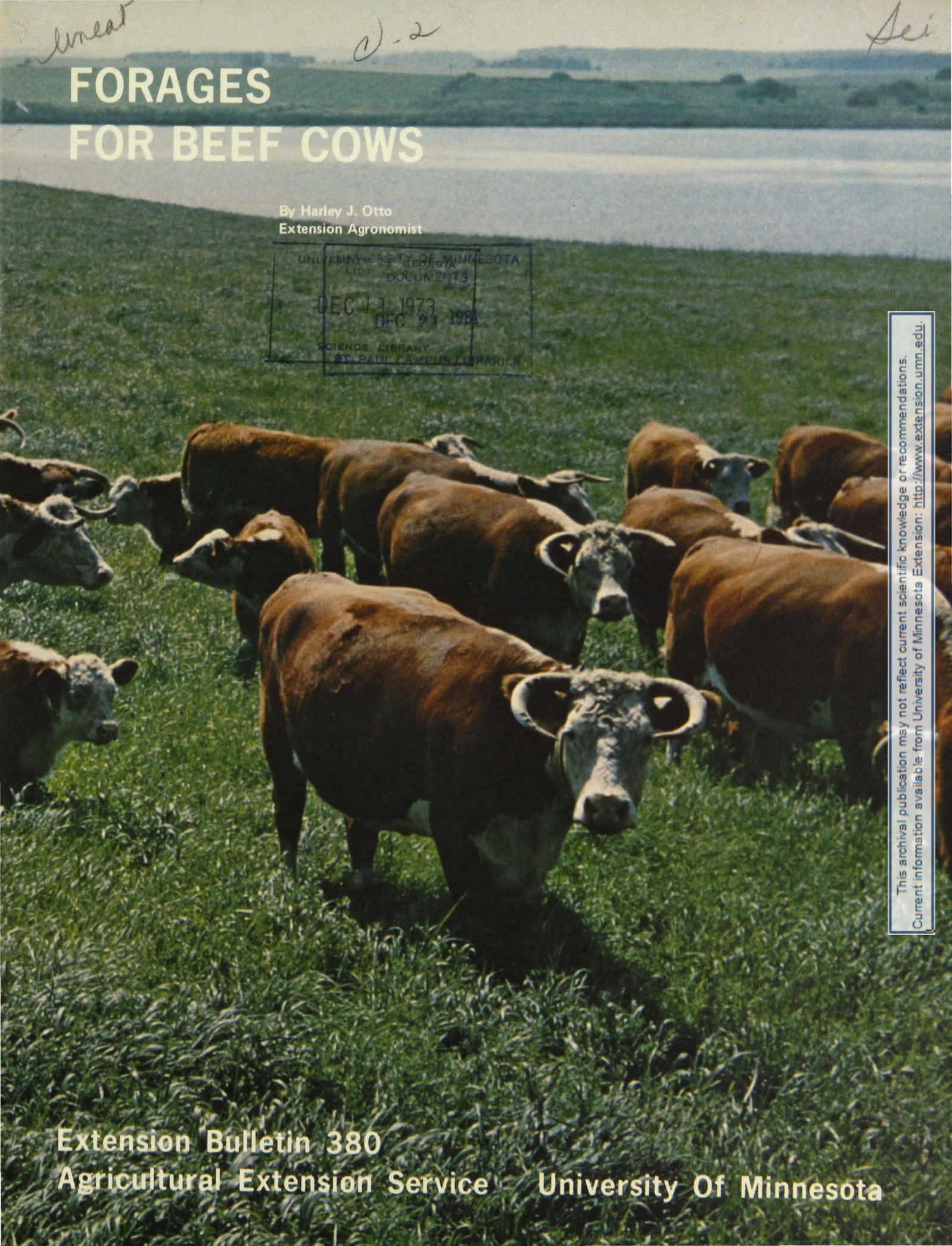
FORAGES FOR BEEF COWS

By Harley J. Otto
Extension Agronomist



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Forages are the major feed source for beef cows. Pasture and stored feed represent nearly two-thirds the total expense of maintaining a herd. Therefore, reducing forage production costs increases profits.

The following relationships between production per acre and feed costs were found on northern Minnesota farms where most pastureland was nontillable:[1]

Producers with highest feed costs required nearly three times more land per cow than those with lowest feed costs. Costs of producing feeder calves can be reduced by increasing hay and pasture production per acre. This increased production must then be effectively used.

Few economic alternatives exist for forage land if production capacity is limited by droughtiness, wetness, etc. However, productivity can often be increased by improved crop and soil management.

	Acres Required Per Beef Cow		
	Hayland	Pastureland	Total
One-fifth of herds with lowest feed costs	1.0	2.5	3.5
One-fifth of herds with highest feed costs	4.0	5.0	9.0

On farms with tillable pastureland, these relationships were found:

	Acres Required Per Beef Cow		
	Hayland	Pastureland	Total
One-fifth of herds with lowest feed costs	1.0	1.3	2.3
One-fifth of herds with highest feed costs	4.0	2.5	6.5

[1]Economics of Beef Cow Herds in Northeastern Minnesota, A. R. Wells, S. A. Engene, and T. R. Nodland. University of Minnesota, Department of Agricultural and Applied Economics. Economic Study Report S68-4, November 1968.

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Forage Production and Utilization in Minnesota

Nearly 9.5 million acres of forages are produced in Minnesota (table 1). This is about 33 percent of the state's total farmland. Regional percentages of farmland used for forages are shown in figure 1. The largest percentages are in northeast and southeast Minnesota.

Nearly 6 million acres are pasture. Of this, about 2.5 million acres are cropland or improved pasture. The remainder is less productive woodland and unimproved pasture.

Several forages are used for stored feed—primarily hay and silage. Alfalfa, alfalfa-grass mixtures, corn si-

Table 1

FORAGE PRODUCTION IN MINNESOTA[1]

ACRES

	All Farms[2]
Total Farmland	28,825,240
Cropland Pasture	2,100,812
Woodland Pasture	1,668,330
Other Pasture	1,440,335
Improved	366,991
Total Pasture	5,952,878

STORED FEED (COMMERCIAL[3] FARMS)

ACRES

Corn (silage & dry feed)	729,823
Sorghum (silage & dry feed)	9,995
Alfalfa and alfalfa mixtures	1,735,203
Clover and clover mixtures	416,471
Small grain hay	23,222
Other hay	189,519
Grass silage	94,531
Green chop	29,447
Total	3,228,211

Estimated stored feed acreage on all farms 3,524,561[2]

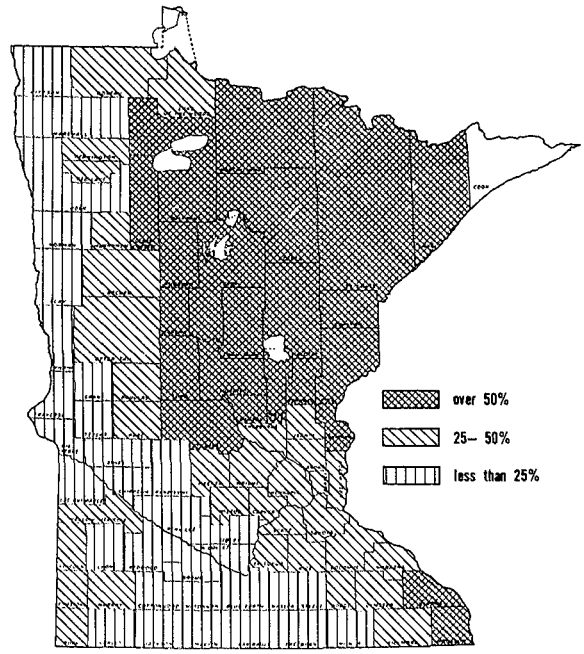
[1]Estimates based on data from 1969 Census of Agriculture

[2]Assuming same proportions on all farms as on commercial farms

[3]Class 1-5 farms (sales over $2,500)

Figure 1.

Percent of Farmland Used for Forage Production



lage, clover, and clover-grass mixtures are most widely used. Crop distribution is shown in figures 2, 3, and 4.

Alfalfa is used widely except in northeastern Minnesota. Alfalfa should be the first choice among perennial legumes unless large amounts of lime and fertilizer are needed or drainage is poor. Clover is often grown where alfalfa is not productive. Corn silage is used extensively in the southern three-fourths of the state.

Beef cow distribution is shown in figure 5. The number has increased from about 200,000 in 1950 to 550,000 in 1973. The most rapid growth has been in areas delineated in figure 6. Further growth can be expected in these areas because additional forage is or can be available.

