USDA United States Department of Agriculture

Natural Resources Conservation Service Minnesota Agronomy Technical Note 34: *Annual Forages for Grazing Systems*

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WHAT ARE ANNUAL FORAGES

Annual forages are annual, winter annual, and biennial species of grasses, legumes, and forbs planted for hay and/or pasture. Annual forages are typically planted in the spring through mid-July.

PURPOSE

This practice is used to accomplish one or more of the following purposes:

- Provide or increase forage supply during periods of low forage production or to extend the grazing season.
- Provide temporary cover to reduce wind and water erosion and forage for sites where perennial forages will be reestablished.
- Reduce excess nutrients from the soil.
- Improve soil microbial life and soil aggregate stability.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to pasture and cropland where annual forages are planted as part of the grazing system forage budget. This practice does not apply to the establishment of annually planted and harvested grain, fiber, vegetable, or oilseed crops. This practice does not apply to forestland or grazed forestland.

SEEDBED PREPARATION AND SEEDING

Site preparation shall be adequate to provide weed suppression and to promote germination and growth of the annual forage species planted. Seedbed preparation and seeding methods are determined by:

- Resource concerns present and/or objectives for planting the annual forage.
- Annual forage life cycle (cool versus warm season, overwintering)
- Current soil surface conditions, moisture level, existing biomass (surface cover)
- Availability of labor, time, and equipment.

SEEDING METHODS

The following provides an overview of acceptable seeding methods for establishing annual forages. For more in-depth information regarding seedbed preparation, seeding methods, seeding equipment, and drill calibration, refer to Minnesota Agronomy Technical Note 31: Herbaceous Vegetation Establishment Guide.

Several seeding and planting options are available to establish annual forages. Successful plantings require seeding within the recommended planting dates, seeding methods that ensure adequate seed to soil contact, adequate soil fertility, and sufficient soil moisture to support seedling growth.

Approved seeding methods for annual forages:

- Drilled into a prepared seedbed.
- No-tilled into crop residue or dead perennial vegetation stubble.
- Broadcast with incorporation into a prepared seedbed. If broadcasting, incorporation of seed following planting or using a roller, cultipacker, or similar tool to embed the seed is necessary to ensure good seed to soil contact and that production goals are met.

Any deviation from the methods described above require prior approval from an Area Grazing/Rangeland Management Specialist or Area Resource Conservationist.

NO-TILL SEEDING (Drill or Planter):

Ensure the no-till drill or planter is designed to handle the amount of crop residue and seed type being planted. This factor is especially important for small seeds or mixtures with varying seed size and/or density. Set and operate the no-till drill or planter to provide an ideal planting depth. Check planting depth often to assure placement doesn't exceed the maximum depth for selected annual forage species. Plant at the incorporated seed rates that are shown on Table 1: Annual Forages Recommended for Planting in Minnesota.

Many split row or narrow row planters (15-inch row width or less) can be equipped with small seed plates, such as those used for sugar beets or sorghum, which work well for many annual forage species. Additional adaptation and/or calibration may be necessary due to variation of seed size among forage species and varieties.

BROADCAST SEEDING WITH INCORPORATION:

Seed may be broadcast onto the soil surface using a broadcast seeder if the seeder can spread seed in a uniform manner AND if the seed will be incorporated or packed after seeding. Broadcasting without incorporation is not recommended because the likelihood of the seeding meeting the production goals of the producer may be unacceptably low. Broadcasting with incorporation will only be allowed into tilled, prepared seedbeds. Broadcasting into un-tilled situations is not recommended due to poor seed to soil contact. Broadcasting large seeded species, such as peas, is not recommended due to the seed depth requirements of many of the large seeded species. Seed incorporation depth is critical. If broadcasting with incorporation, match the species to the planned depth of incorporation. Premixing the seed with needed fertilizer or pelletized lime and utilizing an airflow applicator can also be an effective broadcast method. Immediately spread seed blended with fertilizer to prevent seed damage. The following guidelines will reduce the risk of seeding failure when annual forages are planted using the broadcast with incorporation method:

Specific Guidelines for Broadcasting Annual Forages Followed by Seed Incorporation:

1. Seed incorporation depth is critical when using this method of planting annual forages. Incorporation depth must not exceed the maximum planting depth for selected species.
2. Maximum planting depths for each species is found on Table 1: Annual Forages Recommended for Planting in Minnesota.
3. Plant at the seed rates shown in Table 1: Annual Forages Recommended for Planting in Minnesota.

FERTILIZATION

Maintaining optimum soil fertility levels is essential for optimizing forage production and meeting the production goals of the producer. Soil tests will be completed by a Minnesota Department of Agriculture certified lab and shall be no older than four years. Apply fertilizer, manure, and lime according to University of Minnesota fertilizer recommendations based on realistic yield goals for the site. Manure nutrient samples will be done in the year of application. The sample tests will also be performed by a Minnesota Department of Agriculture certified lab. Apply manure with a calibrated spreader using guidelines from the Nutrient Management (590) practice standard. Do not over-apply nutrients.

SPECIES SELECTION AND SEED QUALITY

- Select annual forage species that are adapted to soil, climatic, and ecological site conditions. When selecting species, consider soil condition, landscape position, and attributes such as pH, available water holding capacity, aspect, slope, drainage class, fertility level, salinity, depth, flooding and ponding, and levels of toxic elements that may be present.
- Select species suited for the planned purpose, that will address the resource concerns present, will meet the goals and objectives of the producer, maximize the desired benefits, and appropriate for the specific site conditions. Refer to Table 2: Identification and Comparison of Annual Forages Performance and Benefits by Species.
- Where multiple grazing events or harvests are needed, select tolerable species and varieties adapted to multiple harvests.
- Where feasible and when it meets the production goals of the producer, consider utilizing species of different functional groups to enhance diversity (cool-season grass, cool-season broadleaf, warm-season grass, warm-season broadleaf).
- Select species that meet animal nutritional requirements with no or limited anti-quality issues. Consider negative plant/animal interactions, and/or animal toxicity issues.
- Select species based on intended use, level of management, realistic yield estimates, maturity stage, season of use, and compatibility with other species.
- Consider resistance to herbicide carryover and disease/insects common to the site or location.
- Use of heavy stemmed forages with high carbon to nitrogen ratios, such as millets or sudangrass, or sorghum-sudangrass crosses, are beneficial for both livestock forage and increases above and below ground organic materials.
- Select species that are adapted to the desired planting date with ample time to germinate and reach an acceptable growth stage for grazing or forage harvest.
- Seeding dates have been divided into North of Interstate 94 and South of Interstate 94. It's crucial to plant within the seeding dates to ensure adequate forage production for grazing or harvest.
- Inoculate legumes with the proper Rhizobium bacteria if the specific rhizobium bacteria are not present in the soil. This inoculation helps legumes produce nodules that fix atmospheric nitrogen into a form of nitrogen that the plant can use. Producers should consult with their local agronomist on what type of Rhizobia species they should utilize. Pre-inoculated seed or inoculum coated seed is acceptable. All inoculum used must be within its life expectancy timeframe when seeded.
- Do not plant species identified as restricted or prohibited by law.
- Use certified seed (tested) that has been cleaned and is free from noxious weeds.
- Non-commercial (Bin-run) seed can be used if the seed has been tested for germination and purity by a USDA Accredited Seed Laboratory along with scale tickets provided. Be aware of considerations to remain compliant with the Plant Variety Protection Act.
- Seeding rates are based on certified seed tags obtained from commercial sources.
- All seed and planting materials shall be labeled and meet state seed quality law standards. All seed shall be of high quality and be labeled in accordance with Minnesota Seed Law, section 21.82 including limits on noxious weeds.
- Seed must be planted within 24 months of the germination test date. If seeding will exceed these time limits, the seed shall be re-tested for germination and purity to ensure seed quality. Variances may be granted by the State Resource Conservationist or State Agronomist on a case-by-case basis.

SEED MIXTURES FOR ANNUAL FORAGES

The seeding mixture used will depend on the goals/objectives of the producer as well as the planned purpose for the seeding. Annual forages for grazing or forage production can include a diverse mix of grass, non-legume broadleaves (brassicas, sunflower, etc.), and legume plants. Seed mixtures may also be single species or simple mixtures of just 2 or 3 species in one or more functional groups. If the purpose of the planting is to improve soil microbial life and soil aggregate stability, increased diversity of species from multiple functional groups will be desired to create a balanced stand of above ground biomass and below ground root structure to enhance soil building and soil biological activity. A diverse seed mixture also feeds beneficial organisms, improves soil structure, reduces compaction, improves water infiltration/water holding capacity, and increases the root structure to allow for more nutrient exchange sites in the soil. When using multi-species mixtures, the planned seeding dates for all species must be considered. For example, a diverse mix of warm and cool season species should not be planted until the soil temperature has reached acceptable levels for the warm season species in the mix.

When planning multi-species mixtures, consider the influence of species growth characteristics, anticipated growing conditions, nutrient needs, planned seeding rate, seed size, and the termination method and date.

