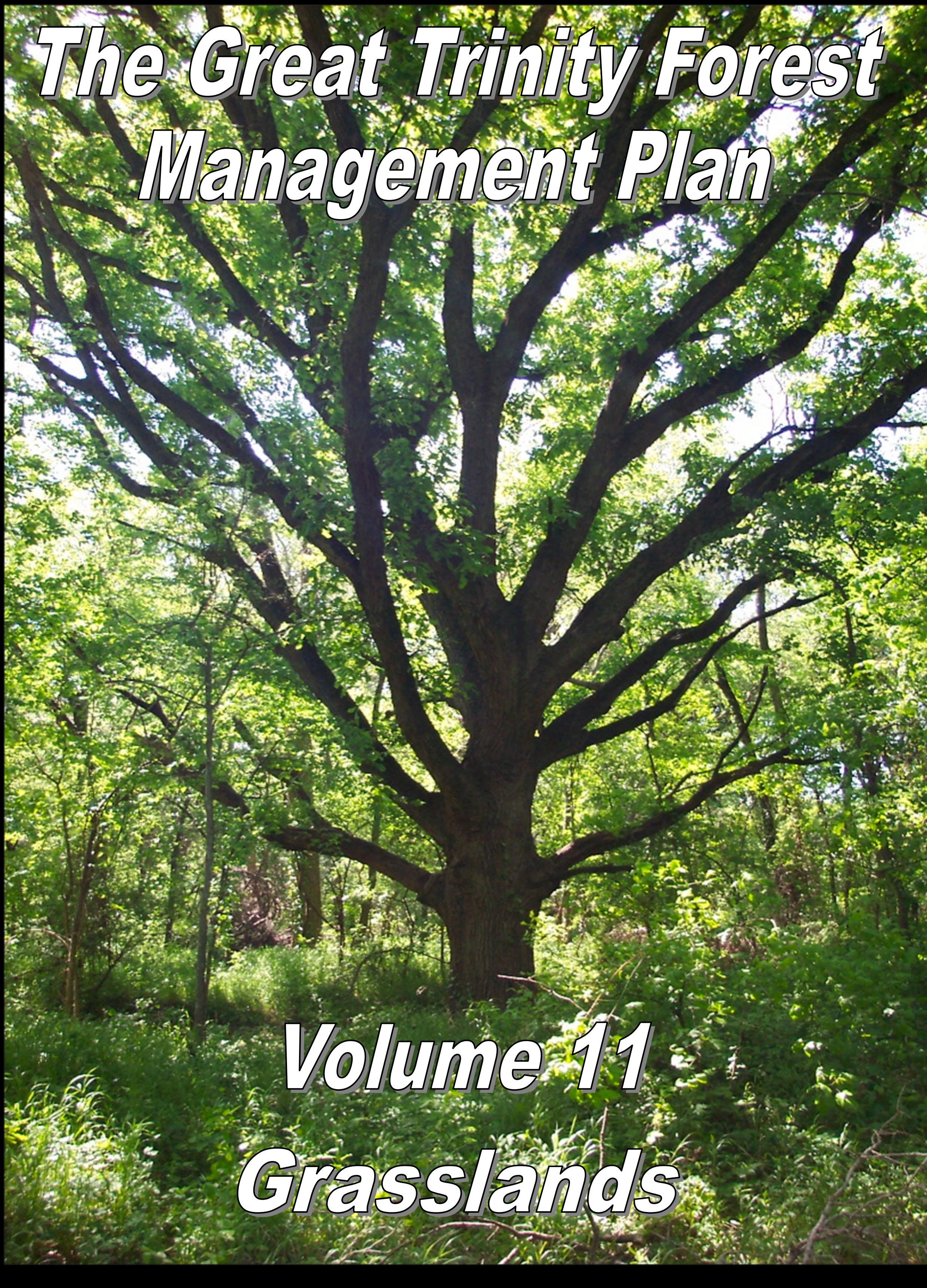


The Great Trinity Forest Management Plan

Volume 11

Grasslands

GREAT TRINITY FOREST

Grasslands

Volume 11

Table of Contents

Great Trinity Forest Management Plan

Grasslands

Introduction

Grasslands are open areas that are dominated by grass and are relatively free of trees and shrubs. These areas are an important part of the ecosystem providing habitat for many unique species as well as promoting groundwater recharge, protecting water quality, controlling erosion and storing atmospheric carbon. These areas also can be economically productive by providing forage for livestock, hay and biofuels. Unfortunately this habitat type has dramatically declined to approximately 50% of the almost 1 billion acres that used to cover the United States. Today, these areas are still being destroyed and degraded by fire exclusion, the spread of exotic and invasive plant species, fragmentation, urban development, overgrazing, brush encroachment and conversion to row crops and non-native pastures.

Grasses are usually divided into two types: warm season and cool season grasses. Warm season grasses were the main component of native grasslands and are very drought tolerant, well adapted to many sites and need very little maintenance once established. The peak growth periods of these grasses occur from June to August and they provide excellent wildlife habitat mainly because of their growth form. Bunch grasses provide excellent cover for nesting and brood rearing while providing bare ground between the plants. Cool season grasses were introduced by settlers in the late 1800s. These grasses grow best when it is cool and moist and go dormant in the summer months. Unfortunately, these species need rich soil or fertilization and generally provide less than optimum wildlife habitat.

The following is an overview of literature pertaining to restoring grasslands; however, it is not all inclusive. Therefore, when restoring an area to grassland, experts from such agencies as the Texas Parks and Wildlife Department and the Natural Resources Conservation Service should be contacted.

(Conner et al. 2001, Hays et al. 2004, Ryan and Marks 2005, Rothbart and Capel 2006, Harper et al. 2007, Stony Brook-Millstone Watershed Association 2007)

Before Starting

Before restoring or enhancing a grassland site it is important to consider the following:

1. Objectives: Some objectives may include improving water quality, water quantity or wildlife habitat. The objectives can help determine which plant species should be planted and how the area should be maintained.

2. Site condition: The topography, drainage, soil type, species present, history, climate, potential future use, and management tools that may be used must be determined. This is a very important step since these factors will determine if the area can be restored, site preparations needed and what species would be best suited to the site. Sites with extreme surface temperature, droughty soil and sites without sufficient water and soil depth should be avoided. An inventory of species will help determine if the site needs to be seeded. If less than 10% of the existing vegetation is desirable species or previous enhancement attempts have failed, then the area should be seeded. However, if more than 10% of the existing vegetation are desirable species then the site can be managed to increase theses species. Another natural source of seed is the seedbank, which is the collection of seeds in the top few inches of soil. This is a good management option that can be used if there are not enough desirable plants, since many species seed can last over 100 years in the seedbank. Other factors, such as history of the site,

will determine any potential management problems, such as herbicide carry over or potential weed problems.

3. Accessibility and Resources: It must be determined whether heavy equipment can be brought into the field, if needed equipment and man-power are available, and if appropriate grass seed is available.

(Rector 2000, Rothbart and Capel 2006, Stony Brook-Millstone Watershed Association 2007, Harper et al. 2007)

Seed Selection

When selecting the seed mixture it is important to consider what species will be best suited to the site, the objectives, the availability of the seed, and the site preparation and maintenance that the species may require. For example, warm season grasses are not suitable on sites that are continuously flooded or on heavily compacted soils with more than 30% clay. Therefore, Rothbart and Capel (2006) suggest planting big bluestem, little bluestem, indiangrass and switchgrass on warm, well drained sites and eastern gamagrass, switchgrass and wild rye on cool, poorly drained sites. It is also important to choose species that are adapted to the local area and occur in that ecological region in order to reduce the risk of failure. To be certain that a species is adapted to the area, seeds should be chosen that originated no more than 200 miles north or south and 100 miles east or west of the area to be planted. Some species that Brown et al. (2007) recommend for central Texas include big bluestem, Indiangrass, sideoats grama, switchgrass, native sunflower and Engelmann daisy. If one of the objectives is wildlife then a diverse mixture of grass species along with legumes and wildflowers would be best since a variety of species means that the area will have a stable seed source, a better insect population and a diverse environment that will provide habitat for many wildlife species. For more information on range plants see Ragsdale and Welch 2000, Welch et al. (2001) and Harper et al. (2007).

(Rector 2000, Rothbart and Capel 2006, Brown et al. 2007)

Site Preparation

Prior to seeding, site preparation activities that can be preformed include fertilization, weed control and seedbed preparation. If fertilization is necessary then Rothbart and Capel (2006) suggest only applying potassium and phosphorus since nitrogen will stimulate the growth of weeds. For weed control, it usually will be most effective to use a combination of activities such as plowing, disking and herbicide; however, it is important not to stimulate weed seeds in the seed bank by disking too deep. If brush is a problem then activities such as root plowing and roller chopping can be used.

Seedbed: An ideal seedbed is firm below seeding depth, free from live plant competition and has moderate mulch or plant residue. If broadcasting seeding method is used then the seedbed should be prepared with conventional tillage techniques and should be cultipacked before and after seeding. If drilling is used then the seedbed needs to be firm and clean. No matter which method is used the seedbed should be properly compressed so seeds will be planted at the proper depth, providing sufficient contact with soil and increasing seedling survival. This can be accomplished by using mechanical means or by allowing sufficient time for the soil to naturally settle after a disturbance. For example, Rector (2000) suggests that if the area is to be planted in March or April then the seedbed should be prepared in late August or September. If heat or wind is a problem, then a crop such as sorghums and small grains can be used to protect the soil and create dead litter mulch.

Converting coastal bermudagrass pastures to grassland:
When converting a non-native pasture, such as coastal bermudagrass, the grass should be burned, mowed and heavily grazed during winter and herbicided in the spring once it is actively growing (when soil is 65˚F). Hays et al. (2004) suggests using glyphosate (41% active ingredient) at a rate of 4 quarts per acre on sandy soil and 6 quarts per acre on clay soil once the grass is 6 inches high and the weather is hot and humid. Hays et al. (2004) then suggests seeding 2 weeks after applying the herbicide at a rate of 6-7 pounds of live seed (PLS) per acre either by using no till drilling into the dead sod or disking the area and broadcasting double the amount of seed. If the weather is not favorable or if more than one herbicide application is needed, then the seeding can be delayed until late winter or early spring.

(Rector 2000, Welch et al. 2001, Hays et al. 2004, Rothbart and Capel 2006, Brown et al. 2007, Harper et al. 2007)

Seeding

Percent of live seed (PLS) and Seeding Rate:
Seeds should be bought and seeded based on percent of live seed (PLS) which is (% pure seed * % total germination) /100. To determine how many pounds per acre of bulk material from the seed bag to plant in order to plant the recommended PLS, use this formula: [desired rate ÷PLS] × 100. This is a very important step since not planting enough seed can cause failure of the stand. The seeding rate is determined by the species and objectives but most warm season grasses are seeded from 5 to 12 Ibs of PLS per acre, which equals about 30 to 60 seeds per ft^2. Legumes and wildflower can be added to the grass seed mixture at approximately 1 Ib of PLS per acre. Seeding rate may also be obtained from a seed dealer or local NRCS office.

Dormancy:
Another factor to consider is the dormancy of the seed, which is indicated by the germination rate. If the seed has a germination rate less than 50%, then germination can be increased by cold stratification (which is described by Harper et al. 2007) or by buying pre-treated seed. It is also important that the seed mixture has no noxious weeds, which is indicated on the tag.

Depth:
Seeds are usually planted from 1/4 to 1/2 inch deep but not usually deeper than 3/4 inch. A good rule is to plant a seed at a depth four to seven times the diameter of the seed. When using a mixture of seed sizes, use the smallest seed to determine depth. If the seed is broadcasted, do not disk the area since this will bury the seeds too deep; instead, cultipack the site.

Methods:
Two seeding methods are broadcasting and drilling. Broadcasting is when the seed is scattered over the soil surface. This method can be done from the ground or aerially but it is most effective if the soil is disturbed before seeding. Drilling is when the seed is placed in the ground by a machine. This method is best since it will provide adequate soil contact and better germination success but may not be practical

for large areas or in rough terrain. Grasses, such as big bluestem and indiangrass, with fluffy seeds need special equipment so the seeds will not clog the machine. Rothbart and Capel (2006) suggest adding a light rate of oats or an inert carrier to the seed mix so the machinery will not get clogged; however, other sources state that this method produces mixed results. If the area is being restored using the seed bank, then the non-native cool season grasses need to be removed with herbicide. Then the area should be burned and then disked to stimulate the seeds in the seed bank

Timing:
Native warm season perennial grasses should be planted from March to May but only if there is sufficient moisture in the soil and if the forecast calls for adequate rainfall. Cool season grasses may be planted in the late summer or early fall.

(Rector 2000, Welch et al. 2001, Rothbart and Capel 2006, Brown et al. 2007, Harper et al. 2007)

After seeding

During the first year after planting, mow in early spring and maintain the grass at a height of 8 to 10 inches until the warm season grasses show evidence of growth. Once the warm season grasses start growing the area can still be mowed but cut higher so the desirable grasses are not cut. If weed control is needed after planting then weeds can be controlled using a selective herbicide, mowing or shredding but the area should not be grazed or burned until the stand is established. Once the grasses are established, which takes about 2 to 3 years, then the area can be maintained with rotational mowing, disking, prescribed burning, grazing and herbicide, which will create a mosaic of habitat types and keep the grass from becoming too dense. It is important to remember that the grasses will not show considerable aboveground growth until the second growing season, so remember to be patience and only evaluate the success of the seeding after it has had time to establish.

(Welch et al. 2001, Harper et al. 2007, Stony Brook-Millstone Watershed Association 2007, Rothbart and Capel 2006)

Management Options

Mowing and Haying

Mowing and haying are good management options for controlling weeds and woody plants as well as creating a mosaic of habitat types. It is important not to mow or hay the entire area at one time, instead the site should be divided into sections that are mowed or hayed every 2 to 3 years. This rotational management strategy provides habitat for many different species as well as cover and food throughout the year. The timing of management is also very important and depends on the objectives of the landowner; however, any mowing activities should be postponed until after the peak nesting and rearing season of ground nesting birds and mammals, which varies by region but can last until late summer in Texas. If the area is being used for haying then warm season grasses such as big bluestem, little bluestem and indiangrass, should be cut in late June while cool season grasses are usually cut in May and June.   If the area is being managed for wildlife then mowing should be conducted in the late summer or late winter to maximize the benefits for wildlife and minimize mortality. To control woody plants, the area can be mowed in late winter (February or early March) or early fall (September). To control weeds, the area can be spot mowed while the weed species is flowering. No matter when the area is mowed or hayed, unmowed areas should be at least 10 feet wide and at least a half-acre in size to prevent an increase in predation. Other beneficial activities for wildlife include placing a one foot high bar in front of any tractor to flush wildlife, raising the blades to at least 10 inches to allow grass to recover and allowing the grass to flower and seed every few years. Also, if clippings are not removed then they should be spread thinly since it can shade and smother plants, which will allow for erosion and weed invasion. To prevent the spread of exotic and invasive weeds it is important to clean all machinery.

(Eddy 2002, Pennsylvania Game Commission 2006, Rothbart and Capel 2006, Brown et al. 2007, Harper et al. 2007)

Prescribed Burning

This is a very effective management tool which can control woody plants, remove vegetative litter, increase diversity of forbes, produce succulent vegetation, promote vigorous warm-season grass growth and release nutrients back to the soil. To create a diverse habitat, prescribed burning should be used every 3 to 5 years or 1/3 to 1/5 of the area can be burned each year. This management option can be used in early spring, late summer or fall depending on the goals and conditions of an area but nesting and rearing season should be avoided. Advantages of burning in March and early April is that the nesting season will not be affected, the wildlife will only have a short time without winter cover and it will stimulate rapid new growth. Burning in the late summer will also not impact the nesting season, it will increase the amount forbs and will reduce woody competition; however, it will increase smoke production and decrease grass density. It is important to only conduct prescribed burns with appropriate technical assistance, equipment and in accordance with all state and local laws. For more information on conducting a prescribed burn and its effects of the environment see the Prescribed Burning section of the Great Trinity Forest Management Plan.

(Natural Resources Conservation Service 1999, Eddy 2002, Rothbart and Capel 2006, Brown et al. 2007, Harper et al. 2007)

Disking

This management option provides many of the same benefits as prescribed burning and is useful where burning is not possible. The goal of disking is to cut the existing vegetation, incorporate at least 1/2 of the vegetation into the soil and to expose the soil. This option should be done every 3 to 4 years by disking the entire field or disking only 1/4 to 1/3 of the site each year. One important consideration when using this option is timing, since this will influence the specie composition of the site. For example, disking before March stimulates desirable forbs while disking after March can stimulate undesirable grasses. The intensity is another important consideration. This depends on the equipment, the soil texture and soil moisture. If a heavy offset disk is used then 1 or 2 passes may be all that is needed. But if a tandem disk is used then 5 to 10 passes may be needed. Clay soil, especially if dry, will require more passes than other soil types. If dense vegetation is present then more passes may be needed or the vegetation will need to be mowed or burned before disking.

(Harper et al. 2007)

Grazing

Grazing creates disturbance which will allow the area to have greater species and structural diversity. However, it is very important not to overgraze an area since this will lead to erosion, reduced invertebrates, diversity, plant vigor and increase weed invasion. To prevent overgrazing, a rotational grazing system should be used since it allows for adequate vegetation recovery and a mosaic of habitat types. Brown et al. (2007) and Hanselka et al. (2000) describe several rotational systems that can be adapted to fit the objectives and needs of an area. But before a plan is implemented the timing, intensity and duration should be considered. Harper et al. (2007) suggests starting grazing when the grass is 24-30 inches tall; but grazing can be started when the grass is 12-18 inches tall with lighter stocking rates. Once the grass is 8-10 inches tall the livestock should be removed and the area should be rested for at least 4 weeks. As with the other management options, grazing should be avoided during peak nesting and rearing season and grasses should be allowed to flower and seed. It is also important to not graze an area until it is established (1-3 years) and to quarantine livestock so undesirable plant species are not introduced into the area.

Overbrowsing by wildlife species can also damage grasslands and may need to be controlled by harvesting the species, providing supplemental food or discouraging the species' presence. To determine if an area is being overused, you can utilize browse indicators such as degree of use, hedging, browse lines and presence or absence of seedlings. The degree of use should indicate that 40-65% of the current season's growth is removed. There should only be moderate hedging and shrubs and trees should not have a browse line. Another indication of over- browsing is when low preference browse species show high browse pressure.

(McGinty 2000, Welch et al. 2001, Eddy 2002, Rothbart and Capel 2006, Brown et al. 2007, Harper 2007)

Weed Control

Weeds (broadleaf herbaceous plants) compete with grasses for nutrients and other resources so they are generally considered to be undesirable. However, these plants are important for many wildlife species and should not be completely removed from the site. If the area has not been seeded yet, then a combination of mechanical and chemical methods will be most effective. Stony Brook-Millstone Watershed Association (2007) suggests disking the top several inches several times to damage the weed's root system and tops, yet it will not dredge up weed seed. Once the area is seeded, then herbicide, mowing and shredding can be used. To control and prevent weeds in a grassland it is also important to maintain groundcover, minimize soil disturbance, quarantine livestock, clean equipment and vehicles, and avoid introducing organic matter. To see details on weed management see McGinty et al. (2005), McGinty et al. (2000) and the Herbicide and Prescribed Burning sections of the Great Trinity Forest Management Plan.

(Brown et al. 2007, Stony Brook-Millstone Watershed Association 2007, Eddy 2002, Welch et al. 2001)

Brush Control

Brush are "shrubs and trees which are considered undesirable to the planned use of the area" (Nelle 1997). Without disturbance or proper management, brush species will take over an area. However, woody plants also supply cover and food for many wildlife species. Therefore, when planning and implementing a brush control plan, it is important to consider the wildlife species being managed for, the value of the brush species being removed and the benefits of leaving a few individuals to create islands or travel corridors. Some beneficial shrub species in central Texas include Texas mulberry, possumhaw, rusty blackhaw, black cherry and Carolina buckthorn.

When developing a brush control plan you need to set your objective, conduct an inventory, consider management strategies, analyze the economics of treatment and improve the system with feedback. To determine which management method or combination of methods will be the most effective and beneficial, it is important to consider the trees per acre, equipment needed, objectives, costs, species present, life of treatment, degree of control, and effects on the habitat and wildlife. Management methods may include prescribed burning, mechanical, chemical and biological methods. Mechanical methods, such as roller chopping and root raking, provide immediate results, but may only provide short term control especially if the root system is not removed or damaged and if the species will sprout. Chemical methods are those where herbicides are applied using aerial or ground methods to control woody species. The advantages of this method include little or no soil disturbance, a variety of application methods from which to choose, effectiveness. However, this method may suppress woody plants that are beneficial to wildlife and it can only be used during favorable weather conditions. Prescribed burning may also be used but this method usually does not kill many brush species. However, some advantages of this method include increased palatability of forage and minimal soil disturbance. Biological methods involve using natural enemies to control the target species. However, it is usually difficult to affect only the target species. One method that has been used successfully is goats since they will browse many woody species and can extend the effectiveness of mechanical treatments. For more details on these management methods see Koerth (1997), Wiedemann (1997), Welch (2000), McGinty et al. (2005), McGinty et al. (2007) and the Herbicide and Prescribed Burning sections of the Great Trinity Forest Management Plan.

(Koerth 1997, Nelle 1997, Wiedemann 1997, Hanselka et al. 1999, Welch 2000)

Other Management Options

Other management options that may need to be addressed on an area include:

1. Wildlife species management- Some wildlife species, especially in large numbers, can be detrimental to the plant and animal communities in grasslands. For example, rabbits, feral hogs and deer can cause significant damage to the vegetation and soil, while other species (such as cats, dogs, imported fire ants and brown-headed cowbird) can injure bird and small mammal populations. Other species may be desirable and may need to be increased by providing suitable habitat with abundant food, cover, space and water. For more information on wildlife

species management see Brown et al. (2007) and the Wildlife Management section of the Great Trinity Forest Management Plan.

2. Controlling Invasive and Exotic Plants- These species can outcompete native plants and become overabundant. As soon as an invasive or exotic plant is located the individual(s) should be removed with chemicals, mechanical methods or with prescribed fire,. For more information see the Invasive Species, Prescribed Fire and Herbicide sections of the Great Trinity Forest Management Plan

(Eddy 2002, Brown et al. 2007, Stony Brook-Millstone Watershed Association 2007)

Monitoring

Monitoring a grassland can reveal how the plant community responds to management activities and natural events, which can lead to improved management. To monitor an area a manager can use detailed measurements, photopoints, vegetation sampling or excluding small areas from management. Detailed measurement involves measuring botanical composition at some regular interval. This method is difficult and time consuming. However, it can reveal more subtle changes in the plant community. Photopoints involve taking periodic photographs of an area either yearly or seasonally, which will allow a manager to see changes in specie composition and structure or even to monitor specific situations. These photos, along with detailed notes on management activities and other conditions, can then be compared over time by looking for changes in brush, weeds, bare ground, species present and changes in erosion. Healthy grasslands have plenty of vegetation cover to prevent erosion and provide wildlife habitat as well as a large diversity of plant and animal species. Signs of an unhealthy grassland include pedicelled plants, bare ground, gullies and steep denuded stream banks. All of these signs indicate that erosion is a problem that needs to be addressed immediately. Other signs include browse lines and plant communities dominated by annual plants, both of which indicate an abused grassland ecosystem.

(McGinty and White 1998, McGinty 2000, Eddy 2002)

Appendix A

The following is a partial list of some of the larger native grass seed suppliers in Texas provided by Native Prairies Association of Texas <http://texasprairie.org/>.

Native American Seed http://www.seedsource.com

Bamert Seed Co. of Muleshoe 800-262-9892

Bob Turner Seed Co. of Breckenridge 817-559-2065

Curtis and Curtis in New Mexico has seed for west Texas.

Douglass King's Seed Co. of San Antonio 210-661-4191

Foster-Rambie Grass Seed of Uvalde 512-278-2711

George Warner Seed Co. of Hereford 806-364-4470

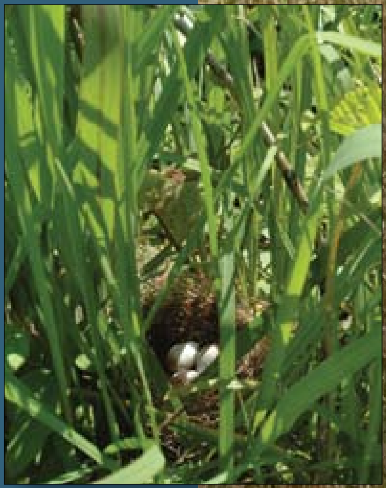
Harpool Seed Inc of Dallas 214-421-7181

High Plains Native Grass, Inc of Maple 806-927-5545

Sharp Brothers Seed Co. of Amarillo 806-352-2781

An up-to-date list of grass and wildflower seed suppliers and nurseries can be obtained from the Lady Bird Johnson Wildflower Center 4801 Lacrosse Avenue in Austin, 78739-1702 (512-292-4200). Or go to the Texas NRCS website, then click on plant materials information. It provides a list of many species native and exotic and suppliers.

$35



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Native Warm-Season Grasses

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a manual for natural resource professionals and other land managers

THE UNIVERSITY of TENNESSEE UT

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Contents

Preface

Native warm-season grasses (nwsg) have received a tremendous amount of attention since the early 1990s, especially among wildlife managers trying to enhance habitat for northern bobwhites, grassland songbirds and other early-successional species. During this time, much work has been devoted to improving methods for establishment, identifying sound management practices and documenting the response of wildlife to habitat restoration efforts. Also noteworthy during this period is the interest nwsg have generated among forage and livestock producers. Research continues to show various nwsg are viable forage for hay production and grazing for several livestock species. This manual is intended to provide in-depth information on identifying, establishing and managing nwsg for natural resources professionals, forage and livestock producers and other landowners attempting to grow and manage nwsg either for wildlife and/or livestock.

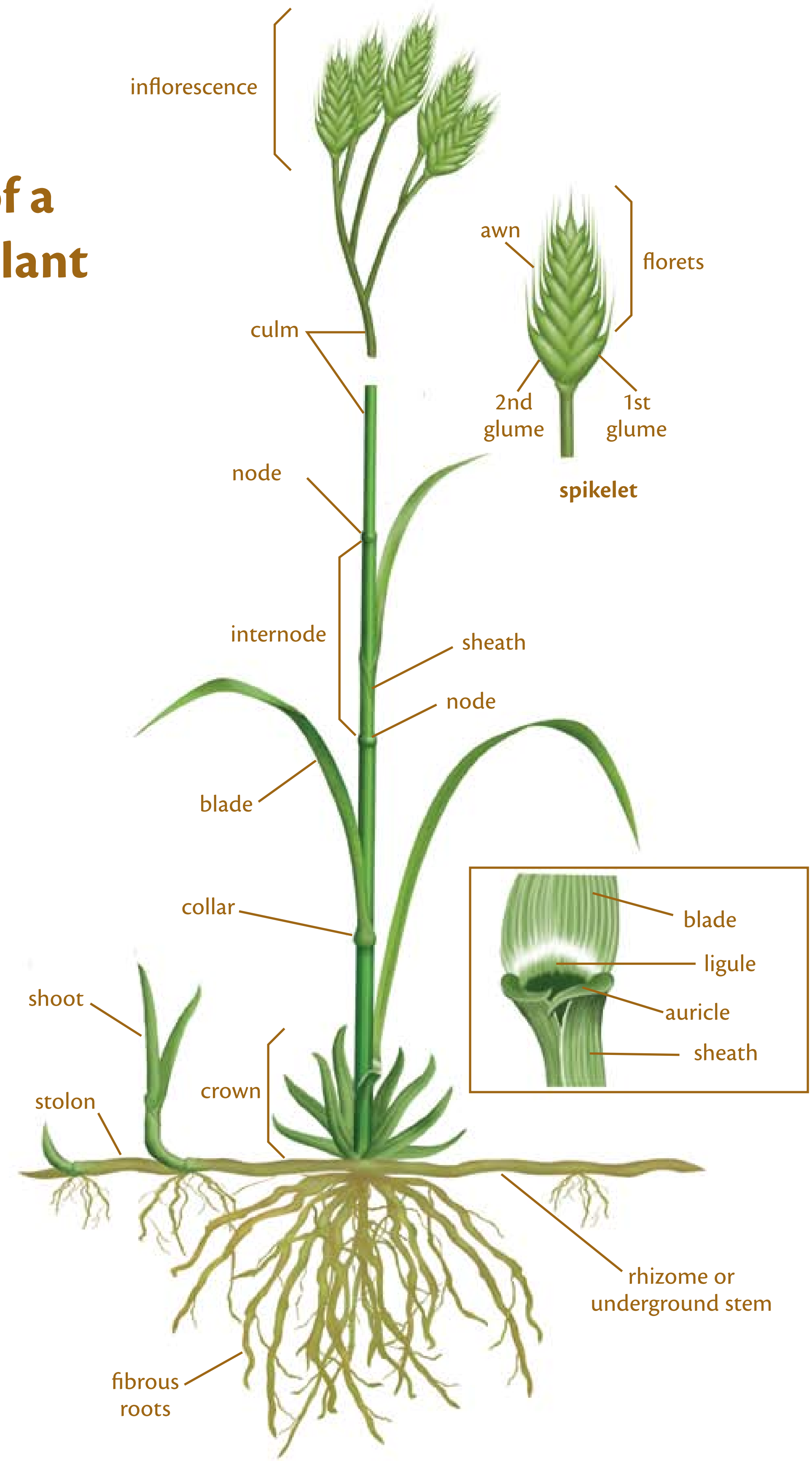
Introduction

Nwsg are grasses historically indigenous to an area that actively grow during the warm months of the year. In the Mid-South, that includes those warm-season grasses that occurred prior to European settlement. Many non-native grasses occur "naturally," but that doesn't mean they are native. Naturalized grasses originated outside a particular region, but are able to exist (and often thrive) in the wild (without cultivation) in self-perpetuating populations. Most naturalized grasses in the Mid-South were brought to North America from Europe (tall fescue, orchardgrass), Africa (bermudagrass, crabgrass) or South America (dallisgrass, bahiagrass) as a forage crop.

Grasses are classified as warm- or cool-season based on their chemical pathways for photosynthesis. Warm-season grasses fix energy into 4-carbon units and are referred to as C4 grasses. As a result, their photosynthetic potential is much higher than that of cool-season grasses. They make most of their active growth when minimum daily temperatures reach approximately 60 F and soil temperatures reach 55 F. The optimum temperature for warm-season grass production is 85 – 95 F. Nwsg are dormant during autumn and winter. Cool-season grasses fix energy into 3-carbon units and are referred to as C3 grasses. They make most of their active growth during fall and spring months when the minimum daily temperature is approximately 40 F. The optimum temperature for cool-season grasses production is 60 – 80 F. What this means is warm-season grasses grow more rapidly during a relatively short period, while cool-season grasses grow more slowly during a longer period.

Technically, the term nwsg could include numerous warm-season grasses native to the Mid-South region. Nonetheless, seven species are most commonly promoted for their value as cover for wildlife and/or forage for livestock. These include big bluestem, little bluestem, broomsedge bluestem, indiangrass, sideoats grama, switchgrass and eastern gamagrass. It is important to realize not all of these have the same quality for wildlife habitat or livestock forage. For example, broomsedge offers excellent nesting habitat for bobwhites, but poor forage for livestock.

Parts of a grass plant



Chapter 1

Identification and description

There is more than one suitable cultivar[1] of most nwsg within the Mid-South region. It is important to identify and determine the cultivar best suited for the intended use (whether wildlife habitat, livestock forage or both) and site conditions (such as bottomlands or dry uplands).

Fig. 1.1 The grand grass of the tallgrass prairie, big bluestem, was once quite prominent throughout the Mid-South.

Big bluestem
Andropogon gerardii

Big bluestem is a warm-season perennial that spreads by short rhizomes, creating clumps. Stems may reach 8–9 feet, depending on variety and site conditions. Growth begins in April; however, the majority of growth occurs after June 1. Growing points are close to the ground until late summer (after seedhead has formed) when they are 2–4 inches above ground. Leaves are long, flat and rough along the margins. The ligule is small and membranous; the sheath is somewhat flattened, open and usually hairy. One of the best features used to identify this grass before flowering is the presence of fine silky hairs on the sheath and widely dispersed on the upper leaf surface. The stem is usually purplish at the base and covered with fine hair. The seedhead is two or three distinct racemes on the top of the stem, resembling a turkey's foot. Awns make the seed appear

[1] For clarification, a cultivar (or variety) is an ecotype that has gone through years of testing before release by a plant materials center. Cultivars are tested and selected for specific characteristics such as disease resistance, forage yield, or plant vigor. An ecotype is a selection of pre-varietal materials and differs from other ecotypes in morphological and physiological traits, such as height, stem diameter or growth rate. A genotype refers to the hereditary make-up and characteristics of a pure line (no genetic manipulation) or variety.

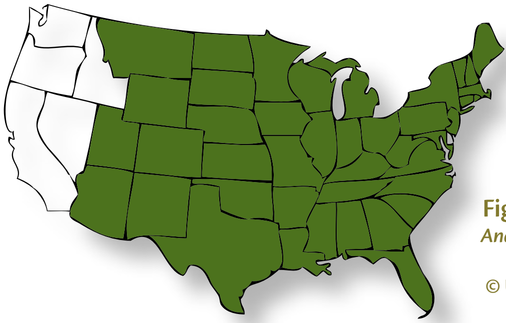


Fig. 1.2
Andropogon gerardii Vitman
Distribution by State
© USDA PLANTS Database

Fig. 1.3 Big bluestem can be identified fairly easily before flowering by the presence of small individual hairs at the base of the leaf.

Fig. 1.4 Big bluestem seed

"hairy." Big bluestem grows on a wide variety of soils, even on sites with a pH as low as 4.0. Big bluestem is extremely drought-tolerant, with root systems that may grow 12 feet deep. Cultivars of big bluestem adapted to the Mid-South region include:

Rountree — originally collected in Monona County (west central), Iowa and released for use in northern Missouri, Iowa and Illinois, this cultivar was developed for areas of the upper Midwest and eastern U.S. *Rountree* is well-adapted to the higher humidity levels of what once was the eastern tall grass prairie and prairie remnants of the north-eastern U.S. *Rountree* has a relatively short growing season, reaching maturity earlier than most varieties.

Niagara — originally collected in Erie County, New York, this cultivar was released for its superiority over Midwestern cultivars in the northeastern U.S. It is adapted to various soil types, but grows best on moist, well-drained, fertile loam. *Niagara* is tolerant of hot, dry conditions, low-phosphorus soils and low pH. Root development may reach deeper than 10 feet. For these reasons, *Niagara* is suitable for planting sand and gravel pits, strip mines and roadsides. *Niagara* has been grown successfully as far south as Tennessee, but is recommended from West Virginia to Maine.

Kaw — originally collected along the Kaw River in eastern Kansas, *Kaw* thrives in hot, dry conditions, shows superior leafiness and vigor, and is considered more disease-resistant than some big bluestems. *Kaw* tends to develop rust in eastern, high-humidity regions. It has a broader genetic base than *Niagara* or *Rountree*, thus *Kaw* matures over a longer period.

Earl — originally collected in Texas, this cultivar is adapted to all soil types in the South.

Oz-70 — originally collected in northern Arkansas and southern Missouri, this cultivar was released for its ability to grow in shallow, poorer soils. It has a very broad genetic base, including materials from all the regions where collected. *Oz-70* is expected to do well in the southern Appalachians and have very good rust resistance in high-humidity regions.

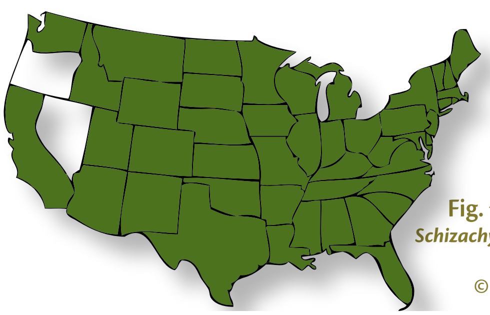


Fig. 1.5
Schizachyrium scoparium (Michx.) **Nash**
Distribution by State
© USDA PLANTS Database

Little bluestem
Schizachyrium scoparium

Little bluestem is a warm-season perennial bunchgrass that grows 2–4 feet in height. Primary growth occurs from mid spring through summer, reaching maximum height in July. Leaves are flat, often folded along the midrib, 6–10 inches long, less than ¼-inch wide, and bluish-green through early summer until stems begin to form. The ligule is small and membranous, resembling a ring of short hairs on some plants; the sheath is flattened, open and may be purplish at the base. The stem is flattened at base and often red or purplish during early growth. Mature plants are reddish-brown. The seedheads are racemes found singly, in pairs or in groups and are produced in early fall. Awns make the seed appear "hairy." Little bluestem grows on a wide

Charles Dixon

Fig. 1.6 By mid-summer, little bluestem becomes quite stemmy (if not previously hayed) and the red coloration begins to appear.

Fig. 1.8 Little bluestem seedheads are not partly enclosed in a spathe as are broomsedge seedheads.

Fig. 1.7 Little bluestem seed

variety of soils and is a very attractive grass in summer and fall. It has great potential for landscaping and erosion control on poor, droughty soils. The cultivar best adapted and marketed for the Mid-South region is:

Aldous — originally collected from the Flint Hills of Kansas, this cultivar is leafy and late-maturing. *Aldous* produces better stands than other varieties and none are more adaptable or hardier. However, new cultivars are needed for the Mid-South region where high humidity and low soil pH can affect production of *Aldous*.

Fig.1.9 This is a comparison of broomsedge (left) and little bluestem (right) in mid-October. The light tan color of broomsedge is most noticeable compared to the dark red stems of little bluestem. Color, however, may vary. Most important in distinguishing these species is the seedheads.

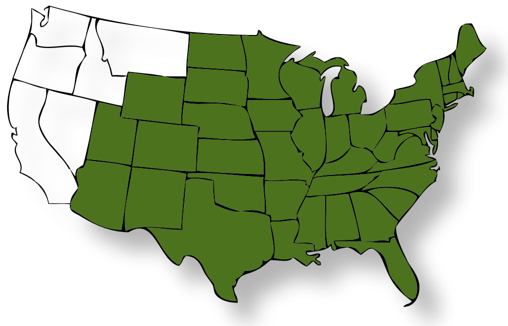


Fig. 1.10
Andropogon virginicus L.
Distribution by State
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Fig. 1.11 Broomsedge remains erect through winter better than any other native warm-season grass.

Broomsedge bluestem
Andropogon virginicus

"Broomsedge" is a warm-season perennial bunchgrass that grows 2–4 feet in height. Growth begins in spring when daytime temperatures reach 60–65 degrees F. Leaves are flat to partly folded (⅛–¼-inch wide) and may have sparse hairs at the leaf base on the upper side. The ligule is fringed and approximately 1/16-inch long; the sheath is flattened, overlapping at the base and usually pale yellowish-green. The stem is flattened at the base and smooth. Mature plants are tannish-brown. The seedheads are racemes partly enclosed in a large straw-colored spathe (reduced leaf or bract) as long as or longer than the raceme. Little bluestem does not have this spathe (**this is a definitive way to distinguish broomsedge from little bluestem after flowering**). Mature broomsedge appears lighter in color than little bluestem, which usually has a reddish hue. Also, the stem and leaves of little bluestem often appear narrower than those of broomsedge. When dormant, broomsedge appears quite orange-tan, while little bluestem is distinctly more reddish-brown. Broomsedge grows on a wide variety of soils and is renowned for growing in old-fields low in fertility.

Fig. 1.12 Broomsedge bluestem seed

Fig. 1.13 Indiangrass seed

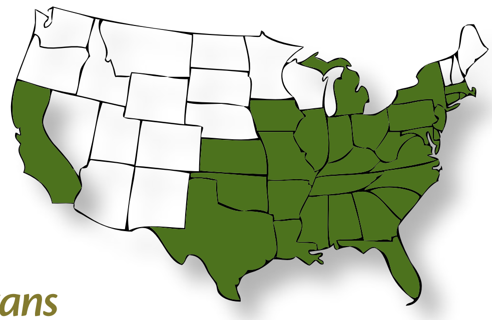

Fig. 1.14
Sorghastrum nutans (L.) Nash
Distribution by State
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Fig. 1.15 The golden seedhead of indiangrass is easily distinguishable and very attractive.

Indiangrass
Sorghastrum nutans

Indiangrass is a warm-season perennial that spreads by seed and short rhizomes; however, it normally occurs in bunches, much like big bluestem. Growth begins in April and, depending on site, will reach 3–7 feet in height. Leaves are flat and narrow at the base, growing 10–24 inches long. The ligule is quite prominent (up to ½ inch long) and notched at the tip, making it resemble the rear sight on a rifle—**this is one of the best features used to identify indiangrass before flowering**. The sheath is round and open and is generally shorter than the internodes. The seedhead of indiangrass is a beautiful golden bronze-to-yellow, tight panicle 6–12 inches long, usually formed in August. Awns may be ½ inch long, making indiangrass seed "bearded" and very fluffy. Indiangrass produces a deep root system, making this grass quite drought-tolerant. It is a heavy seed producer and one of the first perennial native grasses to re-colonize old-fields and disturbed soils if a seed source is nearby. Cultivars of indiangrass adapted to the Mid-South region include:

Fig. 1.16 Indiangrass has a very prominent ligule at the base of the leaf, unlike any other nwsg. This is a very good identifying characteristic before flowering.

Osage — originated from collections made in southeastern Kansas. It is a vigorous, leafy cultivar, well-adapted to drier climates. *Osage* is the latest-maturing cultivar of indiangrass and produces excellent forage, even during drought years.

Newberry — recently released cultivar from Newberry County, South Carolina intended for use in conservation buffers, wildlife habitat improvement and critical area stabilization.

Rumsey — originally collected in Jefferson County, Illinois for use in the Midwest, this cultivar is relatively late to mature, but displays rapid growth in mid- to late-summer.

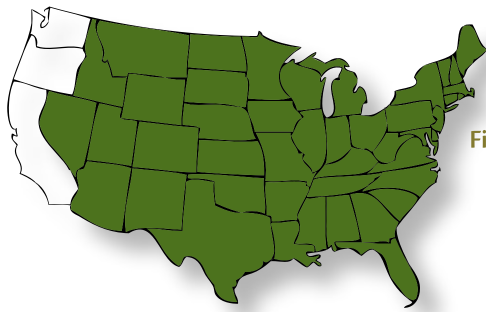

Fig. 1.17 *Panicum virgatum L.* Distribution by State © USDA PLANTS Database

Switchgrass
Panicum virgatum

Switchgrass is a warm-season perennial that typically grows to 3–7 feet high. Although switchgrass spreads by rhizomes (and seed), loose clumps or patches are usually formed. Switchgrass is an early-maturing warm-season grass (late May–early June); growth usually begins in April. The rhizomes, however, may grow actively from January–April. Growing points are 4–5 inches aboveground during the latter part of the growing season. Leaves are flat, ½ inch wide and sometimes up to 30 inches long. The ligule is often a fringe of short hairs with a dense patch of hair extending onto the upper leaf surface [**this is one of the best features used to identify switchgrass before flowering**]. The sheath is round and open and often purplish or red at the base. The seedhead is an open panicle, usually formed in late May through June. Switchgrass is adapted to a wide variety of soils and site conditions. With an extensive root system, switchgrass is extremely drought-tolerant, but also does well on relatively wet sites with some cultivars tolerant of extended flooding. Switchgrass can be divided into

Fig. 1.18 The ligule of many switchgrass ecotypes is a dense fringe of pubescence. This is an excellent characeristic for identifying switchgrass prior to seedhead formation.

Fig. 1.19 The seedhead of switchgrass is an open panicle, usually appearing in late May.

Fig. 1.20 Switchgrass seed

two broad types: upland and lowland. Lowland types are quite coarse and may lack the hair patch at the ligule as described above. Planted in monocultures, upland types tend to thrive for 10–15 years before declining in productivity. In mixtures, they may tend to dominate (depending on management) before declining into a more harmonious balance with other native grasses and forbs. Cultivars of switchgrass adapted to the Mid-South region include:

Cave-in-Rock — originally collected in southern Illinois, this upland-type cultivar was selected for its palatability and disease resistance. *Cave-in-Rock* is later-maturing than other switchgrass cultivars and grows best on fertile, well-drained soils. It is well-adapted to the high-humidity areas of the eastern U.S. *Cave-in-Rock* seed tends to have high dormancy.

Kanlow — lowland cultivar well-suited to the lowland sections of the South. *Kanlow* not only performs well on poorly drained sites and areas subject to periodic flooding, but also on upland sites. It can tolerate inundation for more than a month during the growing season and is often used along shorelines to reduce bank cutting and erosion. *Durham* — newly released from materials collected in Durham County, North Carolina, this cultivar is a tall, robust grass, which produces attractive foliage and a whitish panicle in the fall. *Durham* was selected primarily for conservation benefits, including wildlife habitat improvement, erosion control and ecological restoration; however, its use as a livestock forage has great potential.

Alamo — developed in Texas, this lowland-type cultivar matures relatively late, which ensures production into early fall. *Alamo* may reach 10 feet in height and its foliage is coarser than some switchgrass cultivars.

Blackwell — produces heavy roots and stems that make it an excellent choice for conservation use and wildlife cover. *Blackwell* is disease-resistant and produces lush foliage longer into the growing season than most varieties of switchgrass. It is also a relatively short variety, only reaching 3–5 feet in height.

Shelter — originally collected in West Virginia, this cultivar is adapted to provide nesting and escape cover for wildlife and possibly for biomass energy production. *Shelter* has short rhizomes; thicker, stiffer stems; and fewer leaves than other varieties of switchgrass. At maturity, *Shelter* reaches 4–6 feet in height, depending on soil conditions, and may remain erect through winter snow, rain and wind. *Shelter* is adapted to a variety of soil conditions, but grows best on well-drained or moderately well-drained sandy loam, silt loam or silty clay loam soils. Nonetheless, *Shelter* can tolerate long periods of soil saturation. *Shelter* is adapted to sites as far south as Tennessee, but does best from Virginia to Maine.

Fig. 1.21
Tripsacum dactyloides (L.) L.
Distribution by State
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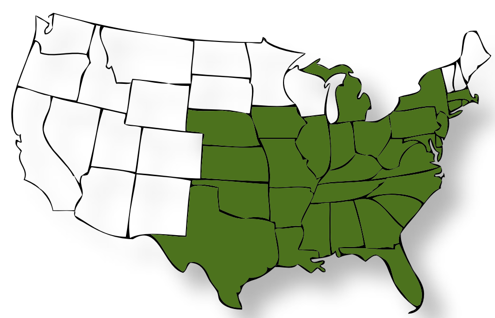


Eastern gamagrass
Tripsacum dactyloides

Fig. 1.22 Eastern gamagrass seedhead. Male flowers are still present. What will become seed is just below the male flowers.

Eastern gamagrass is a warm-season perennial that spreads by thick, short-jointed rhizomes, but produces conspicuous stools up to 4 feet in diameter. Over time, stool size increases with age and the center will lack stems and leaves. Eastern gamagrass starts growth in early spring, reaches a height of 5–9 feet and usually remains green until first frost. Leaves are flat, smooth, up to 1½ inches wide and 2 feet long and have a pronounced light-colored midrib. The ligule is a ring of short hairs; the sheath is flattened and open. The seedhead is comprised of two or three terminal spikes (sometimes one) 6–10 inches long. This seedhead resembles the central "stem" found on a tassel of corn, of which eastern gamagrass is a close relative. The female part of the seedhead is the lower one-fourth and the male part is on the upper three-fourths. The seed are sunken in the joints of the female portion and when mature, these joints separate with each part containing one seed. Eastern gamagrass grows

Fig. 1.23 Eastern gamagrass produces excellent forage for haying and grazing.

Fig. 1.24 Eastern gamagrass seed

best on moist, well-drained fertile soils but does not tolerate standing water for long periods. Cultivars of eastern gamagrass adapted to the Mid-South region include:

Pete — developed from seed collections in Oklahoma and Kansas, *Pete* is a superior seed producer.

Highlander — robust plant noted for disease resistance. *Highlander* is a recently released cultivar collected in Montgomery County, Tennessee. Seed should be available for planting in 2009.

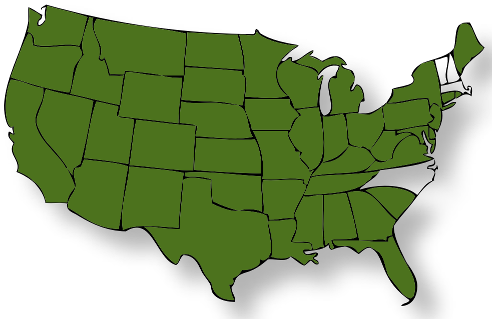


Fig. 1.25
Bouteloua curtipendula (Michx.) Torr.
Distribution by State
© USDA PLANTS Database

Sideoats grama
Bouteloua curtipendula

Sideoats grama is a warm-season perennial that spreads by short rhizomes. Growth begins in early spring, reaching a height of 1–4 feet. Leaves are flat, up to ⅛-inch wide and 4–8 inches long with small hairs present along the margins. The ligule is small and membranous with short hairs on top; the sheath is round, open and overlapping. Seedstalks appear between June and September. The oat-like seeds hang down uniformly along one side of the slender rachis, thus the name "sideoats." Sideoats grama typically has two growth forms: 1) short (8–14 inches) rhizomatous growth, which produces few seedheads and spreads by rhizomes; and 2) tall (16–48 inches), upright bunches with many seedheads, which reproduces by seed. Sideoats grama grows on a wide variety of soils, including well-drained uplands and shallow ridges. Cultivars of sideoats grama adapted to the Mid-South region include:

El Reno — produces strong leafy plants. *El Reno* is noted for its disease resistance and winter hardiness. Developed at Manhattan, Kansas from materials collected in north-central Oklahoma, it is probably the best-suited cultivar for the Mid-South.

Trailway — requires most of the growing season before seeding. *Trailway* is winter-hardy and relatively long-lived. Developed from materials collected in Nebraska, it does well far south of its origin.

Fig. 1.26 Sideoats grama provides excellent nesting cover for bobwhites and other birds. It persists best in a mixture with other relatively short grasses, such as little bluestem.

Fig. 1.27 Sideoats grama seed

Other native warm-season grasses

There are many other less-recognized nwsg that occur in the Mid-South. Their value to wildlife varies, but their value as forage is minimal. Some of the more common ones include: splitbeard bluestem (*Andropogon ternarius*), Elliot's bluestem (*Andropogon gyrans*), bushy bluestem (*Andropogon glomeratus*), purpletop (*Tridens flavus*), giant cane (*Arundinaria gigantea*), beaked panicum (*Panicum anceps*), paspalum (*Paspalum* spp.), silver plumegrass (*Saccharum alopecuroidum*), purple lovegrass (*Eragrostis spectabilis*) and several low panicgrasses (*Dichanthelium spp.*).

Fig. 1.28 Splitbeard bluestem

Fig. 1.29 Bushy bluestem

Fig. 1.30 Florida paspalum

Fig. 1.31 Deertongue

Fig. 1.32 Beaked panicum

Fig. 1.33 Low panicgrass

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

Chapter 2

Using native warm-season grasses to enhance wildlife habitat

Figs. 2.1 and 2.2 Native warm-season grasses and associated forbs can remain viable in the seedbank for many years. Many thousands of acres currently forested across the Mid-South were oak savannas just a couple of hundred years ago. This scene on the Catoosa Wildlife Management Area near Crossville, TN shows what timber thinning and annual burning can do in just five years. None of this area (1,000 acres) has been planted or sprayed, but the early-succession plant community has arisen naturally from the seedbank.

Native grasslands are the most endangered ecosystem in the Mid-South. As a result, several wildlife species associated with grasslands in this region (particularly grassland birds) have experienced steep, long-term declines. Establishing and managing nwsg can enhance habitat conditions for those species that need early successional habitats to meet various life requirements (see Appendix 1), especially when a variety of legumes, other forbs and shrubs are growing in association with the grasses. Many properties are managed specifically for wildlife, while on others, wildlife management is a secondary objective to farming or some other land-use practice. Regardless, nwsg can be used to meet objectives in both scenarios. The first step is to develop a comprehensive management plan that includes a current assessment of the property, future goals and objectives and a timeline for development. The necessary steps for developing wildlife habitat within the constraints of the goals and objectives then can be identified.

Figs. 2.3 and 2.4 Plenty of bare-ground space should be available in a field managed for wildlife. This allows better mobility for small wildlife, enables forbs to germinate from the seedbank, offers enhanced foraging habitat for seed and invertebrates, and provides dusting opportunities.

Benefits of nwsg over other cover types

Fields of nwsg are attractive to many wildlife species because of the **structure** presented. Simply put, nwsg are promoted for wildlife because they provide an excellent **source of cover**. The grasses themselves offer little as a food source and stands of **nwsg are not food plots**. Providing quality cover for wildlife is extremely important because cover is more often a limiting factor for wildlife than food. The availability and quality of cover on a property often limits the number of species (richness), as well as the number of individuals within a species (abundance). However, quality cover for one species may be quite different for another and the type of cover needed for one species often changes two or more times during the year (as described below). Fortunately, depending upon density, age, associated vegetation and management, nwsg can be used to meet several different cover requirements for many different species.

Structure

Because most nwsg grow in clumps or "bunches," open space at ground level can be provided when the grasses are not too dense. An open structure at ground level makes fields of nwsg and associated forbs especially attractive to small wildlife, including bobwhite quail and rabbits, as well as young wild turkeys. Mobility for animals no more than 6 inches tall is enhanced when the structure at ground level is open. Dense vegetation at ground level makes it difficult for these animals to travel and feed. A build-up of dead vegetative material (thatch) also precludes mobility of these animals. When faced with such habitat conditions, broods of quail, turkeys and grouse often use the periphery of a field instead of the interior. When these conditions prevail, available habitat, in essence, is removed; thus, the area's carrying capacity (the number of animals

Fig. 2.5 Insects and other invertebrates are the primary source of nutrition for bobwhite chicks and many other birds. Invertebrate abundance may be high, but that doesn't matter if invertebrate availability is low. Managing for the correct brood habitat structure that allows chicks to feed upon invertebrates should be the primary consideration, not invertebrate numbers.

an area can support) is reduced. Forced movement through such areas causes increased energy expenditure, which requires additional feeding to meet physiological and nutritional demands. Increased movement and exposure can lead to increased mortality, resulting from exposure to the elements, starvation and/or predation. All of this can result in stagnant or declining populations.

In addition to increasing mobility, an open structure at ground level facilitates feeding by broods and some songbirds, such as grasshopper sparrows, field sparrows, Henslow's sparrows and eastern meadowlarks. Invertebrates are the primary food of young broods; however, vegetation and seed become increasingly prevalent in the diet as broods mature. Seed is not available when a thatch layer is present, because quail do not scratch and turkeys do not begin scratching until approximately 4 months of age (about the time acorns begin to fall). When the structure at ground level is open with sparse bunches of nwsg and various forbs and the ground layer has been "cleaned" by burning, conditions for feeding and movement are optimum. Seed from legumes (and other desirable forbs) that have fallen to the ground then are available and insects and other invertebrates can be picked off surrounding vegetation easily. **It is important to realize open structure at ground level is determined largely by grass density and vegetation composition. In fact, optimum conditions for most species occur with only about 50 percent grass coverage. That means at least half the vegetative cover is forbs and scattered shrubs. The only way desirable vegetation composition and an open structure at ground level can be maintained is by periodic burning and/or disking.** Management techniques for nwsg are described on in Chapter 6.