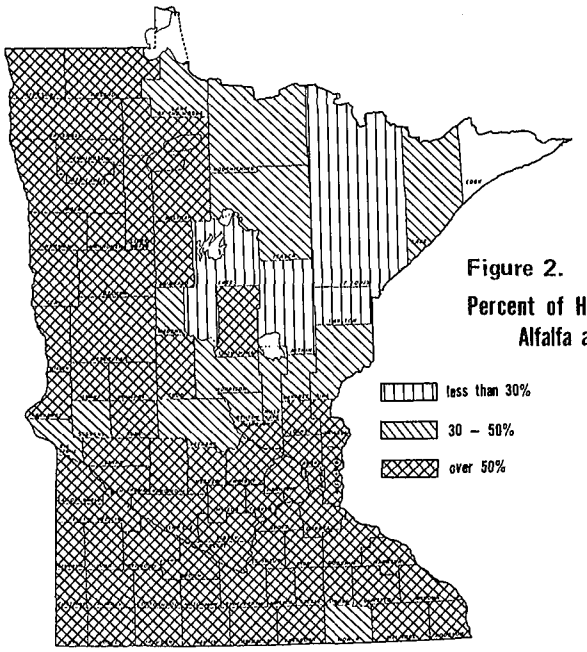


Figure 2.
Percent of Harvested Forage Land in Alfalfa and Alfalfa Mixtures

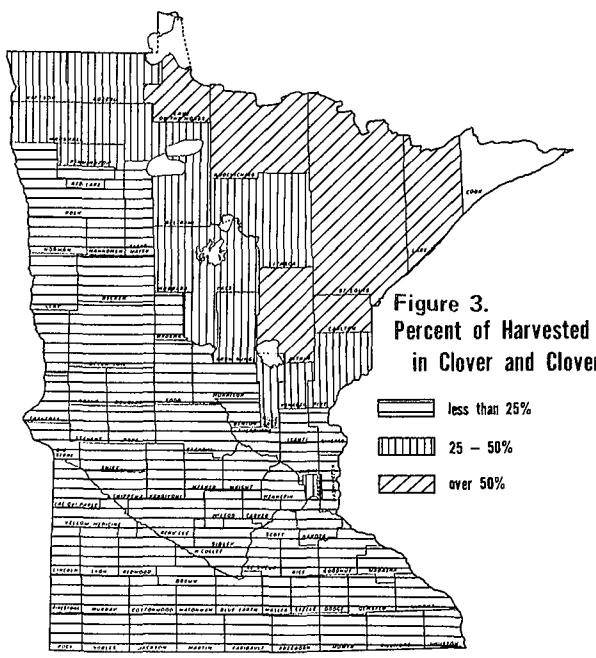


Figure 3.
Percent of Harvested Forage Land in Clover and Clover Mixtures

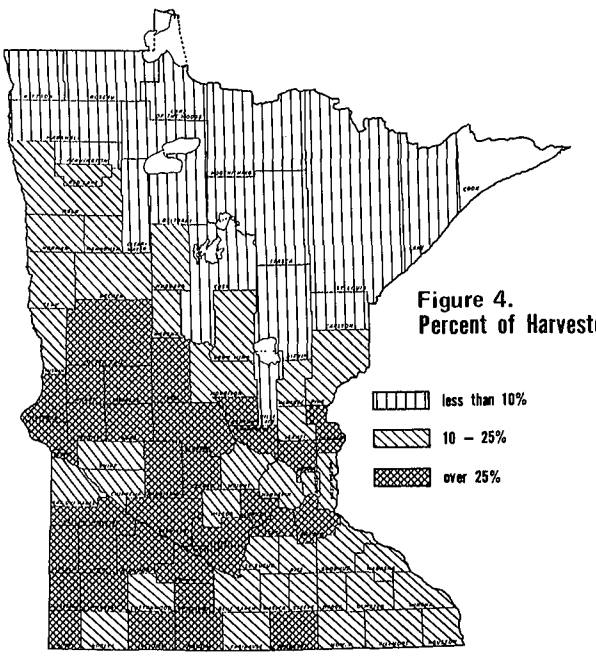


Figure 4.
Percent of Harvested Forage Land in Corn Silage

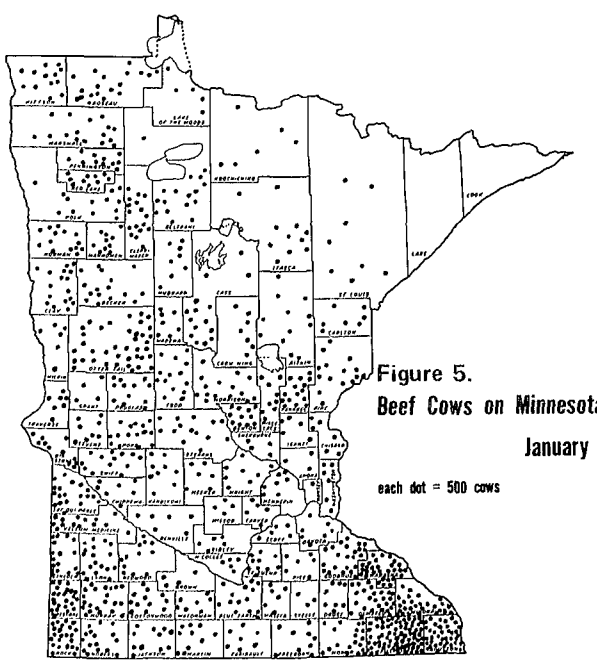


Figure 5.
Beef Cows on Minnesota Farms January 1, 1972

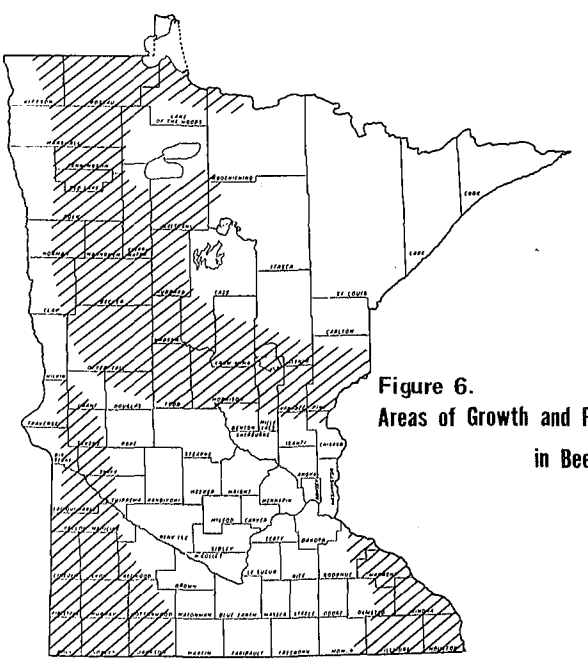


Figure 6.
Areas of Growth and Potential Growth in Beef cow Numbers

Improving Forage Production

Several alternatives can improve forage production. Appropriate ones depend upon soil productivity, feasibility of tilling the soil, kind of existing vegetation, size of herd in relation to amount of existing forage, and available time and money.

Some alternatives are:

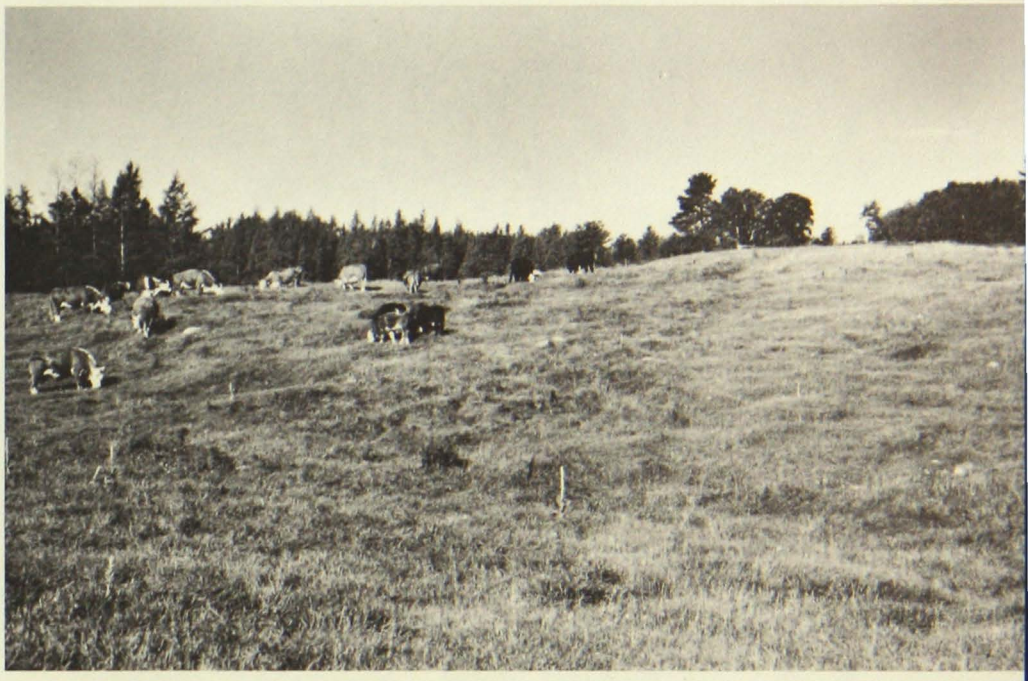
1. Land clearing – this costly operation should not be undertaken until it has been carefully analyzed (including the possibility of purchasing cleared land). Methods include herbicide spraying, bulldozing, and use of specialized machines. If tree growth is not heavy, herbicide application (usually by air) will open up the cover, allow light to penetrate, and thereby stimulate grass production. To kill most of the trees, several applications will be needed over a few years.

2. Drainage – in wet areas, drainage may allow production of better forage species and improved use through timely grazing or harvest.

3. Fertilizing existing forages – this may be the best choice if desirable species are present; if the soil is so shallow, steep, or rocky that preparing an adequate seedbed is impractical; or if the soil is so droughty that more desirable species could not produce their potentials during part of the growing season.

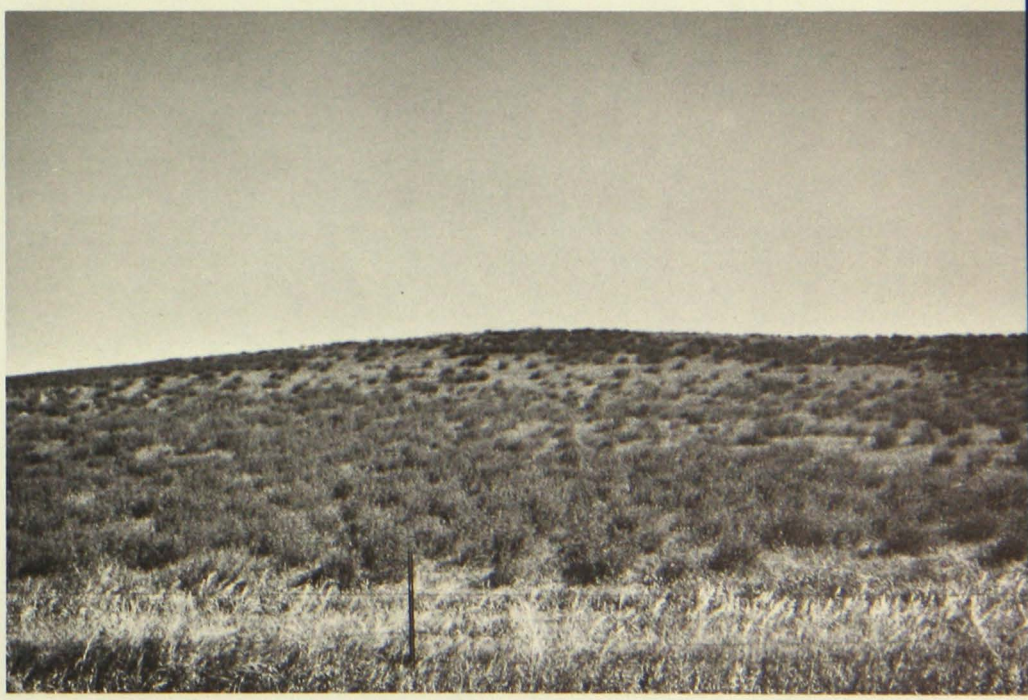
4. Renovating and establishing more productive species – this is the best choice on productive land currently covered with less productive species and where increased production can be effectively utilized. For pasture renovation information, see Agronomy Fact Sheet No. 18, "Pasture Renovation."