Use the following reference to evaluate annual forages species for growth characteristics and conservation benefits:

- Table 2: Identification and Comparison of Annual Forages Performance and Benefits by Species.
- "Midwest Cover Crop Decision Tool" http://mccc.msu.edu/
- Brummer, Fara; Sedivec, Kevin; Nester, Penny; Gaugler, Erin; and Schaunaman, Crystal. 2015. Annual Cover Crop Options for Grazing and Haying in the Northern Plains. North Dakota State University Extension. R1759

ANNUAL FORAGE SPECIES FUNCTIONAL GROUPS

The following section provides a summary of the different types of functional groups of annual forages. Selecting species in the proper functional group for the time of planting is crucial for meeting the purpose and production goals of the planting. Refer to the chart below for some of the common annual forage species by functional group. Note: Other species may also work as annual forages. Refer to "Table 1: Annual Forage Species Recommended for Planting in Minnesota" and "Table 2: Identification and Comparison of Annual Forages Performance and Benefits by Species".

Chart 1: Annual Forage Species for Grazing Systems						
Cool Season Grasses	**Warm Season Grasses**	**Warm Season Legumes**	**Cool Season Legumes**	**Brassicas**	**Winter Annuals**	**Other Forbs**
Oats	Pearl Millet	Cowpeas	Common Vetch	Turnips	Winter Rye	Chicory
Spring/Winter Barley	German Millet	Sunhemp	Hairy Vetch	Radishes	Winter Wheat	Safflower
Wheat	Japanese Millet	Soybeans	Crimson Clover	Hybrid Brassicas	Winter Triticale	Sunflower
Triticale	Sorghum-sudangrass	Mung Beans	Berseem Clover	Forage Collards		Buckwheat
Annual Reygrass	Forage Sorghum		Red Clover	Rape		
	Teff		White Clover	Kale		
	Corn		Forage Peas	African Cabbage		
			Winter Peas			
			Chickpea			

COOL SEASON GRASSES

These species are generally planted in the spring to provide forage options in the early part of summer. They like cooler temperatures and do not perform as well during the heat of the summer. All of these are annuals that will winter kill except for annual ryegrass, which may over-winter.

WINTER ANNUAL GRASSES

These species are generally planted in late summer or early fall to provide grazing opportunities the next spring or early summer. They can provide excellent spring pasture options as they may be ready to graze sooner than perennial pastures in most years.

WARM SEASON GRASSES

Ideally suited for summer forage production. Warm season species generally require a soil temperature of 60 degrees or more at planting. Do not plant into soil that is too cold. For best forage production, plant in late May-July. Avoid planting in August as forage production will be limited as the days get shorter and nights get cooler later in the summer and fall. Southern MN may experience a longer planting window than northern MN.

WARM SEASON LEGUMES

Ideally suited for summer forage production. Warm season species generally require a soil temperature of 60 degrees or more at planting. Do not plant into soil that is too cold. For best forage production, plant in late May-July. Avoid planting in August as forage production will be limited as the days get shorter and nights get cooler later in the summer and fall. Southern MN may experience a longer planting window than northern MN. To optimize production and nitrogen fixation, apply the appropriate inoculant for the legume species.

COOL SEASON LEGUMES

Plant these species in the spring and again in the late summer/fall. They like cooler temperatures and do not perform as well during the heat of the summer. All of these are annuals that will winter kill except for red and white clovers, which are perennial species. To optimize production and nitrogen fixation, apply the appropriate inoculant for the legume species.

BRASSICAS

Brassicas are broadleaf plants in the mustard family and consist of many livestock forage species, such as turnips and radishes. If planting as part of a season-long annual forage crop, consider keeping the total seeding rate of brassicas down to 0.5-1 lb per acre, especially on high producing/high fertility fields because they may overtake the other species in the mix if seeded at higher rates. Seeding rates can be higher on coarse-textured soils.

These species have a high water and nutrient content. As such, brassicas should be planted as a part of mixtures with other forages that may have higher dry matter content and lower digestibility. If grazing stands with high percentages of brassicas, consider feeding dry hay while grazing to help the animals balance their diet.

OTHER FORBS

Several other broadleaf plants may be utilized as annual forages. These species may be either warm or cool season.

SINGLE AND MULTIPLE SPECIES SEEDING RATE

Use the Minnesota Annual Forages for Grazing Systems Design Workbook to design seed mixes. When designing multiple species mixtures, multiply the minimum seeding rate for each selected plant species by the planned percentage of each species. The “planned percentage” represents a general proportion of the seed to be planted per species and is not a direct calculation of seeds per square foot or an estimate of canopy cover or plant dominance of a given species. Refer to Table 1: Annual Forage Species Recommended for Planting in Minnesota for the recommended seeding rate by species.

The seeding rates for each species are the minimum required. Seeding rates may need to be heavier, depending on producer objectives and site conditions. Waivers may be granted on a limited basis. Producers will need to provide justification and documentation on why a waiver from the standard and technical note is warranted. Waivers that are granted will have follow-up from the field office. A waiver from the NRCS State Grazing Lands Specialist, Area Grazing/Rangeland Management Specialists or Area Resource Conservationists (ARC) are required when:

- Annual forages are planted earlier or later than the recommended seeding date.
- When planning/designing an annual forage species that is not listed in Table 1: Annual Forage Species Recommended for Planting in Minnesota.

CALCULATING SEEDING RATES AND MIXES

Refer to Table 1: Annual Forage Species Recommended for Planting in Minnesota, which lists the minimum seeding rate by species. The planner can use the seeding rates and multiply by the planned percentage of each species. This will determine the pounds of seed per species to be planted per acre. Consider rounding up to the next full pound of seed if the seeding rate calculation results in a decimal of 0.5 or larger. **All planting rates listed on Table 1 are in pure live seed (PLS).** For single species and multi-species mixtures, a minimum of 100% will be used for the seeding rate. Refer to the Minnesota Annual Forages for Grazing Systems Design Workbook for assistance with designing seed mixes.

MANAGEMENT OF ANNUAL FORAGES

The following provides recommendations for grazing and forage harvest management. Forage harvest will be planned according to Conservation Practice Standard (CPS) 511-Forage Harvest Management and grazing will be planned according to CPS 528-Prescribed Grazing. The grazing or forage harvest events will leave adequate ground cover, and field conditions will be left adequate for establishing the next crop or for seeding perennial forage where applicable. Refer to the 810-Annual Forages for Grazing Systems CPS for practice purposes appropriate for forage harvest management.

GRAZING MANAGEMENT

Grazing shall follow the 528-Prescribed Grazing CPS. A prescribed grazing plan and livestock forage balance will need to be developed during the planning process. See the 528 Prescribed Grazing Conservation Practice Standard and the 528 Prescribed Grazing Statement of Work for more details on planning prescribed grazing. The following provides several considerations for grazing annual forages:

- Provide adequate time after planting and before grazing the forage stand to allow for accumulation of forage growth.
- Consider whether the field will be grazed once or whether multiple grazing events will be attempted during the season.
    - If multiple harvests are desired, select species and varieties that are capable of being harvested multiple times.
- To optimize forage growth and grazing efficiency, manage the timing, duration, and intensity of grazing:
    - Timing:
        - Graze the annual forages at a growth stage that will meet the production goals of the producer and optimize animal performance.
        - Manage the amount of time animals spend in each paddock or field planted to annual forages. If planning to graze multiple times within one season, provide adequate rest between grazing events to allow for forage plant recovery. Rest periods will vary based on growing conditions, which include adequate temperature for the forage species planted and adequate moisture to sustain plant growth. Soil fertility will also impact forage growth and recovery. Average rest periods may range from 25 to 40+ days between grazing events.

- Duration:
  - The length of the grazing period will depend on the stocking rate (number of animals grazing) and the annual forage production available at the time of grazing. As forage production increases, decrease the size of the paddocks and shorten the length of the grazing periods to minimize the amount of trampling loss and optimize grazing harvest. Ideally, grazing periods on actively growing plants should be a week or less on average, especially if multiple grazing events are planned for the forage stand. When grazing the annual forages as stockpile in the fall/winter, grazing periods may be longer (up to two weeks). Note: longer grazing periods may increase forage trampling loss.
- Intensity:
  - Grazing intensity will depend on the forage needs of the livestock and the goals of the producer for the annual forage. As plants mature, the forage quality tends to decrease. Depending on the nutritional needs of the livestock, grazing intensity may need to decrease as forage maturity increases, especially for growing animals such as yearlings.
  - Allow for adequate growth prior to starting grazing. Maintain minimum stubble heights after removing animals to promote forage recovery within the season and to prevent soil erosion during the dormant season. Refer to the chart below for grazing start and stop heights based on dominant forage species functional groups.

Chart 2: Forage Grazing Recommendations

Dominant Species	Start Grazing Height	Stop Grazing Height
Cool Season Annual Grasses	8+"	4"
Warm Season Annual Grasses	24+"	8+"
Teff	8+"	4"
Legumes	8+"	4"
Diverse Cool/Warm Season Mixes	16-24"	6-8+"

General Grazing Requirements

The Stop Grazing Heights will be maintained as an average across the pasture. Use a Grazing stick, ruler, or tape to measure plant height in several places across the pasture. Determine the average vegetation height. Follow a prescribed grazing plan and applicable average stop grazing heights.

