Grazing Systems Planning Guide

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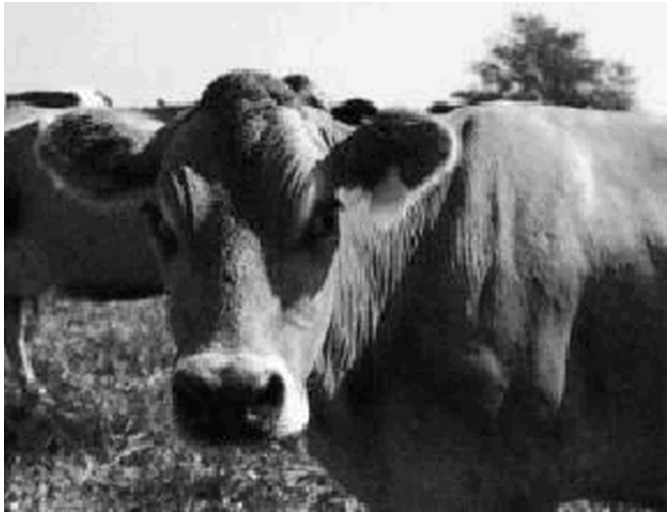

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Introduction

This guide discusses the components of a grazing system by taking you through the grazing management planning process. Information on grazing resource inventory, plan development, pasture management, and system monitoring is provided. Each section has a series of questions that will lead you through the decision-making process of developing your plan. Your grazing plan will become customized to fit your operation depending upon how you answer the questions and integrate the components. Pasture-based livestock systems can be profitable enterprises if the available resources are managed effectively.

With approximately 16% of Minnesota's land in forage production, our pasture land is an important economic resource. Grazing management such as rotational grazing that extends the amount of time that livestock can meet their needs through grazing and reduce the need for harvested feedstuffs will lower feed costs and add to profitability.

Reducing costs and/or increasing production are the two avenues that livestock producers have for improving profitability. Focusing on management and control of production and pasture resources can be a cost reducing strategy. A well-managed rotational grazing system can reduce or eliminate the need for labor-intensive or purchased inputs such as supplemental feed, nitrogen fertilizer, and weed and brush killers. Improved pasture condition and higher forage yields can also lead to more animal production per pasture acre. Since feed costs are the major cost in almost all livestock operations, getting control of them is critical.

Designing a grazing plan is the first step in your pasture management system. By following the planning process, the strengths and weaknesses of your current system will become apparent. The grazing plan should include all the components of the grazing and pasture system and serve as a map for making management improvements.

Components of a typical grazing plan:

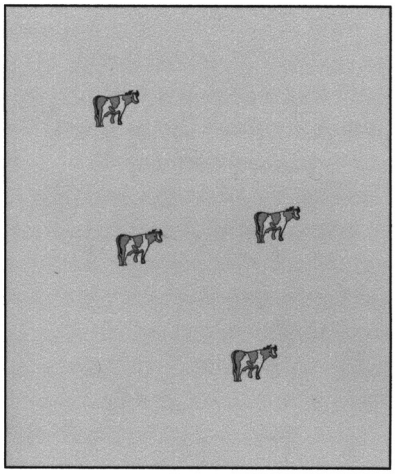
- Goals of the farming operation
- Summary of sensitive areas
- Livestock summary and forage requirements
- Fencing system
- Livestock watering system
- Forages
- Grazing system management

Grazing systems range from continuous grazing of one area over a long period of time to intense rotational grazing on small areas for short periods of time. Livestock systems that use continuous grazing of a pasture experience both overgrazing and undergrazing of forages. A rotational system provides a rest opportunity for forage plants so that they may regrow more quickly. The rotational system provides an opportunity to move livestock based on forage growth, promote better pasture forage utilization and extend the grazing season. The advantages and disadvantages of three grazing management systems are listed on the following page.

Grazing Management Systems

Continuous grazing

is a one-pasture system where livestock have unrestricted access throughout the grazing season.



Advantages

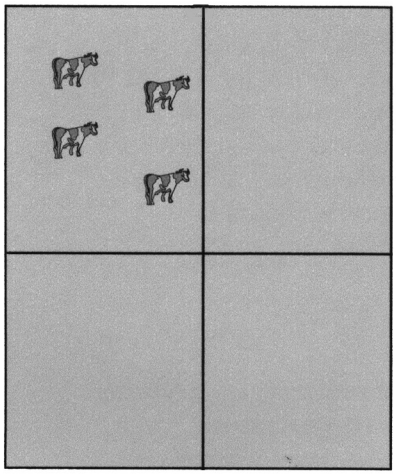
- Requires less management
- Capital costs are minimal

Disadvantages

- Lower forage quality and yields
- Lower stocking rate and less forage produced per acre
- Uneven pasture use
- Greater forage losses due to trampling
- Animal manure is distributed unevenly
- Weeds and other undesirable plants may be a problem

Simple rotational grazing

is a system with more than one pasture in which livestock are moved to allow for periods of grazing and rest for forages.



Advantages

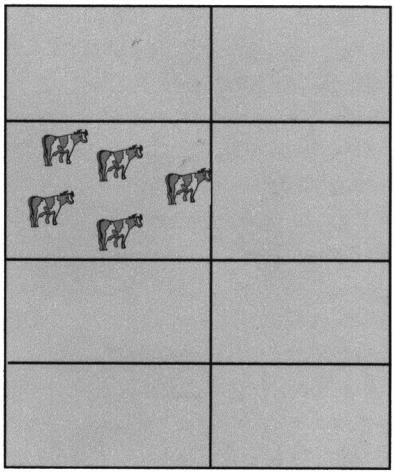
- Can increase forage production and improve pasture condition over continuous grazing
- Allows pastures to rest and allows for forage regrowth
- Can provide a longer grazing season, reducing the need for feeding harvested forages
- Better distribution of manure throughout the pasture

Disadvantages

- Costs for fencing and water systems can be higher than with continuous grazing
- Forage production and pasture utilization is not as high as intensive rotational grazing systems

Intensive rotational grazing

is a system with many pastures, sometimes referred to as paddocks. Livestock are moved frequently from paddock to paddock based on forage growth and utilization.



Advantages

- Highest forage production and use per acre
- Stocking rates can typically be increased
- More even distribution of manure throughout the paddocks
- Weeds and brush are usually controlled through grazing
- Provides more grazing options and reduces the need for mechanically harvested forages

Disadvantages

- Requires careful monitoring of forage supply
- Initial costs may be higher due to fencing materials and water distribution systems
- Requires more management

Grazing Resource Inventory

Goals

What are my goals for the grazing system?

Establish well-thought-out goals to direct the development of a grazing plan. The goals on which to base future business, management, and production strategies will be unique to your own operation.

Examples of goals include:

- Increase livestock numbers and/or forage availability
- Improve animal performance
- Reduce feed costs or labor
- Reduce soil erosion

Annually, goals should be reviewed and updated to fit the current situations and needs of the farm. By making a list of what you want to achieve with the resources you have available, you are now ready to look at the management options to accomplish your goals.

Land and Soils

What land resources are available for the grazing operation?

Locate or draw a map showing the boundaries of the land that is available for grazing.

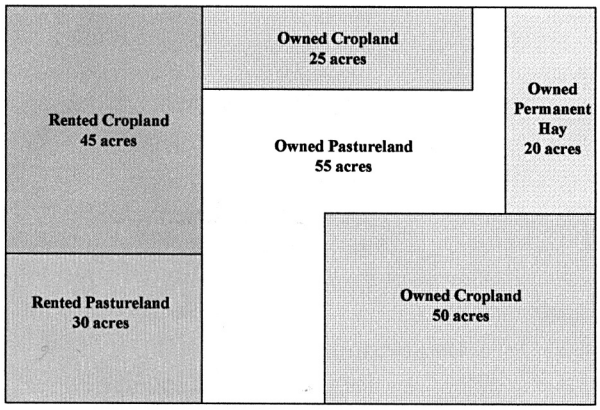
Distinguish land that is owned from land that is rented. There are certain management practices that you can apply to your own land that you may not be able to do on rented land. Determine the number of acres of the different land parcels and label these on the map (Diagram 1.).

Is there additional land available that could be used for grazing? Often times, cropland that is adjacent to postural and may be better utilized by growing forages. Cropland in close proximity to existing pastures are ideal for converting to grazing if pasture expansion is one of the farm goals. Identify and label on the map cropland that could be used for grazing.

What is the productivity of the soils?

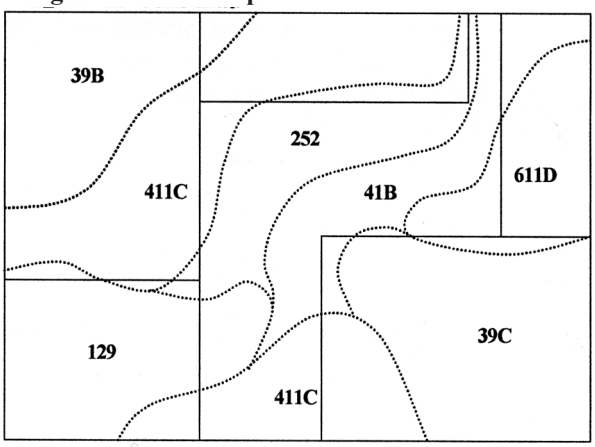
Map soil types and soil fertility of your pastures. Soils vary considerably in their ability to support plant growth. Soil productivity is partially determined by its ability to hold water and nutrients, release them to the plant, and by how well plant roots can grow in the soil. Actual crop yields achieved are a result of the interaction between soil productivity, the level of management, and climatic factors (Diagram 2.).

Diagram 1. Land resources map



Aerial photos from USDA-Farm Service Agency provides a good base map

Diagram 2. Soils map



Legend

Map Symbol	Soil Name	Slope (%)	Estimated Yield (tons/acre) Grass/ Legume	Estimated Yield (tons/acre) Kentucky Bluegrass
39B	Wadena Loam	2-6	4.0	1.7
39C	Wadena Loam	6-12	3.6	1.5
41B	Esterville Sandy Loam	2-6	2.6	1.2
129	Cylinder Loam	0-2	4.0	1.7
252	Marshall Silty Loam	0-2	4.6	2.0
411C	Waukegan Silt Loam	6-12	3.8	1.8
611D	Hawick Loamy Sand	12-18	2.0	0.5

A County Soil Survey is a good first step for determining soil types in your pastures. The publication contains general characteristics of each soil type, including soil texture, drainage, water holding capacity, and organic matter content. Estimated forage yields can be calculated from "Pastures for Profit", Appendix A, the local NRCS Forage Suitability Groups, or farm records.

Are there sensitive land areas or soil limitations for grazing in the pasture?

Sensitive land areas are areas that have a high potential to generate or transport unwanted materials towards ground or surface water. The types of materials that could contaminate these resources are bacteria, nutrients from livestock manure, and sediment resulting from soil erosion (Diagram 3.).

Examples of sensitive land areas to be identified and referenced on a map:

- Location of surface waters (wetlands, lakes or streams)
- Quarries, mines or sinkholes
- Active or abandoned water supply wells
- Coarse-textured and high-leaching soils
- Steep slopes
- Shallow soil to a water table or bedrock
- Wooded areas
- Intermittent waterways

Limiting features also need to be identified and referenced on a map. The most important source of information is observed by walking the pasture with somebody that is knowledgeable in soils and soil management. The Soil Survey publication for your county will also provide additional information on pasture features found below the soil surface.

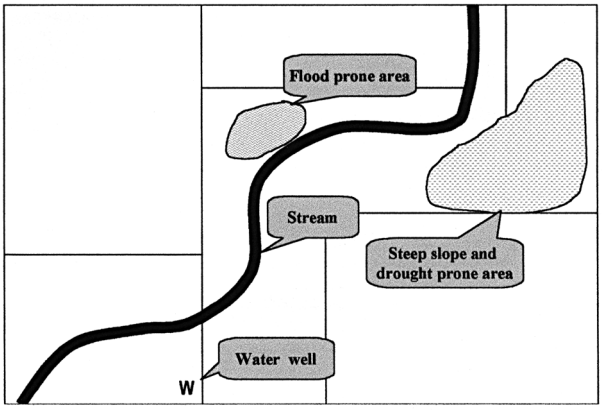
Examples of soil limiting features:

- Sandy soils which have a high potential for drought
- Shallow soils over bedrock that limit the depth of root growth
- Flood prone soils that either restrict growth of certain forages or limit grazing time
- Organic soils which limit accessibility and trafficability
- Extreme slopes or landscapes that make pasture areas difficult to reach

County soil information and maps can be obtained from your local USDA Agricultural Service Center or Extension office.

For help with identifying these areas of your pasture, contact your local USDA Agricultural Service Center or Extension office.

Diagram 3. Sensitive areas and soil limitation area map



Livestock

What are the forage requirements for each livestock herd?

First, estimate the daily requirement for your herd:

(# of animals) x (average weight) x (daily utilization rate)
= daily forage requirement

Daily utilization rate = 0.04. This figure is used because livestock need to have access to approximately 4% of their live weight in forage (2.5% intake, 0.5% trampling loss, and 1% buffer).

