Forage Harvest Management (Acre) 511

DEFINITION

The timely cutting and removal of forages from the field as hay, green-chop, or ensilage. This does not include harvest by grazing livestock.

PURPOSES

- Optimize the economic yield of forage at the desired quality and quantity.
- Promote vigorous plant regrowth.
- Maintain stand life for the desired time period.
- Maintain desired species composition of the stand.
- Use forage plant biomass as a nutrient uptake tool.
- Control insects, diseases, and weeds.
- Maintain and/or improve wildlife habitat.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all land uses where machine harvested forage crops are grown.

CRITERIA

General Criteria Applicable To All Purposes

Forage will be harvested at a frequency and height that will maintain a desired healthy plant community through its life expectancy. (Use Table 1 and other references as guidance.) Michigan State University Extension (MSUE) forage harvest recommendations based on stage of maturity, moisture content, length of cut, stubble height, and harvest interval should be used to meet the criteria in this standard. See references in this standard.

Warm Season grasses have been good and valuable choices as part of a forage system in other parts of the U.S. NRCS in Michigan is awaiting Michigan State University research results, as well as trials from the NRCS Rose Lake Plant Materials Center for recommendations for forage feed on seed rates, planting dates, harvest management for feed quality, and cutting height for plant persistence. Details about planting warm season grasses for wildlife purposes can be found in the conservation practice standards Conservation Cover (327) and Upland Wildlife Habitat Management (645), as well as the Conservation Sheet, 'Native Grass Establishment for Wildlife.'

Stage of Maturity

Harvest forage at the stage of maturity that provides the desired quality and quantity. Stand persistence will also be managed for the normal forage life expectancy. Test standards for forage quality at stage of maturity have been set for legumes, grasses, and grass/legume mixtures. Quality should be matched to type and class of livestock (Tables 1 and 2).

When managing forage stands for multiple use objectives other than usage as livestock feed only, harvesting at a later stage of maturity is acceptable. See the 'Additional Criteria To Improve Wildlife Habitat' section in this standard. Higher maturity and lower quality harvested forage can sometimes be fed to livestock class and type with lower nutritional needs or to balance a feed ration or both (Table 2).

Delay harvest if prolonged or heavy precipitation is forecast that would seriously damage cut forage.

Where weather conditions make it difficult to harvest the desired quality of forage, use mechanical or chemical conditioners and/or ensile.

When foliar diseases, insect infestations, or weather damage (hail) lower forage quality below what is needed for feed for the intended livestock class or type before the proper harvest stage of maturity is reached, then harvest earlier before excessive leaf loss occurs.

Moisture Content

Harvest silage/haylage crops at the ideal moisture range for the type of storage structure(s) being utilized as follows:

- Top-unloading upright, bunker, and horizontal bag silos at 60 to 68 percent moisture.
- Bottom-unloading upright silos at 45 to 55 percent moisture.
- All corn silage regardless of storage structure at 63 to 68 percent moisture.

Critical components for any silage system are to ensure air-tight forage containment and proper moisture content. If moisture content is above the recommended levels, seepage or silage leachate can become a pollutant.

Making balage (ensilage bales of forage) has received varied success because it requires a high level of moisture management. Moisture content is critical, as well as the quality of the air-tight bale containment system.

Treat direct cut hay crop silage (moisture content > 70 percent) with chemical preservatives or add dry feed stuffs to avoid fermentation and seepage losses of digestible dry matter.

For optimal dry hay quality, rake hay at 30 to 40 percent moisture content or invert swaths when moisture is above 40 percent.

Bale at optimum moisture levels to prevent leaf loss and preserve forage quality and quantity (Table 4).

Bale field cured hay at 15 to 20 percent moisture or if treated with preservative at 25 to 30 percent moisture. Bale forced air dried hay at 20 to 35 percent moisture.

Length of Cut

When harvested for ensilage, forage will be chopped to a size appropriate for the type of storage structure (high moisture wrapped or tubed bales) that allows adequate packing to produce anaerobic conditions necessary to ensure proper fermentation. If the size of the chopped forage is too coarse and long, it will reduce the ability to exclude oxygen for fermentation. If the size of the forage is too short and fine, it reduces the ability of livestock rumens to digest normally and may cause acidosis. A theoretical length of 3/8 inch works well for silage. For other forage harvest lengths, see your local MSU Extension office for information.