FORAGE HARVEST MANAGEMENT

Harvesting forage shall follow the 511-Forage Harvest Management CPS. Refer to the Conservation Practice Standard, Statement of Work, and Implementation Requirements for 511-Forage Harvest Management for more details. The following provides considerations for harvesting annual forages as stored feed:

- If the practice purpose is to remove excess nutrients from the soil, then the annual forages must be mechanically harvested.
- Provide adequate time after planting for forage growth to accumulate before harvesting.
- Consider the nutritional needs of the livestock during the time that the forage will be fed. Time the harvest of the annual forages at a maturity stage that will meet the nutritional requirements of the livestock.
- Consider whether the field will be harvested once or multiple times during the season.
    - If multiple harvests are desired, select species and varieties that are designed for multiple harvests.
- Consider whether the forages will be harvested as dry hay, haylage, baleage, or silage. The harvest method will impact species selection and possibly variety selection. Match species and varieties to the harvest method.
- Consider the desired moisture content of the forage based on the harvest method. The following are general guidelines for desired forage moisture content based on harvest method:
    - Dry hay: 15-20%
    - Wrapped hay/baleage: 40-55%
    - Annual Forages for haylage/silage: ~60-65%
- Many annual forage species may be difficult to harvest as dry hay due to their moisture content as well as the potential forage production at the time of harvest.
    - All brassicas may be difficult to harvest as dry hay under normal growing conditions.
    - Sorghum and sorghum-sudan grasses may be difficult to harvest as dry hay due to the potential tonnage and forage moisture content at the time of cutting, especially if planning a single harvest of the crop. If planning multiple harvests, consider harvesting at shorter heights to reduce the volume if attempting to harvest as dry hay.
    - All other species may also be difficult to harvest as dry hay, depending on tonnage and if wet weather conditions prevail while attempting to harvest.
    - Consider leaving stubble height to reduce potential for wind and water erosion. If harvesting multiple times, follow stubble height guidelines listed in Chart 3 below. If a single harvest is planned, maintain a minimum of 4”.
    - Consider the harvest interval period (rest) when planning multiple harvests. More than two harvests of an annual forage may not be achievable in MN, especially northern MN. Rest periods between harvests may vary between 25 and 40+ days, depending on forage quality goals, growing conditions, and time of year.

Chart 3: Forage Harvest Recommendations

Dominant Species	Minimum Cutting Height
Cool Season Annual Grasses	4"
Warm Season Annual Grasses	8+"
Teff	4"
Legumes	4"
Diverse Cool/Warm Season Mixes	6-8+"

Forage Harvest Management Requirements

The Minimum Cutting Heights will be maintained as an average across the area. Use a Grazing stick, ruler, or tape to measure plant height in several places across the area. Determine the average vegetation height. Follow a forage harvest plan and applicable average minimum cutting heights.

GRAZING AND HARVESTING PRECAUTIONS

- *Prussic Acid Poisoning:* Sorghum, sudangrass, and sorghum-sudan grass can build prussic acid during or after a frost. After a killing frost, wait 10-14 days before turning livestock back out onto these forages. Do not graze below 18 inches after a light frost.
- *Coumarin:* Sweet clover contains coumarin, which can turn into dicoumarin, a blood thinner. This increases in concentration as the plant matures and becomes more of an issue if the plant becomes moldy. If poisoning is severe enough, it can lead to death.
- *Bloat:* Grazing fields that are predominantly legumes (greater than 40-50% dry matter) can lead to bloat. Caution should be used when grazing high legume content fields and take precautions to minimize the risk of bloat as it can lead to death in livestock.
- *Brassicas:* Brassicas have a high water content and are highly digestible. They also contain glucosinolates, which can cause thyroid problems. Consider planting as a mix. Provide free-choice supplemental feed when grazing stands with a high percentage of brassicas.
- *Nitrates:* Nitrate Poisoning can occur during drought conditions in cool season and warm season annual grasses as well as brassicas. Monitor growing conditions and consider testing the forages during droughty conditions. Refer to the US Drought Monitor for current drought conditions. If forages test high in nitrates, producers should consult a livestock nutritionist to determine if and how those forages may be used for grazing or feed.

SCENARIOS FOR USING ANNUAL FORAGES FOR GRAZING OR FEED

The following provides common scenarios of how annual forages MAY be incorporated into a grazing system. ***Note: other scenarios may exist other than those covered in this technical note.*** Contact the NRCS State Grazing Lands Specialist, Area NRCS Grazing/Rangeland Management Specialists or NRCS Area Resource Conservationists (ARC) with questions regarding application of this practice.

1. UTILIZING ANNUAL FORAGES TO RENOVATE PASTURE OR HAYLAND

In many cases, applying sound grazing management principles are enough to improve forage production in a pasture to meet the producer's management goals. Sometimes, however, other practices are needed to improve productivity. For example, in pastures heavily dominated by Kentucky bluegrass, other species may not be able to compete with the bluegrass. Improved grazing management by itself may not be enough to improve the productivity to reach site potential or production goals without renovation.

Photo of pasture dominated by Ketucky Bluegrass

Seeding perennial species immediately after terminating a perennial forage stand may result in poor site seeding conditions and poor establishment. The relatively poor establishment may be due to a variety of factors. One of those factors could be a result of high C:N ratio of the dead sod, especially if the stand was predominantly perennial grasses. The high C:N ratio present in the dead sod will mean that the soil microbes responsible for the decomposition of the sod will need to scavenge nitrogen from the soil to ensure that their diet meets their ideal C:N ratio.

Many perennial species, especially grasses, relatively low seedling vigor and are often vulnerable during the establishment phase to competition for moisture and nutrients. Breaking the perennial cycle by adding an annual forage may help to improve the establishment and productivity of a new perennial forage stand. Renovating pastures provides an opportunity to utilize annual forage species to aid in the renovation process as well as provide additional forage for livestock.

Cow/calf pairs grazing annual forages as part of renovating a pasture.

Suggested steps to renovating a pasture/hayland with annual forages:

- Obtain a soil test for the area to be renovated to determine current fertility status as well as the pH.
- Graze early growth of the existing perennial vegetation in May or early June. Most pastures in MN are cool season-dominated, so grazing early will allow for harvesting the most productive stage of the pasture prior to terminating the stand.
- Terminate the existing vegetation with tillage, herbicide, or both. If using herbicide, allow the pasture to re-grow for 1-2 weeks prior to spraying with herbicide to allow for the current vegetation to start actively growing again.

- Plant an annual forage mix in June. Consider planting a warm-season dominated mix to capitalize on the growing conditions during the mid-summer months. Annual forages planted in June may be ready to graze anywhere from mid-July to mid-August, depending on planting date and growing conditions. Annual forages grazed during the summer provide high quality grazing opportunities at a time when cool season forage production and quality may be limited. Another grazing period later in the fall may also be possible. Another option could be to stockpile the annual forages for fall/winter grazing.
    - If using tillage, annual forages may need to be planted for 1-2 years to ensure that the existing sod is adequately terminated.
    - If no-tilling into dead sod, annual forages may need to be planted for 2-3+ years to ensure that the previous sod is adequately terminated.

Several benefits may be realized by utilizing annual forages in the pasture/hayland renovation process:

- Assist with terminating the existing vegetation.
- Providing high quality pasture/forage in the late summer months when cool season forage quality may be poor.
- Provide forage to extend the grazing season in the fall.
- Improve total yield versus perennial pastures alone.

Pasture recently renovated to diverse mix of cool season grasses and legumes.

Once the existing vegetation is satisfactorily controlled, plant a perennial seed mixture. A good perennial seed mixture may contain several grasses and legumes that are adapted to the soil conditions found in the pasture/hayland. The photo to the left shows the results of a perennial pasture that was seeded to a mixture of 5 grasses and 3 legumes. The newly renovated pasture has improved yield over pre-renovation conditions and provides greater forage quality and availability throughout the grazing season.

Functional Groups Ideal for this Scenario

- Warm Season Grasses
- Warm Season Legumes
- Cool Season Grasses
- Cool Season Legumes
- Brassicas
- Other Forbs

2. USING ANNUAL FORAGES ON WINTER FEEDING AND CALVING AREAS

Photo depicting an annual forage mix planted on a winter feeding/calving pasture.

Many operations utilize the same winter feeding and calving areas every year, resulting in excess nutrients building up in the soils of these areas. Ideally, winter calving and feeding pastures are rotated to new locations every year to avoid long-term damage, but that may not be possible. Once the livestock are removed from these areas for the summer, they are commonly left for the remainder of the season with little or no perennial forage growth due to the heavy use during the fall, winter, and spring. Annual forages may be planted and harvested for forage in these areas to reduce excess nutrients in the soil.

Steps to incorporate annual forages into winter feeding and calving areas:

- Once the animals are removed, level the soil as needed. Tillage may be needed to level the ground and to disperse or break-up any build-ups of unused feed and manure.
- Control weeds as necessary with tillage, herbicide, or both.
- Plant the annual forage mixture. Depending on your goals and the timing of planting, cool season species, warm season species, or a mixture of both could be planted.

Benefits of using annual forages on winter feeding/calving areas:

- Improve forage production
- Remove excess nutrients deposited during the winter feeding/calving seasons.

