

# SUSTAINABLE GRASSLANDS



**Franklin County Conservation District  
USDA Natural Resources Conservation Service, Massachusetts**

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### *Sustainable Grasslands*

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# Economic, Environmental, and Aesthetic Benefits of Grasslands

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American grasslands feed millions of dairy cows, beef cattle, sheep, and horses and contribute billions of dollars annually to the U.S. economy. Our grasslands must be protected from development and must be well-managed in order to sustain these grass-based ecosystems and the local communities that depend upon them.

Protecting and restoring grasslands contributes positively to the agricultural economy of many regions of the United States, provides biodiversity of plant and animal populations, improves environmental quality, and provides immeasurable aesthetic value for local communities.

Grass-based agriculture is good for the farmer. Foremost, grass-based systems must be profitable so that farmers can earn a decent living wage. If farmers cannot earn an acceptable return on their investment, they cannot be expected to protect their grassland resources out of the goodness of their hearts.

In New England, grass-based dairy and beef operations are providing farmers with a good net income per animal with relatively little capital investment. Costs for equipment and supplies (fuel, seed, fertilizer, pesticides) for grass-based farming are much less than the costs for row crop or confined animal feeding operations.

Grass-based agriculture is good for the environment. Soil erosion, sedimentation, polluted runoff, and phosphorus pollution are all virtually nonexistent in grass ecosystems. Watersheds with grasslands have higher water quality. Because of the extensive root systems

of grasses and forbs (some reaching over six feet below the soil surface) these plants can recover nutrients from the soil that would otherwise be lost or leached into groundwater in row crop ecosystems or other land uses. Grasslands also store vast quantities of carbon dioxide in the form of soil carbon and soil organic matter. These grass-based ecosystems may prove to mitigate global warming effects.

Grasslands are also valuable recreation and tourism destinations. In many parts of the country grasslands define the character of the landscape. Although this is a hard-to-quantify benefit, what would Vermont look like without grass and cows? How would the loss of grasslands affect the local economies of many small American communities?

Grasslands generate many economic benefits (both tangible and intangible) to local communities and states. Activities such as bird watching, hunting, fishing, hiking, guide services, lodging, and countless other activities generate income for local communities. These activities create jobs for small businesses, local manufacturing, and other service industries, thus creating a beneficial economic ripple effect locally and regionally.

Because of their permanence and diversity, grasslands also provide excellent habitat for wildlife. Research has consistently shown that ground-nesting birds and small mammals thrive in properly managed pastures. Grazing lands can provide nesting habitat, cover, and food when managed properly and when adequate plant residues remain following grazing or mowing.

Unfortunately, grasslands are vulnerable and are fast disappearing from our landscape. It is in everyone's best interest to preserve and protect these vital resources because once the grasslands are gone and houses have taken their place, the grasslands will be gone forever.

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## Evaluating Existing Forage Stands

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When renovating a pasture or hayland, or converting row crop acreage into new permanent grasslands, it is important that the landowner do adequate planning prior to beginning the adventure. Successful pasture and haylands begin with the proper preparations.

What is the ultimate destination of the forage? Will the forage be harvested for animal feed? Or will it be left for wildlife habitat? Or will the forage be harvested for biomass? What type of animal is to be fed? What are the dietary requirements for the animals? What is the most efficient method of harvesting and storing the forage for the farming operation and the given climatic conditions? If dry hay is desired, will labor and machinery be available to accommodate a timely harvest? Or is baleage a better option?

The quality of vegetation (desirable species and numbers) in a field should be evaluated. If there are perennial weeds (milkweed, goldenrod, brambles) or early successional woody vegetation such as poplar and birch present in the field, the soil pH has probably become too acidic for grasses to survive, and the field is changing into a forest ecology. Trees greater than two inches in diameter may be too large to mow with a brush hog and may require more extensive equipment for removal.

What are the present soils? Are there wet or dry sections? Are there any limitations to the soils (shallowness, or low water holding capacity) that might limit forage production. Are there stones? Is it safer to renovate or improve an existing stand of grass than it is to plow and risk exposing even more stones? How rough is the site? Are there rocks or severe ruts that would obstruct or prevent a tractor and harvesting equipment from moving through the field?

These are all issues that can be addressed through the conservation planning process with your local Natural Resources Conservation Service representative. Call your local NRCS Service Center for more information.

Lastly, how quickly does the field need to be put back into production? One to two years? Three to four years? If the answer is three to four years, and the field is relatively smooth, the field will probably only require limestone, fertilizer, and mowing to restore a productive, native grass stand; orchardgrass and bluegrass will eventually dominate this type of grassland which then can be over-seeded or frost seeded with clover species. If the field needs to be in high production in one to two years, the landowner needs to decide if a total renovation is necessary (plow, harrow, lime, fertilize, rock pick, harrow, and finally reseeding) or if a reseeding using no-till technology is more appropriate.