Contaminants

Forage shall not contain contaminants that can cause illness or death to the animal being fed or rejection of the offered forage.

Contaminants are any objectionable matter or toxin such as sand burs, poisonous plants, hardware (wire), alkaloid containing forages to sensitive livestock species, and drought stressed or frosted hydrocyanogenic forages.

When green chopping summer annual grasses containing hydrocyanic acid (HCN), such as sorghum-sudangrass hybrids, delay harvest until grass is greater than 18 inches tall. Test these forages for HCN if stressed by drought, frost, or other environmental conditions prior to green chopping. When Birdsfoot trefoil and White Clover are stressed in this way, they should also be tested for HCN when green chopping them.

When ensiled forages exhibit high levels (> 2,500 ppm) of nitrates, delay feeding of silage for 6 to 8 weeks or until a test shows the levels have come down to less than 2500 ppm.

Additional Criteria To Improve Or Maintain Stand Life, Plant Vigor, And Forage Species Mix

Stage of Maturity and Harvest Interval

Cut forage plants at a stage of maturity or harvest interval range that will provide adequate food reserves and/or basal or auxiliary tillers or buds for regrowth and/or reproduction to occur without loss of plant vigor.

Cut reseeding annuals at a stage of maturity and frequency that ensures the production of viable seed or ample carryover of hard seed to maintain desired stand density.

If plants show signs of short-term environmental stress, management will be applied in a manner that ensures continued health and vigor of stand. An example would be, not harvesting the last cutting due to drought stress if plants have not reached their over-wintering heights (Table 4).

Do not harvest alfalfa 30 to 45 days prior to the mean killing frost date (50 percent medium risk, 10 percent least risk) for the specific area in Michigan (Table 5).

Recent research has shown that alfalfa harvest can be best timed for forage quality and plant vigor by a growing degree-day accumulation. (See references at the end of this standard.)

Stubble Height

Cut forage plants at a height that will promote the vigor and health of the desired species. Cutting heights will provide adequate residual leaf area; adequate numbers of terminal, basal, or auxiliary tillers or buds; insulation from extreme heat or cold; and/or unsevered stem bases that store food reserves needed for full, vigorous recovery (Table 3).

Harvest warm-season perennial grasses (switchgrass, big bluestem, indiangrass) at a height no lower than 6 inches to prolong the life of the stand. Shorter cuttings can substantially reduce yield the following season because of less carbohydrate reserves.

Manipulate timing and cutting heights of harvest to ensure germination and establishment of reseeding or seeded annuals.

Additional Criteria As A Nutrient Uptake Tool

Employ a harvest regime that utilizes the maximum amount of available or targeted nutrients.

Forages may be planned for harvest that are known to have a high uptake rate of soil nutrients such as sorghum-sudangrass taking up large amounts of nitrogen, phosphorous, and potassium from a former grazing sacrifice paddock area. When producing forages on a high fertility/sludge program, test forages for mineral and heavy metal content and balance rations accordingly. Fertility for forages should always be done according to conservation practice standard Nutrient Management (590) and MSUE bulletin E2904, 'Nutrient Recommendations for Field Crops in Michigan.'

Additional Criteria To Control Disease, Insect, And Weed Infestations

Schedule harvest periods as needed to control disease, insect, and weed infestations. When a pest outbreak exceeds the economic threshold and is uncontrollable by harvest management, control measures should be done. When a pesticide is used to control disease, insects, or weeds, adhere to the specified days to the harvest period stated on the pesticide label. Evaluate pest management options by planning conservation practice standard Pest Management (595). Select species and cultivars that are resistant to many forage pests.

Lessen incidence of disease, insect damage, and weed infestation by managing for desirable plant vigor. This could be done through proper cutting and harvest schedules, maintaining soil nutrients with a good fertility program, and maintaining proper pH ranges through liming techniques.

