6

Hay and Pasture

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Illinois hay and pasture acres can contribute in many ways to the success of a farm enterprise. These crops offer opportunities for producers who decide to manage them properly. The information in this chapter is based on forage research from the University of Illinois and land-grant institutions in two adjacent states.

Vigorous, productive stands are the result of proven practices: selecting adapted species to your soils and forage need, choosing disease- and insect-resistant varieties that grow and recover quickly after harvest, following good seeding practices, using current soil tests as the basis for lime and fertilizer application, protecting stands from pests and traffic damage, and harvesting at the optimal time. Selecting species and varieties that are winter hardy and persistent also affects stand productivity. For guidelines on soil fertility management (including soil testing) for hay and pasture, see Chapter 8.

Evaluating Older Hay and Pasture Stands

Is maintaining an older, established stand better than reseeding or establishing a new stand? There are a number of factors to consider when making this decision.

In **pure grass fields**, a thick stand over the entire field is essential. Bare or open areas result because of diseases, winter kill, soil fertility, or other problems; they can quickly become infested with weeds, which can lead to further weakening of the stand. As a guide, if a 3-year-old bunch-type grass (such as orchardgrass or timothy) or sod-forming grass (such as smooth bromegrass or Kentucky bluegrass) has 50% or less ground cover, the stand should be renovated.

While stands that are relatively consistent in covering the soil may need only fertilizer and closer attention to other management practices, fields with large areas of weeds should be considered priorities for renovation.

In **pure legume fields**, a good uniform stand is also important. There are two common methods for making alfalfa stand evaluations:

- *Stem count*. Research has shown that the number of stems per square foot is a good indicator of potential yield. Stem counts can be taken when the plants are 4 to 6 inches tall. Simply count any stem the mower would cut. If there are fewer than 39 robust stems per square foot, consider tearing up the stand.

- *Plant count*. When evaluating a stand in the early spring, you will have to base your decision on the number of plants (crowns) per square foot since stems may not be tall enough to count. Use the following as a guide.

Season when counts are made	Suggested plants per sq ft
Fall of the seeding year	>20
Spring, 1st full production year	>12
Spring, 2nd production year	>8
Spring, 3rd production year	>5

Another guide for plant count in the spring is that 2-year-old stands with 6 or fewer plants per square foot or 3-year-old stands with 3 or fewer plants per square foot will not produce well.

Fall is the best time to evaluate stands. Include a health assessment of the alfalfa crown and root by digging up a

number of plants from different areas in the field to properly determine crown and root vigor. Roots that exhibit disease or severe discoloration more than a couple of inches below the crown may not survive another season. If you are in doubt, take plants to your local extension office for further evaluation.

Establishing Hay and Pasture: Cool-Season Grasses and Legumes

Seeding date in Illinois, either spring or late-summer, depends to a great extent on the field's location (**Figure 6.1**).

Spring seedings tend to be more successful in the northern half of Illinois than in the southern half. Seeding can occur as soon as a seedbed can be prepared, usually late March to early April. Typically as seeding is delayed past mid-May, soil moisture becomes more limited, weed pressure increases, and soil temperature becomes higher. Lack of consistent success with spring seeding in the southern third of Illinois indicates that late-summer seedings may be more desirable.

Late-summer seedings for Illinois legumes should be completed 6 to 8 weeks prior to the first killing frost to ensure that plants become well established before winter: August 10 to 15 in the northern quarter, August 30 to September 4 in the central half, and September 5 to 10 in the southern quarter. Top growth of 4 to 6 inches is needed before dormancy. Cool-season grasses can be seeded 1 to 2 weeks later. A firm seedbed enabling seed-to-soil contact is critical for late-summer seeding, and adequate soil moisture must be present. Use the same seeding rate as in the spring, and do not include a companion or nurse crop.

Frost seeding, or overseeding, is one method of pasture renovation. A spinner-type seeder (**Figure 6.2**) is used to surface-broadcast seed into existing vegetation in late winter or very early spring while the soil is still frozen. Success of this method depends on soil freeze–thaw cycles, late snowfall, spring rain, and the management of existing vegetation before and after seeding. Frost seeding is more successful in a bunch-type grass than in a sod-forming grass. Due to lack of uniform germination and emergence, frost seeding is more suited to pastures than hay fields. Red clover and white clover are better adapted to frost seeding than other legumes. Lespedeza (annual) may also be considered for frost seeding in southern Illinois (see **Table 6.1**). Ryegrass (annual or Italian type) and orchardgrass are two cool-season grasses that have good seedling vigor and are adapted to frost seeding. Frost seeding will not be successful every year and is less successful on sandy soils.

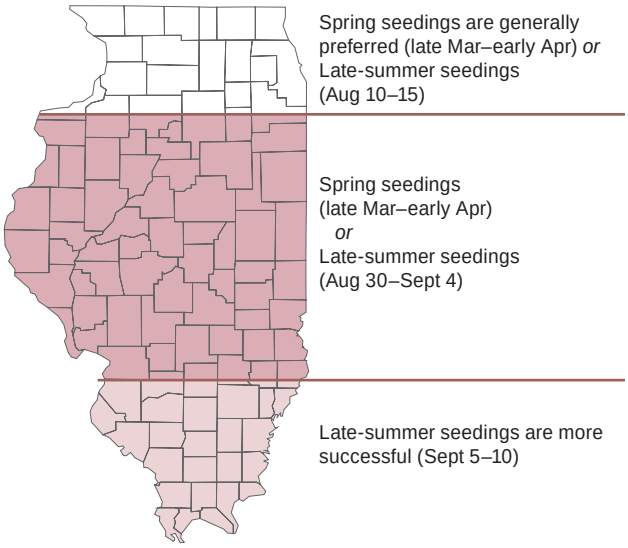

Figure 6.1. Suggested seeding dates for Illinois regions.

Figure 6.2. Spinner-type seeder for frost seeding mounted on an all-terrain vehicle.

Table 6.1. Forage seeding-rate recommendations for frost seeding (in pounds of pure live seed per acre).

Frost seeding of legume			
Moderately well to well-drained soils			
Northern and central IL		**Southern IL**	
Red clover	4–6	Red clover	4–6
		Lespedeza (annual)	20–25
Poorly drained soils			
Northern and central IL		**Southern IL**	
White clover	2–3	White clover	2–3
White clover Red clover	1–2 3–4	White clover Red clover	1–2 3–4

The table reflects recommendations from the University of Illinois, Purdue University, and Iowa State University. Characteristics, strengths, and weaknesses of legumes and grasses are described beginning on page 75. Species grouped between lines are to be planted as a mix.

Table 6.2. Forage seeding-rate recommendations for hay and pasture (in pounds of pure live seed per acre).

Moderately well to well-drained soils

Northern and central IL	
Alfalfa	12–15
Alfalfa[a] Smooth bromegrass	8–10 6–8
Alfalfa[a] Orchardgrass	8–10 4–6
Alfalfa[a] Tall fescue	8–10 8–10
Alfalfa[a] Timothy[b]	8–10 2–4
Alfalfa[a] Perennial ryegrass	8–10 4–8
Red clover White clover Orchardgrass	6–8 ½–1 4–6
Red clover White clover Tall fescue	6–8 ½–1 8–10
White clover Orchardgrass	½–1 6–8
White clover Smooth bromegrass	½–1 8–10
Birdsfoot trefoil Timothy[b]	5–7 2–4
Birdsfoot trefoil Orchardgrass	5–7 4–6
White clover Perennial ryegrass	½–1 4–8
Birdsfoot trefoil Perennial ryegrass	5–7 4–8

Southern IL	
Alfalfa	12–15
Alfalfa[a] Orchardgrass	8–10 4–6
White clover Orchardgrass	½–1 6–8
White clover Tall fescue	½–1 8–10
Alfalfa[a] Tall fescue	8–10 8–10
Alfalfa[a] Perennial ryegrass	8–10 4–8
Red clover White clover Orchardgrass	6–8 ½–1 4–6
Red clover White clover Tall fescue	6–8 ½–1 8–10
Lespedeza (annual) Orchardgrass	15 4–6
Lespedeza (annual) Tall fescue	15 8–10
White clover Perennial ryegrass	½–1 4–8
Lespedeza (annual) White clover Orchardgrass	15 ½–1 4–6