Example:
(25 cow/calf pairs) x (1,200 lb. average weight) x (0.04) = 1,200 lbs/day

The daily forage requirement is used in Section 3, **Grazing Plan Development, Paddock Design and Layout.**

Second, estimate the monthly and seasonal requirements for your herd:

(daily forage requirement) x (# of days per month)
= monthly forage requirement

Example:
(1,200 lbs/day) x (30 days) = 36,000 lbs. monthly forage requirement

(daily forage requirement) x (# of days in the grazing season)
= seasonal forage requirement

Example:
(1,200 lbs/day) x (150 days) = 180,000 lbs. seasonal forage requirement

The Livestock Forage Monthly Balance Sheet (Table 1 and Appendix A) provides a simple method of computing monthly forage requirements.

Remember, the primary goal of most livestock grazing systems is to produce weight gain on the livestock. An increase in animal size will result in an increase in estimated forage needs through the grazing season as long as animal numbers do not change. Adjust livestock weights for each month to provide a more realistic estimate of forage needs.

Table 1. Livestock Forage Monthly Balance Sheet – Current Livestock Summary

				Forage Requirements Per Month (lbs. x 1000)					
Kind/Class Livestock	Number of Animals	Average Weight	Monthly Utilization*	May	June	July	Aug	Sept	Oct
Beef cow/calf	25	1200	1.2	36.0	36.0	36.0	36.0	36.0	36.0
Herd bull	1	2000	1.2			2.4	2.4	2.4	2.4
Totals	26			36.0	36.0	38.4	38.4	38.4	38.4

* 0.04 daily utilization rate (includes forage waste) x 30 days/month

What are the plans for potential expansion of the livestock operation?

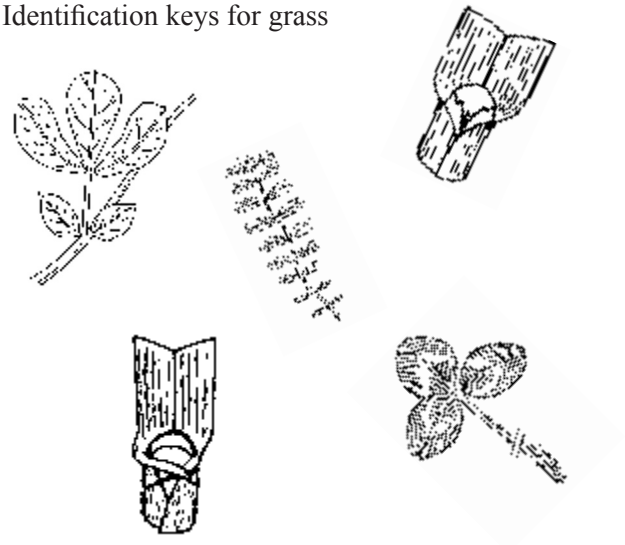
If an increase in herd size is a goal of the operation, adjustments to forage needs and considerations on how to best meet those needs with forage supply can be estimated. Are there enough acres in the existing pasture to meet the needs of the larger livestock herd? What is the potential forage supply if improvements are made to the pasture or grazing system? This issue will be addressed in following section on forages.

How many herds will be grazed?

Separating the grazing herd into groups based on production, animal species, animal size, or class differences should be examined. When there is an increase in the number of herds, you will need to increase the number of paddocks. When dividing the pasture consider:

- How many groups could potentially be grazing at the same time?
- Can the different groups graze next to each other? (Don't place male animals in paddocks adjacent to females in heat.)

Identification keys for grass



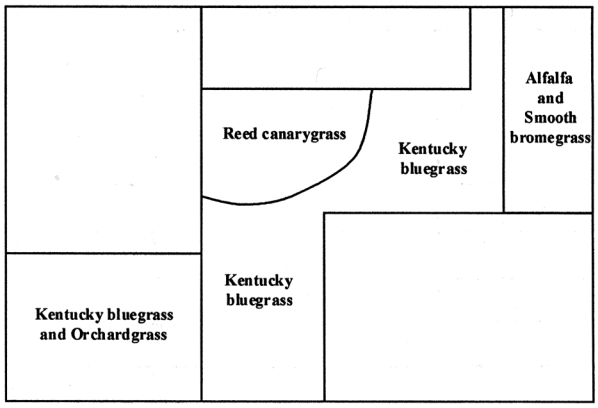
Forages

What are the existing forage species in the pasture?

Forage grass and legume species each have their own unique growth, persistence, and quality characteristics. Because they respond differently to soil conditions, weather patterns, fertility, and grazing management, the plants that are currently growing in your pastures may be different from one area to another. **Identify dominant plant species and areas in which they grow on your pasture map**. A walk through the pastures is necessary to gather this information. The plants you find during the initial inventory of your forage species may or may not be the desired species for meeting the long-term goals of your grazing system. Therefore, information on forage species growing in the pasture may have an impact on future modifications to the grazing system (Diagram 4.).

Assistance in identifying your forage species can be obtained at your local USDA Agricultural Service Center or Extension office. To collect plant samples for later identification, dig several plants along with roots, and place them between sheets of newspaper. Remove all soil from the roots before placing on the newspaper. To aid the plant drying process, apply an even pressure or weight to the newspaper.

Diagram 4. Forage map



and legume species are readily available in Appendix (B). Grass species are often difficult to identify during early stages of growth. Still, there is a need to distinguish between grass species because of potential differences in forage yield and seasonal growth patterns.

How healthy or in what condition is the pasture?

Good pasture condition is critical to a successful grazing system. Pasture quality may vary greatly from one pasture area to another, but the trend over time should show the direction in which the pasture condition is moving. Determining Grassland Condition/Trend (Appendix C) is an evaluation tool to help determine if pastures are in need of improvement and what areas need the most improvement. It is also a useful tool in evaluating results of management decisions. **Determine the condition of your pastures by completing the Determining Grassland Condition/Trend sheet** (an example of a completed form is provided in Table 2).

What are the estimated yields and seasonal distribution of the existing forages?

Based on the plant species, pasture condition, and soil types found in the pastures, forage yields and overall forage supply can be estimated for your grazing system. **Document the forage yields in lbs./acre on the Livestock Forage Monthly Balance Sheet** (example of completed form is provided on Table 3). Remember these are only estimates to provide a starting point for future planning. Changes in climatic conditions from one year to the next can drastically change forage production and the outcome of seasonal forage supply.

Table 2. Determining grassland condition/trend

	Field #	Rented	Owned			
	Acres	30	55			
	Month & Year	M__Y__	M__Y__	M__Y__	M__Y__	M__Y__
Category	**Score**	**Value**	**Value**	**Value**	**Value**	**Value**
1) Species Composition	Undesirable 0 1 2 3 4 Desirable	2	1			
2) Plant Diversity	Narrow 0 1 2 3 4 Broad	1	1			
3) Plant Density	Sparse 0 1 2 3 4 Dense	2	2			
4) Plant Vigor	Weak 0 1 2 3 4 Strong	1	1			
5) Legumes in Stand	Less than 10% 0 1 2 3 4 More than 40%	0	0			
6) Plant Residue	Deficient 0 2 4 Appropriate 2 0 Excess	2	2			
7) Uniformity of Use	Spotty 0 1 2 Intermediate 3 4 Uniform	3	2			
8) Severity of Use	Heavy 0 2 4 Moderate 2 0 Light	0	0			
9) Woody Canopy	More than 40% 0 1 2 3 4 Less than 10%	4	4			
10) Soil Erosion	Severe 0 1 2 Moderate 3 4 Slight	2	1			

Once the forage species and yield estimates have been documented, a monthly forage supply can be determined using the estimated forage production and seasonal distribution percentages. For specific forage yields and seasonal distribution using charts from "Pastures for Profit", NRCS field Office Technical Guide tables, or information in Appendix D. The estimated monthly values follow the seasonal growth patterns of the common forage species. This exercise provides a good estimate of the total amount of forage available to livestock for any month of the grazing season. Subtract the monthly requirement from the monthly forage production to:

- Indicate forage balance for the growing season
- Predict excess forage production by month
- Predict where forage shortages may occur by month

Using the information in Appendix D, net yield and monthly available forage for orchardgrass in a pasture that is in poor condition are calculated in the following procedure:

Forage yield estimates for your grazing system can be found in any of the following publications:
- *The County Soil Survey*
- *NRCS Field Office Technical Guide*
- *Pastures for Profit; A Guide to Rotational Grazing, U of MN Extension Service*

Example: Monthly available forage for orchardgrass in a pasture that is in poor condition are calculated in the following procedure:

Total Yield

(forage yield) x (acres) = forage production

Example:

(2,500 lbs/acre) x (30 acres) = 75,000 lbs of forage (dry matter basis)

Forage Availability Per Month

(total yield) x (% forage available by month from Appendix D) = monthly available forage

Month	% Forage Available*	Monthly Available forage (lbs./acre)	
May	10%	(75,000 lbs. x .10)	7,500
June	30%	x .30	22,500
July	10%	x .10	7,500
August	20%	x .20	15,000
September	20%	x .20	15,000
October	10%	x .10	7,500

* Available in "Pastures for Profit" and NRCS Field Office Technical Guide

Table 3. Livestock Forage Monthly Balance - Current Forage Summary

Field	Kind of Forage	Forage Yield (lbs./acre)	Acres	Total Yield (lbs./acre)	Forage Availability Per Month (lbs x 1000)					
					May	June	July	Aug	Sept	Oct
Rented	Orchardgrass	2500	30	75,000	7.5	22.5	7.5	15.0	15.0	7.5
Owned	Kentucky Bluegrass	1900	38	72,200	7.2	28.9	7.2	10.8	10.8	7.2
Owned	Reed Canarygrass	2700	17	45,900	9.2	13.8	9.2	4.6	6.9	2.3
Total lbs. Forage Available (x 1000)				**193.1**	**23.9**	**65.2**	**23.9**	**30.4**	**32.7**	**17.0**
Total lbs. Forage Required by Livestock (x 1000)				**225.6**	**36.0**	**36.0**	**38.4**	**38.4**	**38.4**	**38.4**
Total lbs. of Excess Divided by Deficiency (x 1000)				**-32.5**	**-12.1**	**29.2**	**-14.5**	**-8.0**	**-5.7**	**-21.4**

Water Sources

What are the existing water sources and where are the drinking facilities?

Water is essential. Without an adequate supply of quality water, animal health, weight gain, or milk production can be negatively affected. **Locate on a map the water sources and drinking facilities that are currently available to the grazing herd** (Diagram 5.). Note all possible sources such as streams, ponds, wells, or springs. By viewing these on a map, we can see how far livestock have to travel to receive water. Consider these questions when making decisions:

- Are there seasonal changes in the water supply? Shallow wells or small streams will often dry up during late summer or during times of drought.
- If water is being hauled to the animals, how much storage is available?
- Is a nearby source of electricity available?
- Will the existing water sources be able to accommodate a pumping system that does not require electricity?

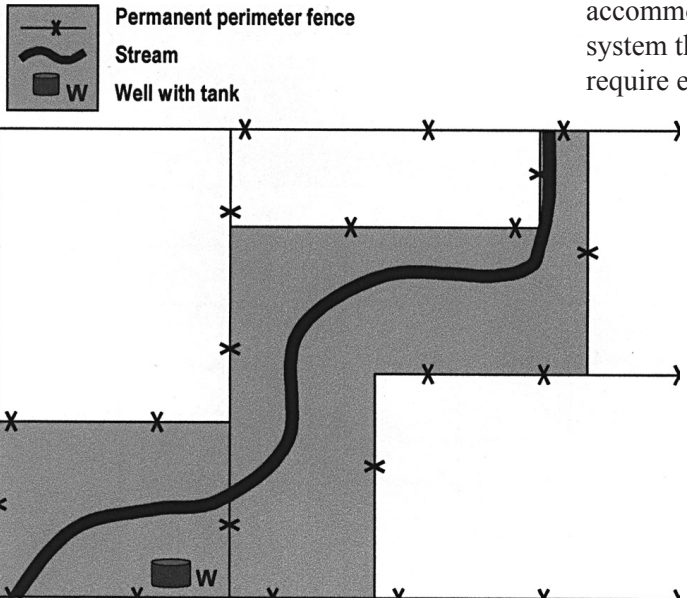


Diagram 5. Existing Water and Fence location map

What are the other potential water sources?

Changes to the grazing system may require making improvements to your livestock water system. Are there other potential water sources that could be made available to the pasture? Does a new well need to be drilled? Where is the best site for a new well? Is there a water source nearby where water can be obtained by constructing a pipeline system? These additional sources provide you with options when making decisions on improving your water system.

If you are not certain of the water quality, tests should be performed to determine whether the water is satisfactory for consumption by livestock. Good, clean water is especially critical to producers who expect high animal performance- as with milking cows, stockers, and replacement dairy heifers - although benefits are realized for other classes of livestock as well.

Fencing

What are the types and condition of the existing fences?

Know the kind and condition of existing fences. **Map the location of these fences including both perimeter and interior fences** (Diagram 5). Will the condition and location of the existing fence meet the needs of the grazing system? Should you plan to improve or change the location of any of the fences? Do not be locked in on the location of existing fences. Are there other livestock handling facilities available such as corrals, dry lots, barns or sheds that are part of the pasture or grazing system?

