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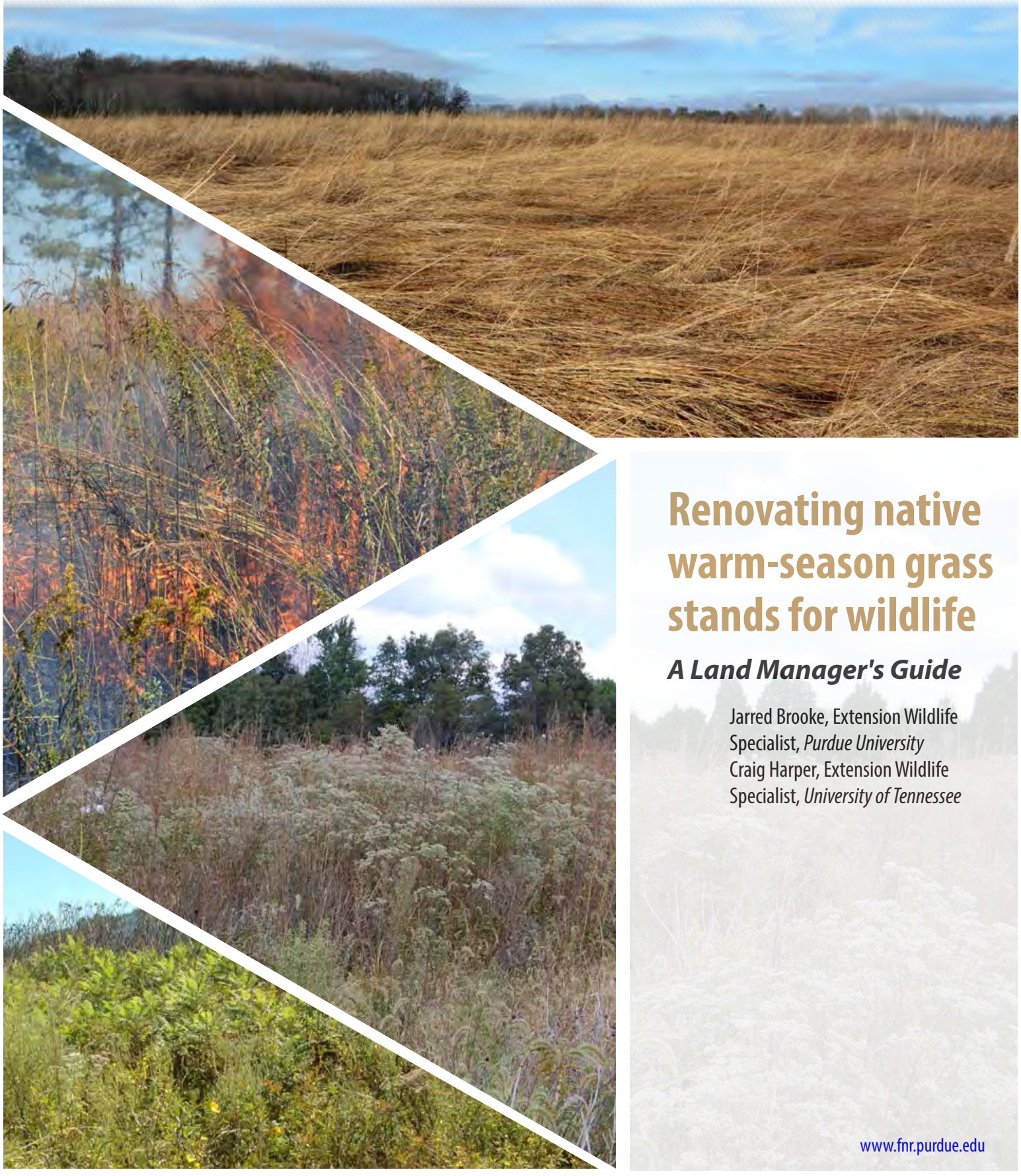

Renovating native warm-season grass stands for wildlife

A Land Manager's Guide

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Introduction

Many wildlife species use or require fields and other areas of early successional vegetation to meet their habitat requirements. Northern bobwhite, wild turkey, ring-necked pheasant, grassland and shrubland songbirds, eastern box turtles, and eastern cottontails all use open areas dominated by forbs, grasses, and shrubs in spring and summer for nesting and raising young. In winter, fields and other openings can provide cover as well as seed for upland game birds and over-wintering songbirds. White-tailed deer frequently use early successional plant communities as fawning areas in the summer and bedding areas throughout the year. Additionally, many of the forbs and brambles (e.g., common ragweed, pokeweed, asters, and blackberry) common in these areas are highly selected forages by white-tailed deer and provide excellent sources of nutrition.

Native warm-season grass and forb mixtures (NWSG) are promoted through various state and federal conservation programs as a means of creating and managing early successional plant communities and as an alternative to nonnative grasses. NWSG are planted to provide cover and food for various wildlife species, to provide cattle forage, to control soil erosion, and to enhance water quality. These plantings typically contain a mixture of tall (big bluestem, indiangrass, switchgrass) or medium-stature (little bluestem, sideoats grama) native grasses with a variety of forb species.

Many people may look at this stand of indiangrass and big bluestem and think it has the correct composition and structure for wildlife. However, this rank stand of native grasses is not what you want for most wildlife species. Too much grass is a common problem in planted NWSG stands.

Planting native grasses and forbs through cost-share programs has become a common practice to create and maintain early successional plant communities for wildlife. However, several problems commonly occur when trying to establish or enhance early succession vegetation by planting NWSG. Common problems include dense native grass, competition by undesirable plants from the seedbank, lack of proper management, and cost associated with planting, especially seed.

The most common problem with planted NWSG is the grass itself! Conservation organizations and cost-share programs commonly recommend or require planting 3–6 pounds PLS (pure live seed) of grass seed per acre. In the past, recommendations often included 6–10 pounds of grass seed per acre, and many of these stands still exist and are in desperate need of renovation. Even with 4 pounds PLS of grass seed per acre included in the mixture, a successful planting will result in more than 50% coverage of grass within 3 years. Extremely thick (or "rank") native grasses is a frequent issue when tall native grasses, such as big bluestem, switchgrass, and indiangrass, are planted. Not only did past planting recommendations consist of high seeding rates of tall grasses, but they also had relatively few forbs with a light seeding rate. More recently, recommendations for planting have included reduced rates (<4 lbs/acre) of grass, favoring medium-height grasses versus tall grasses, and mixtures have incorporated an increased density and diversity of forbs aimed primarily at improving the value of these plantings for pollinators.

Bobwhite commonly use native grasses for nesting, but they also use dead material from a wide variety of other plants like giant foxtail. This picture illustrates the point that native grasses are not the only material bobwhite use for nesting, especially in areas where herbaceous vegetation is not lacking.

It is a common misconception that fields dominated by native grasses with very few "weeds" are best for wildlife. With the exception of grassland songbirds, there are no wildlife species in the eastern United States that need more than 30%–50% grass cover. Northern bobwhite, pheasants, and ground-nesting songbirds certainly use native grass litter for nesting, but they also will build nests from most any other herbaceous material and place nests near other vegetation that provides structure similar to grasses. For bobwhite, a density of 250 to 10,000 native-grass clumps per acre is more than sufficient for nesting

This field dominated by broomsedge, late boneset, wingstem, and horseweed was a tall fescue and orchardgrass pasture just 2 years before this picture was taken. All that was done to this field was a late-fall application of glyphosate followed by burning in March. Planting was not necessary. Now it provides excellent cover for many wildlife species including the wild turkey in the center of the picture.

Seedbank management: a sensible alternative to planting native grasses

Planting native grasses and forbs has become the standard practice to establish early successional vegetation for wildlife. However, on a majority of sites, it is not necessary to plant native grasses or forbs because a wide variety of plants that are desirable for wildlife are waiting to be released from the seedbank. In cool-season and warm-season pastures or old-fields, killing the existing grass cover will provide an opportunity to release the seedbank. In crop fields, allowing the field to remain fallow after harvest will release the seedbank.

The seedbank often contains both desirable and undesirable plant species, but these species are still present if you plant native grasses. Therefore, if undesirable species are present in the seedbank, you still have to deal with them! Furthermore, if you plant native grasses and forbs, most herbicide applications used to control undesirable plants will also kill the planted vegetation.