Sparse stands of nwsg with an open structure at ground level are obviously attractive for brood rearing, but they are also used for nesting (remember: one bunch of nwsg represents one potential nesting site) if the field has not been burned or disked in the past year. In fact, senescent (dead) leaves of previous years' growth are used by birds and rabbits to construct and line nests. An attractive aspect of nwsg is that senescent leaves may remain erect into the following growing season (especially broomsedge). This serves three functions. First, thatch build-up is reduced when senescent leaves remain erect, enhancing mobility discussed earlier. Second, these

Fig. 2.6 Senescent grass from the previous year's growth is important nest building material for birds, such as this bobwhite nest.

leaves are readily available as nesting material. And third, some birds, such as Henslow's and field sparrows, dickcissels and indigo buntings, nest aboveground amongst the senescent flowering stems of the previous growing season.

Although moderately dense stands of nwsg may not be as attractive for brooding, they are used for nesting and escape cover. Obviously, these stands may have more potential as nesting sites than sparse stands, but they also offer more protective cover, especially during winter. Extremely dense stands, however, inhibit movement of some small animals and decrease in value for brooding, loafing, feeding and nesting cover. At this point, management is needed to thin the stand.

Adequate bedding and escape cover can be a limiting factor for white-tailed deer on some properties, especially where row-crop agriculture and/or cool-season pasture/hayfield is the dominant land-use practice. In these situations, deer often feed on rowcrops during the night, but travel one or more miles before dawn to bed and remain on adjacent properties with adequate cover during the day. Nwsg can offer excellent cover for deer to bed during the day. In fact, does readily use fields of nwsg to bed fawns in the summertime. Fawns remain still and bedded in the protective cover until the doe returns every few hours to allow nursing. Where quality fawning habitat occurs, fawn survival increases.

Fig. 2.7 Stems of big bluestem, indiangrass, and switchgrass often fall over and lodge through winter. This material provides cover for several wildlife species. There is a rabbit nest under these stems of big bluestem.

Fig.s. 2.8 and 2.9 Dense stands of nwsg may offer quality nesting and escape cover for many bird species. Brooding cover and food availability within these stands, however, is compromised. The structure and composition of dense nwsg stands can be improved with management.

The picture on the left shows dense nwsg in the 4th year after planting. The picture above is a section of the same field that was disked the previous May. The pictures were taken on the same day.

Importance of forbs and brush

It is important to realize the presence of forbs is critical in making a field of nwsg most attractive to wildlife. Blackberries, ragweed, pokeweed, partridge pea, native lespedezas and beggar's lice all produce quality seed, cover and forage for wildlife. While grasses provide structure for nesting and cover adjacent to the grass clump or bunch, many forbs (such as ragweed) provide a relatively wide protective canopy for quail and turkey broods and songbirds feeding and moving about underneath. For wild turkeys, this "umbrella canopy" is best when about 2–3 feet tall in June, covering the young brood, yet allowing the hen adequate visibility above the vegetation to detect potential predators. Later in the season, many forbs produce fruit and seed that are an important source of energy through the summer and into fall and winter. For deer, rabbits and groundhogs, forbs (especially legumes) offer more nutritious and palatable forage than grasses, with higher percentages of protein and total digestible nutrients.

Scattered brush and small trees also can make a field of nwsg and associated forbs more attractive to many wildlife species, particularly bobwhites

Fig. 2.10 Scattered brush is very important for many songbirds as well as bobwhite quail. Soft mast producers, such as this wild plum thicket, are particularly desirable.

Table 2.1 CP and ADF of selected forbs and grasses

Crude protein and acid detergent fiber analyses for selected forbs and shrubs collected in June after burning a field in April, McMinn County, TN, 2005. It is important to note that while some wildlife species are selective browsers or grazers, plants are not necessarily eaten based on nutritional content. For example, deer did not browse or graze all of the plants in the chart below. While old-field aster and pokeweed were grazed heavily, blackberry, goldenrod, ragweed and 3-seeded mercury were only browsed or grazed occasionally. For other species, such as passion flower and sericea lespedeza, there was no sign of grazing or browsing at all, even though crude protein and digestibility ratings were high.

Common name	Scientific name	CP	ADF	Selectivity by deer	Value as brood cover	Seed value for birds
blackberry	*Rubus* spp.	19.29	18.91	Med	High	High
Canadian horseweed	*Conyza canadensis*	32.85	19.75	Low	Low	None
goldenrod	*Solidago* spp.	16.14	26.19	Med	Med	None
honeysuckle	*Lonicera japonica*	16.16	34.21	Low	Low	Low
old-field aster	*Aster pilosus*	23.25	30.69	High	Med	None
partridge pea	*Chamaecrista fasciculata*	29.56	36.47	Low	Med	High
passion flower	*Passiflora incarnata*	36.64	18.91	None	None	Low
pokeweed	*Phytolacca americana*	32.01	11.98	High	High	High
ragweed	*Ambrosia artemisiifolia*	17.80	23.90	Med	High	High
sericea lespedeza	*Lespedeza cuneata*	22.19	32.62	None	Low	Low
3-seeded mercury	*Acalypha virginica*	24.66	16.73	Med	Med	Med
beggar's-lice	*Desmodium* spp.	28.22	20.70	Med	High	High
winged sumac	*Rhus copallinum*	23.05	12.46	Med	Med	Med
prickly lettuce	*Luctuca serriola*	21.70	21.20	High	Low	None

Fig. 2.11 Blackberry

Fig. 2.12 Pokeweed

Fig. 2.13 Beggar's-lice

Fig. 2.14 Sumac

Figs. 2.11–2.14 Blackberry, pokeweed, beggar's-lice and sumac are quality wildlife plants and should be encouraged along with native warm-season grasses. The presence of forbs in with native grasses is most important for forage, seed production, cover and structure to help keep native grasses erect through winter.

and several species of songbirds. Bobwhites often use brushy cover as a "covey headquarters" during fall and winter. Indigo buntings, dickcissels, yellow-breasted chats, northern cardinals, prairie warblers and white-eyed vireos use scattered clumps of shrubs and small trees for perching and nesting. Many shrubs and small trees also offer a valuable food source for many birds and mammals. Examples include wild plum, smooth sumac, staghorn sumac, winged sumac, American crabapple, hawthorn, wild cherry, persimmon, elderberry, hazelnut, common witch hazel, Carolina buckthorn and

Fig. 2.15 Scattered clumps of sumac provide nesting structure for dickcissels, indigo buntings, yellow-breasted chats and others. Sumac clumps also provide shade, which is critical for bobwhites during summer. Sumac produces seed and browse, eaten by deer that also bed under the shade in summer.

Figs. 2.16 and 2.17 Nwsg provide excellent cover for escape and roosting during winter. Nwsg can provide winter cover in cropped fields by establishing buffer strips. Deer, such as this yearling buck, seek out fields of native grass for bedding cover in winter.

Robin Mayberry

devil's walkingstick. Maintaining the appropriate amount and composition of shrub cover for the focal species requires periodic disturbance (particularly fire). Techniques for preventing a field from being overtaken by non-desirable woody species are discussed on page 133.

Winter habitat

Fields of nwsg can provide an excellent source of cover during winter (provided the grasses are not previously mowed or destroyed otherwise). These fields are often magnets for rabbits, over-wintering sparrows and deer. This can be especially critical for small wildlife at a time when quality cover is at a premium. Taller nwsg species, such as big bluestem, indiangrass and switchgrass, "lodge" (remain somewhat upright, leaning against each other) and provide suitable cover for wildlife even after winter rains, snow and wind. Nwsg that remain erect best through winter include broomsedge and the *Blackwell* and *Shelter* cultivars of switchgrass. Deer seek out these areas on cold, clear days because they can remain hidden in the tall grass, yet are able to absorb the sun's warm rays. In low-

Fig. 2.18 Winter rains and snow often cause tall nwsg to lodge in winter. This provides beneficial cover for rabbits and wintering sparrows. Here, a rabbit has been using this spot.

lying bottomlands that periodically flood in winter, fields of switchgrass (especially the *Kanlow* variety) can attract large numbers of ducks when shallowly flooded. Mallards, black ducks, pintails and green-winged teal readily feed upon available switchgrass seed. Naturally, as prey species use an area, predators follow. Thus nwsg fields also provide habitat for various predators, including red foxes, coyotes, red-tailed hawks, northern harriers, American kestrels and short-eared owls.

Using nwsg when wildlife is the primary objective

When a property is managed specifically for wildlife, the most important consideration is matching the habitat types available to the preferred habitat composition and arrangement for the focal species (see Table 2.2). Close attention should be given to the percentage of an area in various habitat types. For example, ideal habitat composition for bobwhites might be 50 percent early succession habitat including various nwsg, forbs and shrubs, 10 percent mast-producing hardwoods (managed on a relatively short rotation), 10 percent rowcrops (soybeans, corn, wheat) and 20 percent brushy cover. An ideal composition for white-tailed deer might be 40 percent mature forest (primarily oaks), 25 percent brushy cover (young forest, thickets, etc.), 20 percent rowcrops (soybeans, corn, wheat) and 15 percent native grassland (complemented with various forbs and shrubs). Ideal habitat composition, however, will not provide full benefits to wildlife unless habitat arrangement is addressed. A major focus should be to manage the habitat "mosaic" that has been created to benefit wildlife most.

Juxtaposition

Juxtaposition refers to the arrangement (and more specifically, the *placement*) of habitats. This is an important concept when managing an area for wildlife, especially wildlife with relatively small home ranges. Arranging cover, food and water all in close proximity helps minimize travel and exposure for animals using those resources. Arranging nesting cover adjacent to quality brooding cover minimizes necessary travel and exposure soon after hatching for broods. This can lead to improved survival and increased populations over time. When using nwsg in

Fig. 2.19 Juxtaposing necessary habitat types can reduce travel and exposure for some species. Here, quality nesting cover has been placed adjacent to quality brood rearing cover on the Kyker Bottoms Wildlife Refuge in East Tennessee. Quail populations on this area have been above one bird per acre since proactive burning and herbicide management strategies were initiated in 2000.

Table 2.2 Guide to major habitat types preferred by selected wildlife.

Primary species managed	Percent early succession	Arrangement of early succession	Percent cool-season legumes and annual grains	Percent rowcrop	Percent mast-producing hardwoods	Percent low brushy cover
Bobwhite quail	20–70	Blocks ≥ 3 acres or strips ≥ 50′ wide	In firebreaks	5–30	5–20	20–40
Cottontail rabbit	10–70	Blocks 1–5 acres or strips ≥ 50′ wide	In firebreaks or small fields	5–30	15–30	20–50
Wild turkey	10–30	Blocks ≥ 2 acres	2–5; In firebreaks or fields	5–40	30–60	10–30
White-tailed deer	5–30	Blocks ≥ 2 acres	2–5; In firebreaks or fields	5–40	30–60	20–40
Scrub/shrub songbirds (field sparrow, blue grosbeak, indigo bunting, yellow-breasted chat)	30–70	Blocks ≥ 5 acres or strips ≥ 50′	In firebreaks	<10	0	50–70
Grassland songbirds (grasshopper sparrow, Henslow's sparrow, eastern meadowlark, dickcissel)	70–100; without shrubs	Blocks or complexes ≥ 100 acres	In firebreaks	<10	0	<20

a management plan, it is important to consider the size, shape and *placement* of the field in the arrangement. When managing for bobwhites and other species with small home ranges (such as rabbits), all habitats needed to meet various seasonal requirements should be within a 40-acre area and, optimally, should be *juxtaposed* in close proximity.

Whereas the amount of nwsg acreage needed varies among wildlife species, it is always a good idea to have early-successional habitat well-interspersed across the entire property, ensuring this habitat type is located within the home range of all wildlife that need it. Locating a particular habitat type in only one portion of a property may exclude many animals from having access because it is out of their home range. It should never be assumed the habitat needs of quail, rabbits or any other species have been met just because one field of nwsg has been established. In addition, establishing nwsg is only one component of habitat management. Incorporating nwsg into a wildlife management plan should complement other practices, such as forest management and old-field management (which, in most fields, ***is*** nwsg and associated forbs and shrubs). Obviously, what is recommended for a 10-acre property will not be adequate for a 100- or 1,000-acre property. Table 2.2 provides general guidelines regarding the proportion of a property that should be managed in a particular habitat type for various species.

Another important consideration is the surrounding properties (that is, the surrounding landscape), especially for properties or landowner cooperatives less than 1,000 acres. If suitable habitat is lacking on surrounding properties for animals to immigrate to and emigrate from, it is possible the local population may become stagnant or begin to decline. It is also in these situations where predation can become a limiting factor. Predators are fully capable of identifying areas with an abundance of prey. Once located, predation rates can become artificially increased and limit small game populations, even where quality habitat exists.

Planning nwsg acreage for bobwhites and cottontails

Bobwhite quail is the most commonly targeted species for management when using nwsg. However, the biggest obstacle to restoring quail populations to levels of years past may be habitat fragmentation. While the issues surrounding this problem are beyond the scope of this manual, it is important to be aware of the situation and limitations it can present, especially when managing habitat (including fields of nwsg) for quail on relatively small acreages and in isolated "quail areas."

Habitat fragmentation adversely affects quail (and other wildlife species dependent upon early-successional habitat) by isolating local populations. Habitat fragmentation for quail occurs when much of the quality cover over a large area (such as 5,000 acres) is slowly replaced by unsuitable habitat, such as housing developments, shopping centers, continuous and maturing forestland, and unsuitable pasture/hayfields (such as tall fescue and bermudagrass). On a landscape level, the percentage of suitable habitat can decline substantially over time. Often, this change in habitat composition is not perceptible until populations have become isolated. This precludes emigration of quail from one area to another, which limits the flow of genetic variability. Isolated populations are also much more vulnerable to severe declines resulting from environmental pressures. For example, poor nesting success and brood survival two years in a row may reduce an isolated population to a level from which it cannot recover. Increased pressure from predators or over-hunting may produce the same effect; however, a non-isolated population may be able to withstand these pressures as birds immigrate from surrounding areas and buffer the losses. **Where isolated populations occur, it is also common to see little or no increase in the population even when extreme efforts are made to enhance quail habitat. This is frustrating to the land manager, who then often blames the lack of quail on predators or some other "obvious" reason for the decline.** Nonetheless, where viable populations of quail and rabbits are possible, it is critical that habitat arrangement is considered closely and managed appropriately.

No minimum acreage has been determined to best fit the needs of quail; however, nesting success and brood survival may be higher when larger fields (2–10 acres or more) are available. When only small fields and strips of suitable cover are available on a limited portion of the landscape, it is possible for nest predators (such as raccoons and skunks) to obtain a search image for these areas. Because quail are attracted to nwsg for nesting, smaller patches and strips of nwsg can become effective "predator traps," where a raccoon, for instance, could move through a narrow strip or small patch and destroy several nests in a single night. A larger field or wide buffer strip (≥ 50 feet) makes finding a nest more like the proverbial needle in a haystack. Many land managers have wondered why the quail population on their property did not increase after a strip or small patch of nwsg was planted. Naturally, there is much more to managing and increasing quail populations than merely establishing nwsg; however, it is quite possible for quail-nesting success to *decline* after implementing a theoretically beneficial management practice because the habitat was not positioned correctly and/or was insufficient in size and shape. While it is often not practical or sensible to control *predators*, it is practical and sensible to control *predation*. This is possible by managing cover correctly.

Quality brood habitat should be located adjacent to nesting habitat. According to the structure and composition of the field (density of grass bunches and presence of forbs and shrubs), a field may contain quality nesting and brooding habitat, but more often the best brood habitat is in the field that was burned or disked the previous winter. Escape cover (brushy cover, thickets) should be located along at least one side of a field managed for brood habitat. In addition, escape cover should be located along one side of a potential food source, such as rowcrop fields.

While fields with irregular-shaped borders may increase the amount of edge, if the composition and structure of the field is well-suited for quail,

Figs. 2.20 and 2.21 Blocks of cover are recommended over narrow strips of cover. A raccoon or skunk could find every quail nest in this narrow strip of broomsedge (above) in a single night; whereas searching through a wide buffer strip (below) or an entire field of cover is more like finding the proverbial needle in a haystack.

Chris Wolkonowski

Fig. 2.22 This field is managed by burning and/or disking sections on a 2–3-year rotation. This type of management provides diverse plant composition and structure and resembles a field of edge, which benefits bobwhites, early succession songbirds, rabbits, deer and turkeys.

an increase in edge will not necessarily benefit the birds. The objective is to create a *field of edge*, providing attractive habitat across the entire field rather than just along the border of the field. This also applies to rabbits. Fields of nwsg and associated forbs and shrubs can support an amazingly high rabbit population. When quality habitat is established and maintained throughout the field, the majority of rabbits are no longer found along the edge, but in the interior of the field. Locating nwsg fields adjacent to young forest stands or streamside (riparian) woody cover provides excellent habitat for rabbits. Rabbits do not seem as sensitive to larger acreages as quail and have responded surprisingly well to smaller fields (<2 acres).

Planning nwsg acreage for deer and turkeys

Larger animals, such as white-tailed deer and wild turkeys, will use nwsg fields regardless of size. Larger fields, understandably, may harbor more fawns during summer than smaller fields; however, the best response by deer will occur when nwsg fields are well-dispersed across the property. Because adult does maintain a well-established dominance hierarchy, relatively small (<5 acres) high-quality fields for fawning may be used by only one doe— that being the dominant doe in the resident doe group. The majority of use by other adult deer in the summertime may be determined largely by the composition and quality of forbs present in the field. Forbs comprise approximately 70 percent of a deer's diet during the growing season. Grasses are rarely eaten at this time. The nutritional quality and palatability of forbs may be increased the growing season after a winter burn.

Depending on the structure and vegetation composition within a field, wild turkeys may use it for nesting. Similar to the concerns for quail nesting, success of wild turkey nests also might be higher when larger fields are used. Normally, wild turkey hens choose to nest adjacent to some type of object (such as a tree, stump, deadfall, clump of brush). However, if the average field height is $\geq$ 3 feet with bramble growth and scattered shrubs, the field will be more attractive to nesting hens and may contain several nests.

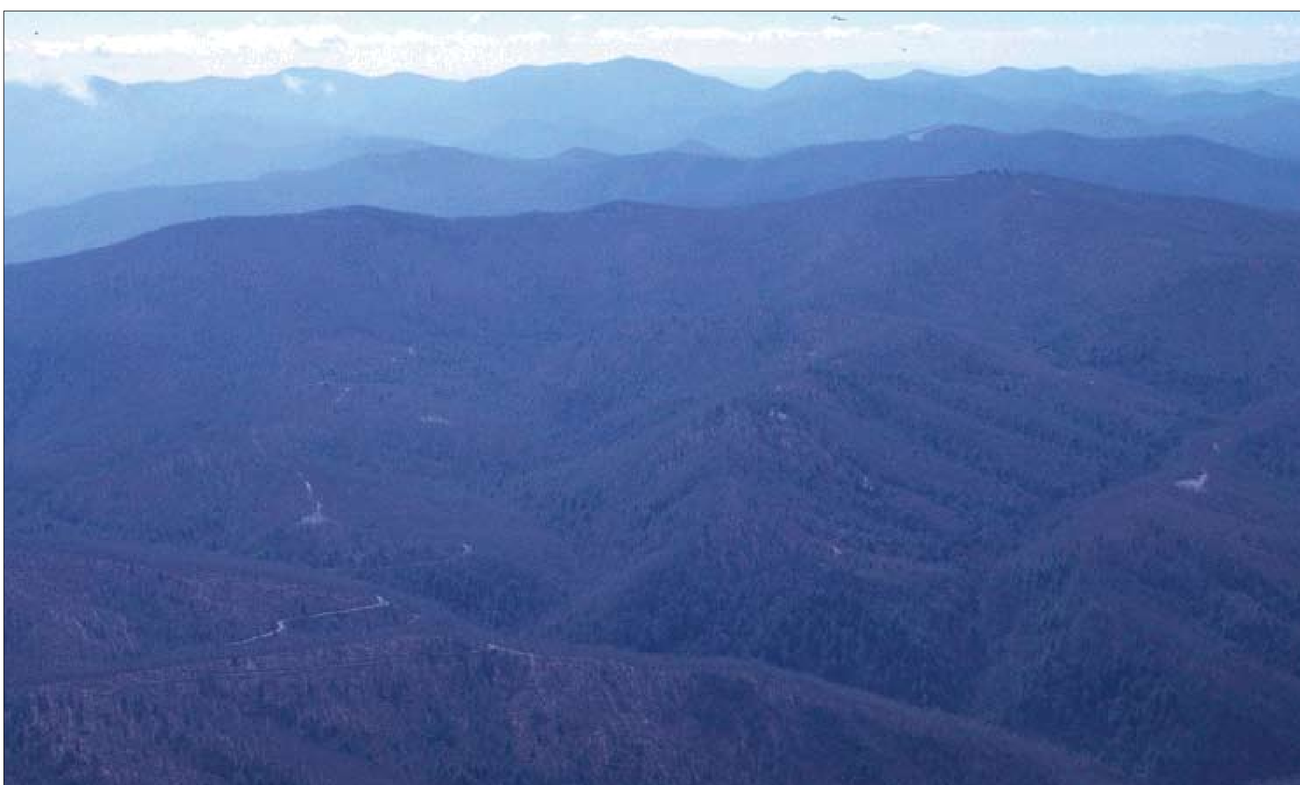
Planning nwsg acreage for songbirds

As with quail, habitat fragmentation has been a major factor associated with the decline of many grassland songbirds. Grassland birds use a wide range of field sizes; however, most species prefer larger blocks of habitat. Some species, such as grasshopper sparrows, rarely use blocks of habitat smaller than 100 acres. Other species, such as Henslow's sparrows, dickcissels and eastern meadowlarks, readily use patches or fields only 20 acres in size (depending on landscape context; see below). One determinant of habitat use is territory size of individual male birds. A male eastern meadowlark may establish a territory of eight acres where he sings in the center and attracts females. Intruding males are driven away. In this situation, it is obvious why a grassland complex of 100 acres or more is needed to sustain a viable local population of eastern meadowlarks, though relatively small fields may be occupied by small numbers of birds.

The overriding determinant regarding use of nwsg fields by many grassland birds is the composition of the surrounding landscape. If there are few other suitable grassland fields in the surrounding *thousands of acres*, some birds, such as Henslow's sparrows, may not occur in the area. This is especially true in vastly wooded areas where a field has been created and nwsg established. It is most difficult (if not impossible) to attract such birds to an *island* of suitable nwsg in a vast *sea* of forest, regardless of habitat quality in a given field or area.

Another challenge when managing grasslands for songbirds is providing grassland habitats in a variety of species assemblages and successional stages. Some grassland songbirds prefer tall grass, others nest in short

Figs. 2.23 and 2.24 Habitat fragmentation is a serious issue for many wildlife species. Some grassland songbirds require blocks of habitat no less than 100 acres, such as the field above. It would be foolish to assume area-sensitive grassland birds, such as grasshopper sparrows, would use small openings located in vast forested areas, such as this aerial view of the Nantahala National Forest in western North Carolina. It is important to realize the composition and structure within a given field might be ideal, but overall use may be minimal or nonexistent because of the surrounding habitat conditions.



grass and others use fields with more forbs and/or shrub cover (Table 2.2). Thus, not only is it important to manage for a variety of field sizes, fields dominated by different grass/forb/shrub mixtures and fields in various stages of succession (years since burning/disking) are also needed.

Considerations for nwsg management

A field of nwsg is no better than the technique(s) used to manage it. If not managed correctly, nwsg can become rank and unattractive to many species over time. Prescribed fire, disking and grazing are recommended for managing nwsg and associated old-field habitats. Regardless of the management practice used, it is most important to manage fields on a rotational basis. Because structural requirements vary among species and seasons, it is certainly not recommended to set back succession on an entire field (depending on field size) or on all fields present (depending on the number of fields and their proximity on a property) at one time. For example, if brood habitat and forage quality are prime in a field the summer after a winter burn, and nesting habitat and soft mast availability are prime two or three years after a burn, then it is undesirable to burn all available habitat every year. Escape cover may be best three or four years after burning. For these reasons, fields should be managed on a rotation. This can be accomplished in a number of ways.

Sections of a field can be separated with a firebreak(s) so they can be burned on a rotation corresponding with the number of sections. For example, a 20-acre field is "separated" using firebreaks into five sections, approximately four acres each. Section 1 is burned in year 1, section 2


Steve Capel

Fig. 2.25 This landowner in Virginia has gone out of his way to see that nesting cover is juxtaposed to brooding cover. A variety of successional stages and cover types, all in close proximity, is advantageous to bobwhite quail and several other wildlife species associated with early-succession communities.

burned in year 2, section 3 burned in year 3, and so on. This way, brooding habitat, nesting habitat and escape cover (diverse habitat conditions) are provided in the same field each year. Likewise, if three or more fields are located in close proximity and the fields are relatively small (< 3 acres), entire fields can be burned on a three-to-five-year rotation, according to the land management objectives and focal species being managed. Often, the rotation used is based upon the response of the field, especially if woody growth is excessive, invasive plants are problematic and/or vegetation litter is accumulating rapidly. Techniques to deal with these problems and other troubleshooting tips are discussed in Chapter 6.

Using nwsg when wildlife is a secondary objective


James Woodall

Fig. 2.26 Quality soil doesn't have to be taken out of production to establish native warm-season grasses. Here, nwsg were planted to provide wildlife habitat on relatively unproductive rocky ground where crop production was marginal. This stand is 6 weeks old.

The majority of early-successional habitat in the Mid-South is privately owned and farmed. In many situations, wildlife management is not the primary objective; however, **a conscientious farmer is a true environmentalist** and certainly interested in conserving natural resources, which includes allowing for adequate wildlife habitat in a farm management plan. Nwsg can be used to accomplish this objective. Because nwsg are most effectively managed by burning, they can be used on areas with steeper slopes and/or rocky soils that might be difficult to maintain by mowing or disking. Also, because nwsg are adapted to grow relatively well in poor soils, these areas can be targeted for nwsg establishment, while preserving better soils for production agriculture. A very popular approach is to enroll in one of the cost-share assistance programs made available by the US Department of Agriculture (USDA).

Using USDA programs to meet objectives

Many opportunities exist for farmers and other landowners to receive incentive payments, sign-up bonuses, cost-share and technical assistance to establish nwsg buffers, hay, pasture and wildlife habitat in a variety of USDA programs (see Appendix 2). Most landowners are not familiar with the term "buffers" or the potential improvements they can provide a farming operation and wildlife habitat. Simply, buffers are strips or areas of intentionally managed permanent vegetation that help control soil erosion and chemical and animal waste runoff while providing wildlife habitat. Wildlife benefits are gained by making maximum use of field edges (increasing usable space) by creating valuable nesting and brood-rearing cover.

Often, landowners want to improve habitat in a large field, but are reluctant to break up the field by planting hedgerows with shrubs and/or trees. In this case, a nwsg buffer can provide excellent escape cover and create more usable wildlife space, while not committing those areas to woody vegetation. When buffers are surrounded by bare cropfields, they are easily and safely burned in late winter or early spring to control invasion by woody vegetation and improve conditions for wildlife. Where burning is not possible, woody encroachment in buffers can be suppressed by spraying various selective herbicides (such as triclopyr) that do not harm nwsg (see ***Herbicides—Woody competitors***, page 133).

Fig 2.27 Native warm-season grasses complement other farm management practices well. Whether established specifically for wildlife or for haying or grazing, native warm-season grasses should be incorporated into the farm management plan of every conscientious producer.

Buffers can provide both environmental and economic benefits, especially if landowners receive annual payments for establishing and maintaining nwsg buffers within certain USDA programs. Environmental benefits, such as improved water quality by reducing runoff and increasing infiltration, can be achieved when buffers are used to prevent sediments, fertilizers, animal waste and pesticides from entering streams, rivers and other water bodies. Research by the USDA Agricultural Research Service National Sedimentation Laboratory in Oxford, Mississippi has indicated nwsg are very good filters during concentrated flows. In fact, a buffer of switchgrass 3 feet wide has been shown to filter the equivalent of a tall fescue buffer 20 feet wide.

Fig. 2.28 Buffers established adjacent to drainages can prevent sediment flow and provide critical habitat that can support many wildlife species and help increase wildlife populations. A native grass buffer is much needed along the edge of this drainage ditch.

Although positive effects on water quality may be realized with narrow buffers, relatively wide buffer strips (≥50 feet) should be used to improve wildlife habitat.

Research by Mississippi State indicated densities of wintering native sparrows were more than twice as high in 65–130-feet wide nwsg buffers than

Fig. 2.29a Nwsg buffers can lead to increased numbers of quail and songbirds using rowcrop fields, even cotton.

Response of bobwhites to nwsg in USDA programs

Various programs supported through the Farm Bill give renewed hope for achieving landscape-level habitat improvement for bobwhites. As a result, bobwhite populations have responded amazingly well. For example, in Crockett County, Tennessee, areas with newly planted nwsg were monitored from 2000–2003 using a whistling bobwhite index on Conservation Reserve Program (CRP) areas (both block and buffer strip practices) using nwsg (n = 24) and control areas (n = 18). The primary land-use practice in Crockett County is row-crop agriculture with cotton the primary crop. All sites monitored were in production agriculture with similar land-cover characteristics, except control areas did not have any acreage in nwsg. There were no nwsg planted in Crockett County until 2000, when approximately 600 acres were established. In 2001, an additional 1,200 acres were planted.

The average whistle count per minute for all CRP sites increased from summer 2000 to summer 2003 by 232 percent, while the average for all control areas decreased by 46 percent. Not all nwsg stands, however, produced a positive response for bobwhites. Little or no increase was observed on stands established near large forested areas. The largest increases were recorded in more open landscapes that were predominately open fields and hedgerows.

	2000	2001	2002	2003
Fields with NWSG	1.5	2.1	3.2	3.8
Fields without NWSG	1.3	0.8	0.9	0.7

The importance of nwsg for nesting cover in open agricultural landscapes was most obvious during this study. One CRP site was a 100-acre cotton field that contained several shrubby areas along abandoned steep slopes and sediment basins. During 2000, only one bobwhite was heard the entire summer. In 2001, the 100-acre cropped area was planted to nwsg. The shrubby areas were not planted, but retained to provide important shrub cover and break up the field. By the summer of 2003, more than four bobwhites could be heard on any given day, with a call rate of one "BOB-WHITE" every five seconds any time during the morning. Fall covey counts documented five large coveys using this area.

Landowner selection and use of nwsg in USDA programs are key to the restoration of local and regional bobwhite populations. Once established, however, management of these grasses is very important to maintaining and/or increasing wildlife populations.

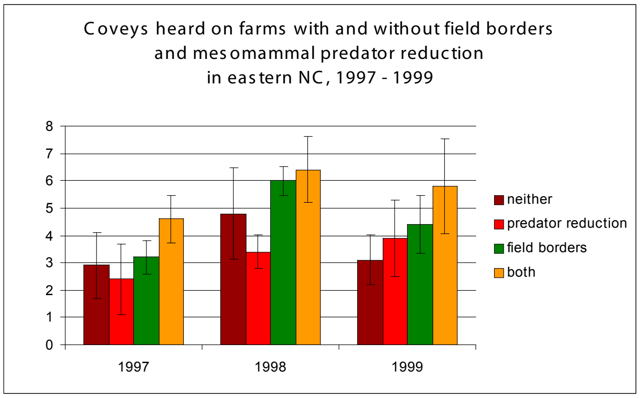


Fig. 2.30a-b Fallow borders around crop fields was the driving factor behind increasing bobwhite populations in North Carolina. Predator control alone did not work. Only when coupled with field borders did trapping mesomammals (racoons, skunks, opossums, foxes) help increase numbers of bobwhite coveys. (Palmer and others 2005)

Table 2.3 Comparison of wintering sparrow densities (per acre) on rowcrop fields in eastern North Carolina with and without field borders, February 1997, 1998 (Marcus and others, 2000).
Most birds (93percent) detected in the field edges were sparrows, including song (*Melospiza melodia*), swamp (*Melospiza georgiana*), field (*Spizella pusilla*), chipping (*Spizella passerina*), white-throated (*Zonotrichia albicollis*) and savannah (*Passerculus sandwichensis*), and dark-eyed juncos (*Junco hyemalis*).

	with field borders	without field borders
Whole-field density	3.6	1.6
Field edge density	14	5.2

in CP33 (CRP Continuous Signup field borders practice) buffers 23–33 feet wide. Wider buffers also harbored more bird species than narrow buffers. Nonetheless, even narrow buffers were advantageous. Bobwhites and dickcissels were completely absent from fields without buffers, while fields with buffers contained these species. Fields with buffers also provided quality nesting habitat. Again, fields with wide buffers contained disproportionately more nests (2.1 nests/acre) than those with narrow buffers (0.1 nests/acre), while no nests were found around fields without buffers.

Planting is not always necessary! By simply allowing field borders to grow fallow, wildlife populations dependent on early-succession habitat should increase. In a four-year study in North Carolina, both bobwhite and wintering sparrow populations increased on farms after field borders were delineated and allowed to grow fallow around crop fields. In fact, even on farms where exhaustive predator removal took place, bobwhite populations remained steady or declined, **unless field borders were established.** The researchers at NC State showed *predator* control alone did not work,

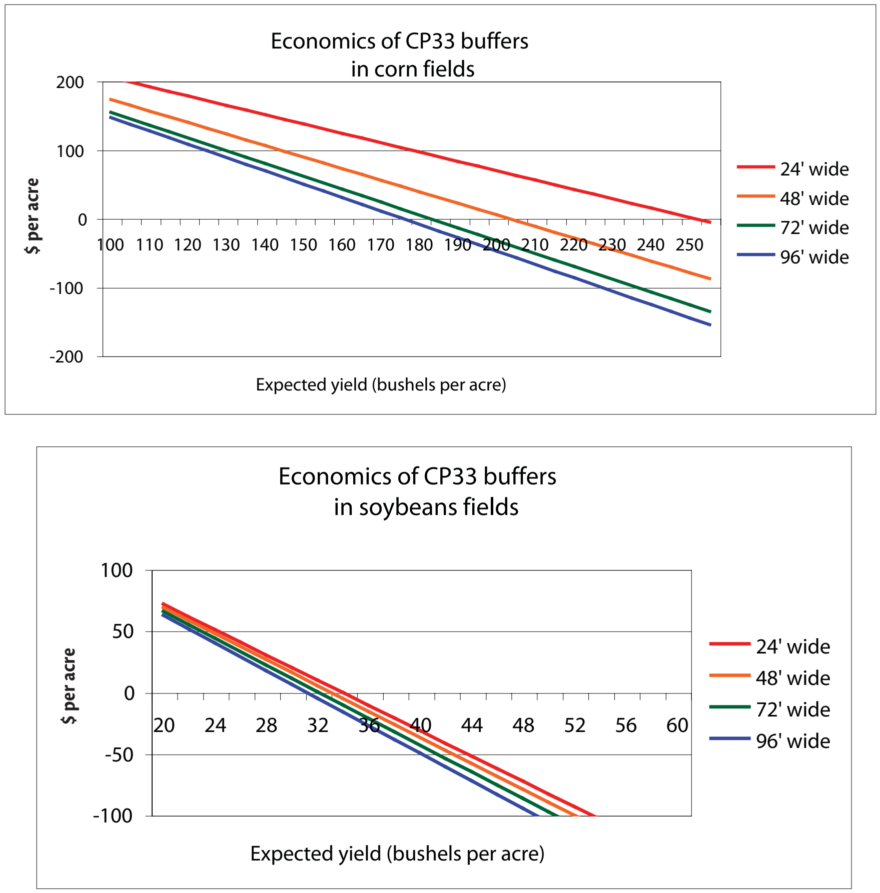


Figure 2.31a and b. These data depict the results from a model developed by Dr. L. W. Burger at Mississippi State University to evaluate economic tradeoffs associated with establishing CP33 field buffers in production soybean and corn fields. Based on Tennessee data (10-year average corn price, $1.98/bu, corn land rental rate, $45.00/ac; 10-year average soybean price $5.72/bu, soybean land rental rate, $37.75/ac), the graphs demonstrate the loss or gain in revenue on a per acre basis for each swath of a 24-foot combine around a field edge when that edge is placed into the CP33 program. Field edges are typically the least productive part of the field as a result of competition with adjacent brush, trees or other vegetation. As an example, a 24-foot (1 swath) CP33 buffer on a corn field with an expected yield of 175 bu/ac, will result in a $100/ac net gain in revenue for the producer for the enrolled acres. A 72-foot (3 swath) buffer on that same field will enhance considerably more habitat for wildlife and still provide about $10/ac in revenue on enrolled acres. As expected, the economic gain associated with CP33 enrollment is reduced as field productivity increases, but the wildlife value increases.

unless *predation* was controlled. The results of the NC study clearly indicated that providing nesting and brood-rearing cover was the reason for the increase in quail populations. Only after the habitat was improved did trapping mid-sized mammalian predators have a positive impact. By providing quality field buffers, adequate screening cover was afforded the quail hens and chicks, which made it difficult for predators to detect them. From an economic standpoint, it is much more efficient (and effective) to spend money on improving early-succession habitat for nesting and brood rearing than trapping alone.

Wildlife isn't the only thing to benefit when fallow borders are incorporated. Farm profits can increase as well. By taking field borders out of production, fuel, fertilizer, lime, seed and herbicide costs are reduced. This, coupled with the fact that borders along wooded areas naturally produce less yield (because of competition for nutrients and sunlight), helps to increase crop profit margins.

Economic benefits are realized by taking marginally productive areas out of production and protecting environmentally sensitive areas (such as riparian buffers, highly erodible soils). Landowners may be eligible for

Fig. 2.32 and 2.33 **By taking edges of crop fields out of production and establishing nwsg buffers, sediments are trapped, wildlife habitat is created and money is saved. Establishing field buffers is truly a win-win situation for producers.**

cost-share assistance to establish buffers and receive annual payments for 10–15 years, depending on the program enrolled. Many buffer locations currently cropped have as much as 40 percent yield loss in some locations, adding additional monetary losses to the farming operation. Popular USDA programs (such as Conservation Reserve Program) can make these areas profitable if enrolled into buffer practices like filter strips or riparian forest buffers. Additional economic gains for landowners can be realized through hunt leases and nwsg hay and seed production.

One of the most important aspects of establishing buffers is selecting the proper vegetation to ensure environmental gains *and provide wildlife habitat*. Consideration should be given to soil type, weed pressure and

Figs. 2.34 and 2.35 The difference in the amount of cover provided by filter strips planted to non-native cool-season grasses, such as this tall fescue (left), and those planted in nwsg is striking and obvious. If you were a quail or rabbit, where would you rather be? In the tall fescue filter strip or in the switchgrass/kobe lespedeza filter strip (right)?

the focal wildlife species. Buffers planted in non-native grasses, such as tall fescue and orchardgrass, may provide erosion control benefits but do not provide quality wildlife habitat. Nwsg, however, provide equal or better erosion control benefits **and** provide valuable wildlife habitat as well. Shorter species (such as little bluestem and sideoats grama) may be selected when improving quail nesting and brood-rearing habitat. Taller species (such as big bluestem, indiangrass and switchgrass) may be used to provide stream bank stabilization and escape cover for rabbits, quail and deer.

Types of nwsg buffers

There are several types of buffers with a variety of names to describe similar buffers with similar benefits. Common types of buffers include field borders, filter strips, riparian forest buffers and contour buffer strips. Field borders are areas established to permanent vegetation along the outer edge of agricultural fields, and can be established around an entire field or just along one or more sides. Filter strips are strips of grass established adjacent to a creek or other water body. Their primary purpose is to trap sediment, fertilizers and pesticides during rain events, but they also provide wildlife habitat when nwsg are used. Riparian forest buffers are a mixture of trees and shrubs planted parallel to streams to filter runoff and absorb nutrients, while providing food, cover and travel corridors for wildlife. Riparian forest buffers, as well as native grass buffers, also can be used to help stabilize streambanks. Riparian forest buffers sometimes include a strip of nwsg between the crop field and the tree planting. Contour buffer strips are bands of perennial vegetation alternated with wider cultivated bands farmed on the contour. Contour buffer strips can be established on existing cropped terraces. Check with your local Farm Service Agency office regarding practice specifications.

Problems associated with tall fescue and other perennial cool-season grasses

Tall fescue is an introduced, perennial cool-season grass originating in Europe. It was first found growing in North America in 1931 on a farm in eastern Kentucky by E.N. Fergus, a professor at the University of Kentucky. It is thought the grass was originally introduced to this farm as incidental seed, present in other grass seed from Europe, which was planted to this site before the owner at that time purchased the farm in 1887. After testing, the grass was released in 1943 as the variety Kentucky 31. Tall fescue was widely accepted in the Mid-South region and a tremendous amount of acreage was planted to Kentucky 31 through the 1950s. The trend continued and by the 1970s, tall fescue had become the most important cultivated pasture grass in the United States. Today, tall fescue is grown on more than 35 million acres and there is hardly a field in the Mid-South that has not been planted to tall fescue at some time in the past 50 years.

Many problems are associated with tall fescue, both for livestock and wildlife. Problems for livestock are associated with an endophyte fungus *(Neotyphodium coenophialum)* found within tall fescue that produces ergot alkaloids, which are highly toxic to livestock. Cattle consuming tall fescue (either grazing or as hay) often experience poor weight gains, reduced conception rates, intolerance to heat, failure to shed the winter hair coat, elevated body temperature and loss of hooves. Problems with horses are more severe, especially 60–90 days prior to foaling. Fescue toxicity in horses often leads to abortion, prolonged gestation, difficulty with birthing, thick placenta, foal deaths, retained placentas, reduced (or no) milk production and death of mares during foaling. As a forage, tall fescue and other perennial grasses are least preferred by white-tailed deer among cool-season forages. Cottontail rabbits had lower weights and smaller litters in tall fescue habitats. When fed a diet of tall fescue seed, bobwhites exhibited cloacal swelling, which ultimately led to increased mortality. Undoubtedly, many of the toxic effects of tall fescue on wildlife that consume the seed or foliage are unknown.

Known problems of tall fescue for wildlife are associated more with the structure created by the growth habit. Other introduced, cool-season perennial grasses (such as orchardgrass, bromegrasses, timothy and Kentucky bluegrass) also develop sub-optimal growing conditions near ground level. Although classified as bunchgrasses, the growth habit and structure of tall fescue, orchardgrass, bromes and timothy is dense, making travel by many small wildlife species (especially ground birds) difficult. In addition, leaves of these grasses droop and fall upon senescence, creating a deep layer of thatch. The dense growth structure and thatch layer preclude birds from picking up seed off the ground and prevent seeds in the seedbank from germinating. Thus, vegetative diversity and weed seed available as food for wildlife are drastically reduced. Tall fescue (and other perennial cool-season grasses) also provides poor winter cover for wildlife because of a lack of overhead cover.

Cool-season perennial grasses (especially tall fescue and bromegrass) are very competitive. When grown in association with nwsg, perennial cool-season grasses will, over time, lead to reduced coverage of nwsg and render otherwise suitable cover undesirable. When grown in association with clovers in a firebreak or forage plot, tall fescue and orchardgrass will dominate the site within 18 months, leaving little to no clover available for forage.

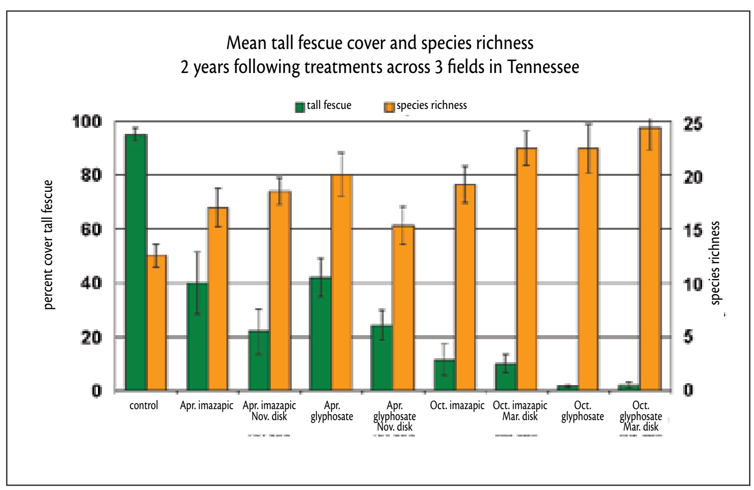


Fig. 2.36 Tall fescue and other non-native, perennial, cool-season grasses are analogous to an ugly shag carpet covering a beautiful hardwood floor. Once the carpet is removed, you can finally see what is underneath. Allowing the seedbank to respond is the best way to promote early-succession habitat on many sites. The data above show how species richness increased on three sites across Tennessee after tall fescue coverage was reduced. (Gruchy 2007)

Fig. 2.37 The structure presented in a field dominated by tall fescue is not conducive to travel by bobwhites, field sparrows, or young turkeys or grouse. Not only is movement through the field restricted, but plant diversity within the field is severely reduced because of the competitive cover and sod. Finding seed and insects in this type of environment would be impossible for a small bird.

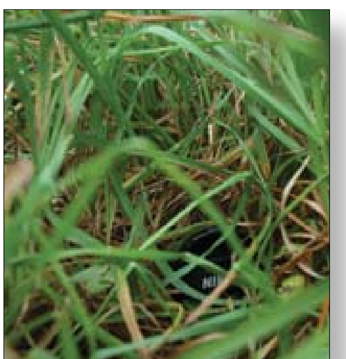


Fig. 2.38 Orchardgrass
In terms of structure and overall wildlife value, orchardgrass is no different from tall fescue. Forage value for wildlife is extremely low, seed value is zero, relatively few invertebrates are associated with the grass itself and orchardgrass will out-compete clovers in a firebreak within two growing seasons. Orchardgrass should not be considered a "wildlife-friendly" grass.

Fig 2.39a Tall fescue

Fig 2.39b Orchardgrass

Fig 2.39a–c These pictures show (a) the structure presented within a plot of tall fescue, (b) an adjacent plot of tall fescue sprayed with imazapic (Plateau®) the previous fall, which resulted in a plot of pure orchardgrass, and (c) an adjacent plot of tall fescue sprayed with glyphosate the previous fall and subsequently disked, which resulted in a plot of ragweed and sticktights (*Bidens aristosa*). This sequence of photos shows 1) the structure presented by tall fescue and orchardgrass are identical, 2) fields of tall fescue should be sprayed with glyphosate instead of imazapic if orchardgrass is present, and 3) the annual weed community provides a desirable open structure at ground level.

Fig 2.39c Annual forbs

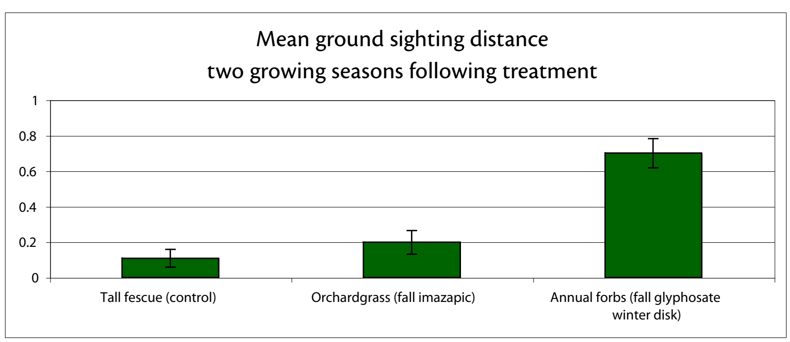


Fig 2.40 These data correspond to Figures 2.39 a – c and show ground sighting distance (openness at ground level) within fields dominated by tall fescue and orchardgrass are identical

Chapter 3

Using native warm-season grasses as forage for livestock

The use of nwsg is not limited to wildlife habitat—they also can provide excellent forage for livestock. In fact, when properly hayed or grazed, nwsg can still provide nesting and brood-rearing habitat as well as winter cover.

The primary characteristic that makes nwsg attractive as a forage crop is that they are warm-season grasses (C_4 plants), meaning they produce the majority of their growth during the summer period, when high temperatures result in reduced growth of cool-season grasses (C_3 plants). On an annual basis, on the same soils and with similar management, C_4 plants will outproduce C_3 plants in terms of total tonnage, by about 1.5–2 times. For example, switchgrass will often produce 5–6 tons per acre of forage versus about 2.5–3 tons per acre for tall fescue. C_4 plants are also more efficient at using soil moisture than C_3 grasses and thus are much more resistant to drought conditions. Because of this growth strategy, nwsg can be used to help fill summer forage voids in livestock operations.

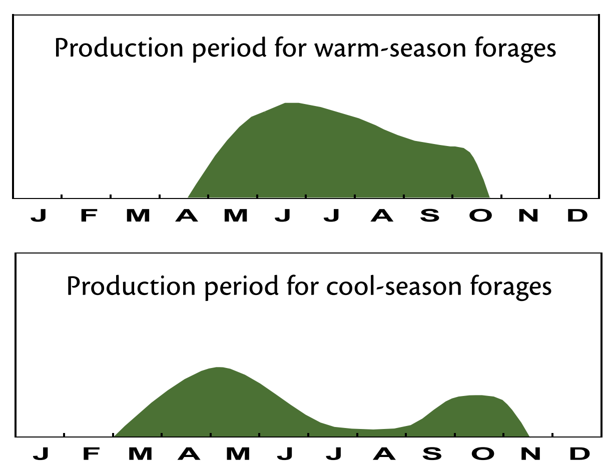


Fig 3.1 Nwsg produce the majority of their growth from June through August. This can be a real advantage for hay and livestock producers.

Native warm-season grasses for hay

Nwsg can make a highly desirable hay crop. Yields of 2–6 tons per acre can be expected, depending on the species grown, rainfall, soil type and other environmental conditions. Little bluestem, a shorter growing species adapted to drier sites, typically produces only about 1.5–2 tons of

Fig 3.2 Switchgrass is the most commonly hayed nwsg in the Mid-South. It produces outstanding tonnage with high quality when managed correctly.

forage per acre. Big bluestem and indiangrass produce about 2.5–4 tons per acre and switchgrass and eastern gamagrass produce about 4–5 tons of forage per acre. On particularly productive soils and with good summer rainfall, these figures could be higher. Yields will be reduced in dry summers, but nwsg are less sensitive to drought than cool-season grasses and yield reductions will not be as pronounced. While all of these species respond to N fertilization, the response is not as strong as with tall fescue or bermudagrass. This is a real benefit to the forage producer.

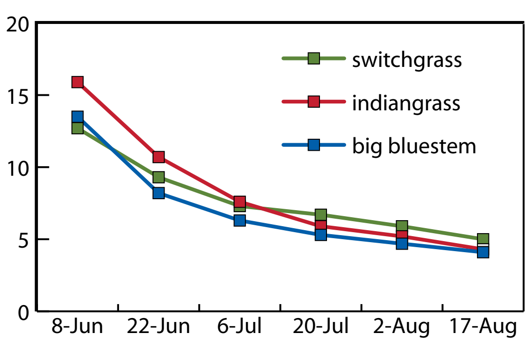


Fig 3.3 Regardless of grass species, forage quality declines over time as the grass matures (without harvesting). Periodic harvesting or grazing (at the correct time) will ensure quality hay throughout the summer. (Perry and Baltensperger 1979)

The nutrient content of nwsg forage can be as high as 16–17 percent crude protein, but normally is 8–12 percent at optimum harvest. It should be noted that in relationship to plant maturity, nwsg forage quality deteriorates more quickly than with cool-season grasses. That is because lignification is more rapid after boot stage in nwsg. Therefore, when managing nwsg, timing of harvest is more critical than with cool-season grasses.

Fig 3.4 This eastern gamagrass field has just begun to flower and is ready to cut for hay.

One of the values of nwsg for hay is the time of production — summer. Two main factors influence the nutrient content of a hay crop. First is the stage of maturity of the plant. Maximum tonnage and high-quality nutrition do not occur at the same time. As plants mature, protein and energy content decreases, while fiber content increases. Although maximum tonnage might occur in August, forage quality at that time is relatively low. Optimum nutrient content is available in May and June, depending upon species. From a practical standpoint, grasses should be cut ***before*** seedheads begin to emerge. Hay produced from a young, immature plant can be outstanding quality, while hay from a mature plant will be low quality. This trend holds true for all forage crops, warm-season **and** cool-season.

Fig 3.5 By mid-July, this previously uncut eastern gamagrass has produced elongated stems with mature seed. Hay quality at this point is significantly reduced.

Fig 3.6 High temperatures and low humidity decrease hay drying time — a major factor influencing hay quality. An inherent advantage nwsg have over cool-season grasses is that warm weather makes better hay-making conditions. This eastern gamagrass was cut the second time in mid-July.

The second factor that influences hay quality is exposure to the environment. Once a plant is cut for hay, protein and energy content slowly begin to drop as a result of respiration losses. These losses do not stop until the plant dries. If rain falls on forage that has been cut but not baled, leaching of protein and energy can occur. High temperatures and low humidity will decrease drying time, resulting in little nutrient loss. Cool, wet conditions cause slow drying, resulting in higher nutrient loss. If the hay is rained on during the drying process, even more nutrient loss will occur.

Delayed harvest and exposure to the environment are the two major factors influencing hay quality; thus, nwsg have fewer problems in hay production than cool-season grasses. There is less chance that rain may delay harvest. Once hay is cut, higher temperatures enable hay to dry faster, resulting is less respiration and leaching loss. The summer growth of nwsg is easier to produce for hay than the spring growth of cool-season grasses. Another factor favoring hay curing of nwsg is the taller cutting heights. When nwsg hay is cut properly (8 inches), the drying hay is suspended above the ground on the residual stems, allowing greater air circulation and more rapid drying than is experienced with lower-growing species.

Switchgrass and eastern gamagrass are most often planted in pure stands for haying or grazing. Most varieties of switchgrass and eastern gamagrass

Robin Mayberry

Sample #	NO NUMBER		SWITCH HICKMAN		SWITCH KNOX	
Lab Number	15734		15735		15736	
Sample Type	EAST.GAMMA GRASS		SWITCHGRASS HAY		SWITCHGRASS HAY	
Moisture (%)	17.34		8.13		22.64	
Dry Matter (%)	82.66		91.87		77.36	
	DM BASIS	AS-FED BASIS	DM BASIS	AS-FED BASIS	DM BASIS	AS-FED BASIS
Protein (%)	10.26	8.48	11.27	10.35	9.75	7.54
Fat (%)	3.84	3.17	3.40	3.12	4.11	3.18
Fiber-ADF (%)	36.77	30.39	39.69	36.46	35.72	27.63
Fiber-NDF (%)	64.68	53.46	63.70	58.52	66.80	51.68
Calcium (%)	0.37	0.31	0.32	0.29	0.08	0.06
Phosphorus (%)	0.17	0.14	0.27	0.25	0.19	0.15
Magnesium (%)	0.19	1.44	0.23	0.21	0.26	0.20
Potassium (%)	1.47	1.74	2.95	2.71	1.32	1.02
TDN	61	50	57	52	61	47
NEl (MCal/lb)	0.62	0.51	0.58	0.53	0.63	0.49
NEm (MCal/lb)	0.51	0.50	0.55	0.51	0.61	0.47
NEg (MCal/lb)	0.34	0.28	0.29	0.27	0.34	0.26
RFV	87		85		85	

Figs 3.7 and 3.8 (UT forage test) This switchgrass hay from Hickman Co., TN was cut in late May 2006 and contained 11 percent crude protein with only 39 percent acid detergent fiber. Quality hay such as this is possible through the summer when nwsg are cut and managed correctly.

begin to flower in late May; therefore, these grasses are commonly hayed from mid- to late May for an optimum hay quality-to-tonnage ratio.