If these investments are to pay, efficient forage use is necessary. High quality hay and silage requires timely harvest and correct handling and storage. In pastures, higher stocking rates and rotational grazing are necessary.



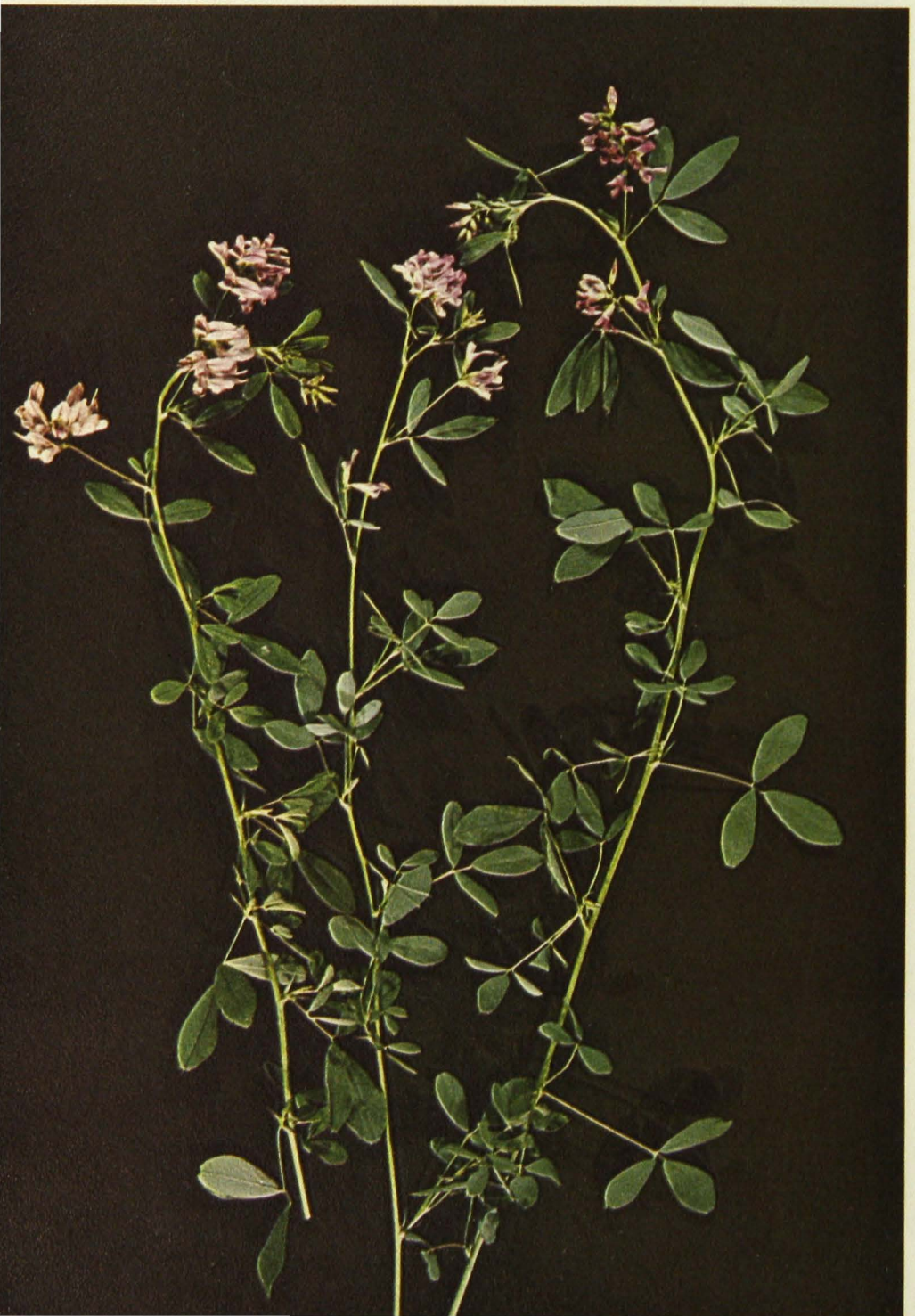
Fertilized pastures can be two to three times more productive. The area on the left was fertilized; the area on the right was not. Good grazing management together with improved forage production is necessary to obtain greatest profits from pastures.

Alfalfa requires good stands for high productivity. Poor stands are one of the most common causes of low alfalfa yields in Minnesota. Several production practices affect alfalfa stands, including choice of variety, seeding methods, plant diseases, soil fertility, and cutting or grazing management. Cool-season grasses in this hayfield contributed to the first harvest yields, but are not contributing to mid-summer production.



Grasses and Legumes Adapted to Minnesota

Several grasses and legumes can be used in Minnesota. Usually, mixtures of species are seeded in new pastures or hayfields. Some species are discussed here.



Alfalfa

Alfalfa is one of the most productive legumes when grown on land suited to its production. In addition, it stimulates grass in mixtures because it fixes nitrogen.

Chief soil limitations are poor drainage, low pH, and low fertility. Alfalfa does not produce well on poorly drained soils. New varieties such as Agate (resistant to Phytophthora root rot) should extend the range of soils suitable for alfalfa production. Alfalfa produces best on soils with p^H above 6.5. Soil should be tested before alfalfa is seeded. If lime is needed, it should be applied and worked into the soil 6 to 18 months before seeding so the soil can be neutralized. Also, if alfalfa is to be productive, the soil must be well supplied with phosphorus and potassium. Other nutrients may be needed in some areas. Fertilizer should be applied before seeding and as topdressing after the crop is established.

Many good varieties are available. Characteristics of varieties sold in Minnesota are given in University of Minnesota Miscellaneous Report 24, "Varietal Trials of Farm Crops," available from your County Extension Agent. Choose varieties with good winter hardiness, bacterial wilt resistance, and high yield potential. Buy certified seed, since it assures varietal purity and the variety's performance characteristics.

Alfalfa in pastures can cause cattle bloat. However, alfalfa is so productive and nutritious that farmers who have land capable of economically producing alfalfa should control the bloat rather than avoid using this crop.

Pastures with a high grass percentage in the mixture are less likely to cause bloat. A mixture of 50 percent legume and 50 percent grass provides good productivity and low bloat danger. This ratio may be attained by proper choice of grass species and seeding rates. A small amount of orchardgrass in mixtures with alfalfa and bromegrass helps increase grass percentage—particularly the year after seeding and in mid-summers of subsequent years.

A low-growing, slow recovery variety such as Teton, Travois, or Rambler will increase grass consumed by livestock, but will decrease total pasture productivity.

Red Clover

Red Clover is more often used for hay production than for pasture. This legume is shorter lived than alfalfa. Often it gives only one good year of hay or pasture. So if alfalfa can be successfully grown, it's a better choice. However, red clover grows in wetter and more acid soils than does alfalfa.

Red clover may also cause bloat if the legume content of the pasture is much above 50 percent.

Alsike Clover

Alsike clover is a short-lived perennial. It tolerates wet and acid soils better than does alfalfa. Therefore, it's useful with alfalfa on soils with varying drainage. In poorly drained spots, alsike clover will become the dominant legume. Alfalfa will dominate in better drained areas. Alsike clover can be the only legume in mixture with grasses on soils too uniformly wet or acid for alfalfa. If drainage is good, it may be more economical to apply lime to correct acidity. Then plant the alfalfa.

On wet or acid soils, alsike clover may be desirable even though it may not persist for long in the mixture. While it survives, it will provide nitrogen for the grass. This will lower production cost compared to seeding grass alone and applying nitrogen fertilizer.

In mixtures, a common seeding rate is one pound per acre of alsike clover with the alfalfa-grass mixture. If used as the only legume, 2 to 4 pounds of seed per acre should be mixed with the grass.

White Clover

Two types of white clover are used in pasture mixtures. The taller, more vigorous type is Ladino while the shorter, less vigorous type is usually called wild white or white Dutch clover.

Ladino is not completely winter-hardy in Minnesota. However, it will usually survive the first winter. It's a productive, nutritious, and palatable legume. However, Ladino will produce livestock bloat if it's too abundant in mixtures. In wet years, it tends to dominate and may be a serious bloat hazard.

Wild white clover is more winter-hardy than Ladino. However, it's considerably less productive. Because it's shorter, it's less likely to dominate in mixtures. Therefore it does not present as serious a bloat hazard as does Ladino. In many parts of Minnesota, wild white clover volunteers when pastures are renovated. Because of wild white clover's low productivity, alsike is better in mixtures for producers concerned about Ladino's bloat hazards. Alsike clover is more likely to result in a 50-50 legume-grass mixture than is Ladino.

Birdsfoot Trefoil

Birdsfoot trefoil is a perennial legume used in pastures in many places in northern latitudes. It is best adapted to nondroughty sites and can withstand moderately poor drainage. This legume presents no bloat hazard. Because it is a low-growing plant, birdsfoot trefoil can withstand considerable grazing. Some varieties establish slowly; others tend to winterkill in Minnesota.

There are two types. The tall-growing type is used for hay and pasture in parts of the United States and in Europe. Viking is an example. This variety should not be planted in Minnesota because it does not have sufficient winterhardiness. The lower-growing type is more winterhardy. However, it is not as productive as alfalfa-grass mixtures in pastures. Although birdsfoot trefoil will produce on soils too acid for alfalfa, it produces best if the p^H is between 6.5 and 7.0

Several varieties of low-growing birdsfoot trefoil are available. Some are described in Miscellaneous Report 24, "Varietal Trials of Farm Crops." The oldest and most commonly used is Empire. However, some newer varieties such as Leo and Carroll establish faster and have more seedling vigor. Seed supplies of newer varieties have not been sufficient for wide scale use. If seed can be obtained, either Leo or Carroll is preferred to Empire.

Under continuous grazing, stands of birdsfoot trefoil sometimes gradually diminish. In other situations, stands have been maintained for several years. This species offers promise for summer grazing when many grasses are not productive. In this instance, grazing is deferred until birdsfoot trefoil is in full bloom (about June 20 to 25 in central Minnesota). Then it is grazed during July and August. Because it doesn't cause bloat, stands with a high birdsfoot trefoil percentage can be used for pasture. Grass, particularly Kentucky bluegrass, will usually increase in a pasture containing birdsfoot trefoil. However, birdsfoot trefoil can be seeded alone for pasture. In the seedling stage, birdsfoot trefoil often has difficulty competing with vigorous grasses so seeding it alone may result in more vigorous stands. If a grass is included, a relatively noncompetitive species (such as timothy) will better allow the birdsfoot trefoil to establish and persist.