Grazing Plan Development

Paddock Design and Layout

The development of a grazing plan involves the following:

- Determining how many paddocks are required and their size and shape
- Determining the kind of fence and locations
- Determining how water will be provided to the livestock

How many paddocks are needed for a rotational grazing system?

The *minimum* number of paddocks in a system is dependent upon the length of the rest period that is required for the forages. The lengths of the rest periods for grasses and legumes can be found in Table 4. The rest period allows time for the forage plants to regrow, producing forage for the next grazing cycle. The length of the rest period varies throughout the growing season. When preparing your plan, use an average length or longer length of time (25-30 days). Using less than the average length of time will result in a plan with too few paddocks or paddocks that are too large.

Another component of determining the number of paddocks is the grazing period. The length of the grazing period in each paddock is based upon the desired level of management, availability of labor, performance objective for the livestock, and growth characteristics of forages.

Grazing periods longer than 6 days will damage new regrowth. The grazing of new growth diminishes the ability of the forage plants to regrow quickly, resulting in an overall yield reduction for the pasture. A shorter grazing period is associated with livestock operations where livestock performance is essential, such as with milking cows. Longer grazing periods are more typical of beef cow/calf operations, ewe/lamb operations, and maintaining dry cows.

Table 4. Optimal rest period for forage species

Species	Cool Weather	Hot Weather
	(Days)	
Cool Season Grasses	14	35-50
Warm Season Grasses	35-40	21
Legumes	21-28	21-28

The minimum number of paddocks *for each herd* in the pasture system is equal to:

$$\frac{\text{Rest period (days)}}{\text{Grazing period (days)}} + 1$$

Guidance on paddock management is provided in the section ***Pasture Livestock Management.***

The required size of the paddock for average growth conditions is equal to:

Paddock Size = (daily herd forage requirement) x (days in grazing period)
(lbs. forage available per acre)

Daily herd forage requirement	Total weight of the herd times 0.04 utilization rate (refer to the livestock inventory).
Grazing period	Length of time animals are in paddock.
Pounds of forage available per acre	Measured height of forage minus minimum stubble height (from Table 5) x pounds of forage per acre per inch of height (from Table 6).

Table 5. Minimum height (in inches) of pasture species for initiating and terminating grazing

Species	Begin Grazing		End Grazin	
	Initial Grazing Heighten Early Spring*	Minimum & Optimum Height of Vegetative Growth	Minimum Stubble Height**	Minimum Regrowth before Killing Frost
Alfalfa		Bud Stage	-	6***
Creeping Foxtail	6	8-10	3	6
Green Needlegrass	4-5	6-8	3	5
Inter. Wheatgrass	4-5	8-14	4	6
Kentucky Bluegrass	2	4-6	2	4
Orchardgrass	3-4	6-10	3	6
Pubescent Wheatgrass	4-5	8-14	4	6
Reed Canarygrass	4-5	8-8	4	6
Russian Wildrye	4	5-7	3	4
Slender Wheatgrass	4-5	6-12	3	6
Smooth Brome	4	8-14	4	6
Tall Fescue	4	6-10	3	6
Tall Wheatgrass	4-5	8-14	4	6
Timothy	4	6-10	4	5
Western Wheatgrass	4	6-10	4	5
Big Bluestem		10-14	6	6
Indiangrass		10-14	6	6
Little Bluestem		5-7	3	4
Sand Bluestem		8-14	6	6
Sideoats Grama		4-6	2	4
Switchgrass		12-20	8	10

Source: Minnesota NRCS Conservation Practice Standard #528A, Prescribed Grazing.

* This applies only to the initial grazing in the spring (early May). The livestock must be moved rapidly throught the paddocks during this time to prevent overgrazing and to keep the forage from "getting ahead of the livestock".

** Minimum stubble height is critical if stand is to be maintained. This applies to that part of the grazing season after the initial rapid growth period in early May, as well as the end of the grazing season.

How do I decide paddock size?

Paddock size is based upon providing an adequate supply of available forage to meet the requirements of the herd. This would be a simple task if the forages grew at the same rate throughout the season. We know this is not the case. For example, cool season grass growth is very rapid in the spring, slows considerably during the hot summer months of July and August, and increases somewhat again in the fall.

Clearly, for a given herd the area required to produce the necessary forage for the planned grazing period will not be the same throughout the grazing season. The strategy for dealing with this variability is this:

- Plan using average growing conditions.
- Vary the length of the grazing period throughout the grazing season when paddock size is fixed.
- Vary the size of the paddock when the size is not fixed, as in a strip grazing system.

The paddock size times the minimum number of paddocks provides us with the minimum required size of the total pasture unit. If the existing pasture is larger than this minimum area, then more paddocks can be planned for. This will likely provide more than enough forage in the spring, some of which could then be harvested for hay. Having more paddocks than the required minimum will reduce the risk of running out of forage during the midsummer slump that cool season pastures normally experience.

If the acreage of the required minimum number of pastures is more than the existing pasture acreage additional acreage should be devoted to pasture to avoid running out of usable forage during the midsummer slump.

What are some considerations for paddock layout?

Some adjustments need to be made to the size of each paddock so they have equal productivity. The information gathered during the inventory process is useful when determining the paddock layout. Each paddock should have:

- Similar soils (refer to Diagram 2.)
- Similar slope aspect (north facing, south facing, etc.)
- Similar topography
- Similar forages (refer to Diagram 4.)

The shape of the paddocks is significant. Paddocks should be as square as possible to promote more uniform grazing. Long, narrow paddocks generally are overgrazed at one end and underutilized at the other end. Paddocks should be planned so that livestock do not have to travel more than 800 feet to get water. This will encourage more water consumption by the livestock and more uniform grazing within the paddock. Livestock tend to utilize the forages close to water much more than forages farther from the water. Additional adjustments may be required based upon access to water sources, which may have an impact on the shape of the paddocks in a grazing system, particularly in situations where natural water sources, such as ponds and streams, are utilized.

Paddock layout will also be influenced by the location of lanes for the movement of livestock. These lanes should connect all paddocks so that livestock can be moved to any paddock from the one they currently occupy, allowing for maximum flexibility in forage management.

Table 6. Estimated dry matter yield per acre-inch for various forages at three stand densities

Forage	Stand Density[1]		
	Fair*	Good**	Excellent***
	lb. Dry matter/acre-inch		
Bluegrass/White Clover	150-250	300-400	500-600
Tall Fescue/Legume	150-250	250-350	350-450
Tall Fescue/Legume	100-200	200-300	300-400
Smooth Bromegrass+Legumes	150-250	250-350	350-450
Orchardgrass+Legumes	100-200	200-300	300-400
Mixed Pasture	150-250	250-350	350-450
Alfalfa or Red Clover	150-250	200-250	250-300
Native Tall Warm-Season Grasses	50-100	100-200	200-300

Source: USDA-NRCS (MN)

[1]Stand condition is based on visual estimate of green plant ground cover after being grazed to a 2-4 inch stubble height.

* Fair Condition: Less than 75% ground cover or greater than 25% bare ground.

** Good Condition: 75-90% ground cover or 10-25% bare ground.

*** Excellent Condition: At least 90% ground cover or less than 10% bare ground.

Fence Design and Layout

What kind of fence should I install?

The kind of fence that should be installed depends upon:

- Purpose of the fence
- Kind and class of livestock to be contained
- Operator preference
- Predator control
- Cost

Permanent or temporary fences may define paddocks within the grazing unit. During initial stages of paddock layout many producers prefer to use temporary fences to create paddocks and lanes. This allows for easy adjustment of the layout as producers learn what size paddock they need, how to easily accomplish livestock movement, and how forages react to managed grazing. After gaining experience, the producers usually install some type of permanent fence to define paddocks and lanes.

A. Permanent Fences:

Permanent fences are used for the perimeters of pasture systems, livestock corrals, and handling facilities. Sometimes they are used to subdivide pastures into paddocks. This is especially true for certain kinds and classes of livestock, such as bison.

1. High Tensile Wire Fences

This is a relatively new type of fence, which has become increasingly popular in recent years. Typically perimeter fences are 4-6 strands of wire and interior fences are 1-2 strands of wire.

Advantages:

- Relatively easy to install
- Can be powered to provide a physical as well as psychological barrier.
- Several contractors available to do installation.

Disadvantages:

- Requires some special equipment, such as a post driver for installing wooden posts.
- Fences with several strands of wire are not easily moved.
- Wire is difficult to handle if fence is to be moved.

2. Woven Wire Fences

Woven wire is another traditional type of fence. It is used primarily for hogs and sheep. Woven wire fences normally have one or two strands of barbed wire installed above the woven wire.

Advantages:

- Not dependent on electrical power. Is useful in remote locations.
- Provides barrier for smaller kinds of livestock (sheep, hogs).

Disadvantages:

- Cannot be powered, provides only a physical barrier.
- Requires much labor to install.
- Not easily moved.
- Weed and vegetative growth promotes snow piling.

3. Barbed Wire Fences

Barbed wire is one of the traditional types of fence, which is still quite popular. Barbed wire fences should be at least 4 strands for perimeter fences. When used for interior fences, they are typically 3 or 4 strands. Barbed wire should never be electrified because of greater potential for animal injury.

Advantages:

- Not dependent upon electrical power, thus is useful in remote areas.
- Most producers are experienced with construction of barbed wire fences.

Disadvantages:

- Not easily moved.
- Provides only a physical barrier.

B. Temporary Fences:

The primary use of temporary fence is to define paddocks within a pasture system, direct the grazing within a paddock to areas that are being underutilized, and to fence in areas that are grazed only occasionally or not part of a regularly-rotated pasture system.

Temporary fences are usually constructed with step-in posts and polywire, polytape, light gauge steel or aluminum wire, and require an electrical source. Easy and quick to move, these fences do not require tools for setup. In addition, these fences are very light and do not require bracing.

Advantages:

- Easy to install and to move.
- Relatively inexpensive.
- Provides considerable flexibility.
- Can be used within permanently established systems to direct grazing pressure.

Disadvantages:

- Components have relatively short lifespan.
- Not suitable for perimeter fences.
- Provides a psychological barrier only, not a good physical barrier.
- Requires an electrical source and maintenance of the fence line from electrical grounding.

Water System Design and Layout

How can I supply adequate water to the livestock?

Water is essential for livestock to effectively process forages. A well-planned and installed water system will provide an adequate quantity of water with minimal disturbance to the soil resource and to the water source itself.

Common sources of water for livestock are streams, ponds, lakes, and wells. Of these sources, well water is preferred because it is cleaner. Research shows that there can be a significant increase in animal performance and improved herd health if the drinking water is clean and free from sediments, nutrients, pesticides, algae, bacteria, and other contaminants.

Alternative methods of delivering the water to the livestock include:

- Ramps to surface water (ponds, etc.)
- Livestock powered pumps
- Solar pumping systems
- Sling pumps
- Hydraulic ram pumps
- Gasoline powered pumps
- Water hauling

These methods can be used to discharge directly into a trough or tank, but normally a pipeline is installed to distribute the water to drinking facilities available in all paddocks. When using a pipeline to deliver water you may need to have a system that is engineered to meet the specific needs of your site. See Appendix E for description of pumping systems.

Considerations in designing a pipeline system include:

- Quantity of water to be delivered
- Pressure differences due to elevation changes
- Length of pipeline
- Protection from freezing

For technical assistance in designing your watering system, contact your local NRCS Field Office.

Where should drinking facilities be located?

Drinking facilities should be available in each paddock. If possible, locate drinking facilities so that livestock do not have to travel more than 600-800 feet to drink. In systems where livestock must travel long distances to water, forages tend to be over-utilized near the water, and underutilized in areas of the paddock that are farthest from the water. Other problems associated with this situation include uneven manure distribution in the paddock and diminished animal performance.

Most livestock watering systems consist of a pump, a delivery system (usually a pipeline), and a trough or tank for the livestock to drink from. Once the paddock layout is established, and the water sources identified, the delivery system must be accommodated. If water is to be hauled, access by the tanker needs to extend to each storage tank. If the water is to be delivered through a pipeline, the route must be determined so that each paddock in the system has access to the water. The pipeline layout should follow the shortest route to minimize cost and maintenance problems. This will ultimately determine the general area in which the watering tanks will be placed.

Water tanks should be placed on soils that can support heavy traffic and provide easy access by livestock without crowding. Permanently installed tanks should have some type of heavy use treatment around them to prevent the formation of a mudhole. Refer to the section on **Heavy Use Area Planning**. Portable tanks offer the most flexibility. Their location can be changed frequently by adding a length of pipeline between the coupler and the tank and placing the tank in a different location. The tanks can be moved as often as necessary to manage grazing and avoid creation of barren areas and mudholes.

When using portable tanks, allow for 2 tanks per herd so that one water tank can be set up ahead of time in the next paddock.

See your local NRCS office for design assistance for stream crossings, unstable sites, and drinking facility pads.

Lanes for livestock do not work well for bison. They do not like to be confined to narrow areas. If lanes are used for bison, make them much wider than they would be for other kinds and classes of livestock.

For more information on Geotextiles read "Using All-weather Geotextiles for Lanes and Paths". Midwest Plan Service publication AED-45.

