SENECA TRAIL
RESOURCE CONSERVATION and DEVELOPMENT AREA
ALLEGANY • CATTARAUGUS • CHAUTAUQUA • WYOMING
2 PARK SQUARE • FRANKLINVILLE, NEW YORK 14737 • TELEPHONE: (716) 676-5111
FAX: (716) 676-5112

FORAGE QUALITY OF INTENSIVE ROTATIONALLY GRAZED PASTURES [1]
1988 - 1990

A three year summary of the
Northeast Dairy Farm Forage Demonstration Project.

Edward B. Rayburn [2]

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2. Grassland Specialist, Seneca Trail RC&D, 2 Park Square, Franklinville, NY 14737.

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SUMMARY

With the introduction of new fencing technology and the continuing cost-price squeeze on dairy farmers, interest has been renewed in using pastures as part of dairy feeding programs. To improve the use of pastures, there is a need to quantify forage quality and the factors that affect quality of forage from pasture systems. There is also a need to develop a method for the rapid determination of pasture forage quality, so that dairy producers can receive timely results from submitted samples. NIR forage analysis provides such a method but calibration equations for pasture samples are not available.

In 1988, 1989, and 1990, 34 dairy farmers, feed dealers, Cornell Cooperative Extension, and Soil Conservation Service staff collected and submitted 746 forage samples to the Northeast Dairy Herd Improvement Association Forage Testing Laboratory to determine the quality of intensive, rotationally grazed pastures in the Northeast. The goals of this project were:

1. To determine the quality of forage produced under intensive rotational grazing over a range of farm environment and management conditions;
2. To develop a data base of pasture forage quality and factors which affect pasture forage quality; and
3. To use these samples to develop a calibration for near infrared reflectance (NIR) analysis for fresh forage samples.

The pastures sampled represent a range of pasture types present in the Northeast, from native grass-clover to seeded alfalfa aftermath. Orchardgrass, bluegrass, and timothy were the most frequent grasses in the pastures sampled, while white clover, alfalfa, and red clover were the most frequent legumes. Broadleaf weeds occurred in 21% of the pasture as one of the three major species. Dandelion was the predominant broadleaf weed. The quality of broadleaf weeds was high and comparable to legumes.

Pastures had the most forage present in May and June, as measured with a standard Plexiglas weight-plate. Estimated forage yields before grazing ranged from 1200 to 3500 lb. DM/acre. In most cases initial forage mass was adequate for the needs of lactating dairy cattle.

Regrowth intervals between grazing events averaged 33 days, ranging from 18 days in May to 46 in October. The average pasture growth rate peaked at 90 lb. DM/acre/day in May and decreased to 30 lb. DM/acre/day in August. May and June provided 52% of the pasture production, 26% was made in July and August, while 22% was made in September and October.

The chemical analysis of pasture samples indicated that the quality of forage grown under intensive rotational grazing is greater than hay and haylage harvested from similar forages and, in many cases, higher than that of corn silage.

Neutral detergent fiber content of pastures averaged 47% and decreased as the legume content of the sample increased. Acid detergent fiber in pastures averaged 27%, increased as the content of grass in the pasture increased, and was lowest in the cool months of May and October. Non-structural carbohydrates in pasture samples increased as the percent legume increased and was highest in May and October. Total digestible nutrient content of pastures averaged 69% with little effect due to forage type, but it was higher in May and October. Net energy lactation averaged 0.69 Meal/lb. DM, increased with increasing levels of legume in the pasture, and was higher in May and October.

Forage crude protein averaged 22%, increased with legume content and was highest in May and October. Protein degradability averaged 72% and was not affected by forage type, but was highest in May and June.

Calcium in pasture samples averaged 0.77%, increased with legume content, and was highest in July, August, and September. Phosphorus averaged 0.37%, with little effect of forage type or season. Potassium in samples averaged 2.91%, was not affected by forage type, and was highest in May, September, and October. Magnesium content of pasture samples averaged 0.26%, increased with the legume content of the forage, and was highest in July, August, and September. Sulfur averaged 0.32% in pasture samples and was highest in grass pastures. The content of micro-minerals in pasture samples was very variable.

Pasture quality increased as legume content of the forage increased. A small amount of legume (25-35%) provided the largest marginal benefit. Pastures grown in the cool weather of May and October had the highest quality, based on chemical analysis. To optimize the use of rotationally grazed pastures, proper barn supplementation, based on forage tests and animal requirements, should be used.

INTRODUCTION

With the introduction of new high tensile fencing and low impedance fence chargers and the continuing cost-price squeeze on dairy farmers, renewed interest in using pastures as part of dairy feeding programs has developed. Historically, pastures were used as the base for dairy cow feeding in the Northeast. However, the dairy cows of today have been bred for greater milk production and require better nutrition than cows 50 years ago. To properly feed these dairy cattle on pasture, a better knowledge of pasture quality and an understanding of how management affects animal production from pastures is needed. Also, dairymen using pastures need a means of obtaining rapid and inexpensive pasture forage test results. Near infrared reflectance (NIR) forage analysis can provide such a forage-testing method, but calibration equations for pasture samples are not available.

The Northeast Dairy Farm Forage Demonstration Project was funded to provide this information to dairymen in the Northeast. The goals of this project were:

1. To determine the quality of forage produced under intensive rotational grazing over q range of farm environment and management conditions;
2. To develop a data base of pasture forage quality and factors which affect pasture forage quality;
3. To use these samples to develop a calibration for near infrared reflectance (NIR) forage analysis for fresh pasture forage samples.

Report Layout

This report is written for progressive dairy farmers, dairy nutritionists, Soil Conservationists, and Extension Agents. It is divided into sections to allow the user to choose the detail to which they study the project methodology and results. Sampling methods, forage analysis methods, weather conditions at selected weather stations, and statistical analyses are available in the Appendix. If you have interest in this information, you may turn to the appropriate section. An introduction to the practical application of the research statistics used in this paper is also located in the Appendix. At the end of the report are several "Pasture and Livestock Notes" on pasture quality and management which may be of help in implementing grazing systems on farms. These may be reproduced for educational handouts for producers and pasture practitioners.

Historical Perspective

Agriculture in the United States has changed greatly with time. This has resulted from the movement of people across the nation and changes in technology and economics. Initially our agriculture was for subsistence. Each farmer produced for family consumption, with any excess being sold to people in town or to merchants who exported the produce to the cities. As technology advanced, yields increased and a larger percentage of the farm's productions could be sold. This resulted in lower farm prices and the migration of people out of farming and into the towns for industrial jobs.

In the early 1800s, the Genesee Valley of New York was considered the "breadbasket" of the United States. With the settling of the prairie, Midwestern farmers, using their larger area and more favorable soil and climatic resources, were able to out-produce northeastern wheat growers. With the invention of improved plows, grain binders, and threshers in the mid-1800s, there was more pressure on farmers in the Northeast to adapt to the market and find new crops for their livelihood. At the same time, there was the growth of industrial cities. These two economic factors encouraged the northeastern farmers to produce more milk and eggs for sale to people in the cities. This started the movement of this region's agriculture to dairying.

In the early stages of dairying, production was on a small scale and seasonal. Much of the milk went into the manufacture of butter and cheese. Only dairymen near transportation to towns and cities produced fluid milk for sale. Milk production was based on pasture, hay, and homegrown small grains. The northeast region of the United States was considered the "pasture and hay region" by the late 1800s.

With the development of hybrid corn varieties, inexpensive nitrogen fertilizer, and tractors, and the availability of cheap fuel, there was interest in using corn and corn silage for the feeding of dairy cattle. In New York, the major use of corn and corn silage began in the mid-1900s. The use of corn and corn silage has proven to be a practical cropping system for farms on good soils. It has allowed the development of larger dairies on a relatively small landbase. It also resulted in the movement to barn feeding of dairy cattle and the movement away from using pastures.

The production of corn has not proven practical for dairymen on northeastern hill soils. Corn grain and silage yields are often not profitable even with good management. This is due to acid, poorly drained soils and cool summer temperatures. Even an educational emphasis on good corn management has not overcome this region's climate and soil limitations. This results in most farmers losing money when growing corn on these soils. Feeding the crop to dairy cattle, which converted the poor crop into a relatively high-value product, covered up the loss. However, with fuel, machinery, and labor costs going up and the relative value of milk going down, it is apparent that corn is not always profitable. The climate and soils of much of the Northeast are still best suited to the production of pasture and hay crops for livestock production.

In searching for ways to reduce the cost of milk production, many dairymen have turned again to the use of pastures and hay crops. This has been helped by the introduction of new fencing technology such as high tensile wire and low impedance chargers. With this equipment, it is easy and inexpensive to establish effective and dependable fencing systems.

The economics of dairy farming do not rest on maximum milk production per cow but on optimizing net return over feed costs and reducing overhead costs per cow. Pasture and hay crop programs can provide these types of savings. In New York, use of pastures has been shown to provide average annual savings of $156 per cow (Emmick and Toomer 1991). When pastures are properly used, savings can go as high as $300 per cow the first grazing season. To get the same increased net return per cow by increasing production in the barn would require a 3,000 to 6,000 pound increase in milk sold per cow.

A benefit associated with using perennial forage crops is the reduction of soil erosion and water pollution that can result from excessive crop farming. Pastures and hay crops cover the soil surface and protect the soil from the beating effect of rain. The root systems of forage crops hold the soil together and protect the soil from the washing effect of rain and snowmelt runoff. In conjunction with wise manure disposal from the dairy barn, these perennial forages can provide a sustainable livestock-based agriculture, with legumes producing nitrogen for crop growth and the manure recycling the major plant and animal nutrients back to the soil.

METHODS

Pasture Sampling

Forage samples were collected from pastures managed under intensive rotational grazing, prior to turning cows into the paddock (Appendix 1). Cooperators in Maine, New Hampshire, New York, and Vermont collected samples. Each forage sample represents 30 to 50 smaller "grab" samples from a paddock. Samples were taken by grabbing the forage and plucking it off at the stubble height to which the animals would graze the stand. Forages in the paddock that would not be eaten by livestock were not sampled. Cooperators were encouraged to watch their livestock to learn how close they grazed and what forages were consumed. The aim was to submit to the laboratory a forage sample similar to what the animals were eating from the paddock.

Forage samples were identified according to a subjective evaluation of the legume content in the sample. The DHIA classification used is:

Legume	86-100% legume
Mixed mostly legume	51-85% legume
Mixed mostly grass	16-50% legume
Grass	0-15% legume

A fifth classification was added for palatable, broadleaf weeds such as dandelion.

The three predominant forage species in the pasture sample were identified and listed. The days of regrowth since the last grazing were noted for each sample. Forage availability was estimated using a standard Plexiglas weight plate to measure the bulk height of the forage prior to grazing (Appendix 2).

Samples were placed in plastic bags and frozen as soon as possible. This was done to prevent protein from being degraded by respiration or fermentation, and was necessary to get accurate estimates of crude protein content and protein solubility. Samples were sent to the NEDHIA Forage Testing Laboratory in Ithaca, New York, by refrigerated truck along with the regular milk and forage sample pick-ups. At the forage testing laboratory, samples were dried in forced air ovens, ground, and analyzed for crude protein (CP), soluble protein, degradable protein, neutral detergent fiber (NDF), acid detergent fiber (ADF), calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K), sulfur (S), sodium (Na), iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), and molybdenum (Mo) by the AOAC methods used by the NEDHIA laboratory (Appendix 3). Non-structural carbohydrates (NSC), net energy lactation (NEL), and total digestible nutrients (TDN) were calculated using standard equations (Appendix 3).

Statistical Analysis

Sample information was analyzed using step-wise multiple regression. Regressions were calculated with the inclusion of independent variables that reduced the error mean square by 1% or more. This resulted in the inclusion of independent variables whose regression coefficients were statistically different from zero at a probability level less than 0.01.

Regressions were run using two sets of independent variables. In the first analysis, forage type, month of harvest and year were discrete variables while days regrowth and bulk height were continuous variables. In the second regression analysis, forage type was replaced with measured NDF and ADF values as continuous variables. This was done since the percent legume in composite forage samples is highly correlated to the NDF and ADF content of the sample. Prediction equations for estimating the percent legume (Leg%) of forage sample from the sample's percent NDF and ADF are:

1. white clover – mixed grasses   Leg% = 167- 3.00 NDF% + 0.26 ADF%
   R^2=0.65   Sy.x=0.21

2. alfalfa – grass hays   Leg% = 117 – 4.53 NDF% + 5.23 ADF%
   R^2=0.97   Sy.x=0.11

Comparison of Pastures to Harvested Forage

Comparisons are made between the pasture samples and average values of harvested corn silage, hay, and haylage (haycrop silage) as summarized by the forage testing laboratory. The harvested forage data is the average of samples processed by NEDHIA during the 1998, 1989, and 1990 seasons. For hays and haycrop silages, mixed mostly grass results were used for comparison since the largest percentage of pasture samples were of this type.

Intensive Pasture Sampling

In 1989 and 1990, a series of pastures were sampled intensively prior to and after grazing to evaluate forage yield, forage utilization, and selective grazing. An estimate was also made of the apparent forage intake. These pastures were managed under two management systems on cooperator farms.

The first set of paddocks was grazed with milking dairy cows. These paddocks were grazed intensively, with the cattle moved to a fresh paddock every 24 hours. Sixty bulk height measurements were taken at random in each paddock before and after grazing. Ten random forage samples were clipped from each paddock before and after grazing. A forage bulk height measurement was taken at each sample point prior to harvesting the strip. The clipped samples were taken from 36 inch long by 4-inch wide strips, cut to the soil surface using electric shears. Each strip was weighed for yield. The ten samples were composited for laboratory analysis. The composite samples were frozen as soon as possible. The paired forage yields and bulk heights were used to develop calibration equations for estimating forage mass from the larger number of bulk heights taken on each pasture. Before and after grazing samples were collected over five days from five pastures, to make an observation period with five replications.

A second set of paddocks was grazed by growing-heifers. These pastures were grazed for three to six days before the cattle were moved to fresh pasture. The length of the grazing stay depended on the animal stocking rate and forage availability.

On these paddocks, 60 bulk height measurements were taken before and after grazing. Clipped forage samples were taken from these paddocks for yield calibration and forage quality determination. Ten samples were taken along each of three random, 100 foot long transects and composited, providing three forage quality replications. The transects were randomized before grazing, then sampled again after grazing. At each sample point, a forage bulk height was taken prior to harvest. Clipped forage samples were taken from 36 inch long by 4-inch wide strips cut to the soil surface using electric shears. Samples were frozen as soon as possible after clipping. Yield and bulk heights taken on the transects were used to develop calibration equations for estimating pasture dry matter yield from a larger number of bulk height samples taken over the whole pasture.

RESULTS AND DISCUSSION

A total of 746 pasture samples was collected and analyzed by wet chemistry and NIR spectral analysis. Samples were evenly distributed between years, with 32% of the samples being taken in 1988, 31% in 1989, and 37% in 1990. Of these samples, 497 were collected as hand-plucked samples during the growing season of May through October (Table 1). Samples from the intensive paddock sampling, those not listing a sampling date, those of pure broadleaf weeds, and those of eastern gamagrass are omitted from Table 1. Samples collected during active growth were mainly from mixed mostly grass pasture (55%), with fewer samples being collected from grass (19%) and mixed mostly legume pasture (18%). Only 7% of the samples were from legume pastures. Samples were obtained over all the months of the grazing season. More samples were taken in July, August, and September than in other months. This bias may be due to the high workloads of planting and hay harvesting in May and June, reducing the priority farmers placed on sampling pastures in these months.

An additional 47 samples were harvested in November and December, when pasture plants had stopped growing (Table 2). These samples were predominantly from straight grass pastures (81%).

Table 1. Number and percentage of forage samples taken from actively growing pastures over three years by forage type and month sampled.

Forage type	May	June	July	Aug.	Sept.	Oct.	Total
			-----Number of samples -----				
Grass	12	8	6	16	33	19	94
Mixed mostly grass	30	37	51	89	51	14	272
Mixed mostly legume	5	13	12	18	32	8	88
Legume	7	0	4	9	8	8	36
Total	55	58	73	134	127	50	497
			----- % of total -----				
Grass	2	2	1	3	7	4	19
Mixed mostly grass	6	7	10	18	10	3	55
Mixed mostly legume	1	3	2	4	6	2	18
Legume	1	0	1	2	2	2	7
Total	11	12	15	27	26	10	100

Table 2. Number of forage samples taken from dormant pastures over two years by forage type and month.

Forage type	Nov.	Dec.	Total
	Number of Samples		
Grass	28	10	38
Mixed mostly grass	1	0	1
Mixed mostly legume	1	0	1
Legume	6	0	6
Total	37	10	47
	% of total		
Grass	60	21	81
Mixed mostly grass	2	0	2
Mixed mostly legume	2	0	2
Legume	13	0	13
Total	79	21	100

Weather Conditions

Average monthly temperature and rainfall for weather stations in New York and Vermont are presented in Appendix 4. The 1988 growing season had a cool, dry spring followed by a warm, dry summer. In 1989, spring temperatures in the western part of the region were cool to normal. Rainfall was above normal in May and June. In the eastern part of the region, the temperatures were above normal and rainfall was near normal. Wet weather in May and June caused some producers to keep their cattle in the barn to prevent the punching of pastures. In some cases, this allowed the forage to get a head of the cattle and to be lower in quality than in 1988. After June, it turned drier. In some locations rainfall was adequate and uniform, while in other areas there were extended periods with little rain. The 1990 grazing season had normal temperatures, though the eastern parts of the region had some summer months with above normal temperatures. The region's precipitation was above normal in May and June, near normal through the summer, and above normal again the fall.

Species Occurrence

The samples analyzed represent pure and mixed forages of a number of species (Table 3). Orchardgrass, bluegrass, and timothy were the grass species found most frequently in the pastures sampled. White clover, alfalfa, and red clover were the legumes most frequently present. Legumes occurred less frequently than grasses. There were few legume and mixed mostly legume samples in May, June, and July. This may reflect the use of these forage types for first cut hay, and the vigor of grasses early in the year, reducing the relative abundance of legumes.

Table 3. The frequency of occurrence of identified forage species in pastures sampled for forage quality.