Crown Vetch

Crown Vetch is a perennial, rhizomatous legume which has produced good beef gains in research trials in several states. However, this species is slow and difficult to establish. In limited research in Minnesota, stands have not persisted under grazing. Therefore, this legume is not recommended for forage.

Smooth Bromegrass

Smooth bromegrass is a rhizomatous, productive, palatable, winter-hardy grass. It's used widely for pasture and hay. Three problems are: (1) its light, fluffy seed which is difficult to plant; (2) its slow starting ability; and (3) its slow regrowth during hot, dry summer periods. Usually this grass does not contribute much in mixtures the first harvest year. The chaffy seed can be planted by mixing it with oats in a grain drill or with fertilizer in a fertilizer attachment or spreader. If smooth bromegrass is to be mixed with legumes for pasture, a faster starting grass such as orchardgrass should be included to increase grass content the first harvest year. This reduces chances of bloat.

Bromegrass is sensitive to grazing or cutting time. An improper mowing or grazing time can result in decreased vigor and slower recovery and may kill the plants. The source of growth of developing bromegrass is the growing point on top of the stem. This eventually becomes the head of the plant. As the plant resumes growing after winter dormancy, the growing point is at or below the soil surface. The first spring growth is in the leaves. The growing point stays at the soil surface for a time. Leaves can be grazed without plant damage if the growing points are not high enough to be eaten. The most dangerous time to completely graze or mow the plants is after growing points are high enough to be eaten or cut off until when the plants are headed. Lenient grazing during this time will not hurt stands since many growing points will remain. If bromegrass is harvested for hay, there is little danger of damage if plants are allowed to head out.

Many people consider reed canarygrass adaptable only to low, wet areas such as sloughs and bogs. It is one of the most water tolerant forage species. Therefore, it is a good grass for low, wet areas. However, it is also one of the most productive grasses for upland sites. It produces better than bromegrass during hot, dry summer periods. It may be more useful in upland areas than in low areas. In uplands, the stands can then be pastured or harvested earlier in the season when nutritive value is higher.

Reed canarygrass is a perennial, winterhardy species. However, it is less palatable than other forage grasses commonly used in Minnesota. If grown with other grasses and legumes, animals may graze the other species first. However, if it is grown in pure stands, animals do not have a choice. Cattle will eat it and perform quite well. Grazing it when it is relatively immature improves palatability. Palatability can also be improved by fertilizer applications. If a soil test shows phosphorous and potassium deficiencies, these nutrients should be included in the fertilizer. Pure stands of reed canarygrass require nitrogen application for productivity and palatability.

At the Rosemount Experiment Station,[2] reed canarygrass was compared with bromegrass on well-drained silt loam soil. When grazed by heifers, the reed canarygrass produced more weight gain per acre than did bromegrass. When both kinds of pastures were grazed intensively (high stocking rate), lower animal gains per day resulted. However with both kinds of pasture, there were greater gains per acre than where grazing was less intensive (low stocking rate). Under less intensive grazing, advantages of reed canarygrass were not as great. These results are shown in the following tables.

When purchasing seed, pay special attention to germination as there is a problem with some seed lots.

Pounds Nitrogen Per Acre	Bromegrass	Reed Canarygrass
	Dry Matter Yield (Tons/Acre)	
0	1.7	2.2
140	3.3	4.4
	Palatability (percent of available dry matter consumed when animals had a choice)	
0	73	35
140	73	44

Stocking Rate	Bromegrass	Reed Canarygrass
	Average Daily Gain (lbs. per animal when animal did not have a choice).	
Low	1.7	1.7
High	1.5	1.5
	Heifer Grazing Days Per Acre (200 lb. Nitrogen/Acre)	
Low	244	283
High	311	383
	Heifer Gain Per Acre (lbs.)	
Low	415	481
High	466	574

[2]"Reed Canarygrass Outscores Brome as Upland Pasture." Gorden C. Marten and John D. Donker. Minnesota Science 24 (2) 13-15, Winter, 1968.

Orchardgrass

Orchardgrass is a vigorous, bunch-type perennial grass. It starts fast after seeding and contributes more the first harvest year than does bromegrass. For this reason, it's useful in a bromegrass-alfalfa pasture mixture. Grass percentage will be higher the first pasture year. This will help alleviate bloat problems. Orchardgrass is one of the most productive grasses during warm summer months.

However, orchardgrass is not as winterhardy as many other grass species. Sometimes it will winterkill. It is most persistent where snow cover provides winter protection. Thus in areas with reliable snow cover, orchardgrass suffers less winterkilling. Plant breeders are attempting to develop more winterhardy varieties. Some progress has been made. The variety Nordstern has exhibited greater winterhardiness than other commercially available varieties.

Orchardgrass recovers quickly after grazing. Its palatability declines rapidly as it approaches maturity. Since it is fast growing, careful grazing management must be used for greatest benefits from the species.

Timothy

Timothy is one of the most widely used pasture and hay grasses in the northern humid United States. It is a winterhardy, bunch-type grass. Timothy has been quite productive, especially in northern Minnesota. It is easier to seed than are bromegrass or reed canarygrass, and it establishes faster. In Minnesota, a large proportion of timothy's total production usually comes in the first growth. However when rainfall is plentiful and temperatures are moderate, timothy will produce well during the summer. Many varieties are available. Some are described in Miscellaneous Report 24, "Varietal Trials of Farm Crops."

Kentucky Bluegrass

Kentucky bluegrass is one of the most common grasses in permanent pastures. It has a high degree of winter-hardiness; it withstands grazing and mowing well; and it is very persistant in pastures.

Kentucky bluegrass should not be included in Minnesota pasture mixtures. If the pasture is heavily grazed or mowed, Kentucky bluegrass will become the only grass in 2 to 3 years.

Kentucky bluegrass does not produce as much forage per acre as do tall grasses such as bromegrass, reed canarygrass, timothy, or orchardgrass. However in permanent pastures, it can produce considerable forage if it is properly fertilized, particularly with nitrogen. In many parts of Minnesota, it will become dominant in pastures even if it is not seeded. This is because seeds and rhizomes are usually in the soil. Plants have strong, vigorous rhizome systems that spread rapidly.

Tall Fescue

Tall fescue is used extensively in areas further south than Minnesota. In those areas, it is more productive than other grasses during late summer and fall. It is often stockpiled for grazing into wintertime. However, it lacks winterhardiness in Minnesota. It is less palatable than most other grasses. Thus, it is not recommended for Minnesota at this time. Other grasses are more suitable to this state's growing conditions.

Warm Season Grasses

Minnesota's native prairie grasses were largely warm-season perennials. These species, such as switchgrass, big bluestem, and yellow Indiangrass, may be useful in some western Minnesota pasture programs. These grasses start growth later in the spring than do the cool-season species discussed before. Most of their growth comes in late June, July, and August. Little regrowth occurs once initial growth has been removed.

Total production per acre is less for the warm-season grasses than for cool-season grasses. However, since production comes when cool-season species are not productive, warm-season grasses may be a valuable addition to a grazing program. If a warm season perennial grass is to be sown, switch-

Switchgrass

grass is the best choice because it is easier to seed and establish.

Establishing stands is difficult because warm-season perennials germinate and grow slowly. Also, weeds must be controlled. Seeding should be done between May 1 and June 15 in a clean, well-prepared seedbed. Only limited testing of switchgrass varieties has been done in Minnesota.

Sudangrass, sorghum-sudangrass hybrids, and forage sorghums are annual warm-season grasses. Sudangrass and sorghum-sudangrass hybrids can be used for pasture. Forage sorghums should only be used for silage or hay; they have high prussic acid content. In Minnesota, cool weather is the chief limiting factor for these crops. Many summers so little growth occurs in the northern half of the state that the crops are of questionable economic value. Further information is in Agronomy Fact Sheet No. 15. "Sorghum-Sudangrass Hybrids."

Big Bluestem

Indiangrass

Sudangrass

Mixtures and Seeding Rates

Usually pastures should be seeded with grass-legume mixtures. For well-drained soils where alfalfa is adapted, a mixture of alfalfa (7 lbs. per acre), bromegrass (8 lbs. per acre), and orchardgrass (2 lbs. per acre) is recommended. This mixture should contain enough grass to prevent bloat.

If the pasture contains low, wet spots, alsike clover at 1 pound per acre or Ladino clover at 1/2 pound per acre should be added to the above mixture. Clover will be the dominant legume in the low spots; alfalfa will dominate on better drained areas.

If alfalfa is not adapted because the land is too acid for economically feasible lime application, or if the land is too wet, a mixture of red clover, 4 pounds; alsike clover, 2 pounds; bromegrass, 5-6 pounds; and timothy or orchardgrass, 2 pounds, may be used.

Further mixture information is available in Agronomy Fact Sheet 30, "Forage Mixtures."

The amount of seed needed to establish a satisfactory stand depends considerably upon the seedbed. One of the greatest problems is loose seedbeds. This results in seed coverage that is too deep. The seedbed should be firm enough so a man walking on it will sink only about 1/2 inch. Information on stand establishment can be found in Agronomy Fact Sheet 19, "Establishing Small Seeded Forages."

Suggested seeding rates and times are summarized below:

Crop	Pounds/Acre*	Time
Alfalfa		
alone	8-12	Early spring to August 10
with grasses	5-8	
Birdsfoot trefoil	5-6	Early spring
Clover		
Alsike (in mixtures)	1-4	Early spring
Ladino (in mixtures)	1/2-2	
Red (in mixtures)	4-8	
Bromegrass (in mixtures)	8-15**	Early spring or late summer
Orchardgrass (in mixtures)	2-6	Early spring or late summer
Reed Canarygrass		
alone	6-8	Early spring or late summer
in mixtures	4-6	
Timothy (in mixtures)	2-6	Early spring or late summer
Switchgrass	5-10	May 1 – June 15

*Seeding rate if seed is over 90 percent germination and 95 percent purity. If germination or purity is lower, seeding rate should be increased to compensate.

**Lower amounts should be used if orchardgrass is included in the mixture.

Planning the Forage Program

To plan a beef herd forage program, the farmer must consider the amount of available land; land characteristics such as productivity, slope, stoniness, and drainage; vegetative cover; and feasibility of renovating and establishing new plant cover. He must also consider his livestock's forage needs--the amount of pasture needed each month during the growing season and the amount of stored feed needed for winter.