Heavy Use Area Planning

Some areas of the pasture system will be used so much that the best option is to place some type of protective material to prevent the formation of mudholes. Two such areas are those that surround watering facilities and the alleyways used for livestock movement.

What do I consider when planning livestock lanes?

Livestock movement must be controlled for a successful grazing system. Lanes that are properly planned will allow for livestock movement from one paddock to any other paddock without moving back through a recently grazed paddock. Livestock will tend to stop moving when they go into a paddock with some fresh forage growth, even though you may want them in a different paddock. Lanes prevent this from happening. The areas within the lanes can normally be grazed along with an adjacent paddock, unless the lane is covered with some type of protective material. The locations of livestock lanes should avoid potential erosion, concentrated water flow, and flooding. Avoid placing lanes up and down hills, in wetlands, or on organic soils.

How do I stabilize the livestock lanes?

Livestock lanes should be protected with lime screenings or some other fine textured material to prevent mudhole development and erosion when:

- There is considerable animal traffic, as in the case of milk cows using the lane for two round trips each day
- Areas of the lane are subject to erosion

Fine-textured materials are preferred over course-textured materials because the course-textured material can injure the feet of livestock. If animals must traverse lanes that are in unstable areas, such as wet draws, then the treatment described below for protecting watering facilities should be installed to avoid difficulty with livestock movement.

How do I keep the area around water facilities from becoming mudholes?

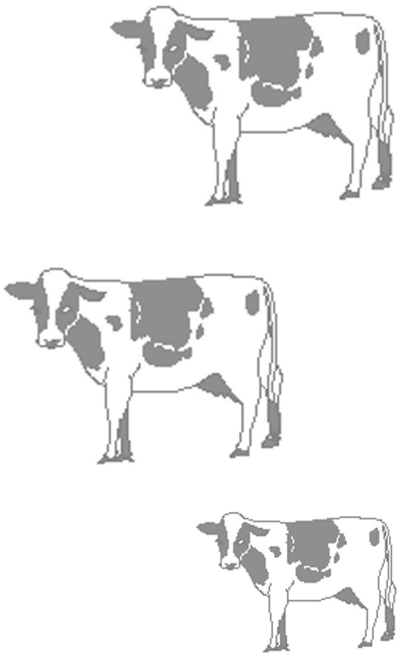
Watering stations that are permanently placed will be subject to heavy use since they are often used to provide water for more than one paddock. Water spillage and leakage, which is inevitable, adds to the mud problem. As a consequence, protective materials will need to be used around watering sites. Portable watering tanks will not generally have the same problems because they can be moved around to spread the use over a larger area.

The recommended method of building pads for water stations is to:

- Prepare a good subgrade by removing debris and vegetation along with at least 8" of topsoil.
- Compact the subgrade.
- Lay down a geotextile fabric (Class I).
- Place a six-inch layer of course aggregate on the geotextile fabric and top with a three-inch layer of fine aggregate.
- Lanes generally need to be 12-15 feet wide and pads around tanks need to extend out 20-25 feet.

Pasture Management

Pasture Forage and Livestock Management



What is proper grazing management for the desired forage species?

To maintain desirable plants for grazing, management that provides adequate rest from grazing will need to be adopted in order to give desired species the competitive edge over less desirable plants. A good mix of desired plants within the pasture will be an additional benefit to a grazing system by providing more ground surface coverage by plants for as many days of the year as possible. Mixtures of grass and legume species that have different growth curves in the same pasture provide greater forage productivity than a single species pasture.

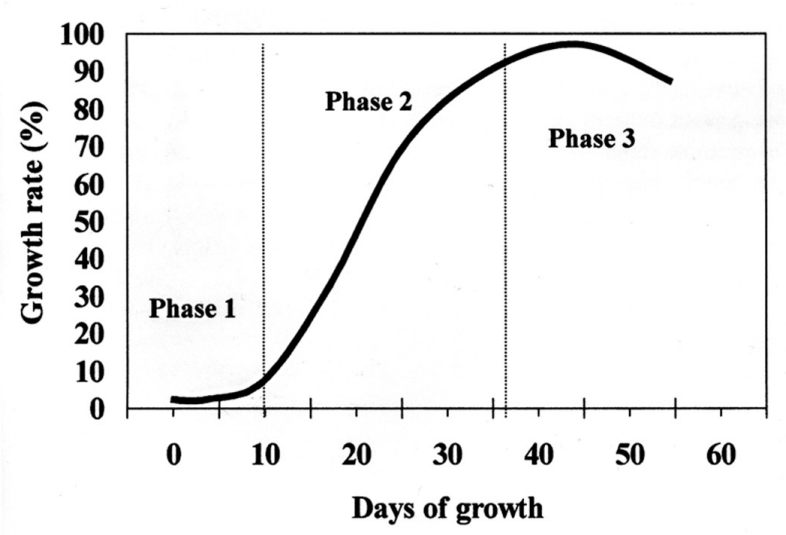
Are the pasture forages adequate to meet the needs of the livestock or are there areas that need improvement? Using the completed **Determining Grassland Condition/Trend** worksheet from the Forage section of Chapter 2, evaluate your pasture. Generally, if the pasture plant population and plant diversity is at a high level but plant vigor is weak, a change in grazing system management to provide a rest period may be all that is needed to increase forage production. In contrast, if plant population is undesirable and plant diversity is low, then establishment of new seedings of desirable plants could add additional forage for the pasture.

The decision to renovate a pasture and establish new forage species or add to the existing forage plants should be well planned. Is a legume component, grass-legume mixture, or a more productive grass to be established in the pasture? Before purchasing seed, consider economics of the intended management practice, animal preference for forages, soil conditions, and landscape of the site.

How do pasture and livestock management affect plant growth and forage quality?

The basis of forage production is to harvest sunlight and rain to produce healthy forage plants for animals to graze. To have healthy vigorous plants there needs to be an extensive, healthy root system. There is a direct relationship between root growth and the amount of leaf area developed. If too much of the leaf area is removed, roots will die back. When management limits the removal of forage to no more than 50 to 60%, root growth will not be significantly reduced. Plants will remain healthy and leaf regrowth will be fairly rapid. This growth rate response is illustrated in Figure 1.

Figure 1. The growth rate curve and three phases of pasture growth



The growth curve is divided into three phases. Plant growth is slowest during Phase 1 when plants are small and there is insufficient leaf area to intercept light for growing leaves and to maintain roots. Root growth stops during Phase 1. Grazing during this time will provide high quality but low yielding forage. However, continued grazing during this phase will cause plant vigor to weaken because of reduced root growth. The loss of an extensive root system ultimately results in lower forage yields because of the plant's ability to take up water and nutrients are reduced.

Growth rate increases when enough leaves are present to maintain existing leaves and roots and also promote growth of new leaves as occurs in Phase 2. Leaves during this growth phase intercept sunlight above what is needed for maintaining the plant and as a result the rest of the energy is used to rapidly develop new leaves and roots. Grazing during Phase 2 provides the optimum balance of forage yield and quality. The goal is to begin grazing a particular paddock when forage growth is high on the Phase 2 curve and then remove the livestock near the transition from Phase 1 to Phase 2. Nutritional needs of the livestock will determine where on the growth curve to start grazing a paddock. Livestock with a high nutritional requirement, such as milking cows or stockers, should be moved to high quality forage more frequently and will require forage growth that is lower on the Phase 2 curve. Livestock with lower nutritional requirements, such as beef cows, can be kept on a paddock for a longer time and can graze starting high on the Phase 2 curve and end when growth is low in that same phase.

During Phase 3, growth rate slows down as plants mature. Most of the plant's energy is going into seed production or maintenance. Grazing during Phase 3 will provide high yields, but low quality forage will limit performance of most livestock. Only livestock with low nutritional needs such as dry cows or dry ewes will have most of their nutritional requirements met during this growth phase.

When to start grazing in the spring?

When to allow livestock to start grazing in the spring is dependent upon what you are trying to accomplish. For most grazing operations managing the early spring growth of forages is the primary consideration to deciding when is the appropriate time to start the grazing season. Because forage growth of cool-season species can be very rapid in the spring, forage production can easily out-pace what livestock are able to consume. As a result, forage quality will decline rapidly in the pasture.

The decision on when to start grazing in the spring is a compromise between maintaining enough growing plant material in the pasture to promote rapid regrowth from healthy plants and keeping forage growth from out-pacing the livestock. Because of rapid forage growth, recommended plant heights for initiating grazing in the spring is less than the heights recommended for the rest of the grazing season. Table 5 provides the recommended plant heights for when to initiate grazing in the spring. Grazing forages starting at these heights and for short time periods (no more than 2 days) in a paddock system will provide higher quality feed for later in the season.

Livestock movement during the spring is another important consideration that will affect the balance between maintaining a rapidly growing, healthy pasture and maintaining quality forage for later in the season. Livestock will need to be rotated through the paddocks at a faster pace than typically averaged for the rest of the grazing season. When initiating grazing the forage production is low but dry matter is accumulating rapidly. For livestock to be rotated through all the paddocks, before forage growth out-paces consumption, the time spent on an individual paddock will need to be kept short. Clipping or harvesting hay in some paddocks can maintain forage quality if grazing is not keeping ahead of the spring growth forage quality.

It should be noted that during Phase 2 (Figure 1) of plant development (late April through late May) the minimum stubble heights are not of primary concern. Grazing during this period of time should be based upon short grazing periods. As the forages approach Phase 3 of their development the focus of grazing management should shift to minimum stubble heights as shown in Table 5.

When to move livestock from paddock to paddock?

Movement of livestock through paddocks in the early spring is discussed in the previous section **When to start grazing in the spring**. Once forage growth begins to slow (normally in late May) the movement of livestock is based upon the amount of forage available and the minimum stubble heights shown in Table 5.

Grazing should be terminated in a paddock when the livestock have grazed the forage down to the minimum stubble height.

A paddock is not ready to graze until the forage has reached the minimum height shown in Table 5, in the column labeled "Minimum and Optimum Height of Vegetative Growth".

Not every paddock will yield the same quantity of forage due to differences in soil conditions and landscape. Knowing how much forage is produced or available in each paddock is important. The following equations and tables determine how many animals will be needed to utilize the forage in a given period of time, and how much time a given number of animals will be able to graze a paddock.

A. *How many animals will a particular paddock support?*

The following equation calculates the number of animals a particular paddock will support:

$$\text{Number} = \frac{\text{(pounds of forage/acre) x (\# of acres)}}{\text{(individual animal weight) x (utilization rate) x (days)}}$$

Example:

$$\frac{\text{(1200 lbs/acre yield) x (8 acres)}}{\text{(1200 pounds/animal) x (4 day grazing period)}} = 50 \text{ head}$$

Pounds of forage/acre	Table 6 x inches of usable forage
Number of acres	Acres in a specific paddock
Individual Animal Weight	From Livestock Inventory
Utilization Rate	0.04 represents forage intake, trampling, and buffer
Days	Length of grazing period for a paddock

B. *How many days can my herd stay on a paddock?*

The following equation calculates the number of days a paddock will support a herd:

$$\text{Days} = \frac{\text{(pounds of forage/acre) x (\# of acres)}}{\text{(daily herd forage requirement)}}$$

For paddock management it is important to be able to estimate the quantity of forage on a paddock at a given time. This is especially important just prior to moving livestock into a paddock. Table 6 indicates forage quantity based on forage species, height of growth, and pasture condition.

Example:

$$\frac{\text{(1200 lbs/acre yield) (8 acres)}}{\text{(42,000 lbs) (0.04 utilization rate)}} = 5.7 \text{ days}$$

Pounds of forage/acre	Table 6 x inches of usable forage
Number of acres	Acres in a specific paddock
Daily herd forage requirement	Total herd weight x 0.04 utilization

There should be some residual stubble left in the paddock. The height of the stubble recommended for common grass species is given in Table 5. Subtract the required stubble height from the total forage height when computing pounds of forage available.

Growing conditions can change dramatically through the season, which will affect plant growth. For this reason, management must be flexible and not follow a set rotation pattern when moving animals. Movement of livestock from one paddock to another should be based on the height and the availability of forage. Grass and legume mixtures should be grazed in a manner that favors the dominant or desired species. The equations and tables referred to in this section provide estimates of available forage and how long livestock can graze an area. These are only estimates for planning with actual decisions based on routine pasture observations. A successful rotational grazing system requires continuous monitoring and adjustment to balance the needs of both the plants and livestock.

Pasture Soil Fertility Management

Proper fertilization of pastures allows for good stand establishment, promotes early growth, increases yield and quality, and improves winter hardiness and persistence. Adequate fertility also improves grass and legume ability to compete with weeds, and increases resistance to insects and diseases. Fields differ in their fertilizer needs. Take soil samples from representative areas to determine fertilization and liming requirements when converting to a rotational grazing system. Soil testing is the easiest and least expensive way to evaluate soil fertility and accurately assess if fertilizer is needed.

Can nutrients from livestock manure be utilized more efficiently in pastures?