Poorly drained soils

Northern and central IL	
Birdsfoot trefoil Timothy[b]	5–7 2–4
Birdsfoot trefoil Smooth bromegrass	5–7 6–8
Alsike clover[c] White clover Timothy[b]	2–3 ¼–½ 2–4
Alsike clover[c] White clover Reed canarygrass[d]	2–3 ¼–½ 6–8
Alsike clover[c] White clover Tall fescue	2–3 ¼–½ 8–10
Alsike clover[c] Timothy[b]	3–4 2–4
Alsike clover[c] Reed canarygrass[d]	3–4 6–8
White clover Perennial ryegrass	½–1 4–8
Birdsfoot trefoil Perennial ryegrass	5–7 4–8

Southern IL	
White clover Tall fescue	½–1 8–10
Alsike clover[c] Redtop	3–4 4–6
Alsike clover[c] White clover Tall fescue	2–3 ¼–½ 8–10
Alsike clover[c] White clover Reed canarygrass[d]	2–3 ¼–½ 6–8
Alsike clover[c] Reed canarygrass[d]	3–4 6–8
Birdsfoot trefoil Timothy[b]	5–6 2–4
White clover Perennial ryegrass	½–1 4–8
Birdsfoot trefoil Perennial ryegrass	5–7 4–8

Droughty soils

Northern and central IL	
Alfalfa	12–15
Alfalfa Smooth bromegrass	8–10 6–8
Alfalfa Tall fescue	8–10 6–8
Reed canarygrass[d]	8–10

Southern IL	
Alfalfa	12–15
Alfalfa Tall fescue	8–10 6–8
Reed canarygrass[d]	8–10

The table reflects recommendations from the University of Illinois, Purdue University, and Iowa State University. Characteristics, strengths, and weaknesses of legumes and grasses are described beginning on page 75. Species grouped in the same box are to be planted as a mix.

[a]Red clover can be added at 4 lb/acre, but the alfalfa rate needs to be reduced by half; alternately, 6 to 8 lb/acre of red clover can be substituted for alfalfa.

[b]Timothy has questionable persistence long-term.

[c]Not to be used in horse pastures.

[d]Reed canarygrass is an invasive species.

Pure Live Seed

In **Table 6.2,** seeding rates are listed in pounds of pure live seed per acre. Pure live seed (PLS) is an indication of seed quality, but this information is rarely shown on seed tags.

Percent PLS is calculated by multiplying the purity of the bulk seed lot by the germination rate and dividing by 100. For example: If a bag of a species of seed is 90% pure and has a germination rate of 80%, the PLS would be 90.0 x 80.0 ÷ 100, or 72% PLS.

To determine how much seed is needed per acre, the PLS recommendation shown in **Table 6.2** would be divided by the PLS percentage and multiplied by 100. For example: If the seeding recommendation in the table is 12 pounds per acre PLS and the PLS is 72%, as in the previous paragraph, the amount of seed to purchase would be 12 ÷ 72 x 100, or 16.6 pounds per acre. In other words, you would have to plant 16.6 pounds of material from the seed bag of that species in order to plant 12 pounds of PLS per acre.

Table 6.3. Forage seeding-rate recommendations for horse pastures (in pounds of pure live seed per acre).

Moderately well to well-drained soils

Northern and central IL		Southern IL	
Kentucky bluegrass	15	Kentucky bluegrass	15
Alfalfa[a] Smooth bromegrass	8–10 6–8	Alfalfa[a] Orchardgrass	8–10 4–6
Alfalfa[a] Orchardgrass	8–10 4–6	Alfalfa[a] Tall fescue[b]	8–10 8–10
Alfalfa[a] Tall fescue[b]	8–10 8–10		

Poorly drained soils

Northern and central IL		Southern IL	
Kentucky bluegrass	15	Kentucky bluegrass	15
Red clover Timothy[c]	6–8 2–4	White clover Kentucky bluegrass	½–1 4–5
Red clover White clover Timothy[c]	4–6 ¼–½ 2–4	White clover Orchardgrass	½–1 4–6
Birdsfoot trefoil Timothy[c]	6–7 2–4	Red clover Orchardgrass	6–8 4–6
White clover Tall fescue[b]	½–1 8–10	White clover Tall fescue[b]	½–1 8–10
		Red clover Tall fescue[b]	6–8 8–10

The table reflects recommendations from the University of Illinois, Purdue University, and Iowa State University. Characteristics, strengths, and weaknesses of legumes and grasses are described beginning on page 75. Species grouped between lines are to be planted as a mix.
[a]Red clover can be added at 4 lb/acre, but the alfalfa rate needs to be reduced by half; alternatively, 6 to 8 lb/acre of red clover can be substituted for alfalfa. Red clover can cause some horses to salivate.
[b]If seeding tall fescue, plant "low" or "friendly" (novel) endophyte variety.
[c]Timothy has questionable persistence long-term.

Table 6.4. Forage seeding-rate recommendations for hog pastures (in pounds of pure live seed per acre).

For all soil types, anywhere in Illinois	
Alfalfa White clover	8 2
Alfalfa Red clover White clover	4 4 2
Forage rape Oats	4–6 32–64 (1–2 bushels)

The table reflects recommendations from the University of Illinois, Purdue University, and Iowa State University. Species grouped between lines are to be planted as a mix. Characteristics, strengths, and weaknesses of legumes and grasses are described beginning on page 75.

Seeding-rate recommendations for hay and pasture are shown in **Table 6.2** and are listed in pounds of pure live seed per acre (see the sidebar "Pure Live Seed" for more discussion). Specific recommendations for horse pastures are provided in **Table 6.3** and for hog pastures in **Table 6.4**. These rates are for seedings made under average conditions, either with a companion crop in the spring or without a companion crop in late summer. These tables are not meant to be all-inclusive; rather, they list commonly used species that have been researched and evaluated.

A spring seeding rate for alfalfa higher than that shown in **Table 6.2** has proven economical in northern and central Illinois when solo-seeded and when two or three harvests were taken in the seeding year. In northern and central Illinois, but not in south-central Illinois, seeding alfalfa at 18 pounds per acre (bulk seed) has produced yields 0.2 to 0.4 ton per acre higher than seeding at 12 pounds per acre (bulk seed).

A **companion crop,** or nurse crop, of oats has historically been used with spring forage seedings. With improvements in seeding equipment and herbicides, more alfalfa is direct-seeded (without a companion crop). Some dairy producers seed a small grain–pea mixture with spring-seeded alfalfa to increase crude protein and yield. The advantages of a companion crop are quick ground cover, additional forage, and reduced soil erosion and weed invasion. The disadvantages are competition with the perennial forage for moisture, nutrients, and light and the potential to smother the forage.

Two options for companion crops are spring oats (1 to 1.5 bushels per acre) and Italian ryegrass (2 to 4 pounds per acre). The use of fall-planted winter rye (cereal or grain rye) is not encouraged due to its aggressive growth. The decision to use a companion crop during spring forage establishment is site-specific. However, remember that the "money crop" is the perennial forage that is being established, not the companion crop.

Seeding on a prepared (tilled) seedbed. After the field has been tilled, seeding can be accomplished in one of two ways:

- *Broadcast seeding.* The seed is spread uniformly over a firm, prepared seedbed; then the seed is pressed into the seedbed surface with a corrugated roller (**Figure 6.3**). Fertilizer is applied during seedbed preparation. Typically, soil conditions are too loose (or soft) after tillage, and the soil should be firmed with a corrugated roller before seeding. The soil is firm enough if you don't leave a footprint any deeper than the sole of your shoe. The best tool for broadcast seeding is the double-corrugated roller seeder (**Figure 6.4**).

- *Band seeding.* A band of phosphorus fertilizer (for example, 0-46-0) is placed about 2 inches deep in the soil in rows 7 to 8 inches apart using a grain drill; then the seed is placed on the soil surface directly above the fertilizer band (**Figure 6.5**). Before the seeds are dropped, the fertilizer should be covered with soil, which occurs naturally when soils are in good working condition. A presswheel or packer wheel should roll over the forage seed to firm the seed into the soil surface.

Which is the better seeding method? Illinois studies have shown that band seeding often results in higher alfalfa yields for spring and late-August seedings. Seedings on soils that are low in phosphorus also yield more from band seeding. Successful early seeding on cold, wet soils is favored by banded phosphorus fertilizer. The greater yield from band seeding may be a response to abundant, readily available phosphorus from the banded fertilizer.

Broadcast seedings yield similarly to band seedings when soils are medium to high in phosphorus-supplying capacity and are well drained, so that they warm up faster in spring.