## Soil Fertility

Just as proper nutrition is important to maintaining human health, so proper soil fertility and plant nutrition are required for healthy grassland plants to remain productive, to outcompete weeds, and to fend off insects and diseases.

To maintain the productivity of hayland and pastures, and to prevent grasslands from reverting to barren fields dotted with multi-flora rose bushes, soil fertility must be maintained at an optimum level. When soil fertility is not replenished, the weeds will flourish and the desirable grasses and legume species will succumb to the early successional forest.

## Soil Testing

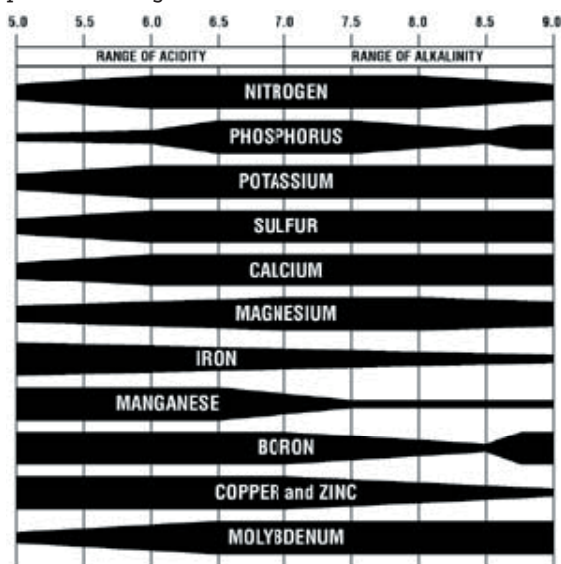
The first step in properly managing hayland or pasture is to take a representative soil sample and have it analyzed by an accredited

soil testing lab, preferably a local Land Grant University soil testing lab that utilizes fertilizer recommendations developed by the local university for local conditions. Information on gathering soil samples, soil testing services in Massachusetts, and how to interpret soil test results can be found at the following web site: <http://www.umass.edu/plsoils/soiltest/>

## Nutrient Availability and Soil pH

Why is soil pH so important? Soil pH governs the solubility of all soil nutrients (see figure below); if nutrients are not soluble in water, the plants' root systems will not be able to absorb sufficient quantities of nutrients. When soil pH is less than five, the solubility of phosphorus, calcium, and magnesium drops significantly; this pH is fine for growing blueberries or rhododendrons, but a pH of five adversely affects the plant health of grasses and deciduous plants.

With time, nutrients such as calcium and magnesium can leach below the plant's rooting depth. As this process continues and soil pH levels decrease, grasses and legumes will be smothered by opportunistic weeds, and then woody species of plants will begin to dominate the stand.



Soil acidification also can occur with poor management practices. If a hayland is continually harvested, and the essential plant nutrients are not replaced, calcium and magnesium will be mined from the soil by the plants. If only nitrogen fertilizer is applied, the acidification process will be quicker. As nitrogen is mineralized in the soil, acid-producing hydrogen ions are formed and the leaching of the calcium and magnesium is accelerated.

Landowners must keep in mind the quantity of nutrients that are removed with every cutting of hay; approximately every ton/acre of mixed legume/grass hay that is harvested contains 40 pounds of nitrogen, 15 pounds of  $P_2O_5$ , and 40 pounds of  $K_2O$ . If a hay crop yields 4 tons of dry matter per acre, then 160 pounds of N, 60 pounds of  $P_2O_5$ , and 160 pounds of  $K_2O$  are removed from the soil. It is essential that these nutrients be replaced either through fertilization or good grazing management (even distribution of nutrient-rich manure across the field) for yield levels and forage quality to remain high.

## Cation Exchange Capacity and Percentage Base Saturation

Soil test results will also include information on the soil's "Cation Exchange Capacity" (CEC); this is a measure of the soil's ability to retain and to supply plant nutrients. The majority of this capacity, in limed New England soils, resides in finely divided particles of soil organic matter. A small contribution to CEC comes from the soil's clay particles. Clay particles have a high CEC, however, most of our soils have few clay particles and greater quantities of sand and silt. The basic nutrient

cations (positively charged ions) of Calcium ( $\text{Ca}^{2+}$ ), Magnesium ( $\text{Mg}^{2+}$ ), and Potassium ( $\text{K}^+$ ), and the acidic cations of Aluminum and Hydrogen account for nearly all the adsorbed cations in the soil. Very sandy soils, low in organic matter, commonly have CEC's less than five. New England soils with very high CEC's (greater than 40) are invariably rich in organic matter. A CEC between 10 and 15 is typical and usually adequate.

