alfalfa fall stockpiled DM yields remained nearly unchanged from November through January in previously unharvested plots, two summer-harvest alfalfa yields decreased by approximately 75% and one summer-harvest alfalfa yields decreased by 50%. Birdsfoot trefoil plots showed similar but greater yield decreases during the same period. Stockpiled forage quality was lowest in summer-unharvested alfalfa at East Lansing in late December 1994. The highest forage quality was found in November 1 samples of two summer-harvest alfalfa at East Lansing in 1995. At the Lake City site in 1994 smooth bromegrass maintained a higher percentage of forage yield and quality longer into winter than legumes in mixed smooth bromegrass-alfalfa and smooth bromegrass- trefoil plots.

DEDICATION

To my wife Maggie, for her encouragement, love, trust and advice during the research, classwork, and especially writing of this thesis. She gave up three years of her beloved farm so we could move to East Lansing and learn more about the mysteries of farming. She helped me with all aspects of my research from forage sampling to dissuading me from destroying my computer during times of stress. Finally for creating an atmosphere of quiet peace and intellectual challenge, for paying the bills, and taking care of our family, our border collies, Monty , Jess, Beth, and Bolt.

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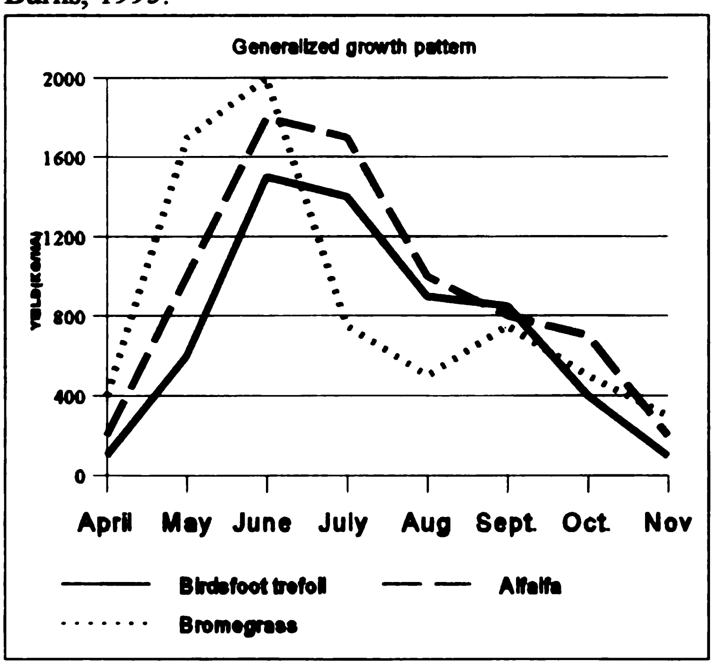
REVIEW OF THE LITERATURE

Stockpiling herbage is the practice of allowing forage to accumulate in the field until it is needed for grazing. (Forage and Grazing Terminology Committee, 1992). With the expanded use of grazing as a forage management tool the use of stockpiling as a part of a grazing strategy is likely to increase. Mays and Washko, 1960 said; "If stockpiling is to assume an important place in the forage management programs of dairy and livestock farms it must supply total digestible nutrients to livestock as cheaply as they can be supplied by rotation pasturage supplemented with harvested forage. Furthermore stockpiled pasturage must be palatable enough to be readily consumed by livestock."

Previous research on stockpiling concentrated on two main areas: 1) Stockpiling of alfalfa (*Medicago sativa* L.), birdsfoot trefoil (*Lotus corniculatus* L.), red clover (*Trifolium pratense* L.) sanfoin (*Onobrychis viciifolia* Scop.) and other legumes for summer use. Some legumes maintained their quality during the summer slump, when the combination of heat, moisture stress, or both caused decreased growth in

Figure 1. Distribution of growth for alfalfa, birdsfoot trefoil, and smooth bromegrass. Source: Matches and Burns, 1995.



many cool season forages (Figure 1). The shortage of forage was filled by stockpiling early summer growth for use during midsummer. 2) Stockpiling late summer and early fall growth of grasses for winter use. Tall fescue (*Festuca arundinacea* L.)was the most commonly stockpiled grass for winter grazing. This was practiced primarily in the "fescue belt," an area from Missouri east and south to the Carolinas where extensive winter grazing of fescue is common.

Summer stockpiling has concentrated on alfalfa and other legumes because they have less tendency for summer dormancy in hot weather (Collins, 1982). Alfalfa and birdsfoot trefoil have deep tap roots, alfalfa being deeper rooted than birdsfoot trefoil. Alfalfa was better able to recover from cutting in hot dry weather, perhaps because of greater root carbohydrate reserves (Cowett and Sprague, 1962).

Birdsfoot trefoil compared very favorably to alfalfa and other legumes because of its ability to retain high forage quality into later flowering stages (Table 1). Birdsfoot trefoil both retains high quality leaves on mature growth and continually produces new high quality shoots from axillary buds as the stems mature (Grant and Marten, 1985).

Table 1. Total digestible nutrient content (TDN) of alfalfa and birdsfoot trefoil at three maturity stages (Three-year average).

	Maturity Stage		
	Bud	10% Bloom	50% bloom
Species	Percent TDN		
Alfalfa	62.5	54.1	52.1
Birdsfoot trefoil	65.8	58.2	62.6
Source:Hall and Cherney, 1991.			

Mays and Washko, 1960 found birdsfoot trefoil to be suitable for stockpiling until mid-July under Pennsylvania conditions. Empire birdsfoot trefoil appeared to be superior to other the other species in the study, ladino clover (Trifolium repens L.), common orchardgrass (*Dactylis glomerata* L.), S-37 orchardgrass, timothy (*Phleum pratense* L), and reed canarygrass (*Phalaris arundinacea* L.). By mid July the grass portions of the trefoil - grass pasture was largely refused by cattle and it was suggested that it would be advisable to harvest it much earlier than birdsfoot trefoil. Because of this, pure stands of birdsfoot trefoil may be more effectively managed for summer stockpiling.
Birdsfoot trefoil has been successfully summer stockpiled in clear and binary mixtures in a number of states by several researchers (Cooper, 1973; Taylor, et al., 1973; Marten and Jordan, 1979; Mays and Washko, 1960).

Research on stockpiling forages for fall and winter use has almost exclusively involved grasses and researchers concluded that where it was adapted, tall fescue was superior to other grasses for fall and winter grazing (Wedin et al, 1970; Bryan et al, 1970; VanKeuren, 1972; Reynolds, 1975; Templeton et al, 1967). The primary basis for this conclusion was that tall fescue leaves have a tendency to accumulate soluble carbohydrates during the fall, making it very palatable to livestock. Tall fescue is also able to resist frost and continue growth later in the fall than other cool-season grasses. However much of this research was done in the beef grazing areas of the mid to upper south from Missouri to North Carolina and may not be relevant for Michigan and the Great Lakes region.

In research done at Michigan State University's Lake City Experiment Station and Upper Peninsula Experiment Station most cultivars of endophyte-free tall fescue in binary plantings with birdsfoot trefoil showed a high refusal rate by grazing beef cattle in summer but much lower refusal rate in October (Moline and Leep, 1996).

While no references on field research of legumes stockpiled for fall and winter use were available, Matches and Burns, 1995 concluded, "Few legumes can be fall stockpiled mainly because most lose their leaves more easily than grasses either from disease or maturation in summer or from frost in fall". In other references on fall and winter grazing of stockpiled forages, legumes were not mentioned.

No replicated studies on stockpiling grass or legumes in Michigan were found in doing this literature search. Anecdotal information was available from commercial gazers successfully utilizing various combinations of grass, legumes and mixed pastures in Michigan.

Selection of species for forage production in Michigan is not limited by lack of suitable grasses and legumes adapted to Michigan. There were many available grasses and legumes alternatives including orchard grass, smooth bromegrass, timothy, perennial ryegrass (*Lolium perenne L.*), tall fescue, Kentucky bluegrass (*Poa pratensis* L.), and reed canarygrass. Grown throughout Michigan, well adapted legume species are alfalfa, red clover, white clover, alsike clover (*Trifolium hybridum* L.), hairy vetch (*Vicia villosa* Roth.) and birdsfoot trefoil.

Alfalfa, birdsfoot trefoil and smooth bromegrass, were chosen for this experiment because they embodied some of the most important qualities needed in a pasture forage in

Michigan. All were able to persist under grazing conditions in Michigan's climate, although there were considerable differences in length of persistence, depending on local climate, management, and soil fertility, pH, and soil drainage (Moline et al., 1991). Each forage was able to generate acceptable dry matter yields under both preserved or controlled grazing harvest conditions, ranging in Michigan from 2-5 tons/acre for birdsfoot trefoil, 2-8 tons/acre for alfalfa, and 2-7 tons/acre for smooth bromegrass (Christenson et al., 1992). All were also able to continue production through the hot and sometimes dry Michigan summers, longer than other forage species tested because of deep root systems. Of the three, alfalfa rates highest in heat and drought tolerance followed by birdsfoot trefoil and smooth bromegrass.

Birdsfoot Trefoil

Birdsfoot trefoil has been especially successful for early summer-growth stockpiling. Little was known of stockpiling trefoil for use during the fall or winter. Birdsfoot trefoil is a day - long legume requiring a 16-18 hours of daylight for flowering (Grant and Marten, 1985). Day length of less than 16 hours begins in mid- to late summer depending on latitude. Regrowth from cuttings made when there were less than 16 hours of sunlight might be of a vegetative nature. Therefore stockpiled birdsfoot trefoil may have a higher protein and lower fiber content than other forages harvested after midsummer.