After the seedbank has germinated, herbicides can be used to control undesirable plant species. If vegetation emerging from the seedbank is not desirable, spot-spray undesirable species to allow desirable species to grow. In most cases, a desirable early successional plant community will result without planting. If desirable vegetation is not present by the third growing season after releasing the seedbank, then planting desirable vegetation could be considered.

cover, even if the grass was required, which it is not. This density equates to no more than 25% native grass cover in a field. The point is, it is good to have some native grass cover when managing for bobwhite, but it is not necessary, and there is often more than is needed in planted NWSG fields. When managing NWSG stands for most wildlife species, native-grass cover should not exceed 30%–50%. Forbs should represent at least 50% of the vegetation and woody cover may comprise 20%–50% of the field—or more—depending on focal species and management objectives. Certain grassland birds, such as Henslow's sparrow and eastern meadowlark, do well with 50%–80% grass cover.

Regardless of whether or not NWSG are planted, after the existing vegetation in a hay field or pasture is removed, the seedbank will be released and it will contain a mixture of desirable and undesirable species. The same is true when a crop field is no longer planted. Undesirable species germinating from the seedbank should be controlled to favor more beneficial plants. Problematic species, whether from the seedbank or carried in from wind, water, equipment, or animals, also appear throughout the life of the field. A few of the common problematic species include Canada thistle, sericea lespedeza, common teasel, narrowleaf plantain, crabgrass, johnsongrass, bermudagrass, smooth brome, tall fescue, multiflora rose, and autumn olive. These plants compete with desirable native plants and severely reduce the quality of the site for many wildlife species that use or require early successional vegetation. Of course, there also are native species that can become extensive and require management, such as tall goldenrod, blackberry, sweetgum, and red maple.

Often the best composition and structure in planted NWSG stands occurs in the first three years after planting. This is because the stand is dominated by annual or perennial forbs, many of which have arisen from the seedbank such as the asters, goldenrods, horseweed, and common ragweed in this picture. This picture was taken two years after planting and as you can see the native grasses make up a small proportion of the stand. In two to three years without management this field will be dominated by native grass with very little forb component.

One of the main issues in NWSG stands is too much grass. When native grasses become rank, the structure at ground level closes, making it difficult for ground-dwelling wildlife to move and forage.

This is a quail's eye view of a NWSG stand with too much grass. The dense structure at ground level prohibits foraging and movement.

Management Practices

The past seeding recommendations as well as the past management or lack of management in planted NWSG stands often failed to provide desirable composition and structure needed by many focal species and have encouraged problems such as rank native grass or excessive woody encroachment. For example, prescribed fire during the dormant season (Feb.-Apr.) and mowing are by far the two most common practices when managing planted NWSG, both of which encourage grass growth and do not control woody encroachment (top-killed stems readily resprout). A much better approach to enhance the composition and structure in a planted NWSG field is to disk the field and/or spray the native grasses and allow the seedbank to respond. That's not to say techniques such as prescribed fire are not beneficial, but these techniques need to be used in an appropriate way or in combination with other techniques. This publication provides recommendations for renovating planted NWSG fields using management techniques including disking, prescribed fire, and herbicide application.

Viewing the structure of the stand to the left through a quail's eye highlights the openness at ground level that promotes foraging and movement and the overhead cover that protects quail, pheasant, and turkey broods.

Disking

Disking incorporates thatch and aboveground vegetation, thins rank native grasses, and increases coverage of annual forbs and grasses. Disking improves openness at ground level, which makes it easier for ground-dwelling wildlife to move and forage. In some cases, disking can be used to reduce coverage of nonnative plants, but it also can increase coverage of other problematic species. Disking also can be used to reduce woody encroachment. Generally, the positive impact to the structure of the vegetation and increase in desirable plants following disking exceeds the response of undesirable plant species. However, managers should be vigilant and control problematic species (thistles, johnsongrass, etc.), with the appropriate preemergence or postemergence herbicides if they arise after soil disturbance.

Disking multiple passes often is required to disrupt the root system of perennial native grasses and incorporate the thatch in a field of thick native grasses. Light disking will not thin native grasses enough to change the composition or structure of the stand.

Managers also should consider how timing of disking (seasonality) influences the resulting plant composition. Multiple passes of a heavy offset disk are necessary to reduce native grass coverage, as light disking (<3–4 passes) will fail to reduce grass density or encourage forbs. Burning prior to disking clears debris and makes disking more efficient and effective.

Prescribed Fire

Prescribed fire is the most efficient method for managing early successional vegetation. Fire can be used to consume litter, control woody vegetation, control certain invasive species, and increase forb abundance and diversity in a planted NWSG stand. Prescribed fire can be used at various frequencies and in various seasons to accomplish different management objectives. More frequent fires (1–2 years) will maintain grass-dominated fields favored by grassland songbirds, whereas less frequent fires

Burning during the dormant season is an effective method to remove thatch and can be a great site-preparation tool to use prior to disking or applying herbicide. However, burning during this time of year does not thin native grasses or increase forbs and only top-kills woody vegetation. Fire during late winter or early spring will only maintain the current stand's composition and structure, not enhance it.

Burning during the late growing season (Aug–Oct) will help reduce woody encroachment and stimulate increased forb coverage, but burning at this time will not effectively reduce native grass density. Herbicide applications or heavy disking usually are necessary to reduce native grass coverage.

(3–5 years) will allow for more woody encroachment, which is favored by species such as white-tailed deer, eastern cottontails, upland gamebirds, and shrubland songbirds. However, if fire is used too infrequently, the field will advance towards a young forest and may no longer represent habitat for species that require early successional vegetation.

Herbicide Application

Herbicide application is another technique land managers can use to manage composition and control undesirable or excessive vegetation in NWSG plantings. Herbicide applications can selectively target some problematic species in NWSG plantings, but there are many problematic species that cannot be killed without killing planted native grasses or forbs, such as bermudagrass and sericea lespedeza. Herbicide applications can improve plant composition and structure in NWSG stands, but NWSG stands should not be managed solely with herbicides. Other treatments, such as prescribed fire and disking are recommended to consume thatch and other dead plant material, improve the structure at ground level, and stimulate fresh vegetation growth. Over-reliance on herbicides can increase herbicide tolerance or resistance in certain plant species, making them more difficult to control. Prior to applying herbicides, it is important to understand and follow all laws governing herbicide application and always refer to the herbicide label for instructions on application and application rates.

Broadcast applications of herbicide, as opposed to spot applications, may be appropriate in NWSG stands that are heavily invaded by problematic species or consist of rank native grasses.

Interseeding Forbs

Interseeding forbs is a commonly recommended, but largely unnecessary and expensive practice when renovating planted NWSG fields for wildlife. Interseeding forbs can increase forb abundance and diversity in a NWSG field, but only if native grasses are drastically reduced prior to interseeding. Additionally, when you drastically reduce native grasses, forbs from the seedbank will respond just as prolifically—if not more prolifically—than the interseeded forbs, and will often times outcompete the interseeded forbs. More often than not, forbs germinating from the seedbank are equally beneficial to wildlife as planted forbs, and many of the forbs planted often are already present in the seedbank, but just need a chance to germinate and grow (a good example is partridge pea). Wildlife tend to respond similarly to the change in the structure and composition of the vegetation following native grass reduction, regardless of interseeding. The value of interseeding forbs for wildlife is not from seeds themselves, but from the reduction in native grasses opening the structure at ground level and from the response of the seedbank.

Herbicides listed in the publication are labeled for various non-crop areas such as right-of-ways, conservation reserve program lands, forestry sites, fallow areas, wildlife openings, fencerows, rangeland, or grass pastures or hayfields. The herbicides listed in the text and Appendix B are non-restricted herbicides and can be purchased in-store or ordered from various farm supply stores, co-ops, or chemical suppliers.

Interseeding is rarely needed when renovating planted NWSG fields. Usually, all you need to do is thin the native grasses enough to let the seedbank respond. The field in this picture was a 12-year-old NWSG planting and had been maintained only with prescribed fire conducted in March on a one-to-two year return interval. The field was dominated by native grass until we applied imazapyr (Arsenal®, 48 oz/ac) to thin the grasses, and look what responded. Partridge pea and black-eyed Susan were in the original planting and have been waiting for a chance to germinate.