In most areas of the Mid-South, big bluestem begins to flower in late June/early July, while indiangrass and little bluestem usually flower later in July and August. Often, big and little bluestem and indiangrass are used together in a native warm-season hayfield. This is because all three flower relatively late and all are resistant to imazapic (Plateau® and Journey®

herbicides), which makes establishment easier in some areas. Mixtures of big and little bluestem and indiangrass are normally hayed in late June, which is advantageous for many wildlife species that nest in May and June.

In most cases, a second cutting can be taken from nwsg about four weeks after the first cutting. There are, however, two very important considerations in harvesting nwsg hay. First, cutting height is extremely critical to maintenance of stand vigor and longevity. The reason for this is the growing point for nwsg is aboveground. Thus, when a cutting is made below this level, carbohydrate reserves are used to extend a new growing point. This not only weakens the plant, but also results in lost growing time and reduced forage accumulation. This problem is made worse by the fact that virtually no leaf surface area exists below 6 inches and low cutting heights can effectively eliminate the plant's ability to photosynthesize at all. In these circumstances, the plant has to use additional stored reserves just to re-grow leaves. Cuts below even 8 inches reduce quality by increasing steminess of the hay. An 8-inch harvest height is recommended. This may present some problems depending on equipment limitations, but nevertheless, efforts should be taken to reach this goal. These problems are very much the same as with growing and harvesting warm-season annuals such as millets and sudangrass.

Fig 3.9 Harvesting nwsg hay at the appropriate height (above the growing point) is important to maintain stand vigor. Cuts below 8 inches actually reduce hay quality because additional stem is harvested.

A second and related problem is timing of the second or final harvest — in some cases a third harvest could be possible. Like other perennial forages, such as alfalfa, nwsg need time at the end of the growing season to fully restore carbohydrate reserves for the winter dormancy period. Because there is little growth in nwsg after mid-September, it is critical to allow adequate time for re-growth prior to this time. Previously hayed nwsg should be 12–18 inches tall before fall dormancy. To achieve this, a good rule of thumb is to **rest the stand after September 1 at the latest,** and early August is preferable.

If nwsg are managed with low cutting heights and late-season harvests, stands could be seriously weakened and even eliminated within a few years. It is especially critical to not over-harvest during the first two years after establishment when nwsgs are developing their deep root systems. Producers should not expect to harvest any hay during the year of establishment and perhaps only 40–50 percent of full yield during the second year after establishment. Only one cutting should be taken the second year and cutting height is especially important that year. Most likely the main reason nwsg are no longer common in Southern grasslands is mismanagement and their sensitivity to overharvest and overgrazing.

Native warm-season grasses for grazing

The advantage of nwsg as a grazing crop is similar to their advantage as a hay crop. Most producers across the Mid-South use cool-season grasses as the main pasture crop because of the long production season for these grasses. However, during the high temperatures and droughts of the summer months, cool-season grasses are dormant and unproductive. Pastures may become overgrazed, which stresses the plants even further, resulting in stand loss and increased weed pressure.

Nwsg are adapted to high temperatures and limited moisture conditions, which allows them to be used during the summer period. By converting 10–30 percent of the acreage in a cool-season grazing program to nwsg, animals may be grazed on actively growing forage during the summertime, which provides much higher-quality forage while allowing cool-season grasses to rest and minimize overgrazing. Research has shown cattle gain well during the summer on nwsg (see Table 3.1), particularly during the first half of summer. The potential for improved summer performance and the ability to rest cool-season pastures make nwsg an attractive component of a forage program. This strategy also reduces the need for hay, which can be required to supplement cool-season forage during mid-summer.

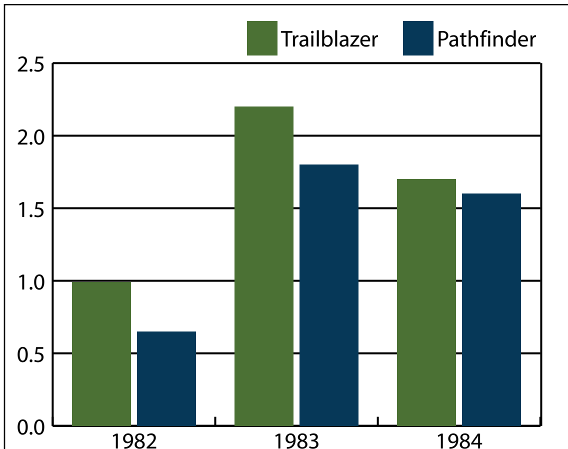


Figure 3.10 Average daily gain (pounds) of steers grazing two switchgrass varieties in Nebraska (Anderson and co-workers 1988).

As discussed for haying, nutrient reserves can be limiting for nwsg when an adequate stubble height is not maintained. This is also true if nwsg are consistently grazed below 8 inches. Yield and persistence may be reduced and increased weed problems may occur. If a stubble height of 8 inches is left, more leaf area will be present for rapid re-growth and to rebuild reserves for next year's production. As with haying, when grazing after early August, the ability of the plant to rebuild reserves for next year's growth is reduced, which can reduce the next forage crop. If nwsg are grazed late in the growing season (September), vigor is reduced and a change in stand

Fig 3.11 This mixed pasture of big bluestem, indiangrass and switchgrass is approximately 2 feet high and ready to graze—22 May 2006.

composition may occur. Disturbance at this time can reduce grass density and, as a result, increase forb density. While this may be good for wildlife, it is not necessarily good for forage quality. Other plants that may appear at this time include cool-season grasses. This is not desirable from a forage or wildlife perspective. Because cool-season grasses mature much earlier than warm-season grasses, forage quality of a warm-season stand is reduced if over-mature cool-season grasses are present.

The primary concern in managing nwsg as pasture is to avoid overgrazing by following the guidelines regarding stubble height and late-season grazing discussed above. **Overgrazing can eliminate nwsg in a pasture!** The basic tool to avoid this problem is to control grazing pressure. This can best be accomplished by monitoring the condition of the stand. For most species suitable for grazing in the Mid-South, (big bluestem, indiangrass, switchgrass and eastern gamagrass), grazing should be initiated when the stand reaches approximately 24–30 inches in height. With lighter stocking rates, grazing could be initiated sooner, perhaps with grass heights of 12–18 inches. Initiation at these lower heights can be particularly appropriate for creep-grazing calves. Cattle should be removed from the stand when stubble heights reach 8–10 inches. Depending on stocking rates (density) and available moisture, this will allow from less than one week to as much as six weeks grazing. A rotational grazing system is strongly recommended to prevent over-grazing.

Fig 3.12 Happy is the cow belly deep in quality forage! This is especially true during summer when cool-season grasses are dormant and provide poor-quality forage.

Rest periods should generally be four weeks or more to allow adequate regrowth. Understocking will result in some plants going to seed. This will result in cattle avoiding these areas and concentrating on the more tender and palatable grasses where grazing pressure had been adequate. Over a season, this can result in "holes" being created in the stand through over-grazing these areas.

As with haying, no production should be anticipated during the year of establishment. During the second year, only one entry should be used and residual heights should be monitored carefully. Late-season grazing should **NOT** be permitted during the second year.

Cattle performance is excellent on nwsg pastures and good gains can be realized. However, producers new to managing these grasses may find cattle unfamiliar with nwsg and may need to learn to accept them initially. Once they are familiar with them, acceptance is high.

It is very important to remember forage quality is influenced by stage of maturity (see Figure 3.3). Crude protein and digestible energy of nwsg can be high, but if plants are allowed to produce seedheads, or if hay harvest or grazing is delayed more than 35–40 days, nutrient content will be reduced.

Table 3.1. Results of several grazing studies with steers on various grasses.

Species	Average daily gain (lbs)	Steers per acre	Steer-days per acre	Location	Duration	Reference
Switchgrass	2.4	3.6	144.1	NC[1]	3 years	Burns and others 1984
Tall fescue and coastal bermudagrass	1.3	3.8	na[2]			
Switchgrass	2.1	2.0	64.8	SD	3 years	Krueger and Curtis 1979
Big bluestem	1.5	1.9	80.6			
Indiangrass	2.4	1.4	44.9			
Sideoats grama	1.9	1.5	56.3			
Eastern gamagrass	1.65	3.0	270.0	AR	3 years	Aiken and Springer 1994
Switchgrass	1.45	2.1	139.0	IA	4 years	Barnhart and Wedin 1984
Switchgrass	1.9	na	81.0	IA	3 years	George and others 1996
Big bluestem	2.4	na	72.0			
Switchgrass–rotational	2.4	na	174.0			
Big bluestem–rotational	2.9	na	187.0			

[1] 630 lbs/ac/year N applied to all species during study
[2] Data not reported in original article

Table 3.2 Nitrogen fertilization recommendations for native warm-season grasses used for forage. University of Tennessee Extension.

use	early summer	mid-summer
	lb actual N per acre	
hay *mid-summer application should be eliminated if soil moisture is limited	45–60	45–60
grazing * apply N only if extra forage growth is needed.	45-60	up to 60 lb N

Fertilization and burning

Soil fertility is important when growing nwsg for hay or grazing. Although nwsg are adapted to poor soil fertility, soil pH should be kept above 5.8 and adequate levels of nitrogen, phosphate and potash must be provided to produce large amounts of high-quality forage. Once the stand is established, phosphate and potash levels should be maintained at medium levels and monitored through soil testing every couple of years. Nitrogen should be applied after weeds have been controlled, when soil moisture is not limiting and if extra forage production is desired.

Robin Mayberry

Fig 3.13 Heavy nitrogen applications are not necessary to obtain high-quality native grass hay, such as this switchgrass in Hickman County, Tennessee. Rates above 100 pounds of N per acre per growing season do not improve yields.

Few data exist from the South for fertility management for most nwsg. One key exception is switchgrass, which has been studied because of its potential for producing biofuels. Results from those studies suggest 50–100 pounds of N per acre *annually* result in maximum switchgrass yields. Higher rates do not result in improved yields. Where high hay production is desired for any species or species mixture, a split application of 25–50 pounds of N per acre should be applied approximately two weeks after dormancy breaks in the spring (roughly mid- to late April), and a second application of 25–50 pounds per acre about two weeks after the first cutting is taken when the grasses are actively growing. As with most crops, N should not be applied during periods of markedly reduced growth, such as during drought periods.

Burning helps rejuvenate nwsg and can improve forage quality. Burning in late March and early April can help reduce invasion of cool-season grasses and stimulate growth of nwsg. Ideally, burning should be conducted when nwsg have produced approximately 1 inch of new growth. Continued burning in late summer and early fall (August–September) may reduce grass dominance and increase forb cover. While this might be desirable from a wildlife perspective, it would not be necessary or even desirable (depending upon forbs present) for forage production. If a reduction in grass density is desired for wildlife habitat, disking in the fall will promote desirable forbs more so than fall burning (see ***Disking*** on p.120).

Figs 3.14, 3.15, 3.16 The ideal time to burn nwsg grown for hay or grazing in the Mid-South is early to mid-April, just before or as the grasses begin to produce new growth. This stimulates quick re-growth and added nutrition.

Terry Best

30 March 2006

Terry Best

7 April 2006

Terry Best

7 April 2006

Maximizing forage production and wildlife habitat

Nwsg are hayed and grazed when many wildlife species are nesting and rearing young. Waiting until after the nesting season to hay or graze will result in poor-quality forage, especially if switchgrass or eastern gamagrass is used. Because big and little bluestem and indiangrass produce stems and flower later in the growing season, optimal haying dates are later than with switchgrass or eastern gamagrass. Thus, haying bluestems and indiangrass should enable early nesting attempts to be completed. By late June, initial nests of all songbirds have hatched and the nestlings fledged. The majority of wild turkey and many bobwhite nests also have hatched by this time. Thus, quality forage is still available with big bluestem and indiangrass after the primary nesting season. Haying at any date, however, can still produce detrimental effects on grassland songbird populations. Figures 3.17 and 3.18 show how haying anytime prior to early August may result in population declines of grasshopper and Henslow's sparrows. Other grassland birds may fare better, especially if the field is hayed no more than once per year.

Proper grazing intensity will not interfere with active nests as long as stock density is not too high. Including little bluestem in a nwsg mixture is especially important for nesting cover.

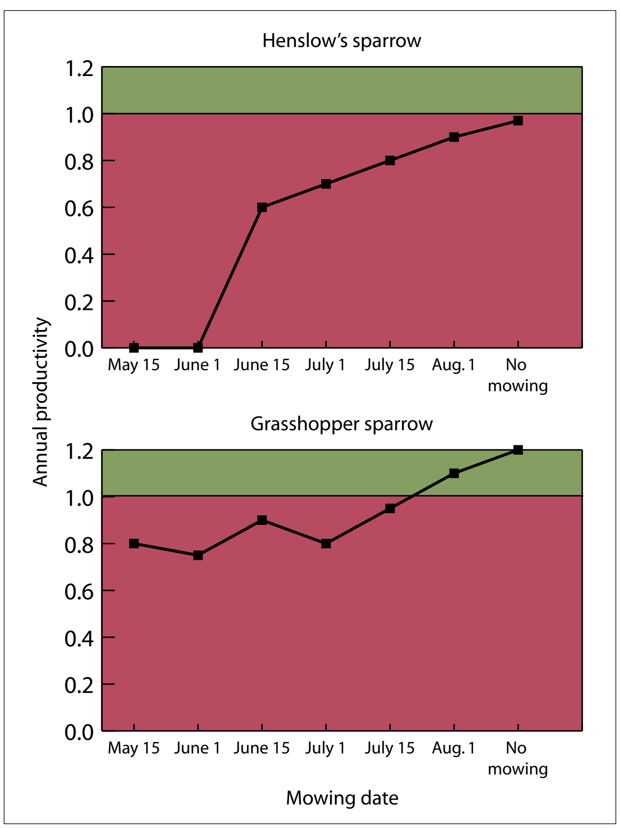


Figure 3.17 Estimated average annual productivity of Henslow's sparrows and grasshopper sparrows at Fort Campbell (assuming adult survival = 0.5, juvenile survival = 0.25, and birds can fledge up to three successful broods within one breeding season). Points below one female young per female indicate decreasing populations (red area) and points above 1 indicate increasing populations (green area) for each mowing date and for no mowing within the breeding season. Henslow's sparrows do not re-nest in the same field after mowing, but grasshopper sparrows will nest in mowed fields with reduced success (75 percent of average nest success). (Giocomo 2005)

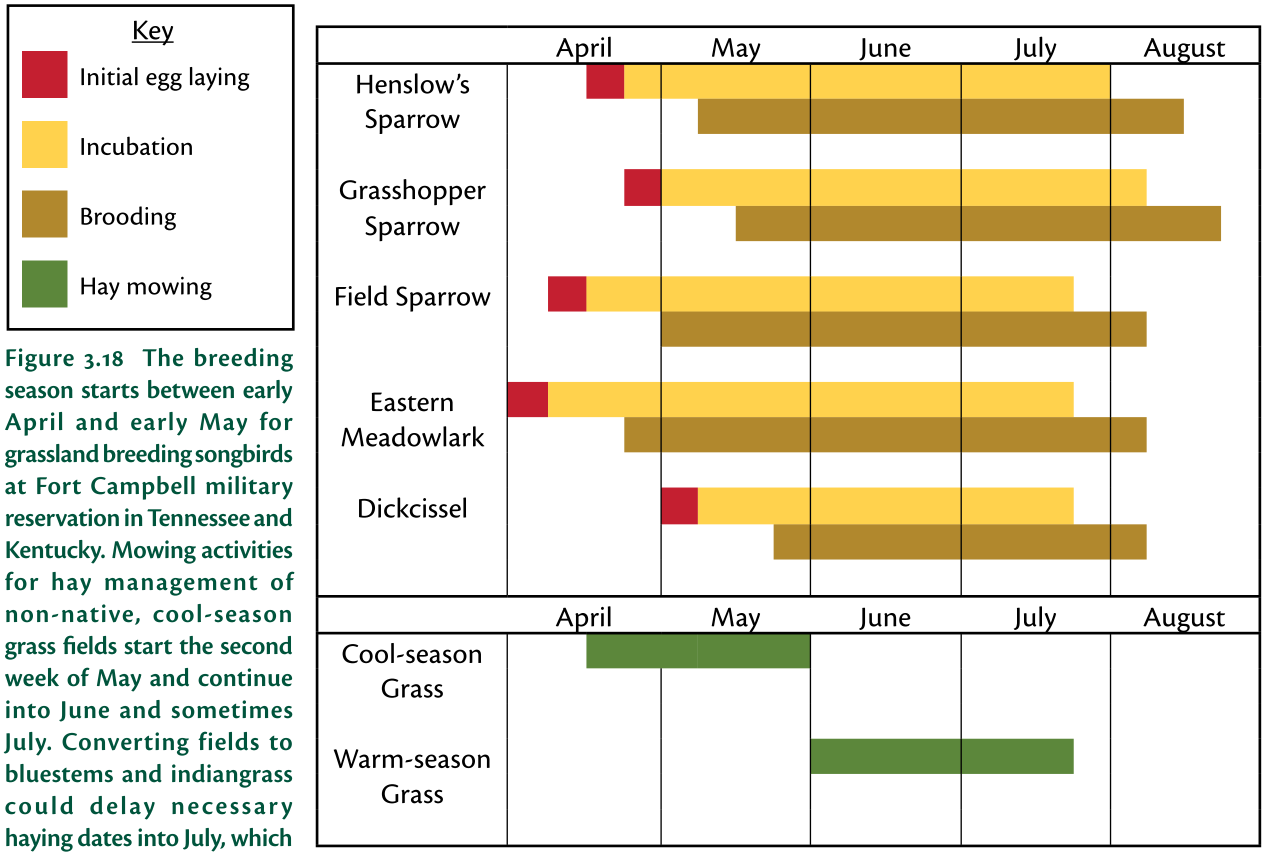


Figure 3.18 The breeding season starts between early April and early May for grassland breeding songbirds at Fort Campbell military reservation in Tennessee and Kentucky. Mowing activities for hay management of non-native, cool-season grass fields start the second week of May and continue into June and sometimes July. Converting fields to bluestems and indiangrass could delay necessary haying dates into July, which coincides with the end of the breeding season for grassland birds. (Giocomo 2005)

Another important consideration for wildlife is to cut or graze the nwsg stand only once per year. Getting a second cutting or grazing after haying will limit cover for wildlife the following winter—appearing much like a field of cool-season grasses. The re-growth produced between the first cutting and first frost provides excellent habitat for many wildlife species at a time when cover is often limiting. **Winter cover is an extremely important benefit (for wildlife) of nwsg grown for livestock forage.** Nwsg grown for haying and grazing may be too dense to provide quality brooding cover and there are few (if any) forbs present to provide cover, forage or seed. If considerable re-growth is not allowed after haying or grazing to produce adequate cover during winter, the stand will not provide as much benefit for wildlife.

Resting nwsg from haying and grazing is another way to improve wildlife habitat in a nwsg forage system. By excluding livestock and refraining from haying a portion of a field every year, additional wildlife habitat is made available. Many other practices and recommendations for improving wildlife habitat using nwsg are described in Chapters 2 and 5.

Robin Mayberry

Figs 3.19 and Fig 3.20 Winter cover is a most important consideration when growing nwsg for hay or grazing. By allowing sufficient re-growth before dormancy, cover is provided for a variety of wildlife species through winter. The cover provided in this switchgrass field, which was hayed only once during the growing season, is in stark contrast with the total lack of cover provided by a cool-season hayfield, such as this tall fescue.

Landowner "testimonials"

August 18, 2003

Dear Mike,

I just wanted to let you know how impressed I am with my plot of warm season grasses. I planted about 5 acres of indiangrass and big bluestem in April, 2002. I achieved an excellent stand with good germination immediately. This was surprising in itself due to the soil types and landscape on which it was planted. It was planted on Smithdale/Shubuta soils (sandy-loam to clay-loam), with slopes between 6 and 15 percent. These are naturally low pH and low fertility soils (~4.5), so I was a little skeptical.

My reason for using these grasses was primarily for hay production, with the by-product of maintaining a resident quail flock [covey] on my property. I have noticed good use by many different species of small game and birds, as well as heavy use by white-tailed deer as a bedding area.

As far as hay production, this was my first year to cut hay. Since this is sort of experimental for me, I did not lime or fertilize this spring to make a comparison. On a single cutting in early July, it produced 1.3 tons of hay per acre. I hope to at least triple that next year with a controlled burn in spring, then fertilizing and liming.

Overall, I am well pleased with what I have seen of these grasses and plan to make them a part of my planned hay production next year.

Thanks for your input and help,

Craig Chrestman
Private Soil Consultant/Agronomist
Morris Chapel, TN

27 October 2003

Dear Dr. Harper,

I have a field of Cave-in-Rock switchgrass that was planted in 2001. Before planting, I kept the field "clean" for a year by spraying Roundup. The switchgrass emerged fine with almost no weed pressure. Keeping it clean during the extra weed cycle really helped on weed suppression. It was not fertilized at any time. In some other areas, I have used a half rate of Atrazine or hit it with 2-4,D to suppress some of the weeds during establishment. The switchgrass tolerated it well.

The first year it grew 2.5 feet tall and headed out. The second year it was 6 foot on heading out, thick as a jungle, and only a few marestail and a brier or two. I allowed it to stand for wildlife cover during the 2002 season.

The third year, 2003, I decided to cut about an acre for hay. The grass was taller than the tractor and, believe it or not, I cut the switchgrass before it headed out. It produced 10 rolls 4x5 feet in size. These commonly weigh 900 to 1000 pounds per roll. There was so much grass after cutting that I had difficulty raking it.

I had two TWRA biologists that wanted to see the switchgrass in the multiple role of hay and wildlife. When they came, the rolls were still on the field. … [They were most impressed with the hay yield.] The biologists also commented on the large number of quail that were calling all around us.

By the middle of August, the switchgrass had re-grown and headed out to about 5-feet tall. I decided to use this for summer grazing. While I was constructing a temporary fence, I ran out several deer that was using the area for bedding cover. At this point, I decided to leave it for the deer to bed in and as escape cover for the plentiful rabbits and quail that were nearby. I have also found turkeys nesting on the edge of it next to the woods.

Most of the switchgrass I have planted is 6 to 12 inches tall the first year but full height the second year. The gamagrass took 3 years to get a decent stand density. I have planted about 5 acres of bluestem, indiangrass, and switch mixture in Cumberland County. The soils are loamy over sandstone bedrock, infertile, and a pH of 5.5. Growth is slow but after 3 years it has a decent stand. Stool size and height seem to be better each year. I burned it last year for the first time and it really helped it.

Carlie McCowen, Soil Scientist
Overton County

November 24, 2003

Dear Dr. Harper,

I appreciate you and Dick Conley taking time to come to the farm and discuss our haying program.

The final production figures for our eastern gamagrass were outstanding. Our 3-acre field yielded 3 cuttings this summer. The first cutting yielded 29 rolls; the second cutting yielded 25 rolls; and the third cutting was square baled and yielded 280 square bales.

Our orchardgrass/ladino clover field didn't produce as well. The first cutting produced 21 rolls; the second cutting produced 400 square bales. We did not get a third cutting on the orchardgrass.

Before you figure the yields were fairly close between the gamagrass and the orchardgrass, remember the gamagrass field is 3 acres, while the orchardgrass field is 15 acres! … Both fields were cut exactly the same leaving about 2 inches of stubble. Both fields were fertilized at the same time with 400 pounds per acre of 19-19-19. Also, I cut the eastern gamagrass before it began to seed out.

Needless to say, we are converting more acreage to eastern gamagrass this year. Thank you again for your time and assistance.

Sincerely yours,
Ralph Carroll, Farm Manager
Congleton Farm
Loudon County

27 November 2003

Dr. Harper,

Our overall experience with native warm-season grasses has been very good. To begin, we took advantage of the instruction from the Tennessee Wildlife Resources Agency, specifically that from Dick Conley. We started plating warm season grasses in 1994. By killing out the fescue, we hoped to establish better quality hay and improve wildlife habitat at the same time. After becoming established (2 years later), we planted another 40 acres. We circled a 30-foot border with lespedeza and bi-color lespedeza for quail food. We were one of the first in the area to plant and harvest eastern gamagrass. In the past 9 years, we have increased our planting of warm-season grasses to over 200 acres.

It is very easy to sell hay from native warm season grasses. At first, some people were afraid to try it because of the unknown. But once people realized there was no [endophyte] (plus the clean-up is better than fescue/orchardgrass and there is less waste), we increased our harvest to meet customer's needs. Rodeo, burro, and llama customers prefer native warm season grass over orchardgrass and timothy. Horse customers really like the protein and the ease of clean-up. The weight gain in beef cattle seems better with native warm-season grasses than with cool-season grasses. Now that the news of warm-season grass is widespread in our community, most customers put their order in a year in advance. We typically add 2–3 new customers per year. People gladly pay in advance to store hay on the farm.

Our hay-tonnage production with eastern gamagrass and big bluestem/indiangrass has been tremendous. We always cut our grass at an early stage for tenderness and protein. With eastern gamagrass, the 2nd cutting seems better than the first. Out of 3 acres, harvest is close to 60 round bales (850-pound bales) for both the first and the second cuttings. The eastern gamagrass seems to grow twice as fast as the other warm-season grasses and at least 3 times as fast as fescue, which allows for a third cutting of eastern gamagrass. We fertilize our native grass fields in the spring. We pull soil samples and normally use 12-24-24 or 19-19-19. We lime when needed, usually about every 3 years. Out of 3½ acres of big bluestem/indiangrass, harvest is an average of 600 square bales (55 pounds each) and it is cut before the grasses begin to flower. We do not cut the big bluestem/indiangrass a second time—we leave it for wildlife habitat.

We have found several wild turkey nests in eastern gamagrass fields that were not harvested. Deer also use these fields extensively for bedding. Our quail population has doubled because there is great cover and insects for broods. The rabbit population has tripled as the warm-season grass fields provide great cover from predators. In short, the hunting has never been better on the property and there are more songbirds around than ever before. We couldn't be more pleased with the native warm-season grasses and highly recommend them to anyone interested in hay production and wildlife habitat.

Sincerely,

Hartman Farm
Gene Hartman, Owner
Steve Woodby, Farm Manager
Roane County, TN

Mr. Mike Hansbrough,

Thanks for contacting me about baling the big bluestem and little bluestem hay. At 60 years old, I have farmed all my life either full or part time. I gave up row-cropping cotton nearly 15 years ago to concentrate on raising cattle and custom baling for the public. I had been custom baling some for about 5 years prior to that. I guess that I have baled every type of hay common to this area. I have baled for horse people as well as cattle farmers, square bales to large rolls. This was the first time for me to bale big bluestem and little bluestem and it turned out to be a learning experience for me. I cut the hay on Monday with a mower-conditioner, and planned to bale on Wednesday. This hay cured very fast, even the hay on the bottom of the windrow. On Wednesday, it rained about ½ inch, Thursday it came another shower, however, to my surprise on Friday, I found the hay to be in good condition for baling without the need for raking. The hay fed into the baler very well and was easy to roll. I was amazed at the tonnage produced. This was the most hay per acre that I have ever baled. I hope the cows like it and that the protein value is good.

I plan to seed some acreage for my own use with the big bluestem. I like the yield, the ease of cutting and baling, and the way it cures. I also like the time of year that this hay is ready for harvest as it is during my slow season of baling.

Sincerely,

Max G. Laman
Gadsden, TN

Chapter 4

Using native warm-season grasses for biofuels

Since gasoline prices escalated in the early 1970s, interest has grown in finding cost-effective and environmentally friendly alternatives to address the transportation liquid fuel needs of the United States. A key area in developing renewable energy sources has been organic materials, such as wood, crop residues and dedicated perennial crops. Several years of research by the U.S. Department of Energy led to the identification of two particularly promising crops: hybrid poplars and switchgrass. A 10-year research program focused on establishment, fertilization and harvest management of switchgrass began in 1993.

Fig 4.1 Switchgrass has received considerable attention for its potential as a biofuel. Single harvests made after the first frost are generally recommended, but the possibility of using an initial harvest in mid- to late May for hay, then a final harvest for biomass is being evaluated.

More recent oil shortages and political instability in key oil-producing regions have brought these issues back into focus. Of the four major energy sources in the United States (petroleum, coal, natural gas and nuclear), petroleum is used most (> 39 percent) and is especially important for transportation, with 97 percent of all transportation fuels petroleum-based. Another issue with petroleum is that approximately 45 percent of all U.S. domestic consumption is imported (the U.S. is a net exporter of all other energy sources), accounting for a substantial portion of our foreign trade deficit. Further complicating the almost complete dependence of transportation in the U.S. on imported oil is the politically sensitive nature of that supply (Venezuela and the Arabian Gulf region).

The greatest potential for switchgrass as a biofuel, therefore, is as a liquid fuel in the form of ethanol. Ethanol has been demonstrated to work in modern engines and can be blended with gasoline, typically either at a low level, 10 percent (E10), or in nearly pure form, 85 percent (E85). Ethanol has been used successfully in the U.S. (corn-based) and most notably in Brazil, where 4.4 billion gallons of sugar cane-based production were used as a gasoline replacement in 2005, representing about 40 percent of that country's non-diesel fuels. Furthermore, ethanol produces fewer carbon emissions, making it less of a problem from a global climate change perspective.

Fig. 4.2 This pyrolysis unit is responsible for converting plant matter into bio-oil using heat in the absence of oxygen.

Burton English

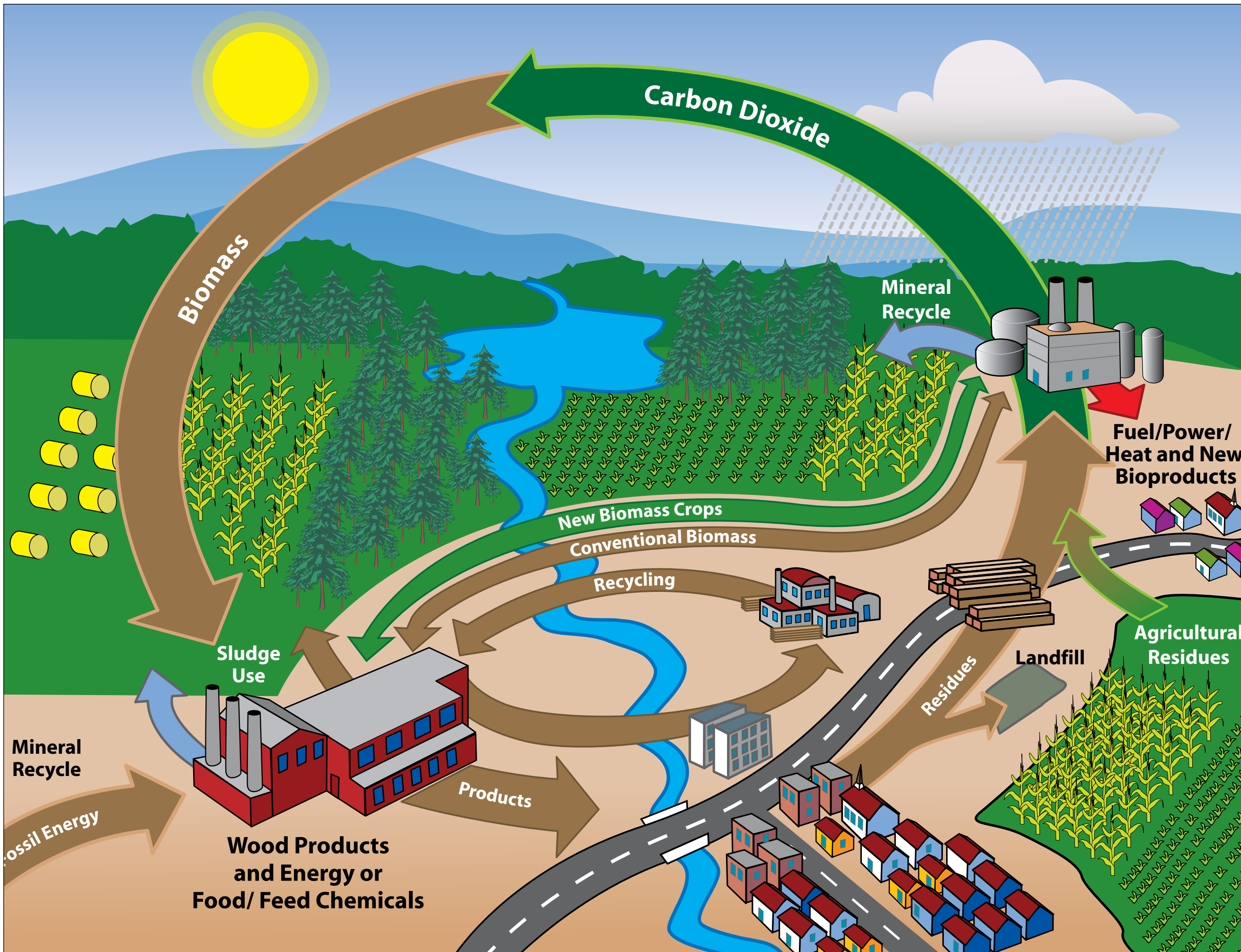


Image adapted from the US Department of Energy.

Fig. 4.3 In a robust bioeconomy, agricultural feedstocks join with municipal residues as energy sources, while sludges are used to feed agricultural crops.

A recent Department of Energy study conducted at Oak Ridge National Laboratory evaluated U.S. supplies of biofuel feedstocks to determine if there were enough to replace 30 percent of our current petroleum consumption. That goal, set by a Congressional panel, would require the production of 1 billion tons of dry matter on an annual basis. Published in 2005, this study identified numerous sources of possible biofuels from forestlands that would account for 368 million dry tons per year and about 1 billion tons from agricultural lands, all without compromising current food production levels. Much of the agricultural contribution (428 million dry tons) would come from crop residues, but a substantial portion (377 million dry tons) would come from dedicated perennial crops, most notably switchgrass. This same report concluded about 55 million acres of cropland would need to be converted to produce that much switchgrass. Another study indicated that if the nation were to achieve 25 percent renewable energy by the year 2025, 105 million acres of dedicated energy crops might be needed, requiring nearly 1.2 billion tons of cellulose, corn grain and soybeans as feedstocks for energy production.

Despite the focus on ethanol, switchgrass can also be used for energy generation through direct combustion. Typically, baled or pre-processed switchgrass would be burned along with coal, natural gas or other primary fuels. In some cases, an entire plant could run off switchgrass with another fuel source as back-up. This area has not received as much attention as cellulosic ethanol because of transportation costs, potential impacts on plant operations, storage issues and the fact that there are sufficient supplies of coal within the nation. However, at a small scale in plants less than 250 megawatts, co-firing of biomass with coal may be feasible. For instance, smaller cogeneration facilities (< 100 tons per year) at existing industrial sites are exploring switchgrass as an alternative to coal and natural gas.

Production of switchgrass for biofuels

Switchgrass has been considered an excellent species for biofuels production because of its wide adaptation, low inputs, ability to grow on poor soils, limited problems with pests and relatively high biomass yield. During the 1990s, much was learned about switchgrass production through extensive studies across the species' range. Numerous varieties were examined for production potential, with a lowland variety developed in Texas (*Alamo*) considered best because of high yields (5 – 8 dry tons per acre based on a 1992 study with 18 field sites in 13 states). *Alamo* grows well throughout most of the South, though it may suffer damage from extreme cold in the central Appalachians and upper parts of the Corn Belt. In the Mid-South, this is rarely a problem. Although best adapted to alluvial soils, *Alamo* does well on upland sites and, like all varieties of switchgrass, is very drought-tolerant. *Alamo* exhibits little problem with seed dormancy, a serious concern with *Cave-in-Rock*, another upland variety with high yields that can be used in more northerly climates where cold hardiness is a concern.

Burton English

Fig. 4.4 The only way to get an accurate estimate on biomass, whether for biofuels or hay, is to weigh several bales on certified scales and get an average. Guessing the weight of hay bales is usually erroneous (most often to the positive side!).

Establishment of switchgrass is straightforward and can be readily accomplished by following the guidelines presented in Chapter 5. Because a basic goal of stands established for biofuels is to maximize tonnage, seed should be drilled at 8 pounds PLS per acre. Minor increases or decreases in planting rate will not affect yield appreciably.

Once switchgrass is established, little management is needed over the life of the stand. Evidence suggests stands should last at least 15 years with proper fertilization and harvest. About 60 pounds per acre of N applied early in the growing season will provide high yields. However, if the stand is not well-established, no more than 40 pounds of N should be applied. Because of the growth habit of switchgrass (typical of all nwsg), there is a high rate of below-ground biomass accumulation (five tons per acre during the first 10 years post-establishment). This high amount of soil organic matter may reduce required N fertilization in more mature stands. Nitrogen should not be applied in the establishment year (or during the fall prior to establishment) as discussed in Chapter 5. During the second year, N may be applied, but only if competition is under control, and at a reduced rate (no more than 40 pounds per acre).

Harvesting switchgrass for biofuels

Most work on switchgrass harvest regimes for biofuel production indicates there should be only one annual cutting. More frequent cuttings tend to reduce stand vigor and reduce yields in subsequent years. Frequent cuttings also require increased harvesting, handling and storage costs versus a single-entry system for little or no improvement in yield. The single harvest should occur post-dormancy, because carbohydrate and mineral content, especially N, is reduced as they have translocated back to the root system, resulting in higher-quality feedstocks with fewer processing concerns. Elevated N and mineral content associated with a mid-summer initial harvest is another reason why two-cut systems are less desirable for biofuel production. Moisture content is also reduced in post-dormancy harvests, making transportation and storage easier.

Although timing the single cut after the first frost is desirable, there are trade-offs in delaying harvest even as late as the following spring. While biomass decreases over the winter, mineral (and therefore ash) and moisture contents decline also. It is worth noting that the loss of biomass is mostly a result of the grasses falling over and being missed during harvest. Nonetheless, producers can delay harvest for several months beyond the first frost if there are storage or time constraints, market conditions are more favorable later and/or maintaining wildlife cover over the winter are important considerations.

Where dormant-season harvests are implemented, cutting height is not as critical as with forage stands (see Chapter 3). Once all carbohydrate reserves have moved back into the root system and active photosynthesis has ceased, there is little production benefit to higher cutting heights needed for growing-season harvests. Nonetheless, retaining stubble heights greater than 6 inches during winter harvests can provide shoot protection for stands that may be grazed the following summer.

Square baling is the preferable harvest method, because it allows more efficient loading, greater density and reduced transport costs. However, a square baler is more expensive than a round baler. Tradeoffs between large round bales and square bales need to be considered carefully. Research is examining ways to reduce bulk through compression of bales or in-field chopping. Limited space at conversion facilities may require storage of harvested switchgrass, either on the farm or at satellite concentration yards, not unlike those used by the pulp and paper industry for pulpwood.

Alternative management strategies

Because of the current uncertainties regarding future biofuels markets for switchgrass, producers should remain flexible. The ability to manage native grass for forage and biofuels, wildlife habitat and biofuels, or perhaps all three is most desirable. One of the attractive aspects of planting native grasses is the possibility to manage for a variety of objectives within the same stand. Therefore, producers should consider a few options before stand establishment.

Fig. 4.5 Value for wildlife is much greater in a mixed stand of native grasses and forbs than a monoculture grass stand. In 2006, a study in Minnesota (Tillman and others 2006) suggested biomass generated from a mixed native grass stand was greater than that from pure switchgrass stands.

Selection of grass species other than switchgrass can enhance the forage and wildlife habitat value of the stand. A recent study indicated mixed species stands produced more net energy than switchgrass monocultures, albeit their study focused on relatively poor sites unlikely to be used for agriculture. In addition, species such as big bluestem and indiangrass may actually yield more than switchgrass in terms of net energy production, because they may be easier to convert to ethanol through existing digestion processes. Furthermore, recent developments in the production of ethanol from cellulose suggest processes can be developed that will not require single-species feedstocks for conversion. Together, these notions suggest that not only may mixed stands be acceptable, but they may even be preferable. At this point, there is some question about which ethanol conversion process will be developed and how that may be able to handle mixed-species stands. Also, more work is needed to determine the acceptable range of variation in feedstocks for firing in cogeneration applications. A high degree of consistency is usually needed, but to what extent, including whether a second or third species of grass in a feedstock will vary the firing properties of the feedstock, is not known.

Producers should consider developing integrated management approaches that allow flexibility to shift production between livestock forage and biofuels in response to markets or seasonal needs (such as drought years when cool-season grass hay is unavailable). As discussed in Chapter 3, nwsg, including switchgrass, can produce high-quality forages. Early-season production (late April–mid-May for switchgrass) produces the highest-quality forage and can be easily diverted for forage either through haying or controlled grazing. The later the forage is harvested, the greater reduction there will be in the final biofuel harvest for that season. Most biomass accumulation in switchgrass occurs during the first half of the growing season. Harvests approaching July 1 will result in substantial reductions in a final post-dormancy harvest. Obviously, delaying the forage harvest too late (past late-boot stage) would be counterproductive for forage production because of deterioration in forage quality in the maturing stand.

Unlike dormant-season harvests, these early-forage harvests (haying or grazing) should leave a minimum 6- to 8-inch residual height to ensure rapid regrowth and an adequate final biofuels harvest. Past research has indicated two-cut systems tend to reduce total biomass production in switchgrass stands over time. However, these studies have generally evaluated a relatively late first harvest and may not have left appropriate residual heights, which resulted in reduced regrowth. Some studies have also shown an increased yield under two cuts. A study is being imple-

Fig. 4.6 Although not nearly as bad as perennial cool-season grasses, the structure at ground level of a pure stand of switchgrass is relatively poor for brooding quail and turkeys. A lack of forbs really minimizes the value of these stands for wildlife.

mented at the University of Tennessee to address some of these questions. In any case, depending on biofuel markets and forage needs, a modest total reduction in yield may not be a problem. With a two-cut system, application of N should be split: half applied per the recommendations above and half 2 – 3 weeks after the first harvest.

For producers interested in wildlife, strategies to enhance wildlife habitat in a biofuel production stand include delayed winter harvest (to retain winter cover) and rotating harvest so that some fields or portions of fields

Blake Brown

Fig. 4.7 If left standing through winter before cutting, switchgrass grown for biofuel can provide winter cover for several wildlife species. .

are harvested only once per 2 – 3 years. Annual entire fall harvests leave no winter or nesting cover; whereas, partial or rotational harvests retain some cover for wildlife. Other methods to enhance wildlife habitat value include leaving buffers and/or fallow strips within and/or around fields and possibly grazing or haying. The important thing for producers to recognize is **high density and largely forb-free grasses provide only marginal wildlife habitat (similar to rank fields of tall fescue)**. This certainly applies to biofuel stands. For more information on incorporating wildlife habitat in nwsg, see Chapter 2.

The future

It is important to realize that while the area of biomass-based fuels seems very promising, those markets have not yet developed in any appreciable way outside of the Corn Belt where ethanol production has become established. While conversion of corn and sugar cane to ethanol is fairly straightforward, commercial-scale processes for conversion of cellulosic materials to sugar have not yet been developed. On the other hand, there have been some promising breakthroughs at the laboratory scale, and in 2007-08, a pilot-scale cellulosic ethanol plant will be built in East Tennessee. Direct-combustion markets will likely remain viable only at smaller-scale, co-generation facilities in the near term. Existing larger facilities would need substantial capital modifications for storage, handling, pre-processing and combustion to handle appreciable amounts of biofuels. Until substantial and cost-effective feedstocks are available, it is unlikely such capital investments will be made.

This combination of the substantial potential and currently non-existent markets suggests producers begin to move into native grass production at this time at a modest scale. The most logical pathway into production over the next few years is to gain experience establishing and managing native grasses, while using the material produced as forage for beef cattle. This would shift the harvest strategy from a single late-season harvest to one focused on optimal forage production (see Chapter 3 for details on forage harvesting). As biofuel markets develop, some or all of the forage could be diverted into that use.

Chapter 5

Establishment

Nwsg can provide excellent habitat for many wildlife species and provide an alternative source of forage for livestock producers. The benefits of nwsg, however, cannot be realized until establishment is successful. Unfortunately, some landowners' attempts to establish nwsg have failed and it is widely acknowledged that establishing nwsg can be slow, especially if certain steps are not taken. Reasons for establishment failure vary, but the most common include drilling (or covering) seed too deep, inadequate weed control, planting too late in the growing season and using inadequate equipment for sowing the fluffy seed of bluestems and indiangrass. Recent equipment innovations and information concerning the use of various herbicides have helped increase establishment success considerably. **Another problem is expectations.** Too often, landowners do not realize what a successful stand of nwsg looks like as it is establishing (especially for wildlife habitat). And in many cases, planting is not even necessary.

Fig. 5.1 An amazing array of plants can arise from the seedbank—some prettier than others! This rough blazingstar was found growing in a field previously covered with tall fescue in Loudon County, TN. Eradicating the tall fescue and managing the field with fire stimulated the seedbank, which included many wildflowers.

Evaluating the seedbank

In the top few inches of soil, there is an untold amount of seed from a wide variety of plants. This collection of seed is called the seedbank. Most of these seeds were produced by plants that once grew on the site, but some were brought in by wind, water and wildlife. The seedbank is the primary base for succession — the way plants arise without being "planted." Surprisingly, many of these seeds can remain viable in the soil for hundreds of years; some lose viability (die) within a year or two. This is extremely important to landowners interested in wildlife. **If seed from desirable plants are present in the seedbank, quality early-successional habitat may be developed without planting, which saves time and**

Fig. 5.2 Does this look ugly to you? If so, you are a poor quail/rabbit manager! This is quality early-successional vegetation—broomsedge bluestem, blackberry, goldenrod, beggar's-lice, native lespedeza and sumac—with an open ground structure. This particular vegetative community provides nesting, brooding and escape cover for bobwhites. And you wouldn't take 10 steps before you jumped a rabbit.

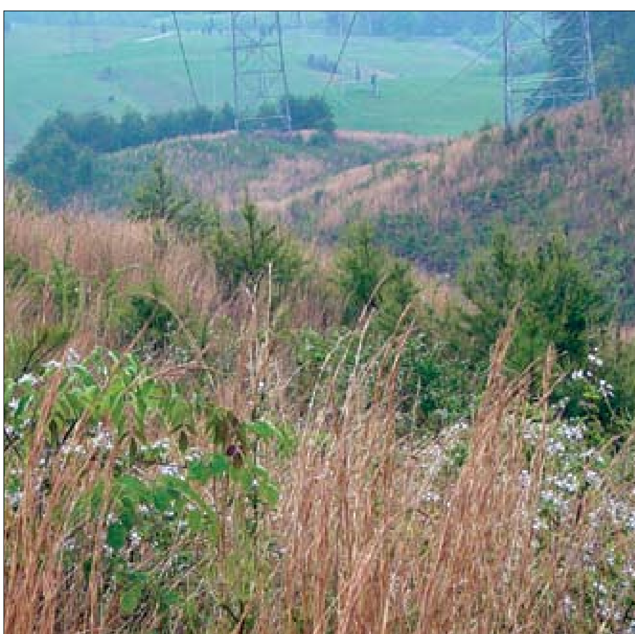


Fig. 5.3 Powerline rights-of-ways and roadsides are good places to check and see what the seedbank holds in a particular area. Usually, these areas are sprayed every 3–5 years to kill/suppress woody growth. As a result, the native herbaceous groundcover often flourishes.

money. Plants such as blackberries, broomsedge, ragweed, pokeweed and partridge pea provide excellent food (seed and/or forage) and/or cover (nesting, brooding, escape) for many wildlife species without planting. There are many other plants that may germinate from the seedbank to enhance early-successional cover for wildlife. Some choice "weeds" include: native lespedezas, beggar's-lice, low panicgrasses, smartweeds, wild strawberry, stick-tights, 3-seeded mercury, bluestems, Carolina geranium, butterflypea, milkpea, perennial sunflowers, doveweed, goat's rue, wild bean and nut rushes. Because of natural successional processes, fire and disking can stimulate and perpetuate many of these species.

Fig. 5.4 Native lespedezas, such as this *L. virginica*, are among the most-preferred plants for bobwhites. Their seed value is tremendous and they can provide quality brooding cover as well.

Wildlife managers use the seedbank by creating conditions that allow these seed to germinate. The seedbank is most often suppressed by introduced non-native grasses, such as tall fescue, bermudagrass, johnsongrass, crabgrass, orchardgrass, dallisgrass, bromegrasses, bluegrass, timothy and bahiagrass. Although some of these grasses are more competitive than others, when present, all of them replace and compete against native

Fig. 5.5 This newly revived oak savanna on the Catoosa WMA in Cumberland County, TN is the perfect example of a long-lived seedbank. The year after a pine beetle epidemic (2001–02) eradicated the pine in this previous closed-canopy mixed pine-hardwood stand, the Tennessee Wildlife Resources Agency began using fire to manage the area. What was an understory of scattered woody saplings and dead leaves is now a thriving early succession community with numerous species of native grasses, legumes and other forbs, none of which were planted.

Figs. 5.6, 5.7, and 5.8 This is often what happens when tall fescue is eradicated. The plot was sprayed in April 2004 with 2 quarts per acre of a glyphosate herbicide. The plot was disked in fall 2004 and by May 2005, ragweed and other forbs from the seedbank dominated the plot and offered quality brooding cover. By August 2005, the ragweed and sticktights (*Bidens*) were flowering and preparing to produce seed—seed that would not have been available if the tall fescue had not been killed.

April 2004

May 2005

August 2005

vegetation that would better serve various needs of wildlife. By killing non-native grass cover, conditions improve for seed in the seedbank to germinate. Burning dead material off a field after spraying, followed by disking, further stimulates the seedbank to germinate.

Fortunately, most nwsg seed remain viable in the seedbank for an exceptionally long time. This is most evident when openings are created in forested areas. Many (if not most) forests in the Mid-South today were once agricultural fields or early-successional openings, historically maintained by plowing or fire (either from lightning or Native Americans). When full sunlight reaches the ground, plants begin growing that have not been present since the forest canopy closed, often 80–100 years ago, or more. The seedbank present in these newly created fields is often rich with a wide variety of early-successional herbaceous species, including nwsg, that have been waiting to germinate for a long time. In many areas, there is enough nwsg seed present that planting is not necessary. Certainly, if 10–30 percent of the vegetative cover is nwsg, planting is not necessary to provide quality early-successional habitat for most wildlife species that would use that habitat. Even if nwsg coverage is less than 10 percent, this coverage will increase if dormant-season fire is used to maintain the habitat type. If planting is warranted, herbicide treatment is usually not necessary in newly created openings that were previously forested.

Seed quality, germination and Pure Live Seed (PLS)

When planting is necessary, seed quality should be an initial consideration. Purity of nwsg seed is often low (50–70 percent) because of an inordinate amount of inert material (stems, leaves, etc.). In addition, the germination rate may only be 50–60 percent. Fortunately, this information is printed on a tag sown onto the seed bag. From the seed tag, the percentage of pure live seed (PLS) can be calculated. This figure is then used to determine the bulk-seeding rate. **This is a critical step when weighing seed and determining the seeding rate prior to planting!** Failure to do so will almost certainly result in disappointment.

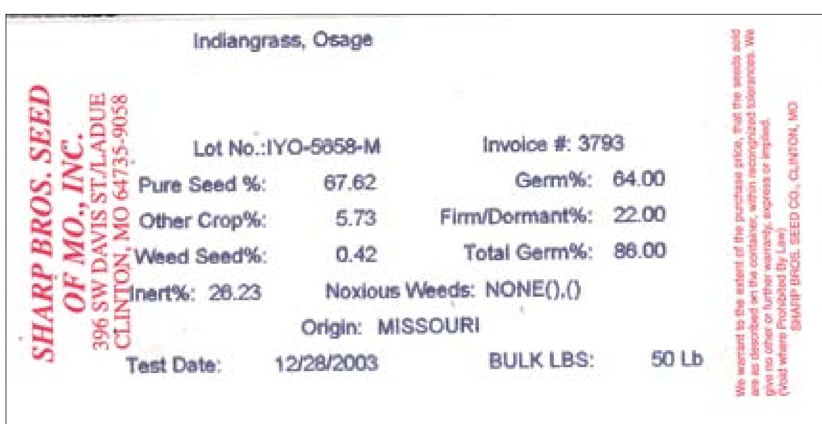


Fig. 5.9 Never plant nwsg without reading the seed tag and calculating PLS.

PLS is calculated as follows:

Seed: Indiangrass (Osage)	
Pure Seed: 67.62%	Germination: 64.00%
Other Crop: 0.05%	Firm/Dormant: 22.00%
Weed Seed: 0.42%	Total Germination: 86.00%
Inert: 26.23%	Noxious Weeds: NONE
Origin: MISSOURI	Test date: 28 December 2003

67.62% (pure seed) × 86.00% (total germination) ÷ 100 = 58.15% PLS
To plant 6 lbs PLS per acre: 6 lbs (desired rate) ÷ 58.15 (PLS) × 100 = 10.32
Therefore, 10 lbs of bulk material from the seed bag should be planted per acre.

Dormancy of nwsg seed can be a problem for eastern gamagrass and switchgrass. It has long been known that 2–3-year-old seed sometimes germinates better than new seed. Germination can be estimated (if not identified from a seed tag) using a "rag doll" germination test. This involves placing a pre-determined number of seed (such as 100) in a moistened paper towel, which is rolled up and placed in a Zip-lock® bag. Place the bag in a warm area for 5–7 days. Remove the paper towel and count the number of seeds that have germinated. Remove those seeds. Replace the bag, wait another 5–7 days and count the number of germinated seeds again. Now divide the total number of germinated seeds by the total number of seeds placed in the paper towel. This will provide a fair estimate of germination.

Problems associated with high dormancy (germination rate < 50 percent) can be improved with wet-chill treatments (cold stratification) and buying pre-treated seed (probably the most convenient option for most landowners). Wet-chilling involves soaking seed placed in a mesh bag overnight in water. Allow the bag of seed to drip dry the following morning for a few hours before storing in a cool location (such as a cellar or walk-in cooler set at approximately 40–45 F). Switchgrass seed should be chilled at least two weeks; eastern gamagrass seed should be chilled for six weeks. After the chilling period, the seed is removed from the bag and allowed to air dry. For best results, the seed should be sown immediately after air-drying. However, if seeds are dried out completely, dormancy may return. If all of the seed are not sown, the remainder may be stored after air-drying thoroughly. Optimally, the chilling process should be conducted during March/April.

Obviously, the wet-chilling process is supposed to simulate natural conditions as if the seed were lying in the ground through winter. However, germination and establishment success may be better with the wet-chilling process than planting in the fall. Perhaps the best option for eastern gamagrass seed is buying pre-treated seed (cold-stratified before shipping). It is important that this seed be planted immediately upon arrival. If not planted immediately, the seed may be stored in refrigeration for a short time (no more than two weeks). Some seed companies offer seed that also has been treated with a fungicide prior to shipment.