CEC is important because it represents the primary soil reservoir of readily available Potassium, Calcium, Magnesium, and several micronutrients. It also helps to prevent their leaching. The ease with which a plant gains access to these nutrients depends somewhat on the relative percentages of the adsorbed cations. For this reason it is suggested that percentage saturation levels be held within loosely defined ranges. For example, a soil with a pH of 6.5 and base saturations of Calcium 70%, Magnesium 12% and Potassium 4% would be considered balanced for most crops.

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## Mineral Soil Amendments

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### Limestone

There are two types of limestone readily available for raising soil pH levels: calcitic (high-calcium) limestone; and dolomitic limestone. Dolomitic limestone contains approximately 28 percent magnesium carbonate and approximately 35 percent calcium carbonate. Calcitic limestone contains no magnesium. These products will both elevate soil pH; however, they will affect the percent base saturation in the soil very differently.

If dolomitic limestone is continually used, high levels of soil magnesium can lead to suppressed calcium levels in forages; ketosis or milk fever can

develop in dairy cows. If calcium or potassium is oversupplied and magnesium is deficient, grass tetany or "grass staggers" can develop. The best solution is to have the forage tested by an accredited forage testing lab.

When possible, limestone should be applied and incorporated at least six months before seeding mixtures that include legumes. This will allow ample opportunity for the limestone to effect change on the soil pH.

If soil pH is low (below 6.0), and if limestone is surface applied, several applications of limestone will need to be made. For surface applications, the maximum application rate should not exceed 1-1/2 tons/acre or 65 pounds/1000 sq. ft. Two applications of limestone per year (e.g., spring and fall) are the maximum number recommended. If lime is surface applied, it may take one to two years to elevate soil pH to the desired level.

### Nitrogen

Nitrogen (N) is usually the most limiting nutrient for hay production. The annual nitrogen requirement for a productive hayfield is approximately 150 to 200 pounds/nitrogen/year for a 4-5 tons/acre/year hay crop. Nitrogen can be supplied to the forage stand through mineral fertilization and nitrogen fixation by forage legumes such as alfalfa or clovers. A dense legume (4-6 alfalfa plants/square foot or 2-5 clover plants/square foot) population will reduce the need for chemical addition of nitrogen. If a 100% legume stand is desired, no fertilizer N should be applied. In pastures, nitrogen fertilization should result primarily from legumes. In forage stands where grasses dominate, three to four nitrogen applications (50-70# of N/acre/application not to exceed 200# N/acre/year) should be made over the course of the growing season: an application early in the spring at green-up (usually mid-to-late April) and an application after each cutting.

## Phosphorus

Phosphorus (P) deficiencies in hayfields can be corrected with phosphate containing fertilizers such as super triple phosphate. For organic operations, rock phosphate or bone meal can be utilized.

## Potassium

Desired potassium (K) levels of the forage should be determined based upon the end use. If the forage is for dry cows, potassium levels should be low to avoid animal reproduction problems. If there is any concern, the forage should be tested through an accredited forage testing laboratory.

If potassium levels are not a concern, two to four percent base saturation in the soil should produce forage with optimal potassium levels. Attain these levels with one or more applications of with a potassium-containing fertilizer such as potassium/magnesium sulfate, potassium sulfate, or muriate of potash.

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## Forage Species Selection

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Plant materials used in forage production fall into two broad classes; grasses and forbs/legumes. A forb is an herb that is not a grass, and a legume is a forb that is able to produce or “fix” its own nitrogen from atmospheric nitrogen with the aid of a soil dwelling bacterium. Because of their higher nitrogen and protein contents, legumes in combination with grasses make ideal animal forage. In New England, grasses fall into two categories, cool season grasses and warm season grasses.

Cool season grasses, as the name implies, are more productive when the air and soil temperatures are cooler. The bluegrasses, fescues, bromes, orchardgrass, and perennial rye are all cool season grasses.

Warm season grasses (Switch grass, Indiangrass, big and little bluestems) are more productive in hotter and drier climates. These warm season grasses, which are native to North America, produce much more biomass, both above ground and below ground, than do the cool season grasses.

Contrary to popular belief, most well known, cool season grasses are not native to North America; they originated in Eurasia. Cool season grasses tend to be less productive in hot and dry periods of the growing season. In areas with excessively well drained soils or areas prone to drought, warm season grasses may be good alternative to the “summer slump” of cool season grasses.

Please refer to Tables 6 and 7 in the Appendices for crop quality information and the environmental constraints of certain forage species.

## Forage Seed

The appropriate plant species and their cultivars need to be selected to match the dietary requirement of the animal to be fed and the characteristics of the site. Plant species should be selected based upon the following criteria:

- Climatic conditions, such as annual rainfall, seasonal rainfall patterns, growing season length, humidity levels, temperature extremes, and the USDA Plant Hardiness Zones.
- Soil characteristics such as drainage class, available water holding capacity, aspect, and likelihood of flooding and/or ponding.
- Plant resistance to disease and insects common to the site or location.
- Plant compatibility with other forage species and their selected cultivar(s) in rate of establishment, maturity, and growth habit when seeded together as a forage mixture.