Common Issues in Planted NWSG Stands

Rank Native Grasses

Native grasses typically become rank within 3–5 years after planting. Extensive grass density increases thatch and limits forb germination, which results in reduced insect abundance and limited mobility and foraging for northern bobwhite, wild turkey poults, ground foraging songbirds, eastern cottontails, and ring-necked pheasants. Big bluestem and indiangrass fall over and lay flat during winter unless various forbs or shrubs are present to keep them upright. The interspersion of forbs, brambles, and shrubs in NWSG stands is far more beneficial to most wildlife species than the grass itself.

Dense native grass stands, especially those dominated by big bluestem and indiangrass, fall over during the winter. When the stand is devoid of forbs and shrubs that provide support for the grasses, they lay completely flat and provide virtually no cover for most wildlife.

Disking and native grass density. Disking is an effective method to not only thin rank native grasses, but also to increase the amount of annual and perennial forbs in the stand. The season of disking influences plant composition. For example, disking early in the growing season (April–May) is more likely to encourage undesirable warm-season annual and perennial grasses and spring forbs, such as crabgrass, johnsongrass, sicklepod, and jimsonweed, but also may encourage species such as foxtails, which produce seed eaten by many birds. Disking during the dormant season (October–March, depending on location), tends to encourage late-flowering forbs—many of which are important seed-bearing plants—such as common ragweed, beggar's lice (*Desmodium* spp.), and beggarticks (*Bidens* spp.).

Impacts of prescribed fire on thinning native grasses. Prescribed fire used during the dormant season (January–March) and early growing season (April–May) encourages and increases native-grass density, does not lead to increased forb coverage, and only top-kills woody species. Prescribed fire during the late-growing season (August–September) increases forb cover and tends to reduce woody encroachment, but does not lead to decreased native grass density. **Regardless of seasonality, you should not expect prescribed fire to thin rank native grasses.** Other techniques, combined with fire, including herbicide applications and disking usually are needed to effectively thin rank native grass.

Disking following a dormant season fire is an effective method to thin native grasses and improve the structure and compostion in NWSG fields. Prescribed fire consumes thatch and dead standing material in the field and allows the disk to more easily cut into the soil, thus improving the efficiency of disking.

Herbicides to thin rank native grasses. Various herbicides can be used to effectively thin native grasses and increase forbs. However, grass-selective herbicides do not reduce native grasses enough to elicit an increase in forbs and a change in composition. Broad-spectrum and broad-spectrum selective herbicides (e.g., glyphosate and imazapyr) effectively thin native grasses and increase forbs after only one application. Herbicides to reduce native grasses are most effective when applied in late spring or early summer (May–June) when grasses are 18–24 inches tall and prior to flowering, but they also may be applied later in the summer (August–September) prior to grass senescence. If applied in late summer, mowing or burning the stand early in August and allowing at least 3 weeks for native grasses to regrow may increase the effectiveness of the treatment.

We recommend imazapyr (Arsenal®, 48 oz/ac) instead of glyphosate if legumes or brambles are present, because most legumes and brambles are relatively tolerant of imazapyr. However, glyphosate (2 qt/ac) should be used when sericea lespedeza is present, because imazapyr does not control sericea lespedeza. Glyphosate also can be used when the stand has few if any forbs. Burning fields after treatment is recommended to reduce thatch and stimulate the seedbank. If sprayed in May or June, the stand can be burned in July or August to stimulate germination of forbs and grasses before fall.

This field was dominated by big bluestem and indiangrass and portions of the field were sprayed to thin native grasses in September 2016. Half of the field was burned in late September 2016, and the other half (including portions of the field sprayed with herbicide) was burned in March 2017.

Following a March prescribed fire alone, the composition of the field has not changed and is still dominated by rank native grasses.

The bottom portion of this picture, with scattered green vegetation and black bare ground, was sprayed with 48 oz/ac of Arsenal in September 2016 and burned in March 2017. The top portion of the picture was burned in March 2017, but was not treated with herbicide. You can clearly see the herbicide reduced the grass density.

Following one September prescribed fire, we see an increase in forbs compared to a March fire, but no change in the amount of native grasses in the field.

Clethodim applied in September at 16 oz/ac followed by a March fire did not reduce the amount of native grass in the field or increase the amount of forbs.

Imazapyr (Arsenal®) applied in September at 48 oz/ac followed by a March prescribed fire effectively reduced the amount of native grass in the field and increased the amount of forbs. The fire also helped to remove the thatch left by the herbicide application.

Glyphosate applied in September at 2 qt/ac followed by a March prescribed fire effectively reduced the amount of native grass in the field and increased the amount of forbs. The fire also helped to remove the thatch left by the herbicide application.

Tilling the firebreak (in between the dashed lines) resulted in a dramatic composition change compared to the portions of the field that were only burned in March. We went from a rank stand of native grasses to a stand dominated by annual forbs such as partridge pea, common common ragweed, and blackeyed Susan.

Problematic Herbaceous Plants

There are many weeds that can reduce the quality of a NWSG stand. It is important to mention that a "weed" is an undesirable plant for a particular objective, and determining which plant species constitutes a weed varies according to the landowner or land manager's objectives. A wildlife manager would not—and should not—control the same plants as an agricultural producer, but noxious weeds such as Canada thistle, sericea lespedeza, and johnsongrass or other invasive species always should be controlled in NWSG plantings. Additionally, state laws may require a landowner to control certain noxious weeds.

Herbicide application typically is the most efficient way to treat undesirable plants in NWSG stands, because you often can selectively treat those plants without killing desirable plants across the whole field. Various nonnative and invasive species respond differently to disking and prescribed fire. However, disking and fire can be used when appropriate for various species. There are many more problematic nonnative plants than the ones discussed below, but these include some of the most common problem plants in NWSG stands.

Numerous undesirable plants are outcompeting desirable plants in this field. Cool-season perennial grasses, such as smooth brome, tall fescue, and Kentucky bluegrass as well as problematic forbs such as wild parsnip and musk thistle have invaded this field.

Johnsongrass

Johnsongrass is a nonnative perennial warm-season grass common in the southern United States. Johnsongrass is present at the time of NWSG establishment in many fields. Excessive johnsongrass can outcompete NWSG seedlings and reduce establishment success, which may lead to a failed planting. Johnsongrass will persist in established stands if left unmanaged, which can lead to a monoculture of johnsongrass that is dense, provides poor structure for some wildlife species, and offers little or no food if forbs are outcompeted. Seedling johnsongrass can be controlled preemergence with an application of imazapic (8 oz/acre). However, johnsongrass arising from rhizomes is not controlled with a preemergence application. Johnsongrass can be controlled postemergence in established NWSG stands with an application of imazapic (12 oz/ac) or sulfosulfuron (2 oz/ac) without harming many NWSG and desirable forbs. Many grasses planted in NWSG stands are tolerant of sulfosulfuron, whereas many grasses and forbs planted in NWSG stands are tolerant of imazapic (refer to herbicide label for specific species). Of course, spot-spraying johnsongrass with glyphosate (2% solution) is an option, if coverage of johnsongrass is not extensive.

Johnsongrass can be problematic in NWSG stands and may be considered noxious in your state. Herbicide applications are the best option for controlling johnsongrass.

Other Nonnative Warm-Season Grasses

Other problematic nonnative warm-season grasses include bahiagrass, bermudagrass, Chinese silvergrass (*Miscanthus* spp.), cogongrass, crowngrasses (*Paspalum* spp.: dallisgrass and vaseygrass), large crabgrass, japangrass, and old world bluestems. Bahiagrass and bermudagrass are forage grasses most commonly planted in the southeastern United States, but bermudagrass occurs throughout the eastern United States. Japangrass is a common invasive annual grass in forested areas, but it can invade NWSG stands. Ideally, these species should be controlled with herbicides prior to planting, but they also commonly encroach into established NWSG stands. Some of these grasses can be controlled without harming some planted native grasses, but others require herbicides that also kill planted native grasses. Grass-selective herbicides generally are not effective at controlling perennial grasses.

Various warm-season grasses, including bahiagrass (pictured), can also be problematic in NWSG stands. Herbicides are the best option to control these species.

Many of these species are greatly reduced with imazapyr, but for complete control, follow-up applications of imazapyr or glyphosate are required. For example, bermudagrass, crowngrasses, Chinese silvergrass, and old world bluestems are best controlled with applications of imazapyr (Arsenal®, 4–6 pt/ac) by spraying in late spring just prior to flowering. Following an application of imazapyr in late spring or early summer, resprouting or newly germinating grasses can be treated again in late summer by spot-spraying glyphosate. Cogongrass is best controlled with a tank mixture of imazapyr (Arsenal®, 1.5 pt/ac) and glyphosate (1 qt/ac).