Use of Plateau® and Journey® herbicides

Plateau® (released in April 1996) and Journey® (released in May 2004) herbicides contain ammonium salt of imazapic as an active ingredient. Imazapic controls several problematic competitors (such as tall fescue and crabgrass—see herbicide labels for complete list of plants controlled) with relatively little harm to many plant species desirable for wildlife (such as bluestems, indiangrass, blackberries and legumes). Imazapic has residual soil activity with a half-life of 60 days after spraying; therefore, it can be applied preemergence as well as postemergence and provide a relatively long window of time for competition control.

Plateau® contains 23.6 percent ammonium salt of imazapic (one gallon contains 2.0 pounds of imazapic), while Journey® contains 8.1 percent ammonium salt of imazapic as well as 21.9 percent glyphosate (one gallon contains 0.75 pound of imazapic and 1.5 pounds of glyphosate). Both herbicides can be used to prepare sites for planting and treat undesirable species prior to planting nwsg; however, because Journey® contains glyphosate, higher rates of Journey® should not be sprayed over existing stands of several nwsg species while growing. Table 5.1 can be used to convert rates of Journey® to equivalent rates of Plateau® and glyphosate.

Fig. 5.10 Applying Journey® just prior to drilling nwsg offers postemergence control of existing vegetation as well as preemergence control for several weeks.

A word about surfactants...

The use of surfactants is critical for success of postemergence herbicide applications. Surfactants, or spray adjuvants, are water- or oil-soluble substances added to herbicides to modify or enhance the effectiveness of the active ingredient. Surfactants are surface-active agents that produce physical changes at the interface of the liquid herbicide mixture and the surface of the plant. Surfactants help herbicides stick, spread, wet, penetrate and disperse on the surface of plants. Hence, surfactants are not added to preemergence applications, only postemergence. Surfactants make many herbicides more effective by helping the herbicide penetrate the plant.

Surfactants include soaps and synthetic surfactants. Surfactants may be anionic, cationic, amphoteric or non-ionic, based on their ionization in water. Soaps are anionic (negatively charged) and are not used with herbicides because they form insoluble salts that precipitate. Synthetic anionic surfactants are not usually used alone because they may react with other ions (possibly the active ingredient in the herbicide solution); however, anionic surfactants are excellent wetting agents and may be used with nonionic surfactants to improve the wetting properties of an herbicide mixture. Cationic surfactants are derived from ammonia and are not usually used with herbicides because they are phytotoxic and precipitate readily in hard water (water with a relatively high concentration of calcium, magnesium and/or iron). Amphoteric surfactants have positive and negative charges, but are not normally used with herbicides. Non-ionic surfactants (NIS) do not ionize in water; therefore, they do not form insoluble salts and can be used with hard water. NIS are outstanding emulsifiers, forming stable emulsions, which enables them to make many herbicide formulations much more effective. NIS are also good dispersing agents, excellent detergents, do not foam much and have low phytotoxicity and low mammalian toxicity. All of these properties, along with the fact that NIS are more soluble in cold water than hot water, make them very attractive for use in solution with many herbicides.

Crop oil concentrates (COC) are petroleum- or vegetable-based oils that increase the absorption of herbicides into plant leaves. Methylated seed oil (MSO), for example, is a vegetable-based COC that enhances the uptake of certain herbicides. COC usually contain 80 percent oil and 20 percent NIS. Depending upon the application, some herbicide labels may recommend COC rather than NIS because of the inherent phytotoxic properties of COC. COC alone can alter the structure of cell membranes, thus causing damage to plants. That is why NIS are normally used with selective herbicide applications, while COC are typically used with "burn-down" applications where the intention is to kill all vegetation present. Nonetheless, it is important to use a high-quality surfactant and follow the herbicide label instructions, as some herbicides perform better with MSO than NIS.

Liquid nitrogen fertilizers, such as urea-ammonium nitrate or ammonium sulfate, may increase the uptake of postemergence herbicides. They are not, however, surfactants, even though they may be recommended on some herbicide labels as an additive to the spray mixture.

Table 5.1 Equivalent rates of Journey®, Plateau® and Roundup®				
Journey® rate (ounces)	Plateau® equivalent (ounces product)	Roundup® equivalent (ounces product)	Imazapic (pounds)	Glyphosate acid equivalent (pound)
32	12.0	16.0	0.188	0.375
24	9.0	12.0	0.141	0.281
16	6.0	8.0	0.094	0.188
12	4.5	6.0	0.070	0.141
8	3.0	4.0	0.047	0.094

Even though glyphosate can kill growing nwsg, demonstration plots have shown that Journey®, when applied at rates as high as 22 ounces per acre, can be used to "clean-up" weeds within a nwsg stand. Nwsg were stunted at higher rates, but the integrity of the grass stands remained intact (see Figures 5.11 and 5.12).

Some nwsg are more tolerant to imazapic than others (Table 5.2). The bluestems and indiangrass are quite tolerant to imazapic. However, growth of these grasses can be stunted by higher rates (10–12 ounces of Plateau® per acre) when sprayed over young seedlings (see Figure 5.13). Postemergence applications (especially higher rates) should not be applied until seedlings have reached the four-leaf stage or until it is apparent the majority of the herbicide will be taken up by competitive weeds that have overgrown the grass seedlings.

Fig. 5.11 This mixed nwsg stand was planted in May 2005. A strip (in front of biologist) was sprayed postemergence in June 2005 with 11 ounces per acre of Journey®. Although the grass was stunted, by August 2005, it is obvious the grass was doing fine.

Table 5.2 Tolerance of native warm-season grasses to imazapic[1]	
Species	Rate (oz / ac)
Big bluestem	<12
Little bluestem	<12
Broomsedge bluestem	<12
Indiangrass	<12
Switchgrass	2–4[2]
Eastern gamagrass	2–6[2]
Sideoats grama	2–8[2]

[1] Plateau® Herbicide Label; BASF Corporation, 26 Davis Drive, Research Triangle Park, NC 27709

[2] Expect stand thinning and possible loss of stand at higher rates.

Fig. 5.12 This mixed nwsg grass stand was planted in March 2005. A strip (in front of biologist) was sprayed postemergence in June 2005 with 22 ounces of Journey®. Obviously, the grasses were stunted by the herbicide application; however, problem weeds (note cocklebur in unsprayed area to left of strip) were controlled very well. By August 2005, the grasses were doing quite well and the resulting bare ground space was very beneficial for quail and other wildlife.

A preemergence application within one week after planting (4–8 ounces per acre Plateau® or 16–21 ounces Journey®) is recommended when establishing bluestems and indiangrass (Tables 5.1, 5.2 and 5.3). Preemergence applications provide the best weed control (especially crabgrass, johnsongrass and foxtails) and usually create "clean" conditions at the ground level, which provides excellent habitat for brood-rearing upland game birds (Table 5.4).

Some species, such as switchgrass, eastern gamagrass and sideoats grama, cannot tolerate higher rates (10–12 ounces Plateau® per acre) of imazapic and stand thinning may occur even at lower rates (2–4 ounces Plateau® per acre). When planted as part of a mixture, a relatively small percentage of switchgrass and sideoats grama usually germinates and grows with a preemergence application (6–8 ounces Plateau® per acre). Postemergence applications may lead to better survival and growth of sideoats grama and switchgrass if they are included in a nwsg mixture. Because of the susceptibility to imazapic, other herbicides are recommended when planting pure stands of switchgrass or eastern gamagrass (discussed under the *Competition Control and Herbicides* sections).

Fig. 5.13 When spraying Plateau® or Journey® postemergence over nwsg, it is important to allow the seedlings to reach at least the 4-leaf stage before spraying. This big bluestem seedling was severely stunted (notice dead top growth) when sprayed with 12 ounces of Plateau®. A few weeks later, it is beginning to produce new growth from below. The best technique for postemergence spraying is to allow the nwsg to reach the 4-leaf stage or when it is apparent the majority of the herbicide will be taken up by competitive weeds that have overgrown the nwsg seedlings.

Table 5.3 Influence of imazapic on native warm-season grass seedling density[1] at the Knoxville Experiment Station, 2002. (Harper and others, 2003)

Plateau® Treatment	Seedling density (plants/m²)				
	BB[2]	LB	IG	SG	SO
PRE 8 oz	81	60	54	12	15
PRE 12 oz	72	45	58	6	18
POST 8 oz	48	73	50	20	38
POST 12 oz	36	63	47	19	38
Untreated	29	47	43	39	23

[1] All grasses top-sown at 10 pounds PLS per acre.

[2] BB=big bluestem, LB=little bluestem, IG=indiangrass, SG=switchgrass and SO=sideoats grama.

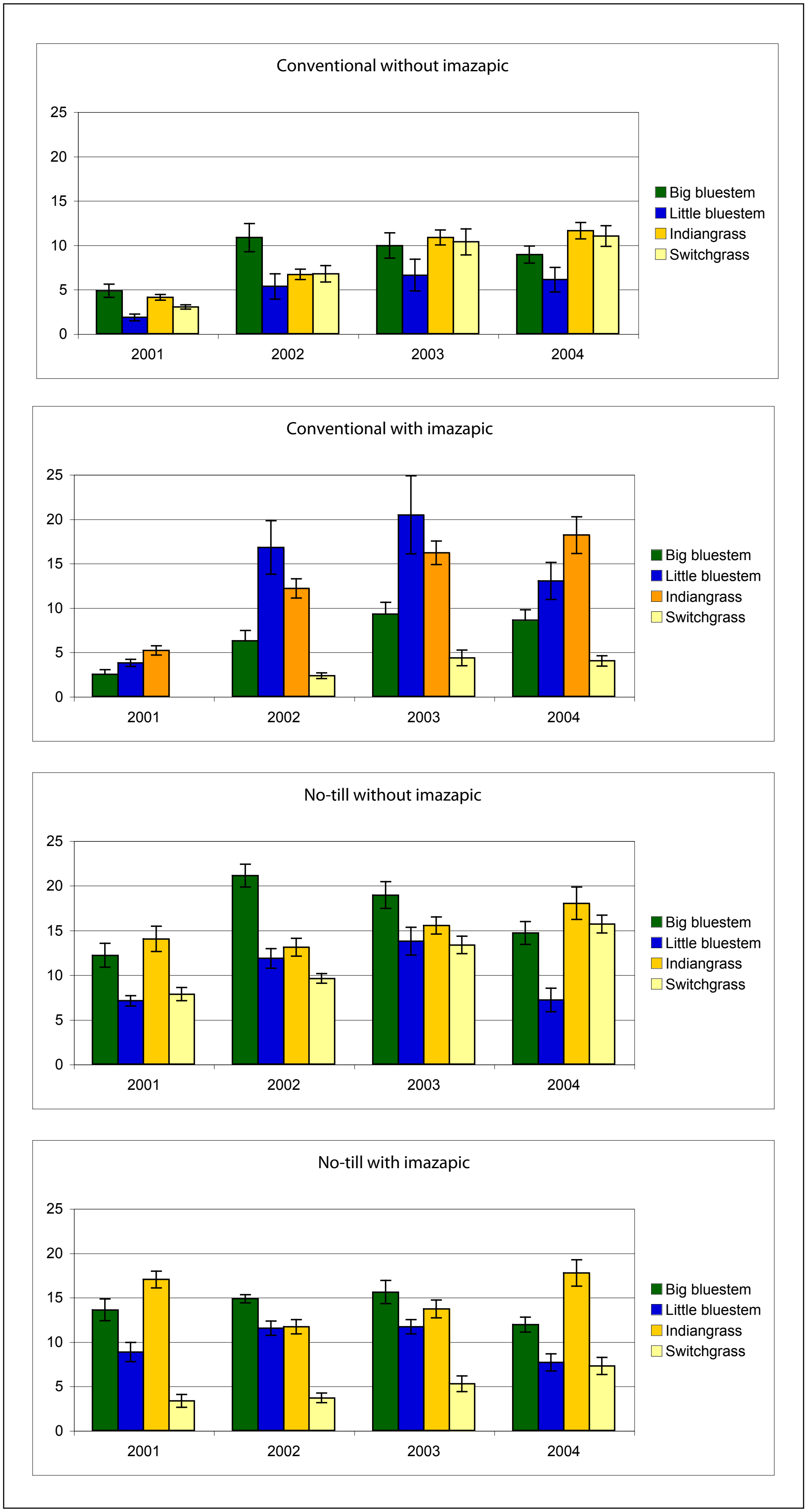


Fig. 5.14 These data show the change in number of nwsg bunches over time following planting in 2000 at the Middle Tennessee Research and Education Center (Harper and others 2002; Jones and others 2004). All plots were planted at 8 pounds PLS per arce. Plots with imazapic were sprayed with Plateau at 8 ounces per acre. Regardless of planting method, most species increase in density over time. It is also obvious, imazapic applications reduce coverage of switchgrass

Table 5.4 Influence of imazapic (Plateau) on percent control of crabgrass, spotted spurge and fall panicum at the Knoxville Experiment Station, 2002. (Harper and others, 2003)			
Treatment	**Crabgrass**	**Spotted spurge**	**Fall panicum**
PRE 8 oz	100	99	99
PRE 12 oz	100	99	99
POST 8 oz	62	68	38
POST 12 oz	69	76	44
Untreated	0	0	0

Competition control

Nwsg do not compete well with non-native grasses, such as tall fescue, bermudagrass, crabgrass and johnsongrass. Control of non-native grasses, as well as many broadleaf competitors, is **critical** to successfully establishing nwsg. It is particularly important to eradicate perennial competitors **before** planting. There are several solutions to weed-control problems with various scenarios based on field-crop histories and seedbank composition. For example, recommendations for establishing nwsg for haying/grazing in a field previously covered with tall fescue are completely different from those recommendations for establishing nwsg for wildlife in a newly created field previously covered with a stand of shortleaf pines (where, most likely, an herbicide application would not be needed). Similarly, competition control for establishing a field of nwsg for wildlife may be quite different from competition control for establishing nwsg for haying or grazing.

Controlling tall fescue and other perennial cool-season grasses

Fig. 5.15 For best results, cool-season grasses (e.g., tall fescue and orchardgrass) should be 8–10 inches high and actively growing when sprayed. Although spraying in the fall is the best time to spray, spring applications can be successful as well.

When converting a field of perennial cool-season grass to nwsg, the optimum time to spray the existing cover is in the fall before planting the following spring (see Fig. 2.36) This is because cool-season grasses are actively growing during October and November, but growth is concentrated primarily in root development as carbohydrates, amino acids and other compounds are being translocated and stored in preparation for hard frosts and freezing temperatures. In the spring, growth is directed towards leaf (forage) production with rapid photosynthesis taking place in an effort to ultimately produce seed. Because compounds are being translocated to the roots in fall, a reduced herbicide rate is possible. Glyphosate (the active ingredient in Roundup®) is the most common multi-use herbicide used to kill cool-season grasses. For fall (October/November) applications, a rate of 1–2

Figs. 5.16a and b Preparing the site before spraying is very important to ensure a complete kill. It is always best to "clean" a field in preparation for spraying. This is done by burning, haying or grazing the field to encourage fresh growth and reduce senescent grass leaves that will block the herbicide from coming in contact with growing grass.

quarts per acre of Roundup® is recommended. For spring (March/April) applications, a full two quart per-acre rate is recommended. One quart per acre of a COC or one pint per acre of MSO should be added if the herbicide does not include surfactant.

Before spraying, the field should be burned, hayed, grazed or mowed and allowed to re-grow. Burning or haying is recommended because most of the vegetative material is removed from the field, providing less chance for the herbicide to be "blocked" by senescent (dead) leaves and other material. To facilitate rapid uptake of the herbicide, perennial cool-season grasses should be actively growing and 6–10 inches in height. Waiting until cool-season grasses begin to flower and seed before spraying will produce less-than-desirable results. To help ensure a complete kill, 17 pounds per acre of liquid nitrogen (28-0-0) may be added to the herbicide mixture. After spraying, the field should not be manipulated (mowed, disked, burned) for approximately two weeks, allowing time for the plants to uptake the herbicide and to realize full efficacy (Note: glyphosate activity may be slowed by cool weather).

When wildlife habitat is the objective, many fields of tall fescue can be enhanced without planting nwsg. By simply eradicating the

Fig. 5.16a

Fig. 5.16b

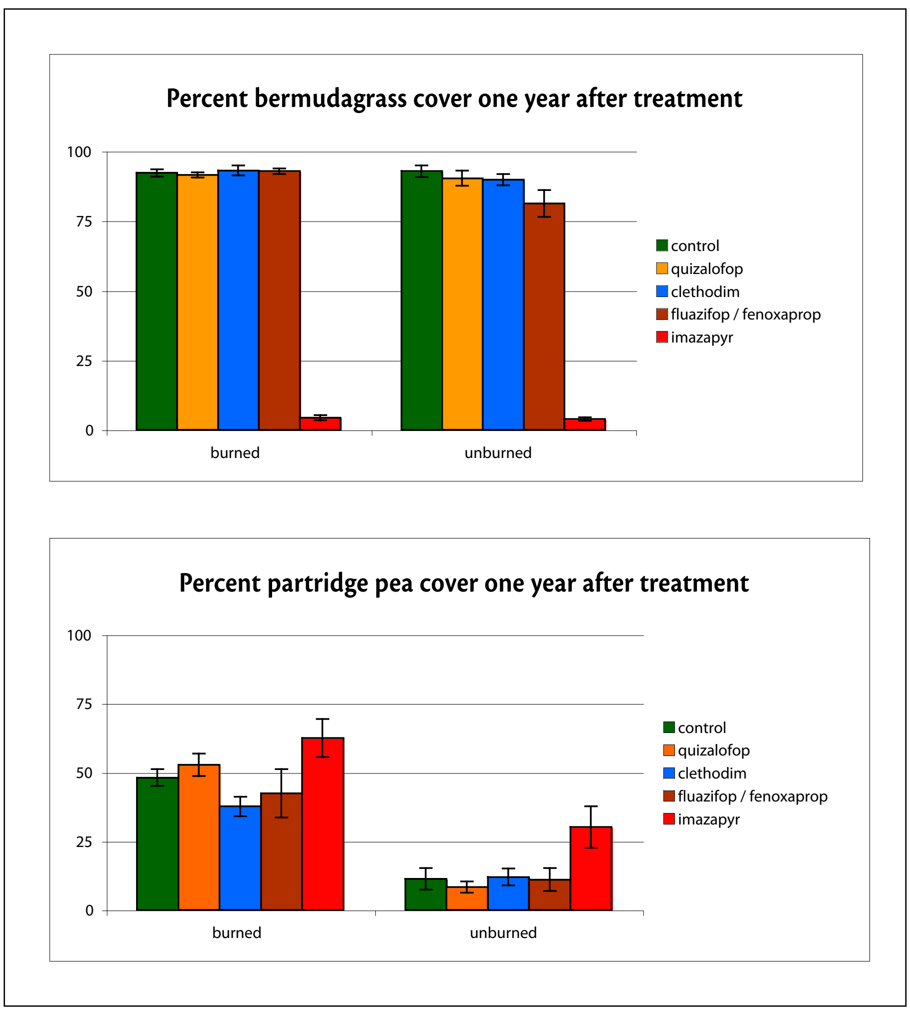
Fig. 5.17 This tall fescue field looks great—it is ready to kill! A few weeks after haying, grass growth is 8–10 inches and adequate moisture has the field green and actively growing.

non-native cover and allowing the seedbank to germinate, quality early-successional cover may develop within two growing seasons (depending upon the composition of the seedbank). To achieve this, the field must be treated as described above. Once the tall fescue has browned over, the field may be burned and then disked to stimulate the seedbank. The field should be checked periodically, especially in April and October for recurring tall fescue. It is not uncommon for tall fescue to re-occur where residual seed germinated several months later. Spot-spraying these areas with glyphosate or imazapic will provide long-term control.

Controlling bermudagrass

Bermudagrass is best controlled with imazapyr (24 ounces of Arsenal AC® per acre with 2 pints of MSO). Before spraying, the field should be burned in late winter (if not hayed) to reduce standing dead vegetation and ensure herbicide contact with growing grass after spring green-up. Burning also helps stimulate forb coverage, especially desirable legumes, such as partridge pea (Fig. 5.18).

Fig. 5.18 Research conducted by Bond and others (2005) in Georgia showed imazapyr (active ingredient in Arsenal AC®) was most effective in killing bermudagrass. Plots that were burned pre-treatment contain more desirable legumes (such as partridge pea) than unburned plots.



Bermudagrass is extremely difficult to eradicate. In fact, it is virtually impossible to eliminate bermudagrass with a single spraying. Patience and persistence are required when dealing with this exotic scourge. Unfortunately, if a spot or two of bermudagrass is left in the field, it may eventually spread over the rest of the field if left untreated. Repeat applications are always necessary.

After the initial spraying, the field should be disked prior to spring green-up following the initial herbicide application and left fallow, allowing the seedbank to germinate. This will stimulate residual bermudagrass as well. The field should be checked through the growing season and spot-sprayed as necessary. The following late winter/early spring, the field should be disked again to further stimulate the seedbank. Again, the field should be monitored throughout the following growing season and residual bermudagrass treated as appropriate. After two growing seasons of monitoring and treatment, the field should be ready for sowing nwsg the following spring (if nwsg have not already emerged from the seedbank).

Another technique often used to eradicate bermudagrass is growing a Roundup Ready® crop, such as soybeans. This technique has produced mixed results. Even after using a Roundup Ready® crop for two years, residual bermudagrass may appear the following growing season. Spot-spraying and persistence is always necessary.

Controlling johnsongrass and crabgrass

Where johnsongrass and crabgrass are known to exist, a preemergence application of imazapic (such as 8 ounces of Plateau® per acre) is strongly recommended when planting bluestems, indiangrass, sideoats grama or mixtures of these species. When establishing switchgrass or eastern gamagrass, johnsongrass and crabgrass should be sprayed the summer prior to planting. Although residual seed will still be present in the seedbank, the objective is to reduce the seedbank of these warm-season competitors as much as possible before planting nwsg. When sprayed postemergence, johnsongrass is best controlled when the grass reaches 18–24 inches in height at the whorl (the first set of three leaves on the plant stem). Optimally, crabgrass should be sprayed before reaching 4 inches in height; however, acceptable control may be achieved if crabgrass is sprayed before flowering. Both crabgrass and johnsongrass can be killed postemergence with a glyphosate herbicide at 2 quarts per acre or clethodim (Select®) at 10–12 ounces per acre. When spraying Select® (or a glyphosate product without surfactant), COC or MSO should be added to the mixture as appropriate. Another herbicide that can be used in switchgrass plantings (as well as other nwsg) to control johnsongrass is OutRider® (sulfosulfuron). A preemergence application (2 ounces per acre) or postemergence application (2 ounces per acre) after nwsg have become well-established (past the 4-leaf stage) should control johnsongrass as well as several other competitors. When spraying postemergence, a nonionic surfactant should be added at 0.5 percent by volume (2 quarts per 100 gallons of solution).

Fig. 5.19 When establishing pure stands of switchgrass, eradicating existing competition (such as, bermudagrass and crabgrass) prior to planting is especially important as there are no selective herbicides that will remove these competitors and not harm switchgrass.

Weed control in retired rowcrop fields

If left fallow, retired crop fields converted to nwsg may require herbicide treatment the growing season prior to planting to help control annual weed growth and their addition to the seedbank. Winter annuals should be sprayed in late winter/early spring before planting nwsg. A glyphosate herbicide application of 1–2 quarts per acre will control or suppress common winter annuals such as henbit, purple deadnettle, common chickweed and ground ivy. In crop residue, a preemergence application of an imazapic herbicide (such as 6–8 ounces per acre of Plateau®) usually promotes an excellent stand when planting bluestems, indiangrass and sideoats grama. A preemergence application of OutRider® (2 ounces per acre) also can be used to control several competitors when planting nwsg in retired rowcrop fields.

Weed control when establishing pure stands of switchgrass or eastern gamagrass

Switchgrass and eastern gamagrass are not very resistant to imazapic (Table 5.2). Therefore, other herbicides and competition control practices are needed when establishing these grasses for haying and grazing operations. Control of existing vegetation is critical and should be addressed thoroughly (as discussed above) because herbicide applications are limited for competing non-native warm-season grasses (such as bermudagrass and crabgrass) after switchgrass or eastern gamagrass germinates. A preemergence application of Atrazine 4L® (refer to label for various restrictions) at 2 quarts per acre will control many broadleaf and grass competitors (refer to label for species controlled/suppressed). Postemergence broadleaf competition can be controlled/suppressed with an application of 2,4-D® and/or dicamba (Banvel®, Clarity® or Overdrive®) with an NIS. Overdrive® can be used during or after establishment to control broadleaf competitors. Overdrive® has a 0-day haying or grazing restriction, which allows producers to graze an established stand of nwsg after spraying without a waiting period.

Another practice is to mow competitive weeds before they flower and seed. Shading limits growth of nwsg considerably and prolonged shading can kill nwsg. The mower should be set relatively high so the switchgrass or

Fig. 5.20 Although nwsg can be established and grow relatively well in soils with low fertility, collecting a soil sample and getting it tested is a good idea, especially if nwsg are established for haying/grazing where maximum production is desired.

eastern gamagrass is not clipped any more than necessary. This method is usually less successful than herbicide applications, but many producers have seen switchgrass and eastern gamagrass out-compete non-desirable plants during the second growing season after planting where the competition was not allowed to flower and produce seed.

pH and fertilizer requirements

One of the biggest advantages to establishing nwsg is that they are adapted to the soils of the Mid-South. Essentially, that means they can grow in nutrient-deficient soils with a low pH. Most of the soils in the Mid-South are slightly to strongly acid, extensively weathered and ultimately leached of nutrients. Often, soil pH is below 5.5 with low nutrient levels. With such a low pH, most of the nutrients present are unavailable to plants. Nonetheless, nwsg will germinate and grow in most of these soils without additions of lime and fertilizers. Optimum growth, however, cannot be attained on nutrient-deficient soils. Before planting nwsg, a soil sample should be collected and sent off for testing, just as if a row crop was being planted. Increasing the pH to 6.0–6.5 and maintaining P and K at medium levels (19–30 and 91–160 pounds available per acre, respectively) are recommended when significant production is desired.

Application of N at planting is generally not recommended because it will stimulate weed competition. However, if bluestems and/or indiangrass is planted and Plateau® is applied preemergence, 15–30 pounds of N per acre may be added once the grasses are 4–6 inches high if adequate moisture is available. If planting pure stands of switchgrass or eastern gamagrass, N should not be applied until the stand is established and weeds controlled. For optimum growth, especially when establishing nwsg for pasture or hayfield, P and K may be elevated to high levels (31–120 and 161–320 pounds available per acre, respectively). In addition, up to 60 pounds of N can be applied either in April/May, after cutting hay and/or after removing livestock from the paddock.

Seedbed preparation

Once the competition is controlled, the seedbed should be prepared before planting. If drilling seed, a firm and "clean" seedbed, free of deep thatch and other material, is desired. This will enable the seed to be planted

Fig. 5.21 NWSG can be drilled directly into dead sod if the thatch layer is not too deep. When fields are sprayed in the fall prior to spring planting, thatch is not a problem as is evident in this field that has just been planted with a no-till drill.

adjacent to mineral soil, which should increase germination success. If the seed is planted in deep thatch, germination and seedling survival may be less than desirable. Cleaning the seedbed is best achieved by burning. A firebreak should be constructed around the field by discing a strip one or two tractor-widths wide. This is important because the firebreak will be used every 2–3 years as the field is maintained with prescribed fire. If the dead material on the field is sparse and/or only a few inches high, no preparation may be necessary.

If the seed is to be top sown (or broadcast), the seedbed should be prepared by conventional tillage techniques. If the soil needs amendment, it is best to do so at this time to ensure the lime and fertilizer are well-incorporated. To ensure firm seed-to-soil contact and improve germination and seedling survival, the seedbed should be cultipacked before and after seeding. Top-sown seed should not be covered by disking because it covers the seed too deep.

Fig. 5.22 Cultivated seedbeds can be planted by drilling or top-sowing. If top-sowed, the site should be cultipacked after planting, not disked. Here, a riparian buffer strip is being drilled with nwsg after the seedbed was prepared by conventional tillage.

Planting techniques, timing, seeding depth and seeding rate

Drilling and top-sowing

Native warm-season grasses can be established by planting with a no-till drill (see Appendix 5) or by top-sowing (broadcast seeding). If planting bluestems and/or indiangrass, a drill with a specialized seed box containing "picker wheels" is necessary. Without this design, the fluffy seed of these grasses lodge in the seed chute and are not planted. Finding a drill designed to plant these grasses should not be a problem. Truax™, Great Plains™ and others make suitable models and many drills are available for use by state wildlife agencies, the Natural Resources Conservation Service and Soil Conservation Districts. If the seed are top-sown, a spreader with a similar device designed to "pick" fluffy seed from the hopper is required. Simply throwing the seed up in the air and allowing the wind to spread the seed usually results in a patchy stand, which may be fine, depending upon objectives. There have been mixed results using cracked corn, pelletized lime, cottonseed hulls or fertilizer as a seed carrier in traditional planting equipment. Using the proper equipment is highly recommended to successfully establish nwsg. Switchgrass can be top sown or planted using the clover seed box on a grain drill, while eastern gamagrass should be planted with a corn planter. Eastern gamagrass is usually planted in rows 18–24 inches apart, but some people like to plant rows only 12 inches apart to reduce stool size and make stems more upright so haying is easier.

Fig. 5.23 and 5.24 Drills with "picker wheels" and agitators in the seed box (such as this Truax™) are recommended when planting bluestems and indiangrass. This ensures an even flow of seed and prevents seed lodging in the box.

Timing of planting

Nwsg are best planted from mid-April through May in the Mid-South. This is a major consideration. Because germination and seedling establishment can be slow, it is important to plant just before the soil temperature reaches approximately 58 degrees. This allows more time for germination and provides seedlings a better opportunity to

Troubleshooting tips when using a no-till drill

Most nwsg plantings are established by using a no-till drill. Drills designed for "fluffy" seed are necessary when planting bluestems and indiangrass because of the long seed awns and light weight of the seed. Several manufacturers offer this type of drill, including Truax™, Great Plains™ and others. These drills have two or more seed boxes designed for different types of seed, including one for fluffy nwsg seed. Agitators keep the fluffy seed from compacting, while picker wheels, located in the bottom of the seed boxes, extract seed and send them down an oversized drop tube designed to avoid seed bridging.

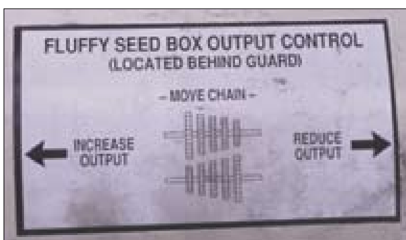


Fig. 5.25 Truax™ sprocket chart

Fig. 5.26 Seed output is adjusted on some drills, such as this Truax™, by a chain sprocket.

Non-fluffy nwsg also can be planted with these drills. Switchgrass seed can be planted in the seed box typically used for smaller seed, such as clovers. Sideoats grama can be planted in the seed box with the picker wheels or in the seed box typically used for larger seed, such as oats, wheat and rye.

Although these drills have aided tremendously in successfully establishing nwsg stands, it is critical that the drill is calibrated for the seed being sown and that attention is given to planting depth and rate. Many plantings have "failed" because the seed were drilled too deep, an inadequate seeding rate was used because the percentage of pure live seed was not calculated and/or because the drill was not calibrated, or too little seed was sown because the drill was not operating properly for some reason. Before using a drill to plant nwsg, inspect the machinery and become familiar with its operation. Appendix 5 provides information on the operation and maintenance of no-till drills.

Many state wildlife management agencies provide drills designed to plant nwsg free of charge to landowners. Drills are also available through some chapters of Quail Unlimited™ and Soil and Water Conservation District offices or may be rented through some state farmers' cooperatives or seed/equipment dealers. Typically, these drills see many hours of use and are not always in the best shape. It is important to check the seed flow from these drills and be sure the proper amount of seed is being planted. The calibration charts on these drills are usually correct when drills are new, but as they get older and parts wear, seeding rates may be higher or lower than those listed. Spending a few minutes before planting can prevent all of the seed being placed on a small portion of the field, or having to run over the field twice because the drill wasn't planting enough seed.

Often, there is little time for the landowner to become well-acquainted with a drill before use. However, merely filling the drill with seed, hooking to the tractor and taking off across the field usually results in disappointment. Even after reading over the user's manual (if one is available), the landowner is often confronted with problems and confused about why the drill is not operating properly. Listed below are a few tips for successful operation and identifying problem sources.

1. Before going to get the drill, have the correct size hitch pin for towing the drill.
2. Make sure the tractor's hydraulic fittings match those for the drill.
3. Calculate the percentage of pure live seed (see p. 73–74) and calibrate the drill for the bulk rate of seed being planted and the desired planting rate.
4. Measure the field being planted— don't guess the acreage (the local FSA office can assist with determining field size from aerial photographs).
5. For best results, plant in a clean seedbed, without thatch buildup or much debris.
6. Make sure the chains on the opening coulters are not kinked and that coulters are in alignment with the seeding furrow.
7. Check all tubes to make sure they are not clogged (this should be evident when calibrating the drill) with mud or by mud daubers or spiders.
8. Check the planting depth bands and adjust planting depth, if necessary.
9. Make note of acreage on drill counter before planting.
10. Operate the drill for a short distance (100 feet) before planting the field and look for planted seed in the furrows. If you cannot see/find seed, it is not being planted! All seed should be within 1/4 inch of the top of the ground (with the exception of eastern gamagrass). Approximately one-third of the seed should be lying on top of the furrow—not covered at all.
11. If seed cannot be found in the planting furrows and on top of the ground, check the planting depth. If depth bands are set correctly, check the output from each tube (this should have been done when calibrating drill). This can be checked easily by placing a plastic sandwich bag over the bottom end of each drop tube—attached with a rubber band—and operating the drill (or by jacking the drill up on the drive-wheel side and turning the drive wheel). If seed doesn't fall into one or more bags, check the hoses to see if they are clogged. If seed doesn't fall into one or more of the bags (or just a very few seeds trickle into one or two bags), the drill isn't operating. Make sure the drill has been engaged (some engage at the wheel hub). If so, then check the chain drive that adjusts the seeding rate. If that is positioned correctly, check the chain drive on the side of the drill (depending upon model) to make sure it is engaged and not off the drive wheel.

Fig. 5.27 It is critical to check drills thoroughly before use. Not only must the drill be calibrated before planting (according to PLS estimation), but general maintenance is also required. This drill wasn't planting switchgrass. Why? The drop tubes coming out of the small seed box were clogged. Drop tubes, chain sprockets, seed boxes and grease fittings all need attention before planting.

Fig. 5.28 and 5.29 Planting seed too deep may be the number one cause of establishment failure. Nwsg seed (with the exception of eastern gamagrass) should not be planted (or covered) deeper than ¼ inch! When drilling seed, as much as 30 percent of the seed should be obvious on top of the planting furrow. When checking furrows for planting depth, it is common to find seed just on top of the ground in places, while the seed is barely underneath along most of the furrow.

become established and develop deeper root systems before potential dry periods of mid- to late summer. Later plantings in June are often successful, but reduced germination and slower initial growth are more likely.

Seeding depth

No-till drills should be set where seed are planted no more than ¼ inch deep. In fact, approximately 30 percent of the seed should be visible (on top of the planting furrow) after planting. This is one of the most important factors in successful establishment. When a seed germinates, it must push its way through the soil to the surface (if not on top of the surface) so it can receive sunlight. Once in the sun, it can produce its own energy. Until that happens, the seedling depends on stored energy to grow. Thus, the deeper a seed is planted, more energy is required for the seedling to emerge from the soil. Nwsg seeds (with the exception of eastern gamagrass) contain very little stored energy.

Seeding depth should be checked by inspecting the initial furrows before the field is

Fig. 5.30 When top-sowing nwsg on a seedbed prepared by conventional tillage, cultipacking ensures firm seed-to-soil contact and improves germination rate and initial growth. Top-sown seed should not be covered by disking.

planted. A pocketknife is useful when inspecting planting furrows. All planted seed not on top of the furrow should be visible just under the soil surface. The only exception to this rule is eastern gamagrass, which should be planted approximately 1 inch deep. If the seed is top-sown, the seed should not be covered by disking, only cultipacked after sowing to ensure firm seed-to-soil contact.

Seeding rate

Seeding rates largely depend upon objectives for the planting. If sown for wildlife, a sparse stand of grasses (20–50 percent coverage) with abundant forbs and adequate bare ground is desired. If sown for forages, a denser stand of grass is desired. Thus, the seeding rate for wildlife habitat is less than that for a forage stand of nwsg. Recommended seeding rates are shown in Table 5.5. Although nwsg can be established by no-till drilling or top sowing with conventional tillage, germination success is increased when seed are drilled. As mentioned previously, many factors influence germination and stand success. However, soil moisture and the number of days until rain after planting are critical. When drilled, seed are somewhat protected in a microclimate afforded by the planting furrow. Desiccation and loss of seed viability are more likely when seed are top-sown, as they lie on top of the ground baking in the sun. To compensate for a possible reduction in germination, higher seeding rates may be used when broadcast seeding. For example, when establishing wildlife habitat, 6–8 pounds PLS of a big and little bluestem, indiangrass and switchgrass mixture might be top sown as opposed to drilling 3–5 pounds PLS of the same mixture.

Fig. 5.31 Nwsg intended for livestock forage are planted at a higher seeding rate than those stands intended specifically for wildlife habitat. Note the bunch density in this recently-planted big bluestem stand intended for hay production.

Table 5.5 Recommended seeding rates[1] (pounds PLS per acre) and planting dates for native warm-season grasses in the Mid-South.

Species	Wildlife Habitat	Forage Stand	Planting Dates
Big bluestem	3–5	10–12	mid-Apr–May
Little bluestem	3–5	10–12	mid-Apr–May
Indiangrass	3–5	10–12	mid-Apr–May
Sideoats grama	4–6		mid-Apr–May
Switchgrass	2–4	8–10	mid-Apr–May
Eastern gamagrass	4–6	10–12	mid-Apr–May

[1] All seeding rates are for a single-species planting. Single-species plantings, however, are not normally recommended, especially for wildlife habitat. Therefore, the rate of each species included in a mixture should be reduced according to the number of species in the mixture, the composition preferred and the desired structure of the resulting stand. The rates given in this table are for drilled plantings. Broadcast rates may be increased by approximately 50 percent.

Recommended mixtures for wildlife and forages

Single-species plantings are not recommended for wildlife habitat. That is not to say, however, that a pure stand of switchgrass, for example, will not benefit wildlife. Even a field of switchgrass hayed for livestock can provide cover for wildlife if the field is managed correctly, but its value is not equal to that of a mixed stand of nwsg along with a variety of wildlife-friendly forbs. Several nwsg mixtures have been developed for wildlife plantings in the Mid-South; however, most can be placed in one of two categories: a tall mixture or a short mixture. Tall mixtures are dominated by big bluestem, indiangrass and/or switchgrass, which normally range in height between 4–8 feet depending upon variety, soil moisture and available nutrients. Short mixtures are dominated by little bluestem, broomsedge (which is usually not planted, but occurs naturally) and/or sideoats grama. These normally range in height between 2–4 feet. Other short nwsg that might occur naturally include splitbeard bluestem, purpletop, several low panicgrasses and povertygrasses.

Mixtures are determined primarily by the objectives and preferences of the landowner. Tall mixtures can provide cover for ground-nesting birds, as well as those that nest aboveground (such as dickcissel, field sparrow, Henslow's sparrow and red-winged blackbird). Tall mixtures can also provide excellent cover for white-tailed deer, and brooding wild turkeys and bobwhite quail (provided there is desirable forb coverage). Thermal cover may be provided in winter for many wildlife species if sufficient structure is present and the grasses remain erect or lodge above ground. Such stands can become magnets for deer to bed in during the day. Short mixtures provide outstanding nesting cover for ground-nesting birds and excellent brood-rearing cover if desirable forb cover is present. Short mixtures also are aesthetically pleasing to many people, especially with a complement of wildflowers.

Fig. 5.32 Tall nwsg mixtures usually include some combination of big bluestem, indiangrass and/or switchgrass. Little bluestem might also be in the mixture, but the taller grasses dominate. Tall mixtures can provide quality nesting and brooding cover as well as winter and escape cover for many wildlife species.

A typical tall nwsg mixture intended for wildlife habitat might include (rates of PLS per acre):

1.5 lbs. big bluestem
1.0 lbs. indiangrass
1.0 lb. little bluestem
0.5 lb. switchgrass
1.0 lb. native legumes and other forbs

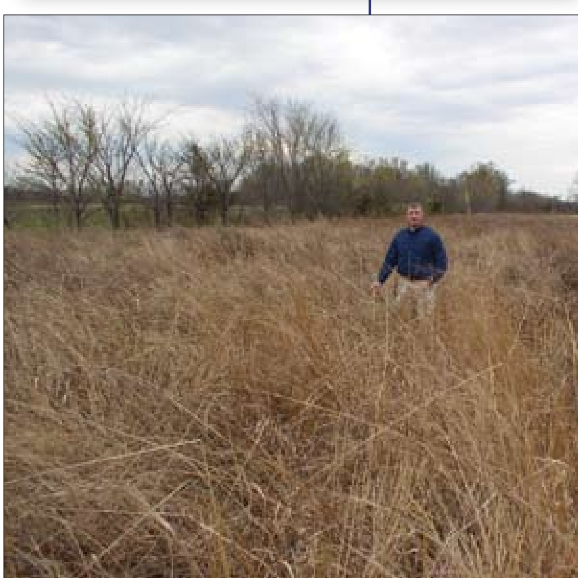
A typical short nwsg mixture intended for wildlife habitat might include (rates of PLS per acre):

3.0 lbs. little bluestem
2.0 lb. sideoats grama
1.0 lb. native legumes and other forbs

Fig. 5.33 This buffer of sideoats grama and little bluestem provides excellent nesting cover for a variety of bird species.

Fig. 5.34 Short nwsg mixtures normally include little bluestem, broomsedge bluestem and/or sideoats grama. Indiangrass or big bluestem might be included in small amounts, but the shorter grasses dominate the stand. Short mixtures provide quality nesting and brood-rearing cover for many wildlife species.

Figs. 5.35 and 5.36 Tall grasses often fall over in winter if there are no rigid forbs growing in association with the grasses (top photo). This is especially true with big bluestem, indiangrass and varieties of switchgrass that do not have large stems. Not only does this leave little cover for wildlife, it also leads to increased thatch build-up. The "short" nwsg remain erect through winter and provide excellent nesting structure the following spring (bottom photo).



Tall or short mix? Which is best?

Most nwsg mixtures can be placed into one of two groups: tall or short. Predominant grasses in tall mixtures include big bluestem, indiangrass and/or switchgrass (depending on variety), while predominant grasses in a short mix typically include little bluestem, broomsedge and/or sideoats grama. Several other nwsg occurring naturally from the seedbank might also contribute to a short grass site.

There are several issues to consider when deciding whether to plant a tall or short mix, but structure is most important. Taller structure is good for wildlife cover, but it can be counterproductive in winter if the grasses fall over and do not remain erect and/or do not "lodge." This is most prevalent when few forbs are present in the field. Several forbs, such as ragweed, goldenrod, pokeberry and blackberry provide more rigid structure and help tall grasses remain erect through winter.

Another consideration is structure for building nests. Most birds prefer relatively fine grasses and other such material for nest construction. Ground-nesting birds (such as bobwhites and meadowlarks) find perfect structure for nesting at the base of broomsedge and little bluestem and sideoats grama. Indeed, these grasses, especially broomsedge, remain erect through winter and provide nesting structure for the following spring. These grasses have an abundance of leaf material near the ground and the leaves of these grasses are relatively narrow. Other birds that nest off the ground (such as field sparrows and dickcissels) use fine grasses (such as *Danthonia* spp.) for nesting material, but position their nests within more coarse material, such as stems of big bluestem or blackberry brambles.

Thus, a mixture of grass types and other vegetation is desired to provide optimum habitat for a variety of birds and other wildlife. But, if specific birds are the focus (such as bobwhites), specific structure should be the objective (such as a short mixture of nwsg).

Figs. 5.37 When a desirable complement of forbs are present, nwsg are more likely to remain erect through winter.

Figs. 5.38 It can easily be argued that broomsedge is the best all-around nwsg for wildlife. With stiff stems, it remains erect through winter better than any other nwsg. It provides unequaled nesting structure for bobwhites and, on many sites, attains a height (4 feet) that provides cover even for white-tailed deer.

Figs. 5.39 Meadowlark nest in broomsedge.

Figs. 5.40 and 41 Many birds prefer to construct nests with fine grasses. This Bachman's sparrow nest (left) has been constructed on the ground with low povertygrass (*Danthonia spicata*) amongst some broomsedge and sumac. This field sparrow's nest (right) was also constructed with fine grass material, but built off the ground within a bunch of big bluestem.

Table 5.6 Selected seedling wildflower and legume tolerance to Plateau® herbicide (4 oz per acre) in mixed grass/forb stands.[1]			
Common name	**Latin name**	**Preemergence**	**Postemergence**
Aster, New England	*Aster novae*	No	Yes
Aster, prairie	*Aster tanacetifolius*	No	Yes
Sticktights	*Bidens frondosa*	No	Yes
Partridge pea	*Chamaecrista fasciculata/ nictitans*	Yes	Yes
Lance-leaved coreopsis	*Coreopsis lanceolata*	Yes	Yes
Plains coreopsis	*Coreopsis tinctoria*	Yes	Yes
Ox-eye daisy[2]	*Chrysanthemum leucanthermum*	Yes	Yes
Shasta daisy[2]	*Chrysanthemum maximum*	Yes	Yes
Purple prairieclover	*Dalea purpurea*	Yes	Yes
White prairieclover	*Dalea candidum*	Yes	Yes
Illinois bundleflower	*Desmanthus illinoensis*	Yes	Yes
Beggar's-lice	*Desmodium canadense*	No	Yes
Purple coneflower	*Echinacea purpurea*	Yes	Yes
Korean lespedeza[2]	*Lespedeza stipulacea*	No	Yes
Birdsfoot trefoil[2]	*Lotus corniculatus*	No	Yes
Alfalfa[2]	*Medicago sativa*	No	Yes
Lemon mint	*Monarda citriodora*	No	Yes
Upright prairie coneflower	*Ratibida columnifera*	Yes	Yes
Black-eyed Susan	*Rudbeckia hirta*	Yes	Yes
Crimson clover[2]	*Trifolium incarnatum*	Yes	Yes
White clover[2]	*Trifolium repens*	No	Yes

[1] Adapted from Plateau® Herbicide Label; BASF Corporation, 26 Davis Drive, Research Triangle Park, NC 27709

[2] Not native to North America

Selected forbs should be added to nwsg mixtures to provide enhanced brood habitat, invertebrate availability, seed production, forage and/or aesthetic value (Table 5.6). Planted forbs are intended to complement the forb community that should arise naturally from the seedbank. Forbs most often added to nwsg mixtures include partridge pea, Illinois bundleflower, roundhead lespedeza, perennial sunflowers, purple praireclover, purple coneflower and lance-leaved coreopsis. Many others might be added for aesthetics (such as black-eyed Susan and blazing star) and use by butterflies and/or hummingbirds.

Species and mixtures for livestock forage are generally determined by objectives, preference and potential problems with competitive weeds. For example, pure stands of switchgrass or eastern gamagrass can provide excellent forage for livestock. However, if crabgrass and/or johnsongrass are prevalent in the field to be planted, a mixture of big and little bluestem and indiangrass might be a better choice because imazapic can be used to help ensure successful establishment. Forbs are not typically added to nwsg mixtures intended for forage production in the Mid-South; however, some producers do add alfalfa in the mixture or seed into an existing stand in February/March after burning.

Evaluating establishment success—what to expect

It is not uncommon to visit a landowner who has sown nwsg and thinks his/her planting effort was a waste of time. This is especially true for fields planted for wildlife habitat. To some people, the field is not "pretty." It is not even. It is not green all over. And there may be lots of "weeds" coming up all over the field. This is all understandable and, in some cases, even intentional, but the landowner does not realize it. Most people are accustomed to sowing non-native cool-season grasses (such as tall fescue, orchardgrass,

Top seven reasons why native warm-season grass plantings fail:

1. Planted too deep—either drilled too deep or disked after top-sowing.
2. Planted too late—planting in July often results in poor germination because of a lack of moisture or not enough time for adequate root development prior to drought conditions.
3. Inadequate weed control—no herbicide, the wrong herbicide or incorrect herbicide application is often the reason for stand failure.
4. Percentage of pure live seed not calculated—not enough seed was planted.
5. Drill not calibrated—not enough seed was planted.
6. Field planted when too wet—mud packed into the depth bands, coulters and/or seeding tubes—or after a hard rain packed a well-prepared seedbed.
7. No patience—the planting was actually a success, but the landowner failed to realize what a successful nwsg stand should look like during the year of establishment. Many successful stands have been disked under during the year of establishment when they would have made excellent wildlife cover and/or livestock forage if allowed to fully establish the following year.

Fig. 5.42 This is what you are looking for! This is a big bluestem seedling with its characteristic "fountain" appearance. Note the bare ground and lack of weeds germinating around the seedling. This is what should be expected from a properly applied preemergence herbicide.

timothy, bluegrass). These sod-forming grasses germinate and grow relatively quickly. As they develop, the ground takes on an ever-increasing green appearance, with small green seedlings coming up all over the field. These small grass seedlings are all pretty much the same size and the field has a very even, "clean" appearance. Within several weeks, the field is green all over and by the end of the first growing season, a turf has developed. This is NOT the case with nwsg!

Nwsg develop relatively slowly during the year of establishment. Most of the first-year plant growth is root development. Leaf and stem growth may not get more than 2 feet high by the end of the first growing season (even with big bluestem). In many cases, relatively little flowering occurs the first growing season and it is not until the second growing season that considerable aboveground biomass develops and the grasses flower and produce seed. However, if the correct planting procedures are followed and soil moisture and nutrition are not limiting, excellent growth will occur during the year of establishment with considerable aboveground biomass and extensive flowering.

It is also important to be able to identify a nwsg seedling. Most folks look out across the field and do not recognize the plants present. All they see are "weeds" coming up everywhere! Most nwsg seedlings have the appearance of a small fountain (Fig. 5.42) and they should not, on average, be close together (especially if wildlife habitat is the objective). Many of the "weeds" germinating and beginning to grow are actually desired forbs that provide cover and seed for wildlife. However, some of them may be undesirable and should be treated before they are able to flower and add to the seedbank.

Fig. 7.43 2 Sept 2005

Fig. 7.44 24 April 2006

Fig. 7.45 30 May 2006

Fig. 7.46 19 August 2006

Fig. 7.43-46 Expectations are everything. Most people would consider this planting a failure. Further, most would think more vegetation is required to keep the soil from eroding in this filter strip, which was planted in May 2005 (see Fig 5.22) at 4 pounds PLS per acre with indiangrass, little bluestem and a small amount of big bluestem. Native grass density increases naturally over time; however, a relatively light seeding rate (4 pounds PLS) will prolong the need for disking to reduce grass density. A light seeding rate also allows for more bare ground space, which is highly desirable for wildlife.

Checklist before planting nwsg

- ❑ If planting for haying/grazing, has a soil sample been collected and tested for lime and fertilizer requirements?
- ❑ Has the appropriate herbicide been identified for weed control prior to planting?
- ❑ Has the sprayer been calibrated?
- ❑ Has the appropriate species and variety of seed been located and purchased?
- ❑ Has the seedbed been prepared as needed?
- ❑ Has the percentage of pure live seed been calculated? Check dormancy for switchgrass and eastern gamagrass!
- ❑ Has the acreage been measured?
- ❑ Has the drill been calibrated and checked to see if it is properly dispensing seed through each drop tube?
- ❑ Has the planting depth been checked?
- ❑ Is it too late to plant?
- ❑ Depending on weed control and timing, would it be more sensible to wait until next spring to plant?

Chapter 6

Managing native warm-season grasses and associated early-succession habitat

Succession will take over an old-field or a field of planted nwsg if it is not managed. Management is especially critical in the Mid-South, where average annual precipitation exceeds 40 inches and growing seasons are relatively long. Management is needed not just to set back succession, but also to create the vegetative composition and structure desired. Prescribed fire and disking are strongly recommended for managing fields of nwsg and associated early-succession vegetation. When used correctly (with respect to timing, frequency and intensity), fire and disking not only set back succession, but also determine plant species composition and structure, which directly influence habitat quality and forage quality. Other methods of managing nwsg fields include grazing, haying, the use of herbicides and bushhogging (mowing).

Fig 6.1 In the Mid-South, a field can turn into a young forest in just a few years. Management is necessary to set back succession.

NOTE: When managing nwsg established under government programs, most notably the Conservation Reserve Program, there are established guidelines and timeframes for "mid-contract management practices" (such as disking, burning and herbicide applications). Landowners and managers should consult the appropriate agency prior to managing lands under an active contract to ensure desired management activities meet program guidelines and are included in the conservation plan.

Prescribed fire

The word "fire" typically elicits fear in many people because of an association with damage and destruction. As Dale Wade wrote in his publication, ***A Guide for Prescribed Fire in Southern Forests***, "Wildland fire is neither innately destructive nor constructive. It simply causes change." This change can be positive or negative, depending on the use of fire and the landowner's objectives. Prescribed fire is the controlled application of fire under specified environmental conditions that allows the fire to be managed at a desired intensity within a confined area to meet predetermined vegetation management objectives. **Simply put, prescribed fire is *not* wildfire. When used properly, it is very safe and achieves specific objectives.** Prescribed fire, or controlled burning, can be used to reduce litter buildup, set back succession, increase nutrient availability and stimulate herbaceous growth, all of which have real implications for wildlife management. Although prescribed fire is used to manage forests (including upland hardwoods!), this discussion will concentrate on its use in fields of nwsg and old-field habitats. Proper burning permits should be obtained from the state forestry agency before using fire and all burns should be conducted and/or overseen by properly trained and experienced personnel.

Fig 6.2 Prescribed fire not only consumes litter build-up and sets back succession, it also exposes seed and various invertebrates, such as snails and beetles, which provide calcium for young turkeys and quail.

The effect of prescribed fire varies greatly with fire frequency, fire intensity, season of burn, amount and type of litter (vegetative debris), moisture and temperature, wind speed and method of burning. **It is important to understand how fire behaves under various conditions and to burn only when conditions are suitable to meet stated objectives.**

Fig 6.3a and 6.3b Burning in late March/early April stimulates quick growth from nwsg. This field was burned April 8, 2002. By April 15 (left), 3–4 inches growth is evident from individual nwsg bunches. By April 22 (right), the nwsg are growing rapidly.

Dormant-season burning

Most often, fields are burned in late winter/early spring, just before green-up. However, when a landowner has considerable acreage that needs to be burned, it cannot all be done at once. Burning throughout the season to meet burned acreage objectives is fine. Nonetheless, burning in March/early April reduces winter cover for only a short time before spring green-up and does not disrupt the wildlife nesting seasons. When nwsg are burned in late March/early April, the heat of the fire often stimulates rapid new growth, which is usually apparent within 5 – 7 days after burning. Depending on conditions, increased nitrogen and other nutrients may be available the growing season after burning. If burning coincides with warm daily temperatures (60 – 70 F) and adequate precipitation, accelerated plant growth is possible. Soil fertility is usually increased after burning grasslands, as nutrients from the ash are translocated downward into the upper soil horizons. Nitrogen, phosphorus, potassium, calcium and magnesium are all released from organic material during a fire, and that which is not volatilized is readily soluble after burning. In addition, the hydrogen ion concentration in the top few inches of soil usually decreases after burning, which may raise soil pH slightly. These increases in soil fertility and pH may persist for 1 – 2 years after burning.