There were several other qualities of birdsfoot trefoil which made it a good subject for stockpiled forage research. There were no documented cases of frothy bloat among animals grazing birdsfoot trefoil. In addition, the nutritional quality of birdsfoot trefoil was similar to but slightly superior to alfalfa, under general conditions (Grant and Marten, 1985). Its nutritional quality was also higher than that of smooth bromegrass at similar maturity dates. It also maintained these important feed qualities in mature growth better than either alfalfa or bromegrass (Table 1).

Birdsfoot trefoil was able to tolerate poorly drained and acidic soils than alfalfa. It was also generally less susceptible to frost damage. Birdsfoot trefoil was generally a shorter lived plant than alfalfa on an individual basis. However, unlike alfalfa it can be managed for natural re-seeding by allowing stands to go to seed at least once every 1 or 2 years. (Grant & Marten, 1985)

According to the Hall and Cherney (1991), birdsfoot trefoil was well adapted to winter stockpiling. It maintained its leaves at maturity and after frosts, maintained a relatively high level of forage quality. This was contradictory to the previous noted study by Matches and Burns in 1995, where legumes were said to be poorly adapted to fall and winter stockpiling because they tended to lose their leaves during cool weather. Fall stockpiling may also improve winter survival if the forage is allowed to accumulate carbohydrates during late summer and early fall (Grant and Marten, 1985).

Alfalfa

Michigan farmers harvested an estimated 5 million tons tons of hay in 1995 of which 4.3 million tons were alfalfa and alfalfa mix hay, ranking eighth in alfalfa hay production in the U.S. (Michigan Agricultural Statistics, 1995-1996). Alfalfa hay and silage were a major component of feeds for dairy cattle, beef cattle, sheep, other ruminants and other forage eating livestock such as horses. There were no new published statistics on acreage of alfalfa being grazed, but it appeared that an increasing number of dairy farmers were grazing alfalfa and alfalfa-grass mixtures (Kole, 1992). When used in grazing systems alfalfa was effectively used in both clear seeding and mixed stands. However, in monocultures it may not be as suited to grazing systems as in conventional stored forage systems because of the danger of frothy bloat (Howarth, 1988).

Alfalfa produced an average of 40% higher yields than birdsfoot trefoil in pure stands (Christenson et al., 1992). Because of its yield advantage, alfalfa even with lower CP and DDM than birdsfoot trefoil, may still provide greater net production of DDM and protein per hectare than birdsfoot trefoil. Alfalfa has vigorous seedling development and is generally considered faster and easier to establish in new seedings than is birdsfoot trefoil (Moline et al., 1991). Alfalfa can be an excellent pasture forage, especially in mixed alfalfa -grass pastures. Alfalfa was generally more competitive than birdsfoot trefoil in mixed seedings. In alfalfa-grass. pastures, with 50% grass component, there is considerably reduced incidence of frothy bloat, though inclusion of grasses may not totally eliminate this serious and often condition in ruminant livestock (Casler,1988).

Research has produced grazing tolerant alfalfa cultivars with most seed companies offering grazing varieties. Research to produce less bloating cultivars of alfalfa has produced strains with lowered incidences of frothy bloat but completely bloat-free cultivars still elude researchers (Moutray, 1996). Potato leaf hopper resistant alfalfa could have significant impact on stockpiling. Alfalfa forage quality can be significantly lowered by potato leaf hopper damage (Eldin and Elgin, 1989). Timely cutting of alfalfa was found to be an effective technique for minimizing leafhopper damage (Roda and Landis, 1996) but may not be an option if alfalfa is to left in the field for stockpiled forage.

Smooth Bromegrass

Smooth bromegrass has a number of characteristics that make it widely used for hay and pasture forage in Michigan. It is very cold tolerant, grown successfully as far north as Alaska (Irwin, 1945; Laughlin et al., 1945). Smooth bromegrass is well adapted to many soil types (Rumbaugh et al., 1965). It does best in well drained soils including dry sandy loams, where its deep and extensive root and rhizome system helps it survive and be productive. Smooth bromegrass is deeper rooted and less drought prone than most cool season grasses. It is very winter hardy, has high livestock feed qualities and is well adapted to MIG. Bromegrass was sown for hay, pasture and conservation as early as the late 1800's in the United States and Canada (Carlson and Newell, 1985). Smooth bromegrass became a more prominent grass species when it was found to be one of the primary survivors of the 1930's drought period in North America.

Smooth bromegrass can be very productive, yielding similarly to orchardgrass , tall fescue, and reed canarygrass. Carlson and Wedin, 1974, stated that the forage quality of smooth bromegrass was similar to or better than other cool season grasses. They also found bromegrass to be free of anti-quality agents such as alkaloids and endophytes which can reduce animal performance. Research in Iowa, Minnesota, and West Virginia found smooth bromegrass produced higher average daily gains of cattle and sheep compared to cultivars of orchardgrass, tall fescue, reed canarygrass, and perennial ryegrass (Wedin et al., 1970; Marten and Jordan, 1979).

Smooth bromegrass was often seeded with legumes for pasture use. Inclusion of smooth bromegrass reduced the risk of frothy bloat from legumes such as alfalfa and white clover (Casler, 1988). Smooth bromegrass was characterized by slow regrowth, low carbohydrate levels, and fewer new tillers if most or all shoot apices were removed during the stem elongation growth stage. In this reference management for productive stands of smooth bromegrass was most enhanced by short duration rotational grazing or other grazing strategies leaving sufficient residual plant material for regrowth.

Smooth bromegrass was least compatible with alfalfa in a high quality hay regime where frequent severe harvests were likely to occur at the critical stem elongation stage (Marten and Hovin, 1980). Smooth bromegrass was very compatible with legumes in pastures (Carlson and Newell, 1985). Bromegrass was competitive with strong growing legumes such as alfalfa but not so aggressive as to completely crowd out less competitive species such as birdsfoot trefoil. In a rotational grazing study at the MSU Lake City Experiment Station (Barclay et al., 1996) smooth bromegrass was seeded in approximately 50/50 ratio with alfalfa or birdsfoot trefoil. Smooth bromegrass maintained a 45% stand in the alfalfa and a 40 % stand in the birdsfoot trefoil pastures.

In another study at Lake City 26 cultivars of five species of forage grasses including smooth bromegrass, orchardgrass, timothy, endophyte free tall fescue, perennial ryegrass, and reed canarygrass were seeded with Norcen birdsfoot trefoil in August 1994, 1995, and 1996 (Moline and Leep, 1996). In this spatially replicated study grass-trefoil plots were sampled and then grazed approximately every 35-40 days, depending on regrowth. For the 1995 growing season of the 1994 seeding, common and Badger cultivars of smooth brome maintained a mean 55 to 40% grass to trefoil ratio of total plot yield. (grass & birdsfoot trefoil - percentage totals less than 100 represent plants other than grass planted or birdsfoot trefoil). This compares to a 79 to 18% ratio for all orchardgrass , 82 to 14% for tall fescue, 46 to 47% for timothy, and 84 to 14% for perennial ryegrass cultivars. A wide range of grass to birdsfoot trefoil component ratios was found among seven orchard grass cultivars. Seasonal yield total for combined Badger smooth brome-birdsfoot trefoil was 9.32 t/ha compared to 11.0 t/ha for all orchardgrass cultivars, tall fescue 12.2 t/ha, and perennial ryegrass 9.9 t/ha. Beef cattle grazing the plots at each sample date were found to prefer smooth bromegrass and timothy cultivars over other grass species as measured by residue samples following grazing.

Forage Quality:

The variables of plant species, cultivar, and maturity and their interactions make absolute conclusions of quality difficult (Van Soest, 1982). The addition of interactions of forage digestion in the rumen further complicates the situation. Different classes of livestock (lactating dairy cow, beef cattle, sheep etc.) can react differently to variances in forage quality. The use of nutrition standards relevant to the livestock being grazed can reduce the problem of determining the effect of forage quality. The performance of ruminants relative to the neutral detergent fiber (NDF) acid detergent fiber (ADF) and crude protein (CP) percentages are well documented in many articles in the literature Marten et al., 1988; Hesterman et al., 1988; Burns et al., 1991). The exact composition of the plant is not well defined by these procedures but their relationship to animal weight gains and lactation is well documented.

The NDF percentage is estimated to be the total volume of cell wall components in the feed (Van Soest et al., 1991). While ruminants are capable of digesting a variable percentage of cell wall or fiber, the digestibility of a plant as well as the amount of intake by grazing animals is negatively related to NDF percentage. Because the NDF represents the more slowly digested and indigestible plant material, higher NDF rates in a forage can result in gut fills that limit intake and result in less net energy for gain or lactation.

Grasses and legumes vary in the type and quantity of cellulose, a cell wall component, with grasses generally having a higher cellulose content but also have a higher percentage of digestibility in their cellulose. Thus a grass having a NDF test the same as a legume will have a digestibility and energy content equal to or better than a legume (Burns et al., 1991). Van Soest (1991) found that a sequential NDF-ADF testing would yield a more accurate representation of the true levels of cellulose and hemicellulose without the possible interference of pectin .

Another major factor that influences the productive potential of ruminants on pasture is total non-structural carbohydrates or TNC (Jung et al., 1976). This was the amount of quickly fermentable cell contents and included a wide variety of constituents including sugars and starches. The amount of TNC in a feed was a good indicator of its energy content. TNC were also quickly digested, giving the feed a high intake potential because of increased rate of passage. TNC were good sources of energy for rumen microbes, which were then able to increase the potential protein available to the ruminant in the form of microbial protein. This was a low cost form of protein for the animal because it was fed in the form of a carbohydrate and utilized the rumen to good advantage

(Van Soest, 1982).