Seeding no-till. With this method, forage seed is planted, using a no-till drill, directly into a field with no additional tillage after harvesting the previous crop. Crop residues on the soil surface will reduce runoff and soil erosion and help conserve soil moisture. Fuel costs are lowered as a result of reduced trips across the field. The no-till drill must be adjusted correctly and be equipped with coulters, double-disc (or other suitable) seed placement units, and presswheels. The drill must open a seed furrow, place the seed at the correct depth, and cover and firm the soil over the seed. Weeds need to be controlled before forage establishment.

Seeding depth. Regardless of seeding method, small forage seeds should be placed 1/4 to 1/2 inch deep. On sandy soil, place seed up to 1 inch deep. A firm seedbed provides good seed-to-soil contact and enables the seed to absorb moisture. This is especially important with late-summer seedings.

Pasture establishment. If a new pasture is established from a prepared seedbed, it is suggested that it be harvested as hay the first year so that a "sod" can be formed to support livestock traffic.

Many pastures are established through a hay-crop program. If you intend for the hay crop to become a pasture, seed the desired mixture of legume(s) and grass(es). Whatever the method of establishment, consider factors such as the investment required (time, labor, money), the erosion potential, the length of time the field will be out of production, and access to equipment and pesticides. Pastures can also be renovated (p. 70) using reduced till or no-till methods or by frost seeding (p. 66).

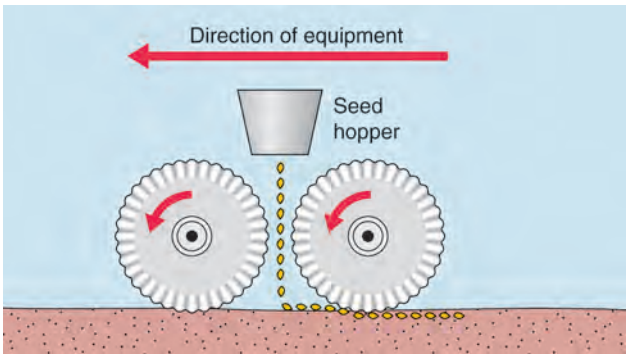

Figure 6.3. Schematic of broadcast seeding with a double-corrugated roller-seeder.

Figure 6.4. Double-corrugated roller-seeder (Brillion brand).

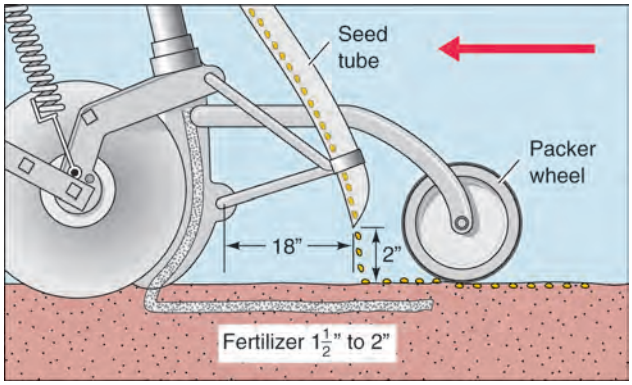

Figure 6.5. Placement of seed and high-phosphate fertilizer with grain drill.

Weed and insect control. Preplant, preemergence, and postemergence herbicides are available to help manage weeds when establishing hay and pasture. The specific herbicide and the time and method of application will depend on the forage species being planted (grass vs. legume vs. mixture), the weed species present, the age of

the forage stand (seeding year vs. established stand), and other factors. Some pesticides have harvest, grazing, or other restrictions that need to be followed. Certain insects may reach damaging levels and may need to be controlled. Consult University of Illinois references for weed, insect, and disease identification and management suggestions. Follow label directions when using any pesticide.

Inoculation of legume seed. Legume seed should be inoculated with the proper strain of nitrogen-fixing bacteria before seeding (see p. 76 for additional discussion). Preinoculated seed should be stored in a cool, dry location from the time of purchase until it is planted. Be sure to observe the expiration date of the inoculant.

Pasture Renovation

Pasture renovation usually means changing the plant species, typically adding one or more legumes, in a pasture to increase quality and productivity. First identify the current species and evaluate the grazing management being used. A soil test will identify the need for lime, phosphorus, and potassium, all of which are very important in the establishment and stand life of forages. Be sure to take soil samples in advance so that if lime and fertilizer are needed they can be applied at least 6 months prior to seeding.

Before seeding new legumes or grasses into a pasture, reduce the competition from existing pasture plants. Tilling, overgrazing, and herbicides labeled for pasture renovation, used singly or in combination, have proven useful in subduing existing vegetation.

As mentioned, **frost seeding** is one method of renovation (see p. 66). **Interseeding** is a second method. The following steps are suggested for interseeding:

1. Where possible, graze the pasture heavily for 20 to 30 days before seeding to reduce the vigor of existing pasture plants. If overgrazing is not possible and if existing grasses are to be eliminated, consider applying a product containing glyphosate (a general-use pesticide) 2 to 3 weeks before the seeding date. In fields where a desirable grass species is to be subdued but not eliminated prior to planting, consider using a herbicide containing paraquat (a restricted-use pesticide) to suppress its growth.
2. Lime and fertilize, using a soil test as a guide. A minimum pH of 6.5 is suggested for legume–cool-season grass mixtures. Desirable phosphorus and potassium soil test levels vary with soil type and location in the state. Optimum phosphorus level is 40 to 50 pounds per acre, and optimum potassium level is 260 to 300 pounds per acre. See the information on soil testing in Chapter 8 for more details.
3. One or two days before seeding, consider applying a herbicide to subdue the vegetation *if a herbicide has not already been applied or if plant growth is excessive.* Paraquat and glyphosate are approved for this purpose. Follow label directions. Where an existing grass species is to be eliminated, use glyphosate at label rates. Where a desirable grass species is to be suppressed temporarily, use paraquat.
4. Seed the desired species, using high-yielding, adapted varieties (see **Table 6.5**). Alfalfa, red clover, white clover, and birdsfoot trefoil are legumes often seeded into pastures that have desirable grasses. To seed, use a

Table 6.5. Forage seeding-rate recommendations (in pounds of pure live seed per acre) for interseeding legume no-till into existing grass sod.

Moderately well to well-drained soils

Northern and central IL		Southern IL	
Alfalfa	7–8	Alfalfa	7–8
Red clover	4–5	Red clover	4–5
Red clover White clover	3–4 ½–1	Red clover White clover	3–4 ½–1
Birdsfoot trefoil	5–6	Lespedeza (annual)	15–20
		Birdsfoot trefoil	5–6

Poorly drained soils

Northern and central IL		Southern IL	
Red clover	4–5	Red clover	4–5
Red clover White clover	3–4 ½–1	Red clover White clover	3–4 ½–1
Birdsfoot trefoil	5–6	Lespedeza (annual)	15–20
Alsike clover[a] White clover	2 ½–1	Alsike clover[a] White clover	2 ½–1
		Birdsfoot trefoil	5–6

The table reflects recommendations from the University of Illinois, Purdue University, and Iowa State University. Characteristics, strengths, and weaknesses of legumes and grasses are described beginning on page 75. Species grouped between lines are to be planted as a mix.
[a]Not to be used in horse pastures.

Figure 6.6. No-till seeder (Tye brand).

no-till drill (**Figures 6.6 and 6.7**) that places the seed in contact with the soil at the proper depth.

5. Seedings may be made in early spring throughout the northern two-thirds of Illinois and in late August throughout the southern three-fourths.
6. Insects that eat germinating seedlings are more prevalent in southern Illinois than in northern Illinois, and an insecticide may be needed. Leafhoppers will usually appear on alfalfa foliage throughout Illinois in early summer and remain during most of the growing season. They must be controlled where alfalfa is seeded, especially in spring-seeded hay and pasture, because leafhopper feeding devastates new alfalfa seedlings. Leafhopper damage may be less where alfalfa is seeded with grass as opposed to a pure alfalfa stand. Leafhopper-resistant alfalfa varieties are available, and several insecticides are approved. Consult University of Illinois references for pest identification and management. Follow label directions when using any pesticide.
7. Management practices based on timely observations will help the new seedings become established (**Figure 6.8**). Rotational grazing will control competition from the sod, but do not allow newly emerged seedlings to be closely grazed. Clipping just above the new seedlings may be needed if weeds become a problem. New seedlings require light to maintain good growth. As a guide, about 5 weeks after spring seeding, the grass should be recovered from paraquat sod-suppression treatment, and managed grazing should be feasible. Close grazing should be avoided.
8. Late-August seedings should not be grazed until the following spring. Alfalfa and red clover seeded in late August should be in the late-bud to early flower stage when spring grazing begins. As with spring seedings, use rotational grazing and monitor the status of newly seeded plants.
9. Monitor and maintain soil fertility by soil testing on a regular basis.