Plan and schedule removal of invasive plants. Use vegetation adapted to the site that will accomplish the desired purpose. Preference shall be given to native species in order to reduce the introduction of invasive plant species; provide management of existing invasive species; and minimize the economic, ecological, and human health impacts that invasive species may cause. If native plant materials are not adaptable or proven effective for the planned use, then non-native species may be used. Refer to the electronic Field Office Technical Guide, Section II, Invasive Plant Species, for plant materials identified as invasive species. Also refer to the conservation practice standard Invasive Plant Species Control in Natural Habitats (797).

Additional Criteria To Improve Wildlife Habitat

If client objectives include providing suitable habitat for desired wildlife specie(s), then appropriate harvest schedule(s), cover patterns, and plant height(s) to provide suitable habitat for the desired specie(s) should be maintained. See the NRCS State Biologist or contact the Michigan Department of Natural Resources (MDNR) for more details.

Harvesting a forage field from the inside-out will allow more wildlife to escape than traditional harvesting from the outside-in.

Additional Criteria On Harvesting, Storage, And Feeding Management

Dry matter and forage quality losses occur during all phases of getting the forage from the field to the livestock - harvest, storage, and feeding.

Harvest losses can be reduced by a number of methods including hay desiccants and properly adjusting equipment to field conditions. Reducing forage losses which occur during baling can be done by proper baler adjustment, as well as other methods already discussed in this standard.

In the moist climate of the Great Lake States such as Michigan's, storage losses can be significant (> 50 percent) depending on type of bale and the storage method. In some cases, it may be necessary to use indoor storage to preserve nutrients in high quality forages. The highest losses occur from weathering on outdoor bales and the bale having contact with the soil. Leachate from silage can be significant when harvested at the wrong moisture level or from weather when left exposed or uncovered. This can have detrimental effects on water quality resource concerns as well. See the references listed in this standard.

Feeding losses also represent an area where forage losses can be high. The method of feeding, type of bale, type of forage, and type of bale feeder all play a role in determining the amount of waste in a given feeding operation.

Research has been done to find solutions to losses such as covers, pads, and various indoor storage methods. To reduce these losses, refer to Michigan State University and MSU-Extension bulletins referenced in this standard, as well as choosing forages that are suitable for storage (Table 4).

Legal Requirements

Forage Harvest Management shall be planned, designed, and installed to meet all federal, state, local, and tribal laws.

CONSIDERATIONS

Consider the potential effects of the installation and operation of Forage Harvest Management on the cultural, archeological, historic, and economic resources.

When pastures produce forage in excess of grazing livestock demand during high growth rate periods, consider preserving forage quality by machine harvesting a portion of the pasture. Where applicable, coordinate this practice with Michigan NRCS conservation practice standard Prescribed Grazing (528).

When nutrients or other soil amendments are applied, coordinate this practice with the current NRCS conservation practice standard for Nutrient Management (590) and/or Waste Utilization (633) as appropriate. An excess or improper balance of nutrients such as nitrogen can produce plant material that causes toxicity in some animals. Proper nutrient management may produce a higher quantity and quality of forage.

For the specific goal of nutrient uptake, select species that can maximize uptake, see Michigan NRCS conservation practice standard Pasture and Hay Planting (512).

To control forage plant diseases, insects, and weeds, clean harvesting equipment after harvest and before storing. Cut forages after dew, rain, or irrigation water on leaves has evaporated.

Follow Integrated Pest Management practices for forages according to MSUE recommendations.

When weed infestation exceeds the economic threshold and is uncontrollable by forage harvest management alone, weed management should be planned and applied.

Delaying forage harvest until midday or later can increase carbohydrate content and forage value.

Take care not to produce stored forages whose quality is not needed for optimum performance of the animal being fed. For instance, immature legume forages can be too low in fiber and lead to metabolic disorders in ruminants and an economic loss to the producer due to lowered animal performance.

Direct cut grass and legume silage can create silage leachate (seepage). Consider the collection, storage, and disposal of this leachate as part of a Comprehensive Nutrient Management Plan (CNMP).