Functional Groups Ideal for this Scenario

- Warm Season Grasses
- Warm Season Legumes
- Cool Season Grasses
- Cool Season Legumes
- Brassicas
- Other Forbs

3. *PLANTING CROPLAND TO SEASON-LONG ANNUAL FORAGES FOR SUMMER GRAZING OR TO EXTEND THE GRAZING SEASON*

Season-long annual forages planted on cropland may be an option to provide additional grazing opportunities during the summer months or to extend the grazing season later into the fall/early winter. They may also have the added benefits of diversifying the crop rotation, improving soil microbial life, and improving soil aggregation. Annual forages may be a useful option for operations short on summer pasture and may be a more cost-effective method of feeding livestock as opposed to supplemental feeding the animals in a feedlot.

Considerations for adding season-long annual forages into the crop rotation.

- Inventory existing forage resources. Most pastures are dominated by cool season forage species, so planting warm season annual forages may be desirable to improve forage quality and quantity later in the summer during times when cool season forage production is slow.
- Consider the current crop rotation and where season-long annual forages fit best into the rotation. How annual forages fit into a production system will vary from one operation to the next based on the crop rotation and specific goals for the operation.
    - Common examples:
        - Plant after harvest of early cool season vegetable crops, such as peas. Crops that are harvested by early July can provide ample forage production during the remainder of the season.
        - Plant after a winter annual cover crop or early season forage. For example, winter rye was planted after a small grain harvest the previous fall. The winter rye was hayed in the spring followed by another annual forage crop for the remainder of the season.
        - A small grain may be planted early in the season for grazing/fodder, such as oats and peas. After harvest, plant a warm season-based mix for the remainder of the season to be used to extend the grazing season later into the fall.
- Select species that will meet the goals/objectives of the producer and fit into their crop rotation. Many species options exist when planting a season-long annual forage.

- Consider the soil type, drainage, and fertility conditions in the field where the annual forages will be planted. Match species to the soil conditions in the field.
- Follow sound agronomic principles for site/seedbed preparation, seeding, and fertility management of the field. If treated as a productive forage crop, the chances of success will likely increase. Cutting corners to reduce cost may lead to poor establishment and production.

Photo courtesy of Hough Farms. Cattle grazing season-long cover crops in December.

The photo to the left depicts annual forages that were planted for the purpose of extending the grazing season. The mixture was planted in June and consisted of cool and warm season grasses as well as broadleaf species. The annual forages were allowed to grow the entire season and grazed late in the fall/early winter after perennial pastures were done being grazed for the season. In this example, annual forages extended the grazing season later into the fall.

Functional Groups Ideal for this Scenario

- Warm Season Grasses
- Warm Season Legumes
- Cool Season Grasses
- Cool Season Legumes
- Brassicas
- Other Forbs

4. *ANNUAL FORAGES FOR EARLY SEASON*

Winter annual forages may be planted in the fall to provide grazing opportunities in the spring. For example, winter rye may be planted after small grain harvest in the fall. The winter rye will then be used for grazing the following spring, which may allow extended rest for other perennial pastures. After grazing has been completed in the spring, the field could then be planted into another annual forage or a row crop for the duration of the summer.

Cool season annual species may also be planted early in the spring to provide grazing opportunities in early summer (June/early July). After the early season grazing has been completed, another annual forage crop could be planted for the remainder of the season. For example, oats and peas are planted in the spring and grazed until late June. The early season planting could be followed by a warm season planting in early July, such as sorghum-sudan or pearl millet, or a diverse mixture of several species.

Considerations for planting annual forages for early season grazing

- Planting date of winter annuals in the fall may impact forage production in the spring. Planting after small grains or similar short season crops works best rather than after corn or soybeans.
- Consider the overall crop rotation and what the next crop will be after the early season forage crop. Another forage crop following early season annual forages may be ideal. Depending on how long the annual forages are grazed in the spring and location within the state, following with a row crop in the same year as the annual forage may or may not be feasible due to the shorter growing season and impact the annual forages may have on soil moisture for subsequent crops (especially in dry years).

HERBICIDE ROTATION RESTRICTIONS

Please review herbicide application records for at least the past two or more cropping seasons. Some herbicides maintain long-term residual soil activity for months or years after application and could impact annual forages establishment and/or their use for forage. **Always check the herbicide labels for planting, harvesting, or grazing restrictions.** See University of Wisconsin Extension publication "Herbicide Rotation Restrictions in Forage and Cover Cropping Systems". Also see Iowa State University Publication Crop 3082 "Herbicide Use May Restrict Grazing Options for Cover Crops".

ANNUAL FORAGES FOR WILDLIFE AND POLLINATOR USE

Diverse annual forage plantings not only provide for additional grazing and forage opportunities, but also may provide for wildlife and pollinator habitat. Generally, the more diversity of habitat types provided and the more interspersed those habitats are, the more potential a property has for wildlife. Providing diversity ensures that wildlife have ample choices to locate their required resources. Annual forages can contribute to habitat diversity.

Annual forages may provide important areas to forage, areas of cover from both predators and the elements, and areas in which to breed and nest. Plant diversity produces insect diversity, and thus, a mix of annual species may be beneficial for young birds that require insects as their main food source in the spring.

Flowering annual species may be especially attractive to pollinators and beneficial insects because they provide pollen, nectar, and shelter. Many natural enemies of crop pests also benefit from these habitat resources for at least one stage of their life cycle. Attracting pollinators and beneficial insects has the potential to boost yields through increased pollination services, natural pest control, and improved soil health. Utilizing a diverse species mixture will maximize beneficial insect activity by generating season-long blooms and variation in vegetative structure.

Annual forage crop termination has the potential to be detrimental to wildlife, but careful management can reduce harmful impacts. Leaving residue and as much physical structure as possible will benefit insects, ground-nesting pollinators, and other wildlife. Finally, minimizing insecticide use in successive cash crops will also reduce harm to beneficial insects that are using annual forage residue.

Annual forage crops can provide significant wildlife benefits, but they should be viewed as a supplement to a comprehensive wildlife management plan, rather than a replacement for perennial cover. Permanent conservation areas (e.g. grasslands, wetlands, field borders, hedgerows of trees and shrubs, etc.) should be composed of primarily high-quality native species to maximize the diversity of beneficial insects and wildlife on the farm.

See Table 3 for wildlife and pollinator suggestions:

Table 3: Generalized Use of Common Annual Forages by Wildlife, Bees, and Beneficial Insects

SPECIES	WILDLIFE - BIRDS AND MAMMALS							BEES AND BENEFICIAL INSECTS		
	COVER				FOOD		GREEN BROWSE			
	Nesting	Brood	Fall	Winter	Fall	Winter		Honey Bee	Wild Bees	Predator Parasitoid
GRASSES										
SPRING BARLEY			X		X		1,2,3	None	None	Low
WINTER BARLEY	X	X					1,2,3	None	None	Low
MILLETS			X		X	X		None	None	Low
OATS			X				1,2,3	None	None	Low
WINTER CEREAL RYE	X		X				1,2,3	None	None	Low
SORGHUM-SUDANGRASS			X	X	X	X		None	None	Moderate
SPRING WHEAT			X		X		1,2,3	None	None	Low
WINTER WHEAT	X	X	X				1,2,3	None	None	Low
NON-LEGUMES BROADLEAF										
BUCKWHEAT		X			X			High	High	High
FLAX								Moderate	Moderate	Moderate
KALE								High	High	High
MUSTARD		X	X		X	X		High	High	High
PHACELIA								High	High	High
RADISH (oilseed/forage)			X		X	X		High	High	High
RAPESEED/CANOLA			X	X	X	X		High	High	High
SAFFLOWER								Moderate	Moderate	Moderate
SUNFLOWER					X	X		High	High	High
FORAGE-TYPE TURNIP			X	X	X	X		High	High	High
LEGUMES										
ALFALFA		X	X		X		1,2,3,4	High	High	Moderate
CHICKPEA								Low	Low	Low
CLOVER; Berseem, Crimson, White		X	X		X		1,2,3,4	High	High	Moderate
CLOVER, Red		X	X		X		1,2,3,4	Low	High	Low
COWPEA		X	X		X			High	High	High
FAVA BEAN								Low	Moderate	Moderate
FIELD/WINTER PEA			X		X		1,2,3,4	Low	Low	Low
LUPIN								Low	Moderate	Moderate
SANFOIN								High	High	Moderate
SUNNHEMP								Moderate	High	Moderate

Key to Green Browse Use

1 – Deer 2 – Geese 3 – Small Mammals

4 – Grassland/Upland Birds

TERMINATION OF ANNUAL FORAGES

Annual forages will be terminated by frost, tillage, and/or with proper herbicide selection. Harvest of grain is not a purpose of this practice standard. Timing of annual forage termination must meet the purpose of the planting as specified in the conservation plan. In instances where another crop will follow the annual forage crop in the same season, higher levels of management may be needed to ensure that the annual forages do not result in soil moisture depletion, nitrogen immobilization, allelopathy, and to prevent unwanted reseeding. During the planning process, determine how and when the annual forages will be terminated, if needed. Early season annual forages should be terminated as late as feasible to maximize forage production, but there is some risk in waiting too long because a vigorously growing annual forage can deplete soil moisture, negatively affecting the following crop. Avoid planting a grain crop the same year after an early season annual forage crop if drought conditions are present. Consider planting another annual forage crop for the remainder of the season. A period of 7-21 days between termination and planting is usually sufficient if there is adequate rainfall to replenish the seed zone and hasten decomposition of the annual forage residue.