All seed should be high quality and meet all

requirements of state laws; certified seed should be used when available. Seed quality of any species can change following initial seed tests. Germination may decline over time, especially when seed is subjected to uncontrolled humidity, moisture, or high temperature. Legume seed should be inoculated with the proper species of nitrogen fixing bacteria specific to the legume. When more than one legume seed is used, each should be inoculated separately.

## When to Seed

Late summer seedings and spring seedings can be equally successful; however, there are trade-offs with both times of the year. Spring seedings usually have ample moisture; however, weeds can out-compete desirable grass and legume species and lead to failed seedings. In late summer seedings, weeds will be less of an issue, but the lack of soil moisture can ruin a late summer seeding. Hard rains can ruin both spring and late summer seedings if conventional tillage methods are used.

The specific date for a successful seeding will vary from with elevation, exposure, soil type, water holding capacity of the soil, and from year to year with prevailing moisture and temperature conditions. Suggested general seeding dates for the USDA Plant Hardiness Zones found in Massachusetts are listed below:

USDA Plant Hardiness Zones	Early Spring	Late Summer
Zones 4b and 5a	April 1--May 31	August 1--September 10
Zone 5b	April 1--May 15	August 1--October 1
Zones 6a, 6b, and 7a	March 15--May 15	August 15--October 31

# Benefits of Conservation Tillage

If a landowner decides that a total renovation of a hayland better fits within the forage management system, serious consideration should be given to a conservation tillage system. Conservation tillage offers numerous benefits over conventional tillage systems. Some of these benefits are:

- **Reduced soil erosion**—Crop residues on the soil surface reduce erosion by water and wind. Depending on the amount of residues present, soil erosion can be reduced by up to 90 percent compared to an unprotected, intensively tilled field.
- **Reduced wear and tear on machinery**—Conventional tillage inevitably brings more rocks and stones to the soil surface that must be windrowed and picked. No-till establishment results in fewer trips across a field reduce machinery wear and maintenance costs.
- **Reduced labor and more time saved**—As little as one trip across a field for planting compared to two or more tillage operations, rock picking, and more tillage, means many fewer hours on a tractor and fewer labor hours.
- **Much fuel saved**—Conservation tillage saves an average of 3.5 gallons of fuel per acre; with increased fuel costs, this can add up to a large amount of money.
- **Improved water quality**—Grassland ecosystems have little to no soil erosion, so there is little off-site movement of sediment and associated nutrients (particularly phosphorous) and associated pesticides. Runoff that leaves grasslands and enters surface water bodies is clean.



- **Improved soil tilth**—Grassland ecosystems have greater soil particle aggregation (small soil clumps) making it easier for plants to establish roots. Improved soil tilth also minimizes compaction. Compaction is also reduced by fewer trips across the field.
- **Increased soil organic matter**—The more soil is tilled, the more carbon is released to the atmosphere and the less carbon is available to build soil organic matter.
- **Improved soil water holding capacity**—Greater soil organic matter content, and extensive root systems help hold soil moisture. The shade produced by the canopy of grass plants also reduces water evaporation, and cools the soil. In addition, the grass canopy reduces runoff and increases the opportunity for water to soak into the soil. Infiltration is also increased due to the channels (macropores) created by earthworms and old plant roots.
- **Improved conditions for wildlife**—Well managed grasslands provide shelter and food for wildlife, such as game birds and small animals.
- **Improved air quality**—Grasslands also improve air quality because there is no wind erosion, thus they reduce the amount of dust in the air. Fossil fuel emissions from tractors are also significantly lower because fewer trips are made across the

field and there is less release of carbon dioxide into the atmosphere because more carbon is incorporated into organic matter.

Several Massachusetts conservation districts have no-till grass seeders and no-till corn planters that can be rented for a fee. If you are interested in renting a no-till drill or have questions about no-till agriculture, contact your local conservation district. A list of Massachusetts conservation districts is available on-line at <http://www.ma.nrcs.usda.gov/partnerships/conservationpartnership.html>.

## Conventional Seeding

If conventional tillage methods are used, seedbeds should be prepared to a minimum depth of three inches. The seedbed should be firm; as a general rule, a seedbed is firm when an adult's footprint is no more than one-half inch deep. This can be achieved by either rolling the soil after broadcasting the seed or using a cultipacker. The seedbed should also be relatively free of competing vegetation; this will ensure that enough fine soil particles can provide shallow coverage of the seed as well as contact with moisture and nutrients. If the seed has access to uniform soil moisture, germination and seedling emergence will be maximized. A firm seedbed also provides a medium that does not restrict or allow roots to become dry.