Fig 6.4 Available nutrition may be increased after burning as nutrients are leached by rainfall from ash down into the upper soil layer. Fuel moisture and fire intensity are related and can influence the amount of ash and nutrient availability post burning.

Fig 6.5–6.9 This series of photos shows expected response from old-field vegetation when burned in the dormant season. Dormant-season burning is normally recommended when the desired plant composition is present and/or when additional grass is desired. This field was burned using a strip-heading fire. Fig 6.5 clearly shows the backing fire moving slowly against the wind to the right and the strip-heading fire moving more quickly with the wind to the left. Wind direction is evident from the smoke column.

Fig 6.6 March 2005

Fig 6.5 March 2005

Fig 6.7 May 2005

Fig 6.8 August 2005

Fig 6.9 November 2005

Dormant-season burning is best accomplished on "bluebird days" when atmospheric stability is slightly unstable or neutral, which allows for rapid smoke dispersal. Good winter-burning conditions often exist for several days after the passage of a cold front that has brought light to moderate rainfall. During this time, a persistent wind, low relative humidity, cool temperatures and clear skies can be expected. The preferred specific conditions for burning fields are a clear day with temperatures between 40 and 70 F, a relative humidity of 25 – 45 percent and a steady wind of 3 – 10 mph. Ideally, fuel moisture should be 10 – 20 percent and soil moisture should be damp. This helps ensure the fire consumes the vegetation and litter layer, yet leaves a thin layer of organic material and ash, which is a source for added nutrients. Normally, burns are best prescribed from mid-morning through mid-afternoon. It is seldom desirable to burn into the evening and night because an increase in relative humidity along with the possibility of a temperature inversion increases the likelihood of smoke problems. This is a most-important consideration when burning large acreage and when burning near roads.

Growing-season burning

Fig 6.10 Growing-season fire can produce considerable smoke because much of the vegetation is still green. Nonetheless, burning in September is effective at reducing undesirable woody encroachment. In fact, September burning was as effective at killing woody stems as applications of imazapyr and triclopyr (see Fig. 6.17).

Once spring green-up begins, burning can be more difficult because of leaf moisture content. Burning fields after spring green-up increases smoke production dramatically, which is undesirable. Nonetheless, growing-season fire is still useful, especially in late summer/early fall. While some sources present conflicting evidence, most lightning-induced fire in the Mid-South occurred during late April through mid-May and August/September. Native Americans, however, burned year-round and had an uncanny ability to know how to use fire during different seasons to achieve specific objectives (normally to improve habitat or drive game). Without question, the activity of Native Americans must be considered a natural influence on the plant and animal communities throughout the region.

One of the greatest advantages of growing-season fire is its ability to reduce woody succession. Young trees and shrubs are most susceptible to fire when leaves are present. While the tops may be killed with a dormant-season fire, the root system remains alive, resulting in prolific sprouting the following spring. Burning during the growing season is more likely to kill the entire tree, including the root system. Growing-season burns are most often implemented in the Mid-South during spring (soon after leaf-out) or during late summer when conditions are usually drier and more favorable for burning. When the leaves and twigs are consumed during the growing season and/or the temperature exceeds 145 F in the crown of the tree or shrub, top-kill is imminent. These temperatures are much more easily reached (at levels 10 – 15 feet above ground) when burning in late summer (September) than in spring. It is also during late summer that trees begin to prepare for fall senescence (much like nwsg), transporting carbohydrates, amino acids and other compounds down from the leaves and twigs to the root system. By burning in August – early October, nutrient reserves needed in the root system to start growth the following spring are drastically reduced. This increased stress is often enough to kill the root system and eliminate future sprouting. Another benefit to late growing-season fire is that the wildlife nesting seasons are not impacted. Also, fire intensity is normally less intense during late summer as much of

Fig 6.11 March burn

Fig 6.12 September burn

Fig 6.13 Imazapyr

Fig 6.14 Triclopyr

Fig 6.15 Mow

Fig 6.16 Control

Fig 6.11 – 16 This series of photos shows the effect of various treatments in reducing woody encroachment one growing season after treatment. These treatments were replicated in a CRP field planted to tall fescue, which had been mowed annually the previous 10 years. September burning reduced woody encroachment as well as the herbicide treatments (data presented in Fig 6.17). In addition, September burning was cheaper to implement than any other treatment, promoted more native legumes than any other treatment and reduced cover of undesirable cool-season grass better than any other treatment. Partridge pea, beggar's-lice and native lespedezas comprised more than 50 percent of the vegetation cover following September burning in this field.

the fuels are still green. This also reduces the chance for spot fires. Disadvantages, however, include a considerable increase in smoke production and reduction of winter cover.

Over time, the density and coverage of nwsg bunches often increase to a level where forb coverage is reduced and there is significantly less bare ground space, which reduces germination of the seedbank, restricts travel and makes the field less attractive to many wildlife species. Repeated burning in late summer/early fall (August through early October) when moisture content is relatively low may reduce grass density and increase forb coverage the following growing season. Disking (as discussed on page 120), however, is much more effective at reducing grass density and increasing forb coverage than burning.

Burning techniques

Before burning a field, a firebreak should be created to contain the fire. Disking a strip one or two tractor-widths wide around the field is sufficient. It is a good idea to create the firebreak in advance of the planned burn. Disking in September – November is sensible, as it is relatively dry then and disking prior to March normally stimulates desirable forb growth the following spring. A firebreak disked in the fall also facilitates planting a cool-season forage (see ***Firebreak management*** on page 113). Disking firebreaks in the fall has two drawbacks. If leaves from adjacent trees fall into the firebreak, it will need re-disking before burning. Also, if firebreaks need to be created on soils prone to erosion or on slopes, erosion problems may occur before vegetation reestablishes. During some years, there are relatively few opportunities to burn when conditions permit. Creating a firebreak just prior to burning may not be possible – often because the soil is too wet for disking in March/April. Anything in the field that needs to be protected from fire (such as a

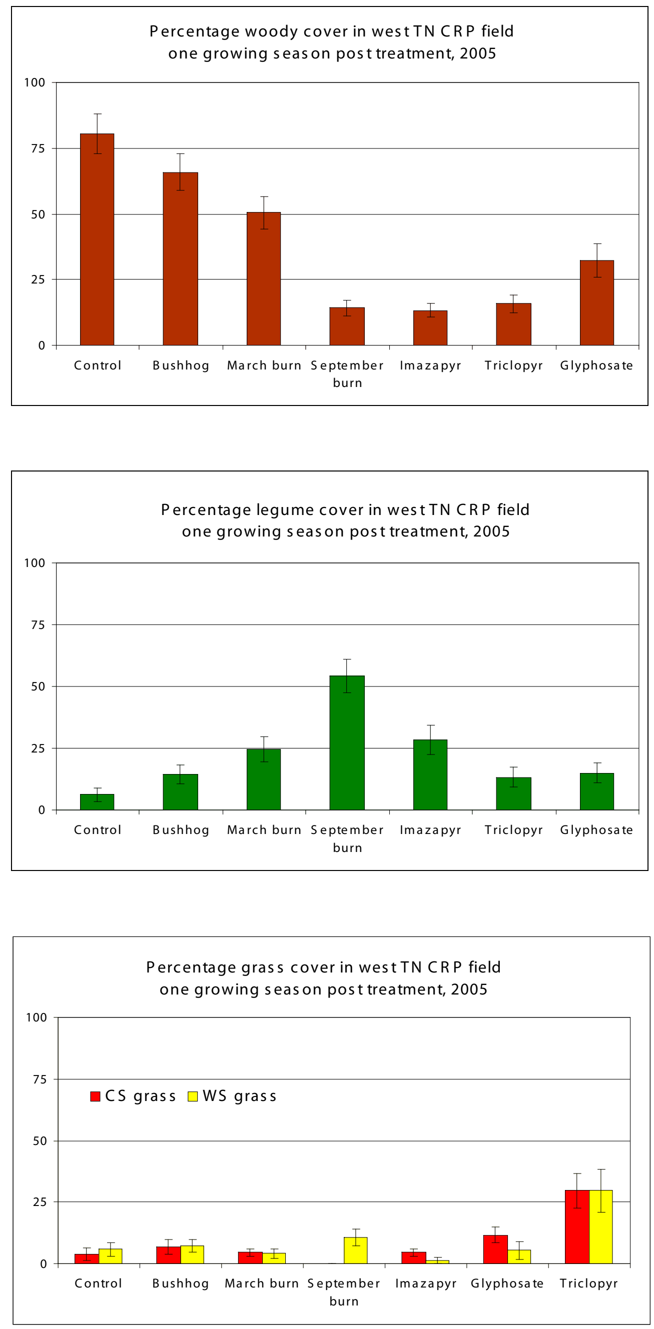


Fig 6.17 Growing-season fire can be just as effective as herbicides in reducing woody encroachment into a field (Gruchy and others 2007). An added benefit is the increase of native legumes from the seedbank and the decrease in cool-season grass coverage.

Fig 6.18 It is foolish and irresponsible to try and burn fields without a firebreak. By disking a strip one or two tractor-widths wide around the field, a sufficient barrier is put in place to contain prescribed fire when used sensibly.

Fig 6.19 When burning fields, it is important to identify areas that shouldn't be burned and disk around them. Here, valuable food and cover for bobwhites and other wildlife has been protected by disking the firebreak in front of a plum thicket instead of around it.

plum thicket) should be disked around also when the firebreak is created.

The recommended method of burning is dependent on the weather conditions and the amount and structure of litter on the field. A *backing fire* moves against the wind. A *heading fire* moves with the wind. A *flanking fire* moves at right angles to the wind.

Fields are normally burned with the aid of a drip torch. Burning a field is always initiated with a backing fire, lit on the downwind side of the field adjacent to and along the firebreak. A blackline is created by allowing the fire to back into the field, creating a safe zone should the wind shift or if a heading fire is used later. Very flammable fuels adjacent to the firebreak can be mowed before burning to slow the rate of burn. A backing fire

Fig 6.20 Fields should be burned by first creating a blackline (burned area) with a backing fire before using a strip-heading fire or flanking fire. Notice in the picture how the fire is moving against the wind. This fire was correctly started adjacent to the firebreak, placed between the field and the white pines, which do not tolerate fire when young. At this point, a strip-heading fire or flanking fire can be used (if desired) to burn the field more quickly than waiting on a backing fire to slowly move across the field.

consumes material on the field very effectively and has relatively low flame heights. Depending on conditions, flame heights might range from a few inches to a few feet. Because it is moving against the wind, a backing fire moves quite slowly. If there is a large amount of litter present or if the wind is a little strong, a backing fire or strip-heading fire is probably the best method to use over the entire field.

If the process can be safely and effectively quickened, a *strip-heading fire* may be used (see Fig 6.5). This involves lighting a series of lines of fire progressively upwind of the initial backing fire. Strips should be narrow enough so the fire does not reach a high energy level before it reaches a backing fire or a blackline. Initially, strips might only be 20–50 feet wide until it is obvious how the fire will behave. Although the same techniques used with dormant-season burning apply with growing-season fire, strip-heading fires with *persistent* winds may be required (depending on moisture levels) to burn a field during the growing season.

When conditions warrant, a field can be burned with a *ring fire*. This is best accomplished by two people (with assistance from others). To begin, a blackline is created on the downwind side of the field. From the blackline, two people walk in opposite directions around the field, setting fire adjacent to the firebreak. This technique actually involves a backing fire (initially), a flanking fire (as the sides burn perpendicular to the wind) and a heading fire (when the two burners finally come together at the opposite end of the field from where they began). Coordination is required to implement a ring fire safely and effectively. The process should begin slowly and be monitored carefully to ensure an adequate blackline is created on both sides before the fire starts to converge. Wildlife in the field should be considered before using a ring fire. There is no safe escape for many species once the two burners meet.

Fig 6.21 The possibility of killing wildlife is increased when using a ring fire, as opposed to backing fire, flanking fire or strip-heading fire. This rabbit was killed when fire from opposite sides of the field converged during a ring fire. There was no escape. Nonetheless, even with ring fires, direct mortality when burning fields is not as high as when mowing fields (bushhogging).

Burning on rotation

While burning is highly desirable and can be used to enhance fields of nwsg and associated old-fields for wildlife, only a portion of a management area should be burned each year. **Creating a mosaic of habitat conditions across the management area is very important in meeting the needs of different wildlife species and the various requirements of a particular species throughout the year.** For example, a field burned in late winter may provide excellent brooding habitat for quail and turkeys the following summer. Nesting cover within the field, however, is greatly diminished. It is not until the second summer after burning that nesting cover is most attractive for some birds, including bobwhite quail. In the third or fourth year after burning, escape cover for many species may be present. Therefore, the needs of various species and life requirements are met in a field for at least three to four years after burning. For this reason, it is widely recommended that one-third to one-fourth of an area be burned each year. Thus, where few fields are present, sections of a given field may be burned on rotation. This is particularly applicable with relatively large fields (>10 acres). Where several fields are present and in proximity, whole fields may be burned on rotation.

Fig 6.22 If wildlife is a concern, it is imperative not to burn all the cover at once. Leaving sections for winter cover and subsequent nesting structure will help increase wildlife populations. In this photo, a 100-acre field in West Tennessee has been broken up into sections approximately 100 feet wide, with alternate sections burned every 2 – 3 years. Disked firebreaks promote forbs from the seedbank and can be planted if desired. Note the brushy cover in the nwsg strip. Leaving quality winter cover for bobwhites is just as important as providing nesting or brooding cover. This shrub thicket was used as a covey headquarters.

The exact burning rotation, of course, depends upon landowner objectives and constraints, site conditions, focal species, the existing seedbank and the rate of woody encroachment. The primary objective is to keep succession in check and meet the various needs of focal wildlife species by influencing vegetation structure and composition.

Season of burn should also be considered when burning on rotation. Consistent burning over time in late winter/early spring may shift composition of the field to increased grass cover and reduced forb cover. While this may be desirable when managing nwsg for haying/grazing, it is

Fig 6.23 Sometimes there are patches in a field that don't burn. Perhaps the fuels weren't continuous, perhaps bare ground space precluded a patch from burning, or perhaps a low-lying spot was too moist to burn. That's OK; it only adds to the diversity of cover and may later provide nesting or escape cover.

Burning and disking to increase invertebrate availability

Periodic burning and/or disking consumes the thatch layer and stimulates fresh growth. This has a dramatic effect on invertebrate populations. Many invertebrates are associated with the thatch layer. When that layer is consumed by fire or broken down by disking, those invertebrate populations are reduced. However, as the seedbank germinates and perennial plants sprout after the disturbance, another assemblage of invertebrates establishes. Most importantly for upland gamebirds, such as quail, turkeys and grouse, the structure at ground level is more open and allows young broods to move about freely and feed upon this new invertebrate population under a protective canopy of forbs and grasses. The invertebrates present within the field now are *available*. Before burning or disking, insects and other invertebrates present may not have been available, depending on the structure at ground level and the ability of broods to navigate through the field. Thus, disturbing fields through burning or disking does not necessarily increase invertebrate *abundance*, but it can increase invertebrate *availability*. The importance of forbs to provide this structure cannot be overstated. Research in Tennessee (Fettinger and coworkers, 2002) found invertebrate biomass within fields of pure nwsg (0.0388 g/m^2) was no different from that in pure fields of tall fescue/orchardgrass (0.0386 g/m^2). Fields containing a significant forb component harbor considerably more invertebrates.

Fig 6.24 Providing favorable structure and cover through burning and disking makes invertebrates available. Invertebrate abundance is of no value if birds cannot travel throughout the field under a protective canopy.

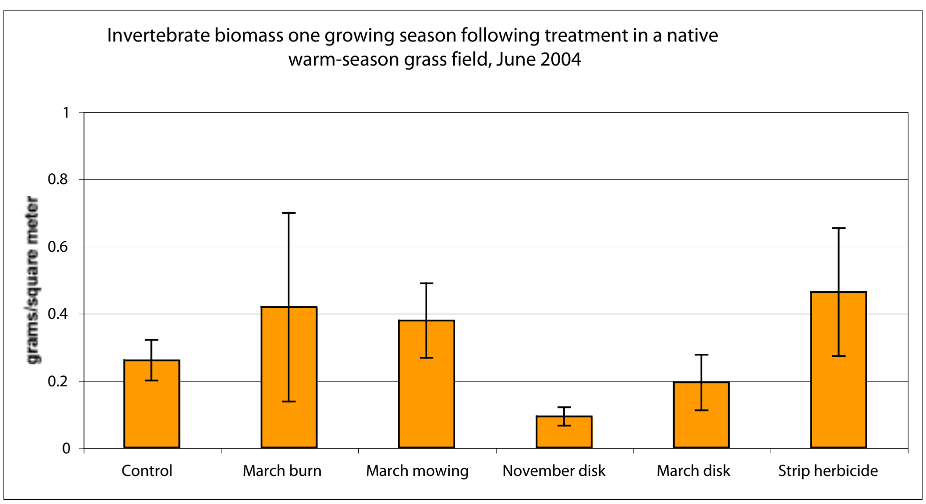


Fig 6.25 Research in North Carolina (Palmer 1995) suggested bobwhite chicks require more than 3 grams of invertebrate mass per day during the first 2 weeks of life. Disking treatments in Tennessee (above) contained 0.10 – 0.20 grams of invertebrates per square meter (Gruchy 2007). Therefore, sufficient invertebrate biomass for a 10-chick bobwhite brood was present within less than 0.10 acre. Obviously, a brood would not be able to prey upon every invertebrate within this area, but the point is that invertebrates are plentiful. The main consideration is whether the brood can travel through the field and if there is protective overhead cover while feeding.

not desirable from a wildlife perspective. Conducting a September burn in between dormant-season burns when and where appropriate will help maintain a diversity of forbs and grass.

Firebreak management

The primary role of firebreaks is to contain fire within a field. They also can be managed to provide additional food for wildlife. Firebreaks can be sown to warm-season plantings, cool-season plantings or left fallow to stimulate the seedbank and establish naturally occurring legumes and other forbs. Warm-season plantings well-suited for firebreaks include small grains (such as grain sorghum and millets), other seed producers (such as sunflowers, buckwheat, partridge pea and annual lespedezas) and forages that also produce seed (such as cowpeas and soybeans). Cool-season plantings include annual grains (particularly wheat and oats), clovers (such as crimson, arrowleaf, ladino and red), and other legumes (such as Austrian winter peas and birdsfoot trefoil). Warm-season plantings are normally planted in late April/May and provide forage and/or seed through summer and autumn. Cool-season plantings are normally planted in late August/September and provide green forage during the fall/winter months and into the following spring/summer. Both types of plantings can be a source of invertebrates for young quail and turkeys and other birds. Before planting any firebreak, soil should be amended with lime and fertilizers as recommended from a soil test.

Fig 6.26 and 6.27 Fallow firebreaks can provide outstanding cover, as well as a quality food source. Here, ragweed provides a protective overhead canopy (left) for young quail and there will be plenty of ragweed seed present in the fall. Below the ragweed canopy (right) open ground space allows broods to move about freely.

Managing firebreaks for year-round food resources is often desirable. This is possible when a section of firebreak is sown to a warm-season mixture, a section to a cool-season mixture and a section left fallow for annual forb production and dusting. Because warm-season plantings are annual, they may be left fallow the year following planting, depending upon burning objectives. Cool-season forages may be annual or perennial. Annual clovers (such as crimson and arrowleaf) are excellent re-seeders and may be maintained the following year by disking in August. Annual cool-season legumes also may be followed with warm-season grains because of the added nitrogen fixed on the site by the legumes. Perennial forages (especially ladino clover) should be planted only on those sites with adequate moisture to sustain them through the summer when hot, dry periods are not uncommon. **Introduced perennial grasses (such as orchardgrass and tall fescue) should never be planted to a firebreak** because over time they will produce sufficient thatch to allow fire to creep across the firebreak, can spread into nwsg, will out-compete clovers and other wildlife-friendly plantings, offer poor forage for wildlife and provide poor structure at ground level for small animals (see sidebar on pages 37–38).

Annual plantings are often recommended for firebreaks. This facilitates the need to re-disk the firebreak before burning again. Perennial plantings can be used if the field is not going to be burned for another 3 – 4 years. The problem with perennial firebreaks is they accumulate dead leaves (if adjacent to woods) and dead plant material over time. Thus, perennial mixtures usually need disking prior to burning.

Construction and placement of firebreaks are other important considerations when managing fields for wildlife. If adjacent to woods or a line of trees, firebreaks should be established approximately 30 – 50 feet from the woods to allow a soft edge to develop between the woods and the firebreak. Getting

David Buehler

Fig 6.28 Firebreaks adjacent to woods should be created at least 30 – 50 feet from the woods' edge to facilitate a soft edge between the woods and the firebreak. The soft edge provides additional nesting and escape cover, as well as forage and soft mast (blackberries).

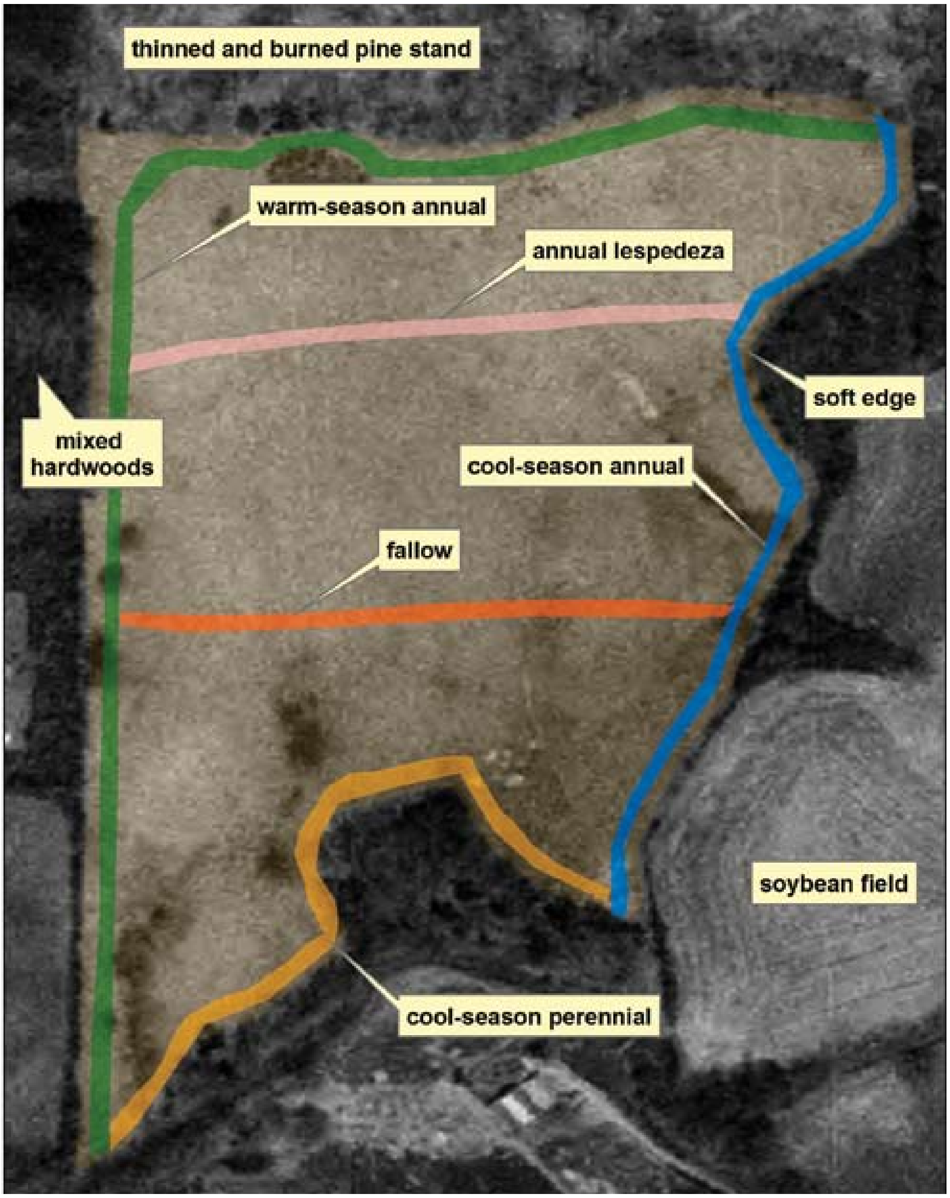


Fig. 6.29 Firebreaks can be managed in various ways. Various sections may be planted to provide supplemental forage and grain through the year. Other sections may be left fallow to provide brood-rearing habitat and seed production. Firebreaks should be established outside the drip-line of adjacent trees to avoid competition for nutrients and sunlight and to allow soft edge to develop between the field and woods.

away from the trees also allows planted firebreaks to grow better because of less competition with trees for sunlight and nutrients. Over time, woody encroachment into the soft edge can be set back by bushhogging, controlled with an herbicide application or reduced to a desirable level by thinning. Also, anytime a firebreak is close to a woods' edge, the possibility of a tree or limb falling into the firebreak exists. Prior to burning, firebreaks should be checked for fallen debris that might allow the fire to creep across the break.

If the field is surrounded on one or more sides by woods, the area can be made more attractive for many wildlife species by thinning 50 – 100 feet into the woods from the field. Those trees not favored for wildlife (such as sweetgum, maples, elms, sourwood) should be selected for removal to reduce canopy closure to 50 percent or less. Sometimes, it is preferable to kill selected trees and leave them standing, which later provide snags for cavity-nesting birds. The recommended procedure is to girdle the tree with a chainsaw or open the bark to the cambium layer using a hatchet or machete. If using a hatchet or machete, leave no more than 1 inch in between hacks around the tree. A few squirts of herbicide are then sprayed into the wound via spray bottle. Garlon 4™ and Arsenal AC™ are excellent herbicides for this use. Their labels provide rates and mixing instructions for various applications.

If a field or section(s) of a field is to be burned annually or every other year, one strategy for managing firebreaks is to maintain a rotating firebreak. This involves disking (which may or may not be planted) an initial firebreak. The following year (or two years later), another firebreak is disked just inside and adjacent to the initial firebreak. The following year (or two years later), the initial firebreak is disked again, while the second firebreak remains fallow. This rotating design continuously provides either a planted strip and a fallow strip, or two fallow strips in two different successional stages. The firebreaks are juxtaposed with perennial grass and forb cover within the field as well as a soft edge outside the firebreak and, where woods are adjacent to the field, a thinned wooded area. Thus, habitat is available for a wide range of activity by a variety of wildlife species, including cover/area for nesting, brooding, escape, feeding and dusting.

Planting recommendations for firebreaks

A wide variety of plantings can be used when planting firebreaks. Two cool-season and three warm-season mixtures that have been used successfully are listed below (adapted from Harper 2007). Rates are per acre.

Cool-season forage mixture (annual)

15# crimson clover
30# wheat

If planting on poor ground and/or cost is a concern, this is the mixture to use. It's cheap, easy, will grow most anywhere and provides high-quality forage for deer, turkeys, quail and rabbits, as well as other species, such as groundhogs and ruffed grouse.

Crimson clover is an excellent re-seeder. It can be retained for many years without replanting if it is not overgrazed and is allowed to flower and produce seed. A few weeks after the crimson clover dies and produces seed (late May), the firebreak should be mowed. A few weeks later (mid-June), the firebreak should be sprayed with a glyphosate herbicide (1 – 2 quarts per acre) to kill weeds. Weeds should be sprayed before they flower to realize a better kill and to help reduce the seedbank. Depending on

Fig 6.30 A lush firebreak containing crimson clover and wheat provides nutritious forage for many wildlife species at a time (Nov.–Feb.) when green forage is limited.

the seedbank and precipitation, weeds may need to be sprayed a couple of times through the summer. After the weeds have died, the firebreak should be top-dressed with lime and fertilizer as recommended from a soil test and disked in early to mid-August. This will effectively re-seed the crimson clover. If desired, additional wheat and/or oats can be sown prior to incorporating the lime and fertilizer or drilled afterwards.

A variation of this mixture is to add red clover (8 pounds) and reduce the crimson clover to 10 pounds. Red clover is relatively slow to establish, but will persist throughout the summer, providing an additional 3 – 4 months of high-quality forage. As the red clover declines in productivity (early September), the firebreak should be disked lightly to stimulate the crimson clover. Additional wheat or oats can be drilled into the plot if desired.

There is nothing wrong with planting a firebreak to wheat *only* (80 – 100 pounds). It is cheap and easy to plant; doesn't require high nutrient levels; provides nutritious forage fall through spring; provides seed through the following summer; and in the second summer after planting (depending upon the seedbank), a productive fallow site results.

Fig 6.31 Perennial clovers and chicory can be maintained for several years with proper weed control and soil amendment.

Fig 6.32 Seed-producing grasses are not as susceptible to deer damage as the peas and beans.

Cool-season forage mixture (perennial)

4# ladino white clover
5# red clover
2# chicory
40# oats or wheat

This is an excellent perennial mixture that provides quality forage and a source of invertebrates for brooding quail and turkeys. The clovers and chicory can easily be maintained for three to four years (for a 3 – 4-year burn rotation) provided the site is top-dressed according to a soil test and weeds are controlled. After the annual grains have produced seed and died, grass weeds can be controlled with 10 ounces of Select™ postemergence and many broadleaf weeds can be controlled with 4 ounces of Pursuit™ postemergence. This mixture should be mowed after the clovers and chicory have flowered and produced seed and as often as necessary (usually 2 – 3 times per year) to help with weed control and stimulate fresh growth.

Warm-season seed mixture (annual)

7# white proso millet
7# foxtail millet
5# Egyptian wheat
4# grain sorghum

Deer eat very little grass during summer; thus, this mixture does well even where there is a high deer density. An abundance of seed is produced for a variety of birds, including quail, doves and turkeys, as well as many songbirds, including cardinals, several species of sparrows, juncos, flickers and others. Non-desirable broadleaf weeds can be controlled with 2,4-D, Clarity™ or Banvel™.

Warm-season forage mixture

60# iron-clay cowpeas
OR
30# Quail Haven soybeans
3# peredovik sunflowers

Fig 6.33 Iron-clay cowpeas and QH soybeans withstand grazing pressure from deer much better than soybeans. Nonetheless, if the peas/beans are not destroyed by deer, a highly nutritious seed source is provided for quail/turkeys in fall.

This forage mixture contains plenty of crude protein (25 – 30 percent) and digestible nutrients (<30 percent Acid Detergent Fiber). Sunflowers are not added necessarily for forage, but as structure for the legumes to climb and grow upon later in the season. This allows the peas/beans to produce additional forage per acre. Prowl™ or Treflan™ can be sprayed and incorporated prior to planting to help control various forb and grass weeds. Select™ can be sprayed postemergence to control grass weeds. Quail Haven soybeans reseed quite well if disked in late winter following good seed production. If deer density is low and weeds are especially problematic, Roundup Ready™ soybeans (70 pounds) may be used instead of iron-clay cowpeas or Quail Haven soybeans.

Warm-season reseeding mixture (annual)

10# Kobe or Korean lespedeza
2# partridge pea

Bobwhites relish seed from these lespedezas and partridge pea, which are available through winter, making firebreaks planted to this mixture primary feeding spots from December through February. The best time to plant is late winter (mid-February – March), which coincides with dormant-season burning. The lespedezas and partridge pea are good re-seeders, which allows them to be retained by disking in March.

Fig 6.34 Annual lespedezas and partridge pea provide a good seed source for quail into late winter.

Fig 6.35 Disking sets back succession, stimulates the seedbank, facilitates organic matter decomposition, incorporates nutrients into the soil and provides an open structure at ground level. Plant composition can be influenced by timing and intensity of disking.

Disking

Disking is another technique highly recommended to set back succession and influence plant composition in fields. In fact, disking can provide many of the same positive attributes as burning. This is especially important in those areas where burning may not be possible. In terms of historical relevance, it has been proposed disking mimics, to some extent, the same disturbance effect of large ungulate herd migrations, exposing soil, reducing grass dominance and stimulating the seedbank. Disking also promotes decomposition of thatch, which improves soil nutrient availability and creates a more open structure at ground level. Two primary factors influence the effect of disking: timing and intensity.

Timing of disking

Disking at different times of the year influences vegetation composition, depending on site conditions and seedbank composition. In the Mid-South, disking in the fall and winter generally produces a different suite of plants than disking in the spring. Disking prior to March normally stimulates more desirable forbs, while disking after March may stimulate less desirable grasses, such as johnsongrass, crabgrass and broadleaf signalgrass, if they are present in the seedbank. A good way to determine the preferred time to disk and the seedbank response in a particular field is to disk a strip every month, especially from October through May.

Disking intensity —“light” or “heavy”?

A question often asked is “How many passes are required when disking early-succession habitat?” Disking intensity is influenced primarily by equipment, soil texture and soil moisture. A heavy offset disk (or “bog disk”) penetrates and breaks the soil much better than a lighter tandem disk (or “farm disk”). Thus, only one or two passes may be needed by an

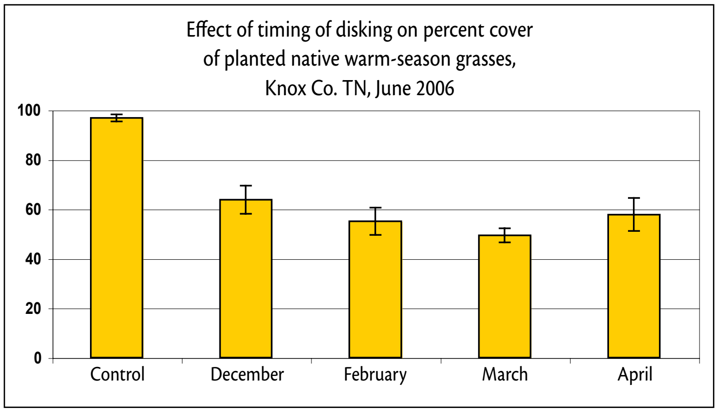


Fig 6.36a Moderate disking reduced native grass density to 50 – 60 percent coverage, regardless of whether disking occurred in winter or spring.

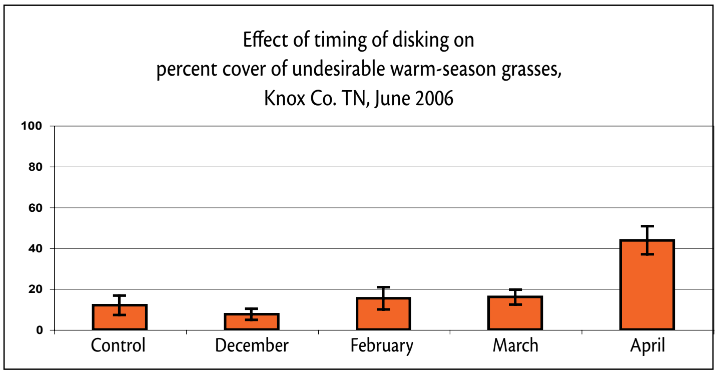


Fig 6.36b Disking in April led to increased coverage of undesirable warm-season grasses, such as johnsongrass, crabgrass, goosegrass and broadleaf signalgrass.

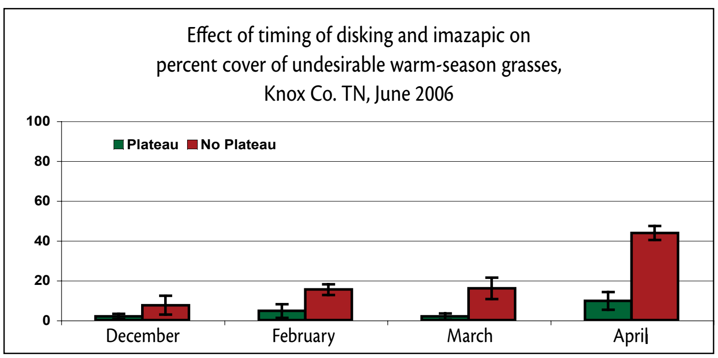
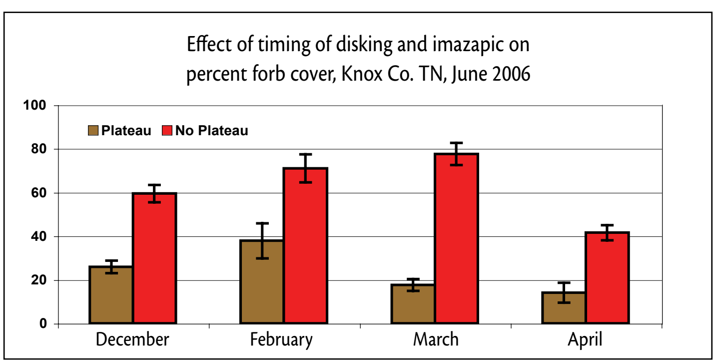


Fig 6.36c A preemergence application of imazapic (12 ounces per acre of Plateau®) suppressed germination and growth of undesirable warm-season grasses. If disking cannot be accomplished until April, this is an important consideration.



(Gruchy and Harper 2006)

Fig 6.36d Disking in winter promoted more forb cover than disking in April. A preemergence application of imazapic (12 ounces per acre of Plateau®) also influenced forb germination and growth. If undesirable species are expected to arise from the seedbank following disking, this is an important consideration.

Fig 6.37 A single pass of a heavy offset disk without mowing may be all that is necessary (according to site conditions) to reduce grass density and increase forb cover.

offset disk to cut the existing vegetation and thatch layer and expose some soil. Tandem disks often require 5 – 10 passes just to cut a few inches into the soil, particularly heavy clays. Indeed, trying to disk a field of heavy clay, especially when it is dry, with a tandem disk is akin to disking pavement. And regardless of soil texture, if the field is covered with tall rank vegetation, it is often not possible to use a tandem disk unless the field is previously burned or mowed. In fact, more than one pass may be required even with an offset disk if thick native grass is present. This problem is accentuated if it has been a few years since the field was disturbed and rank growth has accumulated. Waiting 1 – 2 weeks after mowing rank nwsg will facilitate decomposition and make disking these stands easier.

The goal is to cut the existing vegetation, incorporating at least half of it into the soil, and expose a considerable amount of soil, which creates open space at ground level and stimulates the seedbank. That probably describes "light" disking. However, if native grasses have become too dense and increased forb cover is needed, additional passes may be required to cut the top of the grass root systems. This may describe "heavy" disking. However, even at this level, there is still a considerable amount of vegetative material on top of the ground. It is never necessary to disk to the extent it resembles a seedbed ready to plant.

Burning or mowing prior to disking

As mentioned, it may be necessary to burn or mow prior to disking, especially if the only disk available is a light tandem disk. Burning not only makes disking much easier, but the clean structure created makes herbicide applications more efficient, especially those that require incorporation. Preemergence applications also are more efficient following burning than if applied with debris on the ground, which can block the herbicide spray. Burning prior to disking also creates a clean field for planting additional forbs where few (or none desirable) are present in the seedbank. Light disking after burning creates the perfect seedbed for top-sowing most light-seeded forbs.

Fig 6.38 If a tandem disk ("farm disk") is all that is available, multiple passes will be required to adequately disturb the soil, and it may be necessary to mow a field or sections of a field prior to disking.

Disking on rotation

Rotational disking is recommended just as rotational burning. Rotational disking can be accomplished by disking entire fields every 3 – 4 years or by disking different strips or portions of a field every year. If strips or blocks within a field are disked, approximately one-fourth to one-third of a field should be disked each year to accomplish the 3 – 4-year rotation. This method creates a perpetual mosaic of habitat conditions that favor a variety of wildlife species. Strip disking, in particular, provides a break in vegetation while stimulating increased forb growth. Disked strips, like firebreaks, also can be planted to provide a supplemental food source adjacent to the cover provided within the field. Disked strips across a field can serve as firebreaks, allowing sections of a field to be burned at different times. If possible, strips should be disked along the contour of the field to minimize the potential for soil erosion.

The decision of whether to disk entire fields or strips is largely dependent upon field size and the number of fields in the area. If field size is relatively large (>10 acres), disking 2 – 4 acres each year in strips or sections is recommended. If the field is small and there are several fields in the area, the entire field can be disked while others are disked in following years.

Disking a section of the field every year has many benefits. Not only is brood habitat provided and a mosaic created, quality forage is stimulated as well. Select plants for white-tailed deer, for example, increase dramatically the growing season following fall/winter disking (see Table 2.1 on page 18). Coverage of these plants may decrease significantly by the second year. Thus, disking a different section or strips within a field each year may be necessary to stimulate preferred deer forage plants.

Fig 6.39 Strip disking helps set back succession and provides diverse structure and composition across the field. Five passes with a tandem disk were necessary to disk a strip and stimulate some ragweed and other forbs to germinate in this pure native grass field after it was burned.

Concerns with erosion and Highly Erodible Land (HEL)

Although disking is a highly desirable management practice, it is important to adhere to local soil and water conservation standards. For fields managed under USDA programs (such as CRP and EQIP), this is a requirement. Local standards can be found in the USDA Field Office Technical Guide (FOTG). The FOTG requirements for minimum soil loss vary from county to county. Annual soil loss is influenced by several factors, including soil type, average rainfall, slope and groundcover management. According to the NRCS, average annual soil erosion should not exceed the soil loss tolerance (t-value); those values usually range from 1 – 3 tons per acre per year. This figure should not be alarming. Three tons of soil over an acre is not as thick as a dime. When organic matter decomposition and soil fauna decay are taken into consideration, it is easy to see how a 1 – 3-ton-per-acre soil loss may not be a loss at all. Recent research determined soil loss from "heavy" disking conducted on established nwsg fields was negligible and did not approach unacceptable levels because of the extensive root systems of nwsg. Switchgrass, for example, produces 6.5 times more root biomass than non-native perennial cool-season grasses; 15.5 times more root biomass than corn; and 46 times more root biomass than soybeans. Disking in strips along field contours with slopes less than 18 percent should not be a concern for landowners, as this will not result in soil loss if proper techniques are used in fields with established nwsg.

Herbicides

Fig 6.40 Fields containing extensive coverage of non-native perennial cool-season grasses should be broadcast-sprayed in the fall. Cool-season grasses are storing carbohydrates in preparation for winter dormancy and are most effectively killed at this time.

Herbicide applications are often necessary when managing planted nwsg and other old-field sites. Herbicides are often required to reduce coverage of undesirable forbs and grasses, eliminate/reduce woody species or reduce nwsg coverage where the grasses have become too dense. Herbicides may be applied across the entire field, applied in strips or spot-sprayed. Broadcast-spraying is normally used when undesirable plants occur over the entire field. Common examples include spraying for field invaders, such as crabgrass, johnsongrass, sericea lespedeza or small trees (such as winged elm, red maple, green ash and sweetgum). Broadcast-spraying is also used to combat non-native cool-season grasses when they are not controlled adequately prior to planting.

Using herbicides in strips across the field is similar to strip disking where transition zones in vegetative cover are created. This can be accomplished with two different methods. A strip one or two tractor-widths wide can be sprayed (similar to strip disking) or wider strips (or the whole field) can be sprayed with every two out of three nozzles on the spray boom closed (Fig 6.41–43). Strip spraying can be used to reduce nwsg coverage where they have become too dense in an effort to release forbs from the seedbank. A grass-selective herbicide (such as Select™) can be used to thin grasses if desirable forbs are present; if not, glyphosate can be used. To thin nwsg, they should be sprayed when they are actively growing, usually in late April when the grasses are 12–18 inches tall. If the grasses are taller when sprayed, the forb response may be limited, and burning or disking will be necessary to allow germination.

Spot spraying is commonly used to control woody encroachment into a field, but is also effective in controlling problem areas where unwanted invasive plants (such as bermudagrass and thistles) have persisted and need "another shot." Several herbicides are listed in Appendix 4 with the appropriate rates and applications.

As a general rule, herbicides are applied in a mixture with water and a surfactant at a rate of 10 – 30 gallons per acre using flat-fan nozzles (numbers 002 or 003) at 20 – 40 pounds of pressure per square inch (psi). **In all cases, herbicide labels should be read and followed closely before use with regard to restrictions, precautions, rates, recommended tank mixtures, surfactants and sprayer cleaning recommendations.**

Fig 6.41–43 Strip-spraying can be accomplished by closing off every other or every third nozzle on the spray boom. This method can be used to effectively reduce grass density and intersperse forb cover.

To reference herbicide labels, visit the Crop Data Management Systems, Inc. Web site (www.cdms.net/manuf/manuf.asp).

In most cases, the use of herbicides is the only way to gain control of a field after invasive non-native plants have become established. Mechanical and cultural methods simply do not work to eradicate many non-native plants. **Unfortunately, many managers and agencies resist the use of herbicides. Most often, this only delays or completely precludes habitat improvement or restoration because so many non-native invasive plants resist other control methods.** While it is true herbicide treatments may also kill some native plants, with the exception of rare species, they can be restored to the site after the invasive non-native plants have been eradicated by stimulating the seedbank, sowing seed and/or transplanting individual plants. Thorough eradication of problem plants prior to planting nwsg and associated forbs is the most successful way to minimize long term management problems.

Herbicide treatment usually requires patience and repeated applications. Some competitors of nwsg are controlled relatively easily (such as crabgrass in bluestem and indiangrass plantings); however, others are more difficult and require patience and persistence. Recommendations for controlling grass competitors (such as tall fescue, bermudagrass, johnsongrass) prior to planting are provided in the ***Competition control*** section on page 80. Listed below are specific competitors that are particularly problematic in the Mid-South and the appropriate control techniques.

Sericea lespedeza

Sericea lespedeza is a non-native warm-season perennial legume introduced into the United States primarily as a possible forage from Japan in the late 1890s. It is an invasive leguminous forb that outcompetes native vegetation and can dominate a field in a relatively short time. Ironically, it is for these very traits that many private contractors and even some state and federal agencies still promote sericea lespedeza for erosion control. This is most unfortunate and completely illogical when there are so many native alternatives (especially nwsg) that also can provide erosion control as well as attractive wildlife habitat.

While sericea lespedeza can provide cover for some species (such as rabbits), it has little food value for wildlife. It is not a preferred forage for white-tailed deer, rabbits or groundhogs because of high lignin and tannin contents and the seed produced has little value for quail or other birds because they are extremely hard and relatively indigestible. Sericea lespedeza should be eradicated wherever it is found.

Invading colonies of sericea (as well as other problematic plants) should be spot-sprayed before whole-field treatment is required. When an entire field is treated for sericea, many of the forbs in the field may be killed before the sericea lespedeza is controlled. Killing desirable forbs is not a real problem when sericea growth is excessive because the sericea will uptake the majority of the herbicide. If desirable forbs are killed after treating sericea, it may be necessary to re-establish the forb component by planting after burning or by disking and stimulating the seedbank. Planting desirable forbs is **not** recommended, however, until the sericea has been **eradicated**. This may take a few years because the hard sericea seed in the seedbank may continue to germinate over time. Disking is strongly encouraged *after* killing existing sericea with an herbicide application to stimulate sericea seed in the seedbank. Yes, that is correct, to stimulate

Fig 6.44 Sericea lespedeza spreads quickly and can be a serious problem. It should be sprayed before it becomes prevalent and adds to the seedbank.

it! This is the only way to get rid of it. If it is not stimulated on purpose, it will be stimulated later when the field is managed by burning or disking. **Landowners shouldn't be afraid of sericea (or any other undesirable non-native plant). They should be excited to finally get rid of it!**

Sericea is susceptible to spraying through most of the growing season, but different herbicides may be used during different growth stages. Once sericea is about 12 inches tall, it has enough leaf surface area to translocate the herbicide to the root system. Younger plants may not translocate enough herbicide to kill the root system. Triclopyr™ (such as 1 quart per acre of Garlon 3-A™ with non-ionic surfactant added) does not harm nwsg and performs quite well at killing sericea while it is actively growing. Triclopyr will, however, kill other forbs that may be desirable (such as ragweed, blackberry, various legumes). Triclopyr with fluroxypyr (1.5 – 2.0 pints per acre PastureGard™ with non-ionic surfactant) is very effective in killing sericea and may be less damaging to desirable forbs. Metsulfuron methyl (such as 1 ounce per acre of Cimarron™ or Escort™ with non-ionic surfactant added) kills sericea quite well if sprayed when sericea is flowering. This usually occurs late August through early October in the Mid-South. Similar to triclopyr, metsulfuron methyl does not harm nwsg. Metsulfuron methyl may also kill desirable legumes (such as native lespedezas and partridge pea); however, if sericea is sprayed in early fall, other desirable forbs may have already flowered and produced seed and thus achieved dormancy and are not affected by the herbicide. Cimarron™ or Escort™ may be tank-mixed with 2,4-D, Garlon 3-A™ or dicamba (Banvel™, Clarity™, Overdrive™) to control a variety of other problematic forbs growing with sericea. Herbicide labels should be referenced for appropriate mixing rates and species controlled.

Sicklepod

Sicklepod (sometimes called coffeeweed) is an annual warm-season legume native to tropical America. It is a major contaminant in grain shipments in the US, as it has highly toxic compounds associated with the leaves, stems and seeds. The entire plant is toxic to livestock, humans and wildlife. It has no food value. While not as invasive as sericea, it can present problems in fields by crowding out desirable species. Sicklepod can be killed with a variety of broadleaf herbicides; however, many desirable forbs (such as native legumes) are also susceptible to these herbicides. Sicklepod can be controlled by spot-spraying with glyphosate or heavy infestations can be killed by broadcast spraying 2,4-D and/or dicamba (Banvel™, Clarity™, Overdrive™). Refer to herbicide labels for appropriate mixing rates. Following eradication of sicklepod, which may take a couple of years, desired forbs can be replanted after burning in March or early April. Seasonal disking will stimulate the seedbank and encourage additional forb growth.

Fig 6.45 Thistles can be a real problem when managing fields. If thistles are allowed to get to this growth stage, they should be mowed to prevent them from producing seed. Later, herbicide applications will be necessary.

Thistles and sowthistles

There are several species of thistles and sowthistles, including Canada thistle, bull thistle, annual sowthistle, spiny sowthistle and perennial sowthistle. These bristle-tipped forbs can be dif-

Fig 6.46 Spraying and/or burning over-wintering rosettes of biennial and perennial thistles while nwsg and forbs are dormant is a good way to control these problem plants.

ficult to control, especially when they occur on neighboring properties and are allowed to flower and produce seed, which are dispersed widely by the wind. In many cases, thistles become prevalent in a field after establishing nwsg using imazapic. Thistles are not controlled by imazapic, except with postemergence applications during the rosette or early bolt stage. Thistles also may be spot-sprayed with glyphosate, 2,4-D, dicamba (Banvel™, Clarity™, Overdrive™), metsulfuron methyl (Cimarron™ or Escort™), thifensulfuron methyl (Harmony Extra™), sulfometuron methyl (Oust™) and/or imazapyr (Arsenal AC™). Fall/winter treatment of rosettes with 2,4-D may be the cheapest and easiest method and precludes damage to desired warm-season forbs. Persistence, patience and cooperation among adjacent landowners are often required to get thistles under control.

Robin Mayberry

Fig 6.47 Shrub lespedeza can provide good cover and a seed source for quail; however, it can become quite problematic. It seems more and more landowners are seeing this problem—shrub lespedeza escaping from the hedgerow (left) out into the field.

Shrub lespedezas (Bi-color, Thunbergii and VA-70 varieties)

Shrub lespedezas, most commonly referred to as "Bicolor" because Bicolor 101 was the original commercially produced variety, are warm-season perennial shrubs that have long been planted for bobwhites. Shrub lespedezas produce seed fed upon by bobwhites and the shrub cover provides protection from predators throughout the year. In many areas, however, shrub lespedezas have become problematic by sprouting up throughout fields. In isolated patches, they are easily controlled with an application of glyphosate; however, isolated patches are not usually problematic. When entire fields are being invaded by shrub lespedeza, broadcast spraying is necessary. Applications of triclopyr (Garlon 3-A™ or Remedy™) and metsulfuron methyl (Cimarron™

Fig 6.48 Native alternatives, such as this blackberry field border, offer outstanding cover and food resources for many wildlife species. Wild plum, hawthorn and elderberry are other shrubs that should be considered.

or Escort™) have been successful in reducing bicolor coverage and gaining control of an invasive problem. Labels should be referenced for appropriate rates for foliage treatments and broadcast applications. Shrub lespedeza can be sprayed anytime while actively growing. Because of the invasive nature of shrub lespedeza, other plantings should be considered when managing for quail. Blackberries, wild plum, elderberry, hawthorn and crabapple are alternatives that can be equally attractive to bobwhites.

Horseweed

Horseweed (often called marestail) is an annual warm-season forb that can explode out of the seedbank and present serious competition to nwsg. Horseweed is resistant to imazapic, therefore it is often a dominant forb in the field. Sparse horseweed is not a problem when the field is managed for wildlife. In fact, the structure presented can be favorable for brooding quail and turkeys. However, dense stands can preclude optimum growth of nwsg, especially in the year of establishment or following disking in established stands. A single mowing in June or July (just above the height of the nwsg seedlings) usually will solve the problem.

When spraying horseweed amongst nwsg, an application of metsulfuron methyl (Cimarron™ or Escort™ at 1/10 ounce per acre) should suppress horseweed sufficiently to allow nwsg to come through and establish. Any ap-

Fig 6.49 During the year of establishment, horseweed can proliferate and shade out native grass seedlings on some sites. Mowing no lower than the top of the native grass seedlings will reduce shading, allow the native grasses to develop and allow other more desirable forbs to develop in the field as well.

Robin Mayberry

plication over 1/10 ounce per acre may be injurious to nwsg. If sprayed postemergence, horseweed is best controlled when sprayed early, well before flowering. Dicamba (Banvel™, Clarity™, Overdrive™), sulfosulfuron (OutRider™) and 2,4-D™ can be used to control horseweed, but desirable forbs growing in association with nwsg may be killed. The exception is when horseweed is apparently taking over the stand during the year of establishment. In this situation, most other forbs in the seedbank may be suppressed by the excessive growth of horseweed and relatively little herbicide comes in contact with them. Afterward, a response from other forbs should be evident fairly soon after the horseweed is controlled.

Cool-season annuals and recurring cool-season grasses

Henbit, purple deadnettle, chickweeds and ground ivy are common cool-season annual weeds that often become prevalent after perennial ground cover (such as tall fescue) has been removed or after a warm-season row-crop (such as corn or soybeans) has been harvested. These cool-season weeds are not normally major competitors with nwsg, but can suppress the seedbank and reduce available nutrition to favorable plants, depending on density and growth. In addition, these plants can make dormant-season burning more difficult and can increase smoke management problems.

Henbit, chickweed, purple deadnettle and ground ivy can be controlled with an application of a glyphosate herbicide at two quarts per acre (with surfactant). This application should be made before the plants begin to flower. Other forb-specific herbicides – such as thifensulfuron methyl (Harmony Extra™), 2,4-D™ and dicamba (Banvel™, Clarity™, Overdrive™) – can be used to control these weeds after nwsg have emerged; however, efficacy and control will be reduced because the weeds will have flowered and already produced seed by this time. In this situation, a dormant-season burn is recommended to reduce coverage of cool-season plants and enable better germination of desirable forbs from the seedbank.