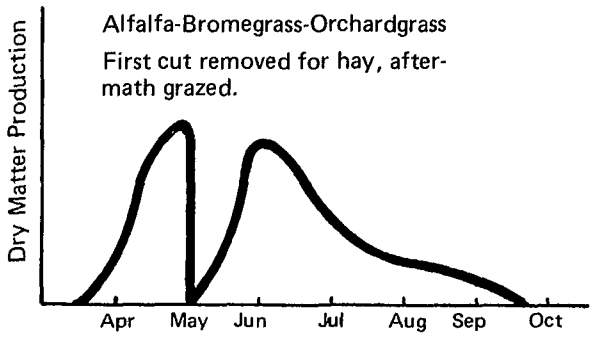
One main objective is to use land to the greatest economically feasible extent. If the land is well drained, nearly neutral in p^H, and can be worked, a mixture of alfalfa and grass will probably be the best choice because of the mixture's productiveness. If large amounts of lime and potassium or phosphorus are needed to produce alfalfa, perhaps the most economical feed will be a clover-grass mixture or straight grass fertilized with nitrogen. If the land is steep, stony, or has many tree stumps, fertilizing existing grass and spraying weeds will be the best alternative.

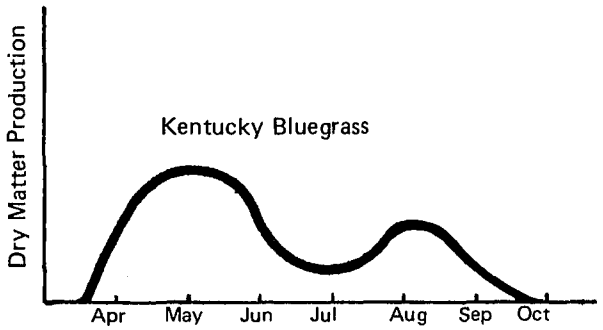
In planning the forage program, consider seasonal and total production of various grasses and legumes. Many grasses widely used in Minnesota produce much more during spring and early summer (May to mid-July) than during mid- to late-summer. These cool-season grasses include smooth bromegrass, Kentucky bluegrass, timothy, reed canarygrass, and orchardgrass.

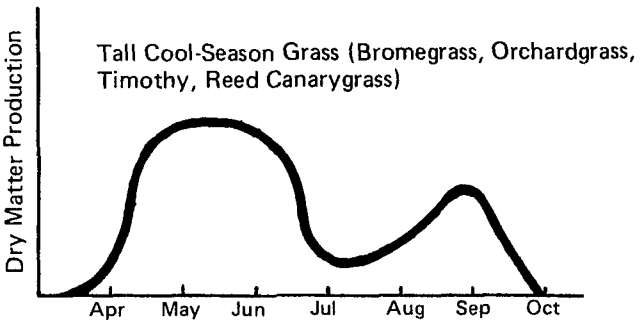
Warm-season grasses start growth later, but they are more productive during warmer parts of the summer. Such grasses are ready to graze about mid-July. The perennial warm-season grasses, such as switchgrass, may be useful for mid- to late-summer grazing. However, they usually produce only about half as much grazing as do cool-season grasses during the total pasture season. Sudangrass and sorghum-sudangrass hybrids are annual warm-season grasses. They serve the same purpose as perennial warm-season grasses, but they must be seeded each year. Annual land preparation and seeding increase production costs.

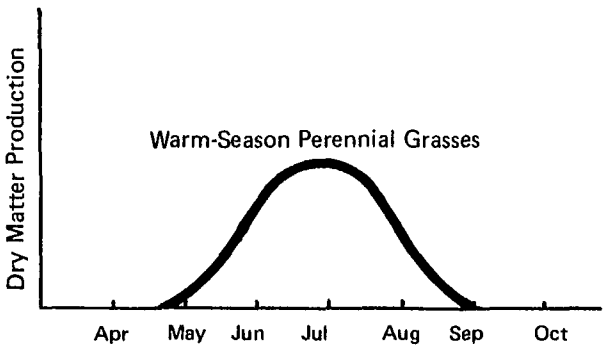
The growing season for various grasses and legumes is shown in figure 7:

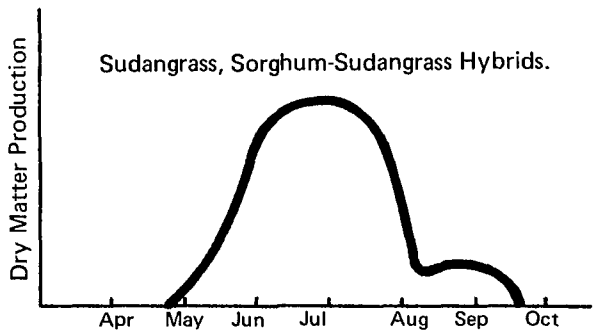
Figure 7. Generalized Growth Patterns of Several Grasses and Legumes.











Pasture Productivity and Carrying Capacity

A pasture's carrying capacity is the number of animals it will support for a given time. Carrying capacity can be expressed as animal unit days per acre. An animal unit is a cow and her calf, a bull, or 1.7 replacement heifers.

Table 2 shows estimated animal unit days expected from various types of pastures. These figures are a rough guide for calculating carrying capacities. You can estimate your pasture's carrying capacity by adjusting these figures. If your pasture is excellent, increase the figures; if it is below average, cut the figures by one-half.

Many factors influence carrying capacity. Management improvements, including plant production and grazing management factors, can double or triple carrying capacity.

Among the most important soil factors is droughtiness. Sandy soils hold less water than finer textured soils. Therefore, sandy soils must have rain more often to supply adequate water to the plants. Slope of the land can also affect soil droughtiness. Land which slopes considerably has more water runoff; it absorbs less water than level land.

Fewer kinds of forage plants can be produced on poorly drained soils. In general, alfalfa is not adapted to poorly drained soils, but it is one of the most productive species for better drained sites. If water stands on the surface occasionally or regularly, species such as reed canarygrass may be the best choice. On soils this wet, livestock often cannot be turned into the pastures early in the spring. Thus animal production is lower.

Some soils have lower native fertility than others. For example, sandy soils may be deficient in potassium. Finer textured soils may be deficient in phosphorus. Nutrient status can be changed by adding fertilizer, but this increases production cost.

The need for phosphorus and potassium can be determined by a soil test. The soil test economically determines nutrient needs and should be used regularly. The soil test does not tell the need for nitrogen. However if the plant species are mostly grasses, good response to nitrogen will usually be obtained. If the pasture contains at least 50 percent legumes, response to nitrogen is minimal.

Table 2. Estimated Animal Unit Days Per Acre[1] and Percentage of Total Seasonal Production by Month.

Kind of Pasture	April	May	June	July	August	September	October	November	Total
Permanent pasture, fertilized	---	30 (30)	30 (30)	20 (20)	8 (8)	8 (8)	4 (4)	---	100
Permanent pasture, unfertilized	---	20 (32)	20 (32)	15 (24)	4 (6)	4 (6)	---	---	63
Reed canarygrass, lowland	---	30 (16)	60 (31)	60 (31)	20 (10)	15 (8)	8 (4)	---	193
Clover-grass	---	40 (30)	40 (30)	30 (22)	10 (7)	10 (8)	4 (3)	---	134
Grass alone (bromegrass, timothy, reed canarygrass on upland), 50-70 pounds Nitrogen per acre.	---	30 (26)	25 (22)	25 (22)	10 (9)	15 (13)	10 (9)	---	115
Alfalfa-clover-grass	---	45 (33)	45 (33)	30 (22)	15 (11)	15*	4*		135 155*
Alfalfa-grass (2nd cut)	---	---	---	45 (69)	20 (31)	8*	4*	---	65 80*
Red clover-grass (2nd growth)	---	---	---	15 (40)	15 (40)	8 (20)	---	---	38
Warm-season perennial grasses	---	---	---	40 (44)	50 (56)	---	---	---	90
Sudangrass	---	---	---	40 (44)	40 (44)	10 (11)	---	---	90
Cornstalks	---	---	---	---	---	2 (5)	30 (75)	8 (20)	40
Rye	15 (20)	45 (60)	15 (20)	---	---	---	---	---	75
Oats	---	20 (29)	40 (59)	8 (12)	---	---	---	---	68

* = do not utilize unless stand will be plowed the following year.
( ) = percentage of seasonal production.

[1]Adapted from: Burson, P.M., A.L. Harvey, and A.R. Schmid. Beef From Grasslands. University of Minnesota Agricultural Experiment Station Bulletin 452. 1961.

Soil depth greatly affects productivity. Shallow surface soils over the water table, over gravel, or over compacted subsoil layers mean low carrying capacity. Amount and distribution of rainfall together with soil characteristics affecting water holding capacity are among the most important determiners of pasture production. With ample rainfall throughout the growing season, cool-season grasses usually produce well the entire summer. However in most years, low rainfall limits production at some time during the growing season.

Temperatures affect productive periods of grasses. Usually cool-season grasses are less productive from mid-July through Sept. 1. This is especially true if high temperatures are accompanied by low rainfall. In northern Minnesota, the summer temperatures can have a tremendous effect on productivity of warm-season grasses such as sudangrass or sorghum-sudangrass hybrids. In summers with no distinctly warm periods, these grasses do not produce well.

Location can affect productivity. In Northern Minnesota, the growing season is considerably shorter than in southern Minnesota. This results in a shorter period of pasture use. If temperatures are adequate and rainfall is sufficient, Minnesota's long summer days permit rapid growth of grasses and legumes.

Pasture productivity is greatly affected by plant species and varieties. Species best adapted to Minnesota were discussed previously. Desirable species and mixtures offer high productivity, growth patterns allowing a long pasture season, presence of legumes, good palatability, disease resistance, and winterhardiness.

Undesirable species, such as weeds, brush, and sometimes trees, can have considerable effect. Usually after a desirable mixture and good stand is obtained, the weed and brush problems are not great if ample fertilizer is applied and good grazing management is practiced. However in the initial stages of establishment or improvement, weed and brush control may be one of the most important factors in improving pastures. Weed control information can be found in Extension Folder 212, "Cultural and Chemical Weed Control in Field Crops."

A second phase of carrying capacity is grazing management. The grazing system (continuous vs rotation) can greatly affect carrying capacity. Rotation grazing includes fencing pastures and alternately grazing and resting them. Livestock are confined to a relatively small area until most of the for-

age is consumed. Then the cattle are turned into a new area. In productive pastures, this system reduces waste and increases carrying capacity. Compared to continuous grazing, it results in greater animal production per acre.

