SECTION TWO
Native Grass Establishment

Through the years, native grasses have developed a reputation for being difficult to establish. As discussed in the previous section, that is not an entirely unfair characterization. However, it is more accurate to simply think of them as having a smaller margin for error for successful establishment than many other grasses. In fact, **establishment of native grasses is a process almost exactly the same as for any other seeded perennial grass**. What makes native grasses more challenging, what creates that smaller margin for error, are several aspects of these species' basic biology — small seed, slow germination, small initial seedling size, an emphasis on root growth rather than top growth during early development and an intolerance for being overtopped by weed canopies. When these factors are taken into account and addressed by implementation of good agronomic practices, **success rates for native grass establishment are quite high**, typically 85-95 percent on the first attempt. Where such appropriate practices are followed, most failures are a result of factors out of any producers' control — timing and amount of rain — and that affect any grass planting in exactly the same way. In the chapters below, proper steps for ensuring successful establishment are provided.

CHAPTER SIX

Planning Your Planting Project

As with any project, success requires careful pre-planning (Fig 6.1). Key considerations for success are addressed in this chapter. These include how many acres to plant, site selection, what species and/or cultivars to plant and pre-planting competition control.

Figure 6.1. This productive stand of mixed big bluestem and indiangrass was established on a conventional seedbed in northern Alabama behind cleared timber and, on a portion of the site, a bermudagrass hayfield. Competition control was excellent and the seedbed was clean, fine and firm. The stand was not planted until July 5th because of a severe spring and early summer drought. Credit, D. Miller.

HOW MANY ACRES SHOULD I PLANT?

The quick answer is not many. Until you have gained some experience with native grass establishment, starting small will be the best route to take. This approach helps reduce the risk associated with having too many acres exposed to potential stand failure during any one year. By planting in smaller units over time, you can gradually arrive at the correct proportion of warm- to cool-season forages for your operation.

From a longer-term perspective, a good rule of thumb for most Mid-South operations is that **about 30 percent of your forage base should be in a warm-season perennial**. This ratio would obviously change as you move either to the south or north. While there is no specific research that can confirm this ratio scientifically — such a project would be extremely expensive and difficult to implement and would have to be repeated under a number of different conditions — there are a couple of obvious ways to arrive at this ratio.

First, simply look at a calendar. In the Mid-South, there are at least three months (December-February) in which we cannot graze actively growing forages. Of the remaining nine months, there are at least three, more realistically four months (mid-May to mid-September) in which warm-season species have an advantage, leaving five to six months when cool-season species should be the primary forage (Figure 6.2). So, for this latitude, having a warm-season perennial for somewhere between 33 percent (3 of 9) and 44 percent (4 of 9) of the grazing months would be desirable. Given the generally higher carrying capacity of C4 species, the number of acres could likely be below the 33-44 percent figure, perhaps 25-35 percent. Those figures could be adjusted as one moves further north or south.

In studies conducted as far north as eastern Nebraska and western Iowa (i.e., 41 degrees N), inclusion of a warm-season component resulted in a 31 percent increase in gain per steer over the full grazing season (cool- and warm-season pastures combined), 96 percent more gain per acre, a three-fold improvement in ADG for cows, a 19 percent improvement for calves, and increased stock density (27 percent)[1]. Together, these results suggest that the benefit of a warm-season component does not diminish even at that latitude.

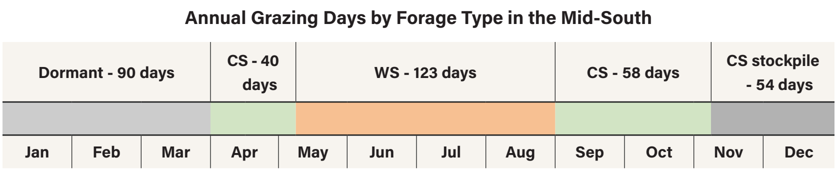


Figure 6.2. Grazing seasons for the Mid-South depicting periods during which cool- (CS) and warm-season (WS) forages will be most useful. For sites either further south or further north, adjustments would need to be made to increase or decrease, respectively, the proportion of a forage base in warm-season species.

Another way to arrive at an appropriate ratio of warm- to cool-season forages is to look at what has occurred in the eastern U.S. historically. As described in Chapters 1 and 3, warm-season species consistently dominated grasslands of the eastern U.S. as far north as 43 degrees — from southern Minnesota to northern Ohio. One reason that KY-31 tall fescue has been so effective growing where warm-season species formerly dominated (Figure 6.3) is that it is, as far as cool-season perennials are concerned, a remarkably drought-tolerant species. However, even with this cultivar, warm-season grasses often begin to replace it under poor grazing management or repeated drought stress, especially on marginal sites. This process of replacement is really just a natural reversion back toward the historical baseline. For example, warm-season species dominate relict native grasslands at about 38 degrees north latitude (i.e., southern Missouri to central Virginia) with 35-46 percent in C4 species with the lower figure from higher elevation sites in the Appalachians[36]. Similarly, the degree to which less desirable C4 species have encroached into cool-season pastures is another good indicator of how many acres of warm-season forages are needed. These species include knotroot foxtail, broomsedge, goosegrass and common bermudagrass (Figure 6.4).

The paragraphs above address how many acres of perennial warm-season grasses are needed for pasture. But what about dedicated

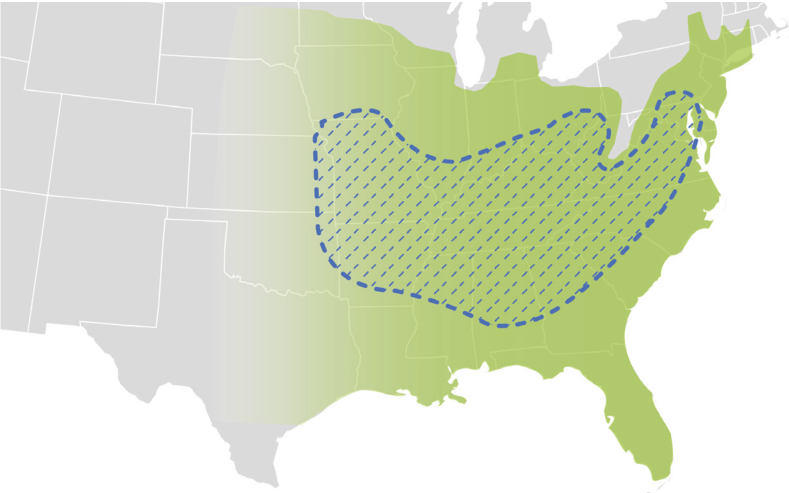


Figure 6.3. Until well into the twentieth century, warm-season species dominated grasslands across most of what is now the eastern U.S. Indeed, the entire area known as the Fescue Belt (blue stippled area) is within the area once dominated by warm-season or C4 species. Reliance on warm-season forages throughout this region for summer forage supply continues to be a good strategy for managing risk and improving production. Credit, K. Keel-Blackmon.

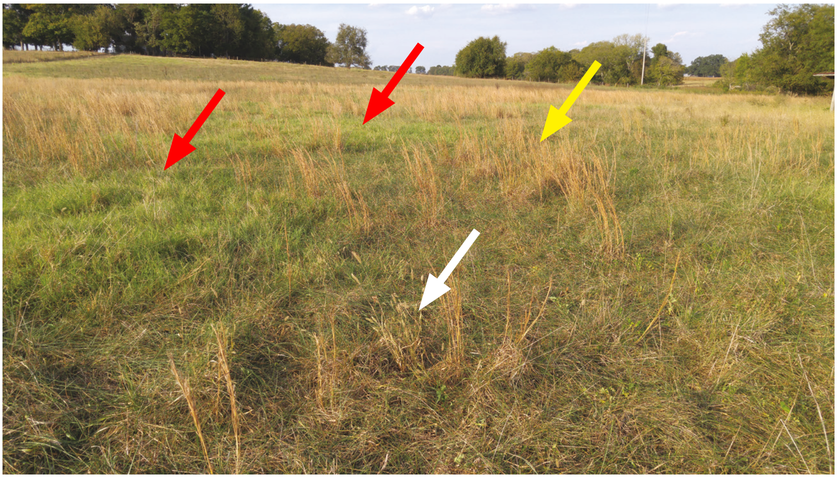


Figure 6.4. A number of introduced—and native—warm-season species have encroached into what was once a vigorous tall fescue pasture. Note bermudagrass patches (red arrows), foxtail (white arrow) and broomsedge (yellow arrow). The increasing dominance of these warm-season competitors is evidence that there is a place for a perennial warm-season forage in this system. A warm-season complement can provide much needed rest for the cool-season species allowing them to remain more vigorous in the face of extreme summer conditions.

hay ground? How many acres of warm-season grass are needed there? Considering that warm-season grasses are more reliable producers (less impact from drought), have greater per acre yields, require fewer inputs (for the native grasses at least) and can be harvested at appropriate stages of maturity during a time of year when hay curing conditions are favorable, a case could be made that dedicated hay ground should be in warm-season grasses (Figure 6.5). Consider that in a trial conducted in Kentucky over eight years, 16 native grass cultivars representing five species, produced an average yield (dry matter basis) of 4.5 tons per acre. At that same Kentucky research station during that same period, a three-year trial was conducted for tall fescue cultivars. The tall fescue produced only 3.1 tons per acre—giving the native grasses a 45 percent yield advantage. It took 180 pounds of N per acre for the tall fescue to achieve this yield while for the natives only 60 pounds N per acre were applied. Furthermore, the tall fescue required four cuttings versus the 1-2 per year for the natives. So the cool-season species required at least twice as many trips across the field, three times more N, but produced 45 percent less yield. Based on this, it should not be a surprise that, as discussed in Chapter 14, native grasses also produce hay at a lower cost per ton. Of course, as with pasture, replacement of cool-season species for hay production should occur as existing stands need to be renovated or new ground (e.g., land clearing, no longer in row crop production) becomes available rather than at a large scale.

Figure 6.5. This second-year stand of big bluestem and indiangrass was cut for hay in July. Hay making conditions in mid-summer can often be quite favorable and native grass hays can cure in as little as 24 hours. Note the 8-inch stubble height in this field. Cutting at this height leaves enough stubble that the harvested hay remains above the ground surface which allows for increased air circulation and faster drying times.

SITE SELECTION

Where should you plant native grasses? A simple answer is wherever it works best for your operation. However, given the choice, there are some guidelines that will ensure the best possible outcome and minimize cost and risk associated with establishment.

First, consider areas **where the impact on existing forage production will be minimized**. Given the lack of forage production for native grasses during the seedling year, this could be important and reduce the financial impact of the project. Two good options are recently cleared ground and acreage being taken out of row crop production (Figure 6.6). Another option is smaller odd areas that for one reason or another have not been productive. Also consider pastures that already need to be renovated. Such pastures may be on ground that is particularly vulnerable to drought or for other reasons have not been able to maintain productive stands of cool-season forages through the years. In all of these cases, lost productivity during establishment will be limited — the land had not been producing forage anyway — and, therefore, will have the least impact on forage availability. Furthermore, because planting some forage on these sites must be done one way or another, the effort, cost and risk of planting native grasses may not be any greater than what will be incurred with any other forage crop.

Figure 6.6. Recently cleared ground such as seen here, typically has much less weed pressure than sites that have been in hay or pasture production for many years. As such, they can be an excellent choice for establishing new stands of native grass forages. Note the weedy portion of the field on the right. This area had been a hayfield prior to the start of the planting project. This site produced an excellent stand of native grasses (see Figure 6.1).

A second key category for where you should **consider establishing native grasses is on the worst ground in your operation** including sites with low productivity due to shallow or coarse-textured soils, low inherent fertility, poor internal drainage (e.g., heavy textured soils, claypans) or sites exposed to frequent flooding during the growing season. As mentioned in Chapters 1 and 3, each of the predominate perennial native grass species has unique ability to survive and thrive under one or more of these marginal site characteristics. Furthermore, as marginal sites, it is likely that they fit the first category described in the preceding paragraph and loss of production during establishment will be minimal. In addition, it is on these sites where the marginal benefit to your operation is likely to be the greatest, where increased yield and reliability of forage production will be most apparent.

A third consideration in site selection — and there will be overlap here with the first two categories mentioned above — is **where weed pressure is likely to be lowest**. Given that the most common cause of stand failure is excessive weed pressure, sites where such pressure is limited are those where the likelihood of success will be greatest. With experience in successfully establishing native grasses, more challenging (i.e., weedier) sites can be tackled on subsequent planting projects. Examples of preferred sites are, in approximate order of increasing weed pressure, new ground (i.e., where closed-canopy tree or shrub cover has been in place for many years), fields with extended histories of crop production (especially non-grass crops such as cotton or soybeans), hayfields and, lastly, degraded pastures. Degraded pastures, because of a history of weak grass cover, will normally have heavy infestations of common pasture weeds that must be controlled if planting is to be successful (Figure 6.7). Low fertility sites also tend to have fewer problems with weed pressure than those with high fertility and, as such, also make good candidates for native grass establishment. Although annual grasses are one of the most serious forms of competition for native grass seedlings, the most difficult scenario is where bermudagrass is present (Figure 6.8). This tenacious grass requires aggressive control measures if native grass planting is to be successful (see sidebar at the end of this chapter on bermudagrass control).

Figure 6.7. Side-by-side comparison of a recent switchgrass planting showing weed pressure during the seedling year. Planted on the same date, a portion of this field (a) was planted into an old, degraded pasture sod. The other portion (b) had been in a woodlot that was cleared. The area formerly in old sod developed heavy weed pressure from its seedbank while the formerly wooded site had a very limited weed seedbank and has very little competition. Site history is clearly important when selecting sites for native grass establishment! Credit, J. Daniel.

Figure 6.8. Where bermudagrass is present, establishment of natives can be particularly difficult. Not only is bermudagrass difficult to kill, but the dense sods left behind after spraying are difficult for some drills to penetrate leading to poor seed-soil contact. This same thatch can also prevent effective seedling recruitment. Native grass seedling recruitment was poor within the dense bermudagrass sod seen in this picture.

Can I have my cake and eat it too?

One question I often am asked is, "Can I plant native grasses into my existing cool-season pasture?" The idea behind this question is, can I have a sure-enough "year-round pasture." The simple answer is no, native grass seedlings will not successfully establish where a sod already exists. But the other part of this story is that although you can have both cool- and warm-season perennial grasses growing in the same field, they will not occupy the same square foot. You either have one or the other at any given spot in the field. So, there is no net gain in production. The total acreage of warm- and cool-season species is not increased, it is just arranged differently — mixed within a field instead of in two separate fields. Because management is much easier where the two are separated, productivity will also be greater in the long run. In fact, where the two do occur in the same field, and must be placed under common management, one or the other will, over time, win the seesaw battle and dominate the field. Keeping the mix is a delicate balancing act, one that rarely succeeds.

One apparent exception to this rule is where an annual such as annual bluegrass grows in a warm-season grass pasture or crabgrass in a cool-season grass pasture. This may seem like an exception, but in reality, it only proves the point that you cannot have your cake and eat it too. Why? Look closely at these mixed pastures and you will discover that where these annuals have a foothold is typically where the perennial is weak or absent, where there is a gap in the stand. But it gets worse. The presence of the annuals represents competition for the perennial. Where crabgrass is able to grow well in what is supposed to be a tall fescue pasture, the crabgrass will hinder the fall growth of the cool-season species, a time that is critical for root growth and energy storage for the cool-season species. Thus, the annual is competing with the perennial and weakening it further. Over time, this can allow the annual to increase at the expense of the perennial. Conversely, if the perennial outcompetes the annual, the annual will diminish. Either way, we are back to the same delicate balancing act and total productivity is not increased. In all likelihood, it is actually diminished.

SPECIES AND CULTIVAR SELECTION

Selection of native grass species and cultivars should be based on the site where you intend to plant and on your specific forage production goals. Because these are native species, they all can be grown on almost any site where you can reasonably manage forages, but some will do better than others based on specific conditions (Table 6.1). Commercially available cultivars and a number of local ecotypes are listed in Appendix A. Another resource is the recently developed web app, "NatiVeg" (www.quailcount.org/NatiVeg), which helps match available cultivars to specific geographic locations.

Table 6.1. Relative comparison of key attributes of five important native warm-season grass species [1].

Attribute	Big bluestem	Little bluestem	Eastern gamagrass	Indiangrass	Switchgrass
Establishment	moderate-easy	easiest	moderate	easiest	difficult
Long-Awned Seed [2]	yes	yes	no	yes	no
Wet Site Tolerance	moderate	low	high	moderate - low	high
Dry Site Tolerance	moderate	high	low	moderate - high	moderate
Grazing Management	easier	easier	moderate	easier	more difficult
Maturity	middle	late	earliest	late	early
Palatability	highest	high	moderate	high	moderate
Yield	high	moderate	very high	high	very high

[1] Adapted from Keyser et al., 2019 (UT Extension Publication PB 1873).

[2] Seed from these species have long awns, which causes the seed to be "fluffy" and impedes proper flow of the seed through standard seed drills. If possible, purchase "debearded" or cleaned seed that has had the long awns removed.