HERBICIDE TERMINATION

If the annual forage is to be terminated with herbicides, assure that timing and selection of herbicides achieve a complete kill. Translocated herbicides will normally perform better under conditions that are ideal for active growth. Make sure herbicides are compatible with the following crop. Follow all federal, state, and local guidelines as well as the manufacturer's label rates and guidelines when applying herbicides. Always apply herbicides according to labeled directions. For additional information to herbicide controls, contact your local agronomist, or Minnesota Extension Specialist.

WINTER KILL TERMINATION

Many of the annual species will be terminated by winter. However, some species may have hard seed that will germinate in the spring prior to the planting of the primary cash crop, or growing plants may over-winter in mild winters, especially if there is snow cover.

MECHANICAL TERMINATION

Tillage may be used to terminate an annual forage. Caution that mechanical termination does not always result in complete removal.

OPERATION AND MAINTENANCE

Consider the following operation and maintenance items for annual forages.

- Evaluate the annual forage crop to determine if it meets the planned purpose(s). If the annual forage crop does not meet the intended purpose(s), adjust the management, change the species, or choose a different technology.
- Invasion of undesirable plants will be controlled. Acceptable methods include:
  - By cutting as forage or clipping invaded areas.
  - Using an herbicide that will not affect planted species.
  - By grazing management through manipulating livestock type, stocking rates, density, and duration of stay.

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810 - Minnesota Annual Forages for Grazing Systems

Table 1

FULL SEEDING RATES			CROP TYPE	SEEDING DATES	
SPECIES	**[1] Minimum Seeding Rate in lbs./ac PLS (Incorporated Seed)**	**PLANTING DEPTH (inches)**		**NORTH OF INTERSTATE 94**	**SOUTH OF INTERSTATE 94**
GRASSES					
SPRING BARLEY	90 lbs/acre PLS	0.75-1.5	CG	April 15-June 15 and July 15-August 15	April 1-June 15 and July 15-September 1
WINTER BARLEY	90 lbs/acre PLS	0.75-1.5	CG	August 15-October 1	August 15-October 15
OATS	90 lbs/acre PLS	0.5-1	CG	April 15-June 15 and July 15-August 15	April 1-June 15 and July 15-September 1
ANNUAL RYEGRASS	20 lbs/acre PLS	0-0.5	CG	April 15-June 15 and July 15-August 15	April 1-June 15 and July 15-September 1
WINTER CEREAL RYE	90 lbs/acre PLS	0.75-1.5	CG	July 15-October 15	July 15-October 15
SPRING TRITICALE	90 lbs/acre PLS	0.75-1.5	CG	April 15-June 15 and July 15-August 15	April 1-June 15 and July 15-September 1
WINTER TRITICALE	90 lbs/acre PLS	0.75-1.5	CG	July 15-October 15	July 15-October 15
SPRING WHEAT	90 lbs/acre PLS	0.75-1.5	CG	April 15-June 15 and July 15-August 15	April 1-June 15 and July 15-September 1
WINTER WHEAT	90 lbs/acre PLS	0.75-1.5	CG	July 15-October 15	July 15-October 15
CORN [3]	30 lbs/acre PLS	2.0-3.0	WG	May 15-August 1	May 1-August 1
FOXTAIL MILLET	20 lbs/acre PLS	0.5-1	WG	June 1-August 1	May 15-August 1
JAPANESE MILLET	20 lbs/acre PLS	0.5-0.75	WG	June 1-August 1	May 15-August 1
PEARL MILLET	20 lbs/acre PLS	0.5-1	WG	June 1-August 1	May 15-August 1
PROSO MILLET	20 lbs/acre PLS	0.5-1	WG	June 1-August 1	May 15-August 1
SORGHUM	28 lbs/acre PLS	0.5-1.5	WG	June 1-August 1	May 15-August 1
SORGHUM-SUDANGRASS	28 lbs/acre PLS	0.5-1.5	WG	June 1-August 1	May 15-August 1
SUDANGRASS	28 lbs/acre PLS	0.5-1	WG	June 1-August 1	May 15-August 1
TEFF	8 lbs/acre PLS	0.25	WG	June 1-August 1	May 15-August 1
NON-LEGUME BROADLEAVES [1]					
BEETS (Non GMO)	4 lbs/acre PLS	0.25-0.5	CB	April 15-September 15	April 1-September 1
CABBAGE	3 lbs/acre PLS	0.25-0.5	CB	April 15-September 1	April 1-September 1
KALE	3 lbs/acre PLS	0.25-0.5	CB	April 15-September 15	April 1-October 1
FORAGE COLLARDS	3 lbs/acre PLS	0.25-0.5	CB	April 20-September 1	April 15-September 1
MUSTARD	5 lbs/acre PLS	0.25-0.75	CB	April 15-September 1	April 1-September 1
PHACELIA	6 lbs/acre PLS	0.12-0.25	CB	April 15-August 15	April 1-September 1
RADISH	5 lbs/acre PLS	0.5-0.75	CB	June 25-September 1	June 25-September 1
RAPESEED/CANOLA	3 lbs/acre PLS	0.25-0.5	CB	April 20-September 1	April 15-September 1
TURNIP	3 lb/acre PLS	0.25-0.5	CB	April 15-September 1	April 1-September 1
BUCKWHEAT [2]	25 lbs/acre PLS	0.5-1	WB	June 15-August 15	June 1-September 1
SAFFLOWER	30 lbs/acre PLS	1-1.5	WB	April 15-August 1	April 15-August 1
SUNFLOWER	4 lb/acre PLS	1-3.5	WB	June 1-August 1	June 1-August 1

810 - Minnesota Annual Forages for Grazing Systems

Table 1

FULL SEEDING RATES			CROP TYPE	SEEDING DATES	
SPECIES	**[1] Minimum Seeding Rate in lbs./ac PLS (Incorporated Seed)**	**PLANTING DEPTH (inches)**		**NORTH OF INTERSTATE 94**	**SOUTH OF INTERSTATE 94**
LEGUMES [1]					
CHICKPEA	80 lbs/acre PLS	0.25-0.5	CB	June 1-September 1	May 15-September 1
BALANSA CLOVER	5 lbs/acre PLS	0.25-0.5	CB	May 15-September 1	May 1-September 1
BERSEEM CLOVER	8 lbs/acre PLS	0.25-0.5	CB	May 15-September 1	May 1-September 1
CRIMSON CLOVER	15 lbs/acre PLS	0.25-0.5	CB	May 15-September 1	May 1-September 1
RED CLOVER	10 lbs/acre PLS	0.25-0.5	CB	April 15-August 15	April 1-August 15
WHITE CLOVER	4 lbs/acre PLS	0.25-0.5	CB	April 15-August 15	April 1-August 15
FAVA BEAN	80 lbs/acre PLS	2-4	CB	June 15-August 15	June 1-September 1
FIELD/WINTER PEA	50 lbs/acre PLS	1-1.5	CB	April 15-September 15	April 1-October 1
LENTILS	40 lbs/acre PLS	1-1.5	CB	April 15-September 15	April 1-October 1
SAINFOIN	40 lbs/acre PLS	0.25-0.75	CB	April 15- September 1	April 1-September 1
VETCH	20 lbs/acre PLS	0.5-1.5	CB	April 15-August 15	April 1-August 15
COWPEA	45 lbs/acre PLS	1-1.5	WB	June 1-August 15	May 15-September 1
SOYBEANS	40 lbs/acre PLS	0.5-1	WB	June 15-August 15	June 1-September1
SUNNHEMP	20 lbs/acre PLS	0.5-2.5	WB	June 1-August 1	June 1-August 1
LEGEND					
CROP TYPE: CG=COOL SEASON GRASS, CB= COOL SEASON BROADLEAF, WG=WARM SEASON GRASS, WB=WARM SEASON BROADLEAF					
[1] Incorporated seed--Seeding methods used that provide good seed to soil contact. PLS=Pure Live Seed					
[1] All Non-Legume Broadleaves and Legume species should always be considered as part of a multi-species annual forage and rarely planted as a single species					
[2] Plantings containing buckwheat may not be seeded within 30 feet of an existing commodity wheat field, or in a field with a planned rotation to commodity wheat within two years.					
[3] These species are to be used for grazing only.					
INFORMATION from Midwest Cover Crops Council (MCCC) Website, MCCC Cover Crop Field Guide, Green Cover Seed, SARE-Managing Cover Crops Profitably, SARE-Cover Cropping for Pollinators and Beneficial Insects, USDA-ARS Cover Crops Chart, USDA-NRCS PLANTS Guide					

Table 2

Identification and Comparison of Annual Forages Performance and Benefits by Species

Identification and Comparison of Annual Forages Performance and Benefits by Species