Hay Harvest Management

Spring seeding year, with a companion crop. Spring-seeded forages for hay will benefit by early removal of the companion crop. The small-grain companion crop should be removed when the grain is in the boot to milk stage. If these small grains are harvested for grain, it is important to remove the straw and stubble as soon as possible to avoid smothering the perennial forage. Subsequent hay harvest of the perennial forage crop can be at 30 to 40 days, but follow the guideline below for last hay harvest.

Figure 6.7. No-till interseeding in April, northern Illinois.

Figure 6.8. Newly emerging red clover sown by no-till seeder.

Spring seeding year, without a companion crop (direct or solo seeding). Spring-seeded forages for hay should be ready for harvest 65 to 70 days after a late March–early April seeding. A second and perhaps a third harvest may follow the first harvest at 30- to 40-day intervals, but follow the guideline below for last hay harvest.

Last hay harvest during the growing season should be in late August or early September for the northern quarter of Illinois, by September 10 for the central half, and by September 20 for the southern quarter. The interval between last harvest date and the first killing frost allows food reserves (carbohydrates) to accumulate in the taproot and increases the chance for winter survival. Following harvest, root reserves decline as new growth begins. About 2 to 3 weeks after harvest, or when new regrowth is 6 to 8 inches tall, root reserves are depleted to a low level, and the top growth is adequate for photosynthesis to support the plant's need for carbohydrates. Root reserves are then replenished gradually until harvest or until the plant becomes dormant.

About 6 weeks of growth is required after a cutting to have enough food reserves produced and stored. This is the basis of the last harvest dates specified.

Dormant harvest is making a cutting of hay when the alfalfa is dormant or growing very slowly. Fall dormancy in alfalfa is a function of air temperature, duration of cool temperatures, and the fall dormancy rating of the variety. Alfalfa becomes dormant with an air temperature of 26 °F for a few consecutive days. Harvests in September and October affect late-fall root reserves of alfalfa more than summer harvests do. Dormant harvest may be taken after mid-October for northern Illinois, in late October for central Illinois, and in early November for southern Illinois.

Factors to consider if you are planning a dormant harvest include age of the stand, plant health status, soil-fertility level, soil drainage, and stubble height remaining after harvest. A spring-seeded stand should not have a dormant harvest taken that same year. If taking a dormant cutting, leave a 6- to 8-inch stubble height to catch snow to better protect the crop.

Established stands. Frequency of hay harvests is a trade-off among quality, yield, and stand persistence. The nutritional needs of the livestock consuming the hay need to be considered.

Maximum dry-matter yield and persistence from alfalfa and most forages are obtained by having the first cutting at nearly full bloom and harvesting every 40 to 42 days. Quality of this forage is lower.

High-quality forages should have the first harvest taken at the bud (for legumes) or boot (for grasses) stage. Subsequent harvests are taken at 28- to 32-day intervals. A very aggressive hay-cutting schedule may shorten stand life. For high-quality alfalfa, producers are encouraged to utilize the PEAQ technique described below.

A *compromise between quality and yield* is to make the first cutting at late-bud to first-flower stage and make subsequent cuttings at 32- to 35-day intervals.

See the sidebar for more discussion on forage quality, including forage testing.

Predicting first harvest for high-quality alfalfa. Producers desiring high-quality alfalfa hay at first cutting are encouraged to use the "Predictive Equations for Alfalfa Quality" (PEAQ) as a guide to determine the date for first harvest. This method provides an in-field estimate of

Forage Quality

Forage quality can be defined as all those characteristics that affect consumption, nutritive value, and performance of livestock. Forage quality is greatly affected by stage of maturity. As forage crops mature, their nutritive value declines.

Relative feed value (RFV) is an indicator of forage quality. The higher the RFV, the higher the quality. RFV, which declines with advancing maturity of the forage, can be calculated as follows:

1. Calculate digestible dry matter (DDM) of the forage on a dry-matter basis:

   DDM = 88.9 – (0.779 x acid detergent fiber)

2. Calculate dry-matter intake (DMI) of the forage as a percentage of body weight:

   DMI = 120 ÷ neutral detergent fiber

3. Calculate RFV:

   RFV = (DDM x DMI) ÷ 1.29

Relative forage quality (RFQ) is a new index to rank the quality of forages. Due to the digestible fiber component, RFQ appears to predict animal performance better than relative feed value. RFQ can be calculated as follows:

RFQ = (DMI, as % of body weight) x (TDN, as % of DM) ÷ 1.23

Forage Quality Definitions

Acid detergent fiber (ADF) is the percentage of cellulose, lignin, and ash in forage. ADF is used to calculate net energy values and indicates digestibility of the forage. As ADF increases, digestibility and energy content of forage decrease.

Neutral detergent fiber (NDF) is the percentage of cell wall material or fiber in the forage. It is inversely related to forage intake. As NDF increases, the amount an animal can consume decreases.

RFV is a calculated index that rates forage by potential intake of digestible dry matter. Average full-bloom alfalfa hay has an RFV of about 100. Higher quality forages would have an RFV above 100.

Crude protein (CP) is a measure of the true protein and nonprotein nitrogen portion of the forage. It is determined by multiplying the actual nitrogen content by a factor of 6.25.

RFQ provides a better quality estimate for grasses and legume–grass mixtures than relative feed value. RFQ can be used for all forages, including warm-season grasses and brassicas (turnips, rape, kale, etc.). However, RFQ should not be used for corn silage. It appears that RFQ and RFV average about the same, so RFQ can be substituted for RFV in pricing, contracts, and other uses.

Forage analysis or a forage test can supply useful information about the nutritional value of hay and pasture. The values described here are measured or calculated in a forage analysis. To find a list of forage testing laboratories, how to take a forage sample, where to purchase a hay probe, and other details, see the National Forage Testing Association website (www.foragetesting.org).

preharvest quality of standing alfalfa. It is not designed to balance rations and cannot account for harvest or storage losses.

The **PEAQ** method predicts relative feed value (RFV) and neutral detergent fiber (NDF) content based on plant maturity and plant height within a 2-square-foot area. With the use of either a table (see **Table 6.6** for University of Wisconsin PEAQ-RFV data) or a specially calibrated "measuring stick" (available from some alfalfa seed companies), estimates of RFV and NDF can be obtained directly from the field. PEAQ is designed for good, healthy stands of pure alfalfa.

Since about 15 RFV units are lost during harvest, alfalfa needs to be cut at 165 to 170 RFV using PEAQ to have 150 RFV of harvested forage.

More details about PEAQ can be found at the University of Illinois website peaq.traill.uiuc.edu.

Drying Agents and Preservatives for Hay

Drying agents or compounds to speed drying are sprayed onto hay at mowing to increase the drying rate. Drying agents contain potassium and sodium carbonates; they work only on legumes, not grasses. These products reduce drying time the most when drying conditions are good, so they tend to work better on second and third cuttings. Typical application rate is 5 to 7 pounds of active ingredient in 30 gallons of water per acre. Thorough coverage of the forage is important.

Preservatives are sprayed onto the hay as the bale is being formed to allow baling of hay that is wetter than normal without spoiling during storage. A commonly used preservative is "buffered" propionic acid. Acetic acid, another organic acid, is about half as effective as a preservative, so twice as much is needed. The application rate for propionic acid depends on the moisture content of the hay: for 20% to 25% moisture hay, the application rate is 0.5% to 0.9% propionic acid (10 lb per ton); for 26% to 30% moisture hay, the rate is 1.0% to 1.13% (20 lb per ton). These rates are for 100% propionic acid solution; if you are using a 50% propionic material, the rate needs to be doubled.

Hay-Making Practices

Various harvest management techniques and strategies will result in quality hay:

- Make hay harvest a top priority.
- Mow early in the day (start at 9:00 to 10:00 a.m.), after some, but not all, of the dew is gone.
- Rake when moisture content is higher than 40%.
- Bale when the moisture content for non-preservative-treated hay is 16% to 20%. Small square bales should be baled at 18% to 20%, medium squares at 16%, large squares (one ton, 8 x 4 x 4 feet) at 14%, and round bales at 16% to 18%.
- Research indicates no difference in drying rate and yield between a disk mower-conditioner and a sickle bar

Table 6.6. Relative feed value of standing alfalfa hay.