Matching the grass to the site

On wet sites, either eastern gamagrass or lowland switchgrass are the best alternatives (see Figures 1.10 and 3.9). Both species can tolerate prolonged periods of inundation during the growing season. Switchgrass has survived up to 60 days of flooding during the growing season [6] and eastern gamagrass has been documented to tolerate as much as 50 days[8]. Clearly, both grasses can endure — and remain productive — on very wet sites. Another advantage of using these warm-season species on wet sites is that their production corresponds to the driest time of year, when these fields would be most accessible for grazing or hay harvest.

At the other extreme, for marginal sites with shallow or coarse-textured soils that are prone to drought, little bluestem and sideoats grama will do well (see Figure 4.6). Both species commonly grew on shaley ridge-tops and thin acidic soils across much of the eastern U.S. before European settlement. Additionally, as mentioned in Chapter 1, these species were prevalent in the central Great Plains where annual rainfall was too limited for the taller species such as indiangrass and big bluestem.

Big bluestem, indiangrass and upland switchgrass are well adapted to most sites between these two extremes. It should be noted, though, that these species can also grow on droughty sites but will be less productive. For example, good stands of big bluestem and indiangrass have been established on reclaimed surface mines where soil quality was extremely low (see Figure 3.10a). Lowland switchgrass can also do very well on upland sites and upland switchgrass, although less flood tolerant than the lowland types, can also be grown on wet sites.

With respect to cultivar selection, almost any can be used, but those with the closest adaptation to the region in which they will be grown are preferable. Moving cultivars 300 miles or so north of their origin can provide an advantage in yield. However, moving them too far north can risk winterkill. For example, Alamo switchgrass (origin near San Antonio, Texas) can do quite well in Tennessee and Arkansas, but winter hardiness becomes an issue moving northward into central Kentucky and Missouri. Conversely, moving cultivars south of their origin will lead to reduced yields relative to their origin due to shorter daylengths forcing earlier flowering. The primary concern with moving cultivars from east to west is reduced drought resiliency of the material from more humid environments when planted in a drier climate. Moving cultivars from west to east may result in more problems with rust since plant

A word about local ecotypes

In recent years, many native grass seed growers have developed local ecotypes, plant material collected from a specific, local ecological area and adapted to those conditions. There can be a great deal of variability in these local ecotypes because they have been through either a limited selection process or none at all. Therefore, how they will perform in any given situation is something that must be determined on a case-by-case basis. Regardless, local ecotypes based on genetic material from east of the Plains can be a good choice for sites in the eastern U.S.

Cultivar trials conducted in Tennessee and Kentucky provide yields for commercially available cultivars and ecotypes of big bluestem, indiangrass, eastern gamagrass and switchgrass (Table 6.2). Most of the cultivars (15 of 21) included in these trials are from sources in the Great Plains. This is because the number of cultivars based on eastern populations is limited. On the other hand, eight eastern ecotypes were included in these trials. Yields vary a good bit among entries, but generally ranged from 3.5 to about 5.3 tons per acre for big bluestem and indiangrass (mean of 4.2 for both species across both trials) with eastern gamagrass and especially switchgrass producing the greatest overall yields. Eastern origin entries generally out-produced those from the western sources at these two eastern U.S. research locations.

material from drier environments has less resistance to this pathogen. It is also important to remember that most released cultivars have had some selection from wild material, but little or no actual plant breeding. As such, most native grass plant material remains largely undomesticated and, therefore, has a wide range of genetic variability[5].

Table 6.2. Yield (dry matter basis) for native grass cultivars based on trials in Kentucky and Tennessee. All yields based on either one or two annual harvests and 60 units N at green-up annually.

Trial location	Species	Cultivar/ecotype	Origin	Yield (DM T/ac)
Tennessee[1]	Big bluestem	Mammoth	ecotype (KY)	5.31
		Karst	ecotype (KY)	5.27
		OZ 70	southern MO/northern AR/ eastern OK/southern IL	4.77
		Kaw	KS Flinthills	4.51
		Prairie View	ecotype (IN)	4.38
		Rountree	west central IA	4.35
		Earl	central TX	3.76
	Indiangrass	Prairie View	ecotype (IN)	4.26
		Boone	ecotype (KY)	3.76
		Americus	GA/AL	3.71
		VA Ecotype	ecotype (VA)	3.52
		Rumsey	southern IL	3.49
		Osage	east central KS/OK	3.21
Kentucky[2]	Big bluestem	Wapiti	ecotype (KY)	4.24
		Pawnee	southeastern NE	3.90
		Kaw	KS Flinthills	3.56
		Rountree	west central IA	3.15
	Indiangrass	Cheyenne	western OK	5.89
		Rumsey	southern IL	5.30
		Nebraska 54	southeastern NE	4.33
		Osage	east central KS/OK	4.32
		Big Barren	ecotype (KY)	3.80
	Eastern gamagrass	Highlander	KY/TN	5.54
		PMK-24 ('Pete')	KS/OK	4.69
		Iuka	central and western OK	3.69
		Jackson	southern TX	3.58
	Switchgrass	Cave-in-Rock	southern IL (upland)	6.20
		Alamo	southern TX (lowland)	6.01
		Trailblazer	NE/KS, improved lowland variety	3.74

[1] trials conducted over four years (2015-2018), Knoxville, Tennessee.

[2] trials conducted over eight years (2002-2009), Lexington, Kentucky.

Matching the grass to production goals

Site adaptation and regional differences aside, the other major consideration in selecting native grasses to plant is the intended use of that forage (Table 6.1). Where high rates of gain are the objective, big bluestem, indiangrass and little bluestem should be selected. These three species work well in blends with one another and can be managed similarly. Where high carrying capacity is a priority, lowland switchgrass and eastern gamagrass are preferable. Upland switchgrass can have relatively high carrying capacity but is less than that of the lowland types. Because most upland switchgrass cultivars do not have an advantage for carrying capacity compared to either big bluestem or indiangrass, and the switchgrass produces lower rates of gain, in most circumstances one of those species should be selected in preference to the upland switchgrass. Furthermore, upland switchgrass may not have the stand life of either the lowland types or big bluestem and indiangrass. For enhanced drought resiliency, all of the native grasses will provide substantial improvement over cool-season forages. However, among the native grasses, eastern gamagrass and especially lowland switchgrass will have the greatest ability to continue to produce forage during dry periods.

With respect to hay production, the problem with saponins in switchgrass (see Chapter 1) makes it a poor choice where hay may be fed to horses, goats or sheep. When harvested in the boot stage, switchgrass makes good quality hay for cattle, but by the time it reaches the early seedhead stage, quality will have declined a good deal making timely harvest of this species particularly important. Eastern gamagrass, although it produces large volumes of good quality hay, creates rough field conditions as the stand ages and the plants mature forming large root crowns (Figure 6.9). If you are considering it for a hay crop, you need to be aware of this issue and take it into consideration when making your decision. Thus, for dedicated hay production, either big bluestem, indiangrass or a combination of the two will be the best choice in most circumstances.

Figure 6.9. Gamagrass grows in large bunches as seen here. The crowns that develop at the base of these plants results in rough field conditions requiring reduced equipment speeds during hay harvest operations.

PRE-PLANTING COMPETITION CONTROL

Given that **weed competition is easily the most significant cause of failed native grass planting**, planning ahead to address competition is critical. Of special importance are perennial grasses. Most of these grasses will not be easily eradicated with a single treatment, herbicide or tillage, immediately prior to planting. Cool-season perennials, warm-season perennials and glyphosate-tolerant biotypes all present challenges that must be addressed well before actual planting (Figure 6.10). Of course, the easiest way to deal with this problem is to choose sites, as described above, where such perennials are not present. However, with degraded pastures and hayfields, these competitors are unavoidable. Relict populations of species such as tall fescue, orchardgrass, dallisgrass and bermudagrass can be common and must be controlled. One very common—and usually fatal—mistake is to make a single herbicide application to a degraded pasture and then immediately plant. **A single spring treatment of perennials is not an effective means of control of these species**. You must be prepared for 2-3 cycles of weed control to ensure control of perennials and produce a high quality seedbed.

Figure 6.10. Herbicide-tolerant weeds such as the marestail seen in this picture can become serious pests when trying to establish native grasses following crop production. Note the numerous big bluestem seedlings competing with the marestail. By a well-timed clipping and a subsequent treatment of the marestail with a broadleaf herbicide, a strong stand developed in this field.

Fighting the seedbank

Where degraded sods occur, it is also critical to recognize that they are suppressing an abundant weed seedbank. Once the sod is killed, the weed seedbank is released and there will be an explosion of about every kind of pasture weed you can think of—and a few you cannot (Figure

Figure 6.11. A wide variety of weeds, broadleaf and grassy, developed into an almost complete cover of this field following the initial termination of the existing sod. Where weed seedbanks have developed over many years in pasture settings, this response can be all too common.

6.11). So even if the sod were to be effectively killed with the first application of herbicide, there will be a tremendous amount of brand new weed competition that must be dealt with if establishment has any chance of success. Thus, you must allow enough time between the first spray and the intended planting date (see Planting Timing, Chapter 7) for a second treatment. This has the additional advantages of controlling plants still alive after the first treatment, as well as any newly emerged seedlings, and treating any skips within the field.

Start early

The most reliable way to control cool-season perennial grasses is to begin the treatment cycle the fall before you plan to plant. Cool-season perennials are much more easily controlled in fall than they are in the spring. The ideal time to spray cool-season perennials is 2-3 weeks before fall dormancy, a time when the plants are translocating nutrients and carbohydrates into their roots for winter. The same principle applies to warm-season perennials, the only difference being that the timing of fall dormancy is several weeks earlier than what it is for the cool-season grasses (Table 6.3). For example, johnsongrass can be sprayed with 2 quarts per acre of glyphosate (1-pound active ingredient per quart formulation) in May and only stress the plants whereas in September that same amount will kill the plant. Fall treatments have two other advantages over those implemented during the spring. First, once fall treatments have been implemented, there is a several month window prior to planting during which you can conduct follow-up weed control, either for skips or newly germinating weed seedlings. Second, fall treatments allow more time for suppressed weed seedbanks to express themselves and for you to address weed populations arising from these seedbanks.

One caution in controlling competition in fields that are presumed to be dominated by cool-season grasses is to be sure that if warm-season species occur in the sward, treatment timing and application rates are adjusted to account for these species. It is not uncommon to have dallisgrass, knotroot foxtail, johnsongrass or bermudagrass become prevalent

Table 6.3. Suggested steps for pre-planting weed control when establishing native grass forages. These are general guidelines. Adjustments to these guidelines including recommended dates for treatments must be made based on conditions for each field. Note that all weed control in this table is based on spraying. Where conventional tillage is preferred, simply substitute appropriate tillage steps for spraying using the same time frame.

		Pre-plant year			Planting Year	
Species to be controlled	**Option**	**Spring**	**Summer**	**Fall**	**Spring**	**Summer**
Perennials						
Cool-season	1	spray, early April; repeat 4-6 weeks later	plant summer annual "smother crop"	spray, Sept./ early Oct.; plant winter annual[1] if desired	graze, harvest or terminate winter annual[2]; spray regrowth, escapes, new weed seedlings	if dormant-season planting, seed Feb. 1-March 15; otherwise as soon after spraying as practical, April 15-July 1
	2			spray, Sept./ early Oct.; plant winter annual if desired		
	3				spray, early April repeat 4-6 weeks later	
Warm-season			spray, early Aug.; repeat 4-6 weeks later	plant winter annual if desired	graze, harvest or terminate winter annual	spray[3] regrowth, escapes, new weed seedlings; plant as soon after spraying as practical, May 15-July 1
Annuals						
Cool-season					will be controlled when treating cool-season perennials	plant as soon after spraying as practical, April 15-July 1
					If dormant-season planting, treat **before** emergence of native grass seedlings (before April 1)	
Warm-season					spray, following initial pulse of summer annual germination; repeat 3-5 weeks later	plant as soon after spraying as practical, May 15-July 1

[1] Winter annuals should be used in this order of preference: cereal rye, tritcale, wheat. Do not use annual ryegrass.

[2] Biomass of winter annuals must be reduced before spraying and/or planting to avoid large volumes of thatch that can preclude successful establishment.

[3] Control of warm-season species will not be possible until they have broken dormancy and are actively growing, typically not until sometime in May.

Spray-smother-spray

One approach that has often been used for pasture conversions is "spray-smother-spray". As the name suggests, the process typically involves an initial treatment to kill the existing, degraded sod. The next step is to plant an annual at a high seeding rate. The goal is a dense stand that not only provides forage and protection from soil erosion but also suppresses further recruitment of weeds. The third step comes after the annual is played out and involves a second spray treatment. Planting of the native grasses would take place following the second spray treatment. If the approach was initiated in fall for spring planted native grasses, the annual would be cereal rye, wheat or triticale. Alternatively, where there is considerable presence of warm-season competitors that must be controlled, the cycle should start in spring and include two annual plantings, one in summer (sorghum × sudangrass hybrids, pearl millet, other millets) and then a second one (rye, triticale, wheat) in the fall. In this situation, there would be three sprays: first spring, following the summer annual/preceding the winter annual and following the winter annual/preceding planting. Where avoidance of herbicide use is a goal, this same approach can be used with rounds of tillage replacing the spray steps.

in tall fescue fields. Failing to account for these species in the weed control program can lead to expansion of their populations and failed plantings. Thus, where these and other warm-season weeds occur in fields otherwise dominated by cool-season species, you must treat the field as if it were a warm-season grass field — as well as one with cool-season species.

All of the foregoing presumes that a non-selective herbicide such as glyphosate is being used to control existing sods. However, producers who want to avoid or minimize herbicide use can accomplish these same goals with tillage. The problem though, is that a single pass with a disc, even one that is very aggressive, will not kill perennial grasses or other perennial weeds. Therefore, you will need to plan for multiple passes with an aggressive (i.e., off-set) disc over an extended period (i.e., during fall and again the following spring), perhaps even over two years. Alternatively, you can use deep tillage such as plowing. Additional information on no-till and conventional seedbeds is provided in Chapter 7.

Where herbicides are used, you need to be aware of potential for residual soil activity with some products. Glyphosate is not soil active and can be used at any point up to and soon after planting. Broadleaf formulations, which will be necessary if glyphosate-resistant biotypes are present, can have residual soil activity (Table 6.4). Including an appropriate broadleaf formulation can be best handled in a tank mix with a non-selective herbicide such as glyphosate. A grass-selective herbicide may be needed for resistant grass species such as goosegrass. Keep in mind that broadleaf weeds, as was mentioned regarding grasses, are either cool- or warm-season and must be treated while actively growing. Products that include the active ingredient imazapic are an excellent tool for the bluestems and indiangrass but not switchgrass or eastern gamagrass. Sideoats grama is also tolerant of imazapic but only at lower rates (i.e., less than 8 oz per acre).

Table 6.4. Herbicides useful during establishment of native grasses. Adapted from Keyser et al., 2019 (UT Extension Publication PB 1873).

Herbicide	Active Ingredient	Rate per acre	Timing Restrictions	Interval prior to planting	Weeds Controlled[1]
2,4-D Amine 4L	2,4-D Amine	1-1.5 pts	beyond 4-leaf stage	2 weeks	BL
Cimarron Plus	metsulfuron methyl + chlorsulfuron	0.6-1.5 oz.	beyond 4-leaf stage	1 week	BL
DuraCor	aminopyralid and florpyrauxifen-benzyl	12-20 oz.	tillering[2]	45 days	BL
GrazonNext HL	aminopyralid+ 2,4-D	1.5-2.6 pts	tillering[2]	4 months	BL
Milestone	aminopyralid	4-7 oz.	tillering[2]	4 months	BL
PastureGard	triclopyr+fluroxypr	2-3 pts	tillering[2]	3 weeks	BL
Crossbow	triclopyr + 2,4-D	2-4 quarts	tillering[2]	3 weeks	BL
Select 2SE	clethodim	8-16 oz.	PRE only	none	G
Plateau, Impose, or Panoramic	imazapic[3]	2-12 oz.	PRE, Established	none	G, *BL*
Outrider	sulfosulfuron	0.75-2.0 oz.	well-established	2 weeks	G, *BL*
Accent 75DF[4]	nicosulfuron	0.67 oz.	beyond 2-leaf stage	not applicable	G

Note: Check label to ensure it is recommended for the species of native grass(es) in the planting.

[1] BL=broadleaf, G=grass. If italicized, control is very selective or marginal.

[2] Only apply on vigorous seedlings, those that have developed multiple tillers.

[3] Will cause severe injury or death of switchgrass seedlings and stunting for mature plants of this species.

[4] Labeled only for switchgrass grown for biofuels in Tennessee.

Achieving a successful burndown with herbicides requires accurate rates and appropriate timing—weeds must be actively growing and should not be under stress. One exception to this are soil-applied herbicides (see Chapter 8, section on imazapic). It is also important to have a complete and consistent spray pattern. Boomless sprayers usually produce a streaked application pattern leaving as much as half the vegetation untreated (Figure 6.12). Any use of herbicides must follow label instructions for your state and care must be taken to avoid volatilization and drift to non-target crops.