ATTRIBUTE RATINGS: 0=POOR, 1= FAIR, 2=GOOD, 3=VERY GOOD, 4=EXCELLENT

	Performance and Roles I								Performance and Roles II				Cultural Traits										Potential Advantages											
SPECIES	**Nitrogen Source**	**Total Nitrogen (lb/ac)**	**Dry Matter (lbs/ac/yr)**	**Nitrogen Scavenger**	**Soil Builder**	**Erosion Fighter**	**Weed Fighter**	**Quick Growth**	**Lasting Residue**	**Grazing**	**Mechanical Forage Harvest Value**	**winter Survival**	**Heat Tolerance**	**Drought Tolerance**	**Shade Tolerance**	**Flood Tolerance**	**Salinity Tolerance**	**Life Cycle**	**Growth Habit**	**Preferred Soil pH**	**Water Use**	**Low Fert Tolerance**	**Subsoiler**	**Allelopathic**	**Choke Weeds**	**Attracts Beneficials**	**Bears Traffic**	**Short Windows**	**C:N Ratio**	**Crude Protein**	**Arbuscular Mycorrhizal Associations**	**Seed Count (seeds/lb)**	**Germination Temperature (F)**	**Notes**
GRASSES																																		
SPRING BARLEY	0	0	2000-5000	3	3	3	3	3	3	3	2	Never	2	2	1	2	2	Cool Season, Annual	Upright	6-8	Low	2	2	3	3	2	2	4	20:1	hay 10-15%, Grain 11-15%	Benefits from	13,600	35	If small grains are planted too early in the fall, depending on the crop rotation there can be disease problems (especially with tan spot) Self Pollinator (wind).
WINTER BARLEY	0	0	2000-10,000	4	3	4	3	3	4	3	2	Seldom	2	2	1	2	N/A	Cool Season, Annual	Upright	6-8	N/A	3	2	3	4	2	2	4	20:1	12%	Benefits from	13,600	35	Tolerates moderately alkaline conditions but does poorly in acid soils of less than 6 pH. If small grains are planted too early in the fall, depending on the crop rotation there can be disease problems (especially with tan spot).
OATS	0	0	2000-6000	3	3	3	2	4	2	4	3	Never	2	2	2	2	1	Cool Season, Annual	Upright	4.5-7	Medium	3	2	2	3	0	3	4	33:1	Hay 9-15%, Grain 13-18%	Forms	19,600	38	Prone to lodging in N rich soil. Self Pollinator (wind). Non-host for root knot nematode, soybean cyst nematode, and sugarbeet cyst nematode. Host for Penetrans Root-Lesion Nematode. Slow to release Nitrogen to following crop unless growth terminated in mid-vegetative stage (12-18 in).
ANNUAL RYEGRASS	0	0	1000-8000	3	3	3	2	3	3	4	3	Seldom	1	1	3	3	N/A	Cool Season, Annual	Upright	5.5-7	N/A	2	2	2	4	1	3	3	20:1-31:1	9%	N/A	190,280	40	Heavy Nitrogen and water user. Cutting boosts dry matter significantly. Not advised for wheat rotations. May take two applications to chemically terminate. Must be killed before it joints. Host for Penetrans Root-Lesion Nematode.
WINTER CEREAL RYE	0	0	2500-6000	4	4	4	4	4	4	4	3	Expected	2	3	2	3	2	Cool Season, Annual	Upright	5-7	High	3	2	4	4	1	3	4	14:1 young 40:1 boot	Straw 4%, Grain 14%	Forms	18,160	34	Kill 1.5-2 weeks before planting corn. Not recommended before corn due to allelopathy. Corn seed maggot/armyworm, cutworm could be issues. Tolerates triazine herbicides. Self Pollinator (wind). Non-host for root knot nematode, soybean cyst nematode, and sugarbeet cyst nematode. Host for Penetrans Root-Lesion Nematode.
SPRING TRITICALE	0	0	2000-5000	4	3	4	3	3	4	4	3	Never	2	2	2	2	2	Cool Season, Annual	Upright	5.2-7	High	2	2	2	4	1	3	4	20:1	Hay 9-16%, Grain-17%	Forms	15,000	38	
WINTER TRITICALE	0	0	2000-5000	4	3	4	3	3	4	4	3	Expected	2	2	2	2	2	Cool Season, Annual	Upright	5.2-7	High	2	2	2	4	1	3	4	20:1	Hay 9-16%, Grain-17%	Forms	16,000	38	Self Pollinator (wind). Non-host for sugarbeet cyst nematode, soybean cyst nematode, and root knot nematode. Host for Penetrans Root-Lesion Nematode.
SPRING WHEAT	0	0	1200-3000	3	3	3	2	3	3	3	3	Never	2	2	2	2	2	Cool Season, Annual	Upright	6-7	Medium	2	2	1	3	1	3	4	15-95:1	Straw 4-10%, Grain 12-16%	Benefits from	11,360	38	Heavy Nitrogen and water user in spring. Absorbs Nitrogen and Water heavily during stem growth, so kill before then. Carbon: Nitrogen Ratio--Leaf 15-29, Stem 31-65, Root 24-74, Straw 80-95 (end of season). Self Pollinator (wind). Southern MN has Hessian Fly-free planting dates to be heeded. Host for Penetrans Root-Lesion Nematode.
WINTER WHEAT	0	0	2000-5000	4	3	4	3	3	4	4	3	Expected	2	2	2	2	N/A	Cool Season, Annual	Upright	6-7	N/A	2	2	1	4	1	3	4	20:1	9%	N/A	11,360	38	Kill 1.5-2 weeks before planting corn. Corn seed maggot, armyworm, and cutworm could be insect issues. Heavy Nitrogen and water user in spring. Southern MN has Hessian Fly-free planting dates to be heeded. Non-host for sugarbeet nematode, soybean cyst nematode, and root knot nematode. Wheat curl mite can spread wheat streak mosaic virus. Use 2 weeks of broken green bridge to break the pest cycle (cover crops can harbor the pest, allowing transfer from spring to winter crops). If small grains are planted too early in the fall, depending on the crop rotation there can be disease problems (especially with tan spot).
Corn	0	0	1000-12000	3	2	3	4	4	4	3	2	Never	3	2	3	1	1	Warm Season, Annual	Upright	5.5-7.5	High	1	2	1	4	NA	NA	NA	57:1	6.5-8.5%	Good	2,450	50	

Table 2

Identification and Comparison of Annual Forages Performance and Benefits by Species

ATTRIBUTE RATINGS: 0=POOR, 1= FAIR, 2=GOOD, 3=VERY GOOD, 4=EXCELLENT																																		
	Performance and Roles I								Performance and Roles II				Cultural Traits										Potential Advantages												
SPECIES	Nitrogen Source	Total Nitrogen (lb/ac)	Dry Matter (lbs/ac/yr)	Nitrogen Scavenger	Soil Builder	Erosion Fighter	Weed Fighter	Quick Growth	Lasting Residue	Grazing	Mechanical Forage Harvest Value	winter Survival	Heat Tolerance	Drought Tolerance	Shade Tolerance	Flood Tolerance	Salinity Tolerance	Life Cycle	Growth Habit	Preferred Soil pH	Water Use	Low Fert Tolerance	Subsoiler	Allelopathic	Choke Weeds	Attracts Beneficials	Bears Traffic	Short Windows	C:N Ratio	Crude Protein	Arbuscular Mycorrhizal Associations	Seed Count (seeds/lb)	Germination Temperature (F)	Notes
GRASSES (continued)																																		
FOXTAIL MILLET	0	0	4000-8000	3	3	3	3	4	3	2	2	Never	4	4	1	1	0	Warm Season, Annual	Upright	5.5-7	Low	3	2	2	4	1	3	4	44:1	15%	Forms	220,000	65	Self Pollinator (wind). Do not feed to horses as it may have a laxative effect.
JAPANESE MILLET	0	0	1500-5500	3	3	3	3	4	3	3	2	Never	4	4	1	1	N/A	Warm Season, Annual	Upright	4.6-7	N/A	3	2	2	4	1	3	4	42:1	16%	N/A	142,880	65	Does not germinate or thrive in cold soil. Non-host for root knot nematode, soybean cyst nematode, and sugarbeet cyst nematode. Host for Penetrans Root-Lesion Nematode
PEARL MILLET	0	0	2000-6000	3	3	3	3	4	3	4	2	Never	4	4	1	1	0	Warm Season, Annual	Upright	5.5-7	Low	3	2	2	4	1	3	3	50:1	13%	Forms	82,320	65	Self Pollinator (wind). Slower to establish than sudan or sorghum-sudangrass. Does not germinate or thrive in cold soil. Non-host for root knot nematode, soybean cyst nematode, and sugarbeet cyst nematode. It is the best known cover crop for reduction of population densities of Penetrans Root-Lesion Nematode, but this can be variety specific.
PROSO MILLET	0	0	2000-4000	3	3	3	3	4	3	3	2	Never	4	4	2	2	0	Warm Season, Annual	Upright	5.5-7	Medium	3	2	2	4	1	3	4	12-35:1	10%	Forms	80,000	65	Carbon: Nitrogen Ratio--Leaf 12-16, Stem 12-35, Root 17-26. Self Pollinators (wind).
SORGHUM	0	0	3000-11000	4	4	3	4	4	4	3	4	Never	4	4	1	2	1	Warm Season, Annual	Upright	5.5-7	Medium	2	2	2	4	2	3	4	10-30:1	5-10%	Forms	14,000	65	Stress conditions that limit growth (e.g. drought, frost) can contribute to prussic acid accumulation in leaves. Don't graze until it's 24" tall and for 2 weeks after a killing frost- prussic acid Be wary of prussic acid toxicity if using for forage/grazing.
SORGHUM-SUDANGRASS	0	0	3000-11000	4	4	3	4	4	4	3	4	Never	4	4	1	2	1	Warm Season, Annual	Upright	5.5-7	Medium	2	2	2	4	2	3	4	10-30:1	Hay 7%, Stover 5%, Grain 10%	Forms	17,280	65	Alternate Name Grain Sorghum. Carbon: Nitrogen Ratio--Leaf 11-17, Stem 10-27, Root 22-30. Self Pollinator (wind). Mature, frost-killed plants become quite woody. Stress conditions that limit growth (e.g. drought, frost) can contribute to prussic acid accumulation in leaves. Don't graze until it's 24" tall and for 2 weeks after a killing frost- prussic acid Be wary of prussic acid toxicity if using for forage/grazing. Mid-season cutting increase yield and root penetration. Has been used in tree fruit, small fruit and vegetable production systems since the middle 1960s for management of Penetrans Root-Lesion Nematode and root knot nematode. Non-host for soybean cyst nematode and sugarbeet cyst nematode.
SUDANGRASS	0	0	3000-11000	4	4	3	4	4	4	4	4	Never	4	4	1	2	1	Warm Season, Annual	Upright	5.5-7	Medium	2	2	2	4	2	3	4	48-63:1	Hay 7-11%, Silage 6-17%	Forms	42,240	65	Self Pollinator (wind). Stress conditions that limit growth (e.g. drought, frost) can contribute to prussic acid accumulation in leaves. Be wary of prussic acid toxicity if using for forage/grazing. Drought stressed plants can cause nitrate poisoning. Known allelopathic effects on annual ryegrass. Non-host for root knot nematode, soybean cyst nematode, and sugarbeet cyst nematode. Host for Penetrans Root-Lesion Nematode.
Teff	0	0	2000-8000	2	3	3	3	4	3	4	4	Never	4	4	1	2	2	Warm Season, Annual	Upright	5.0-7.0	Medium	2	2	1	3	NA	NA	NA	20:1	18%	Forms	1,300,000	65	