Jung, et al., 1976 in a study in Pennsylvania and West Virginia found that Pennfine a turf type perennial rye, and a forage type perennial ryegrass (cultivar Norlea) were the highest in TNC concentrations at all stages of their growth from vegetative to full bloom when compared to cultivars of timothy, orchard grass, smooth bromegrass), tall fescue, Kentucky bluegrass, redtop (*Agrostis alba L.*), and reed canarygrass. They also produced the highest two year average of TNC per hectare at 50% flower head stage at 934 kg/ha with Sac smooth bromegrass second at 926 kg/ha.

Statement of Hypotheses

Birdsfoot trefoil and alfalfa have shown potential as early summer stockpiled forages. However late summer, and fall are not typified by normal growing conditions and differences in plant physiological maturation were expected. The ability of birdsfoot trefoil to maintain high quality into mid summer may be based on response to long daylight and high temperatures, conditions that will not be present when stockpiling for winter use.

Matua bromegrass (*Bromus willdenowii*),smooth bromegrass, tall fescue, orchardgrass, and other grasses have shown potential and usability in stockpiling for fall and winter use in other states. Research on stockpiling smooth bromegrass in Michigan was lacking and it was believed to be important to test stockpiled performance in our climate. The purpose of this study was to provide replicated field evaluations on winter stockpiling of alfalfa, birdsfoot trefoil, smooth bromegrass (*Bromus inermis* L.) for use in Michigan.

Therefore:

1). Alfalfa and birdsfoot trefoil would differ in yield and quality when stockpiled for winter use when subjected to different summer cutting schemes.

2). Alfalfa, birdsfoot trefoil, and smooth bromegrass in binary mixtures will differ in yield and quality when stockpiled for winter use when subjected to management intensive rotational grazing during the previous growth season.

METHODS and MATERIALS

East Lansing

Michigan State University Teaching and Research Farm (East Lansing) was the experimental site for part of this study. Clear stands planted in August 1992 of birdsfoot trefoil, (cultivar Norcen) and alfalfa, (cultivar Big Ten) were used. The soil type was Capac loam (fine-loamy mixed mesic Areic Ochraqualfs). Soil samples were taken in early spring of 1994. Potash fertilizer (0-0-60) was applied at a rate of 114kg/ha in April 1994. Quackgrass (*Elytrigia repens* (L.) Nevski) was controlled with a spot mix strength of Fusilade® herbicide. Most of the quackgrass was killed or severely browned by this treatment. Broadleaf weeds in the birdsfoot trefoil were controlled where possible by wiping with Roundup® herbicide.

Two main plots 13.7 X 47.6m (one each for birdsfoot trefoil and alfalfa) were marked out within the existing stands (Figure 2). Main plots were further divided into subplots 13.7 X 11.9m using four replications. Each replication contained three randomized summer harvest treatments 4.6 X 11.9m (H2,H1,H0). Summer treatment plots were further subdivided into randomized fall/winter harvest sample subplots 4.6 X 4m (S3,S2,S1).

H2 summer harvests were taken June 14 and August 4, 1994, and June 12 and August 19, 1995. H1 summer harvests were taken August 4, 1994 and August 19, 1995. All no-summer (HO) treatments were left unharvested until the fall/winter sampling dates

(Figure 3). Each subplot was sampled before harvesting. The 12 samples for each forage resulted in 24 samples for each harvest date. One meter square (m^2) quadrat samples were harvested with hand clippers from all plots. The m^2 samples were placed in paper bags, dried at 150 degrees F for 24-48 hours, weighed and then ground for quality testing. Cutting treatments were completed the day of sampling using a BCS sickle bar mower. All summer harvests were representative of hay harvests, taken at 5 cm.

Figure 2. East Lansing. 1994 & 1995. Field Map. Evaluation of alfalfa and birdsfoot trefoil for winter stockpiled forage in Michigan.

	ALFALFA			BIRDSFOOT TREFOIL		
Block 1	H0S2	H1S1	H2S1	H0S1	H1S1	H2S3
	H0S3	H1S2	H2S2	H0S2	H1S3	H2S2
	H0S1	H1S3	H2S3	H0S3	H1S2	H2S1
Block 2	H2S3	H1S3	H0S1	H0S2	H2S1	H1S1
	H2S2	H1S1	H0S2	H0S3	H2S3	H1S3
	H2S1	H1S2	H0S3	H0S1	H2S2	H1S2
Block 3	H0S3	H2S2	H1S2	H1S1	H2S2	H0S1
	H0S1	H2S1	H1S3	H1S2	H2S1	H0S3
	H0S2	H2S3	H1S1	H1S3	H2S3	H0S2
Block 4	H0S1	H2S3	H1S2	H2S1	H0S3	H1S2
	H0S2	H2S2	H1S3	H2S2	H0S2	H1S3
	H0S3	H2S1	H1S1	H2S3	H0S1	H1S1

Legend:

H0 = No Summer Harvest
H1 = One Summer Harvest (August)
H2 = Two Summer Harvest (June & August)

S1 = Sampled November 1
S2 = Sampled December 1
S3 = Sampled December 31

Figure 3. East Lansing, 1994 & 1995. Summer harvesting and fall sampling timetable.

Treatment	Harvest or Sample Date				
	June	August	Nov.1	Dec.1	Dec.31
H0S1			**S1**		
H0S2				**S2**	
H0S3					**S3**
H1S1		**H1**	**S1**		
H1S2		**H1**		**S2**	
H1S3		**H1**			**S3**
H2S1	**H**	**H2**	**S1**		
H2S2	**H**	**H2**		**S2**	
H2S3	**H**	**H2**			**S3**
LEGEND:	Harvest = **H**	Sample = **S**			

1994 - Summer Cuttings and Winter Samples

The first 1994 harvest (June 14, 1994) of alfalfa had to be taken at 1/10th bloom stage due to an exceptionally cool spring. Birdsfoot trefoil was at approximately 1/2 bloom. Harvested material was then removed from the plots.

August 4, 1994 was the first and only summer harvest for the H1 plots and the second summer harvest for the H2 plots. All spacial replications of H1 and H2 (24 within each legume for a total of 48 samples) were taken in m^2 quadrats to a height of 5 cm using hand shears. Non-legume plant material was separated from the legume samples. Legume samples were placed in paper bags, dried, weighed and ground twice in preparation for forage quality testing. For the August harvest the H2 alfalfa plot were at 1/2 bloom and the H2 birdsfoot trefoil at 1/10 - 1/2 bloom. All H1 plots of both forage species were in full bloom and setting seed. In addition, the H0 and H1 alfalfa averaged a height of 95 cm and suffered from lodging. Considerable leaf yellowing and spotting (50-80%) had occurred in all H0 and H1 alfalfa plots beginning mid-July. The H0 and H1 birdsfoot trefoil plots also showed leaf yellowing and spotting, but to a lesser extent (20-30%).

1995 - Summer Cuttings and Winter Samples

Sample and harvest procedures for 1995 was identical in form to 1994 with the following exceptions: 1) No harvesting or sampling was done on the birdsfoot trefoil plots because a combination of winter kill and red clover infestation left little or no birdsfoot trefoil in most plots. Summer harvests were done on different dates and at a more advanced stage of development (1/2 to full bloom) because wet weather delayed harvests.

Lake City

Lake City Experiment Station facilities were used for evaluation of winter stockpiled plant material on previously grazed plots of either alfalfa-smooth bromegrass or birdsfoot trefoil-smooth bromegrass. Cultivars of Webfoot alfalfa, Badger smooth bromegrass and Norcen birdsfoot trefoil were used. The experimental area was seeded in 1992, cut for hay or silage in 1993 and grazed beginning in 1994. Soil type was Nester sandy loam (fine mixed type Eutoboralfs) The grazing experiment involved 108 Holstein heifer on 18 paddocks covering 29.2 ha (Barclay et al., 1996).

Forage samples were taken on November 1, December 1 and December 30 in 1994 and on October 31 in 1995. The pastures at Lake City had snow and frozen rain in 1995 eliminating the second and third samples.

The pastures had been grazed during the previous spring, summer and early fall by six Holstein heifers per 3.1ha paddock. All samples were taken from intensively grazed paddocks, which had been grazed for 3-5 days and rested for 33-45 days. Grazing ended on the sampling paddocks on September 12 in 1994 and September 28 in 1995. Four random m^2 samples were taken from the same paddocks in 1994 and 1995. Plant material was cut with hand shears to 5 cm above ground level. Samples were taken to the laboratory for hand separation into alfalfa, smooth bromegrass and other plants, or birdsfoot trefoil, smooth bromegrass and other plants. Separated samples of smooth bromegrass and legumes were dried, weighed, ground and tested for forage quality.

To determine the yield and forage quality of the combined grass-legume samples, DM weights were combined and the percent of each component calculated. The percentage was used to calculate the forage quality of the combined sample. (Example in figure 4).

Figure 4. An example of determination of forage quality of combined samples from component part tests.

Example:	Component	Weight	% of total	%CP	Component Effect
	Grass	20 g	40	18	7.2
	Legume	30 g	60	14	8.4
	Combined	50 g	100	15.6	15.6

Kellogg Biological Station

Kellogg Biological Station (KBS) was used for evaluation of winter stockpiled alfalfa (cultivar Alfalfagraze) and birdsfoot trefoil (cultivar Norcen) on previously grazed or mechanically clipped fields. The experimental area was seeded in August 1994 and grazed beginning in 1995.

Sampling Procedure

Samples were taken from previously mechanically harvested and grazed areas of the site on the same dates as at East Lansing and Lake City. Forage samples were taken on November 1, December 1, and December 29 in 1995. Paddocks had been grazed during the previous spring, summer and early fall by 12 Holstein steers per 3.1 ha paddock. All samples were taken within paddocks which had been grazed for 3 days and rested for 33 days. Grazing ended on the sampled areas on August 21 in 1995. Four random m^2 samples were taken from two paddocks.