**Table 2. Seed Mixtures for Pasture and Hayland Seeding Rates of Pure Live Seed per Acre**

Legume Seed (If using only one legume, use high rate)				Grass Seed (pounds/acre) (In mixtures, use the low rate)			
Primary Legume	Rate (pounds/acre)	Secondary Legume	Rate (pounds/acre)	Orchard-grass	Timothy	Smooth Brome-grass	Kentucky Bluegrass
Alfalfa	8-10	--	--	4-6	2-4	4-6	--
Alfalfa	12-18	(hayland only)	--	--	--	--	--
Alfalfa	6-8	Red Clover	2-4	4-6	2-4	5-7	--
Alfalfa	4-6	Red Clover	2	3	--	--	--
Alfalfa	6-8	Ladino Clover	¼	4-6	2-4	5-7	--
Red Clover	6-8	--	--	4-6	2-4	5-7	--
Red Clover	4-6	Ladino Clover	¼	4-6	2-4	5-7	--
Red Clover	6-8	--	--	--	6-8	--	--
Red Clover	6-10	Ladino Clover	½	4-6	2-4	4-6	2-4
One Grass Only	--	--	--	16	10	10	--

Grass and legume seed should be drilled uniformly over the area at a depth of ¼ to ½ inch using a grassland drill, grain drill with press wheels, cultipacker seeder, or by broadcasting and cultipacking before and after broadcasting the seed.

On fields where the predominant slope is greater than eight percent all tillage and planting operations should be done along the contour of the slope, and seeding should be done with the use of a companion (nurse) crop or by leaving at least 30 percent of the crop residue on the surface after planting.

Seeding rates for broadcast seed which is then rolled or cultipacked should be increased by 10-20 percent over the drilled rates listed above.

## Nurse Crop or Companion Crop at Seeding

The use of a companion crop, in either no-tillage or conventional tillage seedings, is a good option with spring seedings where summer annual weeds may be a concern. The cool season grasses/legumes will be protected from soil desiccation and weed competition by the oat crop. Oats sown at a rate of one to 1-1/2 bushels per acre or annual ryegrass sown at a rate of four pounds per acre are good companion crops for spring seedings. Oats should be mown high (4" or higher) and baled or green-chopped when they are in the "boot" stage of growth. Alternately, oats can be grazed lightly when oats are 10 inches high.

## Frost Seeding

If an existing hayland or pasture consists mainly of grasses, forage protein levels can be raised by adding legumes to the stand. Legumes are most easily introduced into existing stands through the practice of frost seeding. Frost seeding is sowing seed on the soil surface that has been made friable by freezing and thawing. In March or early April

the soil surface is usually honeycombed with small cracks; these cracks allow for broadcast legumes to enter the soil cracks and achieve contact with the soil. Frost seedings should not be made on areas covered with ice or snow, but must be made before frost leaves the soil. Recommended seeding rates are given below:

Legume	Rate (#/acre)	Expected Plants/Square Foot
Ladino Clover	2-3	1-2
Red Clovers	6-12	2-5

## Weed Management

The weed population composition (spring annual weeds, winter annual weeds, or perennial weeds) and the weed pressure will greatly affect the success of pasture and hayland seedings. If a field is comprised of mostly perennial weeds, it will be very difficult to establish hayland or pasture species that can out compete the stored reserves in the root systems of the weeds.

Systemic herbicides that will kill the whole plant are effective means of control for hard-to-control perennial weeds; best results usually follow applications made just after the plant flowers. Hard-to-kill genera of weeds such as milk weed, Canada thistle, Multiflora rose, may require repeat applications. Energy reserves of such hard to control weeds can also be depleted with repeated mowings; this management strategy will eventually slow down the weed to tolerable levels.

Fields with high populations of annual weeds will benefit from seedings that are done before the weeds germinate. For example, if a field has a high incidence of a winter annual weed (such as Shepherd's Purse), an early spring no-till seeding would benefit from the addition of a nurse crop that will out compete the winter annual weeds. The winter annual weeds are already established

(in the rosette stage), however, the nurse crop should be able to out compete the weeds for light, water, and nutrients.

For pesticide and herbicide use on pasture and haylands, contact the University of Massachusetts Extension Service for current information and recommendations on pesticides registered for use in the Commonwealth of Massachusetts.

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## Forage Harvest Management

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### Before the Harvest

Before forages are harvested, it is important to clear fields of debris that could damage machinery or, if ingested by livestock, lead to sickness or death. Landowners should also plan to harvest forages from the inside of the field toward the field edges rather than mowing from the perimeter of the field inward. This will allow wildlife to escape surrounding unmown parts of the field rather than trapping animals into a more constricted area.

It is also important to monitor weather conditions and forecasts. Forage that is cut, wilted, and cured properly will result in quality feed and will prevent forage swaths or windrows from smothering underlying plants.

Where weather conditions make it difficult to harvest the desired quality of forage, use mechanical or chemical conditioners and/or ensile. Foliar diseases or insect infestations can lower forage quality before proper harvest stage or maturity is reached. If disease or pest pressure is high, forage should be harvested early or the pest should be treated with a registered pesticide.