Species	----Occurrence as ----						Total Occurrence	
	Sp#1		Sp#2		Sp#3			
Grasses	#	%	#	%	#	%	#	%
Bluegrass (sp)	55	10	74	19	39	12	168	31
Bentgrass (sp)	1	0	3	1	1	0	5	1
Bromegrass, smooth	17	3	1	0	2	1	20	4
Fescue (sp)	13	2					13	2
Grass (sp)	45	8	4	1	4	1	53	10
Orchardgrass	165	30	59	15	28	9	252	46
Quackgrass	6	1	10	3	10	3	26	5
Reed Canarygrass	7	1	5	1	2	1	14	3
Ryegrass	16	3	4	1	8	2	28	5
Timothy	57	10	43	11	35	11	135	25
Legumes								
Alsike clover	3	1	1	0	6	2	10	2
Alfalfa	33	6	5	1	10	3	48	9
Birdsfoot trefoil	4	1	6	1	4	1	14	3
Clover (sp)	5	1	9	2	10	3	24	4
Legume (sp)			5	1	12	3	17	3
Red clover	14	3	13	3	13	4	40	7
White clover	93	17	115	29	67	21	275	50
Broadleaf weeds								
Broadleaf weed (sp)	1	0	14	4	11	4	26	5
Dandelion	10	2	14	4	57	18	81	15
Plantain			3	1	1	0	4	1
Other								
Sedge (sp)			4	1	1	0	5	1
All samples	545	100	392	100	321	100	545	

Occurrence of the major species was related to the species' growth habits. Orchardgrass was the grass identified most often, present in 46% of the pastures sampled. When present, it occurred as species #1, 65% of the time and as species #2, 23% of the time. Alfalfa was the second most frequent legume, found in 9% of the pasture. When present, alfalfa was species #1 in 69% of the pasture and species #2 in 10% of the pastures. This occurrence pattern of these two species would be expected of vigorous upright growing forages that are well adapted to periodic defoliation and rest, but are not adapted to continuous grazing. Bluegrass was the second most prevalent grass species, being present in 31% of the pastures sampled. When present, bluegrass occurred as species #1, 33% of the time and as species #2, 44% of the time. White clover was the most prevalent legume, found in 50% of the pastures sampled. When present, white clover occurred as species #1 in 34% of the pastures and as species #2 in 42% of the pastures. This pattern of occurrence would be expected of species subject to competition from taller growing plants. Due to the short stature of these species, they are less tolerant of competition from more upright growing plants under rotational grazing.

Dandelions were the major broadleaf-weed identified in pastures. Broadleaf weeds occurred mainly as species #3 and were present in only 21% of the pastures as one of the three most prevalent species.

Pasture Sample Legume Content

Sample NDF and ADF were used to predict the legume content of the submitted forage samples. When compared to the subjective forage type, it was found that differences in the two estimates were within the error of the prediction equation. However, the accuracy of the predicted legume content depended on the legume species present and the equation used (Table 4). Alfalfa and other upright legumes occurred more frequently as the legume content of the sample increased.

Table 4. Comparison of the legume content of the forage type classes as calculated by regression equation and the average of the range of legume content allowed in the forage type class.

Forage type	Fiber content		-----Legume content -----						
			Defined			Calculated			
						Reg 1		Reg 2	
	NDF	ADF	Low	High	Avg	Est	Err	Est	Err
			-----------% DM ---------------						
Grass	53	28	0	15	8	15	-7	.23	-15
Mixed mostly grass	48	27	16	50	33	30	3	41	-8
Mixed mostly legume	44	28	51	84	68	42	26	64	-4
Legume	31	23	85	100	92	80	-12	97	-5

Reg 1 clover-grass pasture: Leg% = 167 – 3.00 NDF% + 0.26 ADF%
Reg 2 alfalfa-grass hays: Leg% = 117 – 4.53 NDF% + 5.23 ADF%
Avg = average legume % based on average of the legume percentages allowed in forage type
Est = estimated legume % based on regression
Err = error between forage type average and the regression estimated legume content (Avg – Est)

The occurrence of these legumes as a percentage of total legume in the forage sample was: grass (36%), mixed mostly grass (25%), mixed mostly legume (43%), and legume (61%). When the legume percentage was calculated using the alfalfa-grass regression, the calculated legume percentages for the mixed mostly legume class and for the legume class were greatly improved as compared to using the white clover-grass equation.

When visually estimating legume content in forages, it is easy to overestimate the legume content, due to the flat, broad leaves of legumes. The cooperators appear to have accurately estimated forage type on the average. When using equations to estimate the percent legume in a sample, it is important to know what legume species are present so that the correct equation can be used.

Dry Matter (DM)

Pastures are succulent feeds and are often accused of being so wet as to reduce feed intake. The pasture samples submitted averaged 21% dry matter. Only 16% of the samples contained less than 16% dry matter, the point at which water could be expected to reduce dry matter intake (NRC, 1987). The vast majority of samples were high enough in dry matter than water content would not be expected to decrease dry matter intake, especially when animals are barn fed dry supplemental feeds.

Bulk Height (BH)

Forage mass available in the pasture determines in part how much forage an animal can graze. Pasture intake decreases when forage mass drops below 1,000 lb.. DM/acre. Dense, vegetative grass-legume pastures average 432 lb. DM/acre/inch bulk height when measured with the standard Plexiglas weight plate (Appendix 2). The pastures sampled averaged 5.6 ± 2.7 inches in bulk height (Table 5).

Table 5. Dry matter content, bulk height, and days regrowth of rotationally grazed pastures sampled for forage analysis over three years (average" standard deviation).

	Dry matter	Bulk height	Days regrowth
	%	Inches	Days
Pastures	21± 5	5.6 ± 2.7	33 ± 17

This indicates that pre-grazing forage mass ranged from 1,200 to 3,500 lbs DM/acre. Pasture bulk height was affected by forage type, with mixed mostly grass and legume pastures having lower bulk heights than grass or mixed mostly legume pastures (Table 6). Bulk height was affected by month of sampling. June pastures were significantly greater in bulk height than pastures in the other months. Bulk height was maintained through the summer by increasing the days regrowth between grazing. Pasture bulk height increased by 0.09 inches per day of regrowth.

Table 6. Forage bulk height of pastures sampled for forage quality over three years.

Forage type	May	Jun	Jul	Aug	Sep	Oct	Avg.
			----- Days -----				
Grass	6.8	10.9	6.1	5.7	6.7	6.1	6.7
Mixed mostly grass	6.1	7.5	4.8	4.3	4.0	4.0	4.8
Mixed mostly legume	9.4	8.8	5.8	7.2	5.8	5.5	6.7
Legume	6.0			6.1	4.3	4.7	5.3
Average	6.5	8.4	5.0	5.0	5.2	5.2	5.6

Days Regrowth (DRG)

Sampled pastures averaged 33 days regrowth (Table 5). As the grazing season progressed and forage growth slowed, the regrowth interval increased from 18 days in May to 46 days in October (Table 7). Days regrowth was affected by forage type. Grass pastures had 5 days greater and mixed mostly grass had 6 days less regrowth than mixed mostly legume and legume pastures.

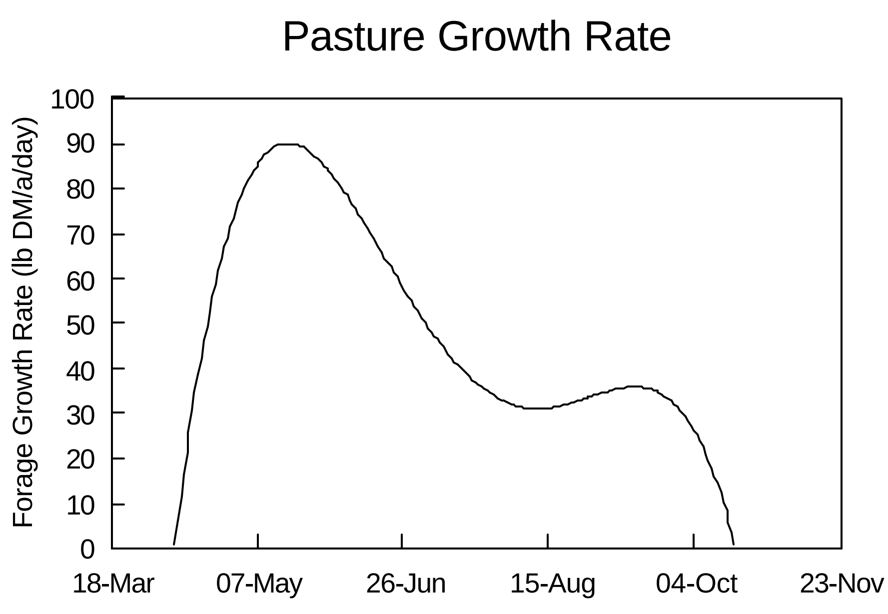
Table 7. Days regrowth of pastures sampled for forage quality over three years.

Forage type	May	Jun	Jul	Aug	Sep	Oct	Avg.
			----- Days -----				
Grass	18	19	35	38	42	55	42
Mixed mostly grass	19	21	26	29	34	37	29
Mixed mostly legume		29	28	34	38	40	34
Legume			42	37	36	46	40
Average	18	23	28	31	37	46	33

Pasture Growth Rate and Distribution

Pasture growth rate and herd size determine the acreage needs for a grazing herd. In the spring, with high pasture growth rates, less acreage is needed than in the summer when forage growth slows. The pasture growth rate, estimated from pre-grazing bulk height and days regrowth, reached a peak in May (90 lb. DM/a/day) and dropped into August (30 lb. DM/a/day) with a slight increase in September (35 lb. DM/a/day) (Figure 1).

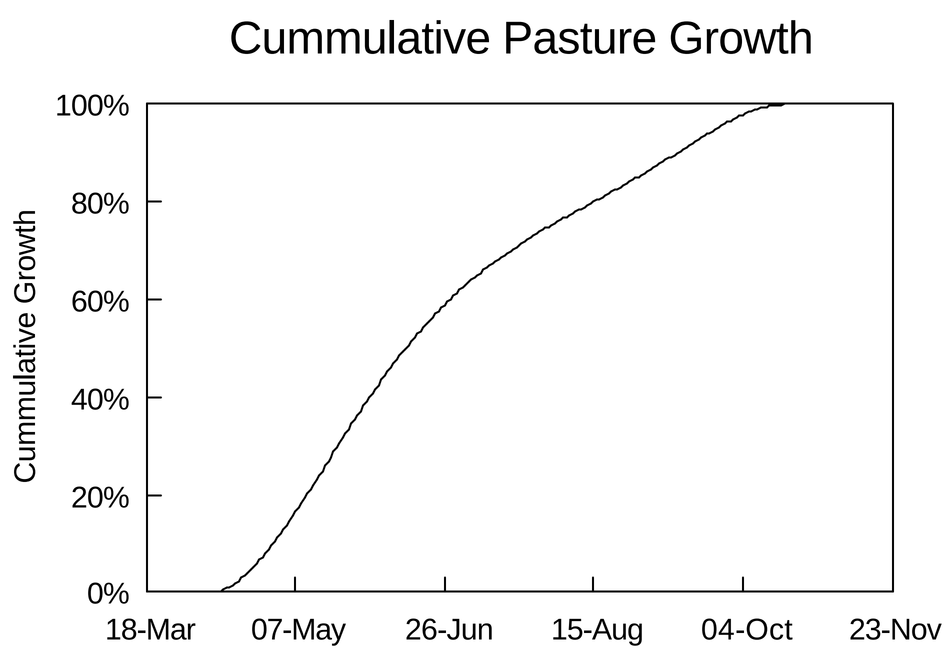
Figure 1. Average pasture growth rate of intensive rotationally grazed pastures in the Northeast during the 1988, 1989, and 1990 growing seasons.



On a given field, approximately 50% of the total forage production potential occurs in May and June, 33% in July and August, and 17% in September and October (Rayburn, 1987). However, under practical farm management, the distribution of forage growth used for grazing was 52% in May and June; 26% in August and September; and 22% in October and November (Figure 2). This is due to farmers using their more productive stands for hay in the spring and grazing the aftermath growth. This production distribution results in the practice of harvesting half the forage acreage for first cut hay and using twice the regrowth interval and all the acreage for grazing during the summer.

Forage maturity, as well as day's regrowth, must be considered when making grazing management decisions. Some forage species, such as orchardgrass, remain vegetative after seed head removal in the spring. Other species, such as timothy and alfalfa, go to flower in any regrowth if sufficient time is allowed. Under New York conditions, timothy and alfalfa should be grazed between 35 and 42 days regrowth. If they are allowed to go to 49 days regrowth, quality of these species will drop greatly as stems and seed heads develop. Cattle grazing such stands will reject this forage and trampling losses will be high. When considering forage regrowth rate and plant maturity effects in mixed species pastures, the current grazing recommendation is to allow 21 days regrowth in the spring and 42 days regrowth in the summer and early fall.

Figure 2. Average cumulative pasture growth at harvest of rotationally grazed pastures in the Northeast during the 1988, 1989, and 1990 growing seasons.



Chemical Analysis

Forage type affected pasture quality more than any other variable. Depending on the quality component, month was also a major factor in determining forage quality. In these samples, age of regrowth and forage bulk height do affect forage quality, but to a lesser extent.

Fiber and Carbohydrates

Neutral Detergent Fiber (NDF)

NDF is a measure of the cell wall content of forages and limits total feed intake in high forage diets. High producing dairy cattle can consume 1.2% of their body weight in NDF/day. As the total ration NDF increases, total dry matter intake will decrease. When forage NDF increases, total feed intake usually decreases and milk production decreases.

Pasture samples were higher in NDF than corn silage but lower than hay or haylage produced from similar forage types (Table 8). NDF content of pasture samples was affected by forage type (Table 9), decreasing as the percent legume increased from grass (53%), to mixed mostly grass (48%), to mixed mostly legume (44%), to legume (31%) samples. Forage NDF increased by 0.77 units/inch bulk height. Samples analyzed in 1988 averaged 4 units higher in NDF than those analyzed in 1989 and 1999 (Appendix 6).

Table 8. Neutral detergent fiber (NDF), acid detergent fiber (ADF), non-structural carbohydrates (NSC), total digestible nutrients (TDN), and net energy lactation (NEL) of rotationally grazed pastures, comparable hay and haycrop silage, and corn silage (average ± standard deviation).

	NDF	ADF	NSC	TDN	NEL
		----- %DM -----			Mcal/lb.
Pasture	47 ± 10	27 ± 5	17 ± 7	69 ± 5	0.69 ± 0.08
Mixed mostly grass					
Hay	60 ± 6	38 ± 4	18	62 ± 2	0.54 ± 0.05
Silage	58 ± 6	41 ± 4	13	60 ± 2	0.51 ± 0.05
Corn Silage	45 ± 6	26 ± 4	34	70 ± 2	0.73 ± 0.04

The effect of NDF on forage intake is readily apparent with dairy cows on pasture. When moving milked cows from pastures containing 20 to 30% clover, to nitrogen-fertilized grass pastures containing no clover, milk production repeatedly drops 5 6o 10 lb./head/day. Largely the difference in forage NDF content and its effect on feed intake can account for this loss in milk production.

Acid Detergent Fiber (ADF)

Forage ADF content is a measure of the cellulose and lignin in forage, and is the best indicator of forage digestibility and the fiber needed by dairy cows to maintain milk butterfat test. Forage ADF is part of the NDF. Pasture samples averaged 37% ADF (Table 8). When compared to typical conserved forages, pasture samples were higher in ADF than corn silage but lower in ADF than hay or haycrop silage harvested from similar forage types.

Pasture samples differed in ADF due to forage type and month of the year (Table 9). Grass and mixed mostly grass samples were higher in ADF (2.6% and 1.9% ADF respectively) than mixed mostly legume and legume samples (Appendix 6). May and October samples were lower in ADF than samples taken in the summer months. Forage ADF increased by 0.49-units/inch bulk height and by 0.055 units/day regrowth.

Table 9. Neutral detergent fiber (NDF), acid detergent fiber (ADF), non-structural carbohydrates (NSC), total digestible nutrients (TDN), and net energy lactation (NEL) of rotationally grazed pastures by forage type and moth sampled.

Forage type	May	Jun	Jul	Aug	Sep	Oct	Avg.
			----- NDF % dry matter -----				
Grass	48	58	56	57	53	52	53
Mixed mostly grass	47	50	49	49	47	44	48
Mixed mostly legume	38	45	44	44	45	38	44
Legume	24		32	40	26	31	31
Average	43	50	48	48	46	44	47
			----- ADF % dry matter -----				
Grass	24	30	30	29	28	28	28
Mixed mostly grass	24	30	28	27	26	22	27
Mixed mostly legume	23	27	28	27	30	25	28
Legume	19		25	27	20	23	23
Average	23	29	28	27	27	25	27
			----- NSC % dry matter -----				
Grass	18	11	12	11	14	15	14
Mixed mostly grass	16	15	15	15	17	16	16
Mixed mostly legume	25	19	19	20	19	23	20
Legume	33		29	25	32	26	29
Average	20	16	16	16	18	18	17
			----- TDN % dry matter -----				
Grass	73	69	68	69	70	71	70
Mixed mostly grass	71	67	68	69	70	73	69
Mixed mostly legume	72	69	69	69	67	71	69
Legume	73		68	67	72	70	70
Average	72	68	68	69	69	71	69
			----- NEL Mcal/lb. DM -----				
Grass	0.73	0.64	0.64	0.65	0.66	0.67	0.67
Mixed mostly grass	0.73	0.65	0.68	0.69	0.71	0.76	0.69
Mixed mostly legume	0.74	0.69	0.68	0.70	0.66	0.72	0.68
Legume	0.81		0.74	0.71	0.80	0.76	0.76
Average	0.74	0.66	0.68	0.69	0.69	0.72	0.69

Forage ADF content was correlated to NDF content (Appendix 6). When NDF is used in place of forage type, ADF averaged 0.30/unit NDF. ADF increased 0.32-units/inch bulk height and 0.039 units/day regrowth.

Non-structural Carbohydrates (NSC)

Forage NSC are the sugars, sugar-related carbohydrates, and starches found inside the cell walls of plant tissue. These compounds are nearly 100% digestible. NSC are needed in the rumen for bacterial growth and for the production of higher quality bacterial protein from plant protein. The bacteria are then digested beyond the rumen by the cow for energy and protein.

Pasture samples averaged 17% NSC. Compared to conserved forages, pasture NSC were lower than corn silage, comparable to hay, and higher than haycrop silage made from similar forage (Table 8). Forage NSC were affected by forage type, year, and days regrowth (Table 9).

NSC in legume and mixed mostly legume samples were 8.9 and 4.3 units higher than mixed mostly grass samples, while NSC in grass samples were 5.2 units lower. Forage NSC increased by 0.078-units/day regrowth. Forage NSC were 2.4 units lower in 1988 than in the other two years.

When NDF and ADF were used in place of forage type, the percent of variation in NSC accounted for by the regression (R^2) increased from 31% to 82% and all effects of year and days regrowth were removed (Appendix 6). Pasture forages decreased 0.83 units NSC/unit NDF and increased 0.46 units NSC/unit ADF.

Estimated Energy

Total Digestible Nutrients (TDN)

Forage TDN is an estimate of the digestibility of a forage and is about equal to the percent digestibility of the forage dry matter. In the laboratory, forage TDN is often calculated from, and negatively related to, forage ADF. This results in forage TDN following the reverse trends of forage ADF.

Pasture samples averaged 69% TDN, slightly lower than corn silage but greater than hay crops harvested from similar forage types (Table 8). There was little effect of forage type on sample TDN content. Pasture samples were highest in TDN in May and October. Forage TDN content decreased 0.31 units/inch bulk height.

Net Energy Lactation (NEL)

Forage NEL is a measure of the quality of the forage in terms of the milk production that can be achieved from the forage. The forage intake and digestibility determine forage NEL. NEL is related in a negative manner to forage NDF. As NDF increases, forage intake decreases. Within a forage species, as NDF increases, ADF increases and forage digestibility decreases. The combined effect of digestibility and intake affect the ability of the cow to produce milk from the forage.