Table 2

Identification and Comparison of Annual Forages Performance and Benefits by Species

ATTRIBUTE RATINGS: 0=POOR, 1= FAIR, 2=GOOD, 3=VERY GOOD, 4=EXCELLENT																																		
	Performance and Roles I								Performance and Roles II				Cultural Traits										Potential Advantages												
SPECIES	Nitrogen Source	Total Nitrogen (lb/ac)	Dry Matter (lbs/ac/yr)	Nitrogen Scavenger	Soil Builder	Erosion Fighter	Weed Fighter	Quick Growth	Lasting Residue	Grazing	Mechanical Forage Harvest Value	winter Survival	Heat Tolerance	Drought Tolerance	Shade Tolerance	Flood Tolerance	Salinity Tolerance	Life Cycle	Growth Habit	Preferred Soil pH	Water Use	Low Fert Tolerance	Subsoiler	Allelopathic	Choke Weeds	Attracts Beneficials	Bears Traffic	Short Windows	C:N Ratio	Crude Protein	Arbuscular Mycorrhizal Associations	Seed Count (seeds/lb)	Germination Temperature (F)	Notes
NON-LEGUME BROADLEAVES																																		
BEETS	1	N/A	N/A	3	1	1	N/A	4	1	4	3	N/A	1	2	3	3	1	Cool Season, Biennial	Upright and Spreading	N/A	High	1	2	2	1	N/A	4	4	Tops 11-14:1	Tops 12-15%, Root 7-10%	Does Not Form	N/A	40	Self Pollinator (wind)
CABBAGE	1	N/A	N/A	2	3	3	N/A	3	3	4	3	N/A	3	2	3	4	N/A	Cool Season, Annual	Upright and Spreading	N/A	N/A	1	1	1	3	N/A	1	3	12-30:1	N/A	N/A	N/A	42	
Forage Collards	0	N/A	N/A	N/A	3	3	4	3	1	4	3	N/A	4	4	3	2	2	Cool Season, Annual	Upright and Spreading	N/A	N/A	2	3	1	4	N/A	1	N/A	12-30:1	N/A	N/A	175,000	42	
KALE	0	N/A	N/A	N/A	N/A	N/A	3	N/A	N/A	4	N/A	Seldom	N/A	N/A	N/A	0	1	Cool Season, Annual	Upright and Spreading	N/A	Medium	N/A	N/A	N/A	3	N/A	N/A	N/A	10-30:1	30%	Does Not Form	N/A	45	Introduce slowly to livestock because it is highly digestible. Should never be more than 35% of diet. Likes seed to soil contact so incorporated seeding at a shallow depth is best.
MUSTARD	0	30-100	1200-3000	3	2	2	3	3	1	0	0	Never	2	2	1	1	0	Cool Season, Annual	Upright	5.5-8	Low	2	2	2	3	3	1	4	10-30:1	Hay 10%, Grain 24-35%	Does Not Form	180,000	40	Host soybean cyst nematode, don't plant with other brassicas, can be harmful to livestock. Surpasses nematodes and weeds.
PHACELIA	0	N/A	N/A	2	2	3	N/A	3	1	4	1	Seldom	3	3	2	4	0	Cool Season, Annual	Upright	N/A	Low	1	1	1	2	4	1	3	10-15:1	N/A	Forms	235,000	42	
RADISH	0	30-100	1200-3000	3	3	2	3	4	0	3	0	Never	2	2	2	1	0	Cool Season, Annual	Upright	6-7	High	2	3	2	3	1	1	3	19-20:1	26-30%	Does Not Form	34,000	45	Good Nitrogen scavenging and weed control; Nitrogen released rapidly. Winter kills at 25 degrees F. Odor during decay. Attracts earthworms. Non-host for soybean cyst nematode. Some species are commonly used as a trap crop for sugarbeet cyst nematode. Host for root knot nematode, Penetrans Root-Lesion Nematode and sugarbeet cyst nematode.
RAPESEED/CANOLA	0	30-100	1000-2500	3	2	2	2	3	1	0	1	Seldom	2	2	1	1	2	Cool Season, Annual	Upright	5.5-8	Medium	2	2	2	2	2	1	2	12-37:1	Shoots 20-30%, Hay 16%, Grain 21%, Silage 12%, Pasture 17%	Does Not Form	156,960	41	Suppresses Rhizoctonia. Carbon: Nitrogen Ratio-Leaf 12-16, Stem 21-37, Root 24-43 Rapeseed is a non-host for root knot nematode and sugarbeet cyst nematode. Essex rape is used as a non-host for control of dagger nematodes in tree fruit production. Rapeseed is a host for Penetrans Root-Lesion Nematode.
TURNIP	0	30-100	1200-3000	3	2	2	2	2	1	4	1	Never	2	1	1	1	0	Cool Season, Annual	Upright	5.3-6	High	1	0	2	2	1	0	2	20-30:1	Tops 16%, Roots 12-14%	Does Not Form	192,800	45	High producing late-season forage for grazing. Can become a serious weed if let to go to seed. Non-host for soybean cyst nematode. Carbon: Nitrogen Ratio-shoots 20-30, Roots 10-20. Host for root knot nematode. Penetrans Root-Lesion Nematode and sugarbeet cyst nematode.
BUCKWHEAT	0	0	1500-2500	3	2	2	3	4	0	2	0	Never	4	2	1	1	0	Warm Season, Annual	Upright to Semi-Upright	5-7	Medium	3	1	1	4	4	0	4	8-32:1	Straw 5%, Grain 13%	Does Not Form	20,400	50	Cool Season but has Warm Season Growth Characteristics. Enhances soil Phosphorus availability. Carbon: Nitrogen Ratio--Leaf 8-10, Stem 12-32, Root 28-47. Summer smother crop, breaks down quickly. Buckwheat sets seed quickly. Potential honey income. Very frost sensitive. Does not germinate or thrive in cold soil. One variety of buckwheat has been successfully developed for use as a sugarbeet cyst nematode trap crop.