In conjunction with harvest options, explore storage and feeding options that will retain acceptable forage quality and minimize digestible dry matter loss. Also consider storage location for large square and large round bales/baleage with regards to inside vs. outside, along hedgerows, winter/mud considerations, etc.

Where weather conditions make it difficult to harvest the desired quality of forage, use mechanical or chemical conditioners and/or ensile.

In regions where rainfall and/or humidity levels cause unacceptable forage quality losses, consider green chopping or ensiling the forage to reduce or eliminate field drying time. Other options are the use of desiccants, preservatives, conditioners, macerating implements, and barn curing techniques to reduce field drying time. These techniques can improve the timeliness of harvest and preserve forage quality.

To reduce safety hazards, avoid operating harvesting and hauling equipment on field slopes over 25 percent, particularly on cross-slope traffic patterns.

PLANS AND SPECIFICATIONS

Place the detailed specifications in a site-specific conservation design sheet or job sheet or in the practice narrative of the conservation plan.

These plans and specifications shall be consistent with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

The following items marked with an asterisk shall be recorded as minimum documentation requirements when developing a Forage Harvest Management Plan. Other items are optional. See the Forage Harvest Management Conservation Sheet for Michigan.

*1. Soil Map(s) - Outline the area on the Soil Survey Maps or have a unique map for the practice. List soils present and their limitations to hay production.

*2. Plan Map(s) - Location of the field(s) outlined and marked on the Conservation Plan Map or have a unique map for the practice.

*3. Acres planned to be harvested.

*4. Type of forage made and storage method planned (silage, baleage, direct-cut, dry hay, etc.).

*5. Moisture content needed.

*6. Forage species harvested.

*7. Maturity stage to harvest.

*8. Minimum stubble height.

*9. Forage recovery or rest period if applicable.

*10. Operation and maintenance statements.

11. Optional - Soil erosion control information.

12. Optional - Forage balance worksheet.

13. Optional - Nutrient management plan or part of a CNMP.

OPERATION AND MAINTENANCE

Before forage harvest, clear fields of debris that could damage machinery or if ingested by livestock lead to sickness (for example, hardware disease) or death. Also, if possible, “flush out” wildlife to avoid processing them with the hay during harvest.

Monitor weather conditions and take action accordingly before and after cutting to optimize forage wilting or curing time, preserve feed quality, and prevent forage swaths or windrows from smothering underlying plants.

Inspect and repair harvesting equipment following manufacturer’s preventative maintenance procedures and schedules.

All shields shall be in place during machine operation to prevent human injury or death. Shut off machinery before working on or unplugging moving parts.

Select equipment sizes and capacities that will, in a timely and economically feasible manner, handle the acreage normally harvested.

Operate all forage harvesting equipment at the optimum settings and speeds to minimize loss of leaves.

Set the shear-plate on the forage chopper 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.

Regardless of silage/haylage storage method, ensure good compaction and an air-tight seal to exclude oxygen and mold formation.

Fertility and liming should be maintained in the soils at the levels needed to grow the forages present according to MSUE. See References.

REFERENCES

- Timing Spring Alfalfa Harvest - The Final Word? paper by Dr. Rich Leep, et al. MSU Extension, 1996. Also available at http://www.msue.msu.edu/fis/index
- Ball, D.M., C.S. Hoveland, and G.D. Lacefield, Southern Forages, 1991. Potash and Phosphate Institute, Norcross, GA.
- Hanson, A.A., D.K. Barnes, and R.R. Hill, Jr., Alfalfa and Alfalfa Improvement, 1988. American Society of Agronomy, Madison, WI.
- Ishler, V.A., et al. Harvesting and Utilizing Silage, 1991. Penn State University Circular 396, University Park, PA.
- Matches, A.G., Anti-Quality Components of Forages, 1973. Crop Science Society of America Special Pub. No. 4, Madison, WI.
- Pitt, R.E., Silage and Hay Preservation, 1990. Northeast Regional Agricultural Engineering Service, Ithaca, NY.
- Serotkin, N., Ed., The Penn State Agronomy Guide, 1995-1996. Pennsylvania State University, 1994, University Park, PA.
- Smith, D., Forage Management in the North, Third Edition, 1975. Kendall/Hunt Publishing Company, Dubuque, IA.
- Taylor, N.L., Clover Science and Technology, 1985. American Society of Agronomy, Madison, WI.
- Barnes, R.F., D.A. Miller, and C.J. Nelson, Forages, The Science of Grassland Agriculture, Fifth Edition, 1995. Iowa State University Press, Ames, IA.
- Minimizing Losses in Hay Storage and Feeding. National Forage Information Circular 98-1, 1998.
- Kaiser, C.J., Management of Legumes and Grasses. Shawnee RC&D, Marion, IL.
- Fall Management of Alfalfa by Dr. Rich Leep and Jeffery Anderson, MSU Extension, 1998.