A rotational system is necessary to maintain a good stand of alfalfa. Alfalfa must rest periodically to replenish carbohydrates in its roots. The rotation grazing system also helps maintain most of the cool-season perennial tall grasses. If bromegrass is pastured too severely during a critical stage such as the preboot stage, productivity may be reduced because of delayed regrowth. In severe cases, plants may be killed.

A rotational system is more costly than a continuous system since more fencing and watering facilities are needed. However, it results in greater pasture productivity.

The stocking rate affects pasture carrying capacity. If the animal number is too low for available forage, plant material is wasted. On the other hand, if the stocking rate is too high or if animals are left in the pasture too long, plant vigor is reduced and some desirable species may be eliminated. In the long run, overgrazing usually results in low carrying capacity. Overgrazing may also result in encroachment of undesirable species such as weeds and brush. Higher stocking rates generally mean more animal production per acre while lower stocking rates generally result in higher average daily gains. The correct balance provides the most profit.

In research trials[3] where heifers grazed bromegrass, the following responses to grazing pressure were observed:

Stocking Rate

	Light	Heavy
Average daily gains per animal (lbs.)	1.7	1.5
Heifer grazing days per acre	244	311
Gain per acre (lbs.)	415	466

Clipping pastures after grazing will increase regrowth and animal acceptance if early growth is not completely utilized. With some tall grasses such as reed canarygrass and bromegrass, animals have been noted to avoid grazing areas having stubble of old stems. Mowing these stems will sometimes increase pasture use during the second grazing period.

[3]Ibid.

Stocking rate of pastures greatly affects forage utilization and animal production. The pasture in the top photo is badly overgrazed. Overgrazing lowers plant productivity and pasture carrying capacity. It is likely to allow invasion of weeds and brush. The pasture in the middle photo is correctly stocked or perhaps slightly understocked. Slight understocking provides reserve feed in case of drought or other unforeseen emergencies. When cool-season grasses are as tall as those in the bottom photo, part of the production should be harvested as hay or low-moisture silage. Otherwise, considerable waste is likely (bottom photo is courtesy of Iowa State University).

Estimating Carrying Capacity

Since many factors affect carrying capacity, considerable experience is required to judge the number of animals a pasture can support. If the hay yield is known or can be estimated, pasture carrying capacity can be estimated. The following assumptions can be made:

1. Pasture management results in 15-25 percent lower yield than does hay management. Research has shown that frequent clipping results in lower yields.

2. Grazing results in 10-25 percent waste. This will vary greatly depending on stocking rate, height of the pasture at the start of grazing, and type of grazing (continuous or rotation) used.

3. Hay has 85 to 88 percent dry matter.

4. Each animal consumes 25 pounds of dry matter per day.

Here is an example:

1. Hay yield is estimated at 4 tons per acre.

2. 8,000 pounds hay X .85 dry matter = 6,800 pounds dry matter.

3. 6,800 pounds dry matter X .85 (hay yield conversion to pasture yield) = 5,780 pounds pasture dry matter.

4. 5,780 X .80 (utilization) = 4,624 pounds utilized.

5. 4,624 ÷ 25 pounds dry matter per animal per day = 185 animal unit days.

The monthly distribution of animal unit days can be considered the same as in table 2.

Table 3. Example Farm Showing Pasture Availability By Month

Kind of Pasture	Acres	Estimated Animal Unit Days Per Acre	Animal Unit Days May	June	July	August	September	October	November	Total
Permanent pasture, fertilized	80	110	2,400	2,800	1,600	800	800	400	---	8,800
Permanent pasture, unfertilized	100	60	1,700	2,000	1,500	400	400	---	---	6,000
Reed canarygrass, lowland	35	190	945	2,100	2,100	700	525	280	---	6,650
Bromegrass-orchard-timothy mixture	50	120	1,250	1,750	1,250	500	750	500		6,000
Cornstalks	45	40	---	---	---	---	90	1,350	360	1,800
Total			6,295	8,650	6,450	2,400	2,565	2,530	360	29,250
Needed for 231 Animal Unit herd (200 cows, 7 bulls, 40 replacements)			7,161	6,930	7,161	7,161	6,930	7,161	6,930	
Alfalfa, bromegrass (first cutting for hay, half of growth pastured)	80	80	---	---	711	5,689	---	---		

Hay 3.5 tons dry matter/acre, (4.1 tons hay/acre): 55 percent in first cut = 2.3 tons hay/acre
First cut 160 acres X 2.3 tons/acre = 368 tons
Second cut 80 acres X 1.8 tons/acre = 148 tons
516 tons

An Example Farm

Once the carrying capacity has been estimated (either by using hay yield, experience, or table 2), the amount of available pasture per month can be calculated. This should be compared with the amount needed each month. The following example shows how this is done. Kind of pasture, number of acres of each kind, and estimated pasture days per acre are shown in table 3. Also, estimates are given for animal unit days available from each pasture each month of the growing season. Totalling these figures provides an estimate of the total animal unit days available each month. Assuming a 200-cow herd with 7 bulls and 40 replacement heifers, feed will be needed for 231 animal units. The number of animal unit days needed each month can thus be estimated.

Comparing the available number of animal unit days with the needed number, the potential monthly situation is as follows:

May—There is a slight deficiency. Usually however, hay is still fed the first half of the month, and pasture growth will be greatest the latter part of the month. Therefore, there may be excess rather than shortage during the latter part of the month.

June—Excess pasture is available. This should be harvested as stored feed from some of the land (perhaps

Table 4. Forage Planning Worksheet.*

Field Number	Kind of Pasture	Acres	Estimated Animal Unit Days**						
			Total	May	June	July	August	September	October
Total									
Animal Unit Days Needed									

Field Number	Kind of Hay	Acres	Estimated Yield		Anticipated Cutting Date		
			Per Acre	Total	1st Cut	2nd Cut	3rd Cut

***Obtain additional copies from your county extension agent.**
****Animal Unit = 1 mature animal or 1.7 replacement animals.**

from the bromegrass-orchard-timothy mixture).

July—There is a slight shortage of available pasture.

August and September—A considerable shortage exists.

How can the July to September shortage be alleviated? The farm also has 160 acres of alfalfa-bromegrass-orchardgrass mixture. The first cutting is removed for hay, and one-half the aftermath is grazed. If the first cutting is removed in early June, the crop should be ready to pasture by mid-July. Pasturing the alfalfa-grass mixture can compensate for the slight July deficit. Also, this field can supply the needed pasture to compensate for the August deficit.

There is also a considerable pasture shortage during September and October. During this time, the alfalfa-grass pasture should not be used unless we are willing to risk reducing the alfalfa stand. September and October grazing could be enhanced by applying extra fertilizer on grass pastures and, perhaps, by saving some of the summer growth for use in September and October. Another possibility would be grazing land in government programs or crop aftermath such as small grain stubble.

Hay is also part of this farm's forage program. The hay balance is summarized on the bottom of the table. If the hay yields 4 tons per acre and if 55 percent is available for the first cut, it will produce 2.3 tons per acre the first cutting. The first cutting from 160 acres provides 368 tons. One-half the regrowth provides 148 tons. Total for the two cuttings is 516 tons. If 2 tons are needed per animal unit for winter, enough hay will be provided for the herd.

It will be useful to make these kinds of calculations for your farm. A worksheet is provided for your convenience (table 4). Your estimates at the beginning of the season may show critical areas of need and surplus. Productivity records of pastures and hay land will help you plan for following years. The record sheet which follows provides space to record production from each field or pasture (table 5).

Table 5. Forage Production and Utilization Record Year ____________

Field Number									
Acres									
Kind of Forage									
Pasture Use:									
Month									
No. Animal Units									
Days Pastured									
Animal Unit Days									
Month									
No. Animal Units									
Days Pastured									
Animal Unit Days									
Month									
No. Animal Units									
Days Pastured									
Animal Unit Days									
Month									
No. Animal Units									
Days Pastured									
Animal Unit Days									
Month									
No. Animal Units									
Days Pastured									
Animal Unit Days									
Total Animal Unit Days									
Stored Feed Use:									
Date Cut									
Method of Storage									
Tons/Acre									
Total Tons									
Moisture Content									

Pasture Alternatives

Some alternatives for spring, summer, and fall pastures are given below:

Spring (Mid-May to July 1)

Cool-season grasses and legumes are at their productive peak in spring. Problems concern effective use of abundant growth rather than shortage. If more pasture is available than can be effectively used before plants mature and become coarse, some growth should be harvested for hay or silage. If some pasture land is steep, stony, or has other features which hinder harvest, it should be pastured first. This leaves harvestable land for use of the first crop as hay if the land cannot be pastured.

Summer (July and August)

Most years, growth of cool-season grasses decreases drastically during July and August. If rainfall is adequate and well distributed, these grasses will remain fairly productive, especially in northern Minnesota. Pastures containing alfalfa will be more productive than pure grass pastures. Well fertilized pastures will exhibit a smaller summer slump than those deficient in plant nutrients.

Some ways to provide feed include:

1. Provide more acres of pasture during the summer than the spring. Hay may be harvested from part of the acreage, then the regrowth is grazed.
2. Use of birdsfoot trefoil. Do not pasture this until late June.
3. Use of perennial warm-season grasses.
4. Use of sudangrass or sorghum-sudangrass hybrids.
5. Allow cattle to eat some of the hay harvested earlier in the season. Here hay can be put up in round bales or loose hay stacks. Allow animals to eat this hay in place to reduce handling costs. Research in Ohio showed 8-11 percent losses when round bales were fed in the field after the bales were fenced into small units. Compared to leaving excess growth standing in the field for later pasturing, this method preserves quality by cutting plants when they have high nutritive value.

Fall (September until snowfall)

The more pasture used in the fall, the shorter is the hay- or silage-feeding period. Less stored feed will be needed.

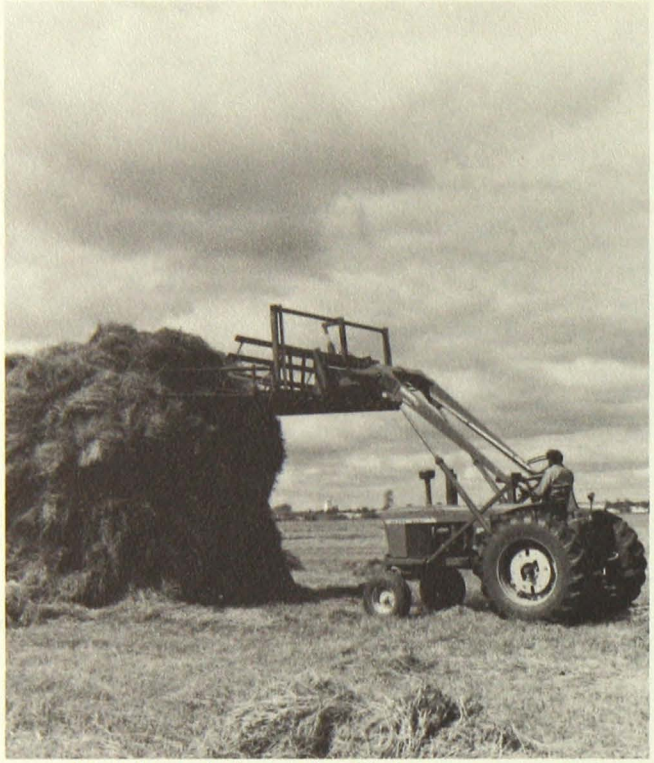
A pasture containing legumes should not be used in the fall unless the field will be plowed. Allow legumes to rebuild their root reserves for winter survival.