Figure 6.12. Boomless sprayers leave a streaked application pattern as seen here. Application of an imazapic product provided good weed control directly behind the sprayer, but between passes, control was very poor and led to a very weak stand within those skips.

Controlling bermudagrass before planting

As mentioned above, bermudagrass-dominated fields are among the most challenging sites for establishing native grasses. Because bermudagrass cannot be readily controlled once the native grasses have been established, it is critical to have complete control prior to planting. If you decide to plant native grasses on such sites, plan to spray with 4 quarts per acre (for 1-pound active ingredient per quart formulations) glyphosate, during mid-summer. Follow-up treatments should be applied (at the same rate) if there are any surviving plants or new ones emerge prior to fall dormancy. A final treatment should be applied the following spring preceding planting but not until it is warm enough for bermudagrass to have begun active growth, typically in mid-May. Thus, a total of three treatments may be necessary. And, because of the dense sod that bermudagrass can develop, be prepared to disc the killed sod before attempting to drill.

SUMMARY

The first—and likely most critical—step for successful establishment of native grass forages is to plan ahead. Selection of an appropriate site, preferably one that minimizes gaps in forage production while maximizing the improvement in your overall forage program is a great starting place. However, it is also important to consider past management history and weed pressure. Sites with limited weed seedbanks should be high priorities for planting native grasses. On the other hand, avoid sites with bermudagrass or high levels of annual grasses. Once the site has been selected, start an aggressive competition control program well ahead of your intended planting date. Among the factors that you as a grower can control, there is no more common cause of failed plantings than poor competition control. Do **not** cut corners here. Such saved steps and/or time are a false economy and will greatly increase the likelihood of a failed planting.

CHAPTER SEVEN
Planting Native Grasses

Once you have made a good plan, and attended to thorough pre-planting competition control, you must pay attention to good agronomic practices. As you will see, these are all very basic and apply to the establishment of any perennial forage. Among these are proper fertilization, seedbed preparation, selection of planting equipment and proper seeding rates. In the case of native grasses though, consideration must also be given to potentially dormant seed. Each of these issues is addressed in the sections below.

FERTILIZATION DURING THE SEEDLING YEAR

Because native grasses have very low requirements for P and K (see Chapter 1 and Chapter 12) and tolerate low pH conditions very well, you will likely not have to amend the soil for establishment. As a rule of thumb, amend P and K if soils test in the low category. Application rates can be per soil test recommendation, but remember that soil available P and K only need to be in the medium category for native grass establishment. Despite the fact that there is a low demand for P for established native grasses, there have been studies linking seedling development to availability of P, so it is important to soil test and address where P is deficient. With respect to pH, lime only needs to be applied as needed to achieve a pH of 5.0. In fact, that may not even be necessary. A study of switchgrass seedling growth revealed no difference between those grown at a pH as low as 4.4 versus those grown near 7.0[9]! Similarly, a study on eastern gamagrass seedlings found no response to liming that raised pH from 3.5 to 4.8 for seedling root growth[7]. Regardless, the value of greater pH in making soil P and K more available to plants makes the 5.0 pH recommendation appropriate overall. It is also worth stressing that having higher pH (those well above 5.0) is fine for native grass establishment.

Because of the small size of the seedlings and their inherently low demand for N, it is not necessary to provide any supplemental N during the establishment year (Figure 7.1). In fact, planting into low-N environments is preferable. One factor researchers have uncovered that may explain the ability of seedlings to thrive without supplemental N is relationships with N-fixing microbes within the rhizosphere[2, 4, 13]. Regardless, where soil-N levels increase, weed pressure will be proportionally greater. In very clean, weed-free seedling stands, N can increase growth of native grass seedlings[13], but that benefit has not been shown to translate into better stands by year two. Given the risk of increased weed competition, **application of any N is not recommended** during the establishment year.

Figure 7.1. The small size of these native grass seedlings demonstrates why no nitrogen is needed during the establishment year. The seedlings are small and slow to develop during their first three weeks following germination and, therefore, their nitrogen demand is minimal.

NO-TILL VERSUS CONVENTIONAL SEEDBEDS

As suggested in the previous chapter, planting native grasses with either conventional or no-till approaches can be successful. In either case, **what is more important than the technique being used is having a high-quality seedbed, one that is clean (no weeds and limited thatch on the soil surface), fine-textured and firm** (Figure 7.2). Thus, a poor-quality conventional seedbed will always be worse than a high-quality one produced by no-till — and vice versa. The choice of which approach to use should be based on the field in question and producer priorities. Where soil erosion is a threat, on fields with emergent rock, rock near the soil surface or other factors that preclude tillage, no-till is preferable. Advantages of no-till include improved conservation of soil moisture and organic matter and seedbeds that are inherently fine-textured and firm due to the undisturbed soil. On the other hand, if avoidance of herbicides is a concern or the field to be planted is rough and needs to be smoothed, conventional tillage will be a better option.

It is also worth noting that some combination of tillage and herbicides could be used. For instance, a conventional seedbed could be treated once with a light rate of herbicide prior to planting to control

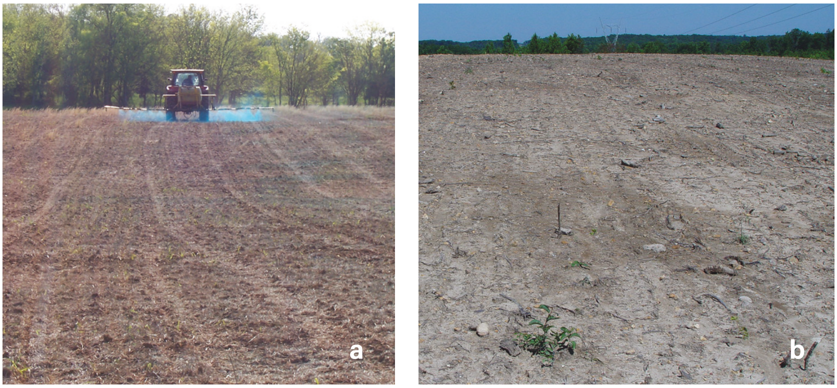


Figure 7.2. Native grasses can be successfully planted using either no-till (a) or conventional seedbeds (b). In either case, the key is to ensure you have a high-quality seedbed that is weed free, fine textured and firm.

the final flush of weed seedlings. This has the advantage of eliminating this weed crop without again disturbing the seedbed and releasing additional weeds. Conversely, difficult to control sod-forming grasses could be sprayed and, if the field is rough, a round of tillage could then follow. In the case of bermudagrass, some tillage will be necessary to ensure proper drill operation through dense sod (see Figure 6.8). The preceding section on pre-planting competition control provided much of the needed information on each of these approaches, but some additional details are described here for both practices.

With either method of planting, the pre-planting competition control previously described is essential to success. At the time of seeding, any remaining weeds from preceding treatments or newly emerged weed seedlings should be destroyed (Figure 7.3). This can be especially critical with annual warm-season grasses (also, see section below, Planting Timing). Keep in mind that even very small weed seedlings at this point have a 3-4 week advantage over the slow germinating native grasses.

Figure 7.3. This high-quality conventional seedbed has a new crop of emerging weeds. Although they are still quite small, they have a head start of several weeks over the native grasses and must be destroyed if the native grass seedlings are to compete successfully. Either a light discing or an application of herbicide can easily remove this problem and enable the native grass seedlings to be far more competitive.

Furthermore, once native grasses have started germinating, there remains a period of several weeks during which weed control options are very limited. Thus, seedbed quality must be good enough to provide as long a weed-free window as possible, at least six or more weeks.

An important consideration **when using no-till is to ensure that thatch is reduced enough to allow for germination and early development of seedlings**. Depending on the field history, considerable thatch may have accumulated (Figure 7.4). Although precise depths of thatch that will result in failed plantings have not been determined, preliminary results from an ongoing study in Ohio suggest that

Figure 7.4. The thatch here (a) is the result of spraying a heavy growth of bermudagrass and tall fescue. It is dense enough (when pressed down by hand, about 2 inches to mineral soil) that it will prevent any native grass seedlings from germinating. The problem can be solved through either tillage or, as was done here, a prescribed burn. Alternatively, removal of excess material through hay harvest or grazing prior to spraying is also effective. The heavy thatch (b) left behind after termination of a winter annual cover crop interfered with effective seed placement and precluded successful germination and growth of the seedlings; the planting failed. Limited thatch (c) is not an issue and will not impact seeding success. Credit (a), K. Rose.

at depths above 1/2 inch, the impact could be substantial (Figure 7.5). Ideally, thatch should be less than that, perhaps 1/4 inch or less. Thus, before spray treatments, it will be beneficial to hay, graze or burn fields to reduce the potential for heavy thatch. Such practices can also be very important for ensuring effective herbicide application by allowing for cleaner spray surfaces, less mature and more rapidly growing plants (more vulnerable to herbicides) and adequate leaf-surface area (also important for effective herbicide uptake) of target weeds Figure 7.6).

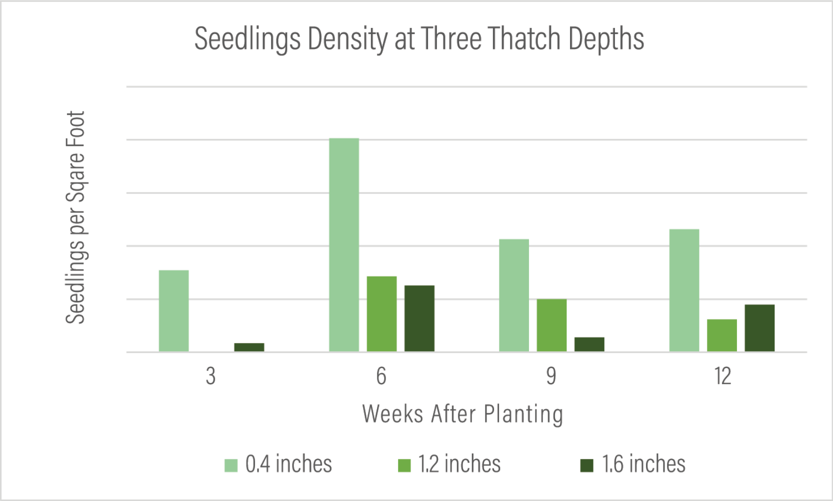


Figure 7.5. A recent experiment conducted at Greenacres Foundation in southern Ohio demonstrated that heavy thatch is very detrimental to seedling emergence and recruitment. Native grass seedlings will not germinate well in the absence of light and cannot grow through dense thatch any more than they can when they are planted too deeply in the soil. K. Swilling, unpublished data, University of Tennessee.

Figure 7.6. The dense growth of annual grasses seen here is at a good stage for spraying. There is no canopy of taller weeds to interfere with application and spray reaching the target plants. Furthermore, these grasses are growing vigorously and are still at an early stage of maturity.

For conventional seedbeds, the repeated **tillage must ultimately result in a fine-textured seedbed** such as would be used to plant crabgrass, seeded bermudagrass or alfalfa (Figure 7.7). Rough, cloddy or coarse-textured seedbeds will give unsatisfactory results due to poor seed-soil contact. Loose seedbeds can result in seed that is planted too deeply. Use of a cultipacker following tillage may be needed to ensure a firm seedbed. A good rule of thumb is that the imprint of your boot should not make an impression deeper than 1/4 inch (Figure 7.8). Tillage will, of course, eliminate any issues with thatch.

Figure 7.7. Conventional seedbeds for native grasses must not be coarse textured (a). Such seedbeds provide very poor seed-soil contact and are prone to having seed placement that is too deep. Instead, seedbeds must be fine textured (b) to provide excellent seed-soil contact and prevent planting seed too deeply. Credit, J. Raines.

Figure 7.8. In addition to being fine-textured, conventional seedbeds for native grasses must be firm. A good rule of thumb is that a boot print should not make an impression deeper than about 1/4 inch. Credit, D. Hancock.

PLANTING EQUIPMENT

Native grasses can be planted using a variety of equipment, although the choice will be constrained by the type of seedbed that has been prepared, conventional or no-till. For no-till it will be necessary to use a no-till drill. For conventional seedbeds, no-till or conventional drills can be used. However, in the case of the no-till drill, which is designed to cut through sods, some adjustment may be needed to ensure the drill settings are not so aggressive as to plant the seed too deeply. On conventional seedbeds, drop-type seeders such as a Brillion also work very well. A pendulum- or cyclone-type seeder is also an option, but for sowing, some additional consideration must be given to good seed distribution and placement. Increased seeding rates (see section below on seeding rates, also Table 7.1), sowing seed using two passes, perpendicular to one another and covering sown seed with a cultipacker will all contribute to more successful stands. Simply leaving seed on the soil surface is NOT a good practice. Such seed may not germinate due to a lack of moisture, may be killed by high soil-surface temperatures prior to germinating, and seed that does germinate will be at a substantial disadvantage for early root formation.

With any of this equipment an important consideration is how clean the seed lot is that you are planning to plant. Most native grasses produce seeds with long awns that result in fluffy or chaffy seed lots (Figure 7.9). While the native grass seed industry has gone to great lengths to produce clean, debearded seed, there is a trade-off in seed viability and how many times a lot passes through the seed cleaners. Each pass through the cleaners has the potential to damage the protective outer layer of the seed and thereby reduce its viability. Regardless, many seed vendors can provide clean, high quality native grass seed. Keep in mind though, even clean native grass seed will not be as clean as what is typical for species such as orchardgrass, tall fescue or annual grasses.

Clean, debearded native grass seed can pass through almost any drill. For drills that have larger cups, tubes and tubes that are not designed

Figure 7.9. Big bluestem seed shown here is similar to that of indiangrass and little bluestem in that they all have long awns that can make the seed difficult to pass through many drills (a). A typical, well cleaned seed lot of mixed bluestems and indiangrass (b). This lot may pass through many conventional boxes, depending on drill configuration. Credit (a), L. Dillard.

with a bend (have a straight drop to the ground from the seed box), passage of seed that is still somewhat chaffy will normally not be an issue. With smaller cups and tubes or with tubes that do not have a straight drop, movement of seed could be more difficult with seed lots that are not as clean (Figure 7.10). For seed lots that are chaffy, the best alternative is to use a drill equipped with a native grass or "chaffy seed" box. These boxes have larger cups, wide tubes and are equipped with more aggressive agitators designed especially to create proper flow of fluffy seed (Figure 7.11). With drop-type spreaders, because of the lack of tubes, chaffy seed is rarely a problem except that bridging may occur if there is no agitator. With cyclone seeders, proper seed flow can be an issue. In such cases, use of various carriers such as pelletized lime (at a rate of approximately 200 lbs. per acre) has proven successful.

Two of the native grasses we are considering here do not have chaffy seed, switchgrass and eastern gamagrass. For switchgrass, which has a very small (250,000-400,000 per pound, depending on cultivar), smooth seed (Figure 7.12) that flows easily, the small (legume) box on any drill will work. Drop and cyclone seeders will also work well. For eastern gamagrass

Figure 7.10. The large seed cups and straight drop tubes on the Truax (a), Tye (b) and Haybuster (c) drills shown here all allow for easy passage of native grass seed. Credit (c), K. Goddard.

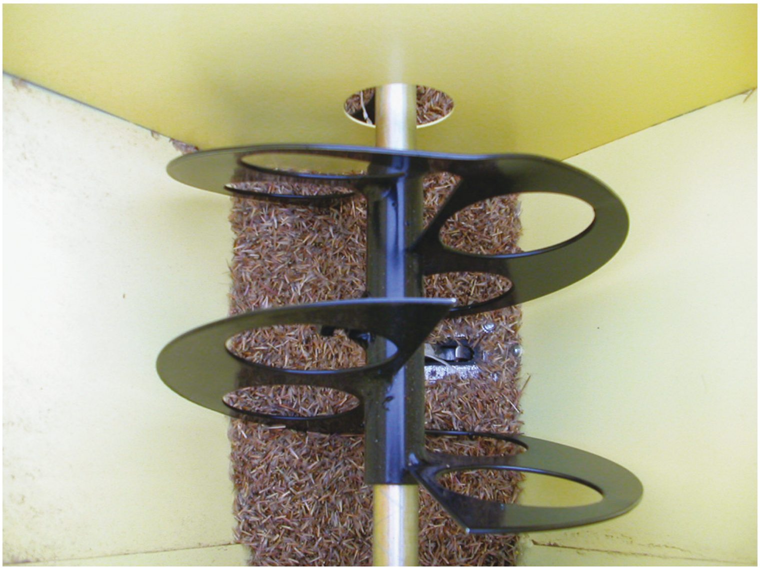


Figure 7.11. The specialized chaffy seed or "native grass" boxes on many drills include large agitators such as those on the Truax drill shown here. These agitators keep the chaffy seed from bridging and maintain an even flow through the box and cups below. Credit, D. Hancock.

seed, which is much larger than those of the other native grasses (3,000-7,500 per pound, depending on cultivar), a common method has been the use of corn planters (Figure 7.12). Older plate-style planters work well, and newer vacuum type planters can also work, but may be more challenging due to the irregular size of the seed. However, drills can also work well for eastern gamagrass. Because of target seeding densities and associated row spacing though, it will be desirable to block every other or even two of three tubes when using a drill to plant this species (see seeding rate section below). Drop seeders and sowing should not be used with eastern gamagrass as target seeding depth is greater for this species than with other native grasses (see section below on seeding depths).