Plant material in an area directly adjacent to the grazing areas was cut with hand shears to 5 cm above ground level. Samples were taken to the lab for hand separation of alfalfa, birdsfoot trefoil and other plants Separated samples of legumes were dried, weighed , ground and tested for forage quality.

Laboratory Analysis Procedures

All samples were hand separated, dried, weighed, and ground through a 2mm screen using a Wiley mill and further processed through a 1 mm screen on a UD cyclone mill (Udy Corp. Ft. Collins CO). Forage quality analysis consisted of : Near infrared reflectance (Pacific Scientific, #6250 Forage System NIR, Silver Spring, MD) analysis for sample grouping (Buxton and Mertens, 1991) combined with wet chemistry for determination of crude protein, sequential neutral detergent fiber, acid detergent fiber (Van Soest et al., 1991). Crude protein was determined utilizing a Hach micro-Kjeldahl sulfuric acid , hydrogen peroxide digestion followed by spectrophotometric analysis using a Hach DR/3000 spectrophotometer (Hach Co., 1988).

Fiber level testing has undergone a number of variations since its origination. Standardization and improvements recommended by Van Soest et al., 1991 were used in the forage analysis.

Statistical Analysis:

The experiment was analyzed using SAS statistical software (SAS, 1987). Analysis of variance(ANOVA) for all sites was performed for DM yield, percent CP, ADF, NDF, and DDM yield. DDM yield was determined by multiplying DM yield by percent DDM, which was calculated using the formula: % DDM= 88.9-(0.779 x %ADF).

Means were separated by Fischer's protected least significance difference (LSD) at the 5 or 1% level of significance. Combined year analysis was not performed.

East Lansing: The statistical design was a randomized complete block, split plot design with three factors and four replications (SAS, 1987). Main plots were legume (alfalfa or birdsfoot trefoil), sub-plots were summer harvests (0,1 or 2 cuttings), with three winter sample dates (November 1, December 1, and December 31).

Lake City: Experimental design was a randomized complete block with two treatments and four replications (SAS, 1987). The main treatments were legume-grass mixture components. These were alfalfa, smooth bromegrass growing with alfalfa, birdsfoot trefoil and smooth bromegrass growing with birdsfoot trefoil. The sub-plots were winter sampling dates, November 1, December 1, and December 31. Combined analysis was a mathematical treatment of mixtures representing alfalfa+smooth bromegrass and birdsfoot trefoil+smooth bromegrass.

Kellogg Biological Station: A hay harvest area and grazed pastures were both used to evaluate winter stockpiled alfalfa and birdsfoot trefoil. For the alfalfa and birdsfoot trefoil stockpiled sample following hay harvest the analysis was a randomized complete block with two main treatments, three sampling dates using four replications (SAS, 1987). The main treatments were legume species (birdsfoot trefoil and alfalfa) and winter sampling date (November 1, December 1, and December 31). For the grazed alfalfa pastures that were stockpiled, samples were taken November 1, December 1, and December 31.

RESULTS AND DISCUSSION

The objective of stockpiling is to provide forage to livestock at times when plant production is minimal. Two factors are believed to be most important for successful stockpiling :

(1) Regrowth following late summer or early fall cutting or grazing in order to supply stockpiled forage in early November. (In this study, the usage period was November 1 through December 31, of 1994 and 1995.)

(2) Forage quality at the beginning of usage period better than needed for the livestock class to which it is offered because forage quality generally declined over the grazing period.

East Lansing

For both birdsfoot trefoil and alfalfa, all no summer harvest treatments (H0-S1,2,3), winter stockpiled DM totals were significantly greater at $P<.05$ than for any of the treatments that were previously summer harvested (H2 and H1)(Table 2 & Table 4). However, in general, forage quality of stockpiled plant material in the H0 treatment was lower than in the summer harvested treatments (Table 3).

1994 Harvest Year

Alfalfa: DM Production

For alfalfa in the H0 plots the stockpiled dry matter was significantly ($P< .05$) higher on November 1, 1994 (2104 kg/ha) then on December 1,1994 (1946 kg/ha) or December 31,1994 (1770 kg/ha)(Table 2).

Table 2. East Lansing. 1994. Alfalfa dry matter yield (kg/ha) for summer harvests and fall samples.

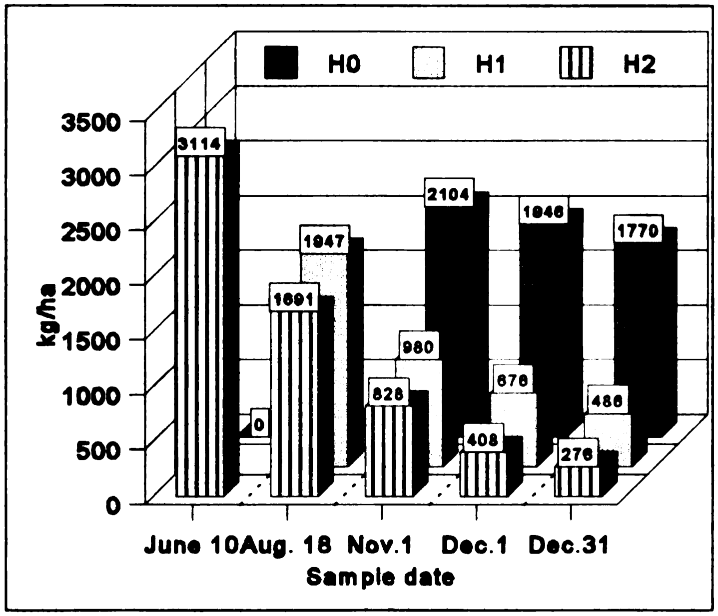
Prior Treatment	Summer Harvest 6-14	Summer Harvest 8-3	Stockpile Sample 11-1 S1	Stockpile Sample 12-1 S2	Stockpile Sample 12-31 S3	Winter Stock pile Total	Mean Winter Stockpile Total	1994 Total Yield (H+S)
NO SUMMER HARVEST H0			2104			2104 a		2104
				1946		1946 ab	1940 a	1946
					1770	1770 ab		1770
ONE SUMMER HARVEST H1		1925	980			980 c		2905
		1918		676		676 cd	714 b	2594
		2000			486	486 cd		2486
TWO SUMMER HARVEST H2	3545	2152	810			810 cd		6507
	2872	1362		465		464 cd	517 b	4699
	2927	1560			276	276 d		4633

Legend: All means in same column followed by the same letters were not significantly different at P<.05.

The relative loss of harvestable dry matter between the November 1 sampling date and the December 31 sampling date was lower for alfalfa in the H0 plots than for the H1 and H2 plots (high durability of yield). The durability of yield is defined as percent of harvestable DM present in the plot on Dec. 31(S3) relative to the amount present on Nov.1(S1): Durability of Yield= (S3/S1x100). However all of the alfalfa plants in the H0 plots were leafless with woody stems and branches on the November 1 sampling date and changed little in dry matter (Table 2) and forage quality (Table 3) between November 1 and December 31, 1994.

Alfalfa with one-summer harvest (H1) plots had a greater total yield in 1994 than the no-summer harvest H0 plots, due primarily to the additions from one extra harvest. The H1 fall-winter stockpiled DM was significantly less than the H0 stockpiled DM (P<.05). This was expected because with no summer harvests in the H0 plots all of the summer and fall growth (less any losses due to leaf drop, animal or insect harvest, or disease) was available as fall stockpiled DM yield.

Figure 5. East Lansing. 1994. Alfalfa dry matter yields (kg/ha) for summer harvests and winter stockpiled samples. LSD@ .05=580.



Alfalfa in the two summer harvest plots (H2), had a greater total yield in 1994 than the the H1 and H0 plots primarily due to the second summer harvest (Table 2, Figure 5). In summer-only yields it produced an average of 2403 kg/ha for each of two harvests, while the H1 treatments averaged 1947 kg/ha for the only summer harvest. This may be due to the loss of leaf material from disease and maturity in the H1 plots, and slow plant growth in the H1 plots from early July to the August 3 harvest. The exceptionally wet June and July weather (Appendix 1) may have both promoted rapid regrowth in the H2 plots after the June 14 harvest and accelerated disease in the H0 and H1 plots. Alfalfa plants in the H0 and H1 plots suffered lodging, fungal and bacterial leaf disease, and potato leaf hopper damage during late June and July.

In 1994 the stockpiled standing alfalfa was significantly ($P<.05$) greater in the H1 plots (980 kg/ha) for the November 1 harvest than for the H2 plots (828 kg/ha)(Figure 5). This was a difference of 152 kg/ha, with H1 alfalfa plots yielding 118 % of the H2 plots. On Dec.1, 1994 the stockpiled DM in the H1 and H2 treatment plots dropped to 676 kg/ha and 465 kg/ha, respectively, with the H1 alfalfa yielding 145% of the H2 treatment alfalfa. On Dec. 31,1994 stockpiled DM in the H1 and H2 treatment plots had dropped to 486 kg/ha and 276 kg/ha, respectively, with alfalfa in the H1 plots yielding 176 % of alfalfa in the H2 plots.

No summer harvest alfalfa (H0) supplied the highest quantity of stockpiled dry matter in 1994. Unharvested during the growing season, by Nov.1 the plants had a woody appearance and virtually no leaves. H0 plants had some basal shoots that began growing in late summer and early fall.