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ATTRIBUTE RATINGS: 0=POOR, 1= FAIR, 2=GOOD, 3=VERY GOOD, 4=EXCELLENT																																	
	Performance and Roles I								Performance and Roles II				Cultural Traits										Potential Advantages											
SPECIES	Nitrogen Source	Total Nitrogen (lb/ac)	Dry Matter (lbs/ac/yr)	Nitrogen Scavenger	Soil Builder	Erosion Fighter	Weed Fighter	Quick Growth	Lasting Residue	Grazing	Mechanical Forage Harvest Value	winter Survival	Heat Tolerance	Drought Tolerance	Shade Tolerance	Flood Tolerance	Salinity Tolerance	Life Cycle	Growth Habit	Preferred Soil pH	Water Use	Low Fert Tolerance	Subsoiler	Allelopathic	Choke Weeds	Attracts Beneficials	Bears Traffic	Short Windows	C:N Ratio	Crude Protein	Arbuscular Mycorrhizal Associations	Seed Count (seeds/lb)	Germination Temperature (F)	Notes
NON-LEGUME BROADLEAVES (continued)																																	
SAFFLOWER	0	N/A	N/A	4	3	1	N/A	3	1	3	3	N/A	4	4	1	0	2	Warm Season, Annual	Upright	N/A	High	3	4	2	3	4	1	0	21-56:1	Hay 10-13%, Grain 18%	Forms	N/A	40	Deep Rooted. Effective at mining mobile nutrients deep in the soil profile. Carbon: Nitrogen Ratio--Leaf 21, Stem 56, Root 73.
SUNFLOWER	0	N/A	N/A	4	3	3	N/A	3	3	3	3	Seldom	3	2	0	0	1	Warm Season, Annual	Upright	N/A	High	3	4	0	2	4	0	4	11-46:1	Silage 11-12%., Grain 20-28%	Forms	N/A	39	Deep Rooted. Effective at mining mobile nutrients deep in the soil profile. Carbon: Nitrogen Ratio--Leaf 11-14, Stem 41-46, Root 50-68, Flower 14-19.
LEGUMES																																	
CHICKPEA	3	N/A	N/A	2	2	3	N/A	3	2	4	3	N/A	3	2	3	4	2	Cool Season, Annual	Upright and Spreading	N/A	Low	1	1	1	1	4	1	3	10-56:1	Straw 6%, Grain 22%	Forms	N/A	42	Carbon: Nitrogen Ratio-Leaf 10-15, Stem 25-56, root 16-27.
BALANSA CLOVER	3	N/A	N/A	2	3	3	N/A	2	2	4	4	N/A	3	2	3	3	2	Cool Season, Annual	Upright, Spreading, or Prostrate	4-8	N/A	1	1	1	4	4	1	3	15:1	15-20%	N/A	N/A	42	Multibranched Rosette but Prostrate when grazed. Requires inoculation with root-nodule bacterium Rhizobium sp. at planting.
BERSEEM CLOVER	4	70-100	1200-3000	2	3	3	2	1	2	4	3	Never	3	2	2	1	1	Cool Season, Annual	Upright	6-8	Low	1	1	1	2	3	1	1	18-23:1	27-29%	Forms	206,880	42	May cause bloat. Excellent as greenchop, less impressive as dry harvested forage.
CRIMSON CLOVER	3	50-90	3500-5500	2	3	2	2	2	2	2	3	Never	3	2	2	1	0	Cool Season, Annual	Upright to Semi-Upright	5.5-7	Medium	2	2	1	3	3	1	1	16-19:1	18%	Forms	149,760	42	Establishes easily, grows quickly if planted early in fall; matures early in spring. May cause bloat. Excellent as greenchop, less impressive as dry harvested forage. Good for interseeding, easy to kill by tillage or mowing. Non-host for sugarbeet cyst nematode. Host for root knot nematode, soybean cyst nematode, and Penetrans Root-Lesion Nematode.
RED CLOVER	4	70-100	2000-5000	3	3	4	3	3	2	4	3	Expected	3	2	3	2	0	Cool Season, Perennial	Upright	5.5-7	Medium	2	2	1	3	3	2	2	15-23:1	15%	Forms	272,160	42	Can cause bloat in livestock. Excellent forage, easily established; widely adapted. Excellent as a greenchop, less impressive as dry harvested forage. Excellent for interseeding into small grains, less reliable in corn and soybeans. Great option for frost seeding/rapid establishment. Non-host for sugarbeet cyst nematode and a poor host for soybean cyst nematode. Host for root knot nematode and Penetrans Root-Lesion Nematode.
WHITE CLOVER	2	50-90	2000-6000	2	3	3	2	1	1	3	3	Expected	3	2	3	3	0	Cool Season, Perennial	Upright	5.5-7	Medium	2	1	1	3	3	2	1	13-23:1	24-30%	Forms	784,000	42	Causes bloat in horses. May cause bloat in cattle/sheep. Excellent as a greenchop, less impressive as dry harvested forage. Aggressive growth in some regions or habitats.

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	Performance and Roles I								Performance and Roles II				Cultural Traits										Potential Advantages											
SPECIES	**Nitrogen Source**	**Total Nitrogen (lb/ac)**	**Dry Matter (lbs/ac/yr)**	**Nitrogen Scavenger**	**Soil Builder**	**Erosion Fighter**	**Weed Fighter**	**Quick Growth**	**Lasting Residue**	**Grazing**	**Mechanical Forage Harvest Value**	**winter Survival**	**Heat Tolerance**	**Drought Tolerance**	**Shade Tolerance**	**Flood Tolerance**	**Salinity Tolerance**	**Life Cycle**	**Growth Habit**	**Preferred Soil pH**	**Water Use**	**Low Fert Tolerance**	**Subsoiler**	**Allelopathic**	**Choke Weeds**	**Attracts Beneficials**	**Bears Traffic**	**Short Windows**	**C:N Ratio**	**Crude Protein**	**Arbuscular Mycorrhizal Associations**	**Seed Count (seeds/lb)**	**Germination Temperature (F)**	**Notes**
ATTRIBUTE RATINGS: 0=POOR, 1= FAIR, 2=GOOD, 3=VERY GOOD, 4=EXCELLENT																																		
LEGUMES (continued)																																		
FAVA BEAN	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	N/A	2	Cool Season, Annual	Upright Vine	N/A	Medium	N/A	N/A	N/A	N/A	4	N/A	N/A	N/A	17%	Forms	N/A	N/A	
FIELD/WINTER PEA	2	50-100	1200-3000	2	2	2	1	3	1	2	3	Never	1	1	1	1	0	Cool Season, Annual	Climbing	6-7	Low	1	2	1	3	2	1	3	13-83:1	Hay 14%, Grain 24%, Silage 15%	Forms	1,840	41	Poor host for soybean cyst nematode. Carbon: Nitrogen Ratio---Leaf 13-25, Stem 27-83, root 17-27. Biomass breaks down quickly; early planting reduces winter survival. Mixes well with grains when grown for forage. Late planting increases heaving/overcrowding. Host for root knot nematode, Penetrans Root-Lesion Nematode and sugarbeet cyst nematode.
LENTILS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	Cool Season, Annual	Upright and Spreading	N/A	Low	N/A	N/A	N/A	N/A	3	N/A	N/A	11-49:1	Hay 14%, Grain 28%, Silage 15%	Forms	N/A	N/A	Carbon: Nitrogen Ratio--leaf 11-21, Stem 25-49, Root 22-30
SAINFOIN	4	N/A	N/A	2	3	3	N/A	3	1	4	4	N/A	3	3	1	4	0	Cool Season, Perennial	Upright	6-8.5	Medium	1	1	1	4	4	1	3	N/A	13-20%	Forms	18,000	42	Is nonbloating and preferred forage for cattle, sheep, deer and elk.
VETCH	4	50-120	1800-4000	2	2	2	2	1	1	0	1	Expected	1	2	2	2	0	Cool Season, Annual	Climbing	5.5-7	Low to Medium	2	1	2	3	4	1	1	10-19:1	13-20%	Forms	16,320	60	Host soybean cyst nematode, high % of hard seed-can become weedy. Seeds are toxic to livestock. Tolerates low fertility, wide pH range, cold or fluctuating winters. Non-host for sugarbeet cyst nematode. Do not plant in fields where small grains are grown for a cash crop since seed contamination decreases small grain value. Hairy vetch is a host for root knot nematode, soybean cyst nematode, and Penetrans Root-Lesion Nematode. Cutworm can also be a problem.
COWPEA	3	50-100	2000-3600	1	2	2	2	2	1	3	2	Never	4	3	2	1	1	Warm Season, Annual	Semi-Upright to Climbing	5.5-6	Low	2	2	0	4	3	0	4	18-22:1	Grain and Leaves 19-30%, Stems 13-17%	Forms	3,600	58	Season length, habit vary by cultivar. Some cultivars, nematode resistant. Host soybean cyst nematode.
SOYBEANS	2	20-50	3000-6000	2	2	0	2	2	2	2	2	Never	3	3	2	1	0	Warm Season, Annual	Upright	5.8-7	Medium	2	2	0	3	3	1	3	14-39:1	Hay 17%, Grain 42%	Forms	3,000	50	Self-Pollinated but flowers may attract pollinators. Host plant for soybean cyst nematode Carbon: Nitrogen Ratio--Leaf 14, Stem 39, root 34.
SUNNHEMP	4	50-100	2000-5000	2	3	3	1	3	3	3	1	Never	4	3	1	2	0	Warm Season, Annual	Upright	5-8	Low	2	2	3	3	1	2	3	14-30	N/A	Forms	15,000	42	Self Pollinates (wind) as well as cross pollinates (insects/birds). Certain Cultivars contain alkaloids which are poisonous to livestock. Avoid grazing after flowering. Has an extensive taproot.
	INFORMATION from Midwest Cover Crops Council (MCCC) Website, MCCC Cover Crop Field Guide, Green Cover Seed, SARE-Managing Cover Crops Profitably, SARE Cover Cropping for Pollinators and Beneficial Insects, University of Minnesota Alternative Annual Forages webpage, USDA-ARS Cover Crops Chart, and USDA-NRCS PLANTS Guide																																	