Figure 7.12. Switchgrass seed (a) is quite small and has no issues flowing through any drill. The legume or small seed box on a drill must be used when planting this species. The unique seed of eastern gamagrass (b) is much larger than that of the other native grasses and does not have awns. It can be planted with the standard box on a drill (but with half or even two-thirds of the drills closed to increase row spacing to 15 or 22.5 inches, respectively) or through a corn planter. Credit (a), K. Goddard.

PLANTING TIMING

Traditionally, most native grass stands have been established during spring. Native grasses require soil temperatures above 60 F before meaningful germination will begin and they do not germinate in large numbers until soil temperatures reach 65 F[10]. Optimum germination rates are achieved between 77 and 88 F[29, 31]. Thus, planting dates should occur when soil temperatures are about 65 F, which will normally correspond to late April in the Mid-South but vary by up to three weeks depending on latitude.

Later plantings are possible, even up until early July, but risk of drought increases and time for germination and seedling development prior to fall dormancy decreases with these later dates. Studies have shown that earlier plantings, those in April, allow for considerably greater development of seedlings by fall dormancy[11]. If a high-quality seedbed has been prepared and competition adequately controlled, later plantings, those in late June or early July, can be conducted but should only be done where soil moisture is good and weather patterns favor a reasonable expectation of continued rain. If drought conditions exist or appear to be developing, late planting should be deferred until the following year.

Dormant-season planting

Dormant-season plantings are also an option. During studies conducted in Tennessee, March seedings proved to be more reliable than those conducted at more traditional times (i.e., May)[14]. In these studies, there was no benefit from increased seeding rates to accommodate the dormant planting. Apparently, there was little loss of viable seed over winter. Furthermore, seed lots with high and low dormancy rates had similar establishment outcomes. Another aspect of the research conducted on dormant-season planting was assessing possible problems with planting behind various winter annuals. Cereal rye, wheat, barley and oats all have some form of allelopathic properties. These compounds are released into the soil and inhibit growth of competitors, a natural herbicide. Because of the presence of these allelopathic compounds, the question arose, "Is it possible to plant native grasses following (or even in) stands of these annuals?" The good news is that we saw absolutely no difference in seedling density for stands planted in a fallow control versus these four annuals (Figure 7.13). And that pattern

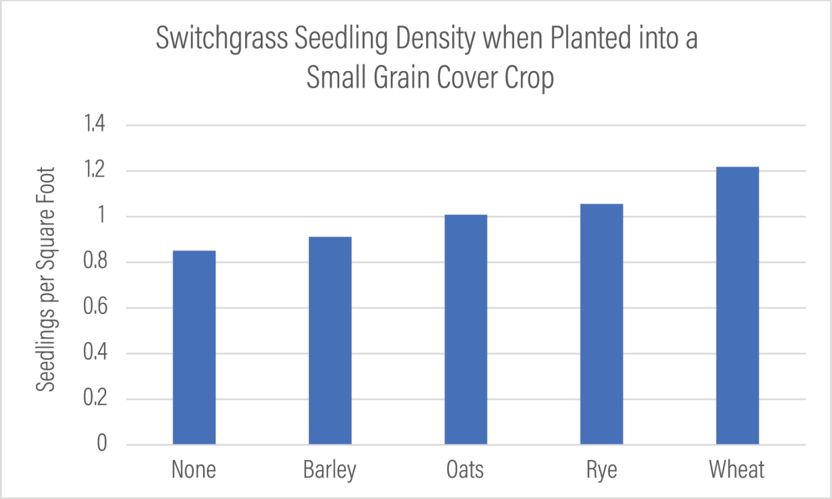


Figure 7.13. Switchgrass seedling density when planted into small grain cover crops. There was no statistical difference in density among these four cover crops and a fallow control, plots that had no cover crop. Adapted from Keyser et al., 2016. Crop Science 56:2062-2071.

Dealing with annual warm-season grass competition

Aside from adequate control of existing perennial grasses, the next biggest challenge in terms of weed competition for native grass seedlings comes from annual summer grasses. Crabgrass, broadleaf signalgrass, goosegrass and foxtails along with seedlings of perennials such as johnsongrass, have caused many stand failures (Figure 7.14). Treatments implemented prior to emergence of these annuals will not preclude germination of an additional crop of these species. Therefore, timing of planting must take into account the potential competition from these species. There are two basic strategies for dealing with annual grasses: get ahead of them or get behind them.

Getting ahead of them requires either dormant-season or early spring planting. In both cases, given adequate soil moisture, native grass seedlings will have an opportunity to get ahead of the pressure from these annuals. Normally, it takes about 21 days for native grasses to germinate, even with adequate soil temperatures. The typical gap between attaining the soil temperatures required for native grass germination and those for summer annuals is, you guessed it — 21 days! So, if you do not get ahead of the summer annuals with an early germination, such as the two-week advantage provided by dormant-season planting, the native grasses will end up germinating into the brunt of the competition from the annuals.

The other alternative, getting behind the summer annuals, means to delay planting until after their initial flush. Once they have emerged, the summer annuals can be easily killed with either a light rate of herbicide or light tillage. One challenge with tillage at this point though is that it may bring up another crop of annual weeds. One strategy that has been used successfully to establish switchgrass is to do precisely that — keep a cycle of periodic tillage going (perhaps as many as three passes) to deplete the seedbank of summer annuals. This will push planting back to mid- or late June, so having inadequate soil moisture becomes a greater risk when using this approach. Regardless, planting after the initial crop of annuals has been destroyed will increase your success. This approach is common with organic vegetable production where the goal is to produce a "stale" seedbed. The difference is that vegetable producers often have irrigation so soil moisture in late June is not an issue.

With the bluestems and indiangrass, as well as sideoats grama, a great alternative, one that increases your flexibility in timing the planting, is the use of the herbicide imazapic. See section in Chapter 8 on imazapic for further details on this herbicide.

Figure 7.14. Two switchgrass seedlings, one in each hand, are being outcompeted by a rank growth of johnsongrass and crabgrass. Such competition from summer grasses can be severe for native grass plantings. In this case, the switchgrass seedlings were lost. More timely control of the summer annuals through clipping or grazing would have saved the stand.

held up whether the switchgrass was planted into still growing annuals (March and April) or whether the annuals had been terminated (April) or harvested at maturity (June)[15].

Part of the explanation for the greater reliability of dormant-season plantings may be reduced seed dormancy through *in situ* stratification following planting. Cold, damp soils that experience natural fluctuations in temperature are ideal for breaking dormancy. However, another benefit of dormant plantings and the associated stratification of the seed is that such seed has a lower temperature threshold for germination, an advantage of approximately 12-15 F. This translates into earlier germination by approximately two full weeks given typical spring warming patterns. Such earlier germination gives native grass seedlings an important competitive advantage with annual warm-season grass competition. In fact, in the same study, plantings in June were also more often successful than those in early May. Likely because these later planting dates allowed more timely control of annual grasses, which tend to germinate at temperature thresholds greater than native grasses, about 76-80 F.

Two key issues must be considered before deciding to plant during the dormant season. First, the same advanced weed control and seed-bed quality will be essential for success at this time of year as any other. Second, you must be prepared to deal with the late winter/early spring flush of cool-season weeds. Even where pre-planting competition control the previous fall has eliminated cool-season perennials, winter annuals will easily follow and, in fact, may even increase in the absence of competition from the perennials. Thus, by the time the native grasses are ready to germinate, there may be a heavy cover of winter annuals that will prevent stand establishment. Therefore, it will be necessary in those cases to spray the winter annuals (a light rate will be fine since these are either annuals or seedlings) before soil temperatures reach the threshold for native grass seedling emergence. This requires sensitive timing as spraying too soon can still leave a window for cool-season annuals to once again dominate the site and spraying too late could kill early germinating native grasses. A two- to three-week buffer prior to expected emergence of native grasses would be ideal.

If you are planting into a winter annual cover crop (e.g., rye, wheat), you must plan to manage that crop so that it does not present problems at planting and for seedling emergence. First, be prepared to terminate the stand, produce haylage or graze the stand to prevent excess thatch from accumulating (see Figure 7.4b). Second, timing for termination, harvest or graze-out must be similar to that described above for controlling winter annual weeds—early April in the Mid-South. Later presence of the winter annual forage crop could inhibit emergence and growth of the native grasses. For this reason, cereal rye, with its earlier maturity date and the opportunity to get the most of the benefit from its planting before emergence of native grasses, is preferable over the other winter annual options. Annual ryegrass, a widely used winter annual in the South, should be avoided because of its later maturity date and its persistence within the field over time. Annual ryegrass is also more difficult to control with glyphosate or with tillage.

One important takeaway on timing of planting native grasses must be emphasized. Given the wide window of possible planting dates—February 1-July 10—**do not rush the planting or lock yourself into a specific timetable dictated by a calendar. Rather, take the time to ensure you have done a good job preparing the high-quality seedbed** that has been emphasized several times in this chapter—clean, fine and firm. If your planting date is off by a week or two from what you had planned, that will not likely make a big difference. Failure to achieve excellent weed control, on the other hand, will certainly make a big difference.

PLANTING RATES, DEPTH AND SEED TREATMENTS

Planting rates recommended for native grass stands that will be fully stocked and be useful for forage production are provided in Table 7.1. Note that for sowing, higher rates are recommended. All rates are based on pure live seed (PLS). For native grasses, this calculation is widely used because it allows for what have traditionally been very chaffy seed lots. Pricing for native grasses is based on PLS so that you are only paying for viable seed and not any other material that may yet be in the seed bag.

Calculating pure live seed (PLS)

Pure Live Seed (PLS) refers to the proportion of a particular seed lot that is viable and germinable seed. It will always be expressed as a percentage and is calculated as follows:

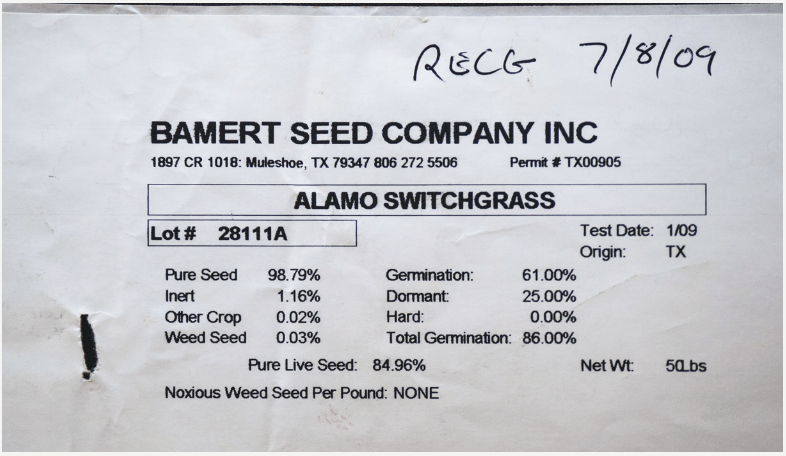
(Germination % x Purity %) x 100 = PLS

A shipping tag or the tag on the bag (Figure 7.15) provides the percent germination and purity. Note the percent germination is made up of two types of seed, that which is ready to germinate immediately ("quick germ") and that which will germinate when stratified ("dormant" or "hard"). Purity is 100 percent minus the sum of the percent inert matter and the percent weed seed. Because native grass seed traditionally could be quite chaffy and/or can naturally be quite high in dormancy, the PLS calculation is very important. PLS rates for most switchgrass seed lots will run in the 80s and 90s, while for bluestems and indiangrass, they will typically range from the 40s to the 80s.

Example calculation based on seed tag shown in Figure 7.15:

- Germination 61.00%
- Hard or dormant seed 25.00%
- Inert matter 1.16%
- Other crop 0.02%
- Weed seed 0.03%
- Total Germination = 61.00 + 25.00 = 86.00%
- Purity = 100 - (1.16 + 0.02 + 0.03) = 98.79%
- 0.8600 x 0.9879 = 0.8496 x 100 = 84.96% PLS

Thus, to plant one acre at the recommended 6 PLS pounds, you would need (6 pounds x 0.8496) 7.1 bulk pounds of the seed from that bag to be planted to achieve the desired seeding rate.


RECG 7/8/09

BAMERT SEED COMPANY INC

1897 CR 1018: Muleshoe, TX 79347 806 272 5506 Permit # TX00905

ALAMO SWITCHGRASS

Lot # 28111A

Test Date: 1/09

Origin: TX

Pure Seed	98.79%	Germination:	61.00%
Inert	1.16%	Dormant:	25.00%
Other Crop	0.02%	Hard:	0.00%
Weed Seed	0.03%	Total Germination:	86.00%

Pure Live Seed: 84.96%

Net Wt: 50Lbs

Noxious Weed Seed Per Pound: NONE

Figure 7.15. Representative seed tag showing information used for calculating pure live seed. Credit, K. Keel-Blackmon.

Table 7.1. Recommended seeding rates (PLS lbs. per acre) for native warm-season grasses for forage production. Adapted from Keyser et al., 2019 (UT Extension Publication PB 1873).

		Pure Stand			Blends (drilled)			
Species	**Approximate seed per pound**	**Drilled**	**Sowed**	**Per sqft[1]**	**Two-way**			**Three-way**
Big bluestem	165,000	9	12	34	6	8	-	6
Little bluestem	255,000	7	10	41	-	1	1	1
Indiangrass	175,000	7	10	28	3	-	6	3
Switchgrass	250,000-400,000	6	8	34-55	nr	nr	nr	nr
Eastern gamagrass	3,000 - 7,500	12	nr[2]	1-2	nr	nr	nr	nr

[1] Number of pure live seed planted per square foot at rate for drilled, pure stands.

[2] nr = not recommended. Blends of either eastern gamagrass or switchgrass with the other three species are not recommended.

It is worth noting that recommended seeding rates result in much greater numbers of seed being planted than what may be necessary for a successful stand. For example, with Alamo switchgrass, target stand densities at the end of the first year are one plant per square foot or 43,000 per acre. However, we recommend planting 6 PLS pounds per acre, which translates into 55 live seed per square foot. Studies have shown that in ideal conditions, productive switchgrass stands can be established with seeding rates as low as 1-2 PLS pounds per acre. So why the higher recommended rates? Simply put, insurance. Given the effort required to create a good seedbed (clean, fine-textured and firm), the time to establish a productive stand and the cost of seed, the buffer in the recommended rates is well worthwhile. Furthermore, conditions in actual practice are rarely ideal!

Because of the small seed size for most native grasses, **they should be seeded at 1/8-1/4 inch deep only**. In fact, when drilling, some seed should still be visible at the soil surface (Figure 7.16). In coarser textured soils (i.e., sandy soils), planting depths can be greater, perhaps up to 1/2 inch deep. However, in heavier textured soils such as the clays common in the Southeast, such depths are not recommended and can result in substantially less seedling recruitment and thus weaker stands.

One key exception to the seeding depths mentioned above is for eastern gamagrass, which has a much larger seed than the other native grasses (about 6,000 seed per pound versus, for example, 165,000 for big bluestem and 175,000 for indiangrass; Figure 7.12). Therefore, the seed has more stored energy and seeding depths should be deeper, about 1-1.5 inches. This depth helps reduce the probability of seed being exposed to drying conditions while still not inhibiting emergence.

It is also important with native grasses, as with most grasses, that seed placement is not too shallow. Seed must be covered with some soil to ensure the seed is situated where it can imbibe moisture from wet/damp soil and to allow the new plant's crown to be placed below the soil surface. If the crown is at the soil surface, appropriate root development will not occur and the new seedling will be much more vulnerable to drought.

Figure 7.16. Like any other small-seeded species, native grasses must be planted at shallow depth, about 1/4 inch deep. When drilling, you should be able to find seed on the soil surface for about 15 percent of the length of any drill furrow. Here, the reddish seed of indiangrass (a) and the much smaller seeds of switchgrass (b) are visible on the surface within the drill furrows.

Seed treatments

Several studies have examined seed treatments to improve germination/emergence rates for native grasses. During the 1980s, several studies showed that an insecticide, when applied at establishment, could improve switchgrass seedling numbers and size [19, 23]. Although the specific mechanism for the improvement was not identified, there have been studies indicating insects can be very serious seed predators [17]. A more recent study examining combinations of insecticides and fungicides also showed improved plant density, vigor and yield [35]. In another study examining use of an insecticide/fungicide combination, seedling counts were improved but results were not consistent among years or locations; there was no impact on yield for treated stands during their second year (P. Keyser, University of Tennessee, unpublished data). Based on these studies, applying a treatment to native grass seed may be warranted but should not be a substitute for the high-quality (clean, fine-textured and firm) seedbed that has already been emphasized.