Bahiagrass is best controlled with metsulfuron methyl (0.33-0.5 oz/ac) in early summer just prior to flowering. Returning patches can be treated with spot-applications of glyphosate later in summer. Large crabgrass and japangrass can be controlled pre- or postemergence with an application of imazapic (8 oz/ac preemergence or postemergence). All of these grasses will need spot treatment the following year, and perhaps for multiple years, to completely eradicate the plants. However, the initial herbicide application will reduce coverage of these grasses significantly and allow other plants to respond from the seedbank.

Nonnative Cool-Season Grasses

Nonnative cool-season grasses including tall fescue, smooth brome, Kentucky and roughstalk bluegrass, timothy, orchardgrass, quackgrass, and reed canarygrass commonly invade NWSG stands, especially when not properly controlled prior to establishment. Taking the time to effectively control cool-season grasses prior to planting with both fall and spring herbicide applications can help mitigate problems later in the life of the planting. Cool-season grasses limit mobility and foraging of upland game bird broods and suppress native vegetation. Cool-season grasses probably are the most common and problematic invaders of early successional areas, but because of differences in phenology (timing of growth) between cool-season and warm-season grasses, cool-season grasses are easily controlled in NWSG stands.

Cool-season grasses, such as tall fescue, orchardgrass, and smooth brome, quickly invade NWSG stands, especially in stands where they were not adequately controlled prior to planting. Cool-season grasses change the structure of the stand at ground level and impede movement and foraging of ground-dwelling wildlife.

Controlling cool-season grass encroachment with herbicides. Certain species may respond differently to specific herbicides, and grass-selective herbicides typically are ineffective in eradicating perennial grasses. An application of a glyphosate herbicide (2 qt/ac) in fall/winter after warm-season plants have entered dormancy is most effective on a majority of these grasses. Tall fescue can be controlled with imazapic (12 oz/ac) or glyphosate (2 qt/ac) sprayed in the fall after a couple of frosts. Imazapic does not control orchardgrass, therefore glyphosate (2 qt/ac) is recommended. Smooth brome and reed canarygrass are most effectively controlled with a fall or spring application of

imazapyr (Arsenal®, 1.5 pt/ac). Quackgrass can be controlled with a spring or fall application of glyphosate (2–3 qt) or imazapyr (Arsenal®, 1.5 pt/ac).

Fields that contain cool-season grasses should be prepared prior to spraying to ensure the herbicide is contacting green, growing grass. For fall applications, fields can be hayed or mowed in late summer (September) and sprayed after a couple frosts (Oct.–Dec.). Alternatively, fields can be burned during the late-growing season, allowed to regrow, then sprayed. For spring applications, mow or burn the field during late winter (Feb.–Mar.) and spray in spring just prior to germination of warm-season plants (Apr.–May, depending on location).

Fire, disking, and cool-season grass encroachment. Management techniques, such as prescribed fire and disking, are not as effective as herbicide application when controlling cool-season grasses. Disking provides short-term control of cool-season grasses, but follow-up herbicide applications will be needed after disking. Prescribed fire during certain seasons actually can increase cool-season grass infestations. However, prescribed fire can be an effective site preparation tool prior to herbicide application to control cool-season grasses.

Canada Thistle & Other Nonnative Thistles

Canada thistle is a perennial noxious weed that is common in the Midwest and northeastern United States. Most of the other nonnative thistles, including bull and musk thistle, are biennial. Canada, musk, and bull thistle all overwinter as basal rosettes. Thistles may not be extensive in a field at the time of NWSG establishment, but they can quickly invade and dominate an established stand. Targeting thistles with herbicide during certain life stages can provide control while limiting damage to desirable species. Thistles are best controlled with clopyralid (0.67–1 pt/ac) or aminopyralid (5–7 oz/ac) from September until the first hard frost or in March and April (rosette stage) in established NWSG stands. Thistles also can be controlled during the growing season—prior to flowering—with 2,4-D, aminopyralid, clopyralid, or dicamba. However, applications during this period will kill desirable forbs. If thistle infestations are small and a growing season application is necessary, spot-spraying should be used to limit damage to nontarget vegetation. Glyphosate also can be used to control small infestations of thistles; this application may be more beneficial in stands where grass density also needs to be reduced.

Sericea Lespedeza

Sericea lespedeza is a nonnative perennial legume most common in the southern and central Great Plains regions of the United States, but occurs throughout most of the eastern United States. In years past, sericea was promoted for cattle forage, as a source of cover and seed for wildlife, and typically for erosion control on reclaimed mine lands. Sericea can invade established NWSG stands and out-compete native forbs, grasses, and woody plants, reducing the quality of these stands for many wildlife species. Sericea seed is indigestible by most wildlife species and extensive infestations may lead to nutritional deficiencies. Unfortunately, any herbicide used to control sericea lespedeza also will kill desirable forbs. Spot-spray applications should be used to control sericea when infestations are not extensive.

Nonnative biennial (musk thistle; left photo) and perennial (Canada thistle; above) thistles commonly invade NWSG stands and are most effectively controlled with herbicide.

Sericea lespedeza is arguably one of the most problematic invaders in NWSG stands. Sericea flowers in August or September and is a prolific seed producer, but the seeds have no value to wildlife because they are indigestible.

Herbicides to control sericea lespedeza. Glyphosate (1–2 qt/ac), triclopyr (1 qt/ac), or a combination of triclopyr and fluroxopyr (Pastureguard HL® 1.5 pt/ac) provide control of sericea lespedeza throughout the growing season. However, aminopyralid (used to control thistles) is not effective in controlling sericea. Metsulfuron methyl (1 oz/ac) may be applied August through September when greater than 50% of the sericea lespedeza is in flower and after some desirable forbs have set seed. Applications at this time may have less detrimental effects to existing forbs, but they also are not as effective as other herbicide applications. Regardless of the herbicide used, multiple applications will be needed to control sericea in a stand. We recommend treating infestations with triclopyr and fluxopyr when sericea is 12–18 inches in height (June–July) and then respraying any remaining sericea with metsulfuron methyl during flowering (August–September).

Controlling sericea with fire and disking. Dormant-season prescribed fire alone is not an effective control method for sericea lespedeza. In fact, dormant-season fire may increase density of sericea. Dormant-season fire can be used to stimulate germination of sericea seed in NWSG stands prior to herbicide application to help reduce the seedbank. Alternatively, herbicide can be applied to control sericea lespedeza during the growing season and then followed-up with a late-growing season fire prior to sericea flowering. Any sericea not killed by the initial herbicide application will be consumed by the fire, thus limiting the amount of seed produced. The following year, any sericea germinating from the seedbank or resprouting from rhizomes should be spot-sprayed with herbicide to further reduce the infestation. Disking also is an effective method to reduce sericea in a NWSG stand. However, disking will stimulate sericea seed in the seedbank and subsequent sericea lespedeza should be spot-sprayed with herbicide the next growing season.

Wild Parsnip

Wild parsnip is an invasive biennial/perennial broadleaf common in planted NWSG stands and other early successional areas. Parsnip is most common in the Midwestern and northern U.S. and can cause phytophotodermatitis, a condition leading to rashes, blistering, and discoloration of the skin after contacting secretions from wild parsnip. Wild parsnip is controlled best with applications of 2,4-D (4 pt/ac), 2,4-D + triclopyr (4 qt/ac), or 2,4-D + dicamba (4–5.6 pt/ac), but also can be controlled with metsulfuron methyl (1.5–2 oz/ac), glyphosate (2 qt/ac), dicamba (2–4 pt/ac), and imazapyr (Arsenal®, 2–3 pt/ac).

Wild parsnip is a nonnative invasive forb common in NWSG stands of the Midwest and northern United States.

Crownvetch

Crownvetch is a nonnative perennial legume often promoted for erosion control and as a forage for cattle. However, crownvetch is very invasive and quickly invades NWSG stands. Eventually, crownvetch will outcompete native vegetation and form a monoculture. Crownvetch is a cool-season plant and can be controlled when most desirable warm-season vegetation is dormant. Crownvetch is best controlled with products containing triclopyr (1qt/ac), metsulfuron methyl (0.5 oz/ac), or aminopyralid (5–7 oz/ac). Small infestations also can be controlled with glyphosate (2 qt/ac) or 2,4-D (4–6 pt/ac).