Alfalfa Forage Quality

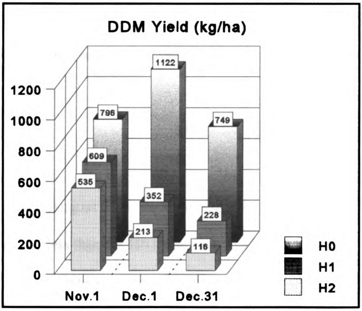
The two-summer harvest H2 plots had higher overall forage quality on each fall sample dates than did the H1 treatment (Table 3). The differences in the interaction of summer harvest and fall sample date between H2 and H1 were not significant for all quality parameters. The H2 plot DDM yields dropped by a greater percentage than the H1 plots between November1 and December 31,1994. This is due to the H2 alfalfa plants increasing in ADF and thus a lower DDM percentage.

Table 3. East Lansing. 1994. Alfalfa percent CP, NDF, ADF, DDM and kg/ha DDM.

SUMMER HARVEST	Fall Sample Date	Percent CP	Percent ADF	Percent NDF	Percent DDM	Kg DDM per Ha
NO SUMMER HARVEST	Nov.1	10.9 de	55.4 gh	74.0 ghi	45.8 a	796 cd
	Dec.1	12.1 cd	59.3 h	79.7 gh	42.7 a	1122 ab
	Dec.31	10.2 e	59.8 h	80.2 i	42.4 a	749 cde
ONE SUMMER HARVEST	Nov.1	17.3 ab	34.3 b	46.7 c	62.2 a	609 def
	Dec.1	12.4 cd	47.3 de	64.6 ef	52.0 a	352 fgh
	Dec.31	11.3 de	53.8 fg	71.4 gh	47.0 a	228 gh
TWO SUMMER HARVEST	Nov.1	19.0 a	31.2 bc	47.1 c	64.6 a	535 efg
	Dec.1	13.1 c	47.0 de	64.0 ef	52.3 a	213 ghi
	Dec.31	12.6 cd	50.3 ef	68.7 fg	49.7 a	116 hi
LSD @.05		1.75	4.5	6.1	-----	285
CV %		8.9	7.4	7.3		45.6

Legend: All means in same column followed by the same letters were not significantly different at P<.05.

Figure 6. East Lansing. 1994. Winter stockpiled DDM yield (kg/ha) for alfalfa. By Summer harvest treatment.



The H0 treatment had the lowest measured quality for all factors except kg/ha of DDM, where the amount of dry matter balanced out the low quality. In 1994 the H1 and H2 treatments were very similar in all quality. The two summer harvest (H2) plots were slightly higher in percent CP on November 1 and December 1 and slightly lower on December 31.

Even though the percent DDM was not significantly different for the H1 and H2 alfalfa plots for all harvests, the yield of digestible dry matter in the H2 treatment was less due to greater yield loss between November 1 and December 31, 1994.(Table 3, Figure 6)

Overall, in 1994, the H2 alfalfa plots supplied the higher forage quality than H0 or H1 plots over the fall sampling period. The H1 plants were only slightly lower in forage quality and maintained a greater amount of plant material through the November 1 to December 31, 1994 period. The H0 alfalfa treatments supplied the highest quantity of DDM over the fall sampling period. The H0 plots changed very little in forage quality, but with a DDM of 42.4 to 45.8 percent the digestibility might be too low for many classes of livestock, especially if used as the only feed (Blaser, 1986).

Birdsfoot Trefoil: DM Production

August 3 birdsfoot trefoil harvest yield for H1 plots averaged 627 kg/ha. This is slightly less than the 586 kg/ha yield on the H2 plots that were previously harvested on 6-14-94. The combined average birdsfoot trefoil summer yield for the H2 plots was 3943 kg/ha or approximately 5.6 times that of the total summer H1 yield of 627 kg/ha. The average single cutting yield for the H2 plots at 1971 kg/ha was significantly higher than the H1 yield of 627 kg/ha.

For birdsfoot trefoil all of the no summer harvested (H0, S1,2,3), plots fall DM totals were significantly greater than for any of the treatments that were summer harvested (H2, H1). This is however, the only annual DM production and was of considerably lower forage quality than any of the summer harvested plots (Table 4 and Figure 5).

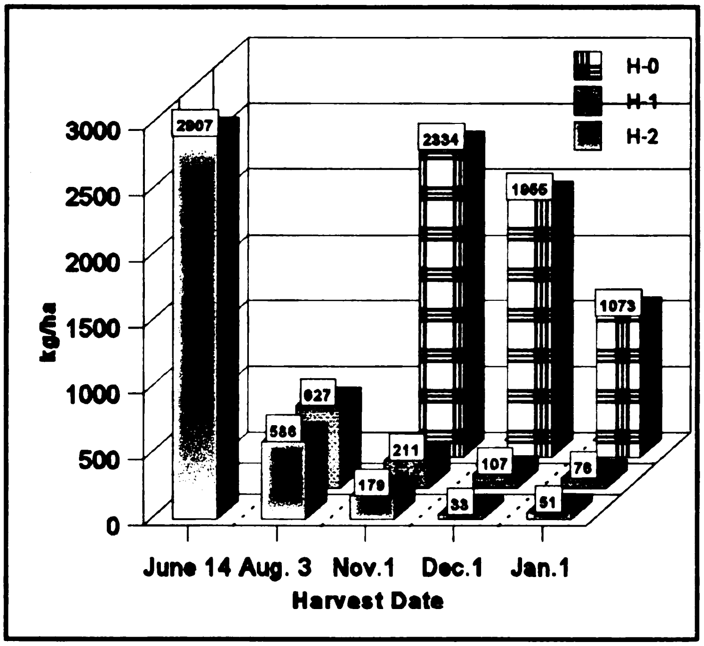
H0 birdsfoot trefoil had a significantly higher Nov.1 yield than alfalfa. H0 alfalfa plots maintained nearly the same amount of standing vegetation throughout the Nov.1 to Dec.31 period and had greater DM production for the Dec.1 and Dec.31 harvest than birdsfoot trefoil plots. Available birdsfoot trefoil DM dropped sharply during the same period. H0 birdsfoot trefoil plots were of higher original forage quality, less lignified than the alfalfa, and suffered more breakdown during the warm, wet fall of 1994 than the stockpiled alfalfa.

Table 4. East Lansing. 1994. Birdsfoot trefoil dry matter yield for summer harvests and fall stockpiled samples. Yields in kg/ha.

PRIOR TREAT MENT	SUMMER HARVEST		SAMPLE DATE			STOCK PILE TOTAL	MEAN STOCK PILE (S1,2,3)	1994 TOTAL YIELD
	6-14	8-3	11-1 (S1)	12-1 (S2)	12-31 (S3)			
NO SUMMER HARVEST (H0)			2334			2334 ab		2334 a
				1955		1955 bc	1787 a	1955 a
					1073	1073 d		1073 a
ONE SUMMER HARVEST (H1)		692	211			211 gh		903 a
		570		107		107 gh	131 b	677 a
		620			76	76 h		696 a
TWO SUMMER HARVEST (H2)	3348	583	179			179 gh		4110 a
	2655	590		33		33 h	87 b	3278 a
	2718	585			51	51 h		3354 a

Legend: All means in same column followed by the same letters were not significantly different at P<.05.

Figure 7. East Lansing. 1994. Birdsfoot trefoil dry matter yields (kg/ha) for summer harvests and winter stockpiled samples. LSD@.05=580



Birdsfoot trefoil regrowth was slow in both the H1 and H2 plots after the August 3 harvests. Regrowth of birdsfoot trefoil was highest in early October and then reduced to a dense green but very low growing rosette by Nov.1 sample date. The H1 birdsfoot trefoil plots had stockpiled yields of 211 kg/ha on Nov.1, 107 kg/ha on Dec.1, and 76 kg/ha on 12-3-1994 respectively.

The two summer harvest (H2)had a similar significant effect on the stockpiled DM for the first fall harvest on Nov.1 and showed a decline in stockpiled material similar to alfalfa during the period from Nov.1 through Dec.31. The H2 plots stockpiled plant material yield averaged 179 kg/ha on Nov.1, 33 kg/ha on Dec. 1, and 51 Kg/ha on Dec.31,1994. However, since the yields were so small for all of the treatments on all of the fall dates and were so short as to be not harvestable, the percentage differences are not very meaningful in terms of differences in available, useable forage.

1995 Harvest Year

Alfalfa: DM Production

The 1994 alfalfa plot sampling procedure was continued in 1995. Summer 1995 weather was dryer and warmer in than in 1994 (Weather-Appendix 1). Fall weather was very different in 1995 than in 1994: In 1994 there was extended fall growth / non-dormant period that extended through mid December. A hard freeze in early November, 1995 ended all above ground growth in the alfalfa plants. This freeze immediately preceded the first fall harvest on Nov.5,1995. The plants were not only frozen but seemed desiccated as well. The alfalfa leaves and stems remained a dark green for approximately one month following the November 4 freeze then gradually turned part yellow. The alfalfa leaves did not turn brown nor did they develop the leaf blotches as they had in 1994. Standing dry matter decreased through the fall sampling period in all summer-cut treatments but showed much smaller kg/ha decreases between sample dates in 1995 than in 1994. In the alfalfa H1 plots the standing DM decreased from a high of 960 kg/ha on Nov.1,1995 to 895 kg/ha on Dec.31, 1995, a decline of 7% of the Nov.1,1995 DM, compared to a decline of 50% in the same plots in 1994.

The 1994 alfalfa H2 had a significantly higher decrease in standing DM than the alfalfa H1 in 1995. The standing dry matter was 935 kg/ha for the Nov.1,1995 fall sample date and ended with 705 kg/ha on Dec.31,1995. The standing DM in the alfalfa H2 plots in 1995 decreased by an average of 24% compared to a decrease of 73% for the during the same period in 1994 H2 alfalfa.

In 1995 H0 alfalfa averaged a standing dry matter of 2389 kg/ha on Nov.1 declining to 1815 kg/ha standing dry matter by Dec.31,1995, a decrease of 24%. During the same period in 1994 the alfalfa H0 plots showed no decrease in standing dry matter.