Height of tallest stem (in.)[a]	Stage of most mature stem		
	Late vegetative[b]	Bud[c]	Flower[d]
16	237	225	210
17	230	218	204
18	224	212	198
19	217	207	193
20	211	201	188
21	205	196	183
22	200	190	178
23	195	185	174
24	190	181	170
25	185	176	166
26	180	172	162
27	175	168	158
28	171	164	154
29	167	160	151
30	163	156	147
31	159	152	144
32	155	149	140
33	152	145	137
34	148	142	134
35	145	139	131
36	142	136	128
37	138	133	126
38	135	130	123
39	132	127	121
40	129	124	118
41	127	122	115
42	124	119	113

[a]From soil surface to stem tip.
[b]>12 in. with no buds visible.
[c]1 or more nodes with visible buds; no flowers visible.
[d]1 or more nodes with open flower(s).

mower. Impeller-type mower-conditioners dry grass hay quicker, while roll-type mower-conditioners dry alfalfa hay quicker (University of Wisconsin data).

- To get faster drying, always condition the hay, maintain proper roller clearance, and spread the swath as wide as possible.
- Ted only when necessary.
- Store hay in a barn or shed, or off the ground and under a cover.

Pasture-Grazing Management

Pasture management involves managing the interactions of plants, livestock, and soil. There are three basic types of grazing systems: continuous, rotational, and management-intensive.

Continuous grazing gives livestock unrestricted access to an area for an entire growing season. The grazier provides limited management; livestock graze when, where, and what they choose. Overgrazing, uneven manure distribution, and lower forage quality and yield often result.

Rotational grazing is a system in which livestock are moved regularly from one pasture to another. Pastures are allowed to rest and regrow, manure is more evenly distributed, and yield and forage utilization are increased. Watering and fencing costs are higher than with continuous grazing.

Management-intensive grazing is a system in which large pastures are divided into smaller areas called paddocks. Livestock are moved more frequently at high stocking rates from one paddock to another. Forage yield and manure distribution are higher than with continuous and rotational systems. Forages are able to rest and regrow before being grazed again. This system requires a higher level of management by the grazier and startup costs for fencing and watering.

To utilize excess forage in the late spring, it would be advantageous to make hay from one or more paddocks. Various crops (stockpiled pasture, oats, brassicas, warm-season annual grasses, corn residue, etc.) can be utilized to extend the grazing season, resulting in cost savings since less hay or other stored feed will be fed.

An example of a basic rotational grazing system is 10 days of grazing with 30 days of rest, requiring 4 paddocks. A more intensive rotational grazing system is 5 to 7 days of grazing with 28 to 30 days of rest, requiring 5 or 6 paddocks. An example of a management-intensive grazing system is 3 to 4 days of grazing with 30 to 33 days of rest, needing 8 to 11 paddocks. Dairy graziers typically utilize 12-hour grazing periods (moving cows twice a day to new forage), requiring more paddocks.

To determine the number of pastures (or paddocks) needed for either rotational or management-intensive grazing, use this formula: days of rest ÷ days of grazing + 1. However, livestock should be moved according to the forage and not by the calendar.

One of the principles of managed grazing, as compared with continuous grazing, is providing forages the time to rest between one grazing and the next. This rest period gives forages the time to grow, build root reserves, and maintain vigor. Many graziers follow the guideline of "graze half, leave half."

Recent developments in *fencing and watering techniques* have made management-intensive grazing more user-friendly. Polywire, polytape, and temporary fence posts can be used for interior, moveable fencing. High-tensile wire can be used for permanent perimeter fencing. Livestock should not have to travel more than 800 feet to access water. Ideally, water should be available in every pasture or paddock.

When adopting a rotational or management-intensive grazing system, consider the forage quality requirement of the livestock, estimate forage production and stocking density, determine the number of paddocks needed, remember to fence quantity and not acres, and remain flexible. The amount of forage growth that can be removed per grazing period and the needed rest period will vary with the forage species and season of the year and from year to year.

Weed control in pastures may be needed. An integrated approach using several different methods will be more effective than relying on a single practice: combine weed control methods that are mechanical (clipping, hand digging), chemical (herbicide), cultural (maintaining dense, active, and vigorously growing forages), and biological. Consult University of Illinois references for weed identification and management suggestions. Follow label directions when using any pesticide.

Selecting Hay and Pasture Species

The University of Illinois has conducted a testing program of public and private forages for many years. The 2008 field locations were Freeport (Stephenson County) and Urbana (Champaign County). The Freeport site is on a dairy farm, and the Urbana location is on the University of Illinois Crop Sciences Research and Education Center.

The Department of Crop Sciences publishes each year *Forage Crop Variety Trials in Illinois*, a report summa-

rizing performance data of forage species and varieties grown at the test field locations by seeding year. The publication is available at extension offices and online at vt.cropsci.illinois.edu.

There is no one "best" forage species. All species, whether grown for hay or pasture, have strengths and weaknesses. Differences exist among species in winter-hardiness, ease of establishment, tolerance to various soil conditions (drought, wet, acidity), persistence, seasonal growth patterns, and antiquality factors (such as bloat, endophyte, and alkaloids). Major strengths and weaknesses of commonly grown legume and grass species for hay and pasture in Illinois are detailed in the following sections.

When selecting a variety within a species, consider yield potential, persistence, winter-hardiness, disease and insect resistance, and forage quality. Using certified seed assures genetic purity and trueness to variety name.

Even though a grass or legume species can be grown alone, mixtures of legumes and cool-season grasses often improve performance of pastures and multi-use pasture and hay fields. Each selected legume and grass in the mixture needs to be appropriate to the field and have a specific purpose. In most situations, a mixture of two to four well-chosen species is more desirable than a mixture of numerous species, some of which may not be particularly well suited to the soil, climate, or use. Generally, seeding prepackaged mixes of several legume and grass species is not encouraged.

See **Table 6.2** for seeding-rate recommendations.

Legume Species

Please note that the following discussion is not all-inclusive of legume species. The focus here is on the species most commonly adapted or evaluated for use in Illinois.

Alfalfa is the highest yielding and highest quality perennial forage suited to Illinois. It requires a well-drained soil with pH of 6.7 to 7.0. Grazing-tolerant, traffic-tolerant, and potato leafhopper–tolerant varieties are available. When deciding to purchase a leafhopper-tolerant variety, consider the frequency at which you scout for leafhoppers and the level of resistance of the variety you are considering (new generation varieties are 80% resistant). Diseases can affect all alfalfa plant parts and at different growth stages. Diseases can reduce yield, quality, and persistence. More information on alfalfa diseases is available at cropdisease.cropsci.illinois.edu. Resistance ratings to various diseases are listed in the current edition of *Winter Survival, Fall Dormancy and Pest Resistance Ratings for Alfalfa Varieties*, available through the National Alfalfa and Forage Alliance (www.alfalfa.org/publications.html).

Major strengths	Major weaknesses
Drought-tolerant	Not tolerant of wet, poorly drained soils
Excellent summer regrowth	Causes bloat in pure stands
Wide variety of uses	Potato leafhopper is major insect pest
	Not suited for frost seeding
	Requires rotational grazing to persist in pasture

Alfalfa produces a water-soluble toxin that moves into the soil and reduces the germination and growth of new alfalfa seedings. This phenomenon is called *autotoxicity*. At least half of the toxin is found in the aboveground plant parts; the balance is below ground.

When a stand is more than a year old, enough of the toxin may be present to cause damage to new seedings reestablished into that field. The main effect of autotoxicity is to limit the ability of root hairs to take up water and thus reduce development of the seedling. Alfalfa does not outgrow the initial effects of autotoxicity.

When the stand is more than a year old, alfalfa should not be reestablished in the field; instead, another crop (corn is best) should be grown for one year. This allows the toxin time to degrade and leach away from the root zone.

Research at the University of Missouri on reestablishing alfalfa found that when there were more than 1.3 plants per square foot, stands failed. Stands were successfully reestablished when there were less than 0.2 plant per square foot (1 plant per 5 square feet).

Alfalfa stands one year old or younger have produced very little of the toxin, so if necessary, alfalfa could be reestablished.