Balancing weather conditions and harvesting at the stage of maturity that provides the desired

forage quality, quantity and stand persistence is often a trade-off in New England, especially when making dry hay. Consider managing for haylands for multiple use objectives other than usage as livestock feed only. Harvesting at a later date and producing a higher fiber/less nutritious feed is acceptable for some animal groups during certain times of the year. Consider feeding later harvested forage to a livestock class and type with lower nutritional needs and balance the feed ration; consult with an animal nutritionist for more information on this topic.

Landowners should also consider storage locations for large square or round bales/baleage with regards to inside vs. outside, along hedgerows, and access to forage during times of winter snow and spring mud constraints.

### Safe Equipment Operation and the Length of Cut

To reduce safety hazards, land owners should avoid operating equipment on field slopes over 25 percent, particularly on cross slope traffic patterns.

Prior to harvesting, forage equipment should be inspected following manufacturer's preventative maintenance procedures. All safety shields should be in place during machine operation to prevent injury or death. Shut off machinery before working on or unplugging moving parts. All forage harvesting equipment should be operated at the optimum settings and speeds to minimize loss of leaves.

The shear-plate on the forage chopper should be set to the proper theoretical cut for the crop being harvested. Keep knives well sharpened. Do not use re-cutters or screens unless forage moisture levels fall below recommended levels for optimum chopping action.

When harvested for ensilage, forage should be chopped to a size appropriate for the type of

storage structure (high moisture wrapped or tubed bales) that allows adequate packing to produce the anaerobic conditions necessary for the ensiling process.

## Moisture Content

Knowing the moisture (dry matter) content of forage at the time of harvest and storage is essential for making and preserving high quality silage and hay. Knowledge of dry matter content is also important for accurate formulation of rations. Hay harvested and stored at too high a moisture content (greater than 20 percent) will result in spoilage and possible spontaneous combustion. Harvesting hay when it is too dry will result in excessive leaf loss; this reduces the feeding value and increases dry matter loss. Harvesting forage for silage at high or low moisture contents will result in improper fermentation, which will reduce the feeding value.

For optimal dry hay quality, rake hay at 30 to 40 percent moisture and ted (mechanically lifting and fluffing hay swaths) or invert swaths when moisture is above 40 percent.

To preserve dry hay for optimum forage quality and quantity, follow these guidelines:

- Bale (small rectangular bales) field cured hay at 15 to 20 percent moisture;
- Bale (large round bales) field cured hay at 12 to 18 percent moisture;
- Bale (small bales only) force air dried hay at 20 to 35 percent moisture.

Where rainfall and/or humidity levels cause unacceptable forage quality losses, landowners should consider green chopping or ensiling the forage to reduce or eliminate field drying time. Storage techniques such as baleage may incur a higher initial capital investment in machinery and supplies (plastic), but will improve the

**Table 4. Summary of Good Hay-Making Practices from “Silage and Hay Preservation” (NRAES-5)**

Practice	Reasons	Benefits
Mow forage early in the day.	Allow full day's drying time.	Faster drop in moisture. Less respiration loss. Less likelihood of rain damage. High quantity, high quality.
Form into spread swath.	Increase drying rate.	Faster drop in moisture. Less respiration loss. Less likelihood of rain damage. High quantity, high quality.
Rake or ted at 40-50% moisture content.	Increase drying rate.	Faster drop in moisture. Less respiration loss. Less likelihood of rain damage. Less leaf shatter. High quantity, high quality.
Bale hay at 18-20% moisture.	Optimize preservation.	Less leaf shatter. Inhibition of molds, browning. Low chance of fire/spontaneous combustion. High quantity. High quality.
Store hay under cover.	Protect from rain and sun.	Inhibition of molds, browning. Less loss from rain damage. High quantity. High quality.

**Table 5. University of Maine's Summary of Good Hay-Making Practices**

Species	Harvest Period	Growth Stage	Minimum Stubble Height After Cutting
Orchardgrass	First Second	Boot to early head stage. After 8-10" recovery regrowth.	2-3" 2-3"
Smooth Bromegrass	First Second	Full head. When basal sprouts appear at soil surface.	2-3" 2-3"
Timothy	First Second	Late boot to early head. When basal sprouts appear at soil surface.	2-3" 2-3"
Alfalfa	First, Second, and Third	Full bud, ¼ bloom or after 5-6 week recovery period.	1-2"
Ladino and Red Clover	First and Second	¼ to ½ bloom or 8-10"	2"

timeliness of harvest and preserve forage quality. Making baleage has become much more popular in the last several years. This process requires close attention to forage moisture management and to the quality of the air tight bale containment.