Crown vetch is commonly found along roadsides, but also invades NWSG stands.

Other Common Broadleaf Plants

Other annual, biennial, and perennial broadleaf plants also might be problematic in planted NWSG stands. Problematic annual species generally will decline over time being most prevalent following soil disturbance and less prevalent when perennial vegetation begins to dominate the site. Many annuals considered problematic in agricultural fields are beneficial to many wildlife species, which is another reason for waiting to plant NWSG until you have evaluated the seedbank.

Native forbs, such as pigweeds, horseweed, common lambsquarters, and common ragweed, may be abundant in a recently planted or disturbed stand (especially in year 1), but are less common in older stands. Pigweeds, common lambsquarters, and common ragweed are prolific seed producers, and a suite of bird species relishes their seed. Horseweed seed is not eaten by many wildlife species, but does provide vertical structure with an open canopy at ground level that is desirable for many wildlife species. These native forbs may represent an issue at establishment or following soil disturbance, but do not need to be controlled unless they are dense enough to reduce germination or persistence of more beneficial vegetation. Other annual species that may exist in NWSG stands, have little wildlife value, and may warrant control are nonnative annual species including jimsonweed, sicklepod, annual sowthistle, and velvetleaf. Products containing 2,4-D or dicamba can control many undesirable forbs, but also may control desirable vegetation (see Appendix B for products and rates). For example, dicamba controls jimsonweed, kochia, annual sowthistle, sicklepod, pepperweed, mustards, chickweeds, henbit, buttercups, perilla mint, pennycress, and velvetleaf, but dicamba also controls beneficial annuals such as horseweed, pigweed, ragweed, lambsquarters, and sunflower.

Biennial and perennial broadleaf plants typically are more problematic than annuals in existing NWSG fields because they persist and may eventually outcompete desirable vegetation. However, controlling these species in an established NWSG stand likely will require killing existing desirable vegetation. Species of particular concern are those considered prohibited, noxious, or invasive, and may include spotted knapweed, common teasel, curly dock, common dandelion, leafy spurge, narrowleaf plantain, perennial sowthistle, poison hemlock, and sweetclover. Certainly, there are many more problematic broadleaf plants, but these represent some of the more common species. The USDA maintains a list of nonnative, invasive, and noxious plants on their Plants Database website (https://plants.usda.gov). We recommend referencing that list to determine the status of certain plant species in your state.

Many herbicides are registered to control problematic biennial and perennial broadleaf plants in non-crop areas. In addition to thistle control, aminopyralid (3–7 oz/ac) provides excellent control of species such as perennial sowthistle, curly dock, and spotted knapweed. Species, such as Queen Anne's lace and poison hemlock, can be controlled with imazapic (8–12 oz), 2,4-D (4–6 pt/ac), triclopyr (0.5–4 qt/ac), 2,4-D + triclopyr (4 qt/ac), and glyphosate (2qt/ac). Leafy spurge can be controlled with imazapic (8–12 oz/ac), dicamba (2 pt/ac), and glyphosate (2 qt/ac). Several of the more common herbicides are listed in Appendices A and B. Many herbicides applied to control problematic broadleaf plants also will kill desirable vegetation. However, some broad-spectrum selective herbicides (imazapic and imazapyr) may kill undesirable plants without harming some desirable plants. Herbicide labels include a list of plants controlled by that herbicide, but consider those lists a starting point. None represent a complete list of plants controlled. Therefore, in most cases, small spot-spray applications should be used. If the problem plant is extensive, whole-field application may be warranted. In addition, websites are available through Purdue University and the University of Tennessee for various herbicide recommendations for various weed species http://www.purdueweedsci.com/indexNC.php and http://www.utcrops.com/weeds/weed%20home.htm.

Woody Encroachment

Certain woody species provide essential thermal and escape cover for upland game birds, eastern cottontail, and white-tailed deer, nesting cover for shrubland songbirds, and a source of seed or browse for various wildlife species. Maintaining 20%–40% woody cover dispersed across a NWSG field provides escape cover and thermal cover needed by a variety of wildlife species. However, grassland songbirds, such as eastern meadowlark, grasshopper sparrow, and Henslow's sparrow, may respond negatively to increases in woody cover. As NWSG fields progress through succession, unwanted pioneering woody species and invasive woody plants encroach in the stand. Undesirable woody vegetation will outcompete grasses and forbs and reduce the quality of these areas for certain species.

Pioneering Woody Plants

Pioneering woody plants include tree species, such as winged elm, Virginia pine, red maple, sweetgum, yellow-poplar, cottonwood, green ash, black willow, sassafras, sweetgum, eastern redcedar, persimmon, black locust, and honeylocust. These species may provide vertical structure used for perching, thermal protection, or brooding or escape cover when they are young, but over time, they grow taller, out-compete herbaceous vegetation, and dominate the stand. That being said, make no mistake, the presence of some woody species makes the area much more attractive and productive for many wildlife species.

This field is quickly being overtaken by sweetgum, green ash, and red maple. Without management, this field is on its way to becoming a young forest.

Pioneering tree species (sweetgum and red maple) and sericea lespedeza have invaded this field. In this case, a spot application of triclopyr would be most appropriate because it would control both tree species and sericea. This field could also be burned in late summer to reduce the woody encroachment and prevent sericea from producing seed.

Native shrub species, such as plums, hawthorns, elderberry, dogwoods, sumacs, leadplant, and false indigo, are extremely attractive to many wildlife species that need woody cover and make planted NWSG fields much more desirable to these species. However, you need to provide the correct amount of woody cover in an attractive arrangement for various focal species, and as succession advances, even some of these shrubs can become too dense for various species and management will be needed to control them.

Sumac mottes provide excellent thermal cover during the heat of the summer for bobwhite, turkeys, and white-tailed deer. However, sumac can become too dense if not managed.

Disking and woody encroachment. Disking can be an effective method to reduce small, pioneering woody plants in a NWSG field. However, if the seedlings grow without manipulation for 3–4 years, they may advance beyond what is feasible to manage with some disking equipment. If this occurs, herbicide application, prescribed fire, or other mechanical treatments (tree grinding, rollerchopping, or chainsawing) will be needed to control woody encroachment.

Fire seasonality and frequency influences woody control. Frequent dormant-season fires (1–2 yr return intervals) may limit woody encroachment and control certain invasive species, but it also will increase native grass density and lead to reduced forb abundance. Infrequent dormant-season fire will top-kill woody stems, but these stems readily resprout. Burning during the latter portion of the summer/early fall (August–October) tends to control woody encroachment better than during the dormant season or early portion of the growing season. However, a single fire rarely causes dramatic shifts in plant composition. Multiple fires are required to see considerable reduction in woody encroachment. Fire may not be possible in some areas, and woody encroachment may advance beyond what is feasible to control with a single prescribed fire, and an herbicide application or mechanical treatment may be warranted.

Late-growing season is the most effective time to conduct prescribed fire with the objective of reducing woody encroachment.

Herbicides to control pioneering woody species. Herbicide recommendations to control individual species vary, but certain herbicides can provide control of multiple woody species. Triclopyr (amine [4–6 qt/ac] or ester [2–8 qt/ac] formulation) as a foliar application provides excellent control of woody encroachment as well as sericea lespedeza in NWSG stands. Applications of metsulfuron methyl (2–3 oz/ac), metsulfuron methyl + chlorsulfuron (1.25 oz/ac), or metsulfuron methyl + 2,4-D + dicamba (0.5 oz/ac Part A and 4 pt/ac Part B) can be effective in controlling ash, elm, black locust, yellow-poplar, maple, and willow. Broadcast applications of triclopyr or metsulfuron methyl also will kill desirable forbs. Alternatively, imazapyr (Arsenal®, 4–6 pt/ac), an herbicide commonly used for hardwood control in southern pine plantations, can provide excellent woody control in NWSG stands and many legumes and *Rubus* species (important for wildlife food and cover) are tolerant of imazapyr. Imazapyr does not control unwanted woody legumes, but it also does not control beneficial woody legumes. Products containing 2,4-D (4–6 pt/ac) can be applied to the foliage of undesirable woody vegetation, but these products typically are not as effective as the products listed above.