DORMANCY IN NATIVE GRASS SEED

Because of the basic biology of native warm-season grasses, seed dormancy can be an issue. For these species, seed maturation and shattering occur naturally in late summer through mid-fall. With adequate moisture, some of this seed would germinate during warm autumns. In such situations, the small seedlings produced would not have enough time to develop adequately to survive winter. Therefore, these species have an adaptation to prevent that loss of viable seed — dormancy. Consequently, for native grass seed to germinate, they have to go through a period of stratification, which is what naturally happens each winter to the seed that shattered out the previous fall. Once spring arrives, and acceptable soil temperature (and moisture) conditions are present, the stratified seed can germinate and have all spring and summer to develop strong seedlings that can easily survive winter. While this may help the species persist, it can be a challenge when we attempt to plant these grasses.

While freshly harvested seed of all native grasses can have high dormancy rates, storage over winter generally leads to reduced dormancy by the time of spring planting. As a result, the degree of dormancy at the time of spring planting is normally low for big and little bluestem and indiangrass. On the other hand, for some cultivars of switchgrass, notably Cave-in-Rock and Kanlow, dormancy rates can remain very high, as much as 80 percent. For eastern gamagrass, the situation is even worse — dormancy rates above 90 percent can be common for any of the cultivars. The good news is that there are several strategies to deal with seed lots that have high dormancy rates.

The first step in avoiding issues with seed dormancy is to inquire about it when purchasing native grass seed so you can either request a different lot or **be prepared to deal with it before planting**. Not knowing what the dormancy level is for your seed is not a good way to start a planting project. While there is no particular threshold that requires treatment, dormancy rates above 50 percent are a concern, as they could potentially cut your effective seeding rate by up to one-half. Or, on the other hand, if seeding rates are adjusted upward to offset the high dormancy rate, establishment costs could be increased substantially.

However, be aware that germination rates on native grass seed tags include seed that requires stratification to induce germination. Based on seed industry standards, all the native grass species addressed here (except sideoats grama) are subjected to a 14-day prechill before germination rates are assessed. Thus, a seed lot may be 80 percent PLS but be 70 percent dormant, still viable seed, but requiring a period of cold

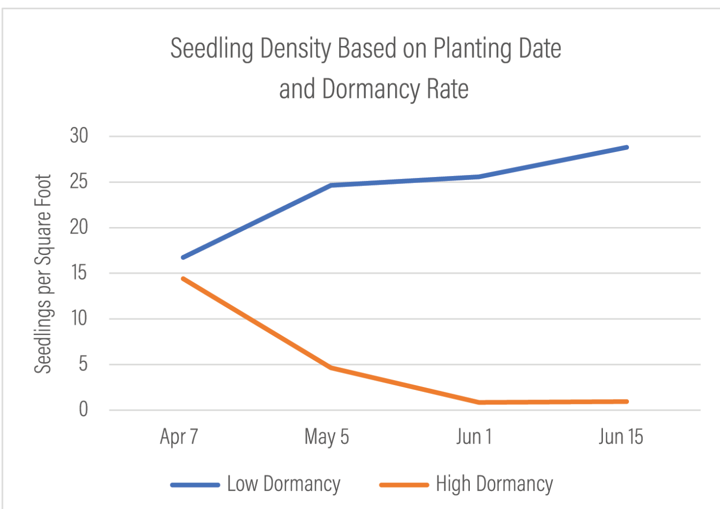


Figure 7.17. An example of planting high dormancy seed (84 percent, in this case) after the opportunity for stratification has passed. Note that once soil warmed in June, very poor stands developed compared to those where high dormancy seed was planted in cool soils. Low dormancy seed (5 percent, in this case) produced good stands regardless of the planting date. With species such as switchgrass, it is important to know the dormancy level of the seed lot you are planting well before you actually plant. Adapted from Sanderson et al., 1996. Bioresource Technology 56:83-93.

and wet to break dormancy. Planting such seed in the spring once soil temperatures have warmed and any chance of stratification is past will result in very poor stands. A study conducted in Virginia in the early 1990s compared a high dormancy seed lot (84 percent dormancy) and one with low dormancy (5 percent) planted at four dates, April 7, May 5, June 1 and June 15[25]. The early April plantings at this high elevation Appalachian study site were into cool, damp soils that stratified the high dormancy seed. In those conditions, both seed lots produced excellent stands. However, as the season progressed and soils warmed, the success of the high dormancy seed dropped such that those at either June planting date failed (Figure 7.17). Later plantings with the low dormancy seed lots produced even better stands than those from April.

Methods for breaking dormancy

Through the years several approaches to breaking dormancy in native grass seed have been developed. Perhaps the easiest is simply storing the seed until the following spring, roughly one year. Dormancy normally drops markedly after such "after-ripening" of the seed (Figure 7.18). If you know ahead of time (and you should) that you plan to plant the next spring, you can purchase the seed in the current year and store it until it is time to plant. Another way to after-ripen seed is to purchase year-old seed from vendors if they have any available.

A second approach, one that is more work for you, is to artificially stratify the seed by placing it in a cold environment such as a cooler (temperature should be 40-45 F) for at least two weeks (three weeks is preferable) following soaking in water for 24 hours. Chilling can be extended for up to six weeks with the advantage that seed will not revert to dormancy after this longer treatment period[30]. Be sure to drain the seed before placing it in the cooler (so it will not mold) and ensure it has dried sufficiently before putting it into the drill (so it will flow properly). Also, once removed from the cooler, it is important to plant the stratified seed within a day or two to avoid premature germination or reversion to dormancy.

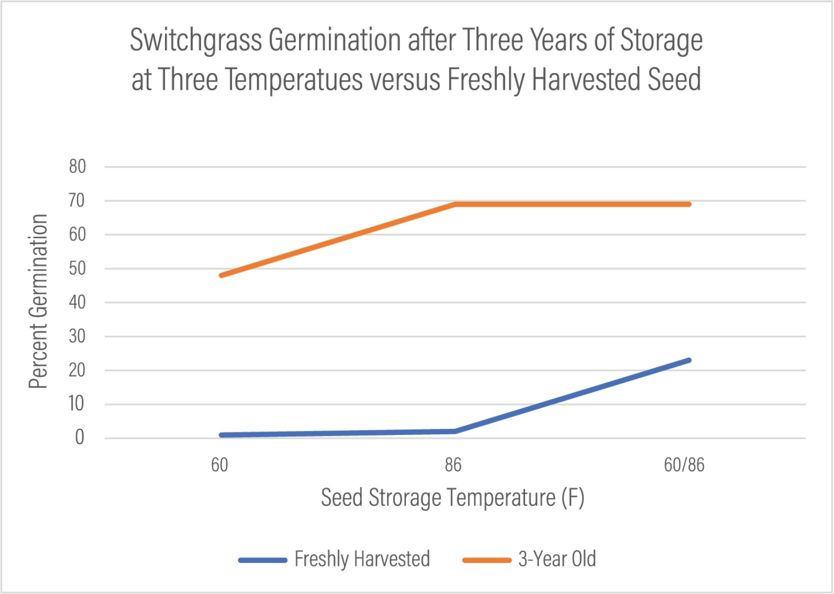


Figure 7.18. In a study that compared freshly harvested switchgrass seed with seed of the same cultivar but that had been stored at one of three temperature regimes, the stored seed proved to have much greater germination rates. This despite being three years old. Adapted from Knapp, A.L. 2000, p. 114.

A third effective strategy for breaking dormancy is planting during winter or early spring (January-March). As described above under Planting Timing, such plantings can be very effective. While any seed lot regardless of dormancy rate can be used for dormant-season plantings, it can be a critical strategy for those with high dormancy rates. For instance, with eastern gamagrass, any date after mid-December and through late March, depending on winter severity in the area where the planting is to take place, can solve the dormancy problem and produce excellent stands (Figure 7.19). A study conducted in Tennessee with switchgrass planted in either December, February, March or May, the dormant-season plantings were normally better than those in May (Figure 7.20). In a second study, switchgrass planted in March generally produced better stands than those planted in May or June (Figure 7.21). Other studies have shown similar success with establishing big bluestem during the dormant season.

Figure 7.19. Eastern gamagrass was planted here on February 9 (a) and an excellent stand developed as seen here (b) in September during its third growing season. Dormant-season plantings work well for this species due to its very high natural dormancy levels.

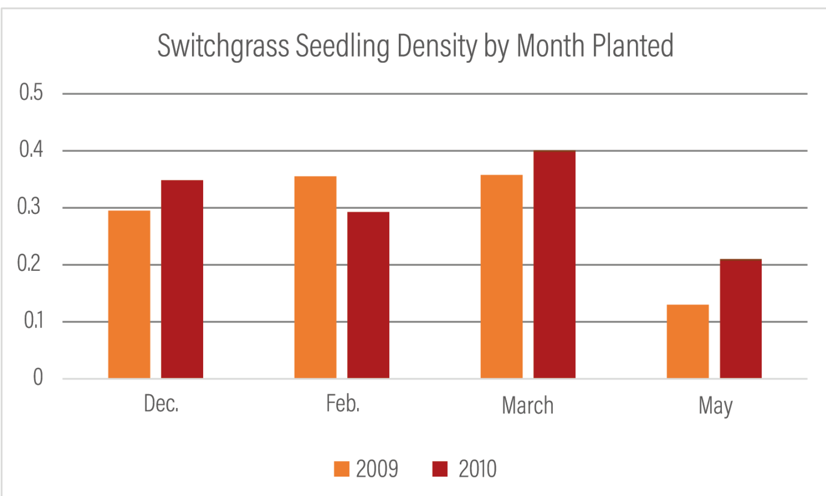


Figure 7.20. Mean density of switchgrass seedlings planted across two study locations for four planting dates and two years. March planting dates produced the most reliable stands in terms of seedling density. Adapted from: Keyser et al. 2016a. Crop Science. 56:474-483.

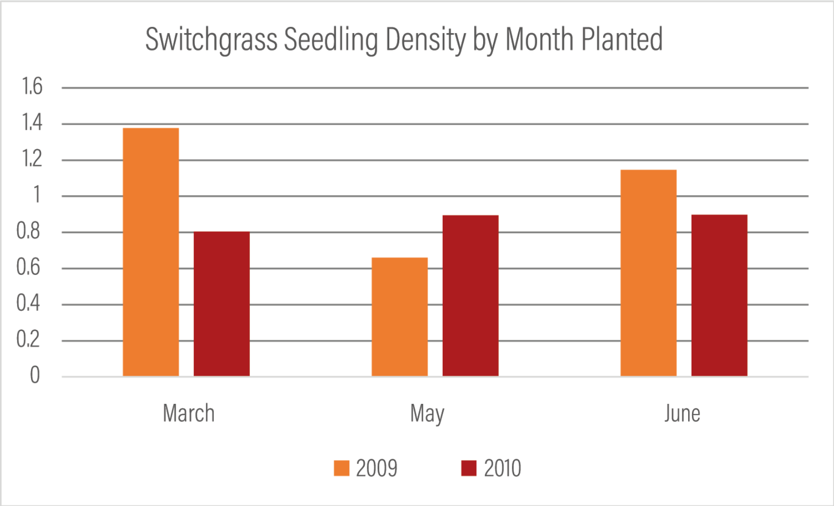


Figure 7.21. Mean density of switchgrass seedlings planted across three locations for three planting dates and two years. March planting dates produced similar (2010) or greater (2009) seedling densities than those planted in May. Adapted from Keyser et al. 2016b. Crop Science. 56:2062-2071.

Another strategy that has been used to break dormancy in eastern gamagrass seed is to soak it in a hydrogen peroxide solution. Solutions of 15 percent hydrogen peroxide may be ideal with those of higher (20 percent or more) or lower (10 percent or less) concentrations somewhat less effective. Seed should be soaked for 18 hours. However, cold-stratified seed shows greater improvement in germination than that treated with hydrogen peroxide leading some to apply both treatments, cold stratification followed by soaking in hydrogen peroxide.

SUMMARY

By following basic agronomic practices, those necessary for successful establishment of any perennial forage crop, native grasses can be readily established (Figure 7.22). For native grasses, the details of those practices vary somewhat from what we are used to with more conventional forages. For instance, fertility need not be — in fact, should not be — high, particularly N. So long as a high-quality seedbed is created,

Figure 7.22. This mixed stand of big and little bluestem and indiangrass was drilled on April 18. Early development was strong as a result of abundant rainfall the first three weeks post planting and excellent weed control during the 12 months leading up to planting. At nine weeks (a) rows were clearly visible and most seedlings had developed tillers. By 17 weeks (b), seedlings had become quite large and vigorous and seedheads were beginning to emerge. Approaching fall dormancy (c), the stand had become impressive. Although this was a particularly good establishment, with timely rain and good agronomic practices as outlined in this section, this is not an unusual experience.

one that is clean (no weeds and limited thatch on the soil surface), fine-textured and firm, either no-till or conventional approaches can be used. The key is not the method, but the end result. The wide effective planting window (February to early July) provides ample opportunity for developing the necessary seedbed and emphasizes that following a strict timetable or preconceived schedule should be avoided in favor of good weed control. With the exception of eastern gamagrass, native grasses must be planted at shallow depths (1/8-1/4 inch deep only) and have good seed-soil contact. With native grasses, you must also consider the possibility—especially with eastern gamagrass and some cultivars of switchgrass—that seed dormancy may be high enough to preclude successful establishment. Always pay attention to seed dormancy rates when purchasing seed so that you will be prepared ahead of time to address the issue.

CHAPTER EIGHT

Managing the Seedling Stand

To ensure success of any grass planting, and natives are no exception, attention must be paid to the developing stand throughout the seedling year. Do not assume that just because seed is now in the ground that your job is done. Perhaps the best place to start preparing for this follow-up is to gain a basic understanding of how native grass seedlings develop. There are some key points here that will help you to be more effective on any follow-up management.

SEEDLING DEVELOPMENT

Slow germination

First, it is important to recognize that native grasses can take much longer to germinate than our widely planted agronomic (i.e., wheat, corn, soybeans) or forage crops. Under normal spring conditions, very few native grass seedlings will be apparent until about 21-24 days post-planting, an interval very similar to that for seeded bermudagrasses. Later in summer, when soils are much warmer, say above 85 F, more rapid emergence can be seen, but it can still take as much as 14 days. It is also worth emphasizing that there is a difference between actual planting date and "effective planting date." In dry soil conditions, seed may remain in the ground for several weeks until enough rain falls to result in substantial emergence. Thus, the effective planting date can be considered to have taken place once there has been enough rain to saturate the upper layer of soil allowing the seed to imbibe and initiate the germination process. I have observed excellent stands develop where the effective planting date was as much as six weeks after planting. In such cases, seedlings will not become evident until well beyond the 21 days mentioned above.

Another aspect of native grass seedling emergence is that it continues over an extended period of time, as many as 70 days. However, the amount of seed that germinates later in the season is much smaller than that which occurs during the initial pulse. Regardless, in stands that are thin, the additional seedling recruitment can be valuable for filling in the planting. Taken together, these characteristics make patience, which is always a virtue, indispensable for these slow-developing stands. Therefore, do not assume that after 3-5 weeks that you have a failure (Figure 8.1). And do not assume that a thin stand at week six or eight will not fill in and become productive, so long as there is sufficient soil moisture (Figure 8.2).

Figure 8.1. Native grass seedlings can be slow to come on. This 3-leaf stage seedling was photographed 39 days after planting. Five weeks is often required before native grass seedlings become apparent. Despite such slow starts, strong native grass stands can develop during the first season.

Figure 8.2. This 8-week-old stand of native grass may look thin, but despite appearances, adequate plant population was present by fall dormancy to allow a productive, well-stocked stand to develop as shown in the second spring's growth (b).

Early root development

Because native grass seed (except eastern gamagrass) is small, the seedlings are also small initially and must rely on a limited root system during the early stages of development. This means that these seedlings are vulnerable to desiccation for the first two to three weeks following emergence. Therefore, just as with germination and emergence, adequate moisture is important during these early (2-3 leaf) stages for both survival and continued root development. There have been many instances where plantings with very good initial plant populations were lost due to extreme heat and drought that occurred while the seedlings were still very small.

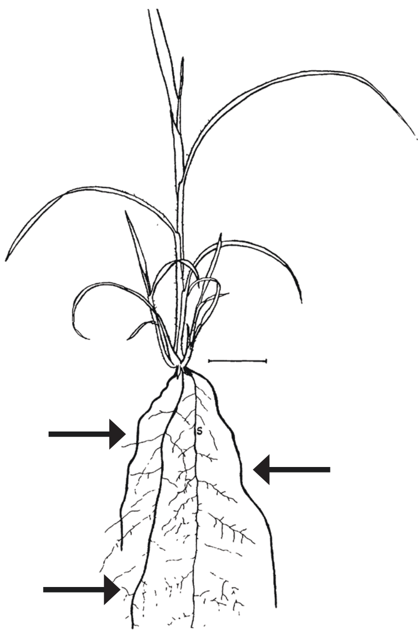


Figure 8.3. Illustration of a big bluestem seedling showing seminal roots (indicated by 'S' on drawing), those that have emerged from the seed, and adventitious roots emerging from the root collar (arrows). Mueller. 1941. Ecological Monographs.