Recurring non-native cool-season grasses (such as tall fescue, orchardgrass, bromegrasses) can be a problem beginning the fall after planting nwsg. When not controlled adequately prior to planting, it is common for these grasses to appear once again across a field. The best control method is an application of a glyphosate herbicide at 2 quarts per acre (with surfactant) after the nwsg have gone into dormancy. This is best accomplished by burning the field in September and allowing the residual cool-season grasses to regrow 6 – 10 inches before spraying in late October/early November.

Fig 6.50 Tall fescue was sprayed in this field before planting nwsg. The second fall after planting nwsg, tall fescue germinated from the seedbank in some areas of the field. If not controlled, conditions for wildlife will be compromised as the tall fescue thickens, limiting openness at ground level and suppressing desirable species in the seedbank. Residual tall fescue and other non-native cool-season grasses are easily removed from nwsg by burning in late September, allowing the csg to regrow 6–10 inches (usually by early November), then spraying a glyphosate herbicide.

Woody competitors

Woody encroachment is often a problem when managing fields of nwsg and old-field habitats for wildlife. As discussed under ***Growing-season burning*** on page 105, burning can be very effective at reducing and/or eliminating woody competition, especially smaller stems. However, where burning is not possible, herbicides such as triclopyr (Garlon™ or Remedy™) and imazapyr (Arsenal AC™) are necessary to re-gain control of a field and reduce/eliminate woody cover or limit woody encroachment. Mowing alone is an inadequate method to reduce woody competitors because mowing woody sapling stems simply encourages multiple resprouting.

Depending upon objectives, fields may be broadcast-sprayed, strip-sprayed or spot-sprayed. If all woody growth is to be killed and woody coverage is extensive, a broadcast application may be used. Strip-spraying may be used when some woody growth is desired. This is particularly applicable (only if desirable woody species are present) when managing for bobwhites and a variety of songbirds, especially scrub/shrub species, such as prairie warblers, yellow-breasted chats, indigo buntings, blue grosbeaks, chipping sparrows and loggerhead shrikes. Spot-spraying is most often used when woody coverage is not extensive. Spot-spraying also allows removal of individual unwanted species (such as sweetgum, ashes, elms), while desirable species (such as wild plum, hawthorn, black cherry, persimmon, oaks) may be retained. Sprayers mounted on the back of a 4-wheeler are quite efficient when spraying fields only a few acres in size and when woody growth is less than 3 feet high. Otherwise, a tractor-mounted or pull-behind sprayer is recommended for larger fields and taller growth.

Fig 6.51 Unless woody competition is severe, spot-spraying using a spray gun attached to a tractor-mounted sprayer is an excellent way to control problem species, such as winged elm.


Richard Harper

Several herbicides are available that will control woody competitors. Herbicide selection should be based on the amount of woody cover present and landowner objectives. If the goal is to reduce woody cover and retain nwsg, landowners should consider an herbicide that does not harm the grasses, such as triclopyr (Garlon 4™). Triclopyr will, however, kill a variety of forbs, including legumes. If additional forb growth is a primary objective, imazapyr (Arsenal AC™) should be considered. Nonetheless, if woody competition is not extensive, a broadcast application is not necessary.

If the field is completely covered in woody growth, a broadcast application is warranted and a mixture of herbicides may be required to ensure control. Herbicide labels should be referenced for a list of species controlled. For example, black locust, honey locust, redbud and winged elm are not controlled by imazapyr, but are controlled by triclopyr and metsulfuron methyl. On the other hand, yellow poplar, sourwood, sweetgum, red maple, hickories and Chinese privet may not be controlled with triclopyr or metsulfuron methyl, but are controlled with imazapyr. For broadcast applications, a mixture of 16 ounces of Arsenal AC™ and 16 – 48 ounces of Forestry Garlon 4™ (OR a mixture of 16 ounces of Arsenal AC™ and 2 ounces of Escort™), along with one quart of MSO per acre or 0.25 percent NIS is recommended to control most woody species. When spot-spraying foliage with a backpack sprayer, 4 ounces of Arsenal AC™ and 16 ounces of Roundup™ per 4 gallons of solution works well. One percent solution of MSO or 0.25 percent NIS should be added to the herbicide mixture.

Mowing and haying

The least-preferred method of managing fields of nwsg and associated old-field habitats is mowing (bushhogging). While mowing does set back succession, it leaves a tremendous amount of debris at ground level, which limits mobility of bobwhites and other birds and suppresses the seedbank. Over time, thatch increases, bare-ground space is eliminated and seed, soft mast production and availability may be reduced significantly. Haying, which removes debris from the field, is preferred over bushhogging. The timing of haying, however, is a real concern as nesting and brood-rearing cover is removed when it is needed most (May through July). Where nwsg are hayed for livestock and there is interest in wildlife, the field should be cut only once per growing season (see ***Maximizing forage production and wildlife habitat*** on page 51).

If a field cannot be burned or disked, and mowing is the only option, it should be done in late winter. At this time, there is much less impact on wildlife, especially if completed just before spring green-up so winter cover is eliminated for only a short time. In addition, mowing is much easier at this time as there is considerably less biomass in the field, conditions are much more comfortable and there is no worry of stirring up yellowjackets! As with prescribed fire and disking, mowing also should be completed on a rotational schedule. It is important that all available habitat is not cleared during one year. Blocks may be set aside in a 2- or 3-year rotation, providing cover for brooding, nesting and escape all in the same field or general area. Problematic woody succession should be controlled by spot-spraying specific herbicides.

Fig 6.52 Fields should not be managed by mowing. Mowing increases the thatch layer, inhibits mobility, reduces availability of seeds and invertebrates and limits germination from the seedbank. Further, when completed during the growing season, mowing destroys reproductive cover along with the nests, nestlings and young wildlife within.

Fig 6.53 In fields where forb coverage is extensive and additional grass coverage is desired, mowing strips during mid-summer can help increase grass density for nesting structure and fine fuel to facilitate burning. This field was completely dominated with goldenrod, dewberry and several other asters. A few strips were mowed in the field in late July to stimulate broomsedge bluestem.

Benefits of mowing

Mowing can be effective in reducing weed competition during the year of establishment for nwsg, especially when herbicide applications are not possible. Several species that are difficult to control during the year of establishment can be effectively "knocked back" by mowing before the competition flowers. This is especially true with annual forbs (such as horseweed and cocklebur) where pure stands of nwsg are being established for haying/grazing and/or where herbicide options are limited. Unwanted vegetation should be mowed to a height of approximately 12 inches and repeated as necessary.

Fig 6.54 Strips also can be mowed in fall to provide sight lanes to facilitate rabbit hunting. However, mowing in the fall can stimulate cool-season grasses, such as tall fescue. Residual cool-season grasses can easily be sprayed and killed in mowed strips; nonetheless, this once again highlights the importance of eradicating non-desirable plants before planting.

When managing old-field habitats, mowing can be used to increase grass cover where the field is completely dominated by forbs. Not only is some grass cover desirable for nesting, but it is also needed to help carry a fire. Fields containing little or no grass can be difficult to burn unless there is considerable wind, which can make burning more dangerous. Mowing strips in the field during mid-summer will reduce forb density and increase grass density if grass is present in the seedbank.

Final thoughts on management

Managing nwsg for livestock forage is much easier than managing for wildlife habitat. Cutting and grazing at the proper time and height combined with the proper soil amendments and a weed control strategy (which usually means spraying all forbs with a forb-selective herbicide) is all that's necessary. Managing early-succession habitat for wildlife is much more involved. Attention must be given to species composition and the structure of cover available. Woody cover is an important component, but it adds another dimension in the correct use of fire, disking and/or herbicide applications. Timing of management is critical to influence plant species composition. Arranging successional stages to juxtapose various cover types and food resources is most important if the goal is maximizing carrying capacity and minimizing home ranges and associated movements of wildlife.

Unfortunately, many landowners and wildlife managers have thought that by simply planting nwsg that they have created desirable wildlife habitat and that they don't have to worry with it anymore. How untrue! With few exceptions, managing wildlife habitat means managing succession. Succession marches forward. Desirable early-succession habitat is short-lived; it passes by in just a few years. **Managing wildlife habitat must not be thought of as a one-time event, but a way of life!**

Conclusion

Availability of quality early succession habitat is a limiting factor for many wildlife species. Throughout the Mid-South, quality habitat has been destroyed by suburban development and degraded by various land-use practices (such as establishment of tall fescue pasture/hayland, "clean" farming and allowing fields to develop into closed-canopied forest). Converting perennial cool-season grass acreage to nwsg and associated vegetation and establishing nwsg around field borders and "odd" areas that are not cropped will improve conditions for wildlife and positively affect wildlife populations dependent upon early-succession habitats. Existing areas of early-succession habitat must be maintained if benefits are expected to continue.

Dependable production of quality forage is critical for livestock producers. Nwsg can be used to provide an abundance of high-quality forage during a period when production of cool-season forages is inadequate. For those producers interested in wildlife, nwsg are a much better alternative than non-native warm-season grasses, such as bermudagrass, sorghum-sudan and the Old World bluestems.

Management of nwsg (as with other habitats) is absolutely necessary for wildlife and is different from that recommended for cool-season forages. Prescribed fire is highly recommended to maintain and improve wildlife habitat and stimulate nutritious forage growth. Timing and intensity of haying and grazing should be considered carefully to ensure quality forage and maintenance of the stand and provide wildlife habitat.

Landowners should not be skeptical about nwsg. The advantages for wildlife and the quality of forage produced have been proven time and again throughout the Mid-South and in other regions as well. With the recent technological advancements in equipment and herbicides, establishment is no longer a concern. And cost of establishment is much reduced, especially with the cost-share opportunities provided through USDA programs. Technical assistance is as close as the county NRCS office or Extension office. Advice and assistance is also available through state wildlife agencies and land-grant universities.


Robin Mayberry

Fig 7.1
The value of native grasses and quality early succession habitat goes beyond wildlife populations and cattle weight gains. Passing on family traditions as pure and wholesome as quail and rabbit hunting is immeasurable.

Finally, another real benefit of nwsg that cannot be underestimated is the aesthetic beauty of a field dominated by native plants. Getting a glimpse of what early explorers might have seen centuries ago as they traveled through the Mid-South region is most pleasing. The beauty of the plants, coupled with the presence of the associated wildlife, provides real satisfaction for many landowners. For those who enjoy quail, rabbit and deer hunting, the benefits go beyond aesthetics and enable many landowners to pass down a tradition that, most unfortunately, is disappearing as quickly as the habitat is destroyed. Hence the need to reverse this trend!

Nwsg should not be construed as a panacea for wildlife or forage management. However, there should be no doubt that nwsg can be used to benefit the landowner who desires quality early-succession habitat for wildlife and/or improved forage for livestock.

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Appendix 1

Use of early-succession fields containing native warm-season grasses and associated forbs by various wildlife species in the Mid-South region.

Wildlife species	Nesting/ Birthing	Brooding/ RaiseYoung	Escape	Thermal	Foraging	Hunting/ Scavaging	Loafing/ Courtship
Birds							
Northern harrier *Circus cyaneus*	X					X	
Red-tailed hawk *Buteo jamaicencis*						X	
American kestrel *Falco sparverius*						X	
Wild turkey *Meleagris gallopavo*	X	X			X		X
Northern bobwhite *Colinus virginianus*	X	X		X	X		X
Common snipe *Gallinago gallinago*					X		X
American woodcock *Scolopax minor*					X		X
Barn owl *Tyto alba*						X	
Great horned owl *Bubo virginianus*						X	
Long-eared owl *Asio otus*						X	
Short-eared owl *Asio flammeus*						X	
Common nighthawk *Chordeiles minor*						X	
Chuck-will's-widow *Caprimulgus carolinensis*						X	
Eastern kingbird *Tyrannus tyrannus*						X	X

Wildlife species	Nesting/ Birthing	Brooding/ RaiseYoung	Escape	Thermal	Foraging	Hunting/ Scavaging	Loafing/ Courtship
Loggerhead shrike *Lanis ludovicianus*						X	X
Horned lark *Eremophila alpestris*	X	X			X		
Purple martin *Progne subis*						X	
Northern rough-winged swallow *Stelgidopteryx serripennis*						X	
Cliff swallow *Hirundo pyrrhonota*						X	
Barn swallow *Hirundo rustica*						X	
Sedge wren *Cistothorus platensis*	X	X			X		
Marsh wren *Cistothorus palustris*	X	X			X		
Eastern bluebird *Sialia sialis*					X		
American Pipit *Anthus rubescens*					X		X
Prairie warbler *Dendroica discolor*		X			X		X
Common yellowthroat *Geothlypis trichas*		X			X		X
Yellow-breasted chat *Icteria virens*		X			X		X
Blue grosbeak *Guiraca caerulea*		X			X		X
Indigo bunting *Passerina cyanea*		X			X		X
Dickcissel *Spiza americana*	X	X			X		X
Bachman's sparrow *Aimophila aestivalis*	X	X			X		X
Field sparrow *Spizella pusilla*	X	X			X		X
Vesper sparrow *Pooecetes gramineus*	X	X			X		X
Savannah sparrow *Passerculus sandwichensis*	X	X			X		X

Wildlife species	Nesting/ Birthing	Brooding/ RaiseYoung	Escape	Thermal	Foraging	Hunting/ Scavaging	Loafing/ Courtship
Swamp sparrow *Melospiza georgiana*					X		X
Grasshopper sparrow *Ammodramus savannarum*	X	X			X		X
Henslow's sparrow *Ammodramus henslowii*	X	X			X		X
Lapland longspur *Calcarius lapponicus*					X		X
Red-winged blackbird *Agelaius phoeniceus*	X	X			X		X
Eastern meadowlark *Sturnella magna*	X	X			X		X
American goldfinch *Carduelis tristis*		X			X		X
Mammals							
Opossum *Didelphis virginianus*						X	
Southeastern shrew *Sorex longirostris*	X	X	X	X		X	X
Eastern mole *Scalopus aquaticus*	X	X				X	
Silver-haired bat *Lasionycteris noctivagans*						X	
Big brown bat *Eptesicus fuscus*						X	X
Red bat *Lasiurus borealis*						X	
Hoary bat *Lasiurus cinereus*						X	
Evening bat *Nycticeius humeralis*						X	
Mexican freetail bat *Tadarida brasiliensis*						X	
Raccoon *Procyon lotor*							X
Longtail weasel *Mustela frenata*						X	
Striped skunk *Mephitis mephitis*	X	X				X	

Wildlife species	Nesting/ Birthing	Brooding/ RaiseYoung	Escape	Thermal	Foraging	Hunting/ Scavaging	Loafing/ Courtship
Coyote *Canis latrans*	X	X			X	X	X
Red fox *Vulpes fulva*	X	X			X	X	
Gray fox *Urocyon cinereoargenteus*						X	X
Groundhog *Marmota monax*	X	X	X		X		
Plains pocket gopher *Geomys bursarius*	X	X			X		
Harvest mice *Reithrodontomys spp.*	X	X	X	X	X		
White-footed mouse *Peromyscus leucopus*	X	X	X	X	X		
Deer mouse *Peromyscus maniculatus*	X	X	X	X	X		
Hispid cotton rat *Sigmodon hispidus*	X	X	X	X	X		
Meadow vole *Microtus pennsylvanicus*	X	X	X	X	X		X
Prairie vole *Microtus ochrogaster*	X	X	X	X	X		X
Meadow jumping mouse *Zapus hudsonius*	X	X	X	X	X		
Cottontail rabbit *Sylvilagus floridanus*	X	X	X	X	X		X
White-tailed deer *Odocoileus virginianus*	X	X	X	X	X		X
Reptiles and Amphibians							
Eastern box turtle *Terrapene carolina*	X				X	X	
Fence lizard *Sceloporus undulatus*	X					X	
6-lined racerunner *Cnemidophorus sexlineatus*	X					X	

Wildlife species	Nesting/ Birthing	Brooding/ RaiseYoung	Escape	Thermal	Foraging	Hunting/ Scavaging	Loafing/ Courtship
Ground skink *Scincella lateralis*	X					X	
Southeastern 5-lined skink *Eumces inexpectatus*	X					X	
Slender glass lizard *Ophisaurus attenuatus*	X					X	
Eastern garter snake *Thamnophis sirtalis*						X	
Black racer *Coluber constrictor*						X	
Rat snake Elaphe obsolete						X	
Northern pine snake *Pituophis melanoleucus*						X	
Black kingsnake *Lampropeltis getula*						X	
Eastern milksnake *Lampropeltis triangulum*						X	
Prairie kingsnake *Lampropeltis calligaster*						X	
Mole kingsnake *Lampropeltis calligaster*						X	
Northern copperhead *Agkistrodon contortrix*						X	
American toad *Bufo americanus*						X	
Fowler's toad *Bufo woodhousei*						X	
Barking treefrog *Hyla gratiosa*						X	X

Note: Inclusion of species in this appendix does not imply native warm-season grasses are necessary for various life requirements, just that the species listed may use early-succession fields for the activities identified. Use of fields containing native warm-season grass may vary greatly among the species listed and is determined by many factors, such as season, size of field, structure of field (such as presence of brush), composition and juxtaposition of surrounding habitats, and management strategy (such as burning/haying regime).

Appendix 2

A brief description of USDA programs provided through the Natural Resource Conservation Service (NRCS) and Farm Service Agency (FSA).

Conservation Reserve Program (CRP) General Signup

The CRP is a voluntary program available to landowners to help improve water quality, reduce soil erosion and enhance wildlife habitat on highly erodible cropland. Under this program, landowners remove highly erodible or other environmentally sensitive land from production under contract for 10 years in exchange for annual payments and cost-share assistance to establish permanent vegetation. During a general signup, landowners have approximately 30-45 days to offer their land into the program. Offers are ranked nationwide by USDA using the Environmental Benefits Index (EBI). Higher EBI points suggest a greater chance of acceptance into the program. In CRP general signups, landowners enroll "whole" fields or large acreage. Many landowners have selected nwsg for this program and have established thousands of acres across the South. Recent changes in CRP regulations require and pay landowners to apply mid-contract practices that enhance wildlife habitat, such as strip-disking, strip herbiciding, legume interseeding and prescribed burning.

Conservation Reserve Program (CRP) Continuous Signup

Conservation buffers (filter strips, riparian forest buffers, contour grass strips and grassed waterways) and other small acreage or targeted practices are offered under a continuous signup for the CRP. This continuous signup allows landowners to enroll strips of cropland or marginal pastureland into the CRP without a competitive bidding process (like the general CRP signup). Recent bonuses and incentive payments have added an additional financial incentive for participation in continuous CRP. If land eligibility requirements are met, the eligible land can be accepted into the program immediately. Certain practices are eligible for a one-time Signing Incentive Payment (SIP) of $100 per acre plus a 40 percent Practice Incentive Payment (PIP) and/or an annual rental payment 20 percent higher than the general CRP rental payment. One of the most flexible and financially beneficial practices is CP33-Habitat Buffers for Upland Birds. This practice allows a landowner to enroll buffers 30 – 120 feet wide on one to all of their eligible cropfield borders, where crop yields are generally lowest and often below "break-even" profitability. An annual rental payment is received on all acreage enrolled into CP33 during the 10-year contract, and landowners are also eligible for the SIP and PIP payments.

Environmental Quality Incentives Program (EQIP)

EQIP is a volunteer program available to all privately owned agricultural land. Landowners typically apply for EQIP funding based on an EQIP plan developed by local NRCS personnel to achieve conservation and environmental objectives. Local working groups help identify environmental concerns and objectives and conservation practices to help meet these objectives during a signup. Applications are evaluated for funding based on a state- and locally-developed ranking procedure to optimize environmental benefits. EQIP assists landowners by cost-sharing 50 – 75 percent of installation costs. Limited-resource producers and beginning farmers and ranchers may be eligible for up to 90 percent cost-share assistance to establish conservation practices. Landowners are required to maintain the conservation practice throughout the contract. Some wildlife provisions such as native grass hay establishment, native grass field borders and other wildlife practices may be eligible within EQIP; however, this may vary by state and county.

Grassland Reserve Program (GRP)

GRP was created by the Farm Security and Rural Investment Act of 2002 (Farm Bill). To be eligible, land must be in a contiguous block of 40 acres or more. Easements (30-year or permanent) or rental agreements (10- to 30-year) are available for landowners to protect grassland from urban development, conversion to crop production or any other development using an agricultural commodity that requires breaking the soil surface. Common grazing practices, haying and maintenance consistent with maintaining the grassland and forb species are permitted.

Wildlife Habitat Incentives Program (WHIP)

WHIP is a cost-share program that assists landowners with establishing wildlife habitat on private lands. Contract lengths vary from 5 – 10 years and applications are competitive with other landowners in the state. Up to

75 percent cost-share assistance is available for establishing a wide range of wildlife-friendly practices, such as establishing nwsg, shrub hedgerows, invasive species control and other wildlife-friendly practices. Management practices, such as prescribed burning and strip-disking can also receive cost-share when included in the initial WHIP plan. No annual payments are provided for practices enrolled into WHIP. Many times landowners who do not have land that qualifies for CRP can enroll their property into WHIP; however, eligible practices may vary among states.

These are general guidelines for program information. Available programs can change upon passage of new Farm Bill legislation, and specific program practices are subject to change from state to state. For the most current information on these or other USDA programs, contact the local USDA Service Center, NRCS office, FSA office or Soil Conservation District. Below are important Web sites for more information.

http://www.usda.gov/farmbill

http://www.nrcs.usda.gov/

http://www.fsa.usda.gov/

Appendix 3

Calibrating sprayers

Accurate herbicide application is essential when establishing nwsg and controlling undesirable weeds. Sprayer calibration involves measuring the output of solution from a spray rig for a given speed over a measured area to determine gallons per acre. This is as essential to successful establishment as selecting the proper herbicide and time and depth of planting. In general, a spray rate of 10 – 30 gallons of water per acre is recommended with a spray pressure of 20 – 40 pounds per square inch (psi).

There are many different methods for calibrating spray rigs. Whichever calibration method is used, it is important to check spray rig calibration:

- when starting a project;
- when using a different speed;
- when PTO or RPM levels change (unless spray output is powered by other sources such as a battery on smaller spray rigs);
- when output or desired volume of water changes;
- when equipment is changed (spray rig, tractor, PTO pump, spray tips, etc.);
- when sprayer pressure is adjusted.

Spray-an-acre method

This is an easy and direct method to calibrate spray rigs. The steps below outline the spray-an-acre calibration method.

1. Measure and mark the boundary for one acre (such as 300 feet X 145 feet).

2. Fill up spray rig tank or fill to a recorded mark on the tank or gauge with water only.

3. Select a gear and engine speed combination that allows a full spray rig to be driven safely and comfortably across the area to be sprayed.

4. With sprayer operating, adjust pressure to desired setting. [Note: this is usually 20 to 40 pounds per square inch (psi). Higher pressure levels tend to vaporize water and may cause drift during application. Select the larger water droplet size for spray tips and low to mid-range psi levels to avoid drift problems.]

5. Refill if needed with clean water.

6. Spray the marked area at the pre-selected gear, speed and pressure. Avoid overlaps when spraying.

7. After the marked area is completely covered, shut off sprayer and measure how many gallons it takes to refill or return to the recorded mark.

8. The number of gallons used to refill is the gallons per acre (GPA) applied.

1/128-acre method

This procedure is a popular and quick method of calibration by capturing a small amount of water over a specific straight driving distance. The steps below outline the 1/128 acre calibration method.

Spray tip or nozzle spacing (inches)	Distance to time for calibration (feet)
18	227
20	204
22	185
24	170
26	157
28	146
30	136
32	127
34	120
36	113
38	107
40	102

1. Referencing the table at right, measure and mark the appropriate distance to be sprayed. Select the straight driving distance that corresponds to the spray tip or nozzle spacing.

2. Fill spray rig with clean water.

3. Select a gear and engine speed combination that allows a full spray rig to be driven safely and comfort-

ably across the straight line distance after adjusting pressure to desired setting (usually 20 to 40 psi).

4. While maintaining the selected gear and keeping the engine speed (RPM) constant from step 3 (if using a PTO-driven pump), record in seconds the time required to drive or pull the spray rig through the marked distance. Do not record time from a standing start, but have the spray rig at desired speed when entering and running through the marked "distance for calibration."

5. Repeat step 4 and average the time for two runs.

6. Return to a level stop and park spray rig while letting it run at the same engine speed (RPM) and pressure as during step 4. Using a measuring cup, measure in ounces the spray output from a single spray tip or nozzle for the same time it took to drive the measured distance in step 4.

7. Repeat step 6 several times with different spray tips and average the volume from individual spray tips or nozzles.

8. The average amount of water, measured in ounces, collected per spray tip or nozzle equals gallons per acre (GPA).

Adding the herbicide to the tank

After the spray rig has been calibrated, the amount of herbicide to be added to the clean water already in the tank must be determined. The tank should be at least half full prior to mixing in any herbicide. After the appropriate amount of herbicide and surfactant (if needed) are added, the tank should be filled with clean water to help disperse the chemical throughout the tank. Herbicides and surfactants should **not** be mixed together before pouring into spray tank. The spray tank should always be half full of water when mixing chemicals. Cloudy water from ponds, creeks or other water sources should not be used because the organic materials present may result in an ineffective application.

For broadcast applications…

1) Divide the full tank capacity by the gallons per acre (GPA) output to get the number of acres (A) covered by one full tank.

2) Multiply the herbicide rate (ounces per acre or pints per acre) by the acres (A) from one full tank.

3) Pour this amount of herbicide into the tank and fill the rest of the tank with clean water. Add the appropriate amount of surfactant, if needed.

Example

A landowner wants to eradicate tall fescue in a field and convert it to nwsg. The prescription for spraying tall fescue is 2 quarts of a glyphosate herbicide with 1 quart of MSO per acre. The spray rig will hold 300 gallons. After cleaning the sprayer and filling it up, a safe speed for spraying the field was determined. A calibration distance of 204 feet was marked off in the field after determining the spray tips were 20 inches apart. It took 35 seconds to pull the spray rig through the calibration distance (204 feet). The spray rig was parked and, with the engine still running at the same speed (RPM), water from one spray tip was collected in a measuring cup for 35 seconds. Fifteen ounces were collected; thus, the output of the spray rig was 15 gallons per acre (GPA). The following calculations were made before pouring herbicide into the tank:

- 300-gallon tank divided by 15 GPA = 20 acres covered by one tank;
- 2 quarts of Roundup™ per acre X 20 acres = 40 quarts in one full tank;
- 1 quart of surfactant per 100 gallons of water = 300 gallons X 1 quart per 100 gallons = 3 quarts per full tank.

Useful Conversions:

1 square mile = 640 acres = 2.590 square kilometers
1 acre = 4,840 square yards = 43,560 square feet = 4,047 square meters
1 mile = 5,280 feet = 1.609 kilometers
1 yard = 3 feet = 36 inches = 0.914 meters
1 inch = 2.54 centimeters = 25.4 millimeters
1 gallon = 4 quarts = 8 pints = 128 ounces = 3.785 liters
1 pound = 16 ounces = 256 drams = 7,000 grains = 453.592 grams

Cleaning sprayers

It is important to thoroughly clean and rinse the entire spray rig, including spray nozzles and tips, before calibrating the spray rig. Residual herbicide in sprayers can cause damage to nwsg, as well as other desired vegetation. Some herbicides, especially the ester formulation of 2,4-D™, Banvel™, Weedmaster™, sulfonylureas and imidazolinones are very difficult to wash out of a sprayer. Dedicating spray rigs to specific herbicides is one way to avoid serious damage to non-target vegetation. Recommendations for cleaning sprayers are provided on many herbicide labels. Household ammonia can be used to clean spray rigs as follows:

1) Drain spray rig in an appropriate area or container. Rinse the tank and flush hoses with clean water.

2) Fill the sprayer with clean water and add household ammonia (1 gallon 3 percent active ammonia product for every 100 gallons of water or 1.5 ounces of ammonia for every 10 gallons of water for smaller tanks). Flush hoses, boom and spray tips.

3) Shut off boom and refill the entire tank with water.

4) Turn on spray rig and allow water and ammonia mix to circulate for at least 15 minutes, then flush hoses, boom and spray tips.

5) Drain tank.

6) Remove spray tips and screens and clean thoroughly.

7) Repeat step 2.

8) Rinse tank, hoses, boom and spray tips thoroughly.

Sprayers should not be cleaned near creeks, wells, sinkholes, drainage areas, other water bodies or near desirable vegetation. If concentrated liquid herbicides are accidentally spilled, absorbent kitty litter should be used quickly to soak up the herbicide. The herbicide-laced litter may be broadcast in an agricultural seeder spreader on targeted vegetation at label rates.

Appendix 4

Herbicides, rates, approximate applications, cost and manufacturer information

Primary active ingredient (%)	Trade name[1]	Sugg. rate per acre[2]	Application[3]	Manufacturer	Approx. cost	Residual soil activity	Purpose for spraying / comments[4]
Broad-spectrum herbicide							
glyphosate	Roundup Ultra-Max (50.2); Gly-4 Plus (41); Accord (53.8); several others	1–5 quarts	postemergence	several	$45–140 per 2.5 gallons	No	Controls existing vegetation when preparing to plant or restore early-succession habitat; kills cool-season weeds in dormant nwsg and forbs.
Herbicides for native grass establishment							
imazapic (8.1) and glyphosate (21.9)	Journey	16–32 ounces	preemergence postemergence	BASF	$275 per 2.5 gallons ($10–20 per acre)	Yes	Controls a variety of forbs and grasses when planting/restoring early-succession habitat, including bluestems, indiangrass and sideoats grama.
imazapic (23.6)	Plateau	4–12 ounces	preemergence postemergence	BASF	$270 per gallon ($10–25 per acre)	Yes	Controls tall fescue, crabgrass, johnsongrass and other grasses and forbs when planting/restoring/managing early-succession habitat, including bluestems, indiangrass and sideoats grama; Plateau is available only through select government agencies.
sulfosulfuron (75)	OutRider	0.75–2.0 ounces	preemergence postemergence	Monsanto	$305 per 20 ounces ($11–31 per acre)	Yes	Controls various forbs and grasses when planting/restoring early-succession habitat, including bluestems, indiangrass, switchgrass and sideoats grama
Grass-selective herbicides							
clethodim (26.4)	Select 2EC	6–16 ounces	postemergence	Valent	$158 per gallon ($7–20 per acre)	No	Controls various grasses in firebreaks planted to soybeans, alfalfa, sunflowers, Brassicas and clovers. Does not harm yellow nutsedge. Also may be used to set back nwsg and allow more forbs to establish.
quizalofop (10.3)	Assure II	5–12 ounces	postemergence	DuPont	$135 per gallon ($8–13 per acre)	No	Controls various grasses in firebreaks planted to soybeans. Also may be used to set back nwsg and allow more forbs to establish.

Primary active ingredient (%)	Trade name[1]	Sugg. rate per acre[2]	Application[3]	Manufacturer	Approx. cost	Residual soil activity	Purpose for spraying / comments[4]
sethoxydim (13)	Poast 1.5L	2–3 pints	postemergence	BASF	$173 per 2.5 gallons ($17–26 acre)	No	Controls various grasses in firebreaks planted to alfalfa, clovers and soybeans.
Forb-selective herbicides							
triclopyr (25); fluroxypyr (8.6)	PastureGard	2–3 pints (herbaceous); 3–8 pints (woody)	postemergence	Dow AgroSciences	$146 per gallon ($37–55 per acre herbaceous; $55–146 per acre broadcast woody control)	No	Controls various forbs in native grass hayland and pastures; no grazing restrictions on non-lactating dairy animals.
metsulfuron methyl (60)	Escort	0.1 ounces (native grass) 1–3 ounces (woody)	postemergence	DuPont	$350 per 16 ounces ($3 per acre native grass; $22–66 per acre for broadcast woody control)	Yes	Controls various forbs when managing native grasses, including bluestems, indiangrass, switchgrass and sideoats grama; controls various woody species.
metsulfuron methyl (60)	Cimarron	0.1–1.0 ounces	preplant incorporated; preemergence; postemergence	DuPont	$230 per 10 ounces ($3–23 per acre)	Yes	Controls various forbs when establishing/managing native grasses, including bluestems, indiangrass, switchgrass and sideoats grama; no haying or grazing restrictions.
metsulfuron methyl (60-Part A); dicamba (10.3-Part B); 2,4-D (29.6-Part B)	Cimarron Max (5 ounces of Cimarron and 2.5 gallons of Weedmaster)	(refer to label)	postemergence	DuPont	$285	Yes	Controls various forbs when managing native grasses, including bluestems, indiangrass, switchgrass and sideoats grama.
aminopyralid (40.6)	Milestone	4–7 ounces	postemergence	Dow AgroSciences	$93 per quart ($12–20 per acre)	Yes	Controls forbs in grassland habitats; apply only to established grasses; no restrictions on haying or grazing following applications at labeled rates.
dicamba (48.2)	Banvel	2–4 ounces for wheat, oats and rye; 8 ounces for grain sorghum; 8–16 ounces for field corn	preplant incorporated; preemergence; postemergence	Micro Flo	$140 per 2.5 gallons ($1–7 per acre)	Yes	Controls various forbs in fallow/old-field habitats (refer to label for rates) and in firebreaks planted to corn, wheat, oats, grain sorghum or soybeans.
dicamba (56.8)	Clarity	2–4 ounces for oats, triticale, and wheat; 8 ounces for grain sorghum; 8–16 ounces for corn;	preemergence postemergence	BASF	$238 per 2.5 gallons ($2–12 per acre)	Yes	Controls various forbs in fallow/old-field habitats (refer to label for rates) and in firebreaks planted to corn, wheat, oats, grain sorghum or soybeans.
dicamba (55.0%) and diflufenzopyr (21.4%)	Overdrive	4–8 ounces	postemergence	BASF	$36 per pound ($9–18 per acre)	Yes	Controls various forbs in native grass hay and pasture; no haying or grazing restrictions.
dicamba (12.4) and 2,4-D (35.7)	Weedmaster	1–4 pints	postemergence	BASF	$34 per gallon ($5–17)	Yes	Controls various forbs in established native grasses and in firebreaks planted to wheat.
2,4-D (47.2)	2,4-D Amine	0.5–3 pints	postemergence	several	$37 per 2.5 gallons ($1–6 per acre)	Yes	Controls various forbs in native grass habitats and in firebreaks planted to wheat, oats, corn and grain sorghum.

Primary active ingredient (%)	Trade name[1]	Sugg. rate per acre[2]	Application[3]	Manufacturer	Approx. cost	Residual soil activity	Purpose for spraying / comments[4]
2,4-DB (25.9)	Butyrac 200	0.7–0.9 pints for soybeans; 1–3 quarts for alfalfa, birdsfoot trefoil, alsike, ladino and red clovers	preplant incorporated; preemergence; postemergence	Agri-Star	$37 per gallon ($3–4 per acre for soybeans; $9–28 per acre for other plantings)	Yes	Controls various forbs in native grass habitats. Does not harm many legumes, but will kill some, including sicklepod. Also controls various forbs in firebreaks planted to alfalfa, birdsfoot trefoil, alsike, ladino and red clovers.
thifensulfuron-methyl (50)	Harmony Extra	0.3–0.6 ounces	postemergence	DuPont	$240 per 20 ounces ($4–7 per acre)	No	Controls various forbs in fallow/old-field habitats and in firebreaks planted to wheat or oats.
Selective herbicides primarily for firebreak plantings							
imazethapyr (70)	Pursuit	3–6 ounces	preplant incorporated; preemergence; postemergence	BASF	$538 per gallon ($13–25 per acre)	Yes	Controls various forb and grass weeds in firebreaks planted to alfalfa, clovers, birdsfoot trefoil, lespedezas, cowpeas and soybeans; **do not apply** preemergence on alfalfa or clovers; Pursuit can also be applied to bluestems and switchgrass to control various problem forbs, annual grasses and yellow nutsedge.
pendimethalin (37.4)	Pendulum 3.3 EC; Prowl 3.3 EC Prowl H_2O	2–4 pints (varies by crop and soil type)	preplant incorporated; preemergence; postemergence	BASF	$100 per 2.5 gallons ($10–20 per acre) $59 per 2.5 gallons ($6–12 per acre)	Yes	Controls various forb and grass weeds in firebreaks planted to corn, various legumes and sunflowers; **do not apply** preplant incorporated before planting corn; apply preplant incorporated **only** before planting Southern peas and sunflowers.
trifluralin (43)	Trifluralin 4EC; Treflan HFP	1–2.5 pints	preplant incorporated	Dow AgroSciences	$46 per 2.5 gallons ($3–6 per acre) $83 per 2.5 gallons ($5–11 per acre)	Yes	Controls various forb and grass weeds in firebreaks planted to cowpeas, chicory, Brassicas, wheat, soybeans and sunflowers; trifluralin can be applied postemergence on alfalfa if 0.5 inch or more of rain occurs within 3 days; trifluralin does not control established weeds.
halosulfuron-methyl (75)	Permit	0.6–1.3 ounces	postemergence	Gowan	$350 per 20 ounces ($11–23 per acre)	Yes	Controls various forbs and yellow nutsedge in firebreaks planted to field corn and grain sorghum; do not use more than 1 ounce per acre on grain sorghum.
S-metolachlor (82.4)	Dual II Magnum	1–2 pints	preplant incorporated; preemergence	Syngenta	$285 per 2.5 gallons ($15–29 per acre)	Yes	Controls various grasses and forbs in firebreaks planted to corn, cowpeas and soybeans.

Primary active ingredient (%)	Trade name[1]	Sugg. rate per acre[2]	Application[3]	Manufacturer	Approx. cost	Residual soil activity	Purpose for spraying / comments[4]
bentazon (44)	Basagran	1–2 pints	postemergence	BASF	$218 per 2.5 gallons ($11–22 per acre)	No	Controls various forbs and yellow nutsedge in firebreaks planted to corn, grain sorghum, cowpeas and soybeans; may cause yellowing or speckling in soybeans and cowpeas, but this is temporary and outgrown within 10 days.
Selective herbicides primarily for woody control, but also for control of various forbs and grasses							
imazapyr	Arsenal AC (53.1); Chopper (27.6)	6–24 ounces	postemergence	BASF	$160 per quart ($30–120 per acre)	Yes	Controls a variety of woody competitors (see label for species); releases legumes; may kill native grasses; controls bermudagrass prior to planting native grasses.
triclopyr	Garlon 3-A; Triclopyr 4 EC	1–8 quarts	postemergence	Dow AgroSciences	$200 per 2.5 gallons ($20–160 per acre)	No	Controls a variety of woody competitors (see label for species); kills forbs (including legumes and blackberry) and releases grasses.

[1] Use of brand, trade or company names in this publication is for clarity and information; it does not imply approval of the product or company to the exclusion of others, which may be of similar composition or equal value. In particular, generic products commonly become available and may differ in price and percentage of active ingredient. Always be sure to read, understand and follow directions and precautions on herbicide labels before use. As herbicides, herbicide labels, and their availability and recommendations may change, it is best to consult your local Extension agent or farm supply distributor for the latest recommendations on herbicide use.

[2] Various crops labeled for a particular herbicide often require or tolerate different types of applications (such as pre- or postemergence) and different application rates. Application rates also may differ depending on soil texture. Always refer to herbicide labels for specific application rates for a given crop.

[3] A surfactant should be added to all postemergence herbicide applications unless the herbicide already contains surfactant. Refer to the herbicide label as to which surfactant to use, mixing instructions and recommended rates.

[4] Many herbicides have multiple uses. Read the herbicide label before use. The purposes stated in this table are for general information. In addition, there are rotation crop restrictions for many herbicides, which may preclude you from planting specific crops for a given amount of time after applying various herbicides. Refer to herbicide label for information concerning crop rotation restrictions. The majority of postemergence herbicides work best when applied to actively growing plants, often before they reach a certain size/height. Refer to herbicide label to identify optimum application effectiveness.

Appendix 5

Using no-till technology to establish nwsg

There have been many changes in agriculture during the last 50 years. One of the most significant changes has been the use of no-till planting methods. When no-till planting is mentioned, most people usually think of crops such as corn, soybeans and cotton. Though often overlooked, no-till technology is also well-suited to establish forage crops, including nwsg, for wildlife or livestock. Soil erosion in conventional row-crop production has been decreased significantly by using herbicides to kill a cover crop and planting without tillage. This same benefit is also realized when no-till planting nwsg.

Why use no-till?

Many fields in Tennessee have been planted to permanent pasture because they were too steep to conventionally plant corn or soybeans. The potential for soil erosion was so great that a perennial cover had to be used to prevent excessive soil erosion, which was inevitable on many slopes. The main advantage to no-till planting is to conserve soil and decrease erosion.

No-till planting has several other advantages. Planting is able to occur soon after rain using no-till, while the soil must be allowed to dry before disking when conventional planting is used. After planting, the soil retains moisture longer when using no-till technology because the soil is not directly exposed to the sun. This is a real consideration when planting nwsg, especially when planting later in the season (June).

Characteristics needed in no-till drills

To be successful, no-till drills must place seed at the right depth, at the right rate and in firm contact with soil. They need to do this across a wide range of soil-moisture gradients, soil types, slopes and residue cover. Listed below are some characteristics to consider when choosing or using a no-till drill.

Weight

A no-till drill needs enough weight to let coulters and seed openers penetrate firm soil, allow press wheels to close the seed furrow and keep drive wheels or coulters in good contact with the ground. Depending on soil moisture, depth of planting and the setup of the drill, this may require 300 to 600 pounds per foot of width.

Coulters

Many drills use coulters to cut through residue in front of seed-furrow openers. In general, narrow coulters less than 1 inch wide disturb less residue, require less weight and work better across a wider range of conditions than wide-fluted coulters. Either narrow-ripple or smooth-edge ripple (bubble) coulters work well. Coulters should be as close to seed furrow openers as possible for better tracking on hills. Generally, coulters should be run at the depth of seeding or slightly deeper. When planting nwsg, this is just below the ground surface. Some drills use offset double-disc openers or angled, single-disc openers instead of coulters. These drills require less weight to penetrate the soil and have fewer moving parts. Disc openers wear out quicker on these drills, and the coulter may be useful in heavy residue.

Seed furrow opener

Double- or single-disc openers give more consistent depth of seeding and handle heavy residue better than hoe or shovel openers. They are particularly better for shallow planting, such as nwsg, alfalfa and clovers.

Depth control

Seeding depth is usually controlled by the press wheels or by depth gauge wheels mounted by the seed openers. Some drills rely on coulter depth to set seeding depth, but this method will not give consistent results.

Press wheels

Press wheels cover the seed, firm the soil and control seeding depth on many planters. Generally, either single 2-inch press wheels or two angled, narrow press wheels in a V-shaped configuration work well on no-till drills. Single, narrow press wheels (1-inch wide) will not control depth well in soft soils and should be used only if depth is controlled by gauge wheels. Press wheels wider than 2 inches will not close the seed furrow unless they have ribs on either side of the furrow. The angled, V-shaped press wheels work well on hard ground, but may clog in heavy residue like corn stubble. Staggering the press wheel/seed opener units helps reduce clogging.

Seed metering

Most drills have internally fluted metering mechanisms that are easy to adjust and are suitable for a wide range of seeds (various species). However, special seed box attachments with an agitator or auger and picker wheels (or similar device) are necessary for bluestems and indiangrass seed that have not been de-bearded. Also, many drills have a small seed box for planting switchgrass, alfalfa or clovers.

Power requirements

Pull-type drills need five to seven horsepower per foot of width.

Tractor hydraulics

Many drills require that the tractor have external hydraulics, so two hydraulic hoses can be plugged in.

Tracking

Proper tracking, with the seed opener and press wheels following in line behind the coulter, is often a problem on hilly ground or in turns. Drills with coulters close to the openers have less problems with tracking. Wider coulters help by tilling a wider zone, but require more weight.

Maintenance and operation

Of course, it is important to follow the recommended maintenance practices for no-till drills and to be familiar with the operating procedures as described in the owner's manual. Drills should be inspected before planting and maintained as necessary. Many drills used to plant nwsg are borrowed or rented from state wildlife agencies, Quail Unlimited chapters, or farm supply companies. The age, type and maintenance of these units vary greatly. It is critical to understand how to adjust the seeding rate, change the seeding depth, realize how the weight and ballasting system works, and know the horsepower and hydraulic requirements of the drill. Drills should be inspected before transport or use for worn, broken or missing parts. Fittings should be greased and hoses inspected for wear and to make sure they are not clogged. Before beginning to plant, coulter settings and seeding depth should be adjusted as necessary, and the drill must be calibrated. More tips on calibration are described below.

Calibrating the drill

Calibrating a drill is nothing more than determining how much seed is being released per acre at a given setting. There are several ways to calibrate a drill, depending upon make and model. Nonetheless, any drill can be calibrated using the following steps.

1) Set the seed flow rate for the drill according to the calibration chart guidelines.

2) Mark a 100-foot length to use for catching seed.

3) Detach the seed flow tubes from above the press wheels.

4) Load seed (when using bluestems and indiangrass that have not been de-bearded, use enough to seed to fill to the top of seed agitators) and pull the drill until seed begins to flow.

5) Tape or tie a bag onto each of the hoses and pull the drill over the 100-foot marked area.

6) Weigh the amount of seed released over the 100-foot area.

7) Seeding rate in pounds per acre can be determined by the following formula:

$$\text{Seeding rate (lb/acre)} = \frac{\text{seed released (lbs)} \times 43{,}560 \text{ sq ft per acre}}{100 \text{ ft} \times \text{drill width (feet)}}$$

Note: this equals the seeding rate in bulk pounds per acre, not Pure Live Seed (PLS).

When more than one seedbox is used, each one should be calibrated individually before seeding. For example, when planting nwsg for wildlife, the seedbox for nwsg must be calibrated, as well as the seedbox for small seeds if forbs are added separately from the grasses. Changing the calibration on one seedbox does not affect calibration of the other boxes.

Some drills provide instructions for calibration by raising the drive wheel with a jack and turning the drive wheel a certain number of rotations at the proper ground speed to approximate a usage distance. This is often easier than pulling the drill several times before getting the seeding rate adjusted properly.

Several factors may affect seeding rates. Humidity, seed density, purity, inert matter and debris in the seed bag, speed of travel, seedbed condition, slope, soil type and tire size may influence the seeding rate. This illustrates the importance of calibrating the drill on the site to be planted, with the seed being planted on the day planting is completed. Operator error also can affect the seeding rate significantly. Overlapping rows, leaving too wide a space between rows and not lifting the drill at row ends can impact grass density significantly.

Coulter adjustment

No-till drills vary in the method used to control coulter seeding depth. Coulter depth on some drills can be adjusted by adding or removing weights to the drill. Some drills have a hydraulic mechanism that can be raised or lowered to adjust coulter depth. A variety of mechanisms are used to adjust disc opener depth. When the drill is being calibrated for seeding rate, several furrows should be checked to determine the depth the coulter is cutting into the ground and the depth of seed placement. Generally, it is best to use only enough pressure, weight or coulter depth to ensure the coulters will turn. The final determination of seeding depth is made by checking the planting furrows when planting and measuring seed depth. If the seeds are not obvious, they are too deep or are not being planted!

Appendix 6

Approximate number of seed per pound for selected grass species

Species		Seed per pound
Native warm-season grasses		
Big bluestem	*Andropogon gerardii*	165,000
Little bluestem	*Schizachyrium scoparium*	240,000
Broomsedge bluestem	*Andropogon virginicus*	?
Indiangrass	*Sorghastrum nutans*	175,000
Switchgrass	*Panicum virgatum*	389,000
Eastern gamagrass	*Tripsacum dactyloides*	7,500
Sideoats grama	*Bouteloua curtipendula*	191,000
Introduced warm-season grasses		
Bahiagrass	*Paspalum notatum*	273,000
Bermudagrass (hulled)	*Cynodon dactylon*	2,071,000
Crabgrass	*Digitaria sanguinalis*	825,000
Dallisgrass	*Paspalum dilitatum*	281,000
Johnsongrass	*Sorghum halepense*	119,000
Introduced cool-season grasses		
Tall fescue	*Festuca arundinacea*	227,000
Orchardgrass	*Dactylis glomerata*	416,000
Timothy	*Phleum pratense*	1,152,000
Kentucky bluegrass	*Poa pratensis*	1,440,000
Smooth bromegrass	*Bromus inermis*	135,000
Annual ryegrass	*Lolium multiflorum*	224,000
Oats	*Avena sativa*	16,000
Wheat	*Triticum aestivum*	11,000
Rye	*Secale cereale*	18,000

Appendix 7

Sources of native warm-season grass seed

Growers/Suppliers

Bamert Seed Company
1897 County Road 1018
Muleshoe, TX 79347
(800) 262-9892
(806) 272-5506
www.bamertseed.com

Ernst Conservation Seeds
9006 Mercer Pike
Meadville, PA 16335
(800) 873-3321
www.ernstseed.com

Garrett Wildflower Seed Farm
1591 Cleveland Rd.
Smithfield, NC 27577
(919) 989-3031
garrettwfseed@mindspring.com

Lickskillet Seeds Inc.
22324 State Hwy HH
Gallatin, MO 64640
(660) 663-3095
www.lickskilletseeds.com

Native American Seed
3791 N. US Hwy 377
Junction TX 76849
(800) 728-4043

Osenbaugh Grass Seed
Rt. 1 Box 44
Lucas, IA 50151
(800) 582-2788

Roundstone Native Seed LLC
9764 Raider Hollow Road
Upton, KY 42784
(270) 531-2353
www.roundstoneseed.com

Sharp Brothers Seed Company
396 SW Davis Street – LaDue
Clinton, MO 64735
(800) 451-3779
(660) 885-7551
www.sharpbro.com

Stock Seed Farms
28008 Mill Road
Murdock, NE 68407-2350
(800) 759-1520
(402) 867-3771
www.stockseed.com

Turner Seed Co.
211 County Road 151
Breckenridge, TX 76024
(800) 722-8616
www.turnerseed.com

Suppliers

Adams-Briscoe Seed Co.
P.O. Box 19
325 East Second Street
Jackson, GA 30233
(770) 775-7826
www.abseed.com

Applewood Seed Co.
5381 Vivian Street
Arvada, CO 80002
303-431-7333
www.applewoodseed.com

C.P. Daniel's Sons Inc.
P.O. Box 119
Waynesboro, GA 30830
(800) 822-5681
(706) 554-2446

Carl R. Gurley, Inc.
P.O. Box 995
Princeton, NC 27569
(919) 936-5121

Pennington Game Food Seed
P.O. Box 192
Madison, GA 30850
(706) 342-1234
www.penningtonseed.com

Seeds, Inc.
2435 Harbor
Riverside Station
Memphis, TN 38113
(800) 238-6440
(901) 775-2345

Spandle Nurseries
RFD#2, Box 125
Claxton, GA 30417
(800) 553-5771
www.spandles.com

Tennessee Farmers Co-op
200 Waldron Road
PO Box 3003
LaVergne, TN 37086-1983
(615) 793-8400
www.ourcoop.com

Turner Seed
P.O. Box 739
LaVergne, TN 37086
(615) 641-7333

The local state farmers' co-op, Southern States Co-op, farm supply outlet or other seed vendors may also be able to provide native grass seed or locate other sources.

Buyers are urged to compare seed quality (germination, purity rates, percent inert material) when shopping among vendors.

Inclusion on this list does not entail endorsement, nor is any discrimination intended by omission from this list of known growers and suppliers.

Appendix 8

Glossary

annual – a plant that completes its life cycle in one year or season

auricle – an ear-shaped appendage or lobe

awn – a bristle-like appendage

axis – the elongated central supporting structure, often specifically called a rachis

backing fire – a fire set to spread into the prevailing wind, or downhill; slow-moving

basal area – the average amount of a given area occupied by the cross-sectional area of tree stems, usually expressed as square feet per acre

beard – a group of long awns

biennial – a plant that completes its life cycle in two years or seasons

blackline – preburned area (with no unburned fine fuels) adjacent to firebreak or other control line

blade – the upper expanded part of a grass leaf

bract – a reduced or modified leaf

bramble – plants from the genus Rubus, including the blackberries and raspberries browse – leaves and twigs of woody plants, including those from brambles and vines, typically eaten by animals such as white-tailed deer and rabbits

bud – an aggregation of undeveloped leaves or flowers on an axis with undeveloped internodes, often enclosed by scales

buffer – strips of land maintained in permanent vegetation designed to trap pollutants, reduce water and wind erosion, and provide other environmental benefits, including wildlife habitat

bulb – a short underground stem surrounded by fleshy leaves or scales

bunchgrass – a grass that grows in a well-defined clump, as opposed to sod-forming grass that spreads by stolons or rhizomes

clump – a single plant with two to many stems arising from a branched rootstock or short rhizome

collar – the outside area of a grass leaf where the blade and sheath join

composition – a mixture of a variety of plant species

controlled burn – see prescribed fire

cool-season grasses – grasses that make their active growth during the cooler months of the year, generally September through November and March through May

covert – the area where three or more habitat types come together

culm – the flowering stem of grasses and sedges

decreaser – a plant that decreases as a result of overgrazing

disseminate – to scatter or spread seed for growth

dominant – superior to the other grasses with which a grass is associated

dormant-season burn – prescribed fire implemented during the dormant season (generally October – March for warm-season plants) drip torch – hand-held tank holding a fuel mixture (usually 55–70 diesel; 30 – 45 gasoline) used to ignite fires by dripping flaming liquid, at an adjustable rate, onto ground litter

ecotone – the transitional zone between two vegetative communities (a.k.a. "edge")

edge – the area where two habitat types come together

emigration – movement of animals out of a local population, typically as a result of dispersal

entire – a leaf margin without teeth, lobes or divisions

fallow – describes an area previously planted but since left to respond to successional growth

firebreak – a natural (creek, road) or artificial (disked strip) discontinuity of fuels (grass, leaf litter) used to contain/control fire and limit the area burned

flame height – the vertical distance from the ground to the upper limits of the flame

flame length – the distance from the base of the flame to the flame tip, usually at an angle as wind directs the fire

flanking fire – a fire set to spread at right angles to the prevailing wind

forage – leaves and stems of herbaceous plants typically eaten by various animals

forb – a broad-leaved herbaceous plant (as opposed to grasses, rushes, sedges and ferns or woody plants)

germination – the percentage of seed that is capable of producing healthy plants when placed in a suitable environment.

glumes – the pair of bracts at the base of a grass spikelet

growing-season burn – prescribed fire implemented during the growing season (generally April – September for warm-season plants) hard seed – the percentage of seed that is viable, but will not germinate immediately due to a hard or waxy seed coat

heading fire – a fire set to spread with the prevailing wind, or uphill; generally fast-moving

herb – a vascular plant without a woody stem

hydric – wet

immigration – movement of animals into a local population, typically as a result of dispersal

increaser – a plant that increases as a result of grazing

inert material – the percentage of sticks, stems, leaves, broken seed, sand and other such material mixed with the desired seed in the bag

inflorescence – the seedhead or flowering part of a plant

internode – that part of the grass stem between two nodes or joints

interspersion – refers to the number of habitat changes and amount of edge created over a management area

inundate – to cover with water (flood)

invader – a non-native (exotic) plant that spreads in an area where it is not native

juxtaposition – refers to the placement (proximity) of habitat types

keel – the sharp fold at the back of a compressed sheath, blade, glume or lemma

lemma – the bract of a spikelet above the pair of glumes

ligule – the thin, membranous, hairy or ridgelike appendage or projection on the inside (base) of the leaf where the blade and sheath join

litter – represents dead natural fuels on the ground, including leaves, needles, sticks, limbs, grass, etc.

membrane – a thin, soft, pliable structure serving as a covering or lining

mesic – moist

midrib – the central vein of a leaf

node – the joint of a grass stem that normally bears one or more leaves

noxious weed seed – the number of undesirable (potentially invasive) seed present per pound of desired seed

palatability – indicated by the preference an animal shows for feeding on a particular plant

panicle – a seedhead (inflorescence) with a main axis and subdivided branches; may be open or compact and spikelike

pedicel – the stalk or stem of a spikelet or single flower in a cluster

peduncle – stalk of a flower cluster or of a solitary flower when that flower is the only member of an inflorescence

perennial – a plant that produces aboveground parts from the same root system for at least three years or growing seasons

petiole – the stalk of a leaf blade

prescribed fire – controlled application of fire under specified environmental conditions that allows the fire to be managed at a desired intensity within a confined area to meet predetermined vegetation management objectives

pure live seed – the percentage of seed that is capable of germinating soon after planting in a suitable environment

raceme – an elongated seedhead in which the spikelets are pedicelled on a rachis

rachis – the axis of a spike or raceme (an axis bearing flowers or leaflets)

rhizome – an underground horizontal stem with nodes (usually producing roots), buds and scale-like leaves ring fire – a fire set by igniting the entire perimeter of an area, allowing the fire to converge in the center

rootstock – subterranean stem; rhizome

rosette – a cluster of radiating basal leaves

scabrous – rough or gritty feeling to the touch

scale – the reduced leaves at the base of a shoot (especially said of those rudimentary leaves on a rhizome)

seedbank – the collection of seed occurring naturally in the soil

seedstalk – the stem on which a grass seedhead develops

senescent – dead or dying vegetation; often used to refer to deciduous leaves in the fall and winter, or dead grass from the previous growing season

serrate – with sharp teeth pointing forward

sessile – without a stalk (petiole or pedicel)

sheath – the lower part of a grass leaf that encloses the stem

shoot – individual stem and leaf growth

spathe – a large bract enclosing or surrounding an inflorescence (flower)

spike – an unbranched, elongated seedhead in which the spikelets (flowers) are sessile on a rachis

spikelet – a flower; the basic unit of a grass seedhead, consisting of one or more florets and a pair of glumes

stolon – a propagative, horizontal, shoot, stem or runner that is usually aboveground, rooting at the apex

strip-heading fire – fire set by a series of strips ignited upwind of a firebreak or blackline intended to burn with the wind into the firebreak or backing fire succession – the orderly progression through time of changes in community composition, usually described in terms of plant life

terminal – at the tip

tuber – a fleshy enlarged portion of a rhizome or stolon with only vestigial (rudimentary) scales

warm-season grasses – grasses that make their active growth during late spring and summer

winter annual – an annual plant vegetatively persistent through the winter, flowering and fruiting in late winter or spring

xeric – dry

Appendix 9

Suggested reading and references for those interested in native warm-season grass management for early-successional wildlife and forages

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Restoring Native Grasslands

K. Brian Hays, Matthew Wagner, Fred Smeins and R. Neal Wilkins*

The native grasslands of Texas have been steadily disappearing since the arrival of the first settlers. With urban development and the conversion of land to row crops and pastures of non-native grasses, only about 96 million of the original 148 million acres of native grasslands remain. Much of the remaining grassland area has been degraded by overgrazing and the encroachment of brush.