Red clover is the second most important hay and pasture legume in Illinois. There are two major types: medium (an early, two-cut type) and mammoth (a late, one-cut type). The medium type is preferred for Illinois. Red clover is generally considered a short-lived perennial (2 to 3 years); however, newer varieties are more disease resistant and may persist longer.

Major strengths	Major weaknesses
Easy and quick to establish	Not persistent; susceptible to root diseases
Tolerates wetter soil and lower pH than alfalfa	Not as drought-tolerant as alfalfa
Tolerates shade	Pubescent, so hard to dry for hay
High-yielding	Causes bloat
Reseeds easily	Can cause horses to salivate ("slobbers")
Adapted to frost seeding	Does not grow well on coarse-textured soil

White clover is commonly found in pastures and some hay fields. There are three types, or subspecies, of white clover. Ladino commonly refers to the large type of white clover that is higher yielding. White clover is generally

considered a low-growing perennial legume, but new varieties have more upright growth.

Major strengths	Major weaknesses
Very high quality	Causes bloat
Prolific seed producer and self-seeding	Shallow-rooted
Tolerates lower soil pH than alfalfa and red clover	Low-yielding, especially for hay
Adapted to close grazing	Not drought-tolerant
Tolerates wetter, poorly drained soil	

Birdsfoot trefoil is a nonbloating, long-lived, winter-hardy perennial legume traditionally grown in northern Illinois pastures. It is more commonly grown for pasture than hay.

Major strengths	Major weaknesses
Does not cause bloat	Low seedling vigor; slow to establish
Adapted to poorly drained, acidic soils	Shallow-rooted; does not tolerate drought
Will reseed itself	Presence of tannins may reduce palatability

Alsike clover is a short-lived perennial that can be grown for hay and pasture. Because of fine stems that lodge, it should be grown with grass to help keep the legume erect. It should not be included in horse pastures, since this legume causes photosensitivity.

Major strengths	Major weaknesses
Well suited for wet, poorly drained soils	Not drought tolerant
Tolerant of acidic soils	Low-yielding
	Causes bloat and photosensitivity

Kura clover is a relatively new perennial, winter-hardy legume with a rhizomatous rooting system, well adapted to grazing. Evaluations of the species for pasture and hay, grown with and without grasses, are in progress. Seed may be difficult to obtain, and very slow stand establishment should be expected. Seed 6 to 8 pounds per acre in mixture with cool-season grasses.

Major strengths	Major weaknesses
Winterhardy	Poor seedling vigor
Very persistent once established	Slow to establish
	Causes bloat
Spreads by underground rhizomes	Nonpubescent, attacked by potato leafhopper
Tolerant of poorly drained, acidic soils	Requires special *Rhizobium* inoculum in order to fix nitrogen

Lespedeza (Korean) is a popular warm-season annual legume in the southern third of Illinois. The annual species is more palatable and higher yielding than the perennial type (Sericea).

Major strengths	Major weaknesses
Will tolerate low productive, eroded soils	Lower yielding
	Relatively shallow root system
Easy to establish; can be frost seeded	Risk of rapid leaf shatter when harvested as hay
Will reseed itself	Seed may contain considerable amount of hard seed
Does not cause bloat	

Sweetclover is now used mainly as a green manure crop and a forage crop for bees. Two common types of this legume exist in Illinois, yellow-flowered (biennial) and white-flowered (annual and biennial).

Major strengths	Major weaknesses
Biennials have deep taproot; drought-tolerant	Needs soil pH of at least 6.5
	Not tolerant of poorly drained soil
Biennial is winter-hardy	Contains coumarin, which may cause "bleeding disease" in cattle and reduced palatability
Excellent for soil improvement	
Good source of nectar and pollen for bees	Hay can get stemmy
	Grows prolifically on roadsides, etc., so is considered invasive

Hairy vetch is a winter annual legume most often grown for soil improvement or as a winter cover crop instead of a forage crop. It has a viney growth habit.

Major strengths	Major weaknesses
Can grow on a wide variety of soils	Less winter-hardy than alfalfa and red clover
Green manure crop providing source of nitrogen, especially in central and southern Illinois	Medium palatability
	For best establishment, seed in August
If grown for hay, should be seeded with small grain (winter rye, winter wheat, or winter triticale)	

Crownvetch is a well-known perennial legume used mainly as a soil conservation crop protecting erodible areas (such as road banks) and for land reclamation, rather than as a forage crop. It is a member of the pea family.

Major strengths	Major weaknesses
Deep-rooted	Slow to establish, low seeding vigor
Winter-hardy, long-lived	Low palatability
Drought-tolerant	Slow regrowth
Does not cause bloat	Difficult to harvest as hay due to prostrate growth habit
	Invasive

Inoculation of legumes. Legumes, such as the species just described, can meet their nitrogen needs from the soil atmosphere if the roots have the correct *Rhizobium* species and favorable conditions of soil pH, drainage, and temperature. *Rhizobium* bacteria are numerous in most soils; however, the species needed by a particular legume species may be lacking.

There are seven general groups and some other specific strains of *Rhizobium*, with each group specifically infecting roots of plants within its corresponding group and some specific strains infecting only a single species. The legume groups are alfalfa and sweetclover; true clovers (such as red, ladino, white, and alsike); peas and vetch (such as field pea, garden pea, and hairy vetch); beans (such as garden and pinto); cowpeas and lespedeza; soybean; and lupines. Some of the individual *Rhizobium* strains are specific to birdsfoot trefoil, crownvetch, cicer milkvetch, kura clover, and sainfoin. Legume seed should be inoculated with the proper *Rhizobium* bacteria before each planting.

Cool-Season Grass Species

Please note that the following discussion is not all-inclusive of cool-season grass species. The focus here is on the species most commonly adapted or evaluated for use in Illinois. **Table 6.2** lists seeding-rate recommendations for grass–legume mixtures. **Table 6.7** lists seeding-rate recommendations for pure grass stands for both perennial and annual grasses.

Table 6.7. Forage seeding-rate recommendations for cool-season grasses (in pounds of pure live seed per acre).

Cool-season perennial grasses (pure stand)	
Festulolium	20–25
Kentucky bluegrass	10–15
Meadow fescue	15–20
Orchardgrass	10–15
Reed canarygrass	6–10
Ryegrass, perennial	20–25
Smooth bromegrass	15–20
Tall fescue	10–15
Timothy	6–8
Cool-season annual grass (pure stand)	
Oats, seeded in mid-August	96 (3 bushels per acre)

The table reflects recommendations from the University of Illinois, Purdue University, and Iowa State University. Characteristics, strengths, and weaknesses of legumes and grasses are described beginning on page 75.

Timothy is a bunch-type perennial grass for hay and pasture that is best suited to the northern half of Illinois. Since it matures relatively late, timothy is commonly grown with red clover or birdsfoot trefoil. Timothy requires a long rest period after grazing or hay harvest for maximum productivity and persistence.

Major strengths	Major weaknesses
Winter-hardy	Poor tolerance to heat, drought, and traffic
Grows best in cool, moist soil conditions	Shallow-rooted
Compatible with legumes in mixtures, provided maturities are similar	Seedheads are constantly produced, thus stemmy
	Stand does not persist
	Limited production after first harvest

Smooth bromegrass is a winter-hardy, high-yielding, sod-forming perennial grass for northern and central Illinois hay and pasture. Smooth bromegrass works well in mixes with alfalfa or red clover.

Major strengths	Major weaknesses
Adapted to well-drained and droughty soils	Fluffy seed is hard to flow through seeder
Winter-hardy	Slow to establish, low seeding vigor
Highly palatable	Less summer production than orchardgrass
Responsive to nitrogen	Must be rested after harvest or stand will not persist. Hay harvests must be limited to 3 cuts a year.
Heat-tolerant	Not tolerant of close grazing

Orchardgrass is a high-yielding, bunch-type perennial grass adapted throughout the state for hay and pasture. Winter-hardy varieties need to be grown in northern Illinois. Orchardgrass grows best on soils with good moisture-holding capacity. Seed medium- to late-maturing varieties when grown with legumes.

Major strengths	Major weaknesses
Easy to establish and can be frost-seeded	Not drought-tolerant
Palatable	Varieties differ in susceptibility to rust and leaf spot diseases
Quick recovery after harvest	Varieties differ greatly in maturity
One of the most productive grasses in midsummer	Moderately winter-hardy for the northern quarter of Illinois
Grows in partial shade better than other grasses	

Reed canarygrass, a sod-forming, winter-hardy perennial grass, is not widely used, but it has growth attributes that deserve consideration. Low-alkaloid varieties should be sown, as they typically provide better animal performance and better intake. Keep in vegetative stage for best performance and to prevent seed escape to wetlands.