Nutrients are primarily removed from pasture ecosystems by making hay. Animals also remove nutrients through grazing. When pastures are grazed, many of the nutrients are returned to pastures via urine and feces. About 60-80% of the nitrogen, 60-85% of the phosphorus, and 80-90% of the potassium are excreted in urine and feces. Manure also contains many micronutrients needed by pasture plants. If manure is evenly distributed throughout the paddocks, fertility can almost be maintained through natural nutrient recycling.

Often, a majority of the urine and feces is concentrated around water, shade, and other areas where livestock congregate. This concentration of manure can lead to nutrient deficiencies in other parts of the pasture. Not only does concentration of manure around water and shade sites lead to lower pasture productivity, it also leads to greater opportunity for nitrate contamination of surface and ground water.

To evenly distribute manure and increase soil fertility throughout the paddock, shorten the rotation, increase stocking rates, and place water, shade, salt, and supplemental feeders in nutrient poor areas. To minimize the amount of time animals spend around water, the cattle should not have to travel more than 600 to 800 feet in each paddock.

For more detailed information on soil test recommendations, contact your local Extension office or USDA Agricultural Service Center.

If additional fertilizer is needed, the applicator should avoid spreading materials within 100 feet of permanent watering or shade sites because manure is often concentrated in these areas.

When is increasing soil pH with lime important for forage production?

Overall, soil microorganism activity and plant nutrient availability are nearly optimum at a soil pH of 6.5 to 7.0. Lime applications should be made to increase soil pH to a level appropriate for the crop being grown. It is often best to grow species that are adapted to your soil pH (Table 7). Grass species are more tolerant of lower pH, whereas legumes need a more neutral pH. If the pasture planning strategy is to increase or introduce legumes into the pasture, correcting to the recommended soil pH is a must. Apply lime to the pasture following soil test recommendations. Surface applied lime will react slowly, so it should be applied 12 months before seeding.

Table 7. pH recommendations for different forage crops

Species	Optimum pH
Alfalfa	6.5 - 7.0
Smooth Bromegrass	6.0 - 7.0
Red Clover	6.0 - 7.0
Tall Fescue	5.6 - 7.0
Timothy	5.6 - 7.0
Switchgrass	5.6 - 6.5
Orchardgrass	5.6 - 6.5
Birdsfoot Trefoil	5.6 - 7.0

Table 8. Nitrogen recommendations for various pasture management situations

Management Situation	Nitrogen Rate* (lbs./acre)
Rotational grazing with adequate rainfall	150*
Continuous grazing with adequate rainfall	100*
Moderate rainfall	50
Sandy soils, steep slopes, low rainfall areas	30
Organic soils	50

* Use split applications
Source: Fertilizer Recommendations for Agronomic Crops in Minnesota, Minnesota Extension Service, BU-6420-E, 1995

How much nitrogen fertilizer do I need to put on my pasture?

Nitrogen (N) is often the most limiting nutrient in the production of grass for pasture or hay. Grazing animals normally return 60-80% of available nitrogen back to the pasture. Additional N fertilization may be needed depending on your yield goals (Table 8). Nitrogen will not only improve dry matter yield; it will lead to increased plant crude protein content and dry matter digestibility if plants are grazed before they get too mature.

Since legumes can fix their own nitrogen from the atmosphere, pastures with more than 30% legumes rarely need additional N fertilizer. It is often reported that 80-100 lb. N/acre produced by the legumes is gradually available to the associated grass plants.

Does phosphorus and potassium fertilizer improve pasture productivity?

Grasses may respond to phosphorus (P) and potassium (K) when nutrients limit plant growth. Phosphorus and potassium levels can increase seedling success by encouraging root growth. However, response to applied P and K is not usually profitable unless nitrogen supplies are adequate.

Legume-grass pastures have a higher requirement for P and K than do grass pastures. These two nutrients not only increase legume yields but also enhance disease resistance, winter hardiness, and stand life. Timing of application of P and K on legume-grass pastures is not critical, however, early spring or August applications are favored.

Applications can be made each year or you can double the rates and apply every other year. Tables 9 and 10 list the P and K recommendations based on soil test results.

Pasture Brush and Weed Control

Weeds compete with desirable plants for water, nutrients and light. They can reduce yields of desirable species and can cause problems with animal health, animal weight, and/or milk production. Effective weed management begins with proper establishment of forage species that are adapted to soil, climate, and intended uses. Under these conditions, weeds can often be managed through appropriate grazing management and proper maintenance of soil fertility.

Broadleaf weeds tend to be the most troubling in perennial grass pastures. Many broadleaf weeds are on the noxious weed list and several are poisonous to livestock. These broadleaf weeds are generally less palatable, less nutritious, lower yielding and are less dependable as a forage supply for livestock. Weeds with known palatability problems include: musk, plumeless and bull thistle, nettles, absinth wormwood, perennial sowthistle, swamp smartweed, and common mullein.

Can unwanted weeds be controlled through grazing?

Many weeds are unpalatable when mature but readily grazed when immature. Therefore, grazing practices can greatly influence whether weeds are routinely grazed or selectively passed over. Continuously grazing a pasture with low stocking density frequently leads to selective grazing. This can lead to increased weed and brush problems. Continuous grazing at high stocking rates will often weaken desirable species. This can lead to rapid weed invasion.

Table 9. Phosphate recommendations for grass and grass-legume pasture based on soil test results.

		Phosphorus (P) Soil Test (ppm)				
Pasture Type	Bray:	0-5	6-10	11-15	16-20	21+
Yield goal/acre	Olsen:	0-3	4-7	8-11	12-15	16+
		P_2O_5 to Apply (lb./acre)				
Grass						
2 ton		40	20	10	0	0
> 2 ton		60	40	30	0	0
Grass-Legume						
2 ton		35	25	15	0	0
3 ton		55	40	25	10	0

Source: Fertilizer Recommendations for Agronomic Crops in Minnesota, University of Minnesota Extension Service, BU-6420-E, 1995

Table 10. Potash recommendations for grass and grass-legume pasture based on soil test results.

	Potash (K) Soil Test (ppm)				
Pasture Type	0-40	41-80	81-120	121-160	161+
	K_2O to Apply (lb./acre)				
Grass					
2 ton	70	50	25	0	0
> 2 ton	110	90	65	20	0
Grass-Legume					
2 ton	95	65	40	15	0
3 ton	140	100	60	20	0

Source: Fertilizer Recommendations for Agronomic Crops in Minnesota, University of Minnesota Extension Service, BU-6420-E, 1995

Noxious weeds must be controlled according to Minnesota State law (primary noxious weeds) and county law (secondary noxious weeds). Listed are the primary noxious weeds in Minnesota; other states may have different lists.

Perennials	*Biennials*	*Annuals*
Poison Ivy	*Bull thistle*	*Hemp*
Leafy spurge	*Musk thistle*	
Field bindweed	*Plumeless thistle*	
Perennial sowthistle		
Canada thistle		

Producers who have successfully implemented rotational grazing management often find that their pasture weed problems begin to diminish within the first few years of grazing. This is primarily because of the improved vigor and competitiveness of desirable

species and regular grazing of weeds in their more palatable, immature growth stage.

Grazing management alone, however, will not normally correct serious preexisting weed problems without great losses in animal performance. Plants such as thistles, brush, and poisonous plants may continue to be a problem even after you have intensified your grazing system. This is because even at high stocking rates cattle seldom eat these weeds.

Sheep or goats can offer an alternative weed control method. They often will consume plants that other animals avoid. As a result, there are opportunities for sheep and goats to be used as an environmentally friendly and cost effective way to control weeds. This method of control is especially practical when the weeds are located in areas where other control means are impractical.

What are the cultural and mechanical brush and weed control alternatives for pastures?

A. Cultural Control:

Several cultural practices help maintain a weed-free pasture. Weeds are generally more of a problem in overgrazed, in fertile, well-managed pastures. Good grazing management (which includes pasture rest periods) and good fertility will go a long way in keeping the desirable forage species healthy and able to compete with pasture weeds. To prevent the spread of weeds, avoid spreading manure contaminated with weed seeds, clean equipment after working in weed-infested pastures, and keep fenerows free of problem weeds.

B. Mechanical Control:

Mechanical weed management involves the physical removal of all or part of the weeds and brush. Repeated mowing, clipping and hand weeding can diminish weed infestations. When in the bud to early bloom stage, cut weeds 3 to 4 inches above the soil. Mechanical weed control is more successful when coupled with good fertilization and grazing management.

Biennial and perennial weeds tend to be the most troublesome in established pastures. Biennials, such as musk and plumeless thistle, reproduce only by seed. They require a two-year period to produce seed. Clip annual and biennial weeds to prevent seed production.

Perennial weeds, such as Canada thistle and absinth wormwood, reproduce by seed, but also spread by vegetative parts such as underground roots or rhizomes. Clip perennial broadleaf weeds at the bud to flowering stages to maximize depletion of root carbohydrates. Repeated clipping of perennial broadleaf weeds with upright growth habits at 4-week intervals will eventually kill an infestation over a 2 to 3 year period, but may not be practical. Many perennials that persist in hay fields are adapted to the cutting schedules and growth habit of forages such as alfalfa. One such weed is quackgrass, the most common perennial grass weed of Minnesota. It is often similar in forage quality and yield to forage grasses. Other than hemp, annual weeds should not persist beyond the establishment year, unless soil disturbance such as overgrazing, exposes soil.

Other options include tillage and burning. Tillage can be used to suppress weeds as part of a pasture renovation program but is seldom used to manage weeds in a good pasture. Periodic burning may be a beneficial weed suppression tool and can be used in combination with mowing on woody plant species. Burning should be used as the first treatment and mowing used for the subsequent years.

When is control of brush and problem weeds with herbicides the best option?

Even with the best cultural and mechanical methods of control, serious weed problems may need to be controlled with herbicides. The use of herbicides is justified when used with proper grazing management and where herbicide use results in desirable economic returns. Frequently, weeds are patchy, making spot spraying the preferred method of control. Spot spraying is less costly than broadcast applications. Correct identification of problem weeds is critical for successful control with herbicides. Consideration should be given to impacts on surface and groundwater, plant communities and wildlife habitat before herbicides are used. Always read and follow labels when selecting and using herbicides.

A variety of herbicide options exist for broadleaf weed control in grass pastures. No herbicides are labeled to selectively remove broadleaf weeds from legume-grass pastures without severe legume injury. Likewise, no herbicides are labeled to selectively remove unwanted grasses from cool-season grass pastures.

To control biennials such as musk thistle in pastures, apply herbicides in the spring or fall to the rosettes. This results in better control than herbicides applied after the flower stalk elongates. Perennial weeds are typically best controlled with herbicides after the early bud to flowering stage of growth. Fall herbicide applications usually provide the best control of biennial or perennial weeds. Fall applications of herbicide also control any seedlings that may have emerged. In established hay, most herbicides are applied to dormant forages or between cuttings to avoid excessive injury.

Sacrificial Paddock Management

How will the livestock be managed during times of drought or wet conditions?

At some point in time, very wet weather or very dry weather will dominate a significant part of the growing season. Long periods of wet weather can be detrimental if the soil is so wet that livestock traffic causes damage to the roots and growth buds of the forages. Livestock traffic on wet soils can also destroy soil structure, cause compaction, reduce the ability of the soil to absorb rainfall, and reduce the exchange of air between the soil and the atmosphere. Livestock travel in wet lanes can cause the lanes to become muddy, rutted, and easily eroded.

Extended dry weather will reduce the ability of the forage to produce new growth, reducing pasture yield. Paddocks may not have an adequate rest period to replenish the forage to a point where livestock can be allowed to graze them. The tendency of producers is to allow the livestock to continue the rotations, leading to an overgrazed situation. This will have a detrimental effect on forage production in the future.

In both situations (very wet or very dry) it is best to remove livestock from the pasture into a feedlot. Grazing can resume when forage and soil conditions permit.

Another method is to retain the livestock in one paddock or a portion of one paddock and provide some type of emergency feed, such as hay, until weather conditions improve. This is referred to as a sacrificial paddock. It is better to have a serious negative impact on a small area of the pasture system than to continue moving livestock through the paddocks, grazing the forages below the minimum stubble heights which will cause long-term yield reduction.

The area used as a sacrificial paddock should be one where the soils have good trafficability, erosion potential is slight, there is easy access to provide feed, and rejuvenation is relatively easy.

Will sacrificial paddocks be rejuvenated after removal of livestock?

When livestock are placed back into a regular rotation, the sacrificial paddock will likely be in poor condition. The vegetation will most likely be gone or in very poor condition and the area may be in a rough and rutted condition. There are two options to consider:

1.) The sacrificial paddock can be left to regenerate on its own. This may be successful if the livestock did not cause significant damage to the soil. The forages that were on the site prior to its use as a sacrificial paddock may resume growth after an extended rest period. The primary risk involved is that undesirable vegetation, such as weeds, will become the predominant vegetation on the site.

2.) Another option is to prepare the site with tillage equipment and reseed it to desirable forage species. This may be the best option if the sacrificial paddock has been in use for a relatively long period of time.

See University of Minnesota bulletin AG-BU-3157, Cultural and Chemical Weed Control in Field Crops

Grazing System Monitoring

Pasture Record Keeping

How do I know I have enough forage available?