At about four weeks of age — assuming adequate soil moisture for initial development — seedlings begin to grow a secondary root system, known as adventitious roots (Figure 8.3), that enables them to become much more resilient to drought and other stress. Adventitious roots appeared in seedlings as young as three weeks of age in a greenhouse study[20] and in a field study were common by 4-5 weeks of age, and quite large and well developed by 8-9 weeks of age[32]. The above ground portion of the plant has normally reached the 4-5-leaf stage when adventitious roots begin to develop. Once the above ground portion of the plant begins to develop new tillers, you can be confident that the root system has many adventitious roots (Figure 8.4). It is at this stage that native grass seedlings can be considered well established and will be able to withstand substantial stress, including extended drought. In fact, native grass seedlings develop root systems that reach depths of 4 feet their first year making them extremely resilient[37].

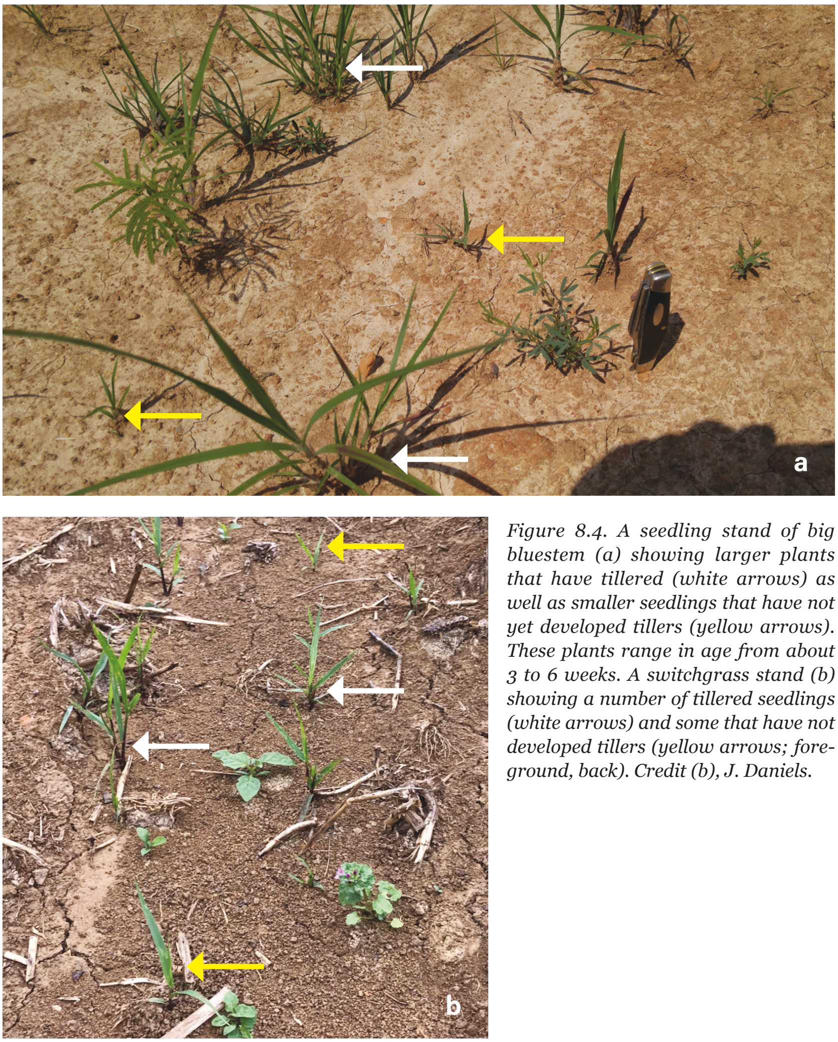


Figure 8.4. A seedling stand of big bluestem (a) showing larger plants that have tillered (white arrows) as well as smaller seedlings that have not yet developed tillers (yellow arrows). These plants range in age from about 3 to 6 weeks. A switchgrass stand (b) showing a number of tillered seedlings (white arrows) and some that have not developed tillers (yellow arrows; foreground, back). Credit (b), J. Daniels.

Another important aspect of having these well-developed adventitious roots is that the seedlings can then tolerate many common broadleaf herbicides. They also can withstand the impact of some limited defoliation associated with clipping for weed control. Such seedlings will also survive winter even if they are still relatively small plants[20] (Figure 8.5).

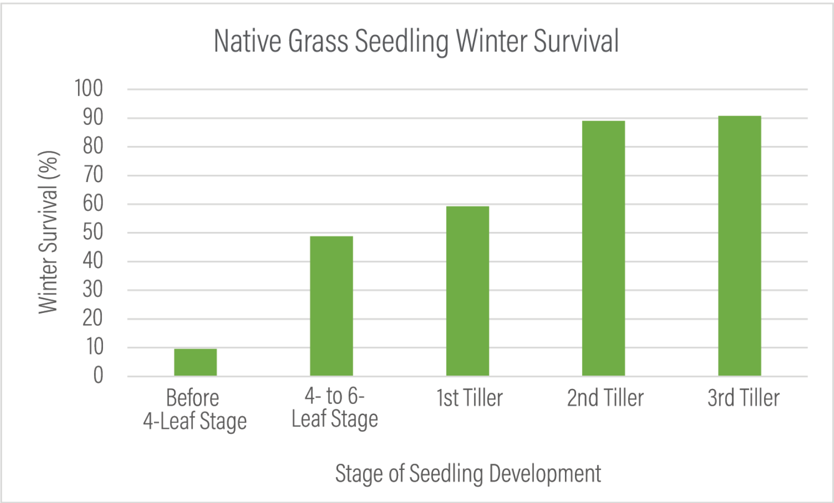


Figure 8.5. Development of tillers—and more importantly the adventitious roots that occur at a similar stage of development—is a good indicator that the seedling can be considered well established. In a study in Nebraska, winter survival of big bluestem and switchgrass seedlings was much greater when that seedling had developed two or more tillers. Adapted from O'Brien et al., 2008. Forage and Grazinglands.

FOLLOW-UP COMPETITION CONTROL

Despite excellent pre-planting weed control and appropriate suppression of annual grasses prior to planting natives, you can count on a new crop of weeds in the weeks following planting. A relatively weed-free window of up to six or even eight weeks is about all you can expect, especially during warm weather and with ample rainfall. Because of the small initial size of the native grass seedlings, **it is important to address encroaching weeds in a timely manner**. The most important criterion for

What about seed that did not come up? Will it come on next year?

I have often heard it said that stands that appear much thicker during their second growing season are that way because of a large amount of seed that has waited to emerge until the second spring. Similarly, I am often asked if seed that does not emerge in year one will come on the following spring. The best answer is maybe. In the case of thicker stands in year two, they are almost always the result of far more robust plants (as one would expect because of their age) rather than increased plant populations. Furthermore, second-year plants have filled in considerably as they develop increasing numbers of tillers. Although native grass seed can remain viable in the ground for many years and could, therefore, contribute to second year (or older) stands, I have rarely seen situations where that has been the case. First, a good deal of seed will have been lost to seed predators, fungus or even simply rotting. Another reason for minimal recruitment in later years is that the conditions important to successful initial seeding — limited/no weed competition and minimal thatch — must also be present for emergence in subsequent years. Furthermore, those surface conditions must be present when soil temperatures and soil moisture are conducive to germination. Typically, this happens in the Mid-South during April, a time when spring weeds are abundant and thatch from last year's plants may have covered much of the ground. Therefore, if there is some expectation of additional seedlings recruiting into the stand, measures will have to have been taken to address surface conditions and provide a desirable seedbed. A late winter/early spring burn is an excellent way to remove both thatch and competing weeds. Another option is use of herbicides to eliminate cool-season weeds about two weeks before soil temperatures would be expected to reach targets for native grass emergence.

intervention is **to prevent weeds from forming a canopy over the developing native grass seedlings** (Figure 8.6). Ample light is essential for the development of these seedlings. Larger native grass seedlings can tolerate more shade, but smaller ones (at or before 4-leaf stage) will die if shaded for extended periods. Thin, scattered weeds may be of concern in terms of going to seed or being unsightly, but they will not normally present serious competition to seedlings.

Figure 8.6. Overtopped native grass seedlings competing with a much taller canopy of pigweed (a). Note that this indiangrass seedling (to left of knife) is in almost complete shade. Without intervention, such small seedlings (3-leaf stage, in this case) will succumb and the stand will be lost despite good germination. By comparison, the seedlings in full sun (b) while not completely weed free, are not competing with a closed canopy of weeds. Note also that these seedlings in full sun are much larger and more vigorous than those under the canopy; both photographs were taken in the same field on the same day.

Mowing

Perhaps the cheapest and easiest method of managing weed pressure is a rotary mower. Mowing, unlike spraying, has the advantage of being possible whenever needed and under a wide range of weather conditions. The primary limitation will be when the field is too wet to support the tractor without rutting or damaging seedlings.

When using a rotary mower, it is important to clip above the growing seedlings. Early in the season when seedlings are small this will be easily accomplished. As the season progresses and seedlings grow, mowers may need to be held as high as 16 inches or more. If you cannot avoid partially clipping the seedlings, at least try to minimize the degree to which they are impacted. Removing 10-30 percent of the leaf surface area on a seedling that is 12-14 inches tall will be a worthwhile trade-off for reducing the weed canopy. Later in the season, when native grass seedlings have gotten as much as 2 feet tall, mowing to 16 inches will generally be acceptable. These larger plants have a greater ability to overcome increased defoliation.

If the volume of weeds to be removed is such that a mat of thatch will form as a result of clipping, seedlings will be at risk of being smothered. This problem reinforces the importance of timely intervention for weed control. If you are not able to mow before large amounts of material are present, consider using the material for hay. Even if the quality of the material is not good, baling it off the field could be critical to having a successful stand. Another option is to cut initially at a greater height thus producing less thatch and then, a week or two later, clip a second time to the lower target height and perpendicular to the first pass with the mower.

If you are relying on a mower to control weeds, you need to be prepared to clip three or more times during the course of the summer. Toward the end of summer, approximately mid-August, clipping may do more harm than good. At that point, the native grasses should be well established and able to compete with most weeds. The energy that you are removing from the plant by mowing may off-set any gain from suppressing weeds that may be only minimally impacting the now large seedlings.

Flash grazing

A second option for weed control is to use cattle. In this situation, the weeds you are seeking to control must be palatable to cattle. Competitors such as johnsongrass (rhizomatic or seedling) and crabgrass can be easily controlled by grazing so long as the plants are still young and highly palatable. For grazing to be an effective tool though, stock density must be high and grazing duration short. This is sometimes called flash grazing. Lighter stock densities will require longer grazing bouts that could lead to greater selectivity by cattle and, in turn, a greater risk of damage to seedlings. A good target is to stock at a level that will allow the weed canopy to be removed in under 48 hours, preferably within 24 hours. This may require subdividing the field with temporary fencing. As with mowing, you may need to conduct flash grazing several times during the summer to keep weed canopies from impacting the seedlings. And, as with mowing, there is a point in late summer where the need for competition control is lessened and you may do more harm than good with further grazing. Under wet conditions, delay grazing until soils will support hoof traffic and not damage either the seedlings or the field.

Herbicides

A third option for weed control during the seedling year is use of herbicides. In general, however, this will only be an option for control of broadleaf weeds. Chemical options for grass control in the developing stand of grass are limited. For broadleaf weed control, there are a number of products that can be used on seedling native grasses (Table 6.4). However, you must pay attention to the stage of seedling development to be sure that you do not apply a product that will cause injury to the native grasses. In order of increasing potential risk of injury, consider using imazapic, 2,4-D or a blend of metsulfuron methyl and chlorsulfuron. Those that should be avoided unless the seedlings are very large or the weed problem particularly acute are products containing an aminopyralid or triclopyr. One other caution in using herbicides is that they may suppress further seedling recruitment. This will be the case with 2,4-D and may also be a problem with imazapic or the metsulfuron methyl/chlorsulfuron products. With thin stands, those with marginal seedling populations, it may pay to hold off on spraying and manage weeds another way. On the other hand, if the plant population is already acceptable, or the weed pressure is severe, spraying can be a good choice.

IMAZAPIC

Imazapic can be very useful as a post-planting, preemergence treatment, but not for switchgrass or eastern gamagrass. Those two species have limited tolerance to imazapic as seedlings, especially switchgrass. However, for the other native grasses discussed here, application of imazapic following planting can help control many problematic weeds, especially summer annual grasses such as crabgrass, broadleaf signalgrass, foxtails and seedling johnsongrass (Figure 8.7). Control of

Figure 8.7. The herbicide imazapic can be very effective at suppressing summer grasses as shown by this skip in the corner of a mixed planting of big and little bluestem and indiangrass. Where the herbicide was not applied, there is a proliferation of crabgrass, foxtail, broadleaf signalgrass and johnsongrass. Where the herbicide was applied, there are a large number of well-developed native grass seedlings that have only limited competition.

goosegrass with imazapic is only moderately effective as this species has some tolerance to this herbicide.

When applied as a preemergence treatment, imazapic can be effective at rates as low as 4 ounces per acre. However, at rates at or above 8 ounces per acre, some injury will occur on native grass seedlings and emergence may be reduced as well. A good compromise is a rate of 5-6 ounces per acre. However, if spray patterns are not precise and frequent overlapping is likely to occur, the lower rate (4 ounces) should be used to avoid excessive damage under those areas with the 2X (overlapped) rate. It is also important to have a consistent spray pattern where there are not excessive skips. Boomless sprayers normally leave a streaked pattern and untreated areas will become very weedy leading to poor stands in these skips (Figure 6.12).

Timing of application of imazapic can be somewhat flexible in preemergence applications. A delay in application for 7-10 days after planting has the advantage of extending the weed control window further into the period when seedlings will emerge and need to compete with weeds. Do not apply imazapic once seedlings begin to emerge. At that point, you should wait until they have reached the 5-leaf stage to apply imazapic. As with any soil-applied herbicide, heavy rain can flush it out of the soil and under very dry conditions activation can be limited and it will not be as effective. Application prior to planting can also work but reduces the period of weed control that overlaps with emerged seedlings. For instance, an application two weeks prior to planting reduces the competition control window by as much as three weeks versus one implemented a week following planting. Those three weeks can be critical in allowing seedlings to develop in a weed-free environment. Post-drilling applications also have the advantage of sealing the drill furrow and not being disturbed once applied.

Imazapic can also be used (with a surfactant) as a postemergence treatment. Keep in mind though, that for emerged weeds, imazapic must be applied at considerably higher rates to be effective. For instance, for emerged summer annual grasses, rates of 8 ounces per acre or more will be required for effective control, depending on the size of the plants in question. Once native grass seedlings have developed adequately (i.e., post-tillering), they can tolerate these higher rates without injury.

NURSE CROPS DURING ESTABLISHMENT

Because of the loss of forage production during the seedling year, nurse crops have been considered as an option to provide forage while establishing native grasses. Summer annuals of smaller stature such as foxtail (German) and browntop millet, or those with more open canopies including various "diversity mixes" and cool-season annuals that mature early, such as oats, have all been tried. In most cases, seeding rates are reduced to one-half or less to allow ample sunlight to reach the developing native grass seedlings. Where nurse crop stands are thin enough to allow native grass seedlings to grow unimpeded, they will normally work well. However, in stands that are thin enough to allow adequate light through to the seedlings, nurse crop yields may be low enough to make them of little value for forage production.

If annuals are planted at higher rates and thicker stands are produced, they can present serious competition to the native grasses. In this case, they will meet their goal of providing forage, but timing of grazing or hay harvest becomes critical. Just as is the case with weeds, once canopies of nurse crops close, they begin to be a problem to successful native grass establishment. This was borne out in a recent study at the University of Tennessee using browntop millet. The millet, in the first year of the study, suppressed weeds (one goal of a nurse crop) and produced 1.3-1.5 tons (dry matter basis) per acre. However, switchgrass and big bluestem seedling populations were suppressed to unacceptably low levels by both millet seeding rates (Figure 8.8). The problem was that canopies were not treated in a timely manner resulting in excessive shade on the native grass seedlings. When the study was repeated the following year, millet seeding did not affect seedling populations but produced only 1.2 tons per acre of

Figure 8.8. In a recent trial evaluating browntop millet as a nurse crop for native grass, both switchgrass and big bluestem seedlings (center) were suppressed by the aggressive growth of the millet. Use of any nurse crop will require reduced seeding rates of that crop and timely management of its canopy to ensure adequate light reaches the developing native grass seedlings.

forage. The difference in year one and two of this study was that the timing of the millet planting was influenced by rain (delayed in year two) such that the millet never fully developed due to competition from weeds that got started during that rain delay interval. What all of this should make clear is that timing of planting for the nurse crop as well as its canopy management both had an impact on the outcome. Put another way, at least with browntop millet, the margin for error was unacceptably small.

In a follow-up study where browntop millet was once again used in addition to a high-diversity summer annual mix, grazing was used to remove the nurse crop instead of mechanical harvest as in the first study. Grazing should, at least in theory, allow for more timely and flexible canopy reductions for the nurse crops. Unfortunately, rapidly growing summer annuals quickly overtopped the native grasses leading to stand failures (Figure 8.9). Once again, the lesson was that timing of canopy removal was critical. This study is continuing and more aggressive and

Figure 8.9. As was the case with the previously mentioned nurse crop trial, competition from aggressive annuals requires very well-timed reductions in the canopy to allow enough light to reach the smaller seedlings of the native grasses. Here, a high diversity summer annual blend was grazed to reduce competition. However, given the small size of the native grass seedlings (immediately in front of hand), very few survived and an acceptable stand was not established.

timely grazing of the summer annuals during year two appears to be having a very favorable impact.