Major strengths	Major weaknesses
High-yielding	Slow to establish
Aggressive once established	Older varieties had low palatability due to presence of alkaloids
Persistent	Careful management needed for high quality
Can tolerate wet and dry soil conditions	Considered an invasive species, especially in wetlands
Deep-rooted	
Can utilize high soil fertility	

Tall fescue is a high-yielding, bunch-type perennial grass used for hay and pasture. Historically, it has been the predominant grass grown in the southern half of Illinois, but it can be grown throughout the state.

Major strengths	Major weaknesses
Widely adapted	Low palatability and quality of endophyte-infected varieties
Tolerant of livestock and vehicle traffic	Winterhardiness and disease resistance vary by variety
High-yielding	Fescue toxicosis caused by the endophytic fungus
Best grass for stockpiling (deferred grazing) since it maintains quality and palatability	
Moderately drought-tolerant	

"Endophyte" refers to a fungus living in the plant tissue; it contributes to plant persistence and other desirable characteristics, but it also has a negative influence on animal health and lowers the palatability and digestibility of tall fescue during the summer months. Varieties are available that are endophyte-free or low in endophyte. Recently, novel or nontoxic ("friendly") endophyte-infected tall fescue seed has been released. Preliminary data suggest that animal performance on novel endophyte can be excellent and similar to endophyte-free tall fescue. Novel endophyte appears to give tall fescue improved vigor, drought and grazing tolerance, and pest resistance. Research is continuing. If you are establishing tall fescue, consider seeding either low-endophyte or nontoxic endophyte varieties.

Tall fescue plant samples, taken at the vegetative stage, can be tested for the presence of the endophyte fungus by one of a number of commercial and university laboratories.

Kentucky bluegrass is a sod-forming, winter-hardy perennial pasture grass that tolerates close grazing and can be grown throughout Illinois. Production is greatest in the spring and fall.

Major strengths	Major weaknesses
Long-lived	Low-yielding
Fine-leaved and high quality	Shallow-rooted
Low maintenance	Poor drought tolerance
Compatible with white clover	Doesn't compete with more aggressive species
	Becomes dormant in summer

Ryegrass is a bunch-type, high-quality cool-season grass that consists of several species: annual, Italian, perennial, and hybrid crosses. For use in hay and pasture, select "forage"-type, not "turf"-type, varieties.

Major strengths	Major weaknesses
Quick establishment	Not tolerant of hot, dry conditions
High quality and palatable	Poor drought tolerance
Grows rapidly	Winterhardiness varies by variety
Grows best in fertile, well-drained soils	Varieties differ in susceptibility to stem rust and endophyte

Annual ryegrass, a weak perennial, can also used as a winter cover crop. It is lower-yielding. It is adapted to frost seeding but will produce seedheads in the seeding year. *Italian ryegrass* can be a perennial with a mild winter or snow cover. It can be used as a companion crop (seed at 2 to 4 pounds per acre) instead of oats for spring forage establishment. There are both heading and nonheading types. Nonheading types are preferred for frost seeding. Late maturity types have more uniform yield throughout the season. *Perennial ryegrass* is tolerant of close, frequent grazing and yields in the spring and fall.

New cool-season perennial grasses being evaluated.
Meadow fescue is a bunch-type grass, adapted to cool, moist conditions and a "distant relative" of tall fescue. Initial data indicate that it is lower-yielding but has greater palatability than tall fescue. Ease of establishment, tolerance to close grazing, and rapid regrowth have been observed. Seed 8 to 12 pounds per acre in a mixture; see **Table 6.7** for the rate if seeded alone.

Festulolium is a bunch-type grass resulting from a hybrid cross between meadow fescue and Italian or perennial ryegrass. The intent is that drought, heat, and cold tolerance are transferred from fescue and ease of establishment and high quality transferred from ryegrass. Seed 4 to 10 pounds per acre in a mixture; see **Table 6.7** for rate if seeded alone.

Annual Forages

Please note that the following discussion is not all-inclusive of annual forage species. The focus here is on the species most commonly adapted or evaluated for use in Illinois; see **Table 6.8** for seeding-rate recommendations.

Annual forages are commonly grown as an emergency/supplemental forage crop, to fill the "summer slump" of cool-season perennial species, to work into a rotation, or to extend the grazing season. As the name indicates, these forages must be seeded yearly. Seed cost, cost of establishment, and risk of getting a stand must be considered.

Sudangrass, sudangrass hybrids, sorghum–sudangrass hybrids, and forage sorghum are warm-season, annual, bunch-type grasses that are very productive during the summer. They may be used for silage, green chop, or grazing. These tall-growing, succulent grasses are difficult to make into high-quality hay. They produce prussic acid

(hydrogen cyanide), a compound toxic to livestock, when stressed by frost or drought. Since the concentration of prussic acid is greatest in young plants and in the leaves, to minimize prussic acid poisoning these grasses should not be harvested until they reach a "safe" height (see below). These crops should not be fed to any class of horse.

Seed of sudangrass and sorghum–sudangrass hybrids can be purchased that contain the brown midrib (BMR) trait. The BMR trait greatly improves the digestibility, palatability, and resulting daily gain of livestock, but the plant still has prussic acid potential. Warm soil temperature (65 to 70 °F) is required for ideal germination. Seed by late June and for southern Illinois by mid-July.

Sudangrass and sudangrass hybrids

Major strengths	Major weaknesses
Finer stems than sorghum–sudangrass hybrids	Do not harvest until 18 inches tall
Rapid regrowth	Prefers well-drained soil
Drought-tolerant	Possible nitrate toxicity with drought
Hybrids will yield slightly more than nonhybrid varieties	Must leave 6-inch stubble

Sorghum-sudangrass hybrids

Major strengths	Major weaknesses
Higher-yielding than sudangrass and sudangrass hybrids	Not as leafy as and more stems than sudangrass
Rapid regrowth	Do not harvest until 24 inches tall
Drought-tolerant	Prefers well-drained soil
	Possible nitrate toxicity with drought
	Must leave 6-inch stubble

Table 6.8. Forage seeding recommendations for warm-season grasses (in pounds of pure live seed per acre).

Warm-season annual grasses (pure stand)	
Sudangrass[a] and sudangrass hybrids[a]	25 drilled (30 broadcast)
Sorghum–sudangrass[a]	20 drilled (30 broadcast)
Forage sorghum[a]	12–15 drilled
Pearl millet	15 drilled (25 broadcast)
German (foxtail) millet, Japanese millet	12–15 drilled
Teff	4–6 drilled for uncoated seed
	8–10 drilled for coated seed
Warm-season perennial grasses[b]	
Single species	
Switchgrass[c]	6–9
Eastern gamagrass[c]	8–10
Big bluestem	10–12
Indiangrass	8–10
For mixtures, seeding rates should be reduced in proportion to the number of species. For example, if two species are used in a mixture, use half of the rate listed for each.	

The table reflects recommendations from the University of Illinois, Purdue University, and Iowa State University. Characteristics, strengths, and weaknesses of legumes and grasses are described beginning on page 75.
[a]Not to be used in horse pastures.
[b]Suitable for moderately to well-drained and droughty soils anywhere in Illinois. Not recommended for poorly drained soils.
[c]Will tolerate somewhat poorly drained soil.

Forage sorghum is an annual, tall-growing, warm-season, bunch-type grass belonging to the sorghum family. Some varieties are called "sweet sorghum" due to sweet and juicy stems.

Major strengths	Major weaknesses
Best as a silage crop	Not recommended for grazing or haying
Typically produces more silage dry matter yield than corn	Lower total digestible nutrients per acre than corn
	Matures late in the season
	Contains high level of prussic acid even late in the season
	High moisture content

Freeze on the sorghum family of crops breaks cell walls and allows *prussic acid* to be released within the plant. For this reason, it is advisable to remove grazing ruminant livestock from freshly frozen sudangrasses and sorghums. When the frozen plant material is thoroughly dry, usually after 3 to 5 days (following a "light" frost), grazing can resume. With a killing freeze (28 °F or colder), grazing should be delayed 8 to 10 days. After this drying period, observe the plants closely for new tiller growth, which is high in prussic acid. Livestock should be removed when there is new tiller growth that could be grazed.