Nonnative Invasive Woody Species

Nonnative olives. Nonnative olives (autumn, silverthorn, Russian, and others) are woody shrubs commonly planted in the mid-20th century to provide cover and food for wildlife. When occurring adjacent to a NWSG field, they usually spread throughout the field and may create dense thickets within the field, which can be desirable for some wildlife species, but they are problematic as an invasive species. Nonnative olives can be controlled with foliar applications of triclopyr (Garlon 4®, 4–8 qt/ac) or imazapyr (Arsenal®, 4–6 pt/ac), whereas glyphosate and metsulfuron methyl typically provide limited control.

Nonnative olives are commonly spread across NWSG fields by birds dispersing seed. Olives can quickly invade open areas and they should be controlled with herbicide.

Bush honeysuckles. Similar to nonnative olives, Amur, Bell's, Morrow's, and Tartarian honeysuckle—referred to as bush honeysuckles—originally were planted to provide food and cover for wildlife. Infestations are extensive in woodlots throughout the Midwest, Mid-South, and northeast U.S., and bush honeysuckles commonly invade NWSG stands. Bush honeysuckles can be controlled with applications of triclopyr (Garlon 4®, 4–8 qt/ac), imazapyr (Arsenal®, 4–6 pt/ac), or glyphosate (3–4 qt/ac). The early leaf emergence and late leaf drop of bush honeysuckles allow for control during time periods when warm-season plants are dormant.

Bush honeysuckle is invading the edge of this NWSG field. A March prescribed fire topkilled the shrub, but it resprouted following the fire. A spot-herbicide application would effectively control bush honeysuckle in this field.

Multiflora rose. Multiflora rose is another nonnative shrub promoted by conservation agencies as a "living fence row" for livestock in the mid-1900s. It is terribly invasive and spreads throughout fields and woodlots. Multiflora rose provides excellent cover for species such as northern bobwhite, eastern cottontail, and some shrubland songbirds, but its aggressiveness outweighs its benefits. Native roses (Carolina, prairie, and swamp rose) also provide excellent sources of cover and food, but are not as aggressive as multiflora rose. Multiflora rose is easily controlled by spot-spraying glyphosate (2% solution [2.6 oz/gal of water), imazapyr (Arsenal®, 1.5% solution [2 oz/gal of water]), metsulfuron methyl (1 g/gal of water), or triclopyr (Garlon 4®, 2-4% solution [5 oz/gal of water]) during the growing season after the plant has fully leafed out. Fire will top-kill multiflora rose, but multiple stems resprout following fire and must be treated with herbicide to ensure control.

Multiflora rose has climbed almost 15 feet into this hawthorn fence row. Can you even see the hawthorn? Its leaves are barely showing in the top of the picture. Native roses — which typically have pink flowers like swamp rose (below) as opposed to white flowers of multiflora rose — provide similar cover and food for wildlife without the invasiveness.

Callery pear. Callery or Bradford pear is an ornamental tree used widely in residential landscaping. Originally thought to be incapable of reproducing naturally, varieties of callery pear can cross-pollinate and have become extremely invasive and commonly invade NWSG stands. It typically appears sporadically, but then forms extremely dense clumps that outcompete native herbaceous and woody vegetation. You should aggressively try to control this plant. Callery pear can be killed with glyphosate (2% solution [2.6 oz/gal of water), imazapyr (Arsenal®, 1.5% solution [2 oz/gal of water]), metsulfuron methyl (1 g/gal of water), or triclopyr (Garlon 4®, 2–4% solution [2.5–5 oz/gal of water]).

The trees with white flowers invading this old-field in southern Indiana are Callery pears. Pears are easy to identify in the spring, because they generally are the first trees to flower. This picture was taken in early March, prior to most trees breaking dormancy.

Shrub lespedezas. Federal, state, and non-governmental conservation organizations often cultivated, promoted, and planted bicolor lespedeza, Thunberg lespedeza, and other shrub lespedezas to provide woody cover and seed for northern bobwhite. Make no mistake, shrub lespedezas are NOT needed to manage for northern bobwhite! More common in the southern United States, shrub lespedezas are very invasive and form dense thickets in NWSG stands and throughout woodlands where prescribed fire is used. The invasive nature of this plant quickly shades-out desirable plants. Shrub lespedezas are still cultivated and sold, but are no longer recommended for wildlife, and many states consider them an invasive plant. Prescribed fire is not an effective tool to manage shrub lespedezas because of resprouting, and prescribed fire can enhance the germination of shrub lespedeza seed leading to further invasions. Shrub lespedezas are controlled with applications of triclopyr (Garlon 4®, 4–8 qt/ac), metsulfuron methyl (2–3 oz/ac), or glyphosate (3–4 qt/ac).

Shrub lespedeza commonly invades NWSG stands in the southern United States and the use of prescribed fire only enhances its invasiveness. Herbicide should be used to control invasions.

Other nonnative woody plants. Other common nonnative woody plants found in NWSG stands include privets, tree-of-heaven, winged burningbush, common buckthorn, Siberian elm, and white or paper mulberry. Generally, these species and others can be controlled with the same herbicides to control the species above. For example, imazapyr (Arsenal, 4–6 pt/ac) and triclopyr (Garlon 4®, 4–8 qt/ac) will control all of these species. Additionally, glyphosate (2% solution) spot-sprayed also will provide control of most of these species and provides better control of privet compared to triclopyr.

Conclusion

Planted NWSG stands can provide important cover and food resources for a variety of wildlife species. However, without proper management, these stands quickly lose their benefit to most wildlife by becoming increasingly dense and invaded by undesirable vegetation. Moreover, planting native grasses and forbs is seldom necessary to provide habitat for wildlife that require early successional plant communities. If you are considering planting NWSG, you should evaluate the existing seedbank for at least 3 years after killing existing nonnative cover. Most often, desirable species respond and planting is not necessary.

Disking, prescribed fire, and herbicide applications are effective at renovating planted NWSG stands and improving their value for wildlife. The specific problems associated with a given NWSG stand will dictate which habitat management tool(s) should be used. In certain situations, a combination of techniques will be most effective to improve composition and structure. Herbicides should be considered along with other practices to selectively control undesirable species. They should not be relied upon solely for managing planted NWSG stands. By considering all the habitat management options collectively when making management decisions, you will be more successful in improving the quality of the early successional plant communities on your property.

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APPENDIX A: Management uses for various herbicides in native warm-season grass stands

Herbicide Active Ingredient \ Management Use	Thin native grasses	Johnsongrass	Other WSG	Cool-season grasses	Nonnative Thistles	Crownvetch	Sericea lespedeza	Wild parsnip	Common broadleafs	Pioneer woody plants	Nonnative olives	Bush Honeysuckle	Multiflora Rose	Callery Pear	Bicolor Lespedeza
Grass selective															
clethodim		X	M	M											
fluazifop-P-butyl		M	M	M											
sethoxydim		M	M	M											
Broadleaf selective															
2,4-D					M	X		X	X						
2,4-D + triclopyr					X	X		X	X						
clopyralid					X				X						
clopyralid + 2,4-D					X				X						
dicamba					X			X	X						
dicamba + 2,4-D					X			X	X						
triclopyr						X	X		X	X	X	X	X	X	X
triclopyr + fluroxypyr							X		X	X	X	X	X	X	X
Broad-spectrum selective															
aminopyralid					X	X			X	X					
aminopyralid + 2,4-D					X	X			X	X					
aminopyralid + metsulfuron methyl					X	X	X		X	X			X		X
imazapic		X	X	X					X						
imazapyr	X	X	X	X				X	X	X	X	X	X	X	
metsulfuron methyl						X	X	X	X	X			X	X	X
metsulfuron methyl + 2,4-D + dicamba							X		X	X			X	X	X
metsulfuron methyl + chlorosulfuron							X		X	X			X	X	X
sulfosulfuron		X	X												
Broad spectrum															
glyphosate	X	X	X	X	X	X	X	X	X	X		X	X	X	X

M = multiple applications are required to provide adequate control

APPENDIX B: Active ingredients, trade names, application rates, and application timings for herbicides used for managing native warm-season grass stands