Pasture samples averaged 0.69 Mcal NEL/lb. DM. This is a little lower than average corn silage but greater than conserved forage of a similar forage type (Table 8). Estimates of NEL follow the same trend as NDF analysis across the year and forage types since NEL is calculated from NDF and forage type. Pasture NEL content was highest for legumes and lowest for grass pastures (Table 9). NEL content was also affected by month, being highest in May and October.

Protein

Crude Protein (CP)

Crude protein is a measure of the protein in a forage and is estimated by measuring the nitrogen content of the sample and multiplying that by 6.25. In typical pastures 18% of this CP may be non-protein nitrogen (Wilson and Brigstocke, 1981). Much of the protein in forages is degraded in the rumen by bacteria. These bacteria use this protein for growth and for digestion of the forage fiber and carbohydrate grains fed as supplements. As the bacteria are washed out of the rumen, they are digested for energy and protein by the cow in the abomasum and intestinal tract.

Pasture samples averaged 21% CP. This is twice the CP content of corn silage and 33-63% higher than in haylages or hay harvested from similar stands (Table 10). Forage type and month (Table 11) affected pasture CP content. Mixed mostly legume and legume samples averaged 2 to 4 units higher in CP than did grass and mixed mostly grass samples. Samples taken in May and October were 2 to 3 units higher in CP than those taken in other months of the year. Samples taken in 1990 averaged 1.5 CP units higher than those taken in 1988 and 1989 (Appendix 6). CP content of pasture samples decreased by 0.47 units/inch bulk height and by 0.094 units/day regrowth.

Table 10. Crude protein (CP), protein solubility (SOL), and protein degradability (DEG) of rotationally grazed pastures, comparable hay and haycrop silage, and corn silage (average ± standard deviation).

	CP	SOL	DEG
	% dry matter	---------------- % CP	-----------------
Pasture	22 ± 5	27 ± 8	72 ± 6
Mixed mostly grass			
Hay	12 ± 3	31 ± 6	
Silage	14 ± 3	49 ± 10	
Corn silage	9 ± 1	44 ± 9	

When NDF and ADF replaced forage type in the regression analysis, the effects of month and bulk height were removed and the variation in CP explained by the regression increased from 24% to 45%. Pasture CP decreased by 0.58 units/unit ADF and 0.057-units/day regrowth. Samples taken in 1990 averaged 1.3 units lower in CP than those taken in 1988 and 1989 (Appendix 6).

Protein Solubility (SOL)

Protein solubility is a measure of the protein that is rapidly degraded to ammonia in the rumen by bacteria. Bacteria digesting the NSC and digestible fiber in the ration can use soluble protein. When protein solubility is high, more ammonia may be produced than can be used by the bacteria. Any excess ammonia will be lost from the rumen into the blood. When ammonia is present in the blood in high levels, it can depress feed intake. To remove ammonia from the blood, the animal has to expend energy to convert it to urea, to be excreted in the animal's urine.

Table 11. Crude protein (CP), protein solubility (SOL), and protein degradability (DEG) of rotationally grazed pastures by forage type and moth sampled.

Forage type	May	Jun	Jul	Aug	Sep	Oct	Avg.
	-----CP % dry matter -----						
Grass	22	18	20	20	21	21	20
Mixed mostly grass	24	20	22	22	22	26	22
Mixed mostly legume	22	21	22	22	21	24	22
Legume	26		24	21	26	26	24
Average	23	20	22	22	22	24	22
	----- Solubility % CP -----						
Grass	25	31	24	24	29	34	28
Mixed mostly grass	26	29	23	22	21	24	24
Mixed mostly legume	32	30	28	27	31	33	30
Legume	34		32	25	29	37	31
Average	27	30	24	23	26	31	26
	----- Degradability % CP -----						
Grass	75	78	75	69	72	72	72
Mixed mostly grass	74	73	73	71	71	74	72
Mixed mostly legume	74	72	74	72	71	71	72
Legume	77		66	69	70	77	72
Average	75	74	73	71	71	73	72

Pasture protein solubility averaged 27% (Table 10). Protein solubility was greater in mixed mostly legume and legume forage than in grass and mixed mostly grass forage (Table 11). Differences in protein solubility were correlated to forage type, bulk height, and day's regrowth. Solubility increased 0.86-units/inch bulk height and 0.05 units/day regrowth (Appendix 6).

When NDF and ADF replaced forage type, protein solubility was affected by month, year, NDF, ADF, bulk height, and day's regrowth. Samples taken in October averaged 3.0 units higher than in other months. Samples taken in 1990 averaged 5.9 units higher in solubility than those taken in 1988 and 1989. Protein solubility decreased 0.25 units/unit NDF and increased 0.43 units/unit ADF. Protein solubility increased 0.12 units/day regrowth and 0.72 units/inch bulk height (Appendix 6).

Protein Degradability (DEG)

Protein degradability is a measure of the total protein degraded to ammonia in the rumen. Soluble protein is a part of the degradable protein. Excess degradable protein can cause the same problems as excess soluble protein, namely, high ammonia levels and energy expense for removing the ammonia from the body. In pastures having moderately soluble protein and fairly high degradable protein, the major problem of excess ammonia probably arises from the total protein content and high protein degradability.

Table 12. Macro-mineral content of rotationally grazed pastures, comparable hay and haycrop silage, and corn silage (average ± standard deviation).

	Ca	P	Mg
		----- % dry matter -----	
Pasture average	0.77 ± 0.31	0.37 ± 0.08	0.26 ± 0.06
Mixed mostly grass			
Hay	0.76 ± 0.27	0.25 ± 0.06	0.20 ± 0.06
Silage	0.88 ± 0.15	0.27 ± 0.06	0.22 ± 0.06
Corn silage	0.28 ± 0.15	0.22 ± 0.05	0.21 ± 0.04
	K	**S**	**Na**
		----- % dry matter -----	
Pasture average	2.91 ± 0.81	0.32 ± 0.07	0.029 ± 0.040
Mixed mostly grass			
Hay	1.72 ± 0.46	0.20 ± 0.05	0.019 ± 0.046
Silage	2.18 ± 0.65	0.26 ± 0.06	0.025 ± 0.055
Corn silage	1.05 ± 0.29	0.14 ± 0.04	0.008 ± 0.049

Protein degradability averaged 72% in pastures (Table 9). Average protein degradability for harvested forages was not available for comparison. The protein degradability was less variable than protein solubility (standard deviation of 6 versus 8) (Table 10). Year was the only factor that significantly affected protein degradability. Protein degradability was 2.4 units lower in 1988 than in 1989 and 1990. When NDF and ADF were used in place of forage type, protein degradability decreased 0.088 units/unit NDF (Appendix 6).

Macro-minerals

Macro-minerals are those minerals needed in the cow's diet in relatively large amounts. These minerals include calcium, phosphorus, potassium, magnesium, sulfur, chlorine, and sodium. These minerals are important in skeletal growth, body fluid ion balance, and energy and protein metabolism. They are readily available as mineral and salt supplements when needed.

Calcium (Ca)

Calcium is the most abundant mineral in the cow's body. Calcium is needed for milk production, skeletal growth and maintenance, and the proper functioning of muscles, nerves, blood and enzyme systems. The NRC recommendation is that Ca be 0.43% to 0.66% of the ration DM for lactating dairy cattle, depending on the level of milk production.

The calcium content of pasture forage averaged 0.77%, being much higher than in corn silage and comparable to hay crops harvested from similar forage (Table 12). Calcium content of pasture was primarily related to legume content. Calcium decreased from legume (1.21%), to mixed mostly legume (0.99%), to mixed mostly grass (0.75%), to grass samples (0.43%) (Table 13). Samples collected in 1988 were 0.08% higher in calcium than those collected in 1989 and 1990.

When NDF and ADF replaced forage type, there was a significant month effect, with September and October having 0.08 and 0.16-units lower calcium than forage samples taken in the other months. Samples taken in 1988 averaged 0.17% higher calcium than samples taken in 1989 and 1990. The calcium content of pasture samples decreased 0.024%/unit NDF.

When feeding dairy cows on grass and mixed mostly grass pastures, calcium should be provided as a supplement to ensure adequate intake. On mixed mostly legume and legume pastures, the level of calcium in the forage may be adequate to meet the cow's requirements.

Phosphorus (P)

Phosphorus is needed by the cow for milk production, for skeletal growth and maintenance, as a buffer in the blood and rumen, and for energy metabolism and rebreeding. The NRC recommendation is that P be 0.28% to 0.41% of the ration DM.

Pasture samples averaged 0.37% phosphorus (Table 12). This was almost 50% above any of the harvested feeds. Phosphorus content was influenced little by forage type or month (Table 13), but decreased with age of regrowth by 0.002 units/day regrowth.

When feeding dairy cows on pasture, supplemental phosphorus should be used to ensure adequate phosphorus intake.

Magnesium (Mg)

Magnesium is needed by the cow for skeletal development, milk production, and nerve and muscle activity, as well as in many enzyme systems. The NRC recommendation is that magnesium be fed at 0.20 to 0.25% of the ration DM. On spring pastures subject to grass tetany, a magnesium level of 0.30% ration dry matter is recommended.

Table 13. Macro-mineral content of rotationally grazed pastures by forage type and month sampled.

Forage type	May	Jun	Jul	Aug	Sep	Oct	Avg.
			----- Ca % dry matter -----				
Grass	0.50	0.43	0.41	0.51	0.37	0.39	0.43
Mixed mostly grass	0.61	0.69	0.79	0.79	0.79	0.72	0.75
Mixed mostly legume	0.92	0.97	1.01	0.95	1.01	1.01	0.99
Legume	1.24		1.12	1.21	1.33	1.10	1.21
Average	0.70	0.72	0.81	0.81	0.79	0.71	0.77
			----- P % dry matter -----				
Grass	0.35	0.34	0.37	0.33	0.41	0.42	0.38
Mixed mostly grass	0.39	0.37	0.38	0.38	0.38	0.38	0.38
Mixed mostly legume	0.40	0.36	0.35	0.37	0.33	0.35	0.35
Legume	0.35		0.32	0.29	0.33	0.36	0.33
Average	0.38	0.36	0.37	0.37	0.38	0.39	0.37
			----- K % dry matter -----				
Grass	2.80	2.52	2.95	3.12	3.96	3.59	3.38
Mixed mostly grass	2.98	2.70	2.75	2.67	2.68	3.26	2.76
Mixed mostly legume	2.39	2.55	2.71	2.64	2.66	2.90	2.65
Legume	3.36		2.63	2.45	2.99	3.80	3.07
Average	2.96	2.64	2.75	2.74	3.06	3.45	2.91
			----- Mg % dry matter -----				
Grass	0.81	0.17	0.19	0.25	0.24	0.21	0.22
Mixed mostly grass	0.21	0.22	0.26	0.29	0.27	0.26	0.26
Mixed mostly legume	0.29	0.30	0.28	0.30	0.30	0.25	0.29
Legume	0.31		0.28	0.36	0.29	0.23	0.30
Average	0.23	0.23	0.26	0.29	0.27	0.24	0.26
			-----S % dry matter -----				
Grass	0.32	0.27	0.29	0.35	0.35	0.31	0.32
Mixed mostly grass	0.33	0.30	0.33	0.35	0.37	0.36	0.33
Mixed mostly legume	0.32	0.29	0.29	0.31	0.28	0.32	0.30
Legume	0.27			0.22	0.30	0.25	0.26
Average	0.32	0.29	0.32	0.33	0.33	0.31	0.32
			----- Na % dry matter -----				
Grass	0.015	0.009	0.018	0.007	0.009	0.009	0.010
Mixed mostly grass	0.020	0.040	0.049	0.042	0.058	0.033	0.043
Mixed mostly legume	0.019	0.020	0.031	0.027	0.033	0.031	0.028
Legume	0.005		0.005	0.024	0.006	0.011	0.011
Average	0.016	0.031	0.041	0.034	0.035	0.019	0.032

Pasture magnesium content averaged 0.26% which is comparable to the content in harvested forages (Table 12). Magnesium content of pasture forage increased as the legume content increased (Table 13). Magnesium levels were lowest in spring grass pasture samples. Pasture magnesium increased 0.003 units/inch of forage bulk height. Samples taken in August were higher in magnesium than samples taken in other months.

Pastures are marginal in magnesium content for dairy cattle so magnesium supplementation should be considered. One practical means is the use of magnesium oxide as part of a buffer package in the grain mix.

Potassium (K)

Potassium is the third most abundant mineral in the cow's body. It is required for body fluid regulation, nerve and muscle function, oxygen and carbon dioxide transport, acid-base balance, and enzymatic reactions. The NRC recommendation is that potassium be available in the ration at 0.90% to 1.00% of the ration DM. High potassium levels in spring pastures and silages may be a factor in causing grass tetany or hypomagnesia in lactating cattle.

Forage potassium (K) content averaged 2.91%. This was higher than in corn silage or hay but comparable to haycrop silage made from similar forage. The potassium content of pasture decreased 0.013 units/day of regrowth. Mixed mostly grass samples were 0.30 units lower in potassium than other forage types. Samples taken in September were 0.43 units higher in potassium than samples taken in other months.

Pastures are high enough in potassium than supplemental potassium is not needed.

Sulfur (S)

Sulfur is an essential component in proteins and is needed for protein metabolism in the rumen and for the formation of B vitamins. The NRC recommendation is that sulfur be 0.20% of the ration DM, or that the nitrogen to sulfur ratio be 12:1.

Sulfur (S) content of pasture forages averaged 0.32%. This is twice the content found in corn silage and a little higher than in hays or haycrop silage made from similar forages (Table 12). Legume samples contained 0.088 units less sulfur than other forage types (Table 13). Samples taken in September were 0.039 units higher and those taken in October were 0.043 units lower in sulfur than samples taken in other months. The sulfur content of pasture decreased by 0.0077 units/inch bulk height.

Pastures in the Northeast are relatively high in sulfur and supplemental sulfur should not be required in the ration unless a high rate of barn feeding of low sulfur feeds is part of the program.

Sodium (Na)

Sodium is needed by the cow for glucose and amino acid transport, controlling nerve transmissions, maintaining osmotic regulation of body fluids, and maintaining acid-base balance. When salt is not supplemented to dairy cows, sodium can be the limiting nutrient in the diet. The NRC recommendation is that sodium be in the ration at 0.18% of the ration DM.

Sodium in pastures averaged 0.029%. There was little practical consistency in the sodium content of pasture samples. Adequate salt should be provided to dairy cattle on pasture to ensure that they meet their needs for sodium and chlorine. Usually this is provided in the grain mix in the barn.

Chlorine (Cl)

Pasture samples were not analyzed for chlorine. Chlorine is the major anion in the blood and lymph system of the body and is needed for osmotic regulation, maintaining acid-base balance, transporting oxygen and carbon dioxide, and digestive functions. The NRC recommendation is that chlorine be in the ration at 0.25% of the ration DM. Chlorine is closely associated with sodium in metabolism. It is a major part of regular salt used to supplement sodium in diets, so it is often assumed that if the sodium requirement is met, then the chlorine requirement will be satisfied.

Table 14. Mineral ratios of rotationally-grazed pastures.

Forage type	May	Jun	Jul	Aug	Sep	Oct	Avg.
	-----Ca:P Ratio -----						
Grass	1.45	1.28	1.17	1.56	0.94	0.94	1.16
Mixed mostly grass	1.62	1.91	2.14	2.15	2.18	1.89	2.05
Mixed mostly legume	2.30	2.75	3.01	2.70	3.13	2.97	2.91
Legume	3.64		3.55	4.32	4.15	3.14	3.80
Average	1.92	2.02	2.28	2.29	2.25	1.91	2.17
	----- K:(Ca+Mg) Ratio -----						
Grass	4.69	4.57	5.21	4.59	6.70	6.24	5.67
Mixed mostly grass	3.80	3.13	2.75	2.61	2.67	3.49	2.89
Mixed mostly legume	2.40	2.21	2.44	2.32	2.12	2.48	2.27
Legume	2.21		1.91	1.79	1.88	2.89	2.15
Average	3.67	3.12	2.85	2.77	3.46	4.28	3.25

Micro-minerals

Micro-minerals or trace minerals are those minerals needed at low concentrations in the cow's diet. This does not mean they are any less important, only that those smaller quantities fill the animal's needs. A deficiency of these minerals can cause serious health and production problems. With the availability of trace mineralized mineral mixtures and trace mineral salt, there is no need for cattle to be deficient in trace minerals. However, there can be toxic effects and harmful interaction between mineral if not fed near recommended rates.

Iron (Fe)

Iron is needed by the cow for blood cells and in enzyme systems involved in the transport of oxygen to the cells. The NRC recommendation is that iron be in the ration of 50 PPM.

Pasture samples averaged 224-PPM iron and were highly variable with a standard deviation of 406 (Table 15). The iron content of pasture was comparable to that of harvested feeds. Iron content was lower in grasses than in legumes (Table 16) and decreased 1.6 PPM/day regrowth. Iron content of forages in 1990 averaged 60 PPM higher than in the other years.

Table 15. Micro-mineral content of rotationally grazed pastures (average " standard deviation).

	Fe	Zn	Cu	Mn	Mo
Pasture	224 ± 406	31 ± 9	10 ± 2	79 ± 64	2.2 ± 1.2
Corn silage	227 ± 340	30 ± 16	7 ± 2	43 ± 27	
Mixed mostly grass					
Silage	312 ± 306	32 ± 25	9 ± 7	71 ± 41	
Hay	157 ± 212	28 ± 10	11 ± 19	68 ± 45	

Table 16. Micro-mineral content of rotationally grazed pastures.

Forage type	May	Jun	Jul	Aug	Sep	Oct	Avg.
	----- Cu PPM -----						
Grass	8.3	9.8	11.0	9.4	7.7	8.7	8.7
Mixed mostly grass	10.0	10.1	10.7	10.6	10.3	10.1	10.4
Mixed mostly legume	8.6	8.8	10.0	9.9	9.4	9.0	9.4
Legume	8.9		8.8	10.8	10.6	7.1	9.3
Average	9.3	9.8	10.5	10.5	9.5	8.8	9.9
	----- Fe PPM -----						
Grass	154	114	177	126	120	175	141
Mixed mostly grass	224	251	230	219	214	189	223
Mixed mostly legume	222	214	206	176	268	234	228
Legume	99		101	1174	88	387	430
Average	190	224	215	265	195	221	222
	----- Mn PPM -----						
Grass	87	54	100	117	69	84	84
Mixed mostly grass	59	64	74	103	103	74	86
Mixed mostly legume	79	104	45	58	63	42	65
Legume	45		48	72	65	58	60
Average	65	71	70	96	81	70	79
	----- Mo PPM -----						
Grass	1.7	1.6	2.0	2.0	1.7	1.3	1.7
Mixed mostly grass	2.5	2.6	2.6	2.1	2.3	2.8	2.4
Mixed mostly legume	2.7	2.9	2.9	2.7	2.7	3.3	2.8
Legume	1.3		1.4	2.3	0.9	1.4	1.5
Average	2.1	2.5	2.6	2.2	2.1	2.0	2.3
	-----Zn PPM -----						
Grass	28	30	37	33	23	26	28
Mixed mostly grass	31	31	34	36	36	30	34
Mixed mostly legume	29	29	28	30	30	26	29
Legume	32		30	32	30	24	30
Average	30	30	33	35	31	27	32

Copper (Cu)

Copper is necessary for the normal red blood cell formation, in enzyme systems, and in bone formation. The NRC recommends that copper be 10 PPM of the ration DM.