While the concept of summer nurse crops makes sense, the variability in stand densities of the annuals with respect to seeding rate, the sensitivity in timing of planting the nurse crop relative to the native grasses and the narrow window for reducing the canopy of the annuals all make this a fairly high-risk strategy. Based on these studies, it appears that summer annuals should be planted at only moderate densities (no more than one-half the full recommended seeding rates), about 16-20 days later than the native grasses and be drilled at a 90-degree angle to the native grasses to minimize disturbance of the previously planted seed. The delay in planting the summer annuals is important because of their more rapid germination. If they were planted at the same time, or even before the native grasses, they could quickly overtop the slower emerging native seedlings. Finally, grazing, which is less constrained by weather than hay harvest and is thus more flexible in terms of timing, should be used to harvest the summer annuals. As has been mentioned when using grazing to manage weed pressure, a flash grazing approach should be used that quickly reduces canopies of nurse crops.

A study that compared spring oats (planted at 60 pounds per acre on the same date as the native grass) to unplanted controls (no nurse crop) found that the oats did not negatively affect establishment of the native grasses. On average, the oat crop produced 1.9 tons (dry matter basis) of forage when harvested as hay. This approach holds promise as it requires less sensitivity in timing of the planting of the nurse crop and only a single planting date. However, this project was conducted in Minnesota[12] and it still needs to be determined if the same approach will work in areas further south. One concern about the use of a cool-season annual, though, is that for many areas in which native grasses may be planted, the forage produced by the nurse crop becomes available at a time when existing cool-season perennials are already producing ample, even excess forage. Thus, cool-season nurse crops may have less marginal benefit further south.

WHAT DOES SUCCESS LOOK LIKE?

When advanced planning, a high-quality seedbed and appropriate follow-up weed control have all been implemented, what should you expect from a first-year stand of native grasses? What does a successful planting project look like? Really, the answer is very simple — about **one established seedling per square foot**[28, 14, 34]. And as explained previously, an established seedling is one that has "perennated," that is, developed perennial structures, specifically multiple tillers and adventitious roots (Figure 8.10). Even if such a plant is still very small, perhaps only 6 to 8 inches tall, it should be considered an established plant, one that will survive the winter and contribute to the future stand (Figure 8.5).

Figure 8.10. A well-developed first year stand on October 20. These plants have numerous tillers, deep roots and are even producing seedheads. It is worth noting that at five weeks post-planting, seedlings were barely visible.

As long as your stand meets or exceeds this target, do not be overly concerned with how weedy the field may be. It is not uncommon to have a field late in the seedling growing season that looks like, well, a mess. Your neighbors may have already done you the favor of pointing this out to you, repeatedly! Most of these weeds will be annuals though and, therefore, will not be nearly as prevalent the second year. Perennial weeds can be readily controlled the second spring and summer through a prescribed fire, herbicides, grazing or some combination of these tools (see section below, Second-year Management).

Concerning plant density, there is certainly no harm in having a seedling density greater than one plant per square foot. In some cases, seedling stands can have as many as ten to twenty times that number[22, 14]. Such denser stands can help suppress competing weeds during the first year. Regardless of how many more seedlings there may be above the one per square foot threshold though, yield in the future stand is not likely to improve much. The reason that yield becomes relatively stable above that population threshold is that an individual, mature native grass plant, certainly among the tall species, can fully occupy one square foot. Such plants can often have 100 or more tillers. If you have more than one plant occupying that square foot, a process known as density-dependence causes each plant to become smaller. Put another way, they compete with one another. A study conducted in Texas during the 1990s showed that switchgrass plants increased in leaf area, tiller number and plant dry weight all as spacing of plants increased[26]. Plants with more room to grow became larger. So you get the same yield, more or less anyway, from a smaller number of large plants or a larger number of small plants. The advantage of having fewer larger plants is that each plant is more robust and can withstand greater stress whether that is drought, pests or poor management.

Plant densities below the one plant per square foot threshold (i.e., nine plants per square yard) but greater than one plant per 1.4 square feet (seven plants per square yard) will have minimal impact on yield and such stands do not need to be thickened through further seeding. Furthermore, because native grass stands can thicken through rhizomatous spread, at this lower density (seven plants per square yard) they will, in time, become thicker, so long as management is not abusive (see Chapter 9 for more information on thickening thin stands). If plant densities are well below seven per square yard, say only four plants per square yard, overseeding could be pursued the following spring (Figure 8.11). This will require reducing thatch and winter weed pressure prior to seeding in the spring. It will also require management of the existing grass from the initial seeding to ensure that it does not shade seedlings that result from the overseeding. At densities below three plants per square yard, certainly as low as one plant per square yard, you should plan to thicken or even reseed (at the lower densities) the field the following spring and treat it as a brand-new planting.

One important exception to the above guidelines for plant densities is with eastern gamagrass. Because this species develops much larger crowns, as much as 2-3 feet in diameter, densities can be lower without negatively affecting yield. Reasonable targets for eastern gamagrass are

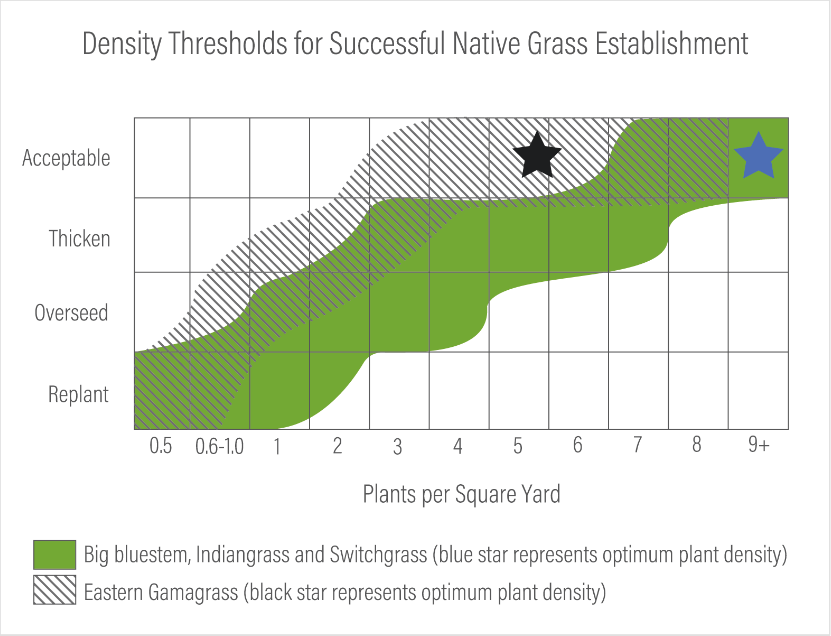


Figure 8.11. Schematic diagram showing approximate thresholds for acceptable native grass plant population densities and actions that may be needed based on those densities.

3-6 plants per square yard (Figure. 8.11). In a study in Oklahoma, the optimum yield under high fertility inputs was achieved at four plants per square yard but yields dropped only slightly between six and three plants[33]. Yields remained good even with plant densities of 1-2 plants per square yard. Again, as with other grasses, this is because where stands are thinner, individual plants become larger. With eastern gamagrass stands between one plant per square yard and one plant per two square yards, steps should be taken to thicken the stand. At densities below one plant per two square yards, reseeding should be pursued.

As you assess seedling density, keep in mind it should be conducted at the end of the growing season, September or October. Recall, even in August, new seedlings that will contribute to the future stand are often still being recruited. Also, keep in mind that whatever estimate you arrive at for plant density at the end of the year, it is likely to be low.

This is because there are always more plants there than you think; they are often obscured by weeds and/or may be small and easily overlooked. One way to improve the reliability of the seedling density estimate is to wait until after a killing frost to count. Native grass seedlings generally have a stiff enough stem to remain upright after a frost while many of the annual weeds will melt down and lay on the ground.

SECOND-YEAR MANAGEMENT

There are several considerations to keep in mind as you enter the second year of the native grass stand. First, there may be a great deal of weed pressure that is a direct result of the establishment process. Soil disturbance under conventional seedbed preparation will have released a large amount of annual weed seed from the seedbank. Similarly, conversions of degraded sods will also result in a proliferation of all sorts of pasture weeds, annuals as well as perennials. The limitations on control options imposed by the developing seedlings will, in many cases, have allowed these weeds to remain vigorous and/or go to seed. And finally, a large crop of winter annual weeds may get started following fall dormancy of the seedling native grass stand. Therefore, **you should be prepared to assess the need for weed control at least twice — once in late winter** (cool-season weeds) **and a second time in mid-spring** (May in the Mid-South) once warm-season weeds are beginning active growth. In either case, standard weed control practices can be employed — applying appropriate herbicides, grazing (for more palatable weeds) or even a prescribed fire. Before the native grasses break dormancy, you can also use a non-selective herbicide such as glyphosate to control cool-season weeds, annuals and perennials. In the case of the fire, timing should correspond to the initial dormancy break of the grasses as indicated by elongation of basal buds to about 3-4 inches in length. The broadleaf herbicides in Table 6.4 can all be used on established (second-year and later) stands without concern for injury with the clear exception that imazapic should not be used on either switchgrass or eastern gamagrass.

Also, nicsulfuron is only labeled for use on switchgrass. For more on weed control in established native grass stands, see Chapter 15.

The second key consideration for second-year stands is fertility management. As explained previously in Chapter 7, native grasses do well in low fertility and acidic soils. So, as long as P and K remain in the Medium test category per soil test and pH remains above 5.0, the only consideration is N amendment. If weed pressure is severe and has not been addressed, wait to apply any N. Application of N to any native grass stand should only occur once the grasses have dominance of the site. Also keep in mind that the appropriate timing for application of N to warm-season grasses is later than what is typical for cool-season perennials. Wait to apply N until the native grasses are actively growing and are able to quickly exploit it. This will occur when the grasses have broken dormancy and have reached a canopy height of about 12 inches. In the Mid-South, this will normally be in mid- to late April. Depending on how well the stand got established the seedling year, apply 40-60 units N per acre, but only if you want additional production. For more on fertility management in established native grass stands, see Chapter 12.

Second year stands are able to support grazing or haying in almost all cases. However, native grasses continue to develop during their second growing-season. On average, second-year stands will only produce 70 percent of the yield that they will produce during their third year and thereafter. During the second year, the extensive root system of native grasses (see Chapter 1) continues to expand and this requires some portion of the plants' productivity during this year. If you do not allow for this energy demand for the plants' continued development, you will pay a long-term penalty. In a study of second year stands of switchgrass, either one (June 8) or two (June 8 and August 9) hay harvests were taken. Yields from these stands were compared the following (third) year from a mid-June harvest (Figure 8.12) and it was quite clear that the impact was substantial.

Therefore, during the second year you should not push the stand as hard as what will be normal during the following years. Greater **care in**

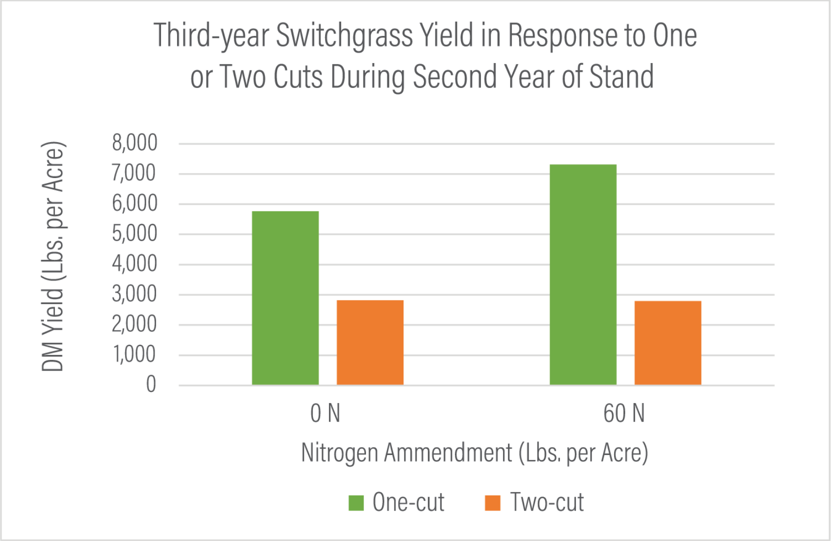


Figure 8.12. Yield for switchgrass from a June harvest during the third year of the stand based on number of harvests the previous year. Regardless of N amendment, taking a second cut during the second year of the stand had a large impact on yields the subsequent year. Because switchgrass continues to develop its deep root system during its second year, hay harvests should be limited to a single cut, preferably as early in the summer as practical. Adapted from J. Schultz, MS thesis, University of Tennessee, 2013.

maintaining minimum canopy heights of 12-14 inches (see Chapter 10 for more information on grazing management) and a shorter grazing season will both be important. By **resting the stand from grazing starting in early August**, you will leave ample time for the grasses to complete their second year's growth. For hay harvest, which imposes greater stress on grasses than grazing because it usually results in almost complete removal of leaf-surface area, **do not cut more than once**. Also, because harvests later in the season tend to cause greater stress on the stand through removal of more above-ground energy storage structures, including stems and reproductive parts, it is better to harvest hay too early than too late in the season. Also, **be careful not to cut the stand too short** in this harvest, keeping residual height at 8 inches. For more on hay production in established native grass stands, see Chapter 11. Second-year stands have produced about two tons of hay per acre, a level of production not far below a good condition cool-season hayfield.

Management of third-year stands will be similar to that of second-year stands but with greater productivity and management flexibility. Fertility guidelines will not change except that greater N inputs will be an option, particularly for eastern gamagrass. Weed control will normally be less of an issue as the mature grasses begin to more fully dominate the site. Stands can be grazed much later in the season and two cuttings of hay will generally be possible. Stands will be more resilient to mismanagement as well. However, general guidelines about hay harvest height and canopy targets under grazing will remain similar (see Chapters 10 and 11 for more on grazing and hay production).

SUMMARY

Successful establishment of native grasses requires follow up after the seed is in the ground. Even the best pre-planting competition control will not hold back weeds all summer. Newly germinating weeds must be controlled in a timely manner if they begin to develop a canopy above the native grass seedlings. Fortunately, a number of tools can be used to suppress this competition including mowing, grazing and herbicides. For the bluestems, indiangrass and sideoats grama, products containing the herbicide imazapic can be very helpful in preventing a number of weeds, notably summer annual grasses (and johnsongrass seedlings) from developing for about 6-8 weeks after application.

Because of the slow initial development of native grass stands, it is important to be patient and not become concerned about what may appear to be unacceptably low populations of seedlings or seedlings that are "too small." A successful, fully-stocked stand of native grasses is achieved with approximately one plant per square foot. And, as long as these seedlings have tillered and are about 6-8 inches tall or taller, they will survive winter. So even if the stand looks weedy and unimpressive by summer's end, do not be concerned if you have met these two goals.

Too, it is important to keep in mind that there are almost certainly more seedlings present than what may be readily evident.

During the second year of the stand (10-15 months post-planting, depending on planting date) you should be able to initiate grazing and/or hay production. It will be important though not to push the stand too hard during this year as the plants are continuing to develop their deep root systems. Thus, you should suspend grazing by early August and, if cutting hay, do so only once. In either case, respect minimum canopy height targets to ensure the plants have adequate energy available to complete their development. Supplemental N should only be applied once the plants are actively growing in the spring and only then if the grass is dominating the site. Finally, during the second spring, you should be prepared to address weed problems that have developed as the result of the establishment process, especially where degraded sods have been converted.

CHAPTER NINE
Renovating Native Grass Stands

Because thickening of native grass stands with unacceptably low plant densities follow similar principles and practices as establishment, these issues are addressed in this section. Whether these thin, weedy stands are a result of problems that occurred during establishment or developed later through poor management or excessive encroachment of particularly problematic weeds, the outcome is the same — reduced productivity and forage quality (Figure 9.1). In either case, the solutions for addressing these problems will be similar.

Figure 9.1. A native grass pasture with an ample supply of thistles and horsenettle, among other undesirable species. These are prospering here because the stand of native grasses is quite weak at this spot allowing the weeds room to become established and thrive.

THICKENING EXISTING STANDS

If you have recently established native grass stands and the plant population remains below an acceptable density as described in the previous chapter, there are a few options available for you to thicken these stands. The simplest solution is to allow rhizomatous spreading and natural increases in plant tiller numbers to fill in the gaps. This will only work though if the gaps in the stand are not consistently large. For example, if the stand has a population density between 4-6 plants per square yard (translating to a spacing of 15-18 inches, on average, between plant centers) and the pattern is similar across the field, this approach will work, but may take more than one growing season. Studies of rhizome development in switchgrass, big bluestem, little bluestem and sideoats grama indicate that spread is only about 1-2 inches per year[21]. It is also important under these circumstances to take a somewhat conservative approach to grazing so that plants remain vigorous and can put on additional growth. Thus, avoiding reduction of canopies below acceptable height targets, particularly for prolonged periods and during late summer, and not grazing after late August will help thicken the stand. It is worth noting that moderate grazing will actually result in plants increasing their tiller density relative to not grazing at all. Also, providing N amendments, 50-90 units per acre, will promote growth and vigor of individual plants.