Direct cut hay silage with moisture contents greater than 70 percent should be treated with chemical preservatives or should be mixed with dry feed stuffs to avoid fermentation and seepage losses of digestible dry matter. To preserve optimum forage quality and quantity of ensiled forages, the moisture levels at ensiling should be as follows:

- Top unload upright (tower), bunker and horizontal bag silos, baleage – 60 to 68 percent moisture;
- Bottom unload upright silos – 45 to 55 percent moisture;
- All corn silage regardless of storage structure – 63 to 68 percent moisture.

Critical components for any silage system (to avoid toxic organisms and chemicals) are to ensure air tight forage containment and proper moisture content.

## Stubble Height and Stand Persistence

Forage plants should be harvested at a height that will promote vigorous regrowth of the desired species. Higher cutting heights will provide adequate residual leaf area and adequate numbers of terminal, basal or auxiliary tillers or buds. This will allow quicker recovery of the plants and also will insulate the plants from extreme heat or cold. Greater leaf area will also shade the soil surface thus keeping the soil cooler and conserving soil moisture. Do not harvest alfalfa for at least 30-45 days prior to the mean killing frost date.

The University of Maine Cooperative Extension Service (CES) forage harvest recommendations

based on maturity, stubble height, and harvest interval listed below in Table 3 can be used as a guide to maximize forage quality.

## Contaminants and Anti-Quality Components

Contaminants and Anti-Quality components (listed in Table 6 of the Appendices) are any objectionable matter or toxin that can cause illness, death or rejection of the offered forage. Hardware (wire) that is harvested and baled could cause serious injury to animals; chemical compounds such as alkaloids, endophytes, and hydrocyanic acid (HCN), can cause digestive disorders. Sorghum-sudangrass hybrids contain high levels of HCN at the immature growth stage; when green chopping HCN forages, harvest should be delayed until the forage is greater than 18 inches tall. These forages should be tested for HCN if stressed by drought or frost prior to green chopping.

Bloat in cattle usually occurs in early spring when animals consume excessive amounts of highly succulent, luxuriant legumes such as white clover. In dry periods of the year when white clover is stressed, nitrate levels in the forage may be excessive. If this is suspected, forage should be tested before green chopping to ensure that nitrate levels are below 2500 ppm. When clover forages exhibit high levels of nitrates, the clover silage should not be fed for at least six weeks.

The following Anti-Quality components are listed for some of the forages in Table 6 of the appendices: A = Alkaloids (decrease palatability); B = Bloat potential; C = Coumarin (hemorrhagic agent, formed during spoilage of hay); CG = Cyanogenic Glycosides (may form hydrogen cyanide-HCN poisoning; also Prussic Acid Poisoning); G = Glycosides (decrease palatability); S = Slaframine alkaloid (slobbers) (from <http://www.manepoints.com/>) A concern especially in the spring and summer; slobbers results when

horses eat legume forages, particularly clover, which have been parasitized by the fungus *Rhizoctonia leguminicola*. This fungus produces an alkaloid called slafrmine, which is responsible for the excessive drooling and slobbering.

## Control Disease, Insect, Weed and Invasive Plant Infestations

To control forage plant diseases, insects, and movement of weeds, landowners should clean harvesting equipment after harvest and before storing the equipment. Forages should not be harvested until after dew, rain, or irrigation water on leaves has evaporated.

The incidence of disease, insect damage, and weed infestation can be limited by managing for desirable plant vigor. This can be done through proper cutting and harvest schedules, proper management of plant nutrients, and focusing on soil health. The removal of invasive plants may be necessary in old fields that are being renovated.

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## Pastures and Wildlife Habitats

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While the majority of the information has focused on mechanically harvested hay production, there is also a wealth of information on grasslands that are managed as pastures and wildlife habitats (Blanchett, et al. 2003).

Grazing has three levels of intensity; continuous, rotational, and intensive rotational. All three levels of grazing intensity require less capital investment in equipment than does mechanical forage harvesting; however, investment in watering systems and fencing will be much greater. In general, with a higher intensity

of grazing management, the economic benefit increases.

Grasslands can be managed as both hayland and pasture, e.g. removing the first harvest as baleage, and harvesting via grazing thereafter, but the forage species should exhibit similar palatability to one another to avoid spot or selective grazing. Generally, pasture mixtures containing perennial legumes will produce higher yields and better forage quality than will pure stands of grass. When legumes are included in pasture mixes, bloat is a potential hazard, especially in early spring when growth is luxuriant.

In most cases, pasture production will be increased more by proper management of existing stands of forage than by interseeding or reseeding. Longevity and persistence will be increased by sound management, such as proper cutting management and prescribed rotational grazing systems that provide plant recovery periods and discourage selective grazing. New seedings should not be grazed until 40 days after emergence or until plants are large enough to be grazed without stand damage.