Pasture samples average 10 PPM copper, comparable to that of harvested forages (Table 15). Copper was lowest in grass samples and decreased 0.46 PPM/day regrowth (Table 16). Samples collected in 1988 were 0.7 PPM higher in copper than in the other years.

Manganese (Mn)

Cattle for proper functioning of enzyme systems require manganese. The NRC recommendation for manganese in the diet is 40-PPM Mn in the ration DM.

Manganese in pasture samples averaged 70 PPM, which was higher than in corn silage but similar to the harvested hay and haycrop silages (Table 15). Manganese was higher in grass pastures than in legume pastures and was higher in August and September than in the other months. (Table 16). When forage NDF and ADF replaced forage type in the analysis, manganese increased 5 PPM/unit ADF and decreased 5 PPM/inch bulk height. Samples collected in 1988 averaged 38 PPM higher in manganese than those collected in 1989 and 1990 (Appendix 6).

Zinc (Zn)

Zinc is required for enzyme systems involved in protein synthesis and carbohydrate metabolism. The NRC recommendation for zinc is 40 PPM in the ration DM.

Pasture samples averaged 31-PPM zinc, which was comparable to the harvested forages (Table 15). Zinc in pasture forages decreased 0.22 PPM/day regrowth. Samples harvested in 1988 averaged 8 PPM higher in zinc than those collected in 1989 and 1990 (Appendix 6).

Molybdenum (Mo)

Molybdenum is reequired by the cow for the maintenance of enzyme systems. There is no established NRC requirement for molybdenum in dairy cattle since deficiency of this mineral has not developed or been observed. Molybdenum toxicity can occur on pasture, and copper deficiency can be caused by molybdenum in the ration. A copper to molybdenum ration of 2 to 4:1 in pasture prevents Cu deficiency problems.

Molybdenum in pasture forage averaged 2.2 PPM (Table 15). Molybdenum was higher in mixed mostly legume and mixed mostly grass pastures than in the other pastures (Table 16). Molybdenum decreased 0.021 PPM/day regrowth. Samples collected in 1990 were 0.7 PPM higher than those collect in the other two years.

Cobalt (Co)

Cobalt was not measured in the pasture sample. Cows need cobalt for proper rumen fermentation and for making vitamin B12 by the rumen bacteria. The vitamin B12 is used by the rumen bacteria in feed digestion and used by the cow as the bacteria are digested. The NRC recommendation is that cobalt be in the ration at 0.10 PPM of the ration DM.

Iodine (I)

Pasture samples were not analyzed for iodine. Iodine is needed for the production of thyroid hormones, which regulate energy metabolism in the body. The NRC recommendation for iodine in the diet is 0.60 PPM of the ration DM. However, under some conditions, the NRC recommendation is 1.00 PPM for lactating cows. Some crops such as Brassica forage (kale, rape, and turnips) are considered "goitrogenic." When as little as 25% of the diet is Brassica forage, iodine deficiency can occur at the lower recommended iodine levers in the diet. Cottonseed and soybean meal can also have a goitrogenic effect.

Selenium (Se)

Samples were not analyzed for selenium. Selenium is needed by cattle for anti-oxidant enzyme systems and to prevent white muscle disease in calves and lambs. Selenium deficiency tends to be more prevalent when animals are fed feeds grown on acid soils. The NRC recommendation is 0.30-PPM selenium in the ration DM.

Trace Mineral Supplementation

The major problem with trace minerals in pasture forage is the great variability in micro-mineral content. The Northeast is considered an area deficient in iodine and selenium, and cattle should be supplemented with these trace minerals. Based on these samples, it appears that copper and zinc content of pasture forage could be marginal for optimum animal performance in many pastures. With the availability of trace-mineralized minerals and salt, moderate supplementation should be considered to provide adequate levels for optimum animal production.

Broadleaf Weeds

Broadleaf weeds are sometimes considered a problem in pastures and are probably an indicator of improper management when present in excessive quantity. Palatable broadleaf weeds, when present in limited quantity, should not be considered a major problem. Dandelions tested high in CP and low in ADF and NDF (Table 17). The protein solubility of broadleaf weeds was lower than for the other forages measured. Dandelions were comparable to mixed mostly legume forage in calcium and higher than any of the other forages in phosphorus, magnesium, and potassium content. Dandelions also had higher levels of Cu and Zn which tend to be low in pasture forage.

Table 17. Forage quality of 11 dandelion samples taken from rotationally grazed pastures (average ± standard deviation).

DM	CP	Sol	Deg		
%	% dry matter	----- % CP -----			
15 ± 2	22 ± 4	21 ± 8	72 ± 4		
ADF	NDF	TDN	NSC	NEL	
	----- % dry matter ------			Mcal/lb.	
22 ± 4	36 ± 9	72 ± 3	29 ± 5	0.76 ± 0.07	
Ca	P	Mg	K	S	
		----- % dry matter -----			
0.93 ± 0.15	0.46 ± 0.15	0.32 ± 0.06	4.81 ± 1.15	0.35 ± 0.07	
Na	Fe	Zn	Cu	Mn	Mo
% dry matter		----- PPM -----			
0.011 ± 0.022	123 ± 52	34 ± 14	11 ± 6	95 ± 160	1.5 ± 0.8

Dormant Season Pasture

The accumulation of pasture forage for grazing during the dormant season is a common way of extending the grazing season in the South. This technique has several names including "stockpiling," "deferred grazing," and "foggage."

Dormant season pasture samples were mostly vegetative grass pastures (Table 2). These pasture samples were higher in NDF, ADF, and NSC, and lower in TDN and NEL, than grass pastures sampled during the growing season (Table 18). Dormant season samples were lower in CP and higher in protein solubility. Protein degradability was not different between the two seasons. There was little difference in the mineral content of dormant and growing season pastures, though Ca content was slightly higher and sulfur content was lower in the deferred forage. The quality of forage harvested as deferred pasture was adequate for dry cows and large growing young stock.

Eastern gamagrass

Eastern gamagrass holds promise for low input agriculture because of its potential as a perennial, high yielding, and high quality silage crop. Previously this grass has not been available commercially due to the lack of seed. However, this problem has been overcome and the seed is available. The ADF and CP quality of eastern gamagrass are comparable to other grasses harvested in the Jun through August period (Table 19). The high content of NDF may be the limiting factor for this grass. However, livestock tend to respond to warm season grasses better than the laboratory analysis would indicate.

Table 18. Forage quality of pasture samples taken from rotationally grazed pastures in November and December (average ± standard deviation).

DM	CP	Sol	Deg	
%	% dry matter	----- % CP -----		
31± 15	18 ± 6	38 ± 6	75 ± 4	
NDF	**ADF**	**NSC**	**TDN**	**NEL**
	----- % dry matter ------			Mcal/lb.
52 ± 12	32 ± 7	17 ± 7	67 ± 5	0.61 ± 0.11
Ca	**P**	**Mg**	**K**	**S**
		----- % dry matter -----		
0.53 ± 0.27	0.37 ± 0.10	0.22 ± 0.04	3.01 ± 1.07	0.26 ± 0.04

Na	Fe	Zn	Cu	Mn	Mo
% dry matter			----- PPM -----		
0.01 ± 0.00	244 ± 113	22 ± 3	8 ± 2	79 ± 32	1.8 ± 1.1

Table 19. Forage quality of eastern gamagrass samples harvested at Big Flats Plant Material Center in 1989 and 1990 (average " standard deviation).

DM	CP	Sol	Deg	
%	% dry matter	----- % CP -----		
26 ± 9	13 ± 4	27 ± 9	61 ± 14	
NDF	**ADF**	**NSC**	**TDN**	**NEL**
	----- % dry matter ------			Mcal/lb.
70 ± 15	36 ± 8	7 ± 4	64 ± 13	0.55 ± 0.12
Ca	**P**	**Mg**	**K**	**S**
		----- % dry matter -----		
0.29 ± 0.11	0.22 ± 0.88	0.20 ± 0.06	1.76 ± 0.62	0.34 ± 0.12

Na	Fe	Zn	Cu	Mn	Mo
% dry matter			----- PPM -----		
0.008 ± 0.005	151 ± 85	29 ± 9	9 ± 2	82 ± 36	0.7 ± 0.3

Selective Grazing

Selective grazing is the ability of livestock to harvest higher quality forage from a pasture tan the average quality of the forage in the pasture. In the intensively sampled pastures, selective grazing was apparent. However, selective grazing did not substitute for losses in pasture quality due to "poor" management. As pasture quality decreased, the quality of forage removed also decreased.

The effects of selective grazing were correlated to pasture quality (Table 20). There was a strong trend for forage utilization to affect the quality of the forage removed. This effect was highly significant in 1989 but significant only at the 10% level when data was pooled over two years. The quality of the pre-graded pasture accounted for 84% to 97% of the variability in chemical analysis of the apparent forage intake DMI (Table 20). The effect of selective grazing appeared to increase when the utilization was less than 50%.

Figure 3. Selective grazing enabled cattle to remove forage containing levels of crude protein (CP) higher than what was measured in the pasture before grazing.

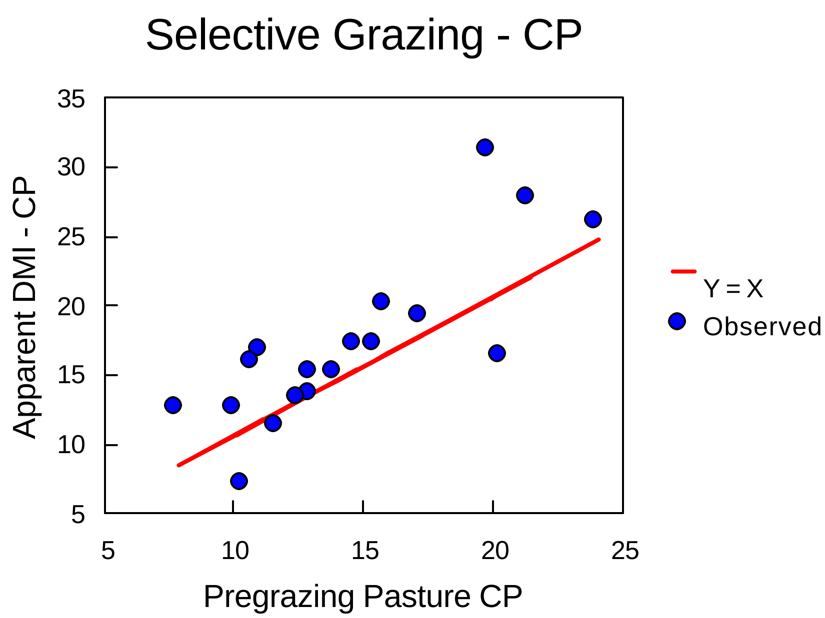


Figure 4. Selective grazing enabled cattle to remove forage containing levels of neutral detergent fiber (NDF) lower than what was measured in the pasture before grazing.

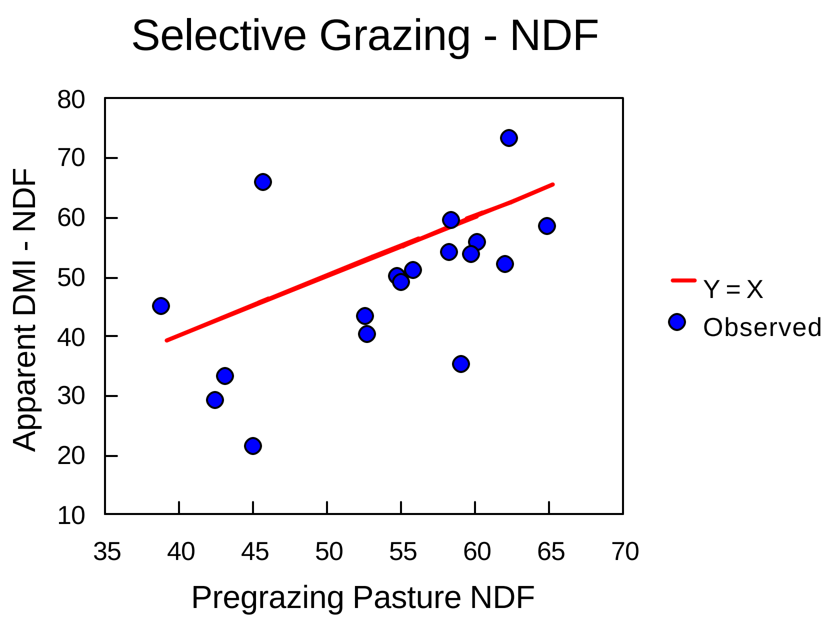


Figure 5. Selective grazing enabled cattle to remove forage containing levels of acid detergent fiber (ADF) lower than what was measured in the pasture before grazing.

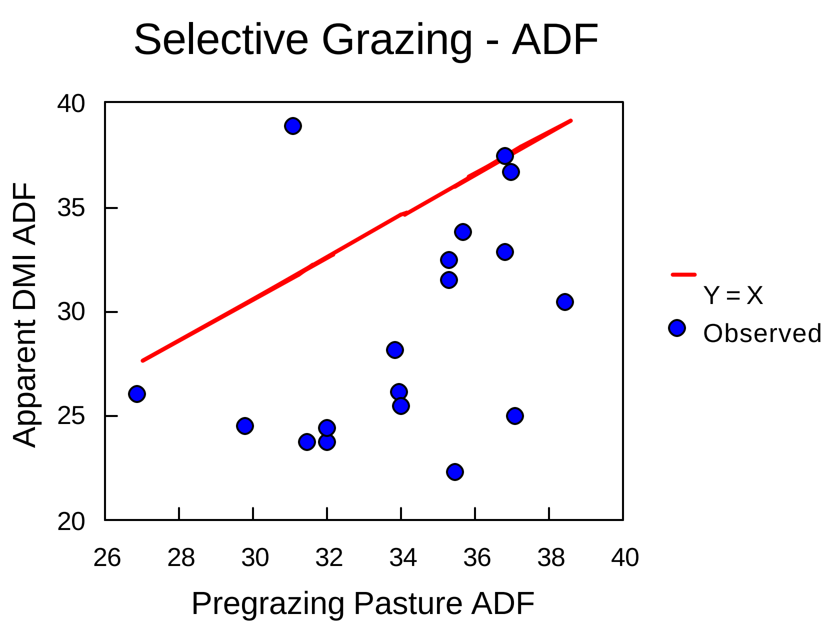


Figure 6. Selective grazing enabled cattle to remove forage containing levels of net energy lactation (NEL) higher than what was measured in the pasture before grazing.

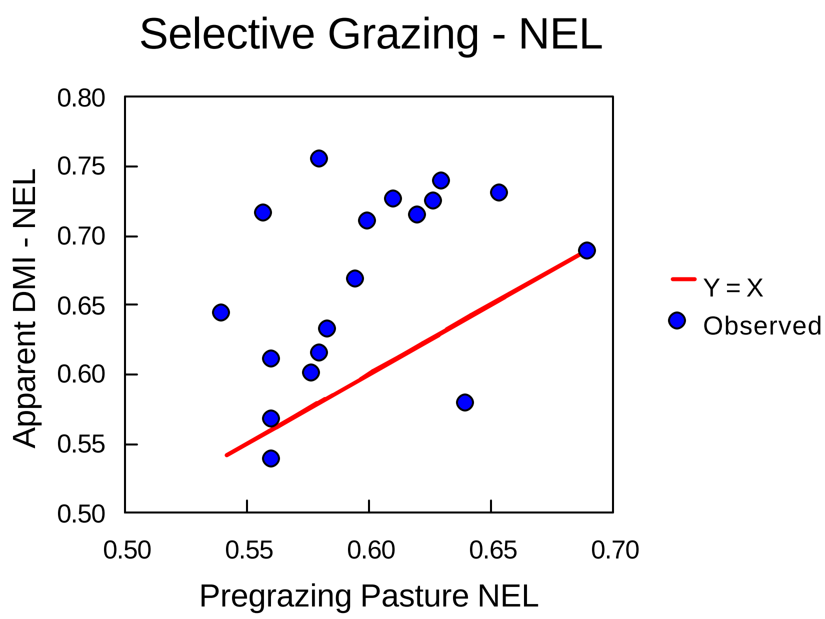


Table 20. Crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), and net energy lactation (NEL) contained in the dry matter removed from the pasture during grazing (g) were correlated to their content in the pre-grazing (pg) pasture canopy.

Regression equation	Sy.x	R^2
CPg = 1.23 CPpg	2.8	0.97
NDFg = 0.79 NDFpg	20.8	0.84
ADFg = 0.79 ADFpg	9.1	0.91
NELg = 1.18 NELpg	0.14	0.97

Apparent Forage Intake

The method used for measuring forage removal from the pasture during grazing is referred to as "apparent forage intake." This is because all loss of forage from the plant canopy is attributed to grazing animal intake. Additional losses may be due to treading, grazing by other animals such as deer or insects, and sample bias or error. Apparent forage intake by this method, when using short periods of stay, gave estimates of forage intake within 2 pound of that predicted by equations for heifers and dairy cows at two locations. However, on one farm where there was considerable sod punching in the spring, apparent forage intake was biased upward. The double sampling technique used in this study provided a good estimate of apparent forage intake when samples were harvested to ground level; grazing stays were limited to 1 to 3 days; sample areas had relatively smooth surfaces; and when the area had been clipped and raked after the previous grazing event.

CONCLUSION

The quality of forage produced under intensive rotational grazing is considerably higher than when comparable forage types are harvested and stored. Forage from these pastures was comparable to corn silage in energy and contained over twice the protein. The concentration of minerals was adequate for many classes of livestock but for high producing dairy cattle proper mineral supplementation programs should be used to ensure adequate intake for optimum milk production.

The legume content of the pasture has the most effect on pasture forage quality. Management practices such as grazing management, liming, and fertilization which increase legume content, will decrease NDF content with a resulting increase in pasture DMI, a decreased grain requirement, and an increase in forage CP, Ca, and Mg content.

Proper pasture management also involves providing adequate forage availability so the cow can consume large quantities of pasture DM. When pre-grazing forage mass is less than 1,000 lb. DM/a the dairy cow cannot consume adequate levels of pasture DM for milk production and ample barn feeding must be used to maintain production. If milk production is to be maintained with low rates of grain feeding pre-grazing forage mass needs to be from 1,500 to 2,000 lb. DM/a and contain 25% to 35% legume.

A post-grazing forage mass of 800 to 900 lb. DM/a will allow near maximum pasture DMI. However, when grazing at this level, cattle may not want to consume supplemental feed in the barn. How close you can make your cattle graze depends on the legume content of the stand, the thatch build up in the stubble, the level of milk production, the level of barn feeding, the body condition of the cattle, and the training of the cattle. Experience watching the cows, the stubble, and the bulk tank will teach the dairyman how close to make the cattle graze.