Because the fermentation process from ensiling substantially reduces prussic acid potential, ensiling is the safest way to handle questionable feed. Harvesting as hay is the second safest way of using crops with questionably high levels of prussic acid potential.

Laboratory diagnostic procedures can determine relative potential.

Pearl millet is an annual, tall-growing warm-season grass that does not have prussic acid. It may be used for grazing, hay, green chop, or silage. Warm soil temperature (70 °F) is required for ideal germination. Seed by late June and for southern Illinois by mid-July.

Major strengths	Major weaknesses
Does not contain prussic acid	Slower regrowth after harvest than sorghum family of grasses
Fine-stemmed and leafy	Must leave 6 to 8 inches of stubble after harvest for regrowth
Higher leaf-to-stem ratio than sorghum family of grasses	Possible nitrate toxicity with drought
Higher yielding than other millets	

Other millets grown for forage include *German (Foxtail)* millet and *Japanese* millet. These warm-season annual grasses are usually seeded for an emergency hay crop, and to a lesser extent for pasture. Careful management is needed so they do not produce seed heads and become a weed problem.

Teff is a warm-season, summer annual grass, native to Ethiopia, and has the appearance of a bunch-grass. Indications are that teff is adapted to a wide range of soil conditions. Due to small seed size, a firm, well-prepared seedbed is needed for establishment. Use of teff as a forage crop in the Midwest has not been widely tested. Trials are in progress to identify adapted varieties and specific management practices.

Major strengths	Major weaknesses
Fine-stemmed	Small seed (1.25 M per pound)
Very palatable	Not tolerant of frost
Can be hayed, ensiled, or grazed	Not tolerant of cool soil temperatures (<70 °F) at planting

Brassicas (turnips, swedes/rutabaga, rape, and kale) are high-yielding, high-quality, fast-growing forbs belonging to the mustard family. They are low-fiber, high-moisture crops best utilized in a managed grazing system, not for hay or ensiling. Due to their high moisture content, they need to be supplemented with dry hay or pasture. The amount of dry matter yield in the tops (leaves and stems) vs. the roots (bulbs) varies by species and variety; see **Table 6.9** for seeding-rate recommendations. Seed by early June for summer grazing and by early August for fall and winter grazing. They can be seeded separately, or in a mixture with small grains.

Warm-Season Perennial Grass Species

Please note that the following discussion is not all-inclusive of warm-season perennial grass species; see **Table 6.8** for seeding-rate recommendations. The focus here is on the species most commonly adapted or evaluated for use in Illinois.

Also referred to as native prairie grasses, warm-season perennial grasses are commonly grown for conservation and wildlife purposes, but they can be an alternative forage for hay and pasture (especially with rotational grazing). In contrast to cool-season grasses, they grow primarily during the warm part of the summer and produce well under hot, dry conditions of midsummer. Seeding a single species is commonly preferred because mixed species are more difficult to manage. A mixture of warm-season and cool-season grasses is generally not recommended because of competition and differences in growth patterns. Typically, warm-season grasses are not compatible with legumes and have lower forage quality than cool-season grasses. They are more difficult and slower to establish than cool-season grasses, but once established they are persistent and vigorous.

Switchgrass is a tall, bunch-type grass with short rhizomes. It has long, broad leaves and grows 3 to 6 feet tall. Switchgrass becomes stemmy as it matures, so harvest before seed heads emerge for higher quality forage. See **Table 6.10** and **Table 6.11** for variety yield data.

Major strengths	Major weaknesses
Winter-hardy	Becomes stemmy as it matures
Drought-tolerant	Palatability and quality decline quickly after heading
Smooth seed can flow through most drills	
Will tolerate moist soils	

Big bluestem is a tall-growing (6 to 8 feet), bunch-type grass that may have short rhizomes. It is considered more palatable than switchgrass (especially after maturity), but it yields less. See **Table 6.10** for variety yield data.

Major strengths	Major weaknesses
More drought tolerant than other warm-season grasses	Seed should be debearded before seeding to enable even flow through the drill
Can tolerate low-water-holding soils	Lower-yielding than switchgrass
Winter-hardy	

Indiangrass is another tall-growing (4 to 6 feet), bunch-type grass with short rhizomes. The grass becomes stemmy if allowed to mature. It is especially adapted to deep, well-drained soils. See **Table 6.10** for variety yield data.

Major strengths	Major weaknesses
Winter-hardy	Yield potential less than switchgrass and eastern gamagrass
Drought-tolerant	Seed must be debearded for good seeding
Easier to establish than other warm-season grasses	

Eastern gamagrass, considered a relative of corn, is a bunch-type grass that produces short, thick rhizomes. It is best adapted to deep, well-drained soil. Corn planters are commonly used to seed this grass. See **Table 6.10** for variety yield data.

Major strengths	Major weaknesses
Winter-hardy	Not drought-tolerant
High palatability	Forms large clumps that make mechanical harvest difficult
	Large seeds are enclosed in a hard shell that contributes to dormancy; seed germination is improved by exposing seed to wet-chilling process

Establishment of warm-season perennial grasses. Warm-season perennial grasses are slower to establish than cool-season species. Seedings need to be made from early May to early June. Seeding in the early part of this range provides more time for seedlings to get well established. As seeding is delayed, grasses are slower to establish, yields are less, and weed pressure increases. Mowing at a height of 6 inches in the summer of the establishment year will help control weeds, but don't mow after the end of August so food reserves can build for the winter.

Seedings can be made on tilled, firm seedbeds using a drill or double-corrugated roller seeder. Seed of Indiangrass and big bluestem should be debearded. Eastern gamagrass is commonly seeded using a corn planter.

No-till seedings may be made into existing grass sods where the grass was previously killed with a herbicide. A no-till drill is needed to place seeds at the proper depth and ensure good seed-to-soil contact.

A seeding depth of 1/4 to 1/2 inch is suggested for all of the grasses described, except for eastern gamagrass, which should be seeded 1/2 to 1 inch deep.

See **Table 6.8** for suggested seeding rates, listed as pounds of pure live seed per acre.

Harvest of warm-season perennial grasses. Stands should not be harvested until they are well established and growing vigorously; this may require 2 to 3 years. Typically it is best not to graze these grasses during the seeding year. Established stands can be harvested when 18 to 24 inches high (late boot stage, before seed heads emerge), but leave 5 to 6 inches for regrowth.

Table 6.9. Forage seeding-rate recommendations for forbs.

Brassicas (pure stand)	
Turnip	2–3 drilled
Swedes (rutabaga)	2–3 drilled
Kale, rape	3–4 drilled

Table 6.10. Species and varieties of warm-season perennial grasses at Dixon Springs.

Species/variety*	2-yr avg dry matter (tons/A)
Switchgrass/Cave-in-Rock	5.47
Eastern gamagrass/Pete	7.20
Big bluestem/Roundtree	4.84
Caucasian bluestem	3.58
Indiangrass/Rumsey	6.03

*Each variety is harvested twice a year.

Table 6.11. Switchgrass variety trial at Shabbona (DeKalb County).

Variety	2002–04 avg dry matter (tons/A)
Blackwell	4.16
Cave-in-Rock	4.37
Pathfinder	3.81
Sunburst	3.67
WIP[a]	3.22
WSB[a]	3.82

The trial was a collaboration among the Northern Illinois Agronomy Research Center, the University of Illinois Department of Crop Sciences, USDA-ARS, and the U.S. Dairy Forage Research Center, Madison, Wisconsin. The trial was harvested once a year, generally in late August.
[a]Experimental variety, not currently available commercially.

Additional Information

These resources provide more details on hay and pasture management:

- North Central Region (NCR) Extension publication NCR547, *Alfalfa Management Guide*; contact your University of Illinois Extension office or see www.pubsplus.illinois.edu to order.
- Current edition of *Winter Survival, Fall Dormancy and Pest Resistance Ratings for Alfalfa Varieties*, available through National Alfalfa and Forage Alliance, www.alfalfa.org/publications.html.
- *Buying Horse Hay*, Extension publication A3772; contact your University of Illinois Extension office or see www.pubsplus.illinois.edu to order.
- *Grazing in Illinois* manual; copy available at University of Illinois Extension and Natural Resources Conservation Service (NRCS) offices and online at www.il.nrcs.usda.gov/technical/grazing/index.html#General
- University of Illinois *Illinois Livestock Trail* website, www.livestocktrail.illinois.edu
- Purdue University forage identification pictures, www.agry.purdue.edu/Ext/forages/ForageID/forageid.htm