Table 5. East Lansing. 1995. Alfalfa dry matter yield (kg/ha)for summer harvests and winter samples.

Prior Treatment	Summer Harvest		Stockpile Sample			Stockpile Total	Mean Stockpile (S1,2,3)	1995 Total Yield
	6-12	8-18	11-1 S1	12-1 S2	12-31 S3			
No Summer Harvest (H0)			2389			2389 a	2037 a	2389
				2309		2309 a		2309
					1815	1815 a		1815
One Summer Harvest (H1		2304	960			960 a	923 b	3264
		2249		905		905 a		3154
		2299			895	895 a		3194
Two Summer Harvest (H2)	2370	1825	935			935 a	806 b	5130
	2373	1818		780		780 a		4976
	2855	1919			705	705 a		5479

Legend: All means in same column followed by the same letters were not significantly different at P<.05.

In 1995 the two summer harvest (H2), summer-only yields were lower on a per-harvest basis but higher on a total yield basis than one summer harvest alfalfa (H1). In summer-only yields H2 alfalfa produced an average of 2194 kg/ha for each of two harvests, and a total summer yield of 4388 kg/ha. The H1 alfalfa averaged 2284 kg/ha for the only harvest. There was a loss of leaf material from disease and maturity in the and very little plant growth in the H1alfalfa from early July to the August 18 harvest. The late June, July, and August weather was drier than in 1994. Alfalfa plants in the H0 and H1 plots suffered less lodging, fungal, bacterial growth, and potato leaf hopper damage during late June and July and early August than in 1994.

For 1995 the there were significant differences in total yield between the H0, H1 and H2 treatments as would be expected with the great differences in type of treatment, but the weight differences as well as percentage differences were reduced when compared to 1994.

The pattern of alfalfa forage quality at East Lansing in 1995 was very different than in the same plots in 1994. This was reflected in the effect of the summer cutting treatments on forage quality for the fall sampling dates (Table 6). In 1995 the alfalfa in the no summer harvest (H0) plots was higher in crude protein, lower in ADF and NDF, and higher in percent DDM for the Nov.1-1995 sample than for the same treatment on the same date in 1994. The average crude protein of the alfalfa H0 treatment plots dropped significantly from 12.1% on Nov.1-1995 to 8.3% on Dec.1-1995 and 6.9% by the 12-31-1995 sample date. In 1994 alfalfa H0 plots showed no significant differences in percent crude protein between the sampling dates. This may be the result of alfalfa in the H0 plots being less lignified at the beginning of fall sampling period: the ADF percentage was 46.3 in 1995 for the H0 treatments on the Nov.1 sampling date, compared to 55.4 for the same sampling date in 1994.

Table 6. East Lansing 1995. Percent CP, NDF, ADF, DDM and kg/ha DDM of stockpiled alfalfa.

SUMMER HARVEST	Fall Sample Date	Percent Crude Protein	Percent ADF	Percent NDF	Percent DDM	Kg DDM per Ha
NO SUMMER HARVEST (H0)	11-1-95 (S1)	12.1 d	46.3 f	62.3 d	52.8 f	653 a
	12-1-95 (S2)	8.3 e	59.5 g	79.9 e	42.6 g	983 a
	12-31-95(S3)	6.9 e	59.4 g	79.8 e	42.6 g	773 a
ONE SUMMER HARVEST (H1)	11-1-95 (S1)	25.9 abc	15.7 ab	23.2 a	76.6 ab	735 a
	12-1-95 (S2)	24.5 c	18.5 bc	29.0 b	74.6 bc	674 a
	12-31-95(S3)	27.5 a	23.0 e	37.3 c	70.9 e	635 a
TWO SUMMER HARVEST (H2)	11-1-95 (S1)	25.3 bc	13.8 a	20.7 a	78.2 a	731 a
	12-1-95 (S2)	25.8 abc	19.6 cd	30.5 b	73.6 cd	574 a
	12-31-95(S3)	26.5 ab	22.8 de	37.9 c	71.1 de	501 a
Legend: All means in same column followed by the same letters were not significantly different at $P<.05$.						

Alfalfa H0 treatments showed a significant increase in NDF and ADF levels between the Nov.1,1995 and Dec.1,1995 samples but no significant fiber level differences between the Dec.1 and Dec.31 samples of 1995. The H1 alfalfa showed a significant increase in percent ADF and percent NDF between Nov.1, the Dec.1, and the Dec. 31 sample dates. NDF levels were below optimum ruminant levels (Blaser, 1986) for most classes of livestock at 23% on the Nov.1 sample date increasing to 29% by Dec.1, and a near optimum 37% by Dec.31.1995. H1 alfalfa ADF levels showed a very similar curve for the same time period.

There were no significant differences between the H1 and H2 plots for all harvest dates for NDF, ADF, crude protein, and percent DDM. In the only significant differences between the H1 and H2 plots, H1 plots were higher in kg/ha DDM means for all fall sample dates and for sampling date by summer harvest interactions. As they did in 1994, in 1995 the H1 plots showed an ability to maintain the forage yield over the Nov.1 to Dec.31 period better than the H2 plots. This, rather than differences in forage quality, was the factor that gave the H1 plots a higher DDM yield.

Again, as in 1994, both the H1 and H2 plots were significantly higher in forage quality than the H0 plots for all sample dates. Overall in 1995 the forage quality of all summer harvest treatments (H0, H1, and H2) were much higher than in 1994 for all fall sample dates and for means of all fall sample dates. The forage quality of the H1 and H2 plots was extremely high: the DDM for all fall sample dates did not drop below 70 percent.

Because of the loss of the birdsfoot trefoil stand at East Lansing there was no yield data for birdsfoot trefoil in 1995. The only plots that had plants remaining in each replication in 1995 were the 1994 H0 treatment. This was surprising, since research has shown that summer stockpiling can lead to stand losses from diseases. (Beuselink, 1984). The H0 treatments would be catalogued as a form of summer stockpiling since they are unharvested during the early summer as are traditional summer stockpiled forages. In this case it appears that the possible disease problems of leaving birdsfoot trefoil standing throughout the warm humid summer months was less damaging than the quick regrowth volunteer red clover in the plots. The red clover plants virtually covered the H1 and H2 birdsfoot trefoil plants after the June and August cuttings.

Weather conditions affected the summer and fall growth, dormancy, and forage quality greatly during this experiment. Weather differences between 1994 and 1995 were those of fall temperatures, rainfall, and time of first killing frost. A number of other weather factors can affect fall growth and dormancy but minimum temperatures, rainfall, and mean temperatures are among the most important (Turner and Begg, 1978. Wilson, 1981).

Weather

The mean temperatures in September, October, November, and December was higher than normal in 1994 and much higher then normal in 1995 (MDA, 1994&1995) (Data-Appendix 1). The first killing frost in 1994 was much later than normal and, depending on location, was not until mid December. Even when temperatures were low enough to be considered killing in 1994, some combination of weather or plant physiology combined to keep plants from dying and/or going dormant. In 1995 after a short but very warm and humid summer, September was cool and dry. During October temperatures dropped to a low of 9^0 F on November 4 at East Lansing. This ended all growth. Similar temperatures at KBS and Lake City appeared to have had the same effect.

In 1994 when the weather allowed the plants to remain green and growing, the forage on the plants suffered from a slow but definite decay while in 1995 the very quick and cold snap in early November seemed to have the effect of preserving the plant material especially the alfalfa in a green desiccated state. In effect it had the appearance of a high quality hay. As will be obvious in the comparison of results, this "freeze dried" alfalfa acted very much like it had been made into hay maintaining a high percentage of its DM and quality evident on Nov.1, 1995 through Jan. 1,1996.

In testing at Michigan State University (Allen and Oba, 1996) found there was a poor relation ship between NDF and lignin levels in fourth cutting alfalfa. Lignin is the major component of fiber that limits digestion (Jung and Allen 1995). This may mean that grazers will need to test stockpiled forages for lignin levels when using stockpiled alfalfa for classes of livestock particularly sensitive to fiber digestibility levels such as dairy cattle.

Lake City

1994

Dry matter yield and forage quality at the Lake City Experiment Station at Lake City, Michigan were statistically analyzed separately from those at East Lansing and KBS. The summer treatments for all of the paddocks(plots) sampled had previously been under management intensive rotational grazing from May 10 until September 12 in 1994. In 1995 the same grazing treatments were again applied and paddocks were grazed from May 16 until October 12, 1995. Early snowfalls in 1995 covered the experimental area with approximately 60cm of snow and frozen rain making sampling impossible for the second and third samples planned for Dec.1 and Dec. 31 in 1995.

Separated Samples

The samples of binary plantings of birdsfoot trefoil-smooth bromegrass or alfalfa-smooth bromegrass were hand separated into legume, smooth bromegrass and other plant fractions and dried, weighed, and ground forage quality testing. There were four components of the separated samples from the Lake City pastures:

1) Alfalfa from alfalfa -smooth bromegrass pasture.

2) Smooth bromegrass from alfalfa-smooth bromegrass pasture.

3) Birdsfoot trefoil from the birdsfoot trefoil- smooth bromegrass pasture.

4) Smooth bromegrass from birdsfoot trefoil-smooth bromegrass pasture.

For the main treatment, plant component, each of the average dry matter yields, were significantly different at $P<.01$ (Table 7). Smooth bromegrass growing with birdsfoot trefoil was the highest yielding component for all sample dates and for the average yield. Plant component yield by sampling date interactions were not significantly different.

Table 7. Lake City. 1994. Dry matter yield (kg/ha) for separated samples from birdsfoot trefoil-smooth bromegrass and alfalfa-smooth bromegrass pastures for all sample dates.