If a landowner's objectives include providing suitable habitat for desired wildlife species, then appropriate harvest schedules, cover patterns, and plant heights to provide suitable habitat for the desired species should be maintained. If wildlife is a major goal of the land manager, harvesting should be avoided until mid-August to protect nesting birds. Harvesting should also proceed from the interior of the field to the field borders to avoid trapping wildlife in center of a mown field.

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## Appendices

**Table 6. Crop Use and Quality Characteristics: E=Excellent; G=Good; F=Fair; and P=Poor.**  
**Anti-qualities: A = Alkaloids; B = Bloat potential; C = Coumarin; CG = Cyanogenic Glycosides; G = Glycosides; S = Slaframine alkaloid**

CROP **	Lifecycle	Habit	Maturity	Palatability	Harvested as Hay	Harvested as Silage	Continuous Grazed	Prescription Grazed	Best Grazing	Anti-quality
<b>LEGUMES</b>										
Alfalfa	Perennial	Tall, Bunch	Early-Mid	E	E	E	P	E	Mid	B, S
Kura Clover	Perennial	Short-Med Spreading	Mid-Late	E	G	G	E	E	Mid	B
Ladino Clover	Perennial	Short, Spreading	Early	E	F	G	E	E	Mid	B, S
Mammoth Red Clover	Short-lived Perennial	Medium, Spreading	Mid-Late	G	G	G	P	P	Mid	B, S
Medium Red Clover	Short-lived Perennial	Medium, Spreading	Mid-Late	E	E	E	P	G	Mid	B, S
Sweet Clover	Biennial	Tall, Spreading	N/A	F	F-P	G	P	F	N/A	C
<b>GRASSES</b>										
Kentucky Bluegrass	Perennial	Short, Spreading	Early	E	G	G	E	E	Early	
Orchardgrass	Perennial	Med-Tall, Spreading	Early-Mid	E-F	E	G-E	G	E	Early-Mid	
Perennial Ryegrass	Perennial	Med-Short, Spreading	Early-Mid	E	E	E	E	G	Early-Mid	
Red Top	Perennial	Short, Spreading	Late	F	F	F	F	F	Mid	
Smooth Bromegrass	Perennial	Med-Tall, Bunch	Mid-Late	E	E	F	F	E	N/A	A
Timothy	Perennial	Med-Tall, Bunch	Late	E-G	E	E	F	G	N/A	
<b>ANNUAL FORAGES</b>										
Annual Ryegrass	Annual	Med-Short	Mid	G	F	F	P	G	Mid	
Millet	Annual	Tall	Mid	F	F	F	F	G	Mid	
Oats	Annual	Med-Tall	Mid	G-E	G	G-E	F	G	Early-Mid	
Rape/Kale	Annual	Short	Mid	G-F	P	P	F	G	Early	G
Sorghum x Sudangrass	Annual	Tall	Mid	F-G	P	G	P	G	Mid	CG
Sudangrass	Annual	Tall	Mid	F-G	P	F	P	G	Mid	CG
Turnip	Annual	Short	Late	E	P	P	P	E	Late, Extended	

**Table 7. Crop Tolerance to Environmental Conditions:**  
**E=Excellent; G=Good; F=Fair; P=Poor; WD=Well Drained; MWD=Moderately Well Drained; SPD=Somewhat Poorly Drained; PD= Poorly Drained; H=High, and M=Medium.**

Crop	Cold Frost	Soil Drought	Wetness	Soil pH	Minimum Soil Drainage	Minimum Soil Fertility
<b>LEGUMES</b>						
Alfalfa	G	G	P	6.6-7.2	WD	H
Kura Clover	E	F	G	5.5-6.2	SPD	M
Ladino Clover	F	P	G	6.0-6.5	PD	M
Mammoth Red Clover	P	F	F	6.2-6.8	SPD	M
Medium Red Clover	G	F	F	6.2-6.8	SPD	M
Sweet Clover	G	G	P	6.8-7.2	MWD	M
<b>GRASSES</b>						
Kentucky Bluegrass	E	P	G	5.8-6.5	SPD	M
Orchardgrass	F	G	F	5.5-8.2	SPD	M
Perennial Ryegrass	P	P	G	5.0-8.3	SPD	H
Red Top	E	G	F	4.5-6.2	VPD	M
Smooth Bromegrass	E	G	F	5.5-6.5	MWD	H
Timothy	E	F	E	5.0-6.2	PD	M
<b>ANNUAL FORAGES</b>						
Annual Ryegrass	P	P	G	5.6-6.2	SPD	M-H
Chicory	F	F	F	5.0-8.3	MWD	H
Millet	P	G	P	6.2-6.8	MWD	M-H
Oats	E	F	P	5.5-7.0	SPD	L-M
Rape/Kale	E	F	F	5.3-6.8	MWD	L-M
Sorghum x Sudangrass	P	E	P	6.0-6.5	MWD	M-H
Sudangrass	P	E	P	6.0-6.5	MWD	M-H
Turnip	E	F	P	6.5-6.8	MWD	L-M