Also available at **MSU Forage Information Systems** website http://www.msue.msu.edu/fis/index

- E2292 Forage Quality: What Is It? Michigan State University Extension, April 1991.
- E0498 Sampling Soils for Fertilizer and Lime Recommendations.
- E2904 Nutrient Recommendations for Field Crops in Michigan.

SELECTED FORAGE QUALITY TERMS

Crude Protein (CP) - The total quantity of true protein and nonprotein nitrogen present in plant tissue. This can be calculated by multiplying the nitrogen fraction by 6.25.

Dry Matter (DM) - The percentage of a plant sample which remains after all water has been removed.

Neutral Detergent Fiber (NDF) - The percentage of cell walls or other plant structural material present. This constituent is only partially digestible by animals. Lower NDF levels are generally associated with higher animal intake.

Acid Detergent Fiber (ADF) - The percentage of highly indigestible plant material. Higher ADF levels are generally associated with lower digestibility.

Digestible Dry Matter (DDM) - The percentage of a sample which is digestible. DDM is a calculated estimate based on feeding trials and from the measured ADF concentration.

Dry Matter Intake (DMI) - This is the amount of forage an animal will eat in a given period of time. Estimates of DMI are based on results from animal feeding trials and the measured NDF concentration of a forage or feed.

Relative Feed Value (RFV) - A measure of a forage's intake and energy value. It compares one forage to another according to the relationship DDM X DMI/100 divided by a constant. RFV is expressed as percent compared to full bloom alfalfa which has an RFV of 100. In most cases, as RFV increases forage quality increases.

Relative Feed Quality (RFQ) - Another way to measure a forage's feed value. RFQ uses Total Digestible Nutrients (TDN) as one of its factors instead of DDM. It is a better measure of how a forage will feed than RFV in some cases.

TABLE 1 - Quality Standard Description (Adopted by the U.S. Alfalfa Hay Quality Committee)

Grade	Species and Stage	CP	ADF	NDF	DDM	RFV
Prime	Legume - pre-bloom	>19	<31	<40	>65	>151
1	Legume - early bloom 20 percent grass-vegetative	17-19	31-35	40-46	62-65	125-151
2	Legume - mid bloom, 30 percent grass-early head	14-16	36-40	47-53	58-61	101-124
3	Legume - full bloom, 40 percent grass-headed	11-13	41-42	54-60	56-57	86-100
4	Legume - rain damaged, 50 percent grass-headed	8-10	43-45	61-65	53-55	77-85
5	Legume - severe damaged, grass-all headed	<8	>45	>65	<53	<75