There are various methods of making a determination of available forage. One of the most useful is the Reserve Herd Days (RHD) concept. This method is a powerful tool because it is quick, easy, sufficiently accurate, and provides meaningful information to producers. The term Reserve Herd Days expresses the number of days of grazing remaining when considering the amount of forage currently on hand in the pasture system. Using this concept will provide the following:

- A determination of how much forage is on hand at the present time, expressed as a number of days of grazing currently available for your herd.
- A determination of where the forage is (which paddocks).
- A measurement of the ebb and flow of forage available over time.
- An indication of pasture condition and the trend in the condition.
- A guide to decision making when excesses and shortages of forages are apparent.

There are two commonly used methods of making RHD determinations, A.) Visual and B.) Calculated.

A. Visual Method:

This method requires a producer to go into the pasture and make an estimate of the number of days the herd will be able to graze each paddock. This estimate is based upon a visual determination of the quantity of forage available and how many days it will take the herd to graze the forage to the allowable stubble height.

The information is recorded so that comparisons can be made from week to week and from year to year. A blank form is available in Appendix F.

B. Calculated Method:

This method is a little more involved than the visual method, but it provides a more accurate estimate. The small amount of extra time required is worth the benefit of having more information on hand with which to make comparisons.

The following information is required to determine RHD with this method:

- The acres within each paddock.
- The estimated pounds of dry matter per inch of height per acre for the forages within each paddock. This information is available from Table 6.
- The estimated pounds of dry matter the herd will utilize per day. This is simply the total weight of the herd multiplied by the utilization rate (0.04).

A blank form is available in Appendix G. Completion of this form requires going into each paddock, measuring the height of the forage, and placing the information in the correct spot on the form. The inches of forage available is the amount of the forage above the minimum stubble height.

The total pounds of available forage divided by the pounds of forage required each day by the herd (Daily Allocation) equals the Reserve Herd Days. If this number is small you may run out of forage soon. If the RHD is large there may be adequate forage available to harvest some as hay. Other options exist, but consideration must be made for the period of the grazing season when the determination is made, the current weather conditions, possible changes in the size or makeup of the herd, as well as your management objectives. Having this information recorded is important for making comparisons throughout the grazing season, as well as from season to season.

Is the productivity of the pasture increasing?

Forages that are in good condition will produce more feed than forages that are in poor condition. The worksheet **Determining Grassland Condition/Trend** (Appendix C) is a useful tool for assessing changes in the condition of the overall pasture. Condition of the forages is a significant factor considered in the completion of the form. An initial determination followed by annual monitoring will provide insight into the overall productivity changes. This evaluation should be done in the same area of the pasture and at the same time of the year each time to make the results meaningful.

Clipping and weighing pasture areas each year at the same location and same time of the year will provide useful information to determine the trend of productivity for a pasture. Instructions for this procedure are found in "Pastures for Profit".

Another method of determining if the productivity is increasing is to weigh livestock at the beginning and end of each grazing season. This assumes that livestock will produce more if offered more forage to consume. This system of monitoring should be used with caution, since many variables can affect the end of season weights, such as parasite infection in the livestock, genetic changes in the herd, calving dates, or even the weather conditions.

Records should be kept to document the number of animal grazing days on each paddock. This provides information regarding how many head of livestock can be supported by a pasture system. The records are basically a record of: a.) day the animals were turned into a paddock, b.) day they were removed, c.) number of animals and their weight, d.) kind and class of livestock, e.) height of the forage when grazing was initiated and f.) height of the forage when the grazing was terminated.

Are the natural resources improving?

The condition of the soil, forages, watercourses, and bird populations within a pasture system provides insight into the effectiveness of the grazing management. Actions that benefit these resources will likely have a positive effect on the production of forages.

It is important to record the results of tests made or observations made so that meaningful comparisons can be made over time.

A. Soils:

Soils are in good condition when they allow easy infiltration of rainfall, easy exchange of air with the atmosphere, and support a wide range of life-forms (bacteria, fungi, earthworms, etc.). In addition, organic matter content is a good indicator of the health of the soil.

B. Watercourses:

Well managed grazing will lead to improvements to watercourses within the pasture system. Features such as erosion in the bottoms and sides of channels should be noted, as well as the condition of the existing vegetation. Monitoring the condition of the watercourses in future years will indicate changes needed in the management of the grazing system.

C. Forages:

Refer to the form **Determining Grassland Condition/Trend**, discussed earlier (Appendix C). This form is very good for monitoring forage condition. This considers such aspects as the species composition of the pasture (desirable vs. undesirable), plant density, and plant vigor.

D. Bird Populations:

Birds are excellent "barometers" of the environmental condition of your pastures and your farm. Their populations react quickly to changes in conditions that affect their food sources and nesting habitat. In general, the more diverse the species and the higher the counts within each species, the healthier the environment on your farm. Select points within the pasture to use to do periodic bird counts, and then plan to do bird counts three times per year at each site.

Grazing Plan Example

This section presents an example of a grazing plan. It represents a starting point for a rotational grazing system. Six elements of the plan are illustrated: Sensitive Areas, Livestock Summary, Fencing System, Livestock Watering System, Forages, and Grazing System Management. This plan is based upon the information gathered in the inventory phase of plan development.

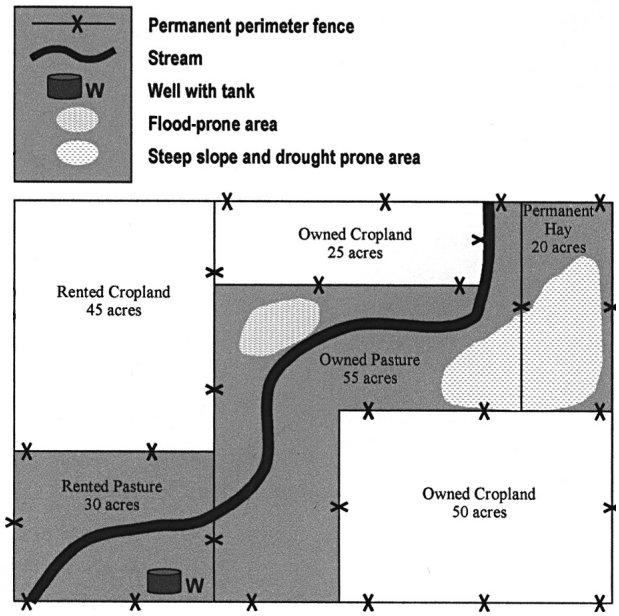
Sensitive Areas

The following sensitive areas are identified in this grazing unit (Diagram 6):

a.) The stream flowing through the pasture is a sensitive area because uncontrolled access to this area by the livestock will cause streambank erosion as well as degrade water quality. Manage these resources by breaking the pasture into smaller paddocks and reducing the amount of time the livestock have access to any segment of the stream.

Currently the streambanks are in poor condition in some locations. This is due to the livestock traveling to the stream to get water. Reduce the impact of the herd on the stream by subdividing the pasture, rotating the grazing, and providing alternative drinking facilities for the livestock. With the planned subdivision of the pasture, the livestock will have access to the stream from only three paddocks.

Diagram 6. Pasture Inventory Map



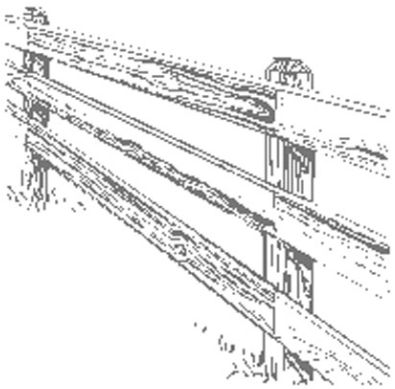
b.) The flood prone area can easily be damaged by livestock traffic during periods of wet weather or shortly after flooded conditions. Proper monitoring of the grazing system will avoid damage to this area.

c.) The steep slope (Diagram 6), which is also drought prone, is a sensitive area because it is easily damaged by over-utilization and livestock traffic. This area can be managed closely by subdividing the pasture into paddocks, rotating the grazing, and monitoring the condition of the forage and soil to prevent damage.

Livestock Summary

Currently there are 25 cow/calf pairs using the pasture. This plan considers increasing the size of the herd to 35 cow/calf pairs. The average weight of the cows is 1200 pounds. These animals are currently managed as one herd. In addition, a herd bull will be used with an average weight of 2000 pounds.

Monthly and season-long forage requirements are estimated on the **Livestock Forage Monthly Balance Sheet** (Table 11). This indicates that there will be a surplus of forage on a season-long basis. The monthly balance indicates that there will be adequate to surplus quantities of forage through July, and a very small shortage of forage in August. A rather large deficiency occurs during the months of September and



October. The forage balance indicates that some of the pasture may be harvested for hay in the spring, and this will be done when weather conditions appear to be favorable to forage regrowth. This will provide feed for the months of September and October. Refer to the **Grazing System Management** portion of this plan for information related to grass management and sacrificial paddocks to be used during this time period.

Fencing System

Perimeter fences are already in place and are in adequate condition. Interior fences will be constructed to subdivide the pasture into paddocks using 1 or 2 strands of high tensile wire. Locations of the fences are shown on the Grazing Plan Map (Diagram 7).

The installation of the interior fences will break the pasture unit into ten paddocks, ranging from 7-10 acres each. Approximately 13,000 feet of interior fence is required for this system. During periods of average growth, each paddock will be capable of approximately 2-4 days of grazing. In addition to subdividing the pasture, lanes will be constructed. The lanes will allow movement of the livestock from a paddock to any other without passing through a recently grazed paddock.

Where the lanes cross the stream, the stream banks and channel will be shaped and stream crossings will be installed heavy use area protection measures.

Table 11. Livestock Forage Monthly Balance Sheet - Current Forage Summary

Field	Kind of Forage	Forage Yield (lbs/acre)	Acres	Total Yield (lbs)	Forage Availability Per Month (lbs x 1000)					
					May	June	July	Aug	Sept	Oct
Rented	Red Clover/ Orchardgrass	4,500	30	135,000	33.8	54.0	27.0	13.5	6.8	0.0
Owned	Red Clover/ K. Bluegrass	3,500	38	133,000	33.3	53.2	26.6	13.3	6.7	0.0
Owned	Reed Canarygrass	3,500	17	59,500	1.9	17.9	14.9	6.0	6.0	3.0
Owned	S. Bromegrass/ Alfalfa	4,500	20	49,500	for hay	for hay	31.5	18.0	0.0	0.0
Total lbs. Forage Available (x 1000)				377,000	78.9	125.1		50.8	19.4	3.0
Total lbs. Forage Required by Livestock (x 1000)				312,000	50.4	50.4	52.8	52.8	52.8	52.8
Total lbs. Forage Excess or Deficiency (x 1000)				65,000	28.5	74.7	47.2	-2.1	-33.5	-49.8

Table 12. Livestock Forage Monthly Balance Sheet - Current Livestock Summary

Kind/Class Livestock	Number of Animals	Average Weight	Monthly Utilization	Forage Requirements Per Month (lbs x 1000)					
				May	June	July	Aug	Sept	Oct
Beef cow/calf	35	1200	1.2	50.4	50.4	50.4	50.4	50.4	50.4
Herd bull	1	2000	1.2			2.4	2.4	2.4	2.4
Totals	36			50.4	50.4	52.8	52.8	52.8	52.8

*0.04 daily utilization rate (includes forage waste) x 30 days/month.

Livestock Watering System

Water will be delivered from the well through a high-density plastic hose system laid on top of the ground (Diagram 8). Portable tanks will be used as drinking facilities. They will be moved with the herd as they graze through the pasture system. Approximately 6,400 feet of pipeline is required, along with two portable tanks. Refer to Diagram 8 for locations of the water pipelines.

The pipelines and tanks do not require frost protection, since they will be drained every fall prior to freezing.

Forages

The existing forages in these pastures are:

Paddocks 7, 8, 10:
Orchardgrass
Paddocks 5, 6:
Reed Canary Grass
Paddocks 1, 2, 3, 4:
Kentucky Bluegrass

The current condition of the forages is poor. To improve the pastures all paddocks, except for the area of reed canarygrass, will be frost seeded with clover to provide nitrogen for increased yield and to improve the nutritional value of the forage mix.

To provide and better quality and quantity of forages during the midsummer slump that cool season grasses go through, the alfalfa/bromegrass hay field will be utilized after one crop of hay has been harvested.

Yields are estimated on Table 11. These are only estimates based upon expected yields with the planned improvements in place. Actual yields should be determined when the rotational grazing system is in place. The grazing system will require monitoring to maximize forage utilization without overgrazing.