Supplemental feeding of dairy cattle on pastures should be based on sound feeding principles. Pastures are high in degradable protein and low in NSC. The basis of the feeding program should start with a grain low in protein and high in available carbohydrates. Such a grain will provide carbohydrates to the rumen bacteria that can then use more of the forage's degradable protein. Rolled shell corn, steam flaked corn, and corn meal provides such a basal feed. An additional advantage of rolled shell corn and corn meal is that the grain protein is not highly degraded in the rumen.

Caution must be taken not to overfeed grain since the ADF content of pasture forage is relatively low and its digestibility high. Feeding levels of ground shell corn over 1.5% to 1.7% of the cow's body weight can result in the depression of milk butterfat test due to excess carbohydrates reducing rumen pH. Other grains which have highly digestible fiber content such as ground ear corn, soybean hulls, and brewers grain appear to be useful when energy requirements indicate the need for higher grain feeding levels.

Dairy producers should develop their own pasture-sampling program to determine the variation of pasture quality on their own farm. Such a sampling program should be based on proper sampling methods if meaningful results are to be achieved. By combining on-farm forage quality with a good ration-balancing program, effective use of intensive rotationally grazed pastures can be achieved.

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Appendix 1

Sampling Pastures for The Northeast Dairy Farm Forage Demonstration Project – 1990

Ed Rayburn
WVU Extension Service Forage Agronomist

With the increased use of intensive rotationally grazed pastures there is a need for standardized pasture sampling methods. The method described her was developed for use by the participants in The Northeast Dairy Farm Forage Demonstration Project. The samples collected in this project will be used to develop a database of pasture quality over the Northeast and to calibrate near infrared (NIR) analysis of fresh forage samples. To have a meaningful database it is necessary that all samples be taken the same way. This sampling method has proven to be practical in both field and laboratory.

Field Sampling

Obtaining an accurate forage test starts in the field. Forage samples for lab analysis should be taken shortly before the cattle are turned into a pasture. Walk over the field and collect 30 to 50 small grab samples. The grab sample is taken by reaching down and grabbing a small section of forage between the thumb and first finger. Remove the forage at the same height that the cattle will graze the pasture. Samples need to represent what the cattle will be eating. Each grab sample should be taken at random from the forages that will be eaten by the livestock. Don't select weeds such as thistle or buttercup that will be refused. Don't bias your sample by taking a greater percentage of clover (or grass) than is in the pasture. You should take 30 to 50 grab samples over a pasture. This is necessary to get an accurate estimate of the average forage in the field. If there are decidedly different forage associations in the pasture divide your sample proportionately between the forage types by plan or by walking the field in a uniform grid. An example of such a situation would be a field having a flat and a sloping section, where there is a greater percentage of clover on the flat.

To properly identify the samples, some descriptive information is needed. Identify the three most abundant forage species in the composited forage sample. Look at both the grass, legume, and forb (broadleaf weed) components. Measure the bulk height of the forage growth using the Plexiglas pasture plate and yardstick as discussed in "The Seneca Trail Pasture Plate for Estimating Forage Yield." This will provide an estimate of how much forage dry matter is available per acre at the start of grazing.

Sample Preparation

Once the sample is collected place it in a plastic bag, remove an excess air, close the bag tight, and freeze it as soon as possible. The freezing is necessary to prevent the natural plant proteins from breaking down to more soluble forms of proteins.

Table 1. Identification codes of forage species listed in the Northeast Dairy Farm Forage Demonstration Project pasture database.

Forage type	Common name	code
Legumes	alfalfa	alf
	white clover	wcl
	ladino clover	lcl
	red clover	rcl
	alsike clover	acl
	birdsfoot trefoil	bft
	vetch	vtc
	hop clover	hcl
	black medic	Bmd
Grasses	timothy	tim
	orchardgrass	og
	bromegrass	brg
	bluegrass	blg
	quackgrass	okg
	bentgrass	btg
	redtop	rt
	seet vernal grass	svg
	poverty oat grass	pog
	browse	brw
Broadleaf weeds	dandelions	dd
	golden rods	gr
	plantains	pl

Forage Sample Information Sheet

The "Forage Sample Information Sheet" has been partially filled out. Seneca Trail RC&D's address and the account being billed have been entered. Also the analyses that will be performed on the sample have been checked.

The sample collector needs to enter name and return address for receiving the lab report. Those coordinating sampling in an area should place their name and address in the bottom box to get a copy of the lab report.

Next check that the sample is a fresh sample and if it represents "legume" (greater than 85% legume), "mixed mostly legume" (between 50 and 85% legume), "mixed mostly grass" (between 15 and 50% legume), or "grass" (less than 15% legume).

In the comment section, list the codes of the three most prominent forage species in the sample being submitted. These are listed in the comments section as "s1=," "s2=," and "s3=" respectively. Codes for forages currently in the database are listed in Table 1. If you collect a species that has no code, assign it a two to three letter code and notify this office of the species and the newly assigned code. Enter in the average bulk height of the pasture as measured with the pasture plate in the space market "BH-." Enter the days of regrowth since last grazing in the space marked "DR=."

Sample Pick Up

The sample collector needs to transport the frozen pasture sample to their DHI pick up point and place the sample in the refrigerator. Contact your DHI supervisor to coordinate access to the refrigerator and to find out local pick up days. The DHI truck will transport the refrigerated sample to the lab in Ithaca for analysis.

Appendix 2

Plexiglas plate for estimating pasture yield in cooperative research demonstrations.

Ed Rayburn
WVU Extension Service Forage Agronomist

Background

In pasture research and management it is helpful to have reliable estimates of forage standing crop. Research has shown that there is a high correlation between forage height and dry matter yield (1. 2. 3. 4). In some forage types the correlation is improved when bulk height is determined by depressing the forage with a weighted plate (2). This weight plate technique, often referred to as a weighted disk meter, appears to improve the estimate of pasture yield.

Weighted disk meters reported in the research literature are generally made from a disk of sheet metal and an etched metal measuring rod. Researchers have used modifications of this design to establish the effect of size and area weight on the performance of these disk meters (1).

Seneca Trail Resource Conservation and Development Area is southwestern New York has had a program of teaching the use of intensive rotational grazing to dairy, beef, and sheep producers. In looking for a means of determining pasture yield the weighted-disk meter was turned to as a research-proven tool. Upon pricing the normally described disk meter it was found to be too expensive to make individually and there was no known available source of manufactured meters. There was the need for an alternative construction that would accomplish the same results.

Material

The material needed for a practical pasture plate has to meet the following requirements: it must be readily available in standard stock across the region, it must be stable in weight per unit area when exposed to moisture in the air and on the forage, and it must be relatively inexpensive.

It has been established that materials other than sheet metal can be used to determine forage bulk height and estimate forage yield (3). The use of plywood was discounted because it would not have a stable weight when exposed to varying moisture conditions. Acrylic plastic sheeting meets all three requirements. This material is available from local glass distributors, will not absorb water from the air or forage, and is inexpensive.

A square of acrylic plastic measuring 0.25 inches thick and 18 inches square was chosen. This thickness of material had a weight per area (1.47 lbs./sq. ft) which results in good prediction of dry matter yield (1). The 18-inch size was chosen since it is a practical size for carrying in the field and is inexpensive. Larger plates may slightly improve yield predictions (1). However, large plates can be impractical for common field use and would double or triple the price. The 1991 cost of the 18 inch plate in rural New York is about $12. When used with a yardstick which may cost $1.50, this results in a very inexpensive and serviceable weight plate for estimating forage yields.

Construction

The pasture plate used in the Seneca Trail RC&D Area pasture program is made of 0.25 inch "Plexiglas" or "Acrylite" acrylic plastic sheet cut in 18-inch squares. A 1.5-inch hole is cut in the center of this plate to allow the insertion of a yardstick for measuring the forage bulk height when the plate is set on the sward. The edges of the center hole need to be smoothed with a wood rasp to prevent rough edges from catching on the yardstick.

In addition 24, 0.125-inch holes may be drilled along five lines set at 3-inch intervals, starting 3 inches from the plate's edge. Holes are spaced at 3-inch intervals along these lines, again starting 3 inches from the edge. This results in 24 holes (the 25th hole ends up being in the yardstick hole). These holes can be used for estimating the ground covered in thin stands and in grazed stubble.

The yardstick should be connected to the plate so that they can be carried as one unit. One way is to tie a string through two of the small holes in the plate and through a hole in the top of the yardstick. The string is made long enough so that it is lose when the plate is on the forage canopy but short enough so that the end of the yardstick does not come out of the hole when it is picked up. A second method is to drill a hole at the bottom of the yardstick and attach a long thin bolt that prevents the plate from falling off the end of the yardstick. By picking up the yardstick the plate is picked up when the bolt reaches the plate.

Use

Use of the pasture plate is accomplished by walking the pasture area, selecting a location and placing the plate gently on the forage until it supports the plate. Placing the plate on the forage is more satisfactory than dropping the plate from a standard height. If dropping the plate, you must measure the drop height each time, the effective drop will change with stand height, and dropping the plate is not practical on hills on windy days. Measure the forage bulk height by placing a yardstick through the center hole and measure the height of the plate's top above the ground.

To achieve a good estimate of forage yield in a pasture you must measure enough points over the pasture. The number of samples does not greatly affect the correlation coefficient of forage bulk height to forage dry matter yield (1). However, the reliability of estimating the true mean pasture bulk height increases as the number of samples increases from 20 to 30 samples, with little improvement as sample size increases to 50 samples per pasture (1). Our recommendation is to take at least 30 and preferably 50 bulk height measurements per paddock to have a large enough sample to give reliable results.

When selecting the sample locations do not bias the average by choosing more productive areas over less productive areas. Walk the pasture to get as uniform a sample over the paddock as possible. When you reach the general area you want to measure, take the sample point at random. Of course if the point has stems from an old seed heads or weeds that will bias the plate height, move the plate to one side to miss the obstruction. When used in well-managed, rotationally grazed and clipped pastures this will not be a major problem.

Calibration

Calibration equations for the pasture plate may vary due to species, season and location. For our calibration sampling we use a square wire frame that just fits over the pasture plate. The frame is set over the sample site and the plate removed. The forage is then separated so that the frame lies on the ground. This results in the forage from plants rooted in the ground inside the frame being inside the frame. The forage is cut as close to ground level as possible with 4-inch battery powered lawn edgers (Disston or Black and Decker). The forage is weighted wet in the field using lightweight spring scales and composited for dry matter determination. Regression equations are calculated from the resulting measured bulk height and dry matter yield.

Testing

The pasture plate has been used extensively in pasture sampling from 1986 through 1990 on cool-season grass-legume pastures managed under intensive rotational grazing. These pastures consisted of orchardgrass, timothy, quackgrass, bluegrass, ryegrass, white clover, and red clover stands. The calibration equation for estimating dry matter yield (DMY) from forage bulk height measured by the pasture plate under average conditions was found to be:

DMY lb./a = 432 BH (inches).

The standard error of the Y estimate is relatively small for a sample size of 42 (Table 4). The standard error of the X coefficient is 2 to 8 percent of the slope value that is lower than those reported in the research literature (1). When the regression is force through the origin the standard error or the Y estimate is not increased significantly and the standard error of the X coefficient is improved. Since the logical model is through the origin and there is basically an improvement in prediction, this model may be the best choice.

Farmers have used this pasture plate over the Northeast as part of the sampling method used in the Northeast Dairy Farm Forage Demonstration Project and it was found very functional. More testing is needed to evaluate the variation in equations due to differences in forage type, season, and management conditions. This plate is as reliable as the more sophisticated metal weight disk meters and provides a practical, low cost means of extending research recommendations to farmers.

Drawings : Plexiglas weight plat for estimating pasture yield.

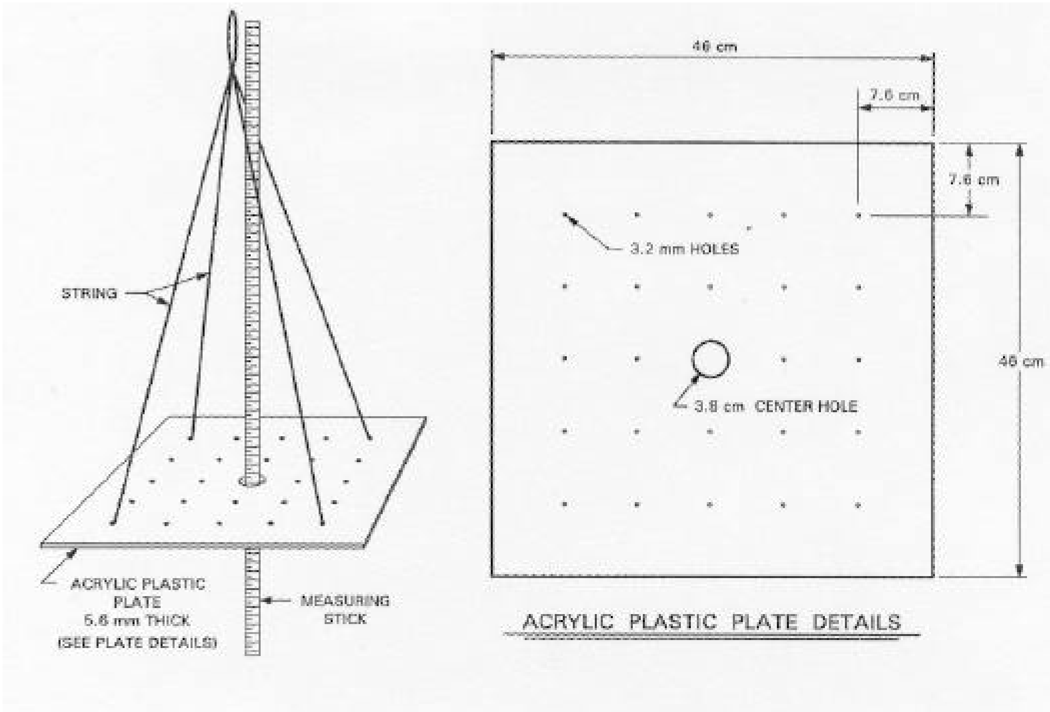


Table 1. Regression of pasture forage bulk height and sample dry matter yield from cool-season, grass-legume pasture in New York.

X coefficient	386	432
Y constant	230	0
R squared	0.78	0.77
No. of observations	42	42
Std error of Y est.	317	322
Std error of X coef.	32	10

[1] 2 Park Square, Franklinville, NY 14737. Published as part of the Northeast Dairy Farm Forage Demonstration Project, funded by the USDA National Research and Extension Program on Low Input Sustainable Agriculture – Northeast Region.

Appendix 3

Forage analysis methods used at the Northeast DHIA Forage Testing Laboratory

Northeast DHIA Forage Lab Analytical Procedures

1/28/91

Method used depends on sample type and/or customer preference.

I. Dry Matter
   A. 135C for 2 hours – AOAC method 7.007.
   B. 60C for 12 hours.
   C. Scanned by Near Infrared Reflectance Spectrophotometer (NIRS).

II. Crude Protein
   A. Kjeldahl Procedure – Very similar to AOAC method #7.033. The main difference is the catalyst. We use between 10.00 – 11.0g of a K_2SO_4, Cu_2S0_4 salt mix. The ratio of the salt is 10g K_2SO_4 to .3g Cu_2So_4. (Any sample over 25% C.P. on a D.M. basis is tested by Kjeldahl.

   B. Tecator Kheltec Auto Analyzer 1030 – essentially the same as the Kjeldahl procedure with automated distillation and titration.
   C. LECO FP 428 Nitrogen Determinator microprocessor-based, software-controlled instrument that determines nitrogen through thermal conductivity (AOAC Interim First Action Approval).
   D. NIRS – may be sued for fresh, fermented or dry grass, grass-legume combinations, legume and corn forages.

III. Unavailable Protein
   A. Acid Detergent Fiber – Nitrogen (ADF-N) – ADF residue is subjected to Kjeldahl, or LECO analysis to determine the protein fraction bound to the ADF.
   B. NIRS – ADF-N fraction may be determined for fermented grass, grass-legume combination or legume forage types.

IV. Soluble Protein: Borate – Phosphate Buffer Procedure

V. Fiber
   A. Acid Detergent Fiber (ADF) – similar to AOAC method 7.074. Main difference is that samples are filtered through Whatman 541 filter paper in a two-piece Buchner funnel instead of a fritted glass crucible.
   B. Neutral Detergent Fiber (NDF) – latest Van Soest procedure using heat stable amylase (Sigma #A0164).
   C. NIRS – ADF and NDF as in crude protein NIRS.

VI. Minerals

A. Inductively Coupled Plasma Spectroscopy (ICP) – samples are ashed @ 500C for 4 hours. Three ml of 1:1HCI are added to the ash residue and evaporated to dryness. Minerals extracted with acid solution (1.5N HNO_3 + .5N HCI) and determined by ICP.

B. NIRS – Ca, P. Mg. K as in crude protein NIRS.

VII. Sulfer – LECO Sulfer Determination Model #SC-132.

VIII. FAT – ether extraction using Tecator SOXTEC HT-6 apparatus.

Northeast DHIA Energy Calculations*

Lactating Dairy Cattle

Legume

$NE_1 = 1.044 – (.0123 X ADF\%)$

$TDN = 29.8 + (53.1 X NE_1)$

Mixed

$NE_1 = 1.044 – (.0131 X ADF\%)$

$TDN = 32.4 + (53.1 X NE_1)$

Grass

$NE_1 = 1.085 – (.0150 X ADF\%)$

$TDN = 31.4 + (53.1 X NE_1)$

Corn Silage

$NE_1 = .94 – (.008 X ADF\%)$

$TDN = 31.4 + (53.1 X NE_1)$

Total Mixed Ration

$NE_1 = 0.866 – (.007 X ADF\%)$

$TDN = 95.88 + (.9111 X ADF\%)$

Shelled Corn

$NE_1 = .94 – (.008 X ADF\%)$

$TDN = 92.22 - (1.535 X ADF\%)$

Ear Corn

$NE_1 = .94 – (.008 X ADF\%)$

$TDN = 99.72 - (1.927 X ADF\%)$

Grain Mix

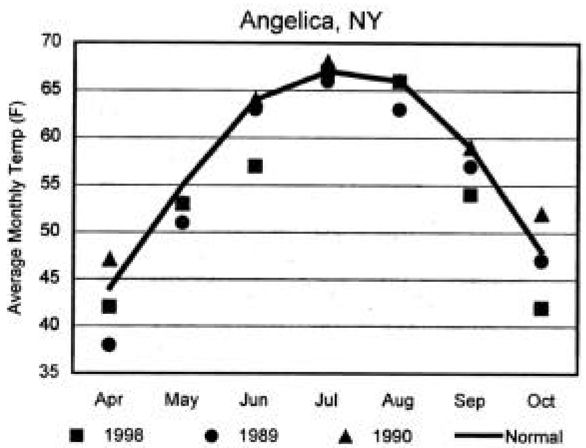
$NE_1 = .454 – \{(.0245 X TDN) – 0.21\}$

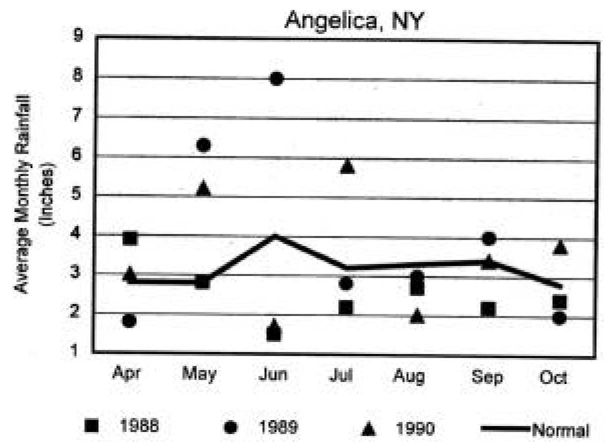
$TDN = 81.41 - (.48 X ADF\%)$

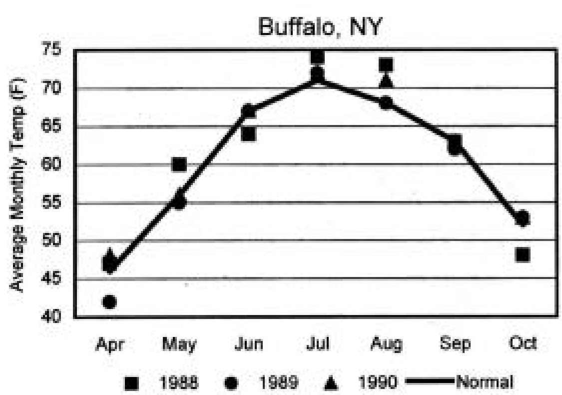
- All figures are expressed on a dry matter basis.
- TDN is expressed as a percentage.
- NE_1 is expressed in Mcal/lb..