TABLE 2 - Forage Quality Needs of Cattle, Sheep, and Horses

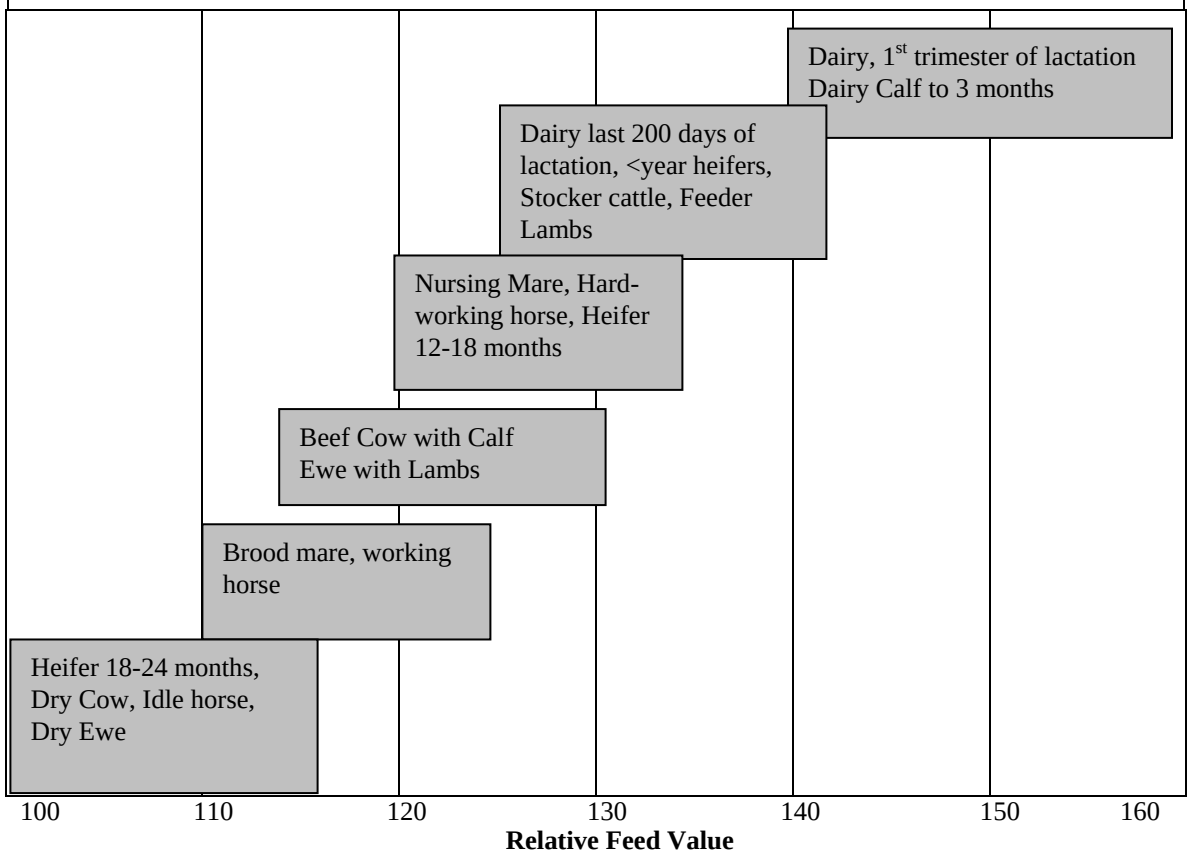

TABLE 3 - Harvest Management - First Year	
Forage	**First Year Clipping/Grazing Height**
Alfalfa	20 inches
Smooth Bromegrass	10 inches
Reed Canarygrass	10 inches
Red Clover	8 inches
Tall Fescue	12 inches
Orchardgrass	10 inches
Timothy	10 inches
Birdsfoot Trefoil	12 inches
Perennial Ryegrass	8 inches
Native/Warm Season Grasses	N/A*

* N/A Not applicable - do not harvest or graze during the first year growing season. Clipping weeds above the grass leaf height is desirable to control shading.

TABLE 4 - Ideal Forage Moisture Range for Silage/Baylage/Haylage/Hay by Storage System	
Trench Silos	65% - 70%
Bunker, Horizontal Bag, and Top Unloading Upright Silos (such as Concrete Stave)	60% - 68%
Oxygen-Limited Upright (tower) Silos	50% - 60%
Balage (Well Wrapped)	50% - 60%
Bottom Unloading Upright Silos	45% - 55%
All Corn Silage Regardless of Structure	63% - 68%
For Dry Hay, Rake the Hay at:	30% - 40%
Bale In-Field Cured Dry Hay at:	15% - 20%
Bale Dry Hay with Preservatives at:	25% - 30%
Bale Dry Hay for Forced Air Drying at:	20% - 35%

If a forage is harvested too wet, butyric acid fermentation can happen as well as seepage or leachate, which can become a pollutant. If a forage is harvested too dry the proteins can be bound and the possibility of smoldering can take place in the storage system.