Diagram 7. Fence Location Map

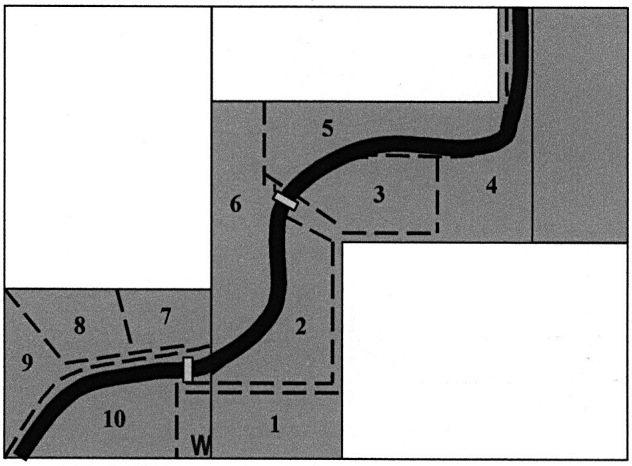
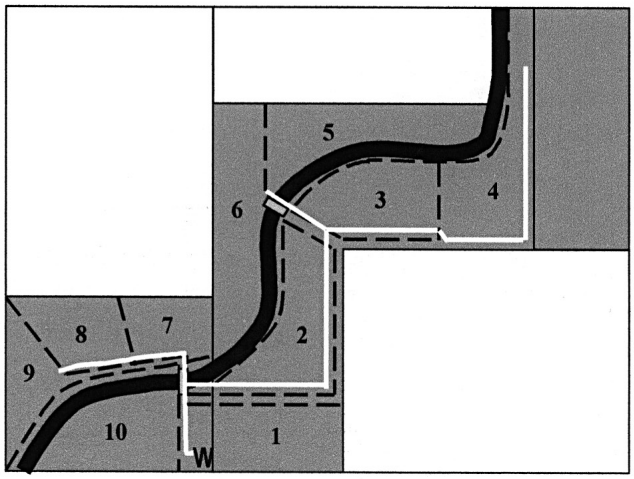


Diagram 8. Water Location Map



Stream
Temporary interior fence
Stream crossing
Water well
Water pipeline

Grazing System Management

The key to maintaining vigorous vegetation is to avoid overgrazing. The forage plants will recover from grazing without depleting root reserves only if there is adequate leaf area remaining to meet the food requirements of the plant.

Initiate grazing in early spring when the orchardgrass is 3-4 inches tall, reed canarygrass is 4-5 inches tall, and the grass in the Kentucky bluegrass paddocks is 2 inches high. Because the grass growth in the spring is rapid, the livestock should be moved through the system from paddock to paddock at a fairly rapid pace, every 1-2 days if possible. As the grass growth slows later in the growing season, slow the rotation through the paddocks to an approximate interval of 4-6 days, basing movement of the livestock on:

- The minimum stubble heights of the forages:
  - 2 inches for Kentucky bluegrass
  - 3 inches for orchardgrass
  - 4 inches for reed canarygrass.
- The minimum required regrowth:
  - 4 inches for Kentucky bluegrass
  - 6 inches for orchardgrass
  - 8 inches for reed canarygrass

The number of actual grazing days will vary with the size of the paddock, and in practice it will vary with the condition of the forage, how much grazing pressure has been applied in the past, weather conditions, and time during the grazing season.

The hay field will be used for grazing during the summer after a crop of hay has been harvested and regrowth is sufficient. This will provide high quality forage for mid to late summer, and will allow an extended rest period for the other paddocks at a time of the season when they need it (35-50 days). The hay field will be subdivided by temporary fence into 3 paddocks to allow better management of the forages.

The balance of forage available and forage required indicates that there will be significant periods of time during September and October when the livestock will need to be placed into a sacrificial paddock in late summer and early fall and fed hay because there will not be adequate forages for grazing in the pastures. Plan on having hay on hand for this from the harvest of excess available in June and July.

During very wet weather, livestock traffic may cause excessive damage to the soil or the forage. If this occurs, move the livestock from paddock to paddock more rapidly, or confine the animals to the feedlot (or use a sacrificial paddock) and provide them with emergency feed. When conditions improve, put the livestock back into a regular rotation.

During very dry weather, the forage growth will slow considerably. The livestock should be moved at a slower pace through the paddocks. If minimum stubble height cannot be maintained, confine the livestock to a portion of one of the paddocks (a sacrificial paddock) and provide them with emergency feed until they can be put back into a regular rotation.

Do not use any of the sensitive areas as sacrificial paddocks.

Regrowth of the forage prior to fall freeze-up is important for maintaining health and vigor of the plants through the winter. Prior to a killing frost, the forage should have 6 inches of regrowth on the reed canarygrass and orchardgrass, and 4 inches on Kentucky bluegrass. Since these heights are not possible to attain on all paddocks, manage one third of the paddocks so that they get the required regrowth each year, and then alternate this treatment from one year to the next. This regrowth can be grazed to the minimum stubble heights as stockpiled forage after the forages go dormant, about mid October.

Fertilization of the pastures will be done to ensure optimum yields. Fertilizer applications will be based on soil tests and economic analysis. The pH of the soil will be maintained between 6.0 to 7.0.

Overwintering will not be done on this pasture system. Each paddock will be clipped as the livestock are rotated out if needed to control weeds.

"Grazing Management, Pasture Fertility, Weed Control and Species

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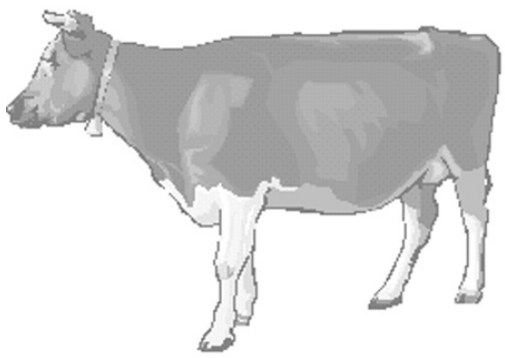


Appendix A. Livestock Forage Monthly Balance Sheet

Producer: _____ **Location:** _____ **Date:** _____

LIVESTOCK SUMMARY

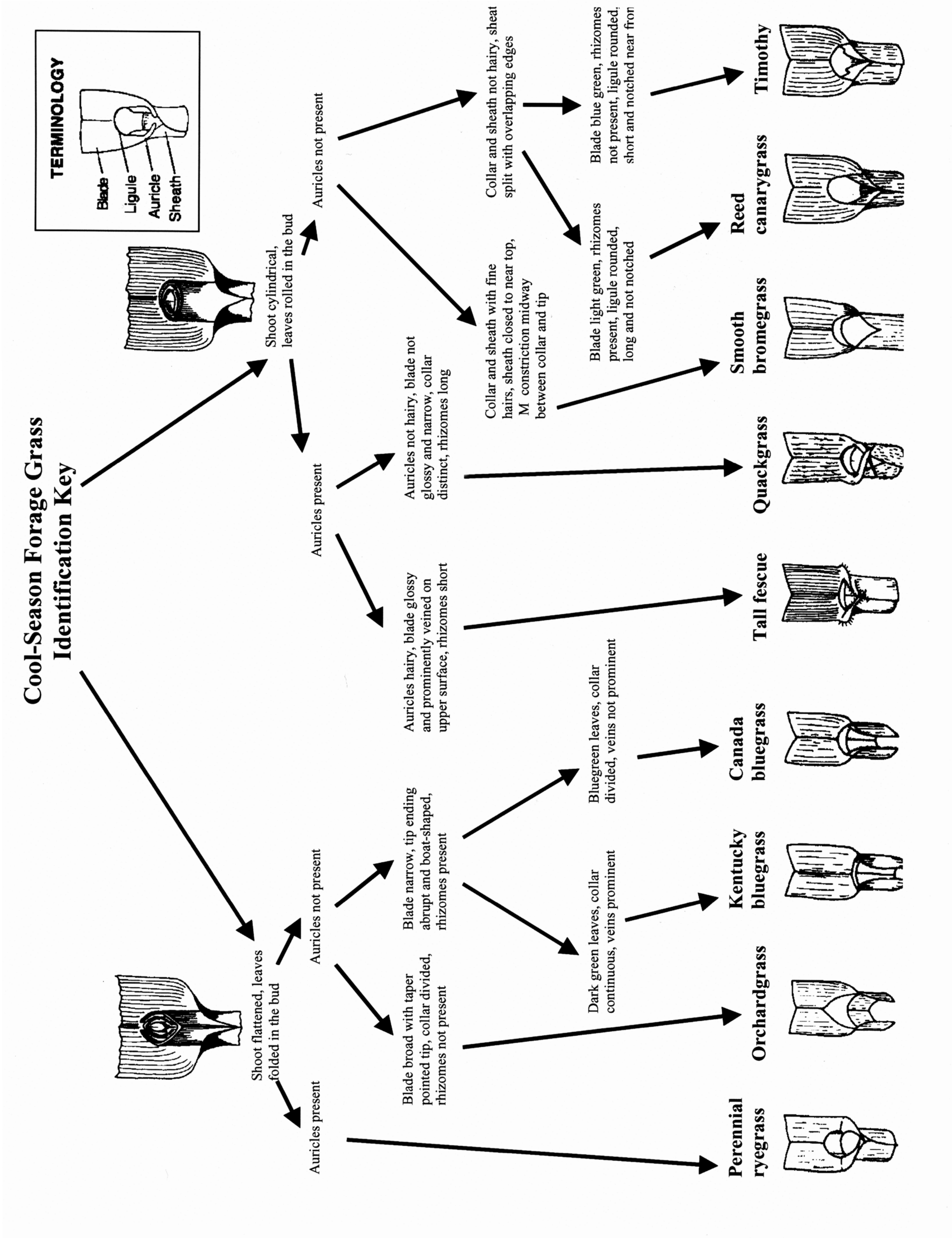
Kind/Class Livestock	Number of Animals	Average Weight		Forage Requirements Per Month (lbs. x 1000)							
				Apr	May	June	July	Aug	Sept	Oct	
			1.2*								
			1.2*								
			1.2*								
			1.2*								
			1.2*								
			1.2*								
Totals											

*0.04 Daily utilization rate (2.5% intake, 0.5% trampling loss, and 1% buffer) x 30 days/month

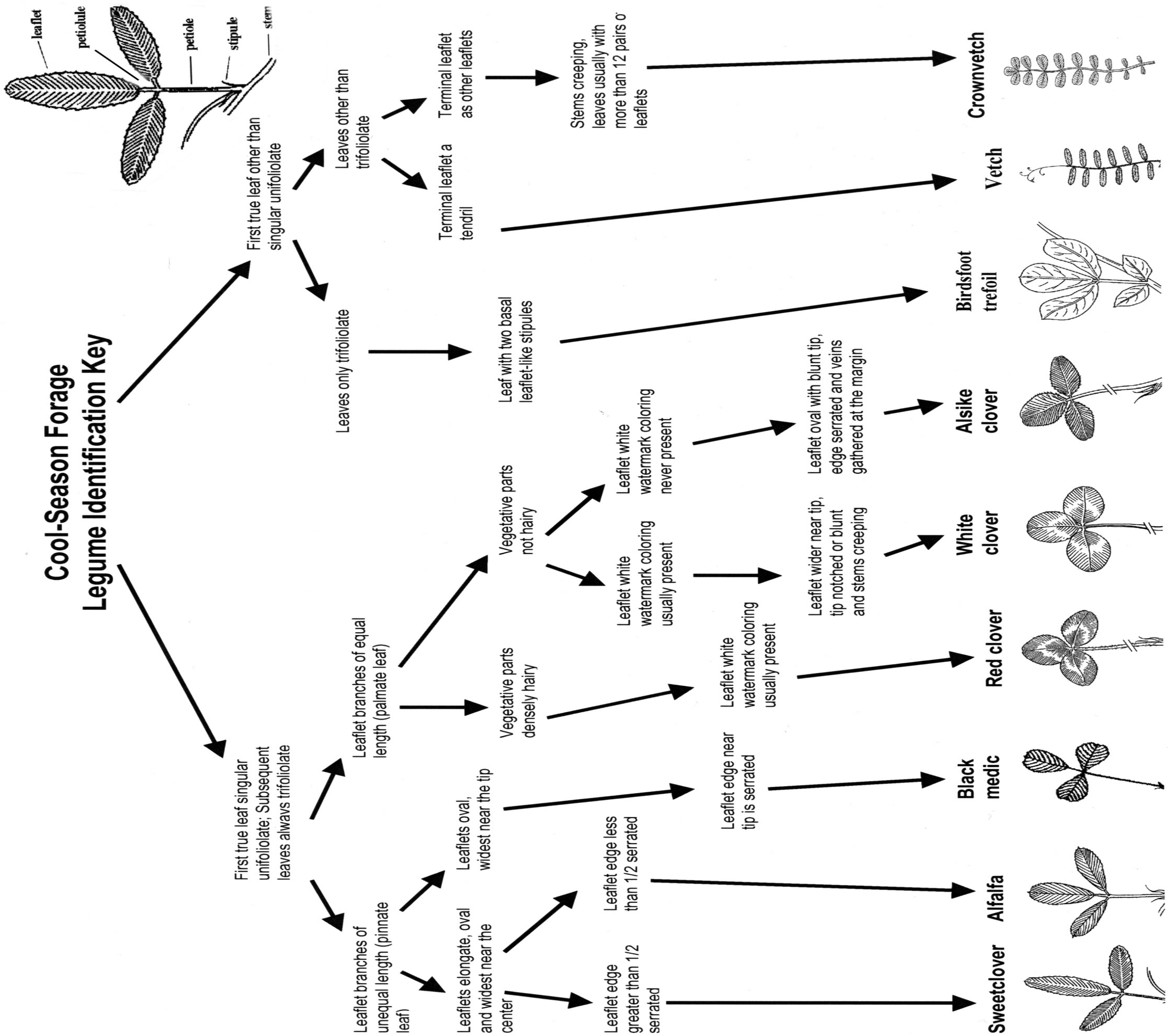
FORAGE SUMMARY

Field	Kind of Forage	Yield/Acre	Acres	Total Yield	Forage Requirements Per Month (lbs. x 1000)						
					Apr	May	June	July	Aug	Sept	Oct
Total lbs., Produced from Forage (x 1000)											
Total lbs., Required for Livestock (x 1000)											
Total lbs., Excess/Deficiency (x 1000)											
Totals											