Component	Average Yield	Sample Date			Durability of Yield (S3/S1)x100
		11-1 (S1)	12-1 (S2)	12-31 (S3)	
Alfalfa	570 b	718 a	556 a	435 a	61%
Smooth Brome (growing with alfalfa)	319 c	515 a	251 a	190 a	36%
Birdsfoot Trefoil	160 d	270 a	108 a	104 a	38%
Smooth Brome (growing with birdsfoot trefoil)	784 a	808 a	808 a	746 a	92%
LSD @.05	116.4	NS	NS	NS	Not Calculated
CV %	30.6				NA
Legend: All means in same column followed by the same letters were not significantly different at P<.05.					

The ability to hold or increase the available dry matter over the winter sample period (Nov. 1 to Dec. 31) is defined here as durability of yield ((S3/S1)x100). Smooth bromegrass growing with birdsfoot trefoil (trefoil smooth bromegrass) had the highest percentage of durability of yield. Alfalfa was close in yield to trefoil smooth bromegrass on the November 1 sample date but because of the difference in the durability of yield alfalfa offered much lower available dry matter by December 31, 1994. The durability of yield for smooth bromegrass growing with birdsfoot trefoil (trefoil smooth bromegrass) was highest at 92 percent, higher than all other components, alfalfa at 61 percent, was higher than both birdsfoot trefoil and smooth bromegrass growing with alfalfa (alfalfa smooth bromegrass).

It might be expected that trefoil smooth bromegrass would compare less favorably to alfalfa in this measurement since normally smooth bromegrass has a lower forage quality (higher %ADF) than either alfalfa or birdsfoot trefoil.

During this sampling period however trefoil smooth bromegrass ADF percentage declined and consequently DDM percentage increased (Table 10). This was the only instance of increasing forage quality over the sample period at any of the three sites. Trefoil smooth bromegrass had the highest average DDM yield, the highest DDM yield for each sampling date, and higher durability of yield of DDM than any other plant component. Durability of DDM yield for alfalfa smooth bromegrass was similar to alfalfa, with both higher than birdsfoot trefoil (Table 8).

Significant differences in forage quality were found between averages of all winter sample dates for alfalfa , smooth bromegrass growing with alfalfa (alfalfa bromegrass), birdsfoot trefoil, and smooth bromegrass growing with birdsfoot trefoil (birdsfoot bromegrass). Alfalfa had the highest level of CP, then birdsfoot trefoil, alfalfa bromegrass and birdsfoot bromegrass lowest (Table 9). In level of CP alfalfa bromegrass was significantly higher than birdsfoot bromegrass and in levels of ADF and NDF alfalfa bromegrass was significantly lower than birdsfoot bromegrass. Birdsfoot trefoil had significantly lower levels of ADF and NDF than alfalfa.

Table 8. Lake City 1994. Digestible dry matter (DDM) yield (kg/ha) for separated samples from birdsfoot trefoil-smooth bromegrass and alfalfa-smooth bromegrass pastures.

Component	Average Yield	Sample Date			Durability of Yield (S3/S1)x100
		11-1(S1)	12-1 (S2)	12-31 (S3)	
Alfalfa	386 b	514 a	382 a	262 a	51% b
Smooth Brome (growing with alfalfa)	222 c	369 a	172 a	125 a	56% b
Birdsfoot Trefoil	117 d	201 a	74 a	76 a	38% c
Smooth Brome (growing with birdsfoot trefoil)	511 a	555 a	478 a	478 a	86% a
CV %	30.6				NA
Legend: All means in same column followed by the same letters were not significantly different at P<.05.					

Table 9. Lake City. 1994. Average percent CP, NDF, ADF, DDM and DDM yield (kg/ha) for separated samples from stockpiled alfalfa-smooth bromegrass and birdsfoot trefoil-smooth bromegrass paddocks. Combined sample dates.

Sample Component	Percent CP	Percent ADF	Percent NDF
Alfalfa	22.3 a	28.0 bc	43.6 b
Smooth Bromegrass *w* alfalfa [1]	16.9 c	25.8 b	50.1 c
Birdsfoot Trefoil	20.9 b	22.0 a	34.6 a
Smooth Bromegrass *w* trefoil [2]	14.8 d	30.6 cd	56.0 d
LSD @ .05	1.2	3.2	3.9
CV %	8.2	14.3	10.3

Legend: All means in same column followed by the same letters were not significantly different at P<.05.

[1]Smooth bromegrass from alfalfa+ smooth bromegrass pasture.
[2]Smooth bromegrass from birdsfoot trefoil+ smooth bromegrass pasture.

Forage quality interactions between winter sample date and forage component were significant differences for levels of ADF, NDF and DDM but not for levels of CP (Table 10). For the first winter sample date on Nov. 1,1995 birdsfoot trefoil had the lowest ADF and NDF levels but was not significantly lower than alfalfa. Both birdsfoot trefoil and alfalfa ADF and NDF levels were significantly lower than either alfalfa bromegrass or trefoil bromegrass. For alfalfa, birdsfoot trefoil bromegrass, and birdsfoot trefoil fiber levels were lowest on the first sample date and increased during the sampling period and were highest on the third sample date. Alfalfa bromegrass did not follow this pattern; NDF levels for alfalfa bromegrass followed the pattern and increased during the sample period but ADF levels decreased during the sample period and were lowest for the final sample date.

Table 10. Lake City 1994. Percent crude protein, NDF, ADF, DDM and DDM yield (kg/ha) for separated samples from stockpiled alfalfa-smooth bromegrass and birdsfoot trefoil-smooth bromegrass paddocks.

Sample Component	Fall Sample Date	Percent Crude Protein	Percent ADF	Percent NDF	Percent DDM	Kg DDM per Ha
Alfalfa	11-1-94	22.6	22.3 ab	34.3 ab	71.5 ab	513 a
	12-1-94	23.1	26.2 bc	42.3 bc	68.5 bc	381 a
	12-3194	21.1	35.7 f	54.1 efg	61.1 f	266 a
Smooth Bromegrass	11-1-94	16.3	29.7 cd	42.4 cd	65.8 cd	338 a
	12-1-94	17.7	25.9 bc	50.9 ef	68.7 bc	173 a
	12-3194	16.7	21.8 ab	57.1 fgh	71.9 ab	137
Birdsfoot Trefoil	11-1-94	21.0	19.0 a	28.6 a	74.1 a	200 a
	12-1-94	20.0	26.1 bc	40.4 bc	68.5 bc	41 a
	12-31-94	21.7	21.0 ab	34.8 ab	72.6 ab	76 a
Smooth Bromegrass	11-1-94	15.9	26.0 bc	48.1 de	68.7 bc	504 a
	12-1-94	15.5	33.9 de	61.2 h	62.5 de	499 a
	12-31-94	13.0	32.0 de	58.8 gh	64.0 de	477 a
LSD @ .05		NS	5.45	6.8	5.4	NS
CV %		8.2	14.3	10.3	16.4	31

Legend: All means in same column followed by the same letters were not significantly different at P<.05.

Combined Samples

The yield, durability of yield, and forage quality of smooth bromegrass growing with birdsfoot trefoil was very different than the bromegrass growing with alfalfa. The same smooth bromegrass cultivar, 'Barton', seeding rate, establishment method, and grazing protocol was used in both test paddocks. Smooth bromegrass yields with birdsfoot trefoil were significantly higher and forage quality significantly lower ($P < .01$) than with alfalfa. (Table 11).

TABLE 11. Lake City. 1994. Percent crude protein, NDF, ADF, DDM and DDM yield (kg/ha) combined samples from stockpiled alfalfa-smooth bromegrass and birdsfoot trefoil-smooth bromegrass paddocks.

Sample	Fall Sample Date	Percent Crude Protein	Percent ADF	Percent NDF	DM kg/ha	DDM kg/Ha
Alfalfa Smooth Bromegrass	11-1 (S1)	20.1 a	21.9 a	37.7 a	1233 a	882 a
	12-1 (S2)	21.5 a	26.1 ab	45.0 a	807 a	555 c
	12-31 (S3)	19.6 a	34.0 c	55.2 a	624 a	387 d
birdsfoot trefoil-smooth bromegrass	11-1 (S1)	14.8 a	24.2 a	43.3 a	1077 a	755 ab
	12-1 (S2)	16.3 a	31.7 c	56.3 a	969 a	623 bc
	12-31 (S3)	14.4 a	30.1 bc	55.0 a	849 a	553 c
LSD @ .05		NS	4.8	NS	NS	152.9
CV %		7.9	11.4	8.8	16.9	16.2
Legend: All means in same column followed by the same letters were not significantly different at P<.05.						

The yield for the mean of all three sample dates was significantly higher for combined alfalfa-smooth bromegrass than for birdsfoot trefoil-smooth bromegrass paddocks. This is primarily due to alfalfa yielding higher than birdsfoot trefoil since the yield of the smooth bromegrass in the birdsfoot trefoil-smooth bromegrass paddocks was higher than was much higher than smooth bromegrass in the alfalfa-smooth bromegrass paddocks.

The mean percent crude protein of the three sample dates of the alfalfa-smooth bromegrass paddocks was significantly higher than the birdsfoot trefoil-smooth bromegrass paddocks. Yield by sample date interactions were not significant. The percent crude protein of both the alfalfa and smooth bromegrass components were higher than their respective legume and grass components in the birdsfoot trefoil-smooth bromegrass paddocks.