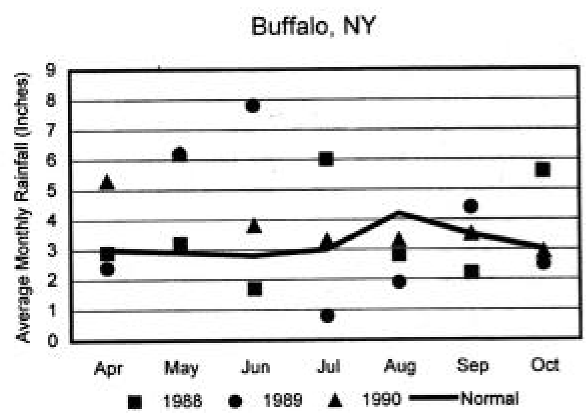
Appendix 4

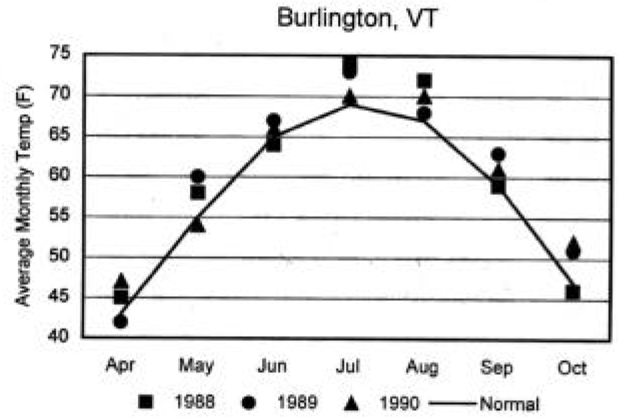
Temperature and rainfall at selected Northeast weather stations
during the growing seasons of 1988, 1989, and 1990

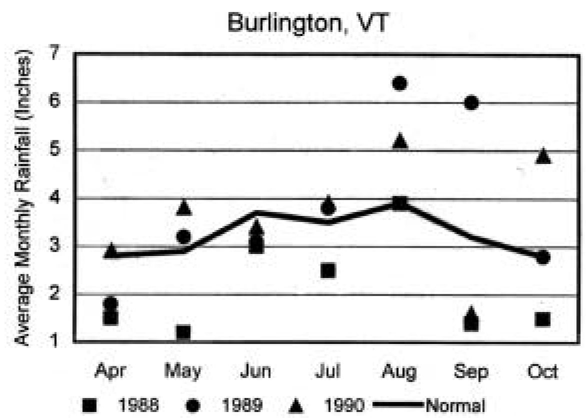


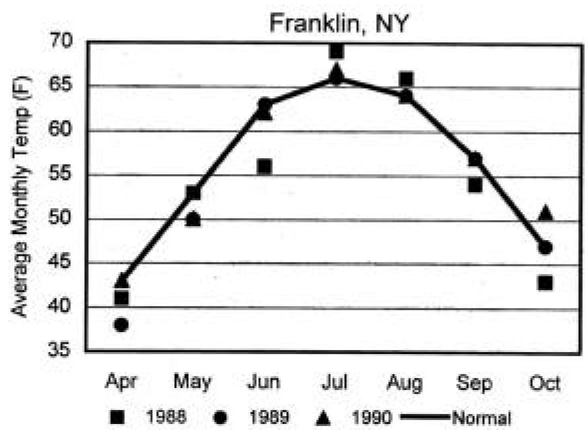


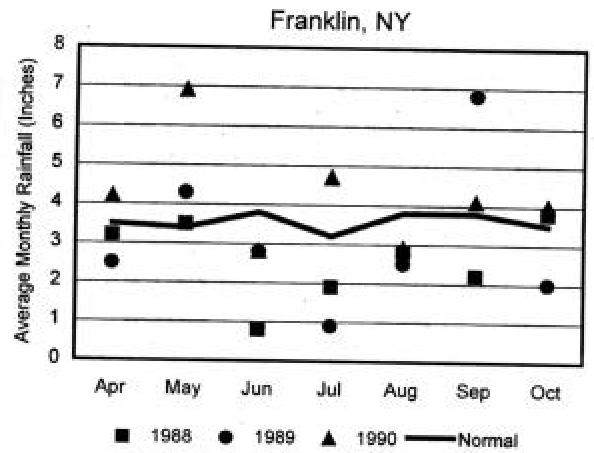


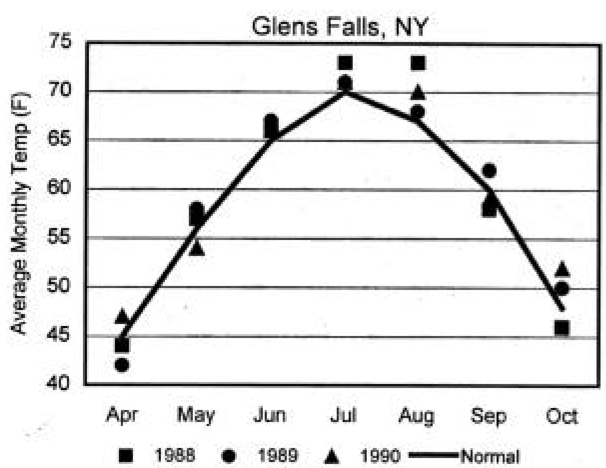


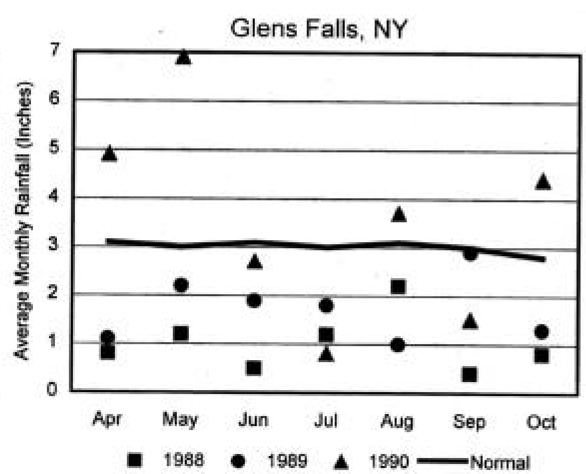

Burlington, VT
Average Monthly Temp (F)
75
70
65
60
55
50
45
40
Apr
May
Jun
Jul
Aug
Sep
Oct
1988
1989
1990
Normal


Burlington, VT
Average Monthly Rainfall (Inches)
7
6
5
4
3
2
1
Apr
May
Jun
Jul
Aug
Sep
Oct
1988
1989
1990
Normal


Franklin, NY
Average Monthly Temp (F)
70
65
60
55
50
45
40
35
Apr
May
Jun
Jul
Aug
Sep
Oct
1988
1989
1990
Normal


Franklin, NY
Average Monthly Rainfall (Inches)
8
7
6
5
4
3
2
1
0
Apr
May
Jun
Jul
Aug
Sep
Oct
1988
1989
1990
Normal


Glens Falls, NY
Average Monthly Temp (F)
75
70
65
60
55
50
45
40
Apr
May
Jun
Jul
Aug
Sep
Oct
1988
1989
1990
Normal


Glens Falls, NY
Average Monthly Rainfall (Inches)
7
6
5
4
3
2
1
0
Apr
May
Jun
Jul
Aug
Sep
Oct
1988
1989
1990
Normal

Appendix 5

Practical statistics for farmers

Ed Rayburn
WVU Extension Service Forage Agronomist

Statistics are mathematical tools used to describe the variability observed in systems like weather and biology. Farmers can benefit from knowing the practical meaning of two "statistics." Most people already know one of these so we are halfway to understanding practical farm statistics.

Average

The statistic you know is the "average" or "mean." Everyone has heard of the "average year." Each day's temperature is different, but we combine the temperatures over the month to get an "average" monthly temperature. The average is the sum of all the observations divided by the number of observations. This is a number that indicates that half the total value is below this point and half above. The old farmer's saying is that, "To be average, you are as close to the bottom as you are to the top."

Standard deviation

The second statistic is the standard deviation. The standard deviation tells you how much variation or range there is in the numbers that make the average. One-third of the observations lies between the average and the average plus one standard deviation. Another one-third of the observations lies between the average and the average minus one standard deviation. This results in two- thirds of the numbers (66%) lying in the range of one standard deviation above and below the average. Another way of looking at it is that only 16% of the observations are greater than the average plus one standard deviation, and only 16% of the observations are less than the average minus one standard deviation. So the farmer whose net income is one standard deviation above average is in the top 16% of the farmers for net income.

Regression

Regression is a moving average of one "dependent" variable as one or more "independent" variables change. The variable on the left side of the equals sign is called "dependent" because its value depends on the value of the variables on the right hand side of the equals sign, which are "independent." When using a regression equation, we are calculating the average value of the dependent variable. Predictions using regression equations are only valid when used under the same conditions and within the same range of values as were used to calculate the regression.

Standard deviation about the regression (Sy.x)

The standard deviation about the regression is named "Sy.x" for short. Just as the name implies, it is the standard deviation about the moving average of the dependent variable in the regression equation.

Coefficient of variation (CV)

The coefficient of variation is the ratio of the standard deviation to the average of the observations. A CV of 1 means that the standard deviation is as large as the mean.

Coefficient of determination (R^2)

A third statistic often reported for regressions is the R^2 ("R-squared") value. This value represents the percentage of variation in the dependent variable that is explained by the independent variables. A R^2 of 0.75 means that 75% of the variation in Y is explained by the variation in X.

Appendix 6

Regression models of pasture nutrient quality

Table 1. Regression prediction of variable effects on pre-grazing forage bulk height.

Regression				
	BH + T + M + .089 DRG			
Where T	0.0	When type =	Grass	
	-1.4		Mixed mostly grass	
	0.0		Mixed mostly legume	
	-1.2		Legume	
Where M	5.2	When month =	May	
	6.4		June	
	3.6		July	
	3.2		August	
	2.4		September	
	1.7		October	
R^2 =	0.89	Sy.x= 2.0	CV = 0.37	N = 391

Table 2. Regression analysis of factors accounting for significant variability in observed days regrowth of sampled pastures.

Regression				
	DRG = 76 + T + M			
Where T	5.3	When type =	Grass	
	-5.5		Mixed mostly grass	
	0.0		Mixed mostly legume	
	-0.0		Legume	
Where M	-49	When month =	May	
	-50		June	
	-45		July	
	-42		August	
	-38		September	
	-30		October	
R^2 =	0.72	Sy.x= 10	CV = 0.27	N = 391

Table 3. Regression analysis of factors accounting for significant variability in observed NDF of sampled pastures.

Regression				
	NDF = 35.0 + T + Y + .077 BH			
Where T	12.8	When type =	Grass	
	7.2		Mixed mostly grass	
	0.0		Mixed mostly legume	
	-6.9		Legume	
Where Y	4.0	When year =	1988	
	0.0		1989	
	0.0		1990	
R^2 =	0.72	Sy.x= 10	CV = 0.27	N = 390

Table 4. Regression analysis of factors accounting for significant variability in observed ADF of sampled pastures.

Regression				
	ADF = 21.1 + T + M + .49 BH + 0.055 DRG			
Where T	2.6	When type =	Grass	
	1.9		Mixed mostly grass	
	0.0		Mixed mostly legume	
	0.0		Legume	
Where M	0.0	When month =	May	
	0.0		June	
	0.0		July	
	0.0		August	
	-1.4		September	
	-2.7		October	
R^2 =	0.21	Sy.x= 4.0	CV = 0.15	N = 391
Regression				
	ADF = 9.3 + 0.03 NDF + 0.32 + 0.039 DRG			
R^2 =	0.52	Sy.x= 3.1	CV = 0.12	N = 391

Table 5. Regression analysis of factors accounting for significant variability in observed NSC of sampled pastures.

Regression when type, month, and year allowed in:				
	NSC = 15.1 + T + Y + 0.078 DRG			
Where T	-5.2	When type =	Grass	
	0.0		Mixed mostly grass	
	4.3		Mixed mostly legume	
	8.9		Legume	
Where Y	-2.4	When year =	1988	
	0.0		1989	
	0.0		1990	
R^2 =	0.31	Sy.x= 6.2	CV = 0.36	N = 390
Regression				
	NSC = 43.7 – 0.083 NDF + 0.46 ADF			
R^2 =	0.82	Sy.x= 3.1	CV = 0.18	N = 390

Table 6. Regression analysis of factors accounting for significant variability in observed CP of sampled pastures.

Regression where type, month, and year allowed in:				
	CP = 26.8 + T + M + Y + 0.47 BH - 0.094 DRG			
Where T	0.0	When type =	Grass	
	0.0		Mixed mostly grass	
	1.9		Mixed mostly legume	
	3.0		Legume	
Where M	0.0	When month =	May	
	0.0		June	
	0.0		July	
	0.0		August	
	0.0		September	
	1.9		October	
R^2 =	0.24	Sy.x= 3.8	CV = 0.17	N = 391
Regression when NDF and ADF allowed in:				
	CP = 39.3 + Y – 0.58 ADF – 0.057 DRG			
Where Y =	0.0	When year =	1988	
	0.0		1989	
	1.3		1990	
R^2 =	0.45	Sy.x= 3.2	CV = 0.14	N = 391

Table 7. Regression analysis of factors accounting for significant variability in observed crude protein solubility (SOL) of sampled pastures.

Regression where type, month, and year allowed in:

SOL = 14.7 + T + Y + 0.66 BH - 0.15 DRG

Where T	0.0	When type =	Grass	
	0.0		Mixed mostly grass	
	3.5		Mixed mostly legume	
	4.5		Legume	
Where Y	0.0	When year =	1988	
	0.0		1989	
	6.4		1990	
R^2 =	0.50	Sy.x= 5.4	CV = 0.21	N = 384

Regression when NDF and ADF allowed in:

SOL = 16.3 + M + Y – 0.25 NDF + 0.43 ADF + 0.12 DRG

Where Y =	0.0	When month =	May	
	0.0		June	
	0.0		July	
	0.0		August	
	0.0		September	
	3.0		October	
Where Y =	0.0	When year =	1988	
	0.0		1989	
	5.9		1990	
R^2 =	0.52	Sy.x= 5.3	CV = 0.20	N = 384

Table 8. Regression analysis of factors accounting for significant variability in observed crude protein degradability (DEG) of sampled pastures.

Regression where type, month, and year allowed in:

DEG = 72.9 + Y

Where Y	-2.4	When year =	1988	
	0.0		1989	
	0.0		1990	
R^2 =	0.06	Sy.x= 4.9	CV = 0.07	N = 367

Regression when NDF and ADF allowed in:

DEG = 76.9 + Y – 0.088 NDF

Where Y =	-2.1	When year =	1988	
	0.0		1989	
	1.3		1990	
R^2 =	0.08	Sy.x= 4.8	CV = 0.07	N = 367

Table 9. Regression analysis of factors accounting for significant variability in observed calcium (CA) content of sampled pastures.

Regression where type, month, and year allowed in:				
	Ca + 0.99 + T + Y			
Where T	-0.59	When type =	Grass	
	-0.26		Mixed mostly grass	
	0.00		Mixed mostly legume	
	0.18		Legume	
Where Y	0.08	When year =	1988	
	0.00		1989	
	0.00		1990	
R^2 =	0.52	Sy.x= 0.22	CV = 0.29	N = 389
Regression when NDF and ADF allowed in:				
	Ca = 1.87 + M + Y – 0.24 NDF			
Where M =	0.00	When month =	May	
	0.00		June	
	0.00		July	
	0.00		August	
	-0.08		September	
	-0.16		October	
Where Y =	0.17	When year =	1988	
	0.00		1989	
	0.00		1990	
R^2 =	0.54	Sy.x= .21	CV = 0.28	N = 389

Table 10. Regression analysis of factors accounting for significant variability in observed phosphorus (P) content of sampled pastures.

Regression where type, month, and year allowed in:				
	$P = 0.04 + T + Y - 0.0056\ BH$			
Where T	0.00	When type =	Grass	
	0.00		Mixed mostly grass	
	0.00		Mixed mostly legume	
	-0.06		Legume	
Where Y	0.00	When year =	1988	
	0.00		1989	
	0.05		1990	
R^2 =	0.11	Sy.x= 0.08	CV = 0.20	N = 389
Regression when NDF and ADF allowed in:				
$P = 0.39 + Y - 0.005\ BH$				
Where Y =	0.00	When year =	1988	
	0.00		1989	
	0.05		1990	
R^2 =	0.08	Sy.x= 0.08	CV = 0.20	N = 389

Table 11. Regression analysis of factors accounting for significant variability in observed potassium (K) content of sampled pastures.

Regression where type, month, and year allowed in:				
	$K = 2.76 + T + Y$			
Where T	0.63	When type =	Grass	
	0.00		Mixed mostly grass	
	0.00		Mixed mostly legume	
	0.00		Legume	
Where Y	0.00	When year =	1988	
	0.00		1989	
	0.34		1990	
R^2 =	0.19	Sy.x= 0.71	CV = 0.24	N = 389
Regression when NDF and ADF allowed in:				
$K = 2.73 + M + Y$				
Where M =	0.00	When month =	May	
	0.00		June	
	0.00		July	
	0.00		August	
	0.26		September	
	0.46		October	
Where Y =	0.00	When year =	1988	
	0.00		1989	
	0.48		1990	
R^2 =	0.14	Sy.x= 0.73	CV = 0.24	N = 389

Table 12. Regression analysis of factors accounting for significant variability in observed magnesium (Mg) content of sampled pastures.