If weed pressure is substantial, use of herbicides or prescribed fire to control them will also contribute to a thicker stand. Burning suppresses weeds and removes thatch, both of which reduce the amount of light available to the native grasses. Studies in Kansas have shown that native grasses are more productive following prescribed fire due to the increased light that reaches the plants. Dormant-season application of glyphosate or, depending on the weeds of concern, a broadleaf or grass-specific herbicide can also increase light reaching the native grasses by eliminating weeds. On the other hand, a growing-season herbicide application may be needed if most competitors are warm-season species.

Regardless, allowing the native grasses to grow unimpeded will help the stand thicken more quickly. In stands where plant density in part of the field—or overall—is lower, only 2-3 plants per square yard, additional seeding will be needed to thicken the stand.

Natural reseeding

One way to overseed a stand is to rely on natural reseeding. When you consider that seed yields for native grasses can be well over 100 pounds per acre, a considerable amount of seed can be obtained even from thin stands by simply allowing established plants to go to seed. Of course, annual seed yield varies a great deal from under five to over 300 pounds per acre[27]. Some of the factors that control that variability are under the grower's control and others, such as amount and timing of rain, are not. Practices that can lead to increased seed yield include—in order of decreasing benefit—harvest management, fire, fertilization with N (60-100 units per acre) and weed control. Harvest of grasses after early to mid-June, by grazing or cutting hay, will negatively impact seed yield with later harvests having increasingly greater effect[3]. Plants that are being grazed or hayed after mid-summer may still develop seedheads but will not have enough time to produce viable seed. Spring burns have been shown to increase seed production as well as seed quality[24:413-414; 27, 18]. Timing of burning in spring does not appear to make a difference in seed production[27].

In order to recruit as many seedlings as possible from natural (or any other method of) reseeding, there are several cultural practices that need to be considered. One such practice is heavy grazing during early spring, which can help "plant" seed still on the soil surface, improve seed-soil contact, compact soil (firm seedbed) and minimize canopy cover when seedlings are ready to emerge. Similarly, spring fire the year following seed fall will remove heavy thatch, warm soils (leading to earlier germination) and reduce competition from cool-season weeds that could suppress seedling emergence. Will fire at this time destroy the seed crop that you have fostered? I do not know. What is known, though, is that native grasses are highly fire-adapted and generally respond very favorably to burning. In past studies, high densities of big bluestem seedlings were observed following spring fire, which suggests that the seed was not harmed by the fire[24]. In fact, native grass seed may respond to the scarification provided by burning. Thus, where thatch is heavy, it will present a greater problem for seedling recruitment than fire. As mentioned above, good weed control is important. Dormant-season treatment of cool-season weeds can be very helpful in this regard. As emphasized with initial plantings, care must be taken with the use of herbicides to avoid products that may injure these new seedlings during their first year.

Finally, recognize that following reseeding you must manage the canopy of the existing grasses through continued grazing, preferably for short durations at high stock densities, or hay harvest to enable new seedlings to fully develop. If grazing, monitor the field regularly to be sure developing seedlings are not being defoliated more than about 20 percent by the cattle. Because of potential damage to seedlings from raking or tedding or residual thatch that may be left behind after baling, grazing is preferable to haying for managing canopies following natural (or other) reseeding. If you do manage the canopy through hay harvest, mow above the young seedlings whenever possible.

Overseeding

A third option is to overseed a thin stand using a drill, much like what was done during the initial planting. This will require purchase of additional seed but will be more reliable than the natural reseeding described in the preceding paragraphs. And, as has been described above, steps must be taken to ensure that seedbed quality is good: thatch must be minimal or removed by burning or raking and competing weeds must be destroyed. A late winter/early spring herbicide application can be a good way to kill cool-season weeds. If planting imazapic-tolerant species, spray 4-6 ounces per acre following drilling (or with natural reseeding) as described in the previous chapter for initial plantings. Ongoing canopy management through grazing or hay cutting will also be required just as described for natural reseeding.

RENOVATING DEGRADED STANDS

For stands that established well but have since become thin, weedy and unproductive, renovation and restoration to a high level of productivity can, in many cases, be readily accomplished. The single most important factor in whether or not a stand can be successfully renovated is the residual population of native grass plants. Just as described for initial establishment (see "What does success look like?" in the previous chapter), having one plant per square foot, or even as few as seven plants per yard, means that the plant population required for a productive stand is still available (see Figure 8.11). In these cases, all that will be necessary is strengthening those remaining plants. Typically, in poor condition native grass pastures or hayfields, plant vigor declines before plant mortality becomes a serious problem. While healthy, vigorous plants should have 50 or more tillers, those that are in poor condition normally have 10 or fewer. In more extreme situations, remaining plants may be reduced to only 1-2 tillers. Recall, too, that the roots will have been diminished in proportion to the above-ground portions of the plant. In degraded little bluestem pastures that had received prolonged, excessive grazing pressure, root mass was diminished by 75 percent versus healthy plants[37:303-304]. So, plants with fewer than 10 tillers will not have the deep, robust roots considered normal for native grasses. But even these weakened plants are still alive and much better able to compete than new seedlings with yet undeveloped roots.

Renovation through rest

Therefore, so long as the plant population is still present, renovation will be much easier, quicker and cheaper than any other alternative. And better still, the most effective tool for restoring productivity for native grasses is one that is very easy to apply and requires no out-of-pocket expenditures: rest! Rest is always important for grasses, native or otherwise. But for stands that have been weakened whether through sustained overgrazing or other factors, rest is absolutely critical. The

Monitoring before there is a problem

Monitoring native grass stands and paying attention to the range of tiller numbers per plant is an important step to **prevent** native grasses from reaching a point where more extreme measures are needed. If you begin to see a large number of plants that have fewer than 20 tillers each, you should be concerned. As the proportion of plants with low tiller counts goes up, and the count per plant continues to go down, you will need to make adjustments in your management to avoid further stand degradation. Another indication that the native grasses have become weakened is increasing weed pressure. Where there is not a vigorous sward, weeds will quickly take advantage of growing space not occupied by the native grasses. The take-home message is that it is far easier to restore a stand to full production when it has only been partially stressed than when it has become severely weakened. "An ounce of prevention is worth a pound of cure," as the old saying goes.

amount of rest needed will depend on the degree to which the stand has been degraded. In some cases, simply allowing rest in late summer or perhaps after mid-summer could be adequate. In the most severe cases though, a season-long rest will be necessary to fully restore stand vigor.

During a study conducted in Tennessee, a switchgrass stand that had become thin and weedy was treated with one of five practices to evaluate their effectiveness for renovation. Treatments included rest, with and without N application (60 units per acre), continued harvest, either once or twice per summer with 60 and 90 units N, respectively, and overseeding (with a drill). The upshot was that stands with the rest-only treatment (no N applied) increased tillers per plant by more than 200 percent, from nine to 28 per plant, on average, and the rest with N increased tillers 177 percent, from nine to 29 (Figure 9.2). It is also worth noting that the plant count in this study changed little

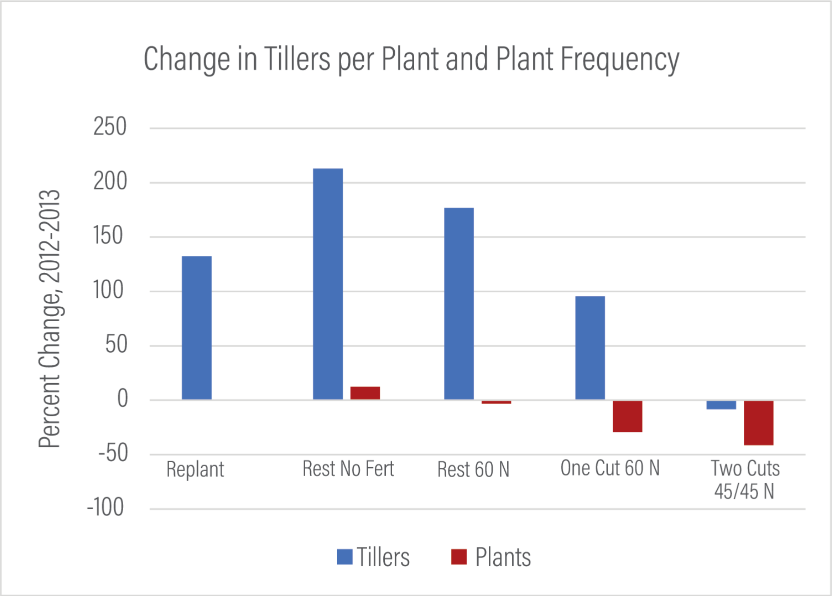


Figure 9.2. Response of weakened switchgrass stands to one of five renovation strategies after one growing season. Resting the stand was the single best approach to increasing tiller density and plant frequency. University of Tennessee, unpublished data.

for the treatments that included rest—the positive response showed up in tiller numbers rather than plant numbers. For the one-cut treatment, the average tiller number per plant increased, perhaps in part because smaller plants that depressed the stand average had died. For the two-cut treatment, which continued to stress the remaining plants, tiller numbers remained constant, but plants dropped out at a high rate (41 percent loss). Furthermore, the simple rest, especially without the cost of N, was a much cheaper option than the replant, which required purchase of additional seed, drill rental, tractor hours and diesel.

In a second Tennessee study, one examining a mixed big bluestem and indiangrass stand that had been exposed to three years of overgrazing (canopies maintained at 4-5 inches all summer), a similar pattern emerged (Figure 9.3). Following a series of treatments including burning, weed control and rest alone, the improvement in tiller numbers over

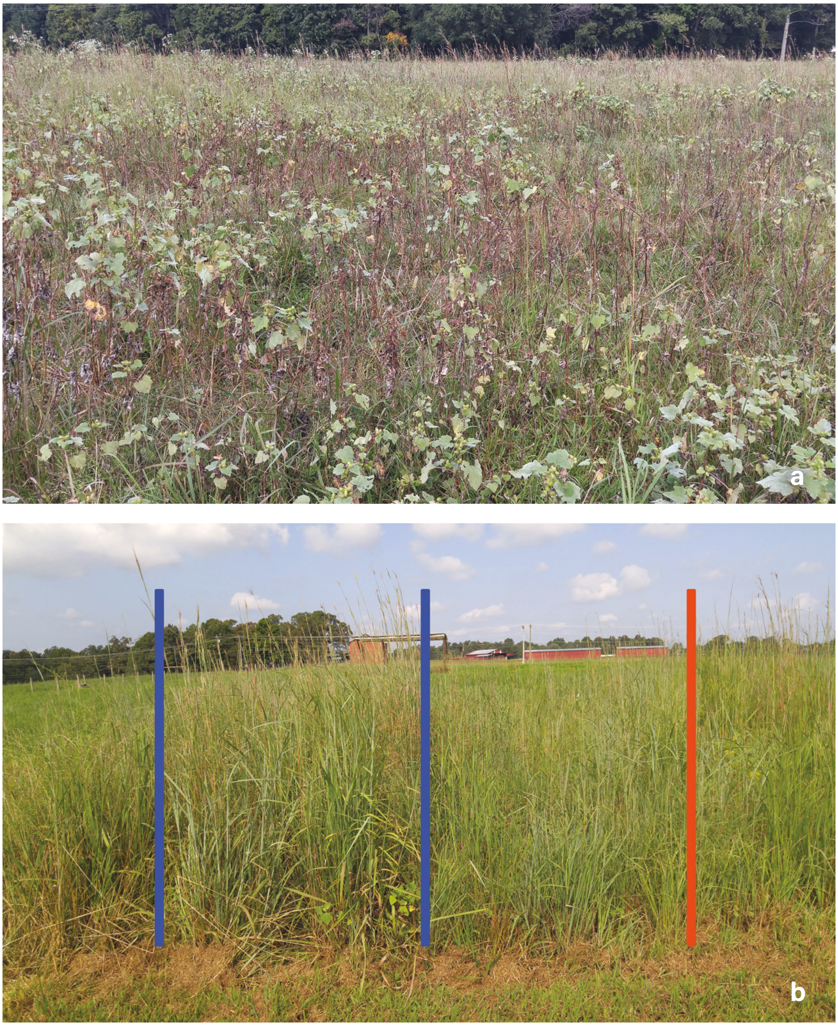


Figure 9.3. An extremely degraded big bluestem-indiangrass stand after three summers of over-grazing during which canopies were maintained at about 4-5 inch heights all season (a). Numerous weeds are occupying the site and native grasses have only 2-3 tillers per plant. One growing season after applying various renovation strategies the native grasses had regained dominance of the site (b). Plot between two blue lines was rested and burned during early April, the plot between the blue and orange lines was burned and had a single hay harvest removed in June, while the plot to the right of the orange line was sprayed with glyphosate to reduce cool-season competition and then burned. Simply burning and resting are inexpensive ways to renovate severely weakened pastures. University of Tennessee, unpublished data.

the one-year study was dramatic. The same study was conducted in a second stand, one that was only moderately degraded. Although both stands exhibited good recovery, the less degraded one became much stronger during the one-year rest period (Figure 9.4).

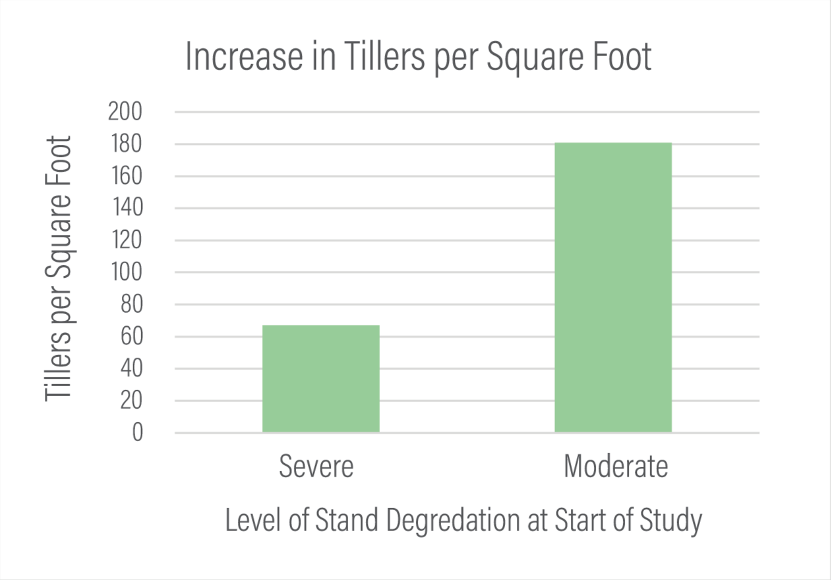


Figure 9.4. Plant response over a single growing season for severely and moderately degraded stands of big bluestem and indiangrass. Starting point for the two stands were two and 22 tillers per square foot for the severely and moderately degraded stands, respectively. These translate into a 30- and 9-fold increase in tiller numbers for the two respective stands. University of Tennessee, unpublished data.

Other renovation tools

Another simple step that can be taken in addition to providing rest is weed control. In thin stands, weeds will take advantage of the growing space vacated by the stressed native grasses and will serve to further weaken the grasses—a downward spiral. If these competitors are broadleaf weeds, annuals or cool-season perennials, they can be readily controlled with herbicides (see Chapter 15 for more on competition control). Reduction of the competitive pressure from these weeds will allow the native grasses to take full advantage of the site's available water, nutrients and sunlight, thus enabling them to gain vigor more quickly. Another option for suppressing weeds is a spring prescribed fire (see Chapter 17 for more on prescribed fire and native grasses). Fire not only will reduce weed competition, but it will also release nutrients into the soil from accumulated thatch, increase sunlight reaching the growing native grasses, warm the soil earlier and, collectively, provide a competitive advantage to the native grasses. Keep in mind, though, neither fire nor herbicide application may be necessary—rest alone can often achieve the desired results. Fertilization is not likely to be of any benefit for renovation. Recall that native grasses maintain a competitive advantage over many species in acidic and low fertility soils. Indeed, fertilization will cost you money and could be hurting you a second time by making the weeds more competitive!

SUMMARY

Thickening or renovating weakened native grass stands can be achieved with little cost by simply providing appropriate rest to strengthen weakened plants. For more severely degraded stands, a full summer of rest could be required (Figure 9.3). In less extreme cases, a few additional weeks of rest may be adequate. Control of competing weeds through the use of prescribed fire or herbicides can also have a positive impact. Where plant density is low enough that these practices alone will not be enough, providing additional seed, either by natural reseeding or overseeding with a drill will be necessary. Regardless of the source of this additional seed, the basic guidelines for successful establishment will come back into play, especially providing a high-quality seedbed—one free of excessive thatch and weed competition. Planning ahead to remove cool-season weeds and thatch will be essential. Application of imazapic prior to emergence of any new seedlings will benefit those species tolerant of this herbicide. And regardless of which species you are dealing with, follow-up canopy management to ensure adequate light reaches the developing seedlings will be required. The same tools used for an initial planting, grazing, clipping or hay cutting should be used for this purpose.

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