Active ingredient	Trade Name	Rate per acre for various applications*	Timing	Additional Information
Grass selective				
clethodim	Clethodim 2EC, Select Max	6–16 oz; 10–16 oz; perennial grass	Cool-season grass: Oct–Nov and Mar-Apr; Warm-season grass: May–Jun	May be applied when annual grasses are 2–8 inches. Multiple full-rate applications required for perennial grasses. Second application should be 2–3 weeks after first application. Add crop oil concentrate at 1qt/acre to tank mixture for perennial grass control.
fluazifop-P-butyl	Fusilade DX, Ornamec	8–24 oz; 10–24 oz; perennial grass	Cool-season grass: Oct–Nov and Mar–Apr; Warm-season grass: May–Jun	May be applied when annual grasses are 2–8 inches. Multiple applications ≥10 oz per acre necessary for some annual grasses. Multiple full-rate applications required for perennial grasses. Second application should be 2–3 weeks after first application.
sethoxydim	Poast Plus	1.5–3.75 pt; 2.25–3.75 pt, perennial grass	Cool-season grass: Oct-Nov and Mar-Apr; Warm-season grass: May-Jun	May be applied when annuial grasses are 2–8 inches. Multiple full-rate applications required for perennial grasses. Second application should be 2–3 weeks after first application. Add crop oil concentrate at 1pt/acre to tank mixture for perennial grass control.
Broadleaf selective				
2,4-D amine	2,4-D Amine 4, Clean Amine, Shredder Amine 4	2–6 pt; 2–4 pt, annuals; 4 pt, wild parsnip; 4–6 pt, perennials including thistles (suppression)	Fall (rosette; Oct–Dec) Spring/Summer (rosette to flower; Mar–Jul)	Apply to annuals when actively growing until bud stage. Apply to biennials or perennials from rosette to bud stage. Multiple applications required to control thistles and some perennials. Does not control sericea lespedeza. Amine formulations provide slightly less weed control compared to ester formulations, but are less likely to volatilize.

*Recommended rates of application are based on herbicide labels. Rates will vary between herbicides with the same active ingredient because of differences in the percent active ingredient. For example, Arsenal and Arsenal AC both contain the active ingredient imazapyr, but Arsenal has 28.7% imazapyr compared to 53.1% imazapyr in Arsenal AC. Check the herbicide label to verify rates prior to use.

APPENDIX B: Active ingredients, trade names, application rates, and application timings for herbicides used for managing native warm-season grass stands

Active ingredient	Trade Name	Rate per acre for various applications*	Timing	Additional Information
2,4-D ester	2,4-D LV 4, Barrage HF, Five Star, Salvo	2–4 pt; 1–2 pt, annuals; 2–4 pt, biennial and perennials; 2–4 pt, wild parsnip and Canada thistle (suppression)	Fall (rosette; Oct–Dec) Spring/Summer (rosette to flower; Mar–Jul)	Apply to annuals when actively growing until bud stage. Apply to biennials or perennials from rosette to bud stage. Multiple applications required to control thistles and some perennials. Does not control sericea lespedeza. Ester formulations penetrate the cuticle better than amine formulations, but are more likely to volatilize. Avoid spraying in hot and dry conditions.
2,4-D + triclopyr	Chaser, Crossbow, Crossroad	1–4 qt, annuals; 4 qt, perennials; 4 qt, wild parsnip and Canada thistle (suppression); 1.5–2 gal, woody species	Fall (rosette; Oct–Dec) Spring/Summer (rosette to flower; Mar–Jul)	Best results when applied to biennial, perennial, or winter annuals during the rosette stage. Applied to other plants when actively growing. Suppression of goldenrod, perennial sowthistle, Canada thistle, and most woody species.
clopyralid	Clean Slate, Stinger, Transline	0.25–1.3 pt; 0.25–0.5 pt, bull and musk thistle; 0.67–1 pt, Canada thistle	Fall (rosette; Oct–Dec) Spring (rosette to flower; Mar–Jul)	Provides control of various annual and perennial broadleaf plants including cocklebur, curly dock, dandelion, jimsonweed, sicklepod, spotted knapweed, nightshade, and vetch. Provides suppression for sowthistles and Russian knapweed.

*Recommended rates of application are based on herbicide labels. Rates will vary between herbicides with the same active ingredient because of differences in the percent active ingredient. For example, Arsenal and Arsenal AC both contain the active ingredient imazapyr, but Arsenal has 28.7% imazapyr compared to 53.1% imazapyr in Arsenal AC. Check the herbicide label to verify rates prior to use.

APPENDIX B: Active ingredients, trade names, application rates, and application timings for herbicides used for managing native warm-season grass stands

Active ingredient	Trade Name	Rate per acre for various applications*	Timing	Additional Information
clopyralid + 2, 4-D	Curtail	2–4 qt; 2 qt, thistles including Canada thistle; 3–4 qt other perennials	Fall (rosette; Oct–Dec) Spring (rosette to flower; Mar–Jul)	Provides control of various annual and perennial broadleafs, such as annual sowthistle, bindweeds, common burdock, curly dock dandelion, horsenettle, velvetleaf, cocklebur, nightshade, mustards, pepperweed, pennycress, spotted knapweed, and thistles. Suppresses perennial sowthistle.
dicamba	Banvel, Clarity, Vanquish	0.25–4 pt; 0.25–1 pt, annuals; 1–3 pt, biennials; 2–4 pt, perennials; 2–4 pt, Canada thistle (suppression) and wild parsnip	Fall (rosette; Oct–Dec) Spring (rosette to flower; Mar–Jul)	Use higher rates when applying to established annuals or biennials > 3 inches. Best control of biennials in rosette stage. Provides excellent control of annuals and biennials, but most perennials will require follow-up applications. Caution should be using dicamba as it may volatilize in hot and dry conditions and could potentially cause off-target injury.
dicamba + 2,4-D	Brash, Outlaw, Weedmaster	0.5–6 pt; 0.5–4 pt, annuals; 2 pt, thistles excluding Canada thistle 4–5.6 pt, perennials; 4–5.6 pt, Canada thistle (suppression) and wild parsnip	Fall (rosette; Oct–Dec) Spring/Summer (rosette to flower; Mar–Jul)	Apply to annuals when actively growing until bud stage. Apply to biennials or perennials from rosette to bud stage. Only provides suppression of Canada thistle.

*Recommended rates of application are based on herbicide labels. Rates will vary between herbicides with the same active ingredient because of differences in the percent active ingredient. For example, Arsenal and Arsenal AC both contain the active ingredient imazapyr, but Arsenal has 28.7% imazapyr compared to 53.1% imazapyr in Arsenal AC. Check the herbicide label to verify rates prior to use.

APPENDIX B: Active ingredients, trade names, application rates, and application timings for herbicides used for managing native warm-season grass stands

Active ingredient	Trade Name	Rate per acre for various applications*	Timing	Additional Information
triclopyr (amine formulation)	Element 3A, Garlon 3A, Remedy Ultra, Triclopyr 3A	1–12 qt; 1–4 qt, broadleafs; 1 qt, sericea lespedeza; 4–6 qt, woody control	Spring/Summer (May–Aug)	Applications during drought conditions may not be as effective. May also be used to control tall goldenrod when it dominates a stand. Also controls undesirable broadleafs, such as curly dock, crownvetch, bindweeds, sicklepod, and cocklebur. Effective for spot-spraying sericea lespedeza or woody plants. Max labeled rate is 12 qt/ac, but 4–6 qt/ac is sufficient to control most woody plants.
triclopyr (ester formulation)	Garlon 4, Element 4	0.5–8 qt; 1 qt, sericea lespedeza, 4–8 qt, woody control	Spring/Summer (May–Aug)	Most commonly used for cut-stump or basal bark applications, but can be used for foliar applications. May also be used to control tall goldenrod when it dominates a stand. Also controls undesirable broadleafs such as curly dock, crownvetch, bindweeds, sicklepod, and cocklebur. Effective for spot-spraying sericea lespedeza or woody plants. Label recommends adding a surfactant at 1–2 qts/acre for broadcast applications. Effective for spot-spraying sericea lespedeza or woody plants.

*Recommended rates of application are based on herbicide labels. Rates will vary between herbicides with the same active ingredient because of differences in the percent active ingredient. For example, Arsenal and Arsenal AC both contain the active ingredient imazapyr, but Arsenal has 28.7% imazapyr compared to 53.1% imazapyr in Arsenal AC. Check the herbicide label to verify rates prior to use.