Appendix B1. Identification Key for Common Forage Species - Grass



Appendix B2. Identification Key for Common Forage Species - Forage



C1. Determining Grassland Condition/Trend

Producer: _____ Date: _____

County: _____ Recorded By: _____

Tract #: _____

	Field #					
	Acres					
	Month & Year	**M __ Y __**	**M __ Y __**	**M __ Y __**	**M __ Y __**	**M __ Y __**
Category	**Score**	**Value**	**Value**	**Value**	**Value**	**Value**
1) Species Composition	Undesirable Desirable 0 1 2 3 4					
2) Plant Diversity	Narrow Broad 0 1 2 3 4					
3) Plant Density	Sparse Dense 0 1 2 3 4					
4) Plant Vigor	Weak Strong 0 1 2 3 4					
5) Legumes in Stand	Less than 10% More than 40% 0 1 2 3 4					
6) Plant Residue	Deficient Appropriate Excess 0 1 2 3 4					
7) Uniformity of Use	Spotty Intermediate Uniform 0 1 2 3 4					
8) Severity of Use	Heavy Moderate Light 0 1 2 3 4					
9) Woody Canopy	More than 40% Less than 10% 0 1 2 3 4					
10) Soil Erosion	Severe Moderate Slight 0 1 2 3 4					

Appendix C2. Inventory Category Items

1) **Species Composition -** Visually estimate the % composition by weight of each group of plants and assign a value. The categories desirable, intermediate, and undesirable refer to the preferred use of the plants by the grazing animal, and intended use of the grazing land. The score ranges from "0", with no or few desirable or intermediate plant species, to "4", which represents mostly desirable or intermediate plant species present.

2) **Plant Diversity -** Evaluate the number of different species of plants that are well represented on the site. If only one species of plant occurs, diversity is narrow; if eight or more species of plants are present, diversity is broad. If 4-5 plant species are present, the score would be in the middle of this range.

3) **Plant Density -** Ignore plants classified as undesirable. Visually estimate the density of living desirable and intermediate plant species that would be present at a 2-inch stubble height. Ask yourself if there is room for more desirable plants? Scores range from Dense (>95%), Medium (75-85%), Sparse (<65%).

4) **Plant Vigor -** Evaluate the health and productivity of the desirable and intermediate plant species. Look for evidence of plant color; leaf area index; plant reproduction; presence of disease, or insects; rate of growth and re-growth, etc. Area plants growing at their potential?

5) **Legumes in Stand -** Visually estimate the % composition by weight of the legumes present in the stand on the area being evaluated. 0=<10%, 1=10-19%, 2=20-29%, 3=30-39%, and 4=>40%.

6) **Plant Residue -** Evaluate the dead and decaying plant residue on the soil surface. Excessive levels of residue inhibit plant growth and vigor. Appropriate levels of residue do not inhibit plant growth but help retard runoff, reduce soil erosion, improve water intake, recycle nutrients to the soil surface, and provide a favorable microclimate for biological activity. Deficient residue levels result in bare or near bare ground cover beneath the growing plants.

7) **Uniformity of Use -** Evaluate how well the animals are grazing all plants to a moderate uniform height throughout the field. Spotty grazing appears as uneven plant heights, with some plants or parts of the field grazed heavily and other areas grazed only slightly or not at all.

8) **Severity of Use -** Evaluate the severity of use by grazing animals based on plant stubble height in the field. For cool season grass species and legumes a stubble height of sell than 2 inches would indicate heavy use; stubble height of 2-6 inches would indicate moderate use; and stubble height more than 6 inches would indicate light use. For warm season grasses increase the height in each category by 2 inches.

9) **Woody Canopy -** Estimate the percent canopy (area shaded at noon) of woody plant cover over six feet tall. 0=>40%, 1=30-39%, 2=20-29%, 3=10-19%, 4=<10%.

10) **Soil Erosion -** Visually observe signs of any type of erosion and assign a severity rating for the field being evaluated.

Appendix D1. Average Forage Yields for Northern Minnesota and Northern Wisconsin

			----------% Availability by Month----------					
Species	**Quality (lb/a DM)**	**Yield**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**
Cool Season Grasses								
Kentucky Bluegrass	Good	4700	30	20	20	10	15	5
	Poor	1240	15	45	15	10	10	5
Orchardgrass	Good	5580	25	20	20	15	15	5
	Poor	1520	20	35	20	10	10	5
Reed Canarygrass	Good	5460	25	20	30	10	10	5
	Poor	1940	25	30	20	10	10	5
Smooth Bromegrass	Good	4900	35	20	20	10	10	5
	Poor	1780	30	30	15	10	10	5
Tall Fescue	Good	6000	15	25	20	15	15	10
	Poor	1740	20	45	15	5	10	5
Timothy	Good	4800	25	30	15	10	15	5
	Poor	1600	15	50	10	10	10	5
Warm Season Grasses								
Big Bluestem	Good	3500	0	0	25	50	25	0
	Poor	2520	0	0	30	45	25	0
Switchgrass	Good	4830	0	0	35	50	15	0
	Poor	2170	0	0	30	45	25	0
Sudangrass	Good	5500	0	0	20	30	30	20
	Poor	3000	0	0	40	45	15	0
Legumes								
Alfalfa/grass	Good	5540	20	30	30	20	0	0
	Poor	3000	20	30	30	20	0	0
Birdsfoot Trefoil	Good	4320	10	40	35	15	0	0
	Poor	2500	10	40	35	15	0	0
Red Clover/grass	Good	5500	20	30	30	20	0	0
	Poor	2750	20	30	30	20	0	0
Alternative Forages								
Oat	Good	2500	55	35	10	0	0	0
	Poor	1600	60	40	0	0	0	0
Oat + Rape	Good	2410	30	45	25	0	0	0
	Poor	1600	30	45	25	0	0	0
Winter Rye	Good	2300	55	25	0	0	5	15
	Poor	1200	65	25	0	0	5	5

Source: “Pastures for Profit”: A Guide to Rotational Grazing, University of Minnesota, AG-FO-6145
[1]Good Condition = lime, P, K and Split Napplication plus rotational grazing management
Poor Condition = no fertilizer added plus continuous grazing management

Appendix D2. Average Forage Yields for Southern Minnesota and Southern Wisconsin

			----------% Availability by Month----------					
Species	**Quality (lb/a DM)**	**Yield**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**
Cool Season Grasses								
Kentucky Bluegrass	Good	5680	30	30	10	10	15	5
	Poor	1900	10	40	10	15	15	10
Orchardgrass	Good	6440	20	35	15	10	15	5
	Poor	2260	10	30	10	20	20	10
Reed Canarygrass	Good	6180	20	30	25	10	10	5
	Poor	2720	20	30	20	10	15	5
Smooth Bromegrass	Good	6080	30	30	15	10	10	5
	Poor	2620	25	35	10	10	15	5
Tall Fescue	Good	7940	20	30	20	10	15	5
	Poor	2740	15	40	10	10	15	10
Timothy	Good	6260	25	35 45	10	10	15	5
	Poor	2340	10		10	15	15	5
Warm Season Grasses								
Big Bluestem	Good	5000	0	10	40	35	15	0
	Poor	2520	0	15	40	35	10	0
Switchgrass	Good	5000	0	15	35	35	15	0
	Poor	2500	0	15	45	35	5	0
Sudangrass	Good	5500	0	0	20	30	30	20
	Poor	3000	0	0	40	45	15	0
Legumes								
Alfalfa/grass	Good	5820	20	25	35	20	0	0
	Poor	3000	20	25	35	20	0	0
Birdsfoot Trefoil	Good	5120	10	50	30	10	0	0
	Poor	2500	10	50	30	10	0	0
Red Clover/grass	Good	5500	25	40	20	10	5	0
	Poor	2750	25	40	20	10	5	0

Source: “Pastures for Profit”: A Guide to Rotational Grazing, University of Minnesota, AG-FO-6145

[1]Good Condition =l ime, P, K and Split Napplication plus rotational grazing management

Poor Condition = no fertilizer added plus continuous grazing management

Appendix E. Water Systems Design Considerations

A. Ramps to Surface Water:

Restricted access points consist of ramps which direct livestock to drink from limited areas of a lake, pond, or stream. During fence construction, a hard surface is installed to keep the livestock confined to the access point.

Advantages:

- Livestock will not have free access to open water sources except at controlled points, helping to reduce water quality problems.
- Capacity is not an issue, unless the water source is unreliable.
- No power required.

Disadvantages:

- The high cost of construction and maintenance.
- Livestock still have access to open sources of water.
- Lack of portability; livestock need to travel to the source of water to get a drink.

B. Livestock Powered Pumps:

Livestock powered pumps (nose pumps) utilize a diaphragm pump which is lever-activated by the nose of the animal as they drink water from a cup cast into the unit.

Advantages:

- Simple and economical, costing half as much as a typical restricted access point.
- Easily moved from one water source to another and from paddock to paddock.
- No water storage required.
- No power required.

Disadvantages:

- Animals must be trained to use pumps.
- Smaller animals, such as calves may not have the strength to use them.
- Sheep will not use a nose pump.
- Generally can pump for distances less than 300 feet.
- Generally cannot lift water more than 30 feet.
- Must be anchored to something solid or a heavy base.

C. Solar Powered Pumps:

Solar panels are used to power direct current electric motors, usually 12 or 24 volt. The pumps can run continuously or the energy can be stored in a battery for use upon demand.

Advantages:

- Can operate in remote locations, no outside power required.
- Low maintenance.
- Can pump water for long distances.
- Variety of pumps and panels allows customization for your site.

Disadvantages:

- Expensive ($1500-6000).
- Must store water. A three-day reserve is recommended.
- Can lift water 35 feet or less.
- Not easily portable.

D. Sling Pumps:

Sling pumps operate by the action of flowing water. The entire body of the sling pump rotates due to a propeller. Inside the pump body is a coiled, open-ended tube. This tube alternately picks up water and air, and forces the water out through an outlet hose. The water is normally stored in a tank and later distributed to the livestock. A wind-powered version is available for use on ponds.

Advantages:

- Can operate in remote locations without an outside power source.
- Low maintenance.
- Can pump for distances, just over 1 mile.
- Can lift water up to 80 feet.
- Low cost ($550-850).

- Portable; easily moved from one water source to another.

Disadvantages:

- Requires wind or water movement to operate.

E. Hydraulic Ram Pumps:

To operate Ram pumps require flowing water, or water under pressure through a drive pipe. A minimum of 3 feet of fall is required to operate a ram pump. Normally, water is pumped to a storage tank for further distribution to drinking facilities in paddocks.

Advantages:

- Economical to operate.
- No outside energy required, can operate in remote locations.
- Reliable, with few moving parts.
- Can lift water to a maximum of 250 feet.
- Can pump water for a relatively long distance.

Disadvantages:

- Adequate water flow required to operate the pump.
- Must be anchored to a solid base.
- Not portable.
- Must be protected from frost, or drained for the winter.
- Overflow water must be drained from the area in which the pump is installed.
- Cost typically ranges from $350-7000.

F. Gasoline Powered Pumps:

Gasoline powered pumps are engine driven and pump water to a tank from which the water is further distributed to tanks located in paddocks.

Advantages:

- Can operate in remote locations.
- Relatively inexpensive ($300-500).
- Can pump water for long distances.
- Can lift water several feet.
- Portable; can be moved from one water source to another easily.

Disadvantages:

- High maintenance.
- More labor intensive, an operator is required to run the pump.

G. Water Hauling:

Water hauling can involve using a tanker to fill stationary tanks in the pastures, or leaving the tanker in the pasture and hooking it to tanks in the paddocks. The preferred system is to fill storage tanks in the pastures so that the tanker can be filled and ready to distribute water before the storage tanks are empty.

Advantages:

- Works well for small herds.
- If a tanker is already available, it will be minimal cost to implement.
- Very flexible.

Disadvantages:

- Labor intensive.
- Time consuming.
- Costly, if tanker needs to be purchased.
- Traffic in pasture may be detrimental to the soil, and may cause erosion if not properly routed.

Appendix F. Visual method for calculating Reserve Herd Days (RHD)

Paddock No.	RHD	Notes
Total RHD's		

Appendix G. Calculated method for Reserve Herd Days (RHD)

Kind and Number of Livestock:

Total Herd Weight:

Daily Allocation (Total Herd Weight x 0.04):

(a)	(b)	(c)	(d)	(e)	(f)	(g)
Paddock No.	Acres	Forage Available (inches)	Pounds of Forage per acre per inch*	Pounds of Forage Available (b x c x d)	RHD's	REMARKS

* Refer to Table 6

** RHD = column e/daily allocation

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