Regression where type, month, and year allowed in:				
	$Mg = 0.27 + T + Y + M$			
Where T	-0.05	When type =	Grass	
	-0.03		Mixed mostly grass	
	0.00		Mixed mostly legume	
	0.00		Legume	
Where M =	0.00	When month =	May	
	0.00		June	
	0.00		July	
	0.03		August	
	0.00		September	
	0.00		October	
Where Y	0.03	When year =	1988	
	0.00		1989	
	0.00		1990	
R^2 =	0.23	Sy.x= 0.05	CV = 0.19	N = 389
Regression when NDF and ADF allowed in:				
	$Mg = 0.34 + M + Y - 0.0021\ NDF$			
Where M =	0.00	When month =	May	
	0.00		June	
	0.00		July	
	0.00		August	
	0.00		September	
	-0.03		October	
Where Y =	0.04	When year =	1988	
	0.00		1989	
	0.00		1990	
R^2 =	0.29	Sy.x= 0.05	CV = 0.19	N = 389

Table 13. Regression analysis of factors accounting for significant variability in observed calcium (Ca) to phosphorus (P) ratio (Ca:P) of sampled pastures.

Regression where type, month, and year allowed in:				
	Ca:P = 2.70 + T + Y – 0.0056 BH			
Where T	-1.70	When type =	Grass	
	-0.86		Mixed mostly grass	
	0.00		Mixed mostly legume	
	0.83		Legume	
Where Y	0.41	When year =	1988	
	0.00		1989	
	0.00		1990	
R^2 =	0.47	Sy.x= 0.77	CV = 0.37	N = 389
Regression when NDF and ADF allowed in:				
	Ca:P = 4.12 + Y – 0.087 NDF + 0.059 ADF			
Where Y =	0.89	When year =	1988	
	0.39		1989	
	0.00		1990	
R^2 =	0.44	Sy.x= 0.80	CV = 0.38	N = 389

Table 14. Regression analysis of factors accounting for significant variability in observed potassium to calcium plus magnesium ratio (K:(Ca+Mg)) of sampled pastures.

Regression where type, month, and year allowed in:				
	K:(Ca+Mg) = 2.12 + T + Y			
Where T	3.38	When type =	Grass	
	0.60		Mixed mostly grass	
	0.00		Mixed mostly legume	
	0.00		Legume	
Where Y	0.00	When year =	1988	
	0.00		1989	
	0.67		1990	
R^2 =	0.54	Sy.x= 1.24	CV = 0.37	N = 389
Regression when NDF and ADF allowed in:				
	K:(Ca+Mg) = M + Y + 0.123 NDF – 0.123 ADF + 0.022 DRG			
Where M =	0.00	When month =	May	
	0.00		June	
	0.00		July	
	0.00		August	
	0.66		September	
	0.84		October	
Where Y =	-0.96	When year =	1988	
	0.00		1989	
	0.83		1990	
R^2 =	0.87	Sy.x= 1.39	CV = 0.41	N = 389

Table 15. Regression analysis of factors accounting for significant variability in observed copper (Cu) content of sampled pastures.

Regression where type, month, and year allowed in:				
	$Cu = 11.4 + T + Y - 0.046\ DRG$			
Where T	-0.9	When type =	Grass	
	0.0		Mixed mostly grass	
	0.0		Mixed mostly legume	
	0.0		Legume	
Where Y	0.7	When year =	1988	
	0.0		1989	
	0.0		1990	
R^2 =	0.19	Sy.x= 2.2	CV = 0.22	N = 389
Regression when NDF and ADF allowed in:				
$Cu = 11.5 + Y - 0.056\ DRG$				
Where Y =	0.9	When year =	1988	
	0.0		1989	
	0.0		1990	
R^2 =	0.17	Sy.x= 2.2	CV = 0.22	N = 389

Table 16. Regression analysis of factors accounting for significant variability in observed iron (Fe) content of sampled pastures.

Regression where type, month, and year allowed in:				
	$Fe = 255 + T + Y - 1.6\ DRG$			
Where T	-66.0	When type =	Grass	
	0.0		Mixed mostly grass	
	0.0		Mixed mostly legume	
	0.0		Legume	
Where Y	0	When year =	1988	
	0		1989	
	60		1990	
R^2 =	0.09	Sy.x= 133	CV = 0.67	N = 388
Regression when NDF and ADF allowed in:				
$Fe = 267 - 1.9\ DRG$				
R^2 =	0.04	Sy.x = 137	CV = 0.68	N = 388

Table 17. Regression analysis of factors accounting for significant variability in observed manganese (Mn) content of sampled pastures.

Regression where type, month, and year allowed in:				
	Mn = 65 + Y			
Where Y	43	When year =	1988	
	0		1989	
	0		1990	
R^2 =	0.09	Sy.x= 66	CV = 0.80	N = 389
Regression when NDF and ADF allowed in:				
	Mn = -33 + Y + 4.7 ADF – 4.9 BH			
Where Y =	38	When year =	1988	
	0		1989	
	0		1990	
R^2 =	0.18	Sy.x= 63	CV = 0.76	N = 389

Table 18. Regression analysis of factors accounting for significant variability in observed molybdenum (Mo) content of sampled pastures.

Regression where type, month, and year allowed in:				
	Mo = 2.4 + T + Y – 0.021 DRG			
Where T	0.00	When type =	Grass	
	0.56		Mixed mostly grass	
	1.11		Mixed mostly legume	
	0.00		Legume	
Where Y	0.00	When year =	1988	
	0.00		1989	
	0.67		1990	
R^2 =	0.19	Sy.x= 2.2	CV = 0.22	N = 389
Regression when NDF and ADF allowed in:				
	Mo = 4.1 + Y – 0.028 DRG – 0.020 NDF			
Where Y =	0.00	When year =	1988	
	0.00		1989	
	0.53		1990	
R^2 =	0.13	Sy.x= 1.2	CV = 0.53	N = 389

Table 19. Regression analysis of factors accounting for significant variability in observed sodium (Na) content of sampled pastures.

Regression where type, month, and year allowed in:				
	$Na = 0.0067 + T + Y - 0.0056\ BH$			
Where T	0.000	When type =	Grass	
	0.030		Mixed mostly grass	
	0.022		Mixed mostly legume	
	0.000		Legume	
Where Y	0.014	When year =	1988	
	0.000		1989	
	0.000		1990	
R^2 =	0.16	Sy.x= 0.039	CV = 1.20	N = 389
Regression when NDF and ADF allowed in:				
	$Na = 0.039 + Y - 0.00043\ DRG$			
Where Y =	0.021	When year =	1988	
	0.000		1989	
	0.000		1990	
R^2 =	0.09	Sy.x= 0.01	CV = 1.24	N = 389

Table 20. Regression analysis of factors accounting for significant variability in observed zinc (Zn) content of sampled pastures.

Regression where type, month, and year allowed in:				
	$Zn = 36 + Y - 0.22\ DRG$			
Where Y	8.3	When year =	1988	
	0.0		1989	
	0.0		1990	
R^2 =	0.32	Sy.x= 8.1	CV = 0.25	N = 389

Appendix 7

Pasture and Livestock Notes

Forage quality – Fiber

Forage quality – Protein

Forage quality – Minerals

Forage quality – Forage availability

Principles of pasture management

Grazing systems

Pasture, part of a 12-month forage program

Number and size of paddocks in a grazing system

Pasture Quality – Fiber

Ed Rayburn
WVU Extension Service Forage Agronomist

Forage from intensive rotationally grazed pasture is low in fiber and highly digestible. There are two types of fiber measured in forages. Each has its own effect on the animal's production.

Neutral Detergent Fiber (NDF) – One type of fiber in "neutral detergent fiber" or NDF. NDF is a laboratory estimate of the forage's cell wall content. Some of this fiber is highly digestible. NDF is the best indicator of how much forage an animal will eat. A high producing dairy cow in early lactation can eat about 1.1% of her body weight in NDF. As an example, if a grass forage has 50% NDF, a 1,300 cow is able to eat about 29 pounds of forage dry matter ((1,300 X 0.011)/0.50 = 28.6). The cow would be able to eat about 36 pounds of dry matter of a mixed mostly grass forage containing 40% NDF ((1,300 X 0.011)/0.40 = 35.75). Thus a cow can eat more of a forage low in NDF than one high in NDF.

As most farmers know, livestock eat more of a legume hay than a grass hay. This is because legumes are lower in NDF than grasses. In addition cattle will eat about 10% more NDF if the NDF is from a legume than if the NDF is from a grass. This results in 5 to 7 pounds more milk from a legume-based ration versus a grass-based ration balanced the same for fiber, protein, and minerals. Table 1 shows the NDF content of forage sampled from different types of pastures in the Northeast. Note that pastures having more legumes in them are lower in NDF. Animals grazing these lower NDF pastures are able to eat more forage and will produce more milk or grow faster than animals grazing straight grass pastures.

Table 1. The range in neutral detergent fiber (NDF), acid detergent fiber (ADF), and Net Energy Lactation (NEL) content of rotationally grazed pastures in the Northeast (average " standard deviation).

Pasture type	NDF	ADF	NEL
	%	%	Mcal/lb.
Grass	53 ± 10	28 ± 4	0.67 ± 0.08
Mixed mostly grass	48 ± 10	27 ± 4	0.69 ± 0.08
Mixed mostly legume	44 ± 10	28 ± 4	0.68 ± 0.08
Legume	31 ± 10	23 ± 4	0.76 ± 0.08

There is the chance that animals will bloat when grazing pure legume pastures. Also, pure legume stands are more subject to damage from insects, diseases, weeds, and winter injury than legumes grown with grasses. A good compromise is to try to keep between 25% and 50% legumes in mixed grass-legume pastures to stimulate animal production and prevent bloat.

Acid Detergent Fiber (ADF) – Another type of fiber is "acid detergent fiber" or ADF. Forage ADF is a laboratory estimate of the less digestible cellulose and lignin or "woody fiber in the plant. This fiber is the best indicator of the fiber requirement for healthy rumen fermentation. Total ration ADF should be greater than 19% for a dairy cow. If it is not, milk butterfat test may be depressed. You can see from Table 1 that the ADF content of pastures can be low. This means that if too much grain is fed to cows on pasture there will not be sufficient ADF in the diet to maintain fat test. In barn feeding situations grain in the ration can go up to 60% of the ration dry matter. In a pasture-feeding program, feeding grain levels over 40% of the total dry matter intake may cause butterfat depression.

ADF is also the best indicator of forage digestibility. However, NDF is the best indicator of net energy lactation (NEL) since dry matter intake has a major effect on a forage's NEL content. As the NDF content of the forage decreases, the NEL content increases. Higher forage intake and NEL allows lower grain feeding rates without reducing milk production. Up to 60 pounds of milk per day can be produced by a cow grazing a mixed mostly legume pasture, without supplemental grain, if not more than 50% of the pasture is utilized. When the price of grain per hundredweight is less than the farm value of milk it may be better economics to feed grain and graze the pastures closer. For cows producing over 50 to 60 pounds of milk, moderate grain feeding is usually necessary when the cow is on normal rotationally grazed pasture.

Pastures are low fiber, high quality feed. Be aware of the effects of NDF and ADF on the cow's feed intake and production and how forage type affects the pasture's NDF and ADF content. Good managers can improve milk production or calf and yearling growth from pastures by using this to their advantage.

Pasture Quality – Protein

Ed Rayburn
WVU Extension Service Forage Agronomist

Livestock for growth and for milk production needs protein. Protein is also needed by the rumen bacteria, which digest most of the feed for the cow. Because both the rumen bacteria and the cow need protein, a feeding program should be developed to meet the needs of the animal for crude protein (CP) and for degradable and un-degradable protein.

The feed protein is divided into classes based on how fast it is digested or degraded in the rumen. These classes are termed the soluble, degraded, and un-degraded intake protein factors. Soluble intake protein (SIP) is protein that is rapidly degraded in the rumen. The rumen bacteria need some of this rapidly available protein when their growth rate is high.

Degraded intake protein (DIP) is all the protein that is degraded in the rumen and includes the SIP. If too much DIP is available in the ration, the excess DIP is broken down to ammonia and is lost from the rumen into the blood stream. This results in wasted protein. The excess ammonia is converted to urea and excreted from the body in the urine. This process requires energy and increases the energy requirement of the animal. In extreme cases this can result in lower milk production or loss of animal body condition. Excess DIP can cause decreased feed intake when high levels of ammonia or urea are present in the blood. DIP is less likely to be used wastefully if carbohydrate energy sources are available to the bacteria.

Un-degraded intake protein (UIP) is protein that is not degraded in the rumen. This protein may be digested in the intestinal tract by the cow. The aim of balancing a ration for dairy cows is to ensure that there is enough CP and that the proportion of SIP, DIP, and UIP will meet the needs of the cow and her rumen bacteria.

Pasture managed under intensive rotational grazing is high in protein (Table 1). The CP content of pasture is usually in excess to the needs of the milking cow (Table 2). However, the degradability of this protein is not in balance with the needs of the cow and her rumen bacteria.

The SIP of pasture forage is slightly lower than that recommended for the milking cow. This is not a major problem since the difference is small and the DIP of pasture is greater than the cow's need. The UIP of pasture forage is lower than the cow needs in the ration. Supplemental feeds such as rolled or ground dry shell corn, distillers and brewers grains, heat-treated soybean products, and meat and blood meal products will provide the additional UIP needed by the cow. At moderate levels of milk production, corn is the best supplemental feed because it provides carbohydrates for the rumen bacteria, some UIP, and is low in cost. At high levels of milk production heat-treated soybean products and meat and blood meal products are of value. This is because of the high quality amino acids present in these feeds.

Rotationally grazed pastures are high protein feeds. Be aware of the effects of protein and protein solubility on the animal's production. Good managers can improve milk production and animal growth by providing supplemental feeds to optimize animal production.

Table 1. Crude protein (CP), soluble intake protein (SIP), degraded intake protein (DIP), and un-degraded intake protein (UIP) content of pastures in the Northeast (average ± standard deviation) and supplemental grains used for dairy cattle.

Feed	CP	SIP	DIP	UIP
Pasture	% of DM	------% of CP -----		
Grass	20 ± 4	28 ± 5	72 ± 5	28 ± 5
Mixed mostly grass	22 ± 4	24 ± 5	72 ± 5	28 ± 5
Mixed mostly legume	22 ± 4	30 ± 5	72 ± 5	28 ± 5
Legume	24 ± 4	31 ± 5	72 ± 5	28 ± 5
Supplemental grain				
Dry shell corn	10	12	30	70
High moisture shell corn	10	40	65	35
Cottonseed, whole	24	33	55	45
Distillers grains	28	15	38	62
Roasted whole soybeans	40	17	52	48
Soybean meal	49	20	72	28
Meat meal	51	13	24	76

Table 2. Dry matter intake (DMI), crude protein (CP), soluble intake protein (SIP), degraded intake protein (DIP), and un-degraded intake protein (UIP) content of the ration required by a 1,350 lb., second lactation cow to meet protein requirements at different levels of milk production.

Milk production	DMI	CP	SIP	DIP	UIP
Lb.	Lb./day	----- % -----			
20	31	12	30	62	38
50	40	15	30	64	36
70	46	16	30	64	36
90	55	17	30	65	35
110	58	18	30	65	35

Pasture Quality – Minerals

Ed Rayburn
WVU Extension Service Forage Agronomist

Cattle for skeletal growth, milk production, and the maintenance of body fluids and enzyme systems need minerals. The mineral content of pastures in the Northeast is variable. It is primarily dependent on the forage species present in the pasture (Table 1). Sometimes low soil fertility limits plant growth. Fertilization can improve plant growth and change the mineral levels in the pasture forage. An example is fertilization and liming may increase legume growth. This in turn increases forage production and the calcium content of the forage by increasing the legume content in the forage.

Calcium (Ca) – Animals need Ca for skeletal growth, milk production, nerve impulse transmission, and the maintenance of enzyme systems. The Ca content of pastures increases as the legume content of the stand increases (Table 1). The Ca content of pastures is usually adequate to meet the needs of lactating and growing cattle (Table 2). Some grass pastures may not have sufficient Ca.

Phosphorus (P) – Animals need P for skeletal growth and for energy metabolism. The P content in pasturage is similar in the different pasture types. The P content of pasture is usually adequate for lactating and growing cattle. On pastures testing low in P, fertilization with P may increase plant growth and forage P content.

Magesium (Mg) – Animals need Mg for skeletal growth, milk production, nerve impulse transmission, muscular control, and the maintenance of enzyme systems. The Mg content in pasture forage is higher when there are legumes present in the pasture. The Mg content of pastures can be marginally adequate for dairy cows and a supplementation should be considered. This is especially so on spring grass-pastures fertilized with nitrogen or potassium.

Potassium (K) – Animals need K for milk production, maintenance of body fluids, nerve impulse transmission, muscle contraction, and the maintenance of enzyme systems. The K content in pasture forage differs little between pasture types. The K content of pasture forage will usually meet the needs of the lactating dairy cow as long as the grain supplement is not more than 40 to 50% of total dry matter intake.

Sodium (Na) – Animals need Na for glucose and amino acid transport, maintaining body fluids, and acid-base balance. Pastures contain only 0.029% Na. When salt is not supplemented to dairy cows, NA can be the limiting nutrient in the diet. Adequate salt should be provided to dairy cattle on pasture to ensure that they meet their needs for sodium.

Sulfur (S) - Animals need sulfur for rumen bacterial growth and protein synthesis. The S content in pasture samples averages 0.32% dry matter. The S content is higher in grass than in legume pastures. The S content in pastures in the Northeast is usually adequate. The availability of S to animals is greater when obtained from the forage than when used as a mineral supplement. When S is deficient in the forage, it is best to use S as a fertilizer.

Trace minerals – These are minerals needed in the ration in low concentrations. Trace minerals include iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), cobalt (Co), molybdenum (Mo), selenium (Se), and iodine (I). The forage content of SE and I are usually inadequate in the Northeast. Other minerals such as Zn and Cu are frequently inadequate. These minerals should be provided in a salt-mineral supplement.

The feeding of supplemental minerals is inexpensive. It should be used where pasture mineral content does not ensure optimal animal production. A combination of equal portions of a mineral mix and trace mineral salt may be used. When P is provided as a supplement, use a 2:1 (Ca:P) ratio mineral on grass pastures and a 1:1 mineral on pastures containing legumes.

Table 1. Calcium (Ca), phosphorus (P), magnesium (Mg), and potassium (K) content of pastures in the Northeast (average ± standard deviation).

Pasture type	Ca	P	Mg	K
		------% -----		
Grass	0.43 ± 0.22	0.38 ± 0.08	0.22 ± 0.05	3.38 ± 0.71
Mixed mostly grass	0.75 ± 0.22	0.38 ± 0.08	0.26 ± 0.05	2.76 ± 0.71
Mixed mostly legume	0.99 ± 0.22	0.35 ± 0.08	0.29 ± 0.05	2.65 ± 0.71
Legume	1.21 ± 0.22	0.33 ± 0.08	0.30 ± 0.05	3.07 ± 0.71

Table 2. Recommended mineral content of rations for a 1,350 lb., second lactation cow, grazing pasture that will provide the animal's mineral needs at different levels of milk production.