TABLE 5 - Harvest Guide for Some Commonly Grown Forage Species in Michigan

Species	Management 2/	When to Cut for Excellent Quality	Over-Wintering Height (inches)	Suitable to Store 4/	Relative Maturity 5/
Kentucky Bluegrass	1 to 2 cuttings	Boot	3	NR	E
Orchardgrass, Tall Fescue, and other non-jointed grasses	1 to 2 cuttings	Boot and peak regrowth	3 to 4	H	E-M *
Smooth brome, Timothy, Reed* Canary, and other jointed grasses	1 to 2 cuttings (2 to 3 for Reed Canarygrass)	Heads just emerging	5 to 6	H	M-L
Alfalfa	3 to 5 cuttings (every 30 to 35 days)	Late bud	6	H	E-M
Birdsfoot Trefoil	2 to 3 cuttings	1/4 to full bloom	5	H	M-L
Ladino & Alsike Clover	1 to 2 cuttings	Early to 1/2 bloom	3	S	E-M
Red Clover	2 to 3 cuttings	Early to 1/2 bloom	5	H	M-L
Sudangrass, Sorghum-sudangrass Hybrids, and Millets	1 to 3 cuttings 3/	Boot	N/A	N/A for Hay, H for Silage	N/A L-VL
Small Grains	1 cutting	Early head	N/A	N/A	N/A
Switchgrass, Big Bluestem, Indiangrass, Little Bluestem 1/	1 to 2 cuttings	Boot to early head	8 to 12 Little Bluestem 6-10	H	VL
Corn Silage	1 cutting	63 – 68% Moisture	N/A	H	L-VL

1/ Leave a minimum 8 to 10-inch stubble at the end of season until after a killing frost. Do not mow any shorter than 6 inches or the stand will be affected.
2/ Subsequent cuttings are dependent upon photosynthetic activity, carbohydrate reserves, and soil moisture.
3/ Dependent upon seeding date.
4/ H = Highly Suitable; S = Suitable; NR = Not Recommended.
5/ E = Early; M = Medium; L = Late; VL = Very Late. *Orchardgrass and Perennial Ryegrass are Early to Medium in maturity.

Birdsfoot Trefoil may spread quickly in certain conditions and soils. Mixed stands generally have less insect and disease damage than monoculture stands of forages.

Boot: Most heads in upper leaf sheath, but prior to emergence.
Early Head: Tips emerging on not more than 10 percent of stems.
Medium Head: About 50 percent of the heads emerged or emerging.
Full Head: Most heads fully emerged, but prior to flowering.

TABLE 6 - Statistics for First Killing Freeze Temperature (28°F or lower) of the fall season, 1951 - 1990 Percent of seasons in which first killing freeze occurs on or before the date given in the table

STATION	90	70	50	30	10
Alma	11/08	10/30	10/23	10/17	10/08
Alpena	10/24	10/14	10/08	10/01	9/21
Bad Axe	11/07	10/27	10/20	10/12	10/01
Caro	10/22	10/13	10/07	10/01	9/23
Chatham	10/19	10/10	9/30	9/22	9/11
Coldwater	11/03	10/26	10/20	10/14	10/05
Eau Claire	11/17	11/09	11/04	10/29	10/21
Grand Rapids	11/07	10/29	10/23	10/18	10/09
Hesperia	10/23	10/13	10/06	9/29	9/19
Lansing	11/09	10/29	10/21	10/13	10/02
Lapeer	11/01	10/22	10/14	10/07	9/27
Monroe	11/14	11/05	10/30	10/24	10/16
Saginaw	11/07	10/31	10/25	10/20	10/12
Sandusky	11/08	10/27	10/19	10/11	9/29
Sault Ste. Marie	10/27	10/18	10/12	10/05	9/26
Standish	10/25	10/16	10/09	10/02	9/22
Stephenson	10/10	10/03	9/28	9/23	9/16
Traverse City	11/03	10/24	10/17	10/10	9/29

Please refer to the MSU Forage Information Systems website (listed as a reference in this standard) for newer information on site specific late summer and early fall cutting management based upon growing degree days.