The conversion of native grasslands to non-native pasture grasses is one of the most notable changes in land use in Texas over the last decade (Fig. 1). There are now more than 10 million acres of non-native pastureland in Texas, with much of it planted to coastal bermudagrass for hay production and cattle grazing. Bermudagrass and other non-native grasses are normally managed as monotypic (single species) stands of grass, so the plant diversity of the original ecosystem is lost.

Non-Native Grasses and Wildlife

The conversion of native grasslands to bermudagrass pasture is detrimental to most native wildlife species. Bermudagrass is a dense, matting grass that provides little cover or nesting habitat for bobwhite quail, turkeys and songbirds. Its growth structure eliminates bare ground, which these birds need for feeding and moving easily through the landscape. Bermudagrass crowds out the native forbs (broadleaf species) and grasses that provide food for birds and other native wildlife.

Species such as bobwhite quail, bobolink, dickcissel, eastern meadowlark, grasshopper sparrow and Attwater's prairie chicken are all dependent upon habitats associated with healthy native grasslands, and all of these species have been declining over the last 2 decades.

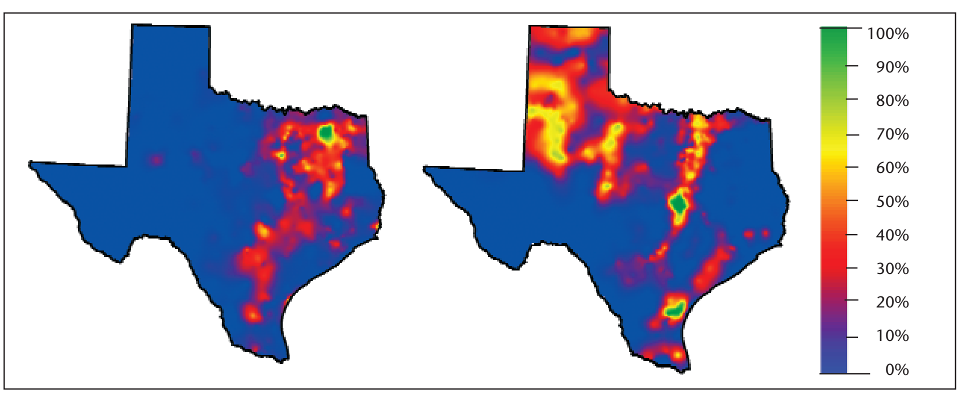

Figure 1. Much of the native grassland in Texas has been converted to improved pastures (left) or cropland (right).

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Reasons for Restoring Native Grasslands

Many cattle producers and other rural landowners are looking for ways to reduce the amount of money and labor invested in their operations. It can be costly to grow bermudagrass because it requires regular fertilization to produce high quality forage and hay. Many warm-season native grasses and forbs produce enough forage, with adequate protein, to meet the needs of livestock without expensive fertilization. Little bluestem, Indiangrass, switchgrass and others are considered excellent forage for livestock and hay production. The native bunchgrasses make ideal habitat for wildlife that depend on these plants for food, cover and nesting. The bare ground between bunchgrasses makes excellent travel and feeding areas for grassland birds and also allows a variety of native forbs to germinate and grow.

Benefits of Native Grasslands

- Wildlife habitat
- Recreation
- Livestock forage
- Erosion control
- Healthy watersheds
- Low maintenance
- Nutrient cycling
- Sustainability

Many landowners are also interested in enhancing wildlife habitat on their properties. The Texas property tax code now allows landowners to retain their agricultural tax valuation if they manage and/or restore their land for wildlife habitat, and this includes the restoration of native grasses. This tax incentive may extend to owners of smaller tracts that are often created when large ranches are sold and subdivided, but there are different acreage minimums in different regions of the state. Restoring native grasslands is an important way to enhance wildlife habitat and meet one requirement for qualifying for wildlife management tax valuation.

This quail has found cover in native bunchgrasses.

Converting Pastures to Native Grasslands

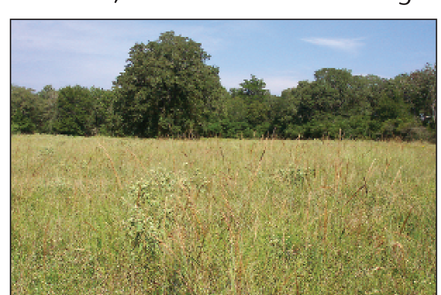
Before native grasses are planted, bermudagrass must be controlled. Treating it with herbicide is a primary means to reduce or remove it. The bermudagrass should be treated when it is actively growing. Bermudagrass usually starts to grow when the soil temperature reaches 65 degrees F, which is earlier on sandy soils than on clay soils. Therefore, bermudagrass on clay soils should be treated later in the year when the weather is warm, and may need more than one herbicide application. A stand also may need more than one application of herbicide if it is especially vigorous. So soil type and the vigor of the bermudagrass will affect the timing of both herbicide application and seed planting.

Suggested steps in restoring native grasses are as follows:

- Determine the location and acreage of the pasture to be converted to native vegetation.
- Burn, mow or heavily graze the site during late winter to prepare it for herbicide application. Remove as much plant litter as possible.
- Purchase seed and herbicide and arrange for services such as tractor work and herbicide application.
- Once the bermudagrass is actively growing and at least 6 inches high, apply glyphosate herbicide (41% active ingredient) at a rate of 4 quarts per acre on sandy soils and 6 quarts per acre on clay soils. The best time for herbicide application in South Central Texas (based on research) is after May 15. The date will vary in other parts of the state. Midsummer, when the weather is hot and humid, may be the best time.

  If more than one application is needed, apply 2 quarts per acre in June, 2 quarts in July and 2 quarts in August.
- If one application is made, use a no-till drill to plant native seed into dead sod about 2 weeks after spraying. The native seed mix should contain several bunchgrass and forb species that occur in the area (ask your county Extension agent, Texas Parks and Wildlife Department biologist, or the local Natural Resources Conservation Service staff about a recommended mix for your area). The recommended seeding rate is 6 to 7 pounds of pure live seed (PLS) per acre.

The photo above shows a treated site on sandy loam soil. The photo below shows the same site, two growing seasons later, after control and seeding.



Another method is to disk the sprayed area and broadcast seed. If seed is broadcast, the amount of seed should be doubled to compensate for weed competition.

If more than one herbicide application is needed throughout the summer, delay seeding until late winter or early spring and plant with a no-till drill. Seed must have adequate soil moisture to germinate.

- Exclude the planted area from grazing for at least two non-drought growing seasons.
- Once the native grasses and forbs are established, manage the area with prescribed burning every few years or with rotational grazing. This will prevent thatch formation, stimulate growth and maintain vegetation diversity.

Factors Affecting Grassland Restoration

- Plant selection
- Soil type
- Planting technique (drill or broadcast)
- Planting time
- Seeding rate
- Site preparation
- Seed quality
- Site maintenance
- Soil moisture

Plants Recommended for Reseeding

Grasses

- Little bluestem
- Indiangrass
- Eastern gammagrass
- Blackwell switchgrass
- Sideoats grama
- Big bluestem

Forbs

- Maximillian sunflower
- Engelmann daisy
- Illinois bundleflower
- Bush sunflower

Expected Results

Research was done on sandy, sandy loam and clay soils in Washington, Falls and Grimes Counties in South Central Texas. Three different rates of glyphosate herbicide were tested–6 quarts, 5 quarts and 4 quarts per acre. Two years after application, the three rates produced an average of 86 percent bermudagrass control on sandy soil, 90 percent on sandy loam soil, and 52 percent on clay soil. Better control might be observed on clay soils if the herbicide is applied later in the spring or more than one application is made.

Native species can be slow to establish from seeding. However, controlling the bermudagrass with herbicide will reduce the competition for sunlight and nutrients and help the native species become established.

Other native grasses and forbs are likely to emerge along with the species that are planted. On test sites, these other species included wooly croton, ragweed and broad-leaf signalgrass. The test sites have gone from one species (bermudagrass) to an average of nine grass species and eleven forb species per site. This diverse plant community can now provide wildlife with food and cover that was lacking before.

Figures 2, 3 and 4 show the diversity of plants at test sites two growing seasons after seeding. All sites were treated with 6 quarts per acre of glyphosate in the spring and planted with a no-till drill in the spring.

Because native grass and forb seeds need moisture to germinate, there is some risk involved with seeding. The landowner must adjust the restoration plan according to the amount of rainfall received. For example, if the spring is drier than normal, it might be best to wait until summer to treat the bermudagrass and then plant in the fall or the following spring. For more information see publications E-53 and E-117 (both from Texas Cooperative Extension and available at *http://tcebookstore.org*)

Figure 2. Sandy soil.

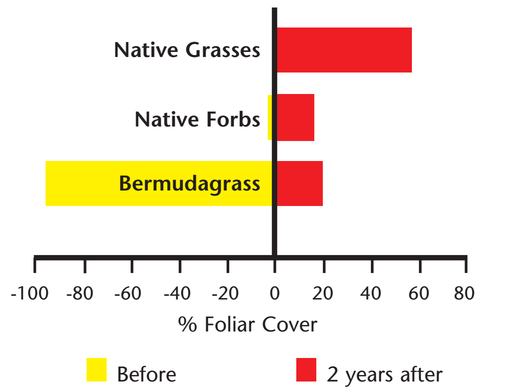


Figure 3. Sandy loam soil.

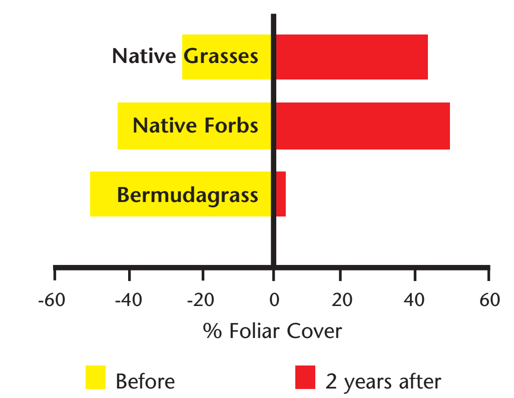
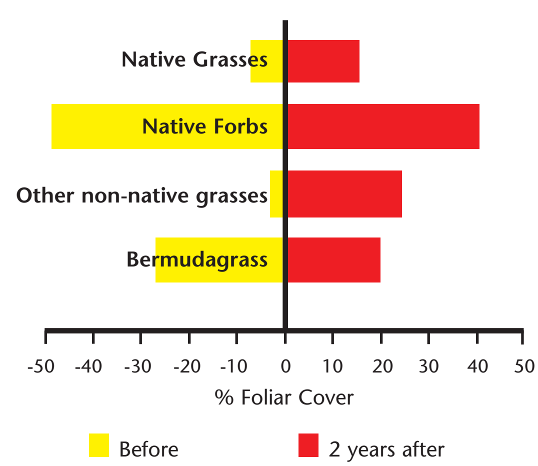


Figure 4. Clay soil.



Landowner Resources

The cost of converting bermudagrass pastures to native grasslands is an estimated $100 to $200 per acre or more, depending on the cost of herbicide and seed. One way to do it less expensively is to stop adding fertilizer and soil amendments to bermudagrass pastures while grazing them heavily during the spring and early summer. Eventually this will reduce bermudagrass vigor and cover and allow native species to become established; it is a much lengthier process, however.

Technical and/or cost-share assistance are available to landowners through the following programs.

PUB–Pastures for Upland Birds

Administered by the Texas Parks and Wildlife Department
1-800-792-1112
http://www.tpwd.state.tx.us/conserve/wildlife_management/post_oak/upland_game/pub

- Provides herbicide and no-till drilling for converting bermudagrass pastures to native grasslands

LIP–Landowner Incentive Program

Administered by the Texas Parks and Wildlife Department
1-800-792-1112
http://www.tpwd.state.tx.us/conserve/lip/

- Helps landowners protect and manage rare species (can include native grasslands)

Farm Bill

Administered by the United States Department of Agriculture, Natural Resources Conservation Service
(Texas NRCS, 254-742-9800
http://www.tx.nrcs.usda.gov/programs/)

- Several programs offer incentives for conserving natural resources

Playa Lakes Joint Venture

http://www.pljw.org

- Provides technical, financial and educational assistance for conservation work on private land in the Panhandle

Ducks Unlimited

Prairie Wetland Project
832-595-0663
http://www.ducks.org

- Provides technical, financial and educational assistance for conservation work on private land

Landowners may also find helpful information at the following Web sites:

http://wildlife.tamu.edu
http://texnat.tamu.edu
http://www.tpwd.state.tx.us
http://www.nrcs.usda.gov
http://cnrit.tamu.edu/cgrm/

Additional Reading

B-182, "Know Your Grasses" (Texas Cooperative Extension).

B-6134, "Texas Rural Lands: Trends and Conservation Implications for the 21st Century" (Texas Cooperative Extension).

E-53, "Seeding Rangeland" (Texas Cooperative Extension).

E-117, "Rangeland Risk Management for Texans: Seeding Rangeland" (Texas Cooperative Extension).

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Produced by Agricultural Communications, The Texas A&M University System
Extension publications can be found on the Web at: *http://tcebookstore.org*

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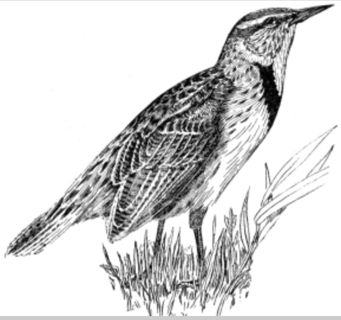
Great Trinity Forest Management Plan

Grasslands

Establishing and Managing Grasslands Naturally

Establishing and Managing Grasslands Naturally

2007



Why Grasslands Stewardship?

- Grasslands are an increasingly rare habitat in New Jersey.
- They support many threatened and endangered species, especially birds.
- Establishing and managing grasslands is essential for their conservation.

Stony Brook Millstone Watershed Association

31 Titus Mill Road
Pennington NJ 08534
Phone: 609-737-3735
Fax: 609-737-3075
www.thewatershed.org
www.giscenter.org
www.thewatershedinstitute.org

What Are Grasslands ?

Grasslands....
... are open areas free of most trees and shrubs, dominated by grasses. They often also have wildflowers and other herbaceous (leafy) plants
... require regular disturbance to maintain this mix of plants and stop "succession" by woody plants. Without disturbance, grasslands turn into forests.
... include meadows, prairies, hayfields, pastures and airfields. Native grasslands, though, are just meadows of "warm-season" grasses.
... have declined precipitously from historical levels in New Jersey. Changing agricultural practices, increased development, and suppression of fire, flood and beavers have virtually eliminated grasslands from the landscape.

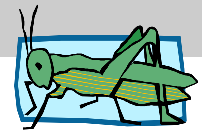
Why Are Grasslands Important ?

1. **Grasslands support vulnerable wildlife.** Only 5% of New Jersey's land mass is grasslands, yet 41% of the state's endangered birds (and 29% of the threatened birds) are grasslands species. Grasslands provide food and nesting areas for birds as well as habitat for insects and small mammals. Bees, butterflies and other pollinating insects, many of which are declining in population, thrive in wildflower meadows.
2. **Grasslands promote groundwater recharge and protect water quality.** Large open vegetated areas allow stormwater to soak into the ground in contrast to paved and built areas that cause stormwater runoff. Native grasses have deep roots that help prevent erosion and sedimentation of waterways. Grassland plants and soils filter out pollutants, helping to keep waterways clean.
3. **Grasslands provide open space for people to enjoy.** The unique qualities of a grassland — the expansive view of the open sky, the unfiltered light and perfumed air, the shooshing of the wind in tall grass, the music of birds and insects — offer special opportunities for relaxation, contemplation, nature observation, and ecotourism.

Why Avoid Chemical Herbicides and Pesticides?

The conventional approach to grasslands restoration includes the use of chemical herbicides and/or pesticides. But these contribute to nonpoint source pollution in waterways and in some cases are potentially toxic to the flora and fauna we are trying to support. Using mechanical disturbance and an ecosystem approach to establishing and managing grasslands is a viable alternative.

Grasslands Stewardship: the Natural Way



1. Before beginning

There are many decisions to make and factors to consider before starting a grasslands restoration. The most fundamental is to determine your **conservation objective**. Which grassland birds can/ should you seek to support? The habitat you will create depends primarily on the site's acreage. Grassland birds' habitat size requirements vary considerably; the minimum would be 5-10 acres, but some birds need 150 acres or more. They also vary in their tolerance for woody plants, and preference for short/medium/tall grasses. Birds live in landscapes, not between property lines. Consider adjacent, connected or nearby grasslands in determining your goals and assessing your site. Work cooperatively with other grassland stewards for regional goals.

Then, evaluate your site's **physical characteristics**. Is it suitable for restoration? What needs to be done to achieve the habitat objective? Soils, Drainage and Topography : Is it well-drained? Is it level, sloping or undulating? Is it prone to flooding? Soil type? (Soil type affects not only vegetation suitability but also the relative difficulty you will have in working it.) Field conditions: Vegetation? (Cool-season grasses? Invasive plants? Trees/shrubs?) Prior herbicide/pesticide use?

Finally, assess your **resource needs and availability**. Accessibility: Can you get your equipment into the field? Equipment: (Do you own? Can you borrow or rent?) You will need: *Tractor* (60-70 hp is the minimum needed to carry out the site practices); *brush hog ; heavy cutting disc*; *cultipacker*, *fine disk or disk harrow*; *drill seeder* . Manpower: allow two acres/hour for any site task; a 20-acre field = 10 person-hours. Time varies with equipment size and site roughness.

2. Site Preparation

Site Preparation Principles

Restoring a native warm-season grassland means planting the native warm-season grasses that grassland birds prefer (although agricultural lands may be managed for grassland birds) by removing existing non-native cool-season grasses from the site and/or ensuring that they do not invade from nearby areas. There are **two objectives** to site preparation for planting warm-season grasses. 1) to ***reduce competition*** from cool-season grasses (and other undesired vegetation); 2.) to ***promote favorable conditions*** for warm-season grasses.

The conventional way to **reduce competition** from undesired vegetation is by poisoning the plants with herbicides. The *natural way* is to use "**mechanical disturbance**": bash them up, cut them, starve them, and damage their root systems….repeatedly!

> Both types of grasses require full sun but otherwise their **optimal site conditions** differ :
> **Warm-season grasses: need warm (50°F) soil to germinate** (May-June in central New Jersey), and **for optimal growth need temperatures of at least 85°F (Summer).** They are very efficient Nitrogen & Potassium users so can thrive under stressful conditions and in **nutrient-poor soil.**
> **Cool-season grasses:** optimal growth is under **cool, moist** conditions: spring and fall. They go dormant in hot summer months, and are heavy feeders (so need **rich soil** or fertilizers).

Site preparation practices:
Brush removal: Use a brush hog if there is substantial woody growth (a forest cutter for anything over two inches in caliper). Disking is sufficient if there is not too much woody vegetation.
Shallow cultivation: Beginning as early as the soil can be worked in the spring, use a heavy disk to disturb only the top several inches. The goal is to avoid dredging up weed seed. Disturb just enough to compromise the weed root systems and tops. Continue shallow cultivation at two-week intervals throughout the growing season. Subsequent disking can be with lighter equipment such as a disk harrow or cultipacker to smooth and firm the surface.
Plant a "nutrient-sponge": sow an annual crop such as corn, or small grain such as oats, to reduce the productivity of the soil and give cover to protect against winter soil loss. If planting later in the season, you will want to consider planting cereal or winter rye at 1-2 lbs per acre.
Resume shallow cultivation the following spring, up until planting: mid May-mid June.
Do not use pesticides: Pesticides harm the insects that grassland birds depend on.

3. *Seeding*

What to Plant**.** The best species are those in grasslands near your site, if any; otherwise, from plants native to the region and appropriate for the site's soils, hydrology and topography. The Natural Resources Conservation Service (NRCS) can assist in selecting plants, identifying seed purveyors and suggesting planting rates. Use seed as local as you can find (and afford); collecting seeds in enough volume in a pure form is problematic. A mix of wet/dry seeds may be appropriate. Plant different heights and species in a "mosaic" to create a complex habitat, promoting wildlife diversity.
Determining rate: Sow 8-12 lbs/acre. Seeds vary in their innate purity and germination rate. Purchase seed volume based on Pure Live Seed (PLS), discounting material that is not seed and seeds that won't germinate. E.g., seeding with a 40 lb bag with 75%PLS at the rate of 4 lbs per acre is really at 3 lbs of pure live seed/acre. Equipment: Warm-season grass seeds are fluffy: gravity alone doesn't get them into the soil. You must use a drill seeder. It deposits the seeds into the soil at the right depth and ensures soil-seed contact. Timing: plant in late spring so soil is warm enough to encourage germination.

4. *Maintenance*

Initial: To give the warm-season grasses an advantage, mow the first year after planting. Mow in early spring, as the cool-season grass seeds begin to germinate and flourish. Mow close since warm-season grasses have not germinated yet. As spring progresses, maintain a mowed height of 8"-10" until the warm-season grasses begin to show evidence of growth.
Long-term: Warm-season grasses are **slow to establish**. The first 2-3 years, the plants establish roots. Be patient! Once established, in order to stay in the early-successional state, grasslands need regular disturbance by **burning, mowing, and/or grazing** in late winter or early spring Use rotational management (e.g. disturb a different 1/3 every year) to create a mosaic of diverse habitats and protect insects.
Burning: This is a preferred option: it gets rid of plant litter that can shade emerging plants; warms the soil; if done late enough in the spring, can destroy the first flush of weed growth (and birds can establish new nests if early ones are destroyed); saves fossil fuels. Check municipal regulations (some towns prohibit burns). New Jersey requires burns to be overseen and carried out by the US Forest Service. Determine, also, whether your insurance covers this practice.
Mowing: If weeds continue to be a problem then continue the initial regimen until a good stand of warm-season grasses has become established. After establishment, mowing may be done in a rotational fashion.
Grazing: Grazers' activities foster a diverse mosaic pattern. Light grazing is beneficial, although heavy grazing may decrease plant diversity and cover, and many grazing livestock prefer cool-season grasses . Light grazing is generally compatible with nesting birds' needs.

Additional Resources on Grasslands Restoration

Technical assistance

Natural Resources Conservation Service can provide assistance on every phase of the restoration project, including site assessment, funding, seed selection and sources; equipment selection and management regimens. To find a service center in your area, see offices.sc.egov.usda.gov/locator/app.
Information on funding available in New Jersey under the Farm Bill (including funding for grassland bird conservation projects and pollinator habitat conservation projects) may be found at www.nj.nrcs.usda.gov/programs/.

Selected bibliography on grassland bird conservation

Grassland birds: an overview of threats and recommended management strategies, Vickery, P.D., J.R. Herkert, F.L. Knopf, J. Ruth, and C.E. Keller, U. S. Geological Survey, Fort Collins Science Center, 2000. www.birds.cornell.edu/pifcapemay/vickery.htm

Grassland Birds, NRCS, US Fish & Wildlife Habitat Management Leaflet No. 8, 1999. Provides detailed habitat management information. www.mn.nrcs.usda.gov/technical/ecs/wild/gnb.pdf

Selected bibliography on grassland stewardship for wildlife conservation

(note that some of these resources may include information on conventional herbicide/pesticide use)

Grassland Birds Conservation:, MassAudubon. Includes three publications on managing large, small and agricultural lands for grassland birds.
www.massaudubon.org/Birds_&_Beyond/grassland/index.php

Prairie Establishment Guide, Prairie Nursery. Information on grassland establishment including site preparation using cultivation.
www.prairienursery.com/howTo/guide/prairie_estab_guide.htm

Early Successional Habitat Development/Management (ACRE),
NRCS Conservation Practice Standard (Code 647), 2002. Technical guidance on the use of mechanical disturbance to manage early successional habitat for wildlife.
efotg.nrcs.usda.gov/references/public/IA/N647_04-2002.pdf

Maintaining and Restoring Grasslands (Managing Grasslands, Shrublands and Young Forests for Wildlife: A Guide for the Northeast, Ch. 3), The Northeast Upland Habitat Technical Committee—
Massachusetts Division of Fisheries & Wildlife. Principles and practices for managing grasslands in the Northeast (from Maine south to West Virginia).
www.wildlife.state.nh.us/Wildlife/Northeast_Hab_Mgt_Guide.htm and www.wildlife.state.nh.us/Wildlife/Northeast_Mgt_Guide/

Resources for More Grasslands Information

New Jersey Audubon
Grasslands symposium, conservation and stewardship guidance, bird surveys
www.njaudubon.org/Conservation/Stewardship.html
www.njaudubon.org/Conservation/PDF/GrasslandsSym.pdf

New Jersey Department of Environmental Protection, Div. Of Fish & Wildlife :
Landowner assistance for grasslands conservation projects
www.state.nj.us/dep/fgw/artwhip06.htm

New Jersey Wildlife Action Plan
http://www.state.nj.us/dep/fgw/ensp/waphome.htm

Pennsylvania Wildlife Action Plan—Grassland Habitats
www.pgc.state.pa.us/pgc/cwp/view.asp?a=496&q=166099

Raritan Piedmont Wildlife Habitat Partnership:
Grassland Conservation Plan
www.conservationresourcesinc.org/rpwhp.htm
www.njaudubon.org/Conservation/PDF/FinalRPWHPPlan_20060915.pdf

Society for Ecological Restoration
www.ser.org/
Also see *Ecological Restoration*, published by the Univ. of Wisconsin Arboretum
www.ecologicalrestoration. info

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Great Trinity Forest Management Plan

Grasslands

Chapter 3. Maintaining and Restoring Grasslands

In Managing Grasslands, Shrublands and Young Forests for Wildlife: a Guide for the Northeast

Chapter 3. Maintaining and Restoring Grasslands

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Northeastern grasslands have provided habitat for grassland birds and other wildlife for many hundreds of years. Historically, most of northern New England was forested with grasslands generally restricted to scattered small openings along river floodplains, wetlands, and beaver meadows. Southern New England, on the other hand, was described by many early settlers as having some extensive openings and many smaller grasslands, usually in the form of coastal sandplain grasslands and heathlands, and openings maintained through Native Americans' use of fire. Further south, in areas such as Long Island and Virginia, large grasslands and savannahs were quite common. These openings were among the first areas settled and farmed by Europeans.

By the 1800s, grasslands were widespread throughout the region and grassland birds including grasshopper sparrows, savannah sparrows, vesper sparrows, upland sandpipers, eastern meadowlarks, and bobolinks benefited. During the late 1800s and the early 1900s, grassland quality and quantity declined due to changes in agricultural technology, a reduction in the use of fire, the loss of farm acreage in New England, and an increase in the human population. Wildlife species adapted to grassland landscapes are now diminishing as farmlands are left idle and revert to forests or are replaced by housing and commercial development.

Remnant stands of native warm-season grasses still remain throughout the Northeast along railroad grades, rivers, roadsides, cemeteries, pastures, old fields, and reverting farmlands. Although cooler temperatures in parts of the Northeast do not allow warm-season grasses to produce as much biomass as they do in the warmer climates, a variety of species have proven useful for reclamation projects, wildlife habitat improvements, and forage production throughout the region.

Comparative values of cool-season vs. warm-season grasses

Grasses are generally categorized into two groups: cool-season grasses and warm-season grasses. Most of the grasses found in the Northeast are non-native, cool-season grasses. They grow best during the spring and fall when soil and air temperatures are cool. This group of plants begins active growth when minimum air temperatures reach 40 to 42o F. Grasses in this group include smooth brome grass, timothy, Kentucky bluegrass, tall fescue, and orchardgrass. Alfalfa and clover, though legumes, are often incorrectly referred to as cool-season grasses.

As agricultural activity spread through the region after European colonization, various cool-season grasses were introduced because they are easily established, they green up earlier than native grasses and thus provide excellent early season forage, they can be closely grazed, and they can be easily managed as monocultures. However, there are some disadvantages to using cool-season grasses. These include high cost to maintain stand vigor (fertilizer, lime, herbicides, and re-seeding), and low quality forage during the summer. Some species such as tall fescue grow so dense that it hinders travel of songbirds, rabbits, and quail in their search for food or bare ground for dusting sites. Tall fescue also produces a toxin that inhibits other plant species including many native species that are becoming increasingly rare. A reduction in plant diversity has a direct impact on the array of butterflies, moths, bees, small mammals, and birds within a particular patch of grassland habitat. Cool-season grasses also mat down easily from winter storms resulting in poor cover for wintering wildlife and for nesting the next spring.

Native warm-season grasses, those species present in the region prior to European settlement, are typically referred to as "prairie or bunch grasses." These grasses grow best in the summer heat, from June through mid-September, and do not begin green-up until the minimum air temperature reaches 60 to 65o F and soil temperatures reach 50° F. Native grasses including switchgrass, indiangrass, big bluestem, and little bluestem once dominated the Great Plains and accented the forested regions of the east as savannahs. Broomsedge is perhaps the most common native species found in many old fields. Today native grasses are typically mixed with wildflowers along roadsides and railroad rights-of-ways, in remnant fields, and in fields planted by conservation agencies and organizations.

Figure 1. (From left) Switchgrass, little bluestem and big bluestem are a few of the native warm-season grass species that are increasingly being planted in the Northeast because of their value to wildlife. Photos by Paul Rothbart.

Warm-season grasses provide a multitude of ecological benefits and management opportunities:

- They are well adapted to a variety of site conditions.
- Maintenance costs are low once stands are established. Native grasses do not typically require ongoing insecticide and herbicide applications. Fertilizer is not needed unless a stand is intensively managed for forage.
- Root systems are extensive, growing 5 to 15 feet deep. Root systems completely regenerate every three to four years resulting in increased soil fertility, organic matter, and carbon sequestration. Deep root systems provide excellent drought resistance and soil holding capabilities. Native warm-season grasses provide excellent wildlife habitat. Most native warm-season grasses are "bunch grasses" that grow in clumps. The clumping nature of these plants typically results in more bare ground under and between individual plants, which provides dusting areas and travel corridors for birds and their feeding broods. The bunchy structure also allows a diversity of forbs, legumes, wildflowers, and insects to colonize the area, creating better foraging conditions. Warm-season grasses do not mat down easily under winter snows. Therefore, they provide excellent winter escape cover and nesting cover the following spring.
- Warm-season grasses are harvested or grazed at a greater height (eight to ten inches) than cool-season grasses, thus offering reliable nesting cover while also providing forage.
- Warm-season grasses provide dependable forage production. They are less influenced by severe weather fluctuations, more disease and insect resistant, they provide quality summer forage when cool-season species have slowed growth, and are long lasting.
- Native grasses are tolerant of and even stimulated by fire. They are readily managed with prescribed burning and can yield excellent nesting and brood-rearing habitat.

Habitat values of small and large grasslands

Grasslands provide habitat for a variety of wildlife, including meadow voles, meadow jumping mice, white-tailed deer, red fox, cottontail rabbits, several species of sparrow, meadowlarks, turkeys, bobwhite quail, bats, butterflies (e.g., swallowtails, monarchs, fritillaries, among others), and a wide array of amphibians and reptiles including green snakes and box turtles.

Although grasslands provide habitat for a wide array of wildlife species, recent concerns over grassland habitat have focused on declines in grassland bird populations. Breeding Bird Surveys throughout the United States have shown alarming declines in the number of grassland birds nationwide. These declines are reflected throughout our region (Table 1).

Table 1. Status of grassland birds in the Northeast [taken from Mitchell et al. 2000)].

Species	CT	DE	MA	MD	ME	NH	NJ	NY	PA	RI	VA	VT	WV
Upland sandpiper	E		E	E	T	E	E	T	T	E	T	T	T
Horned lark	T												
Vesper sparrow	E		T				E						
Savannah sparrow							T						
Grasshopper sparrow	E		T		E		T			E			
Henslow's sparrow			E	T			E	T			T	E	T
Bobolink							T						

E = state endangered; T = state threatened.

Maintaining grasslands provides critical habitat for this group of birds. Following the guidelines prepared by Jones and Vickery (1997) for the Massachusetts Audubon Society, grasslands in the remainder of this chapter will be categorized as small, large, and agricultural. Small grasslands are 10 to 75 acres in size and are not in agricultural use. These types of grasslands include conservation areas, recreation fields, small landfills, corporate parks, and airports. Large grasslands are more than 75 contiguous acres and include conservation lands, airports, and landfills. Agricultural lands are grasslands on active farms including hayfields, crop fields, and pastures.

Small, isolated grasslands

Small, isolated grasslands are not suitable for grassland birds such as upland sandpipers and grasshopper sparrows that require large contiguous tracts for breeding (Table 2). However, these sites do provide summer breeding habitat for bobolinks, eastern meadowlarks, northern bobwhite, and savannah sparrows. In the fall, these fields provide food for migrating sparrows, larks, and warblers.

Figure 2. Bobolinks (a) and savannah sparrows (b) utilize small grasslands. Photos by Paul Fusco.

Large grasslands

Upland sandpipers, grasshopper sparrows, and northern harriers (all listed as threatened or endangered in most northeastern states) nest in large contiguous fields that contain a mosaic of mowed areas, tall grass meadows, and wildflowers. In the fall, large grasslands provide feeding and loafing areas for migrating sparrows and warblers, while waterfowl and shorebirds sometimes feed in flooded portions of these fields. These fields are also important to birds of prey such as American kestrels and short-eared owls that forage for small mammals throughout the year. Large fields are also beneficial to rare snowy owls in the winter. They regularly visit large airports and wet meadows in the region from more northerly climes.

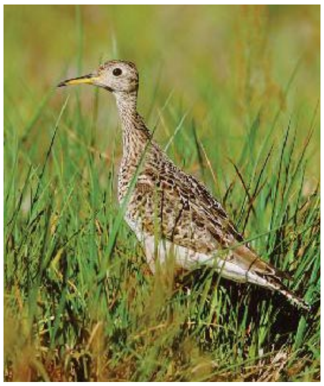

Figure 3. Upland sandpipers (a) and Northern harriers (b) require extensive grasslands of 75 acres or more. Photos by Paul Fusco.

Agricultural fields

Agricultural hayfields, meadows, and pastures have provided homes to grassland birds for hundreds of years in the Northeast. Grassland specialists utilize these sites for nesting, brood rearing, and foraging. Songbirds including bobolinks and eastern meadowlarks build ground nests, raise young, and forage in hayfields, meadows, and pastures during the summer. In the fall, agricultural fields provide feeding sites for migrating larks, sparrows, and warblers. Many hawks and owls including American kestrels, northern harriers, and short-eared owls forage in these fields for small mammals. Waterfowl and shorebirds frequently feed in flooded portions of crop fields during migration.

Managing and maintaining grassland fields

Prescriptions for grasslands

Cool-season grasses and agricultural lands certainly can be beneficial to wildlife. The vast majority of grasslands throughout the Northeast are dominated by introduced cool-season species, which provide valuable habitat to grassland specialists such as savannah sparrows, bobolinks, and eastern meadowlarks. It is essential that we conserve, maintain, enhance, restore, and establish both cool- and warm-season grasslands throughout the region. Due to a heightened interest in establishing native warm-season grasses, increased availability of seed sources, wildlife and ecological values inherent with these native species, and the availability of funding to conduct private land habitat enhancement practices, the management guidelines presented in this chapter will concentrate on these native grasses. Many of the management recommendations such as mowing dates, use of prescribed burning, grazing, and the use of herbicides would also apply to cool-season grass management.

Before rushing into any management project, a thorough evaluation of the project site should be conducted, so no harm is done to any thriving or potentially valuable warm-season grasses. An evaluation may reveal conditions where warm-season species remain but in a suppressed condition. In such situations, a combination of management prescriptions (i.e. prescribed burning, brush and tree removal, mowing, and/or herbicide applications) may restore warm-season grasses without the need to re-plant.

Although established stands of native warm-season grasses require minimum maintenance, periodic management is important. Stand deterioration is usually caused by a combination of competition from woody plants and cool-season grasses, overgrazing, or an accumulation of plant litter. In the Northeast, management may be necessary every three to four years. Activities should be scheduled outside of the primary bird-nesting season (April 15 to August 15) and some untreated sections should remain to ensure that food and cover is always available. Species-specific management must consider individual habitat needs (Table 2).

Table 2. Habitat characteristics for grassland birds in the Northeast [taken from Mitchell et al. (2000)].

Species	Minimum habitat patch size (acres)	Vegetation type[a]	Vegetation height (inches)
Upland sandpiper	64-113 (NY)	Sandplain grasslands (ME), Old hayfields with short patchy grass (NY), Peatlands with ericaceous shrubs (Quebec)	4-6 (WI)
Horned lark	< 2.5 (NY) 2.5-25 (MO)	Sparsely vegetated agricultural fields (NY), Stony acid soils with sparse grasses (WV)	Very short to bare soils (NY)
Vesper sparrow	12-25 (ME)	Sandplain grasslands with patchy vegetation (ME), Acid soils with coarse grasses and 44% open ground (WV)	
Savannah sparrow	12-25 (ME)	CSG pasture (MD, NY), Marshes (Quebec), Sandplain grasslands (ME), Sparse grasslands (WV)	12 (MD) 33 (PA) 8-24 (Quebec) 17 (WV)
Grasshopper sparrow	64-113 (NY)	Sandplain grasslands (ME), Old hayfields with short, patchy grass (NY), Lightly grazed CSG pastures with 9% forbs (NY), Bunchgrasses with 30% bare ground (WV)	22 (NY) 8-14 (WV)
Henslow's sparrow	74-89 (NY)	Old fields with scattered shrubs and dense litter (MD), Ungrazed CSG pastures with 13% forbs (NY), Grass-dominated old hayfields with thick litter (NY) Tall, dense hayfields (PA)	40-46 (PA)
Eastern meadowlark	60 (NY)	Diverse old fields (MA), Sandplain grasslands with high % forb and grass cover (ME), CSG pasture and forb dominated fields (NY)	16 (WI)
Bobolink	4 (MA) 40 (NY)	Grass-dominated old fields (MA), Sandplain grasslands with high % forbs (ME), CSG pasture and forb dominated fields (NY)	13-16 (Ontario)

[a] CSG = cool-season grasses

Prescribed burning

- Prescribed burning is the most effective management tool to maintain and rejuvenate native grasslands. Burns should be conducted between March 1 and April 15. Burns can be conducted later in the summer (after August 15) and early fall to reduce woody plants that invade grassland fields. Check with the state fire authorities to determine if there are any restrictions on proposed burning. Burning increases forb diversity, promotes vigorous warm-season grass growth, releases nutrients back to the soil, and suppresses invasive competition. Burning, unlike other routine management practices, removes accumulation of vegetative litter from the ground's surface. Removal of this thatch can be critical to ground-nesting birds that travel through the fields to forage for food and escape from predators.

- Although a limited number of nests may be destroyed in a prescribed burn, grasslands burned every three to four years have higher avian nesting densities than unburned sites.
- Burning produces more succulent vegetation, which is more palatable to rabbits and deer and supports a larger number of insects that are readily available to young birds.

Refer to the prescribed burning section of chapter 10 for information on planning and conducting prescribed burns.

Mowing

Mowing has long been used to manage grasslands as a means to suppressing invading hardwoods.

- Timing is critical. Mowing should generally be scheduled outside of the primary bird-nesting season (April 15 to August 15).
- Mow every two to three years in fields not used for high quality hay production.
- In intensively managed agricultural fields where mowing occurs during the bird-nesting season, strips and edges should be left unmowed to provide areas of food and cover.
- In agricultural fields over ten acres, delay the cutting of the outer 75 feet of the field and mow the interior portion early. This practice will provide some nesting cover while minimizing the impact on high quality hay.
- Utilize standard wildlife conservation mowing practices such as raising the mower blades to at least ten inches or more, which permits the grass to recover quickly.

Herbicides

Herbicides can be utilized to control weeds in grasslands. Each herbicide controls or suppresses a range of weeds and differs in its effects on warm-season grasses. Selective spraying of isolated patches of woody plants or exotic invasive plants such as autumn olive and multiflora rose can be accomplished with Roundup® or a combination of Garlon® 3A and Escort®. Applying a selective herbicide such as Plateau® throughout an entire field will enhance existing native grasslands where tall fescue may be a problem, but may stunt switchgrass. Refer to the herbiciding section of chapter 10 for a more detailed discussion on applying herbicides.

Figure 4. Prescribed burning (a) is the preferred method of maintaining grassland habitats. However, in situations where burning is not feasible, periodic mowing (b) is a suitable alternative. Photos by Paul Rothbart.

Grazing

- Moderate grazing can benefit grassland wildlife. Grazing produces a diversity of grass heights and reduces ground litter, which at certain densities can be detrimental to foraging birds and wildlife escaping from predators. Grazing on fields with high densities of ground nesters during the critical nesting period (April 15 to August 15) should be closely monitored.
- Develop a rotational system that creates a mosaic of plant species and structure, while providing a longer period of time for animals to graze. On fields utilized by grassland nesters, 40% of the vegetation should be maintained at a minimum height of 8 to 12 inches.
- Do not overgraze. This will reduce plant vigor and lead to erosion, reduced invertebrate diversity, increased weed invasions, and decreased wildlife usage.

  Refer to the grazing section of chapter 10 for other wildlife considerations associated with grazing.

Native warm-season grass planting considerations

A native warm-season grass establishment plan should be considered when high quality grasslands do not exist and management treatments to enhance existing grasslands have failed. Several factors should be considered during the planning process to improve chances of success.

Objectives

Objectives for native grassland restoration may include the following:

- Beauty
- Historical value
- Erosion control due to their extensive root systems
- Enhancing grazing systems by providing quality summer forage to augment cool-season species
- Landscaping that conserves water and reduces chemical applications
- Providing habitat for a diversity of wildlife species.

Specific objectives will play a significant role in determining the desired seed mix and seeding rates.

Site selection

Site selection criteria should include climate, location, existing vegetation, soils, cropping history, potential future site use, and potential use of fire as a management tool. Warm-season grasses can be successfully established on an array of sites ranging from forestland to agricultural fields. All sites must be reclaimed to a plantable condition, which may require herbicides, land clearing, or agricultural equipment. Geographic factors play a significant role in grassland establishment. Regional characteristics will have a major influence on seeding regimes, variety selection, seeding rates, planting dates, and soil nutrient requirements. Few site conditions exist in the Northeast that challenge cool-season grass establishment. In contrast, there are several factors that may create problems for warm-season grass establishment.

- The length of the growing season and the heat received during that time period are key factors that affect seed germination, seedling growth, and ultimately the number of years to achieve good stand density.
- The Northeast region has shorter, cooler growing seasons than the Prairie and Plains states because of the high incidence of cloudy days and the cooling effects of forest cover. Successful plantings require a growing season of 100 to 140 days.
- Frost heaving during the fall, winter, and spring after planting can ruin a promising grass stand. On poorly drained sites where air and soil temperatures are cooler, moisture alternately freezes and thaws causing plants to be uprooted. Such areas should be avoided or planted during late spring or early summer to ensure that the seedlings are well developed prior to the first freeze. Do not burn a stand of young, frost-heaved grass. The fire will kill the roots.

- Soil characteristics must be thoroughly evaluated to determine the type of vegetation needed to meet specific habitat objectives. Native warm-season grasses tolerate a broad range of soil types and conditions. However, there are a few site conditions that are simply not suitable for warm-season grasses. These sites contain soils that remain wet due to poor internal drainage, continuous flooding, and heavily compacted soils comprised of more than 30% clay.
- Elevation and aspect play roles in microclimatic variations that must be considered during seed selection. On warm and better-drained sites big bluestem, little bluestem, indiangrass and switchgrass would be good choices for planting. On cool, poorly drained sites eastern gamagrass, switchgrass and wild rye would be better suited.
- Cropping history provides valuable insight regarding herbicide carryover and potential weed problems that may impact seedling survival and vigor. Pastures and hay fields may have infestations of persistent weeds such as thistle, quackgrass, reed canarygrass and smooth bromegrass, which can reappear immediately or soon after seeding. Warm-season plantings do well following an annual crop rotation in which the preceding crop was corn treated with Atrazine®. Planting a crop such as Roundup®-ready soybeans can also alleviate some weed problems.

Seed Selection

Seed Selection is a key component to a successful planting. Always purchase native grass seed in terms of pounds of pure live seed (PLS) - a combination of germination and purity. This is the best way to ensure that you do not pay for the unavoidable inclusion of leaves and stems in the fluffy seeds of bluestem and indiangrass. PLS % = (% purity x % viable seed) divided by 100. Tags placed on bags of seed by manufacturers list the percentage of pure live seed, germination rates, percentage of inert materials and percentage of dormant seed and weed seeds in each bag. The tags should also indicate a lack of noxious weeds. Do not to use seed originating more than 100 miles north or 200 miles south of the project site to minimize problems with hardiness and disease. Within the Northeast, east-west variation is not critical because precipitation is not a limiting factor. Elevation, however, can be significant. An elevation change of 1,000 feet is equivalent to a move of 175 miles to the north. The number of native grass "cultivars" (species or varieties that have undergone replicated testing for two or more generations to document the heritability of traits, performance, and adaptability) that are commercially available for the Northeast are much more limited than for the Plains states. Still, a number of cultivars are available that are suitable for the growing conditions found in the Northeast (Table 3).

After determining specific objectives and evaluating site characteristics, other factors must be considered.

- Purchase seed from a reliable source, allowing several months lead time to ensure availability.
- Purchase seed of individual species and prepare your own mix. Do not mix small, hard seeds with light, fluffy seeds.
- Purchase warm-season grass seed as pure live seed (PLS). This process ensures that you are paying only for viable seed of the species or cultivar desired, not for dead seed, sticks, stems, and weed seeds.
- Seeding rates of warm-season grasses range from 5 to 12 lbs of PLS/acre, which equates to approximately 30 to 60 seeds/ft^2. This rate is much lower than that needed for cool-season plantings because warm-season grasses are bunch-type plants which occupy more space per plant.
- Eastern gamagrass used for grazing should be planted as a single species because it can be difficult to manage in a mixed stand. Another excellent option for grazing and haying is a mixture of big bluestem, indiangrass, and switchgrass planted at seven to nine lbs PLS/acre.
- Plant diversity is the key for wildlife. A good mix of warm-season grasses is a combination of big bluestem, little bluestem, indiangrass, and switchgrass seeded at a rate of 5 to 12 lbs PLS/acre. Southern and midwestern states plant at a rate of five to seven lbs PLS/acre while in the Northeast a higher

rate of 10 to 12 lbs PLS/acre is used because of greater site and climatic variation. On high quality agricultural soils a lower seeding rate (particularly switchgrass) should be utilized to avoid developing stands that are too dense for optimum wildlife benefits. The switchgrass component on high quality sites should not exceed one lb PLS/acre. Legumes and wildflowers can be added to a seed mix at approximately one lb PLS/acre. Plant variety adds structural diversity and therefore a greater diversity of nesting and perching sites for wildlife. Plant diversity also ensures more stable seed production and increases insect populations.

Table 3. Suggested cultivars for the Northeast.

Species	Cultivar	Geographic Use Area
Big bluestem	Kaw	Southern VT/NH & south
	Niagra	All
Little bluestem	Aldous	NY & south
	Camper	NY & south
Salt meadow cordgrass	Avalon	VA to NH, coastal wetlands
Smooth cordgrass	Bayshore	VA to NH
Deertongue	Tioga	All
Eastern gamagrass	Pete	All
Sideoats gramma	El Reno	NY & south
	Trailway	Southern New England & north
Indiangrass	Cheyenne	VA & south
	Lometa	VA & south
	NE-54	NY & north
	Osage	Central PA & south
	Rumsey	VA & north
Sand lovegrass	Bend	Central VT, NH & south
	NE-27	NY & south
Coastal panicgrass	Atlantic	All
Switchgrass	Blackwell	NY & south
	Cave-In-Rock	NY & south
	Kanlow	Long Island & south
	NJ-50	PA & south
	Shelter	WV to southern NH
	Trailblazer	Central VT & north

Pre-planting preparation

Pre-planting preparation actually begins the year prior to seeding. Once a site has been selected and the proper seed mix has been determined, an evaluation of existing vegetation, mulch, nutrient deficiencies, and weed problems must be conducted. A heavy mulch layer hinders proper seed placement, maintains cooler soil temperatures that slow down germination, and serves as a source of high slug populations (within the northern portions of the region) that can destroy warm-season grass seedlings as they emerge the following spring. Tilling the soil or burning the site the year prior to planting can address these concerns.

On sites being converted from agricultural use, re-growth of grasses such as tall fescue, foxtails, crabgrass, and reed canary grass can crowd out emerging seedlings. Fields dominated by these grasses should be herbicided with Roundup® or another suitable product the fall prior to planting. If the vegetation is over two feet tall the field should be mowed prior to herbicide application.

Figure 5. On sites being converted from agricultural use, perennial grasses, which can crowd out emerging seedlings, can be treated with herbicide prior to planting. Photo by Paul Rothbart.

Planting preparation

Planting preparation considerations prior to seeding include planting date, seedbed conditions, weed control, seeding rate, and equipment. Dormant seedings are not recommended for warm-season grasses in the Northeast because of the probability of frost heaving, seed loss to feeding wildlife, and early spring competition from weeds.

- Optimum seeding dates throughout the Northeast are between mid-spring and early summer, typically May and June. Warm-season grasses require minimum air temperatures of 60 to 65 ^{o} F and soil temperatures of 50 ^{o} F. Later plantings may reduce weed and cool-season grass competition, while earlier plantings allow more time for stand establishment.
- Warm-season grass stands do not usually require fertilizer applications during establishment and if managed for wildlife may never require fertilization. If fertility levels are low due to cropping history or poor soil quality, potassium and phosphorus may be applied at the rate recommended according to soil test results. Nitrogen should not be applied during the establishment year because it will stimulate weed competition.
- Weed control prior to planting is essential for successful establishment of warm-season grasses. If weeds persist after pre-planting year treatments, a selective herbicide such as Plateau® can be applied during the spring. Other herbicide options include Banvel® or 2-4D, but these cannot be used if forbs or legumes are part of the seed mix. Note that Plateau® will suppress or retard switchgrass.
- Tilling is a non-chemical option for controlling weeds. Deep plowing and/or multiple diskings can be used to remove each new crop of emerging weeds up to the time of planting. Tilling should be

followed by soil compaction prior to seeding. A drawback of tilling is that the soil disturbance results in the germination of weed seeds that had laid dormant in the soil.

- A combination of herbicides and tilling is probably the most effective means of controlling weeds. This involves tilling the soil, allowing weed seeds to germinate over a period of 7 to 14 days, applying Roundup® to the newly germinated weeds, and planting a few days later.
- Seedbeds must be firm for successful seeding. This helps to conserve moisture and ensures good seed-to-soil contact, which is critical for adequate germination. Recently tilled soil should be compacted with a roller packer or soil finisher prior to planting. A seedbed is properly prepared when a human footprint penetrates no more than 1/4 inch deep. If the soil is not properly compacted, seeds will be planted too deeply and adequate germination will not occur. Soil packing is not necessary in stubble fields because compaction is already adequate.

Planting equipment and practices

The equipment used to plant warm-season grasses should provide a uniform distribution of seeds planted at the proper depth and provide for good seed-to-soil contact. Seeds should be planted at a depth of 1/4 to 1/2 inch. Up to 25% of the seed should be visible in the drill rows on the soil surface to ensure that the seed is not planted too deeply. Seed of switchgrass, coastal panicgrass, and deertongue are small and hard and can be planted with a regular grain drill that has a legume box attached or a traditional broadcast seeder. Eastern gamagrass seed resembles corn seed and is best planted with a corn planter at a depth of one inch. Most of the seed mixes used for wildlife contain big bluestem, little bluestem and indiangrass, which are all light and fluffy. Poor seed distribution will occur if using traditional seeding equipment to plant seeds of these species because seeder tubes become plugged quickly. This can be overcome by adding a light rate of oats or an inert carrier such as cracked corn or pelletized lime to the warm-season seed mix. These carriers will help the fluffy seeds flow through seeder tubes properly.