A pasture of cool-season grasses not pastured in July and August can be used in the fall. However, 3 to 4 inches of stubble should be left. This helps plants to survive the winter and produce vigorous spring growth.

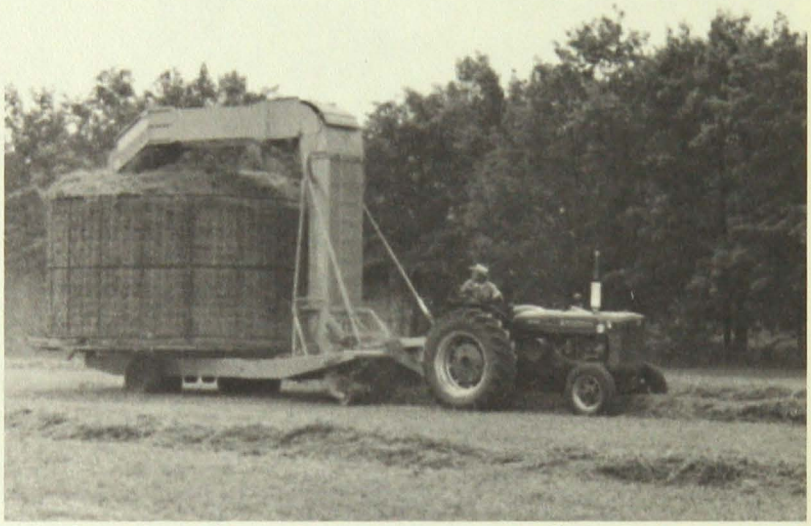
In some areas, corn stalks can be grazed after grain harvest if the land can be spring plowed.

Sorghums, sudangrass, or other crops planted on land in government-sponsored programs can often be pastured in the fall. Care must be taken to prevent prussic acid poisoning (see Agronomy Fact Sheet No. 15, "Sorghum-Sudangrass Hybrids.")

Hay harvested and used in the field as discussed above may help reduce labor needed to produce and feed winter forage.



Loose haystacks have replaced baled hay on many beef cow farms. The primary reason is less labor requirements. Loose hay may be stacked with a tractor-mounted loader equipped with a hay basket. Usually the hay is placed into a stack frame. This frame is then pulled away from the stack and placed in a new location to build another stack.



Several kinds of haystacking machines are now available. These machines pick up the hay from the windrow, convey it into the machine, and then unload the completed stacks in the field. Three of these machines are shown in the photo above and in the top two photos on the opposite page. Stacks up to about 6 tons can be made. The haystacking machines require less labor than do most other hay handling methods. However, such equipment requires relatively large amounts of capital. Thus, the machines are best suited to large operations or custom use.

Stored Forage

One of the biggest problems with beef cows in Minnesota is providing enough stored feed for the winter. With average quality feed, about 2 1/2 tons of hay equivalent is required per animal unit for the winter. This can be hay, low moisture silage, conventional silage, or a combination of these. Protein and total digestible nutrients (TDN) requirements can be met with less feed if the feed's quality is high. Thus, the beef cow owner should be concerned about the quality of feed harvested and stored. Quality is determined by the kind of plant material, stage of growth at which it is harvested, and the way it is handled and stored. The owner should preserve the highest quality feed possible within economic limits. Weather conditions often limit the feed's quality. As a result, at least part of the stored feed is usually of lower quality. Thus, any high quality feed can be used with lower quality materials to supply the animals' nutritional needs.

Since harvesting usually cannot be done in a short time, some feed is likely to be more mature when it is harvested. Harvest of alfalfa and alfalfa-grass mixtures should begin when the alfalfa is in the bud to early bloom stage. Forage harvested at this stage will be very high quality if it is preserved without weather damage. When harvesting is delayed, plants will be more mature and lower in feed value. Harvest of pure grass stands should start when grasses are in the flowering stage.

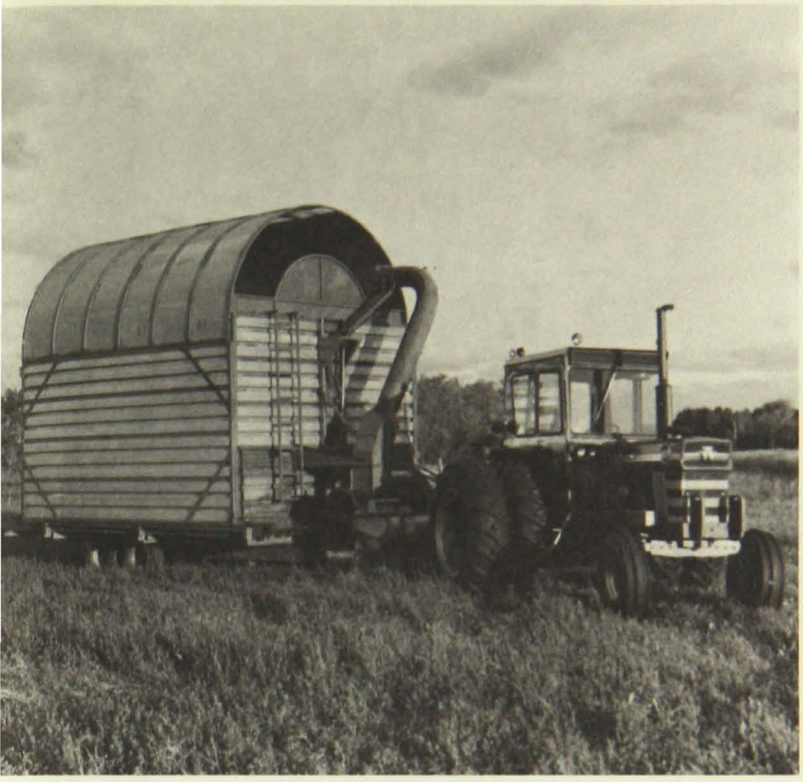
Work at the Grand Rapids Experiment Station has shown that beef cows can winter on about 16 pounds of high quality hay per animal per day. However, a greater amount of lower quality hay would be required to meet a cow's energy and protein needs.

On farms with large numbers of cattle, the required quantity of stored forage presents handling difficulties. Several methods of harvesting, storage, and handling are available. Many growers use loose hay systems. These systems involve stacking hay from the windrow. This can be done with a tractor-mounted sweep and stacker and a portable stacking frame. Several available types of stacking machines can also be used. Stacks are made in the field, allowed to settle, then moved into the feeding area with a stack mover. Loose stacks can be fed mechanically with a grapple fork, or they can be self-fed. Self-feeding requires some means of keeping animals off the stack. An electric fence is one means

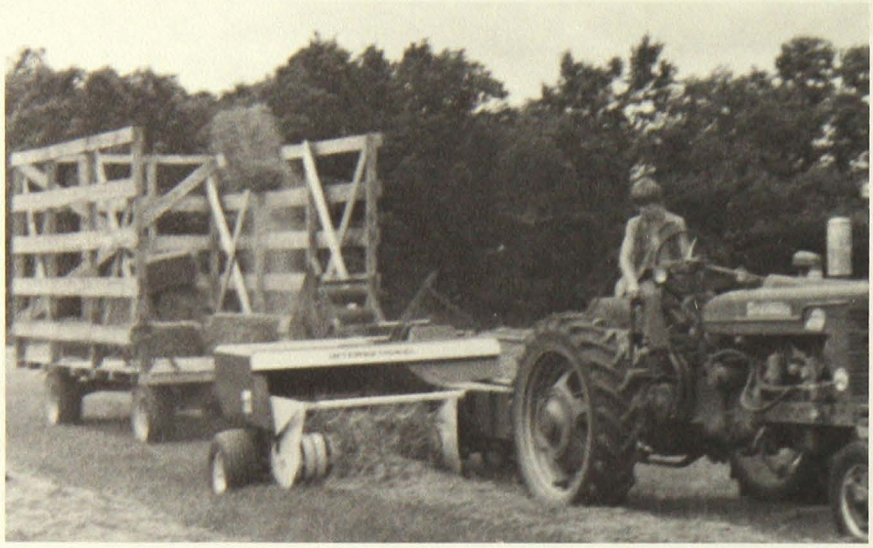
After the loose haystacks have settled, they are moved to a convenient feeding area. One kind of stack mover is shown in the left and middle photos opposite. The stack in the left photo was made by the stacker in the right photo on this page. The stack in the middle photo was made by the stacker in the top right photo on the opposite page.

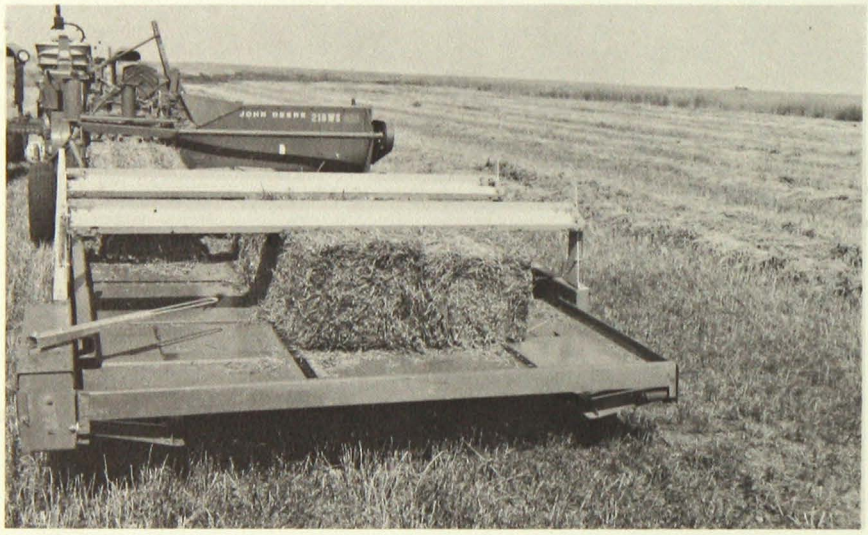
Loose hay may be fed from stacks in several ways. The right photo in the middle row, opposite page, shows a stack mover attachment. This slices off part of the stack, then conveys that portion to the feeding site.