The average ADF levels of the three sample dates of the alfalfa-smooth bromegrass paddocks was higher but not significantly higher than the birdsfoot trefoil-smooth bromegrass paddocks. Significant ($P<.01$) differences in ADF levels between sample dates were found. Acid detergent fiber (ADF) levels increased in a quite linear manner from sample date 1 through 3. The paddock legume (alfalfa-smooth bromegrass vs birdsfoot trefoil smooth bromegrass) by sample date interaction were significant at $P<.05$. alfalfa-smooth bromegrass and birdsfoot trefoil-smooth bromegrass on Nov.1, 1994 were similar and lowest with alfalfa-smooth bromegrass on Dec.31 and birdsfoot trefoil-smooth bromegrass on Dec. 1 similar and highest.

Yield differences between legume treatment (alfalfa-smooth bromegrass vs birdsfoot trefoil smooth bromegrass) by sample date interactions were not significant. Yield differences between means for all sample dates for legume treatment (alfalfa-smooth bromegrass vs birdsfoot trefoil smooth bromegrass) were also not significant. However yield differences between sample dates for means of legume treatments (alfalfa-smooth bromegrass p birdsfoot trefoil smooth bromegrass) were significantly different for all sample dates. Yields decreased in a linear manner between the 11-1 and 12-31 sample dates. (Table 12)

TABLE 12. Lake City. 1994. Percent crude protein, NDF, ADF, DDM and DDM yield (kg/ha) for combined samples from stockpiled alfalfa-smooth bromegrass and birdsfoot trefoil-smooth bromegrass paddocks.

Sample Component	Sample Date	Percent Crude Protein	Percent ADF	Percent NDF	DM kg/ha	DDM kg/ha
alfalfa-sm. bromegrass and birdsfoot trefoil-sm. bromegrass	11-1 (S1)	17.4	23.0 a	40.4 a	1156 a	818 a
	12-1(S2)	18.9	28.9 b	50.7 b	888 b	855 b
	12-31(S3)	17.0	32.0 b	55.1 b	737 c	470 c
LSD @ .05		NS	3.4	4.57	111.3	28.4
CV %		7.9	11.4	8.8	16.9	16.2
Legend: All means with different letters following were significantly different at P<.05. Means with no letters- treatment was not significant.						

Yield differences between sample dates of digestible dry matter (DDM kg/ha)were significant at P< .01. The interaction of pasture legume by sample date was also significant.

Kellogg Biological Station

1995

The experimental areas at KBS were planted in summer 1994. Paddocks were grazed for 135 days in 1995 beginning on May 15 and ending on Sept. 21. Samples were taken from the previously grazed area and in adjacent hay cut areas. In the grazed areas the birdsfoot trefoil plants lost their leaves and had little remaining dry matter by the end of October (less than 50 kg/ha of brown stems). Because there was insufficient birdsfoot trefoil material for analysis only the alfalfa samples were used in the forage analysis and statistical evaluations. These previously grazed samples were analyzed statistically as were samples from the mechanically harvested area. In contrast the birdsfoot trefoil in the areas subjected to two mechanical summer cuttings on the same dates as at East Lansing in 1995 was healthy and had substantial amounts of DM

Percent CP, kg/ha DM yield and kg/ha DDM yield of the average for all sample dates (S1, 2, 3 were taken on Nov.1, Dec.1, and Dec. 31 in 1995) were significantly ($P<.05$) higher for a birdsfoot trefoil than for alfalfa (Table 13). Differences in percent ADF and NDF were not significant ($P<.05$) for combined sample dates. All legume by sample date interactions were not significant ($P<.05$)(Table 14).

Table 13.KBS. 1995. Combined sample dates. Percent CP, NDF and ADF, dry matter and DDM yields (kg/ha) for mechanically summer cut alfalfa and birdsfoot trefoil plots.

Legume	%CP	% ADF	%NDF	DM Yield kg/ha	DDM Yield kg/ha
Alfalfa	13.4 b	44.8	62.5	1515 b	805 b
Birdsfoot Trefoil	16.2 a	43.8	59.6	2233 a	1223 a
CV %	12.8	7.3	5.9	14.7	15.2
Legend: All means in same column followed by same letter were not significantly different at P<.01 except DDM yield which was significant at P< .05.					

Table 14. KBS. 1995. Percent crude protein, NDF, ADF, dry matter and DDM yield (kg/ha) for mechanically summer cut alfalfa and birdsfoot trefoil plots. By sample date.

Legume	Sample Date	%Crude Protein	% ADF	%NDF	DM Yield kg/ha	DDM Yield kg/ha
Alfalfa	11-1 (S1)	14.7 a	39.9 a	53.9 a	1573 a	909 a
	12-1 (S2)	13.1 a	47.1 a	64.5 a	1473 a	768 a
	12-31 (S3)	12.4 a	50.6 a	68.9 a	1500 a	738 a
Birdsfoot Trefoil	11-1 (S1)	18.2 a	35.7 a	49.7 a	2275 a	1374 a
	12-1 (S2)	16.7 a	46.2 a	62.0 a	2265 a	1207 a
	12-31 (S3)	13.8 a	49.6 a	67.1 a	2160 a	1087 a
LSD @ .05		NS	NS	NS	NS	NS
CV %		12.8	7.3	5.9	14.7	15.2
Legend: All means in same column followed by the same letters were not significantly different at P<.05.						

For grazed plots alfalfa appeared to have definite sample date effects, however only fiber levels showed significant differences (Table 15).

Table 15. KBS. 1995. Percent crude protein, NDF, ADF, dry matter and DDM yields (kg/ha) for grazed alfalfa plots By sample date.

Legume	Sample Date	%Crude Protein	% ADF	%NDF	DM Yield kg/ha	DDM Yield kg/ha
Alfalfa	11-1 (S1)	20.2	32.6 a	46.6 a	1760	1116
	12-1 (S2)	17.6	44.5 b	63.7 b	1645	877
	12-31 (S3)	18.0	46.1 b	66.0 b	1480	787
LSD @ .05		NS	5.4	8.8	NS	NS
CV %		12.7	7.6	5.1	34.4	30.4

Legend: All means in same column followed by the same letters were not significantly different at P<.05.

CONCLUSIONS

Alfalfa in clear seedings at East Lansing, Michigan was able to supply a greater total annual yield and fall-winter stockpiled yield than birdsfoot trefoil. However the original alfalfa stand before treatments had a greater plant density than the birdsfoot trefoil. With only one exception, alfalfa produced more fall/winter stockpiled dry matter and DDM per hectare than birdsfoot trefoil at all sites and both years. Birdsfoot trefoil was able to produce higher yields of dry matter and DDM at KBS in 1995 in mechanically summer-cut fields.

Durability of stockpiled forage was greater in 1995 than 1994 at the East Lansing location. Observations of plant reactions plus dry matter yields supported the conclusion that early frost is less damaging than warm wet fall weather on durability of stockpiled forage during fall and early winter.

At Lake City smooth bromegrass in birdsfoot trefoil-bromegrass produced higher fall-winter stockpiled yields than it did in alfalfa-bromegrass pastures. However because birdsfoot trefoil yields were lower than alfalfa, birdsfoot trefoil-bromegrass pastures produced less total dry matter and DDM yields for the first winter sample date. Smooth bromegrass in both birdsfoot trefoil+bromegrass and alfalfa+bromegrass pastures had greater yield durability than either alfalfa or birdsfoot trefoil over the samping period.

Summer-harvest treatments had similar effects on winter stockpiled dry matter yields of both alfalfa and birdsfoot trefoil at East Lansing. No-summer harvest plots produced the highest stockpiled yield of the lowest quality forage. Two-summer harvest treatments had the lowest yield but highest forage quality in the winter sample period. One-summer harvest treatment was intermediate to two summer harvest and no summer harvest in both yield and forage quality. Of the summer cut treatments, one-summer harvest treatments had greater durability of yield over the winter sample period resulting in much greater DM by the end of the sampling period.

The results at KBS showed the difficulty of evaluating birdsfoot trefoil for fall/winter stockpiling. Birdsfoot trefoil yielded greater DM and DDM yield than alfalfa in mechanically- cut fields and much less than alfalfa in previously grazed pastures.

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Appendix 1

East Lansing Weather Data 1994 & 1995

East Lansing. 1994 & 1995. Average monthly temperatures and departure from normal				
	1994		1995	
Month	Temperature	Departure From Normal	Temperature	Departure From Normal
Jan.	13.7	-6.4	25.2	+5.1
Feb.	18.8	-3.0	21.6	-0.6
March	33.4	+.6	35.6	+2.8
April	47.8	+2.5	41.3	-4.0
May	54.9	-1.9	54.7	-2.1
June	67.7	+1.6	67.6	+1.5
July	69.7	-0.8	70.5	0.0
Aug.	65.5	-2.7	73.7	+5.5
Sept.	62.1	+1.0	58.3	-2.8
Oct.	51.2	+1.9	52.1	+2.8
Nov.	42.2	+4.2	30.7	-7.3
Dec.	31.6	+5.8	22.8	-3.0
Avg.	46.2	+0.2	46.1	+0.1

East Lansing. 1994 & 1995. Average monthly precipitation and departure from normal				
	1994		1995	
Month	Precipitation in inches	Departure From Normal	Precipitation in inches	Departure From Normal
Jan.	13.7	-6.4	25.2	+5.1
Feb.	18.8	-3.0	21.6	-0.6

March	33.4	+.6	35.6	+2.8
April	47.8	+2.5	41.3	-4.0
May	54.9	-1.9	54.7	-2.1
June	67.7	+1.6	67.6	+1.5
July	69.7	-0.8	70.5	0.0
Aug.	65.5	-2.7	73.7	+5.5
Sept.	62.1	+1.0	58.3	-2.8
Oct.	51.2	+1.9	52.1	+2.8
Nov.	42.2	+4.2	30.7	-7.3
Dec.	31.6	+5.8	22.8	-3.0
	46.2	+0.2	46.1	+0.1