Milk production	Ca	P	Mg	K	S	Na
Lb.	----- % ration dry matter -----					
20	0.43	0.28	0.30	1.2	0.20	0.18
50	0.53	0.34	0.30	1.2	0.20	0.18
70	0.60	0.38	0.30	1.2	0.21	0.18
90	0.65	0.42	0.30	1.2	0.21	0.18
110	0.66	0.42	0.30	1.2	0.21	0.18

Principles of Grazing Management

Ed Rayburn
WVU Extension Service Forage Agronomist

There are two parts to the discussion of grazing management: what is the effect of grazing management on plant growth and production, and what is the effect of grazing management on animal growth and production.

Grazing management affects plant growth through the rest interval allowed between grazings and the stubble height remaining at the end of grazing. When animals are removed from a pasture the plant starts new leaf growth by using energy reserves (sugars and starches) stored in their roots and lower stems. As new leaves expand and intercept light photosynthesis begins to provide energy for growth and to replenish the energy reserves used to start the growth cycle. If plants are not given enough time to replenish these energy reserves before they are grazed again they will be weakened, production will be lowered, rooting depth will be reduced and in some species the plants will die. The number of days for a plant to restore its root or stem reserves depends on the plant species, temperature, soil fertility, and soil moisture.

Closeness of grazing also affects plant regrowth. If all leaves are removed from the plant, it must rely entirely on root and stem reserves for regrowth. In some grasses where reserves are stored in the lower stem close grazing will physically remove stem energy reserves and slow regrowth. At times it is desirable to use this as a management tool to set forage growth back. Then growing white clovers (Dutch or Ladino) the pasture manager can increase clover in the stand by close grazing. The grasses are set back giving the cloverleaves more time to grow and get above the grasses for sunlight. If Ladino clover-orchardgrass stands are not grazed to a 2- to 3-inch stubble the clover can be lost. In bluegrass-white clover stands grazing should continue until only a 1-inch stubble remains. This management should be accomplished when the soil fertility, soil moisture, and soil temperature are suitable for white clover growth.

With some forage species little stubble or root reserves are maintained and leaves must be left to provide the energy for regrowth. Such is the case with some annual crops grown for supplemental grazing and birdsfoot trefoil.

Pastures should be grazed to the desired stubble height in 7 days or less. Otherwise, the animals will graze the regrowth and weaken the plants. When animals graze a pasture for more than 7 days they start grazing the forage regrowth and seldom clean up the more mature forage. This selective grazing becomes readily apparent between 10 and 14 days of grazing.

Grazing management affects the growth and production of the grazing animal by affecting their daily feed intake. When animals are first placed on a new pasture, they are able to take large mouthfuls of highly nutritious forage and select the more palatable species. As grazing continues less forage is available, less feed can be taken in a bite, and the forage digestibility and protein content decreases. As forage use increases, forage intake decreases and animal production per head decreases. However, as forage use increases animal production per acre increases. This is because as more animals graze an acre of pasture, less forage is wasted, and the increased gain on the additional animals is greater than the reduced gain on the initial animals. Reductions in production per head become significant when about 50% of the pasture is used. Major decreases in production per head occur as pasture use approaches 80%, resulting in reduced animal production per acre. The optimum level of pasture utilization depends on the production potential of the animal, on the forage species being grazed and on the production and market economics affecting the farm.

The pasture manager's job is to determine the best compromise between production per head and production per acre. Balancing pasture growth and use are the factors of most value in making this grazing management decision. Table 1 gives some guidelines to achieve the proper balance under most grazing situations using cool-season grasses and legumes.

Table 1. General grazing management guidelines to balance forage production and use of several cool-season pasture mixes.

Pasture type	Height of growth at which to		Approx. rest inter.
	Start grazing	Stop grazing	
	(inches)	(inches)	(weeks)
Bluegrass-white clover	4-6	0.5-1.0	3-6
Orchardgrass-ladino clover	8-10	2.0-2.5	3-6
Timothy-birdsfoot trefoil	10-12	3.0-4.0	5-6
Alfalfa-bromegrass	12-18	2.0-4.0	5-6

Grazing Systems

Ed Rayburn
WVU Extension Service Forage Agronomist

A grazing system is the combination of pastures, fences, and forage and livestock management used by the farm manager to control pasture production and harvest. Grazing systems can be divided into continuous and rotational grazing systems.

Continuous grazing is the grazing of livestock on one pasture for a long period of time. Advantages of continuous grazing are low fencing cost, little daily management required, and good animal gains per head if the stocking rate is moderate to low. Disadvantages of continuous grazing are less control of animal feed intake, poor forage utilization due to excess spring growth going to waste, the need to clip pastures to remove grass seed heads and weeds, the low stocking rate resulting in low animal gains per acre, and the lower production from the plants exposed to continuous defoliation.

Continuous grazing is of value on farms where pasture is plentiful and a further increase in livestock numbers is not desired. It is best used with dry cows, sheep, growing heifers, and English breed beef cattle.

If you use continuous grazing don't overgraze your pasture. Stock the pastures at a rate that provides adequate pasture in July and August. The animals should maintain a 2- to 4-inch pasture height during midsummer. To get better use of spring forage, increase the stocking rate in the spring, and then reduce it in midsummer. This can be done by feeding some of the cattle in the barn or by allowing cattle to rotationally graze hay aftermath or summer annuals. Clip your pasture once a year between late June and mid-July to control weeds and remove grass seed heads that irritate the cattle's eyes and increase pink eye. Do not continuously graze alfalfa, timothy, or bromegrass stands. These species will not survive under continuous grazing. Bluegrass, orchardgrass, and tall fescue are grasses that can tolerate continuous grazing while white clover and Empire type birdsfoot trefoil are legumes that can be used.

Rotational grazing is where livestock are moved between pastures during the grazing season, concentration their feeding on one pasture for a few days then moving them on to a new field that is ready to graze. The grazed paddock is allowed to rest and regrow for a length of time suited to the forage species and growing conditions.

There are a number of advantages with rotational grazing. The manager has control of forage growth and forage utilization over the grazing season. The sod vigor is increased through adequate plant regrowth intervals maintaining healthy plant roots that grow deeper in the soil and are more tolerant of summer droughts. This helps reduce weed problems through increased competition to weed seedlings and reduced weed establishment. Also, the livestock grazes many weeds when kept in a vegetative state of growth by the frequent close grazings. A proper rest interval also allows for the growth of forage species such as alfalfa that may be more productive than native forages on deep fertile soils. Through the increased forage production and utilization, using good rotational grazing often doubles animal production, per acre.

Rotational grazing has some disadvantages. More fences has to be built and maintained, more time is spent checking and moving livestock, and it is less convenient to provide water.

Rotational grazing is best suited where the manager wants to increase animal production per pastured acre or reduce operating cost by harvesting forage with livestock instead of machinery. Rotational grazing is best suited for dairy cattle, intensively managed sheep, high producing beef cattle, and growing young stock where increased production per acre is a major goal.

The number of paddocks used in a rotational grazing system varies with management goals and personal preferences. At least 7 paddocks are needed to allow for uniform grazing over the year and allow for some hay removal. An 8 to 10 paddock system is more flexible and is adequate for beef and sheep production. The number of paddocks can be as high as the 21 to 84 paddocks used in intensive rotational grazing systems. These systems are best suited for dairy cattle since they provide a more uniform feed supply and a more uniform level of milk production. These intensive rotational systems are of less value to moderately managed beef and sheep operations because of the increased inputs required and the less favorable economic returns to cover the additional cost of management, labor, and fencing.

Rotationally grazed paddocks should be large enough to supply the feed needs for a herd for the planned stay. The animals should consume the available forage to the desired stubble height in 7 days or less. On good soils with adapted forage species 2 acres will provide the grazing needs of a cow for the summer and most of her winter forage. About half of the acreage should be harvested for hay in June to control excess growth. The hay regrowth can be grazed in July and August with any excess taken as second cut hay. In the fall the entire acreage may be needed for grazing due to the slower regrowth that occurs in last fall. In the fall as the cattle finish grazing a paddock they should be excluded to prevent them from overgrazing or punching the sod.

In the Northeast grass-clover pastures need a 3-week rest interval in the spring and a 6-week rest interval in the summer as soil moisture decreases and temperature increases. Orchardgrass-clover stands should be grazed to a 2-inch stubble while bluegrass-clover stands should be grazed to a 1-inch stubble. Alfalfa and birdsfoot trefoil stands need a 5- to 6-week rest interval in both the spring and the summer. These stands should be grazed to a 2- to 4-inch stubble at the end of the grazing stay.

Pasture, Part of a 12-Month Livestock-Forage Program

Ed Rayburn
WVU Extension Service Forage Agronomist

Developing a pasture system for a farm should be done as part of a 12-month livestock-forage program. This program should provide a year-round forage supply in the quantity and quality needed by the livestock, as inexpensively as possible. The goal is to use the farm, crop and livestock resources to optimize the net return to all farm inputs. In developing a 12-month livestock-forage program we need to determine the farm's forage budget over the year. The forage budget is an accounting of the forage production and the animal feed requirement over the year.

Forage production includes pasture, hay, haylage, and corn silage. Add up the acreage used for pasture only, used for pasture or hay, used for hay only, and used for silage. Estimate the forage production in tons of 90% dry matter hay equivalent (HE) per acre from these fields, using known production or estimated yields. Using HE is easiest since most producers think in these terms. Divide wet corn silage yields by 3 and wilted haylage yields by 2 to estimate HE yields.

When yields are unknown you can use average pasture and hay yields of 2.5 t HE/a. Under poor management these yields may run 1.5 t HE/a while under good management they may exceed 3 or 4 t HE/a. On hill soils corn silage yield will be comparable to good management hay yields, on good soils it may be 50% greater.

Enter the acreage and average yields in Table 1. Multiply the acreage by the average yield to estimate the total yields from that crop class. Add the class yields to get the total estimated farm forage yield in tons of HE.

Table 1. Forage inventory by crop management class.

Crop class	Acres	Avg yield t HE/a	Class yield t HE
Pasture only	________	________	________
Pasture or hay	________	________	________
Hay only	________	________	________
Silage	_________	________	________
	Total yield		_________

Forage feed requirement is determined from the number and size of the animals on the farm. List the number of animals by livestock class in Table 2. Enter the average body weight (BW) of the animals in each class. Multiply the number of head times the average BW to get the total class weight. Add the class weights to get the total herd BW. Cattle and sheep normally consume about 2.5% of their BW in forage dry matter. Sheep lambing more than once a year require 3.0% to 3.5% BW forage dry matter. Dairy cattle need more feed than 2.5% BW but the additional feed is usually provided as grain in the barn. There are losses when harvesting forage and when feeding stored feed or pasture and when hay is used for bedding. Forage requirements should be increased at least 10% to account for these losses. On an annual basis you can estimate the tons HE required by the herd by multiplying the herd BW by 0.0055 (use 0.0066 to 0.0077 for sheep lambing more than once a year).

Table 2. Livestock inventory and forage requirement

Livestock class	# head	Avg wt lb.	Class wt lb.
Mature males	__________	_________	_________
Mature females	__________	_________	_________
Yearlings	__________	_________	_________
Calves	__________	_________	_________
		Total herd weight	_________
		X	0.0055
		Feed requirement	_________ t HE

Farm carrying capacity is the number of animals that can be fed on the forage produced by the farm. Estimate the herd size as a fraction of the farm's carrying capacity by dividing the annual forage requirement of the herd by the annual forage production. This number should be less than 1.0, otherwise the animals will be underfed or additional feed will need to be purchased. A rule of thumb in dry climates is that the stocking rate should be 85% of the farm carrying capacity to allow for dry years. In moist climates and where hay is plentiful and inexpensive the optimum-stocking rate may be higher.

Forage production and requirements cycle over the year. The cycle of forage production in the Northeast and the forage requirement for different livestock enterprises is listed in Table 3 by bimonthly periods.

Forage use budgets are beneficial in estimating the pasture and hay needs of a livestock operation. Table 4 shows one way of estimating the requirements for pasture, hay making, and hay feeding by bimonthly periods. On the first line of the table enter the percentage of forage production made in that period. On the second line enter the forage requirement for each of the periods. It is assumed that the grazing needs of the herd will be met first if forage is growing. To find the forage available for haying the forage requirement is subtracted from the forage production. When forage production exceeds forage requirement there will be a positive value to enter in the line "Hay to make." One the line under the "Hay to make" line enter the percentage of forage production made in the period from the first line. Divide the "Hay to make" value by this number. The result is an estimate of the percentage of forage produced that will be the excess to the grazing requirement and should be harvested for hay or silage in this period. When forage yields are similar across fields this is the percentage of acres to be harvested. Where there are major differences in forage production between fields hay should be harvested from the most productive fields to reduce machinery costs per ton of hay. In this case a smaller percentage of acres than indicated will be needed for haying.

Table 3. Forage production and requirement cycles by bimonthly periods.

	May-Jun	Jul-Aug	Sep-Oct	Nov-Dec	Jan-Feb	Mar-Apr
			Forage production % of total			
Avg pasture	52	26	22	0	0	0
Uniform soils	50	33	17	0	0	0
			Forage requirement % of total			
Dairy year-round	17	17	17	17	17	17
Dairy seasonal	19	18	17	16	11	19
Cow calf, spring	18	18	20	14	14	16
Stocker, spring	27	33	40	0	0	0
Sheep, star lamb	17	17	17	17	17	17
Sheep, spring	18	18	20	14	14	16

Table 4. Forage production and use budget by bimonthly periods for a seasonal dairy operation.

	May-Jun	Jul-Aug	Sep-Oct	Nov-Dec	Jan-Feb	Mar-Apr
Production	52	26	22	0	0	0
Pasture use	-19	-18	-17	-16	-11	-19
Hay to make	33	8	5	-16	-11	-19
		Bi-monthly production			Total hay stored	
	÷ 52	÷ 26	÷ 22	÷ 46	÷ 46	÷ 46
Total hay		Hay production % of acres			Hay use % of stored	
33+8+5 = 46	63%	31%	23%	35%	24%	41%

When forage requirements exceed forage production the "Hay to make" line will be negative indicating the need to feed hay or silage. For these periods enter the sum of the positive "Hay to make" periods (33+8+5=46). Divide the negative "Hay to make" values by the total "Hay to make" to estimate the fraction of hay that will be needed in each of the bimonthly periods.

Forage inventory by crop management class.

Crop class	Acres	Avg yield t HE/a	Class yield t HE
Pasture only	________	________	________
Pasture or hay	________	________	________
Hay only	________	________	________
Silage	_________	________	________
	Total yield		_________

Livestock inventory and forage requirement.

Livestock class	# head	Avg wt lb.	Class wt lb.
Mature males	________	________	________
Mature females	________	________	________
Yearlings	________	________	________
Calves	_________	________	________
		Total herd weight	_________
		X	
		Feed requirement	__________ t HE

Forage production and use budget by bimonthly periods.

	May-Jun	Jul-Aug	Sep-Oct	Nov-Dec	Jan-Feb	Mar-Apr
Production	________	________	_________	________	________	_________
Pasture use	________	________	_________	________	________	_________
Hay to make	_________	_________	_________	________	________	_________
	Bi-monthly production			Total hay stored		
	÷________	÷_________	÷________	÷________	÷_________	÷_________
Total hay + + =	Hay production % of acres ________	 _________	 _________	Hay use % of stored _________	 ________	 ________

Number and Size of Paddocks in a Grazing System

Ed Rayburn
WVU Extension Service Forage Agronomist

The questions most frequently asked by livestock producers wanting to develop a grazing system are "how many paddocks do I need?" and "how large should they be?" The answers to these questions depend on forage production, animal number and size, nutritional needs of the animals, and other feeds the animals will be given while on pasture.

Number of paddocks – the First question to answer is how many paddocks are needed in the system. This depends on the regrowth or "rest" interval provided the pasture and the number of days the livestock are allowed to stay on the paddock.

The regrowth interval needed by the pasture for optimum production depends on the forage species and time of the year. In the spring, grass-clover pastures need 21 days of regrowth. This increases to 42 days in mid-summer. Birdsfoot trefoil-timothy and alfalfa bromegrass pastures should have 42 days regrowth all season.

Pastures should be grazed to the desired level in 3 to 7 days to prevent grazing of plant regrowth. A 3-day stay largely prevents regrowth grazing and will increase pasture production. The 3-day stay should be considered where economics justify the increased fencing and management input. Beef producers as a compromise to simplify management often use a 7-day stay. When grazing stays extend beyond 10 to 14 days approximately half the pasture will be regrazed. This can result in a 25% reduction in plant growth in the next regrowth cycle.

In dairy situations, the number of days on a paddock should be decreased due to animal nutritional needs. As a pasture is grazed, forage intake and nutritive quality decrease. For dairy cattle, this results in lower milk production after 3 days on a 7-day rotational system. Dairymen first trying intensive rotational grazing often use one-day grazing stays. Many dairymen then go to 12-hour stays since this provides more uniform nutrition from the pasture and requires little extra labor when using temporary fencing within permanent paddocks.

The number of paddocks needed in a grazing system is equal to the number of days that a paddock will be rested divided by the number of days it will be grazed plus one paddock for the animals to be grazing while the other paddocks are resting. This is written as the equation:

$$\text{Paddocks needed} = (\text{days rested} / \text{days grazed}) + 1$$

The total number of paddocks needed in the grazing system should be based on the longest regrowth interval planned, usually late summer.

An example using a dairy herd grazing a paddock for 2-day stays on an orchardgrass-clover pasture system needing a 42-day rest interval in mid-summer.

$$\text{Paddocks needed} = (42 / 2) + 1 = 21 + 1 = 22$$

Paddock size is determined by the available pre-grazing pasture mass per acre and the forage requirement of the herd.

Grazable forage dry matter (DM) per acre varies. A thick, well-managed, orchardgrass-white clover stand can provide 1,500 to 1,750 lb. DM/a grazable forage above a 2- to 3-inch stubble. Average grass-clover stands provide about 1,000 to 1,500 lb. DM/a grazable forage.

Most grazing livestock consume about 2.5% of their body weight in pasture DM. Dairy cattle require more feed than this, but it is often provided as supplemental grain in the barn.

A good estimate of paddock size is made by multiplying the pounds of pasture DM eaten per head per day, times the number of head in the herd (#hd), times the days on a paddock, and dividing that by the pounds of grazable forage DM available per acre. In equation for this is:

$$\text{Acres} = \frac{(\text{lb. pasture DM/hd/day})\text{x}(\#\text{hd})\text{x}(\text{days on paddock})}{(\text{lb. grazable DM/a})}$$

The paddock size needed for a herd of 50, 1,350 lb. cows, consuming 34 lb. pasture DM/hd/day (0.025 X 1,350), grazing a pasture yielding 1,250 lb. grazable forage DM/a for a 2-day stay would be:

$$\text{Acres} = (34\text{x}50\text{x}2)/1{,}250 = 2.7$$

Estimates made using these equations will provide realistic paddock numbers and size. When livestock forage requirement is greater than the available pasture, increasing the barn feeding will help balance the forage system. When potential pasture production is greater than the animal needs the extra forage can be harvested for stored feed or for sale. Experience, common sense, and proper pasture and livestock management will allow livestock producers to make the most from the developed grazing systems.