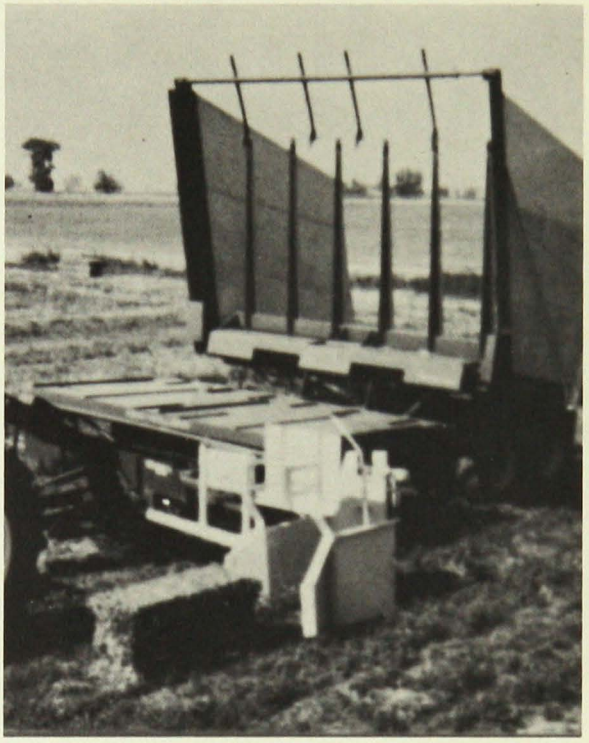
A stack mover attachment can unload hay along a fence where cattle have easy access to this feed (left photo opposite). Animals may be self-fed from loose hay stacks as shown in the right photo opposite. Note the post driven into the haystack. This helps support an electric fence. Such a fence keeps animals off the stack and minimizes wasted hay. Loose hay is also fed with a grapple fork attached to a tractor front-end loader.




HESSTON







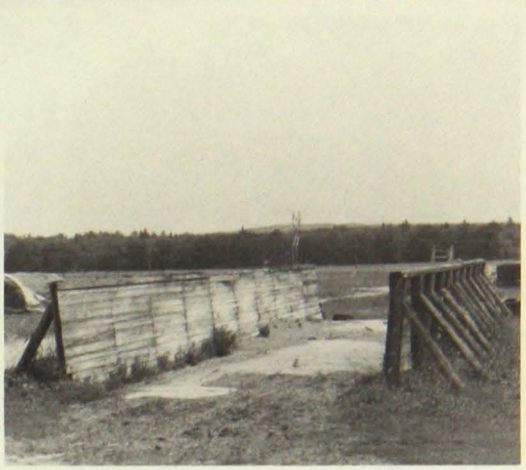
Advances have been made in mechanized handling of conventional hay bales. Among these innovations is the hay baler attachment shown in the top left photo. The attachment throws bales into a wagon. The bottom photo on the left shows a bale accumulator. The resulting groups of bales can be moved with an attachment on a tractor front-end loader (photo is courtesy of Farmhand). The bale wagon in the photo above picks up bales in the field and stacks these bales. The stacks can then be unloaded for storage. Later the same machine can retrieve the bale stacks for moving or feeding (photo is courtesy of New Holland).

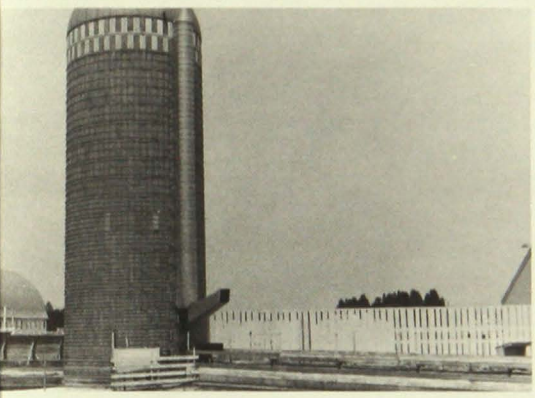
to accomplish this. With self-feeding, the amount of hay fed cannot be controlled. Thus, this system is not suitable for high quality hay because overfeeding will likely result.

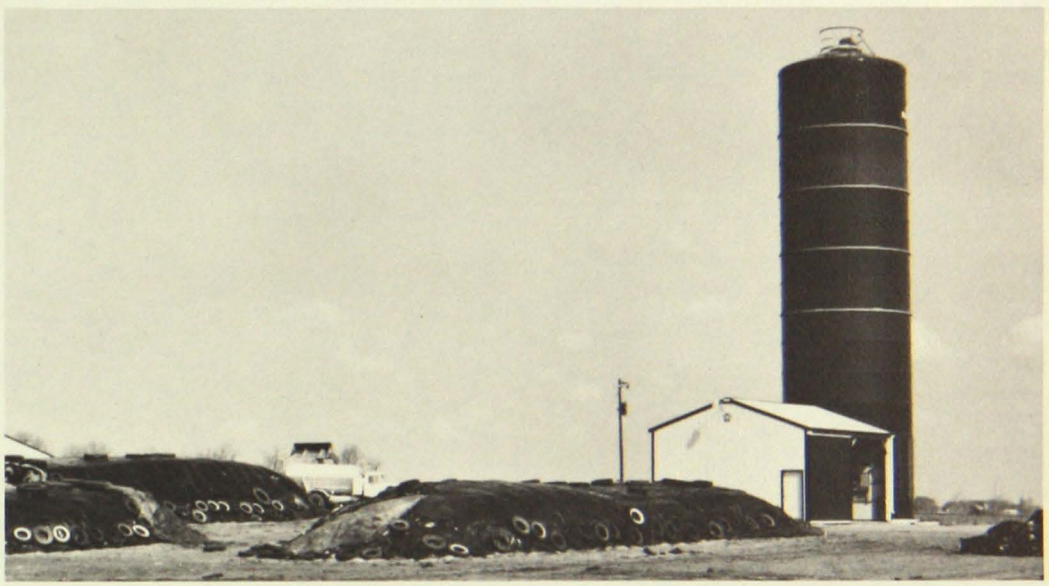
Use of baled hay has decreased because of the labor required to store and feed the bales. However, machines are available for bale handling. Baled hay should be stored inside or covered for weather protection to control mold and maintain feed value.

In recent years, more interest has been shown in low moisture silage (haylage). This forage is cut and allowed to wilt to about 50-60 percent moisture. Then it is chopped and stored in a horizontal bunker silo, an upright silo (either concrete stave or airtight), or it is stacked on the ground and covered with sheet plastic. Curing the hay is often difficult. This is particularly true of the first cutting because of harvest time rains. The shorter time required to reduce moisture content to 50-60 percent rather than 12-15 percent for hay often helps pre-

Photos opposite page: High quality, low moisture grass and legume silage (haylage) can be successfully stored in several kinds of silos. Horizontal structures such as the trench silo (top row, left), bunker silo (top row, middle), and stack silo (top row, right, and second row, right) are low in cost. Proper moisture content, uniform chopping, thorough packing (top row, left) and covering with plastic (top row, right, and second row, right) are important to minimize losses. Upright silos may be constructed of concrete staves (second row, left), coated steel (second row, right), or poured concrete (third row, left). The coated steel and poured concrete silos shown are airtight and have bottom unloaders. So far, poured concrete sealed silos with bottom unloaders are very rare. Upright silos are more expensive to construct than are horizontal silos. However, upright silos usually have smaller storage losses. Special equipment needed for haylage include a blower for upright silos (third row, right) and a silage chopper (bottom photo).








GEHL

Giant round bales up to 1 1/2 tons offer another alternative for hay handling. Two kinds of balers are shown in the top two photos. The machine in the top left photo rolls the hay along the ground to form the bale. The machine in the top right photo picks up the hay and forms the bale using a series of flat belts. The bale is then wrapped with twine before it is removed from the machine. The photo in the middle row, left, shows a completed bale. The right photo in the middle row shows the size of bales weighing 1 1/2 tons. The large round bales appear to shed water fairly well. They are usually stored outside. Machines for making these bales require smaller investments than do the loose haystacking machines.

One method to move large round bales is shown in the left photo in the bottom row. This fork is attached to the tractor on a three-point hitch. The fork has two steel bars which slide under the bale. Similar machines are made which are mounted on wheels. Large bales may also be handled with a front-end loader, but a large tractor is required. The right photo in the bottom row shows one method to feed large, round bales. Such bales may also be unrolled in the feeding yard.

serve the quality. With haylage, earlier harvest is often possible because of shorter drying time. The probabilities for sufficient drying time for haylage are considerably greater than for hay.

Successful use of low moisture silage depends upon the right harvesting time, proper moisture content, proper chopping, good packing, and proper covering with plastic to exclude air. If proper precautions are taken, low moisture silage will be high quality feed. In much of Minnesota, it is possible to consistently make higher quality feed with low moisture silage than with hay. For more information, see Agronomy Fact Sheet No. 12, "Haylage: Low Moisture Hay-Crop Silage."

Proper moisture content is required to make high quality low moisture silage, but this is one of the greatest difficulties in successfully preserving the crop. Measurements or estimates may be difficult. See Agronomy Fact Sheet No. 24, "Determining Moisture Content of Forages."

Among the newer equipment are balers which make the large round bales containing 1/2 to 1 1/2 tons of hay.

Round bales (either small ones of about 50 pounds or larger 1/2 to 1 1/2 ton bales) can help fill the need for high quality forage during the summer and fall. Excess forage during the rapid growth period in June and early July could be mowed, dried, put into round bales, and then left in the pasture. These bales could be self-fed in the field. The field should be fenced to limit animals to a small number of bales until these bales are fully consumed. Then the animals are allowed another small area. Baling results in better quality feed than if this grass is left standing in the field.

In Ohio, research showed that 8.3 percent of forage in small, round bales was not consumed. This is compared to 11.2 percent for intermediate size bales (225 pounds). In these studies, bare spots where the bales had lain soon filled in with grass growth once the bales were gone.

Relative costs for various stored forage handling systems may be obtained from University of Minnesota Ext. Folder 246, "Economic Comparisons of Hay Harvesting, Storing, and Feeding Systems for Beef Cow Herds."

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