APPENDIX B: Active ingredients, trade names, application rates, and application timings for herbicides used for managing native warm-season grass stands

Active ingredient	Trade Name	Rate per acre for various applications*	Timing	Additional Information
triclopyr + fluroxypyr	Pasturegard, Pasturegard HL, Tailspin	(Pasturegard HL) 1–4 pt; 1.5 pt, sericea lespedeza; 1.5–2 pt, woody control < 6 feet tall; 2–4 pt, woody control > 6 feet tall	Spring/Summer (May–Aug)	If woody stems are mowed, allow 9–12 months of regrowth before applying herbicide. Can provide control of woody species such as; blackberry, Callery pear, elm, locust, maple, persimmon, poplar, privet, nonnative olives, multiflora rose, shrub lespedezas, and willow. Effective for spot-spraying sericea lespedeza or woody plants. Pasturegard is 25% triclopyr and 8.6% fluroxypyr, whereas Pasturegard HL is 45% triclopyr and 16% fluroxypyr.
Broad-spectrum selective				
aminopyralid	Milestone	3–7 oz; 3–7 oz, various broadleaf weeds; 5–7 oz, crownvetch and thistles including Canada thistle	Fall (rosette; Oct–Dec) Spring/Summer (rosette to flower; Mar–Jul)	Apply in spring/summer when all plants have emerged until the flowering stage or in fall prior to frost. Can also provide control of spotted knapweed, sowthistle, and multiple thistle species. Also labeled for japangrass control.
aminopyralid + 2, 4-D	Forefront HL, Grazonnext HL	19–34 oz; 19–24 oz thistles excluding Canada thistle; 24–34 oz Canada thistle and wild parsnip	Fall (rosette; Oct–Dec) Spring/Summer (rosette to flower; Mar–Jul)	Provides improved control of biennial and perennial broadleaf weeds compared to 2,4-D. Spot apply up to 68 oz/acre to improve control of dense areas of problematic perennial broadleafs.
aminopyralid + metsulfuron methyl	Chaparral	1–3.3 oz; 1–2.5 oz, thistles excluding Canada thistle; 2–3.3 oz, Canada thistle, sericea lespedeza and wild parsnip; 3.3 oz, multiflora rose, black locust, and other woody plants	Sericea lespedeza: flowering (Aug–Sep); Canada thistle: emergence to flowering (Mar–Jun) and prior to killing frost (Sep–Dec); Other broadleafs (May–Aug); Woody plants: Spring–Fall (leaf expansion to fall color)	Most effective on broadleaf plants, but does control bahiagrass, annual ryegrass, and suppresses smooth brome. Most effective on thistles in spring from rosette to bolting stage.

*Recommended rates of application are based on herbicide labels. Rates will vary between herbicides with the same active ingredient because of differences in the percent active ingredient. For example, Arsenal and Arsenal AC both contain the active ingredient imazapyr, but Arsenal has 28.7% imazapyr compared to 53.1% imazapyr in Arsenal AC. Check the herbicide label to verify rates prior to use.

APPENDIX B: Active ingredients, trade names, application rates, and application timings for herbicides used for managing native warm-season grass stands

Active ingredient	Trade Name	Rate per acre for various applications*	Timing	Additional Information
imazapic	Plateau, Panoramic 2SL	2–12 oz; 8 oz (preemergence) johnsongrass; 12 oz (postemergence) johnsongrass; 8–12 oz, tall fescue, timothy, japangrass	Cool-season grass: Oct–Nov and Mar–Apr; Johnsongrass: Apr–May (preemergence), May–Jun (postemergence); Various grasses and broadleafs: Apr–Jun	Select native grasses and forbs are tolerant of imazapic at specific rates (see label). Apply at 10–12 oz/ac for dallisgrass, bahiagrass, and vaseygrass control. Can also control annual and perennial ryegrass. Does not control Kentucky bluegrass, orchardgrass, quackgrass, and smooth brome.
imazapyr	Arsenal, Arsenal AC, Polaris, Polaris AC	Arsenal) 1.5–6 pt; 2–3 pt, fescue, johnsongrass, Kentucky bluegrass, orchardgrass, quackgrass, smooth brome, various broadleafs; 3–4 pt, cogongrass, thinning native grasses; 4–6 pt, bahiagrass, bermudagrass; 4–6 pt, woody plants	Cool-season grass: Oct–Nov and Mar–Apr; Exotic warm-season grass: May–Jul; Thin NWSG; May–Jun and Aug–Sep; Woody Control: Jun–Sep	Imazapyr is soil active and may damage desirable overstory trees by translocation through the root system. Therefore, do not spray imazapyr within the dripline of desirable trees. Many Rubus species and legumes are somewhat tolerant of imazapyr. Arsenal AC® is Applicator's Concentrate and has 2x the active ingredient of Arsenal.
metsulfuron methyl	Escort XP	0.33–3 oz; 0.33–0.5 oz, crownvetch; 1 oz, sericea lespedeza, musk thistle; 1.5–2 oz, Canada thistle (suppression), wild parsnip; 2–3 oz, ash, black locust, Callery pear, elm, multiflora rose, maple, willow, yellow poplar	Sericea lespedeza: flowering (Aug–Sep); Other broadleafs (May–Aug); Woody plants: Spring–Fall (leaf expansion to fall color)	Many native grasses are tolerant to application. Applications to sericea lespedeza when the stand <50% flowering will compromise control. Provides control of problematic broadleaf species, including, sweetclover, wild carrot, curly dock, henbit, teasel, and poison hemlock.

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APPENDIX B: Active ingredients, trade names, application rates, and application timings for herbicides used for managing native warm-season grass stands

Active ingredient	Trade Name	Rate per acre for various applications*	Timing	Additional Information
metsulfuron methyl + 2,4-D + dicamba	Cimarron Max	0.25–1 oz Part A, 1–4 pt Part B; 0.25 oz Part A + 1 pt Part B, Canada thistle (suppression) and various broadleafs; 0.5 oz Part A + 2 pt Part B, sericea lespedeza, plumeless thistle, multiflora rose; 1 oz Part A + 4 pt Part B, suppression of ash, black locust, elm, and control of tree of heaven and yellow poplar	Sericea lespedeza: flowering (Aug–Sep); Other broadleafs (May–Aug); Woody plants: Spring–Fall (full-leaf emergence to fall color)	Cimarron Max is sold as 2 separate parts. Part A and Part B must be mixed together for application. Suppresses but does not control certain tree/shrub species. Apply to multiflora rose < 3 feet tall and after full leaf expansion.
metsulfuron methyl + chlorsulfuron	Chisum, Cimarron Plus, Report Extra	0.125–1.25 oz; 0.375–0.625 oz, sericea lespedeza; 0.625–1.25 oz, multiflora rose, plumeless thistle; 1.25 oz, suppression of ash, black locust, elm, and control of tree of heaven, willow, and yellow-poplar	Sericea lespedeza: flowering (Aug–Sep); Other broadleafs (May–Aug); Woody plants: Spring–Fall (full-leaf emergence to fall color)	Can be used on existing or newly established native grass stands. Apply to multiflora rose < 3 feet tall and after full leaf expansion.
sulfosulfuron	Certainty, Maverick, OutRider	0.75–2 oz; 1.33–2 oz, johnsongrass, quackgrass and other problematic grasses and forbs	Johnsongrass: May–Jun (prior to bolting); Quackgrass: Oct–Nov or Mar–Apr	Used both preemergence and postemergence on tolerant native grasses. Controls various grass and broadleaf weeds, including roughstalk bluegrass, downy brome, cheatgrass, cocklebur, wild mustard, and quackgrass.
Broad-spectrum				
glyphosate	Round-up, Accord, and others	0.5–5 qt; 1.5–2 qt, thin native grasses, control sericea lespedeza; 2–3 qt, cool-season and warm-season perennial grasses, Canada thistle; 3–5 qt, woody control	Native grasses (thinning): May–Jun or Aug–Sep; Exotic warm-season grasses: May–Jul; Cool-season grasses: Oct–Dec or Mar–Apr; Canada thistle: rosette stage (Sep–Nov) or during bud stage (May–Jun); Sericea lespedeza: May–Jun; Various herbaceous weeds: Apr–Aug; Woody plants: full-leaf emergence (Apr–Jul)	Can be used to thin native grasses in stands with little to no forb component or where sericea lespedeza is also present. Spot-spray applications of 1%–2% solution can control most problematic species. Used as a follow-up application for most nonnative warm-season perennial grass control. Some species (ragweeds, pigweeds, horseweed) have become glyphosate resistant and may not be controlled.

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