A no-till drill, such as a Truax® or Great Plains® seeder, is the most effective means to plant fluffy warm-season grass seed. These drills are designed with multiple seed boxes to plant warm- and cool-season grasses, legumes, wildflowers and small grains. The warm-season box is divided into compartments each with an auger/agitator, picker wheels for feeding the seed into the seed cup and oversized drop holes to ensure proper seed disbursement. Optimum seed placement is achieved with double disc furrow openers, depth bands and independent press wheels. This equipment works well on prepared seedbeds, agricultural fields with residual cover and herbicide-treated sod. Heavy-duty versions of no-till seeders are needed for the latter two scenarios. Specialized broadcast seeders are also available for planting fluffy native seeds on prepared seedbeds and have the advantage of eliminating the artificial row effect that results from using no-till seeders. If broadcasting seed, be sure to roll or pack the soil after seeding to ensure good seed-to-soil contact.

Regardless of seeding equipment used, it must be calibrated prior to seeding. When seeding with a no-till drill, it is critical to routinely observe and clean the seeding tubes and furrow discs to assure proper seed distribution.

Figure 6. A no-till drill, such as a Truax® (pictured) or Great Plains® seeder, is the most effective means to plant fluffy warm-season grass seed. Photo by Paul Rothbart.

Post planting evaluation and management

Patience, patience, patience

A variety of methods can be used to successfully establish warm-season grasses. Success is never guaranteed. However, if the guidelines presented in this chapter are followed, failures should be rare. Evaluating stand development is very important and patience can be the key factor to a successful planting. Native grass seedlings spend most of their first year developing extensive root systems for the long haul. It is often difficult to find the thread-like leaves during the first growing season. Give the stand two full growing seasons before making a final determination as to its success or failure. If a field has one strong plant per square foot by the second growing season the stand is successful. A successful stand may take 2 to 3 years to become fully functional.

During the first two years and in particular the first growing season, weeds are the biggest concern because they may out-compete the warm-season grasses. A variety of techniques may be applied during this critical establishment period and thereafter, for long-term grassland maintenance.

- Mowing should be used to control weeds during the first summer. Every time weeds reach 18 inches in height they should be mowed back to six to eight inches. This mowing regime will reduce competition for sunlight and moisture and prevent unwanted species from producing seed. Mowing before the weeds are too tall will prevent thick mulch layers from developing that might smother the warm-season seedlings. Discontinue mowing or cut higher after mid-August to avoid cutting the warm-season grasses that are developing their root systems. If prescribed burning is not an option, then mowing or haying should be continued every three to five years for maintenance. Generally, clippings should be removed whenever possible since dense thatch can be detrimental to nesting grassland birds. However, some species including upland sandpiper, vesper sparrow, and Henslow's sparrow prefer thicker levels of thatch.
- Prescribed burning can help control many woody plants and cool-season grasses. Burning should not be conducted the first year after planting because damage to young plants may occur. Commence burning during years three or four and every two to five years thereafter. Burns should be conducted during late February through early April when native species are dormant, or new growth is less than two inches tall.
- Herbicides can be utilized to control weeds during and after the establishment period. Each herbicide controls or suppresses a range of weeds and differs in its effects on warm-season grasses. Selective spraying of weedy patches is one approach. Another is to use a selective herbicide such as Plateau® throughout an entire field. Plateau® will provide control of an array of annual and perennial grasses and broadleaf plants. Plateau® can be helpful in establishing big bluestem, little bluestem, and indiangrass but may inhibit or injure eastern gamagrass and switchgrass.
- Warm-season grasses are quite palatable and nutritious for livestock, but are subject to damage by excessive grazing pressure. Grazing for short time periods and/or on a rotational basis can be beneficial to the long-term productivity of a native grass stand. When grass has been taken down to a height of 10 to 12 inches, livestock should be removed to allow the grass to regrow. When the grasses have reached 24 inches grazing can be resumed. The final seasonal rotation should leave a minimum height of 12 inches so the plants have an adequate energy reserve to initiate strong re-growth the following spring.
- Warm-season grasses established for wildlife can be long lived with little or no soil enhancements required. Periodic soil samples will indicate soil amendment needs. Warm-season grasses and forbs that are cut for hay will need occasional phosphorus and potash fertilizer.
- Monitoring should be a component of all habitat projects. Unfortunately, these activities are traditionally under-funded and therefore rarely completed. Typical monitoring efforts should include annual bird and vegetation surveys that are reproducible at designated plots. At a minimum, data collected in vegetation surveys should include species present, percent cover, structural diversity, woody plant and cool-season grass encroachment and ground litter density. Photographs taken from the same location

and looking in the same direction, before and periodically after seeding is a quick and easy means of monitoring progress. Corrective measures should be taken as monitoring results dictate.

Figure 7. Patience is required when trying to establish a stand of warm-season grasses. Stands may require two years to become established. Photo by Paul Rothbart.

Warm-season grasses have unique characteristics that make them especially beneficial to grassland birds and a wide variety of other wildlife. These habitat benefits along with the ecological, aesthetic, and historical values have led to a renewed interest in the restoration of native grasslands. Fortunately, there are funding opportunities available through many government programs (i.e. Wildlife Habitat Incentives Program, Landowner Incentives Program, Conservation Reserve Program, Wetlands Reserve Program, Environmental Quality Incentives Program, and the U.S. Fish & Wildlife Partners Program) that will allow natural resource agencies, organizations, and private landowners to establish and/or enhance these critical but vanishing habitats. Technical assistance may be available through state wildlife agencies, Natural Resources Conservation Service, and U.S. Fish & Wildlife Service staff to work with landowners in evaluating, planning and conducting these valuable grassland projects (refer to chapter 12 for more information on potential funding opportunities and obtaining technical assistance).

When establishing a stand, remember to plant shallow, mow weed competition, and have patience. Stands may require two years to become established.

A multi-faceted approach is essential in dealing with grassland habitat loss (cool- and warm-season) and the associated breeding bird declines on a regional basis. This includes maintenance of existing grassland habitat, restoration of degraded grasslands, creation of new grasslands where feasible, outreach regarding grassland values and development of mutually beneficial agricultural-grassland wildlife operations, and development and continuation of monitoring and evaluating programs.

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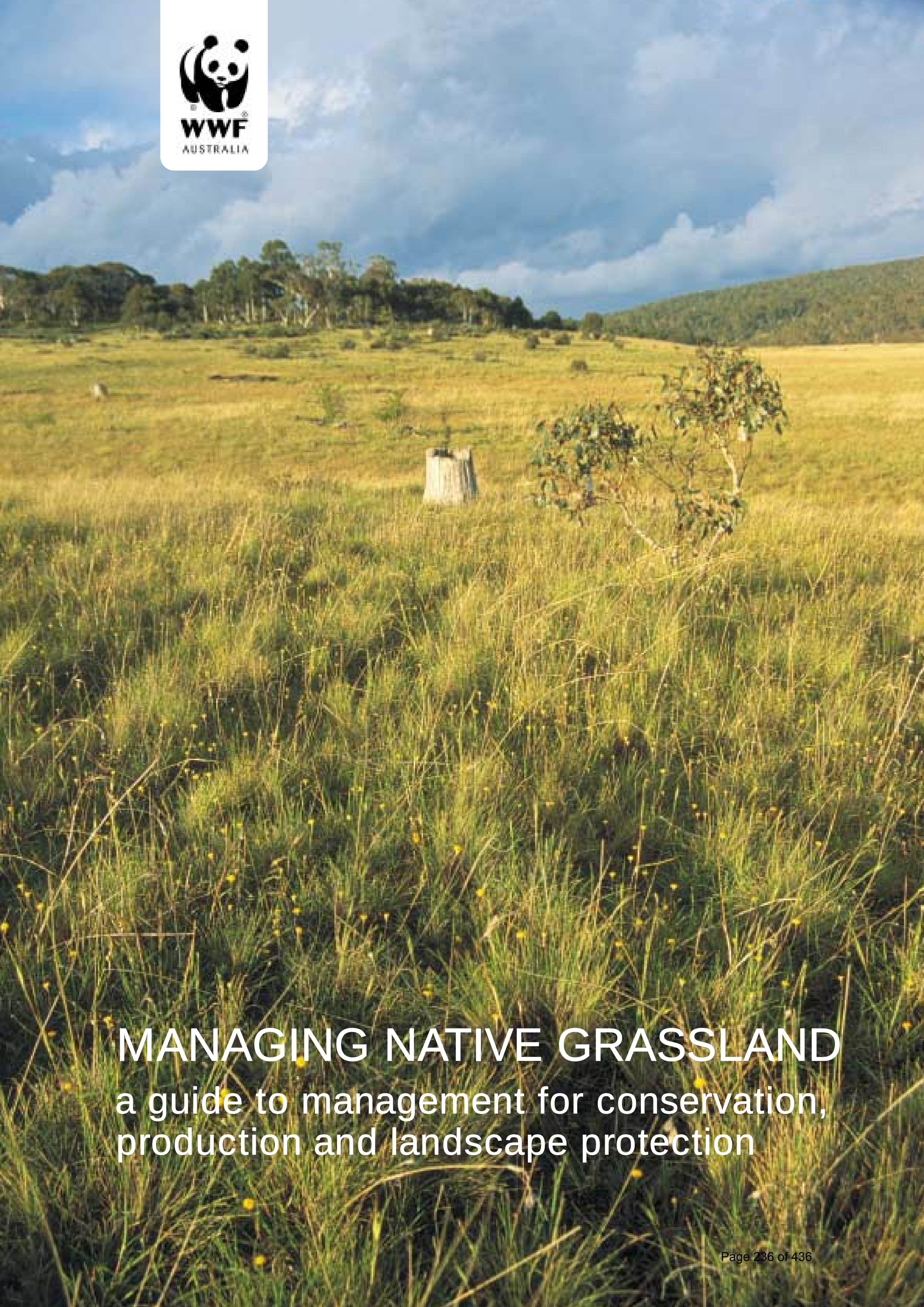
Biographies

Paul Rothbart is the District Operations/Habitat Program Supervisor for the Connecticut Department of Environmental Protection's Wildlife Division. Paul received his B.S. in Natural Resources Conservation from the University of Connecticut and his M.S. in Wildlife Science from Louisiana State University. Paul has been involved with habitat management activities including sage grouse habitat restoration, early-successional field enhancements, and wetlands management throughout his 25-year career. Paul enjoys developing cooperative partnerships essential to delivering habitat management practices both on state and private lands. Paul currently serves as the Northeast Upland Habitat Committee Chair.

Steve Capel grew up in Indiana and Illinois, and headed west for his undergraduate education at Utah State University. He then spent a couple of years working on waterfowl in North Dakota, while pursuing a Master's degree from the University of Missouri. After seven years as a Big Game Biologist in Kansas, he began 17 years as a Regional Wildlife Manager with Kansas Wildlife and Parks, dealing extensively with quail, pheasant and rabbit management, and managing early-successional habitats. He has spent the last 15 years in Virginia, supervising early-successional wildlife efforts, including a major bobwhite restoration initiative.



WWF AUSTRALIA

MANAGING NATIVE GRASSLAND

a guide to management for conservation, production and landscape protection

TEN TOP TIPS FOR MANAGING NATIVE GRASSLAND

- allow all native plant species to grow, flower and set seed at least every few years
- develop a sympathetic grazing, mowing and/or burning regime to prevent loss of diversity
- avoid producing windrows or clumps of grass clippings when mowing or slashing
- encourage a dense, vigorous and diverse plant community to minimise weed invasion
- avoid any unnecessary physical disturbance of the soil - e.g. ploughing, riplines or trenching
- avoid any unnecessary soil compaction by vehicles or heavy equipment
- avoid any change to the fertility of the soil - e.g. fertiliser or lime
- control self sown exotic trees and don't plant any new ones in native grassland
- keep feral animals (grazers and predators) under control or out of native grasslands
- write and follow a simple, effective management plan and monitor its progress

Cover - Native grassland of Snowgrass and Kangaroo Grass, sprinkled with Scaly Buttons, looking toward the Boboyan Divide, on the southern ACT/NSW border.

Above - Snowgrass, Kangaroo Grass and scattered Snow Gums, looking down the valley of Bobundara Creek near Nimmitabel.

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MANAGING NATIVE GRASSLAND

a guide to management for conservation, production and landscape protection

David Eddy, WWF Australia
July 2002

CONTENTS

INTRODUCTION

Native Carraway is common in grasslands around Adaminaby.

The aim of this booklet is to provide background information, guidance and encouragement to managers of native grasslands. Considerable variety is found among the native grasslands of temperate south-eastern Australia. However, many of the ecological concepts and management requirements are common to all. This booklet is based on experience of the NSW Southern Tablelands, but is written in general terms so that the information might be useful throughout the NSW Tablelands and beyond. Much of the information should also be useful to grassy woodland managers throughout and beyond the Tablelands.

Many thousands of hectares of native grassland with significant conservation value remains on both private and public rural land on the Tablelands. This vegetation remains largely because it has not been replaced with sown pastures or crops, nor inadvertently modified by continuous or heavy grazing, soil fertility change or introduction of exotic pasture plants. In recent years these grasslands have become the envy of many people in other parts of temperate Australia where native grassland has been almost completely lost.

Native grasslands in this part of Australia have only recently received significant community and scientific interest. Our understanding of their composition and ecology is therefore not as detailed as that of more treed vegetation communities. However, research and field management experience in recent years has yielded enough information to allow the development of some useful general management recommendations.

Hoary Sunray flowering among Snowgrass and Kangaroo Grass with Weeping Snow Gums scattered on the rise. Weeping Snow Gums are a feature of the shale derived soils to the east of Adaminaby.

Opposite page, top: Grass Triggerplant and Kangaroo Grass at Round Plain near Berridale.

Opposite page, middle: This native buttercup forms dense mats in damp depressions within grasslands.

Opposite page, bottom: A tiny green spider on a Kangaroo Grass stalk gives some insight into the smaller grassland fauna.

Native grasslands hold great value for conservation, production and landscape health and function. This booklet is intended to encourage and assist management of the native grasslands remaining in our care.

WHAT IS A NATIVE GRASSLAND?

Vegetation structure ►

Native grasslands are vegetation communities in which grass plants are structurally dominant because the groundcover of woody plants (trees and shrubs) is less than 10%. A common misconception is that grasslands are completely treeless; however, grasslands often contain scattered trees. When the groundcover of trees exceeds 10% the community is called a grassy woodland. The botanical composition of the grassy understorey in a grassy woodland is very similar to a native grassland because the majority of the non-woody plants (herbs) grow in both grassland and woodland. In practice, the distinction between grassland and woodland is somewhat arbitrary and these communities intergrade, forming a vegetation mosaic throughout the Tablelands landscape. The distribution and density of trees in the landscape today is a reflection of natural processes, active clearing and recolonisation.

More than just grass ►

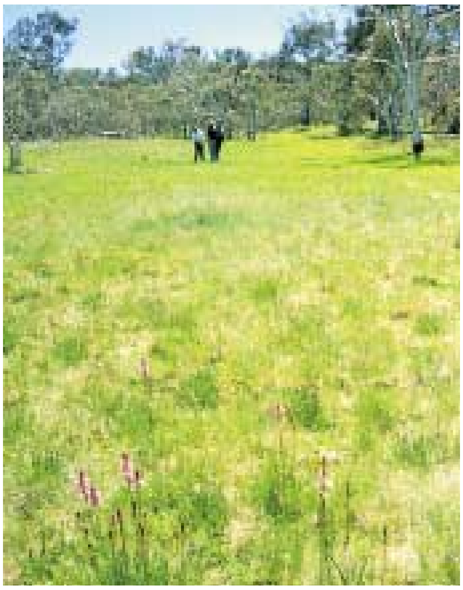
In addition to a wide variety of grasses, native grasslands in their natural state contain a high diversity of other herbs including sedges, rushes, orchids, lilies and forbs (broad-leaved herbs). About 700 species of native herbs have been identified in the grasslands of South-Eastern Australia, the majority of which are not grasses. A typical grassland in good condition is comprised of a wide variety of grass species and a much wider variety of non-grass herbs.

More than just plants ►

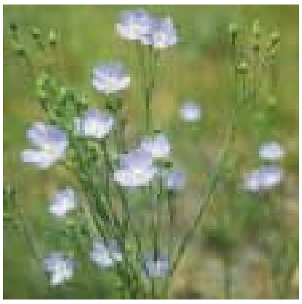
Native grassland communities include a large number of other organisms too. Above ground you might see a wide variety of insects, spiders, frogs, reptiles, birds and mammals. Lichens and fungi live down among the plants, on the surface and into the soil. Below ground there is a huge array of soil organisms including worms, beetles, ants, and micro-organisms. All these organisms play important roles in the function, health and stability of native grasslands.

Dynamic and changeable

The appearance of native grasslands can change dramatically during the course of a year. The herbage mass can fluctuate substantially as fluctuations in soil moisture and temperature, growth and grazing, reproduction and fire each take their course. The grassland can change colour and texture from the new green growth of spring, through the many colours of the flowering season, to the red-browns and straw colours of summer and autumn. Many of the smaller intertussock plants are obvious only during the growing season and while flowering; their above ground parts dying-off after flowering and re-appearing only in the next growing season. For these reasons it can be difficult to recognise or appreciate the quality or beauty of a native grassland.



WHY DO NATIVE GRASSLANDS NEED CONSERVATION ?



Native Flax is an uncommon species in the Monaro region, this one is at Black Lake near Bombala.

Conservation value

The contribution or value of an area of native grassland to the long term conservation of natural temperate grasslands is known as its conservation value. Conservation value is determined by a number of qualities including: species composition; species richness (number of species); presence of threatened, rare or regionally uncommon species; the presence, species and density of weeds; the size, shape and location of the area; and other aspects of vegetation and landscape condition and health.

Pastoral value

Native grasslands today vary considerably in their condition. Some are highly species rich, almost free of weeds and probably closely resemble their original state. A much larger area of native grassland is more modified, often dominated by one species of native grass, with a much lower diversity of other native herb species and often including a significant population of weeds. In some areas such modified grasslands are the only remaining native grasslands. Much of this serves as valuable and productive native pasture. However, it also offers great value to conservation, enhancing the stability, function and aesthetics of the landscape, which could all be improved with careful management.

Loss, fragmentation and diminishing quality

Native grasslands once occupied large expanses of south-eastern Australia. Because they were relatively or completely clear of trees they were very attractive for pastoral settlement and development. The land became divided into properties and paddocks by fencing and roads, and the vegetation was subject to new management, which often differed from paddock to paddock. This resulted in changes to the species composition of much of the area of native grassland and isolation of the remainder into fragments.

The majority of the original grassland area is now occupied by agricultural grassland with a much lower plant species diversity, a lower diversity and reduced population of native fauna, many exotic agricultural plants and weeds, and often less groundcover and soil stability. Relatively unmodified native grasslands now cover only a fraction of their original area, and many remnants are very small and highly vulnerable to change.

Chamomile Sunray and the threatened Monaro Golden Daisy in a short open structured grassland on shale derived soil near Adaminaby.

Habitat for fauna

Native grassland communities provide shelter and food for a wide variety of animals. Many of the smaller mammals such as bandicoots, bettongs, quolls, marsupial mice and the White-footed Rabbit Rat, are now either missing from or very rare in the native grasslands of south-eastern Australia. Even kangaroos, wallabies and wombats have often been relegated to other parts of the landscape. Several other species of animals including insects and reptiles are now threatened with extinction because of the dramatic reduction in the area and quality of their habitat.

Harbours of biodiversity

The diversity of species, and genetic variability both between and within species is known as biodiversity. Conservation of biodiversity is widely recognised as one of the most important aspects of nature conservation and is one of the primary objectives of many government conservation programs. Native grassland remnants harbour many hundreds of species that have largely disappeared from agricultural grasslands. A number of these species are now either locally or nationally threatened and a great many more have become quite uncommon within the region.

Self-supporting systems

Native grasslands conserve species and biodiversity in relatively intact and naturally functioning communities. This is both the most effective and the most appropriate form of conservation as the species within the community interact to provide the conditions that support each of them with a minimum of management effort and cost. It also conserves the ecological processes that have led to their evolution and allows for evolutionary processes to continue.

Genetic reservoirs and corridors

Good grassland remnants provide us with living genetic 'reservoirs' from which we can draw material for a number of worthwhile purposes. Harvesting of seed can help us to reintroduce many native plant species to areas from which they have disappeared. This might be extremely useful in the case of threatened or regionally uncommon species. We may also be able to reintroduce some of the threatened or regionally uncommon animal species to new areas if we protect and enhance remaining areas of suitable habitat.

Even those native grasslands with a relatively low species diversity but retaining native grass dominance are valuable, especially if they are relatively free of weeds. These areas often act as buffers around native grassland of higher diversity and corridors for the continuing movement of genetic material.

Unexplored potential

Many of the hundreds of plant species in our native grasslands may offer significant value for pastoral use and in breeding crop plants. Some may have medicinal value, since most medicines come from plant sources. Many of our grassland plants are attractive and they are all hardy and adapted to local conditions, making them potentially valuable in native gardening and landscaping, and particularly for the burgeoning cut flower industry. The agricultural, horticultural and medicinal potential of most of the native grassland plants is largely unexplored.

Opportunities to learn

Native grassland remnants also provide us with the opportunity to study and learn more about their composition, function, environmental importance and management requirements.

Recreation and enjoyment

The remaining native grassland areas provide examples of the landscape appearance, vegetation structure and composition prior to European settlement. They are a valuable feature for the enjoyment, satisfaction and education of local communities and visitors alike. Well managed native grassland areas offer real potential for tourism, just as the display of alpine wildflowers is enjoyed in the mountains each summer.

Wider community expectations

In addition to these biological and social imperatives for conserving native grasslands, land managers are now obliged under various state and federal laws, to manage native vegetation and plant and animal species responsibly and sustainably on behalf of the community.

Above: Showy Copper-wire Daisies at Round Plain cemetery near Berridale. Many rural cemeteries retain good examples of native grassland.

Right: Antrorse Geranium is also common in the Round Plain cemetery.

WHAT THREATENS NATIVE GRASSLANDS ?

Native grasslands were established and maintained by natural conditions and processes. Soils, temperature and rainfall regimes, interactions between plants, grazing and digging animals, fire and Aboriginal activity all helped to shape the structure and species composition of native grasslands. Prevention of the establishment of trees and shrubs, recycling of organic matter and the creation of openings in the sward for recruitment of new plants and growth were all necessary for maintenance of these grasslands. Some of these conditions and processes have changed with European settlement and management, causing changes in the area, structure, species composition, diversity and function of native grasslands. Conservation of native grasslands will therefore require active management to reinstate some of these natural conditions and processes.

Where native grasslands have not been completely removed, the principal mechanisms of change since European settlement have been alteration of the grazing regime, from sporadic grazing by native herbivores to more constant and selective grazing by domestic livestock, and the complete alteration or removal of the fire regime. Threats are outlined below.

Grazing by livestock

In grazed areas plants are defoliated mainly by grazing domestic livestock. All native grassland plants can withstand some degree of defoliation, but species differ in their ability to recover from repeated or heavy defoliation. All plants need to be allowed periods in which to grow, flower, produce seed, and to recruit new individuals into the sward, in order to maintain their populations. Therefore, the timing and duration of grazing events, in relation to the cycles of growth and reproduction, are crucial to the success of individual species and the native grassland community as a whole.

Grazing animals differ in their diet selection and grazing methods. Under organised agriculture, the intensity of grazing has increased in the understandable pursuit of production. The intensity of grazing at the individual species level has probably changed even more because domestic livestock have a stronger preference for more succulent species and plant parts.

Unfortunately, this has led to the depletion or removal of many native plant species and modification of habitat for native fauna across most of our grassy landscapes. A single grazing event can substantially modify a grassland's structure in the short-term. Structure has an important influence on the community's composition, function and habitat value, all of which are likely to change if the grassland's structure is highly altered for extended periods.

Grazing by feral animals

Another source of defoliation is uncontrolled populations of feral animals, particularly rabbits. The diet selection of rabbits also puts more pressure on those smaller, more succulent species that are less tolerant of regular or heavy grazing. It is likely that a significant proportion of the change in native grasslands has been the result of grazing by rabbits, rather than by domestic livestock.

Heavy grazing over long periods can dramatically change grassland composition. In this photo all the grasses have been removed from the foreground - only bare ground and two species of forbs remain.

Mowing and slashing

Mowing and slashing are another form of defoliation used to manage herbage mass in some small native grassland areas. Like grazing, the main threat of mowing to native grasslands is that it can prevent flowering and seed production, by occurring too frequently or at the wrong times. Mowing and slashing equipment can also bring weed seed into native grassland from another site. Some of the most troublesome perennial grass weeds, such as African Lovegrass and Chilean Needlegrass have been seriously spread in some areas through the regular movement of mowing equipment.

Fire

Fire was a fundamental influence in shaping and maintaining many Australian vegetation communities. Removal of fire or substantially altered fire regimes has caused significant change to the structure and composition of many vegetation communities since European settlement. Fire exerts its influence principally by defoliation, but it also affects some plants and seed through the production of heat and smoke. The timing of fire in relation to the life cycles of plants, the intensity and the frequency of fires, all have a strong influence on the long term results of a fire regime. The primary threats posed to native grasslands by fire are that the grassland is burnt too frequently, too hot or at the wrong time in the plants' life cycles, and that the whole grassland is burnt at one time, leaving no escape for native fauna. In the absence of other adequate defoliation, fire can also be too infrequent, allowing native grassland to become overgrown. Interactions between fire and vegetation are complex and it is not yet clear how we might incorporate fire into the management of native grasslands, particularly in smaller areas where off-site spread is a significant danger.

St John's Wort on the Old Cooma Common Grassland Reserve just outside Cooma. St John's Wort has become a serious problem in this and many other grasslands.

Weeds

Another major mechanism of change has been the invasion of grasslands by weeds. Weeds can become established in native grasslands through introduction of weed seed and physical disturbance of the soil which encourages germination and removes competition for growth.

Many exotic plants, particularly annual and biennial herbs, are widespread though of relatively little economic or environmental concern. However, some have become particularly troublesome by causing loss to agriculture and conservation through depressed production, high control costs, and by invading and dominating native vegetation. A variety of large, perennial and highly invasive weed species such as Serrated Tussock, Chilean Needlegrass, African Lovegrass and St John's Wort, are of particular concern as they have invaded and now dominate large areas, and once established are difficult and expensive to control.

Above: An example of the influence of management on native grassland composition. The dominance has been dramatically shifted to Snow Grass on the right and Tall Speargrass on the left, by grazing management and cultivation, respectively. This photo was taken only a few kilometres from the one on the opposite page on the same soil type.

Below: Fairies Aprons flowering in a periodically wet area next to Ginninderra Creek. Wet areas like this are highly vulnerable to pugging by livestock and changes in soil drainage patterns.

Soil disturbance

Physical disturbance of the soil through cultivation, ripping burrows, laying pipes or cables, fencing, tree clearing or earthworks for water storage or diversion, removes the existing vegetation and exposes freshly turned soil providing a favourable environment for weeds to establish and compete.

Soil fertility change

Changes in soil fertility can alter the competitive relationships between plants to the point that the species composition of the community changes. Fertility can be affected by the application or drift of soil ameliorants (e.g. superphosphate, gypsum, lime), depletion of organic matter through excessive defoliation, compaction, physical disturbance and alteration of the soil flora and fauna (e.g. fungi, ants, worms, beetles).

Altered drainage

Soil moisture is a major determinant of plant community structure and composition. Soil moisture can be altered by changes to local drainage patterns caused by the construction of dams, roads and other earthworks. Changes in the density and structure of soils through compaction, and change in the organic matter content can also change their water permeability and retention. Each of these kinds of change to a soil's moisture regime can cause changes to the species composition of a native grassland.

Traffic and trampling

Frequent traffic will wear tracks in native grassland because many plant species cannot survive the direct trampling or the associated soil compaction. Light and well dispersed traffic is unlikely to cause noticeable change, but regular traffic concentrated along the same route by vehicles, livestock and even people, will result in the death of plants, leaving bare ground which is vulnerable to erosion and to weed colonisation.

Tree planting

The relative or complete treelessness of a native grassland is important in its ecology. The introduction of heavy shade will give a competitive advantage to more shade tolerant species. Leaf litter from trees, especially exotic species, can significantly effect soil fertility. The needles of exotic pine trees for instance, increase soil acidity and physically blanket the ground. Trees also attract animals and birds, which are vectors of weed seeds, and their droppings increase the fertility of the soil under trees. Planting exotic trees in a native grassland is likely to change its structure and composition. Natural recruitment of exotic trees (e.g. pine wildings) from nearby adult trees will lead to the same changes if this recruitment is not controlled.

Herbicide use

Application of herbicides for weed control within a grassland or spray drift from neighbouring areas could inadvertently kill many native species. Little is yet known about the tolerance of most native herb species, and small native animals, to herbicides.

Stockpiling and dumping

Stockpiling, dumping and spreading of soil or gravel in a native grassland will smother plants and create bare areas for weed recruitment. This has occurred on many native grassland areas on road verges and other public land sites causing the loss of native grassland from those areas. In addition to smothering plants, soil or gravel introduced from another site is also likely to introduce weed seed into native grasslands.

Seed collection and introduction

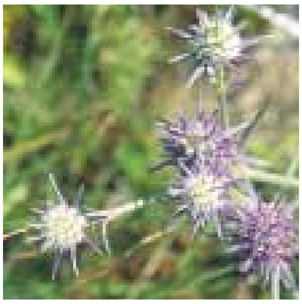
Much interest has emerged recently, in the collection of wild native plant seed, for propagation and revegetation work. This is an essential part of harnessing the potential of native plants for conservation, revegetation, agriculture and horticulture. However, harvesting seed without considering the recruitment requirements of the source community poses a threat to some communities and species. Equally, introducing plants or seed of the same species from another area carries a risk of introducing incompatible genetic material that could harm the existing population.

Threats to native fauna

To provide suitable habitat for fauna, native grasslands need to provide both shelter from the elements and predators, and food. Shelter and food are enhanced by the diversity of the structure and species within the grassland. Any management action, or lack of management, that simplifies the structure or composition of native grassland will reduce its value as habitat for native fauna.

A travelling stock reserve south of Cooma with Blue Devils flowering among the Kangaroo Grass and Snow Grass.

WHY MANAGE NATIVE GRASSLANDS ?



The perennial grasses in native grasslands form the structural backbone of the community yet this structure can fluctuate dramatically with the seasons and in response to soil moisture, temperature, grazing, fire, frost and management by humans. Though most of the plants in the community are perennials, many of them can reach reproductive maturity in their first growing season, and produce seed and recruit new plants readily under favourable conditions. These features allow the community to produce new plants readily if necessary. Because native grasslands can show such a high rate of turn-over, of both biomass and individual plants, disturbance to either the biomass or plant population can change the structure or composition dramatically in a short period. This means that native grasslands are highly dynamic by comparison with other vegetation communities in which a higher proportion of biomass is 'tied up' in woody tissue which can stand for many years.

Because the natural processes and cultural practices that influenced native grasslands before European settlement have been so altered, active management is now essential to maintain and manipulate their structure and composition and minimise the main threats to their conservation.

The overarching objectives of native grassland conservation are to:

- retain stable, resilient and productive vegetation for landscape health
- conserve as much biodiversity as possible, including diversity of native grasslands, diversity of species and diversity within species
- retain examples of the original vegetation for enjoyment, recreation and tourism

To achieve these objectives, we need to retain a significant number of grasslands in a variety of locations and environments, each with as many species as possible and each large enough to function as a viable self sustaining community. In the longer term, with good management, we should also be able to improve the quality of these native grasslands, in terms of their species composition, species richness, weediness, animal populations and in turn their productivity and ecological function.

Above: A native buttercup flowering in a damp depression on Middlingbank Peninsula where a local Landcare project is conserving the grassland with improved long term management.

Left, top: The threatened Creeping Hop Bush flowering on a shale derived soil between Cooma and Dry Plains.

Left, second: Milkmaids are an uncommon lily species shown here at Mulligan's Flat, Canberra Nature Park.

Left, third: Tiger Orchid on O'Connor Ridge, Canberra Nature Park.

Left, bottom: Blue Devils in Ravensworth Travelling Stock Reserve south of Cooma.

MANAGEMENT CONSIDERATIONS

Defoliation management (grazing, mowing and burning)

Some form of defoliation is essential to maintaining the structure and botanical composition of most native grasslands. Without regular removal of some herbage, excess grass will accumulate and die, and can inhibit the growth of many plant species in the sward. Before the introduction of domestic livestock and rabbits, and the displacement of the many species of native fauna, this defoliation was performed by the native animals, including both large and small mammals and grasshoppers and other insects, and by fire, both naturally occurring and those lit by Aboriginals.

The majority of the non-grass plant species in grasslands grow in the intertussock spaces. When the grass canopy closes over these spaces, it shades and out competes these smaller plants, and they can be lost from the sward. Therefore, inadequate defoliation can be as damaging to species richness as excessive defoliation. It can also inhibit the major grass species. For example Kangaroo Grass, one of the most commonly dominant native perennial grasses, is known to become less vigorous and even die when heavy growth has accumulated after a number of years without defoliation.

Defoliation is only necessary to prevent the grassland becoming overgrown by the dominant grasses. The frequency and degree to which it is necessary depends on the inherent productivity or growth rate of the grassland. On more productive areas it will require more frequent or heavier defoliation to maintain open intertussock spaces. On shallow, stony and infertile soils, defoliation management should be much less frequent and intense.

Grazing management

Grazing herbivores, whether native or exotic, have a profound influence on the structure, species composition and species richness of a grassland. Until European settlement, native grasslands had evolved under and reflected the diet selection and grazing pressure exerted by the native fauna. Since European settlement commercial grazing by domestic livestock has been and is likely to continue to be, the primary use and the main method of defoliation in native grasslands. Conservation management of grazed native grasslands will require a good understanding of defoliation requirements and how we can best satisfy these requirements with domestic livestock.

Several factors need to be considered in designing a suitable grazing management regime. The timing, selectivity, intensity and duration of grazing each influence its impact on the individual plants and the whole community. Good management of the grazing pressure on a grassland will require sound stock proof fencing.

Timing

Native grassland must be allowed to grow freely enough to replenish root reserves, flower and set seed, or it will inevitably deteriorate. Plant species differ in their ability to withstand repeated defoliation. The taller and more succulent plant species, such as orchids and lilies, are even more vulnerable to grazing which is probably why they have been lost from a large proportion of native grasslands. Native grasslands should therefore be grazed very lightly (e.g. no more than one sheep per hectare) or preferably completely rested, during flowering and seed production. Most plants in our temperate grasslands do this from late spring to early summer.

Native Buttercups flower on the Adaminaby golf course, managed under a community based Trust, using a combination of grazing, slashing and burning.

Selectivity

All grazing animals have preferences for grazing some plant species and parts, over others. For instance, sheep tend to graze younger growth and more succulent species than do cattle, while goats tend to graze drier and rougher herbs and browse on shrubs. Native animals have different grazing habits again. These differences in diet selection have changed the species composition of native grasslands because the relative grazing pressure on the various species has changed markedly with the introduction of exotic animals. Grazing animals are most selective under continuous light set-stocking. This effect can be reduced by increasing the stocking rate and reducing the time a mob of stock is in a particular paddock. However, higher stocking rates and more frequent stock movements require more intensive management, and reduce the room for error, so this should only be undertaken with great care.

Intensity and duration

A fundamental objective of commercial grazing is to maximise the harvest of herbage by animals in order to maximise production. However, maximising the harvest of pasture in the short to medium term, will lead to a shorter and more even grassland structure. A taller and more diverse structure will allow plants to recover from grazing more quickly, help resist weed invasion by maintaining higher groundcover and competition, and provide food and shelter for a wider variety of native fauna. When herbage quantity or quality become too low to maintain livestock condition, the stock should be moved, rather than being supplementarily fed, to protect the grassland from over-grazing and excessive trampling.

Native grassland managed by mowing - Bibbenluke cemetery near Bombala.

Mowing and slashing management

Timing, height and frequency

Mowing and slashing are used as the main method of defoliation in many small native grassland areas where grazing is not wanted. Timing, height and frequency of mowing influence native grassland species composition and structure and potential for weed invasion in the same ways as grazing and burning. A mowing or slashing regime should allow for periods of good growth between mowings and should allow the grassland to flower and set seed at least every few years.

Grass clippings

Management of the grass clippings produced by mowing or slashing in native grassland is an important consideration. Mowing and slashing equipment often leave windrows or clumps of grass clippings on the grassland. These windrows and clumps of clippings can sit for months, shading and smothering the plants below and sometimes killing them. The death of these plants leaves the soil bare and vulnerable to both erosion and weed invasion. The decomposition of the grass clippings and dead plants also releases nutrients into the soil creating an even more favourable environment for weed growth.

Production of windrows or clumps of clippings can be avoided by using flail type mowers which distribute the grass clippings more thinly and evenly. Where flail type mowers are not available or very heavy growth is being cut, the clippings could either be caught in a catcher or raked and removed from the site.

Weed seed spread

Weed seed is often spread from one site to another by mowing machinery. To avoid introducing weed seed from another site, mowing equipment should be reasonably clean of clippings and seed before use in a native grassland, particularly if this equipment has been used in an area with serious weeds.

Fire management

Fire may be a powerful tool in the management of native grasslands, either in the absence of, or in conjunction with grazing or mowing. Fires can be lit either by people or natural causes, both of which occurred before European settlement and both are possibilities under modern day grassland management.

Potential advantages

Fire may have some advantages over other forms of defoliation. All the native plant species in a native grassland can accommodate fire, but many of the exotic weed species may not have evolved in such an environment. It is possible that a fire regime which is sympathetic to the native species but inhospitable to the weeds may help in reducing the weediness of many native grasslands. At the very least, fire has the advantages of not introducing weed seed, as both livestock and mowing equipment can, and being less selective than livestock in the species it burns.

Timing

The timing of fire should accommodate the need of a native grassland to flower and produce seed. Native grassland could be burnt between the end of seed set (mid to late summer) until the plants begin to produce flowers again in spring. This will also often be the only time the grassland has enough dry herbage to carry a fire and not enough green herbage to preclude a fire.

Intensity

Hot weather, high wind, lots of dry grass and low soil moisture all increase the risk of a grass fire being too hot. Under these conditions the heat of the fire can kill plants and their seeds in the soil and can even burn down into the soil, reducing the soil organic matter and changing the soil structure. Fires should only be lit when the soil is reasonably moist and the temperature and wind conditions will allow the fire to be kept under control. This timing will also help managers comply with fire regulations and reduce the risk of wildfires.

Frequency

The frequency of burning poses the same threat to native grassland as does grazing or mowing too frequently. Fire will only be necessary when a grassland becomes overgrown by the dominant grasses. On more productive areas and in the absence of grazing or mowing, this may be once every few years. In areas with shallower or less fertile soil or lower rainfall, burning may never or only occasionally be necessary.

Patch burning

Fire can threaten the small native fauna within native grassland. One of the most important considerations when using fire as a grassland management tool is to use patch burning, rather than burning the whole grassland area at once. Patch burning involves burning only in patches, leaving substantial areas unburnt to act as fire refuges for small fauna. In grasslands where burning is used regularly as one of the main methods of defoliation, a pattern of rotation should be used, in which one or more discrete patches is burnt on each occasion. The next burn should be in different patches, again leaving good refuge for small fauna. By using a pattern of patch burning, the whole grassland area might be burnt over a number of years without a large proportion of the area being burnt in any one year.

Fire breaks

If the accidental spread of a fire into or from a native grassland is felt to be a real risk, a firebreak could be mown or slashed around its perimeter - it should never be ploughed or sprayed. Ploughing or spraying a fire break will remove competition by native plants and encourage germination of weeds, creating a strip of weedy vegetation right at the edge of the grassland.

Defoliation management in summary

- in most grasslands, herbage mass must be managed by grazing, mowing or burning
- timing, frequency, degree and selectivity of defoliation must be managed to suit the grassland
- allow grassland to accumulate substantial growth between defoliation events
- allow all native plant species to flower, set seed and recruit new individuals
- avoid grazing grassland or graze only very lightly from the onset of flowering until seed set
- destock grassland when feed quantity or quality become inadequate for livestock maintenance
- avoid mowing or burning grassland from the onset of flowering until seed set
- avoid producing windrows or clumps of grass clippings when mowing or slashing
- burn grassland only when soil moisture, herbage mass, weather and fire regulations allow
- burn only in patches, burning a different patch each time
- maintain fences in sound stock proof condition

Lobe-seed Daisy at Bibbenluke cemetery near Bombala

Weed management

A large number and variety of weed species are now found in native grasslands. The majority are annual or biennial grasses or forbs and are not particularly troublesome as long as their populations are kept low. These types of weeds are nearly impossible to completely remove because they can germinate, develop and set seed quickly and the soil already harbours large numbers of their seeds. The best way to keep their populations low is to maintain a dense groundcover of native plants, particularly during late autumn and winter when most weed species are germinating and establishing.

Common perennial weeds

The perennial weeds are usually more troublesome, particularly when their populations become high. These weeds are usually larger plants which can physically dominate a community, but in some ways they are more easily managed because their populations grow more slowly. They include several species of large tussocky grasses, some exotic shrubs and some invasive exotic trees. Serrated Tussock *(Nassella trichotoma)*, Chilean Needle Grass *(Nassella neesiana)* and African Lovegrass *(Eragrostis curvula)* can invade and dominate disturbed native grassland, as has already occurred over substantial areas. The two Nassella species have been listed among the 20 Weeds of National Significance. Two other exotic perennial grasses, Yorkshire Fog *(Holcus lanatus)* and Sweet Vernal Grass *(Anthoxanthum odoratum)* are common in wetter areas and frequently colonise and dominate in damp positions. St Johns Wort *(Hypericum perforatum)* is an exotic perennial forb gaining a strong foothold on the Tablelands and should be removed from grassy vegetation before it becomes well established. Exotic shrubs such as Sweet Briar *(Rubus rubiginosa)* and Hawthorn *(Crataegus monogyna)* can be quite invasive over long periods, but are readily removed from small areas. All these perennial weed species are controllable with early recognition of the problem and diligent action before their populations become too dense.

Weed seed introduction

Weeds can be introduced to native grasslands through a variety of processes beyond our control such as wind, water and animal movement. Weeds can also be introduced to native grassland by humans through any of several mechanisms including the movement of livestock, horses, vehicles or machinery, and the introduction of organic material (such as hay), soil or gravel. Ideally, livestock and horses should be quarantined in weed free native pasture or yards before being moved into native grassland. Vehicles entering grassland for management purposes should be as free as possible from weed seed. Machinery being used for weed spraying, earthworks or other purposes should be cleaned of weed material before entering native grassland. Supplementary feeding of livestock in grassland is likely to introduce weed seed in grain and particularly hay. Introduction of organic material, soil or gravel from outside a grassland should be avoided. Vehicular traffic, either for management purposes or visitation, should be limited to what is reasonably necessary, to avoid the spread of weed seed. On public land sites this might involve erecting fences or other barriers to prevent access and signs to highlight the value of the area.

Volunteers spot spraying African Lovegrass in native grassland on private land near Bredbo.

Volunteers working to control Hawthorn on the newly established Old Cooma Common Grassland Reserve.

Control methods

Although conventional pasture and weed management has tended to rely heavily on the use of herbicides, there are a number of other methods which can be effective, either on their own or in conjunction with other methods and with herbicides. Strategic use of grazing, mowing or burning can be used to reduce seed set by weed species and favour growth of preferred native species. Encouraging and maintaining a dense and vigorous groundcover of native plants and litter is the best and cheapest method of resisting weed establishment in native grasslands. A combination of several of these techniques is likely to be more effective than any of one method on its own.

Weed management in summary

- maintain high groundcover, especially during autumn and winter to resist weed establishment
- quarantine livestock and horses in a weed free area before moving them onto native grassland
- do not supplementarily feed (hay or grain) livestock in native grassland
- do not introduce soil or gravel (e.g. stockpile, dump or spread) from outside the grassland area
- ensure vehicles and machinery are reasonably clean of weed seed before entering native grassland
- control perennial weed species by spot spraying before populations become dense
- encourage a dense, vigorous and diverse plant community to minimise weed invasion

Soil management

Physical disturbance

Physical disturbance of the soil can kill existing plants and bring buried weed seed to the surface. By removing native plants and exposing freshly turned soil, competition is reduced and germination and growth of weeds is encouraged. Disturbing the soil may be necessary in land management; for example, in construction or maintenance of dams, ripping rabbit burrows and repairing eroded areas. However, disturbance to native grassland may be avoided or minimised with care.

If the soil is disturbed for necessary works, the area should be rehabilitated. Rehabilitation might include levelling the soil, removing weed species that germinate on the area and sowing, or encouraging natural recruitment of, at least the native plant species that dominate the adjacent vegetation.

Soil structure

Any activity that might change the organic matter, porosity, water permeability or moisture retention of the soil, such as compaction by vehicles or earthworks that alter water drainage patterns, should also be avoided.

Chemical disturbance

Any temptation to enhance the sward with fertiliser, or other soil ameliorants, should be resisted. An increase in the level of phosphate or nitrogen, or a change in pH may give a competitive advantage to exotic plants. The soils under native grasslands have evolved with the plant and animal community. Any substantial change to their chemical fertility is likely to change the composition of the grassland.

Stockpiling, dumping and spreading

Many areas of native grassland on public land have been used for quarrying or stockpiling soil or gravel for construction purposes. Some gravel pits are quite large and have been dug within areas of good native vegetation. These would involve substantial cost and effort to rehabilitate. Soil and gravel stockpiles provide a place for weeds to colonise and produce seed, which can then spread into adjacent vegetation. No new gravel pits or stockpiles should be established within areas of significant native grassland.

Soil management in summary

- avoid or minimise any physical disturbance of the soil
- control weeds and revegetate if disturbance becomes necessary
- do not modify the chemical fertility of the soil
- avoid soil compaction by regular traffic along the same route by vehicles or heavy equipment
- avoid or minimise earthworks and other development which alters drainage patterns
- do not establish new gravel pits, or soil or gravel stockpiles in native grassland

Soil disturbance removes competition and encourages weeds to germinate and grow. In this case near Cooma, native grassland has been converted to a very weedy paddock by repeated cultivation.

Fauna habitat management

Native grassland can provide shelter for small animals in the form of grass tussocks and inter-tussock spaces, soil cracks and holes, rocks, shrubs, trees and their bark, fallen timber and litter. Each of these niches provide places for small native fauna to shelter from the elements, predators and fire. In turn, the more niches there are and the more species of fauna shelter within the grassland the greater the abundance and variety of food for other species of fauna. A useful general principle is that to maximise the habitat value of a native grassland for a wide variety of fauna, the grassland should be managed to maintain or enhance the diversity of its structure and species composition.

Structural diversity and shelter

Structural diversity can be provided not only uniformly across a paddock, but also by providing different types of structure in different parts of a paddock or landscape. This should be readily achievable, even difficult to avoid, in larger paddocks that contain different landscape units such as different slope angles and aspects, soil depths and even vegetation types. Managing grassland structure for maximum structural diversity may sometimes conflict with maximum short term pasture utilisation, but will provide other benefits such as provision of a dry feed reserve and a healthier grassland.

High grazing pressure resulting in lower herbage mass, clearing trees and shrubs, removing fallen timber and rocks, burning grassland in warmer months when small fauna are most active and vulnerable, or burning the whole area at once, will dramatically reduce the shelter value of a grassland.

Species diversity and food

The fauna habitat value of a native grassland will also be enhanced by management that provides the biggest variety and supply of food for animals. The backbone of this food chain is the plants and the greater the diversity of plant species, the greater the variety of food types available to support fauna.

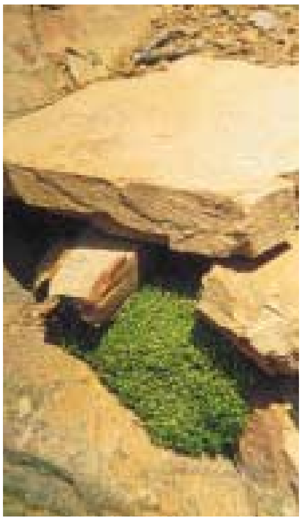
Native grassland can provide food for birds, reptiles, frogs, mammals, a wide variety of insects (both above and below ground) and an even wider variety of other soil organisms, each of which eventually become food for others.

The web of life

Enhancing the variety of shelter and food for fauna, and thus the diversity and activity of fauna species in a native grassland, will enhance the growing conditions for plants and the health of the grassland. The habitat value of native grassland will be even greater when it contains or is adjacent to other healthy ecosystems, such as woodland, forest or wetland. Many animal species use native grassland for only some of their needs and need to spend some of their time in other ecosystems.

Fauna habitat management in summary

- retain trees, fallen timber, rocks, plant litter, tussocks and inter-tussock spaces
- avoid cultivation which will destroy soil structure, cracks and holes
- enhance structural diversity at a range of scales from individual tussock to landscape level
- enhance species diversity to maximise the variety of food sources for fauna



Twin-flowered Knawel making use of moisture in a rock crevice.

A short, open structured grassland with a rocky surface, good structure and high species diversity.

These Snow Gums in a reserve near Berridale are typical of scattered tree populations within native grasslands.

Tree management

Native grasslands often include a scattered population of trees. Many paddocks on the Tablelands contain both treeless or lightly treed grassland, and more heavily treed plant communities of woodland or open forest.

Native trees

Trees can have a strong influence on grassland structure and species composition through competition for light, moisture and nutrition. Trees also provide nutrition to the plants under their canopy through litter fall and by attracting birds and other animals that leave droppings under the tree. The natural populations of native trees within grasslands should be retained and managed as an integral part of the vegetation and have evolved with and continue to interact with the ground layer plants.

Exotic and other non-local trees

Planting exotic trees, can have an even stronger influence on native grassland. Typically, grass species affected by shade are replaced by more shade tolerant grasses and the number of intertussock forb species is greatly reduced. Good examples of this can be seen in many rural cemeteries. Many exotic tree species also set seed which results in self sown exotic trees nearby. Exotic trees should not be planted in native grasslands and self sown exotic trees should be removed while they are still young.

Tree management in summary

- retain native trees as integral components of native grasslands
- do not plant exotic or non-local tree or shrub species in native grassland
- remove self sown exotic trees (such as pine wildings) while they are still young
- consider removing older exotic trees (if present) and replacing with local native species

Feral animal management

Rabbits

Feral animals can have a strong impact on native grassland. Rabbits have a strong dietary preference for smaller and more succulent plants and plant parts. These are often the more vulnerable native forb, lily and orchid species. Diligent management of rabbit populations is important in the continuing conservation management of native grasslands. In rabbit prone country, exclusion of rabbits from native grasslands with boundary netting can be very valuable. In larger grassland areas, where the cost of rabbit netting has become prohibitive, a more popular approach is to manage the rabbit population at the local landscape level, fumigating and ripping burrows. Ripping burrows involves major soil disturbance and should be followed by the rehabilitation measures discussed under soil management.

Cats and foxes

Feral predatory animals such as foxes and cats may also have an impact on grasslands, principally by hunting the smaller native animals such as small mammals, birds, lizards, snakes, frogs, spiders and insects. Predation by foxes and cats could cause local extinction or at least alter the balance of native fauna populations which could effect the ecology of the whole community. Feral cat and fox populations should be controlled in conjunction with neighbouring landholders and local authorities such as rural lands protection boards and shire councils.

Pigs

Feral pigs can also have a strong impact on native grassland. A significant area can be severely dug up by pigs in a single night, doing as much damage as cultivation by machinery. Pigs have a preference for digging in the lower parts of the landscape, where the soil is deeper and more often moist. These areas contain the more sensitive and less well conserved types of native grassland. Grasslands adjacent to the shelter of timbered areas are more prone to this type of damage. Only diligent pig control in cooperation with adjacent landholders is likely to achieve effective control of feral pigs.

Feral animal management in summary

- control rabbit populations and revegetate disturbed soil with suitable local grassland species
- control feral cat, fox and pig populations in conjunction with neighbours and local authorities

MANAGING FOR LONG TERM CONSERVATION

Native vegetation management and conservation only becomes really meaningful and achievable when viewed in the long term. Vegetation composition and structure, particularly in grasslands, is highly responsive to external influences, and can readily be altered by management. A native grassland dominated by one species of native grass can be substantially altered and become dominated by a very different species (native or weed) either through intentional or inadvertent management.

Planning for management

Good management of native grasslands for conservation in the long term requires adequate knowledge and continuing input of resources and commitment by managers, the community, governments and funding agencies. A management plan is essential to support considered management actions, seek assistance and as a basis for monitoring success.

Native grassland enhancement

With appropriate and sensitive management it is possible to improve the quality of native grasslands. Through assisted rehabilitation, the structure and composition of the grassland community may be returned to a state that more closely resembles its natural condition. Interest in harvesting seed from wild populations, producing seed in seed orchards and nurseries, and purchasing seed for revegetation and landscaping has burgeoned in recent years. Specialised equipment and techniques are being developed, produced and promoted. However, great care should be used in collecting or harvesting seed from wild populations and in introducing seed to existing native grasslands. Wild populations of plants differ in their genetic make-up. Moving genetic material from one population to another can cause harm to the local population. In general, when introducing seed to a grassland it is safer to use the most locally sourced seed practicable to avoid this problem. When this is not possible expert advice on the likely risk should be sought. Collection of plants and seed in the wild is also subject to legal restrictions which vary from state to state.

In a more natural condition, native grasslands are likely to improve the stability of the landscape and enhance its capacity to support industries and communities. Populations of the less common native species of plants and animals might also be increased and become both more visible and sustainable.

Monitoring

Adaptive management

Careful monitoring of native grassland management can be invaluable in revealing the grassland's responses to both management and natural events and their interactions. This information can then be used to direct and improve management in response to any undesirable change. This process of monitoring the results of management actions and adjusting or adapting management accordingly is called adaptive management. A good place to start is with a survey of the condition of the grassland and the species present. This will provide a benchmark for monitoring and comparison.

Photopoints

Changes in the species composition and structure of native grassland often take place without being recorded. Simply taking photographs in the same direction from the same reference point (like the top of a strainer post) can record useful information when compiled over a number of years. General trends, such as changes in the prevalence of major species (e.g. Kangaroo Grass, Poa Tussock, African Lovegrass or Sweet Briar), or outstanding seasons or flowering events can be revealed.

Detailed measurement

Another technique is to measure botanical composition at some regular interval. This can reveal more subtle changes, particularly in the less obvious species. This more detailed method requires more specialist skills, experience and resources. Managers can obtain advice or assistance in monitoring through local or state government agencies, the various threatened species and ecological community Recovery Teams and special interest community groups.

Community involvement

Many individuals and community groups are interested in being involved in and contributing to nature conservation. These people are a potentially valuable resource in the conservation management of native grasslands. Neighbours and local community groups are likely to better understand and appreciate native grasslands and their value if they are actively involved in their management and enhancement. Some of the knowledge of native grasslands gained in this work is likely to be taken away and applied in other grasslands on both private and public land. Such community involvement is likely to be of benefit to the local and broader communities and to long-term conservation of grasslands across the region. Contacts provided under 'Public assistance' overleaf can help you with ideas, including what has worked elsewhere. The types of assistance include: survey, monitoring, weeding, fencing, seed collection and propagation, replanting.

Monitoring grassland composition as part of a Landcare project on Middlingbank Peninsula, Lake Eucumbene.

Tourism

Growing awareness and appreciation of our natural environment and native vegetation has opened new opportunities, such as environmental tourism, for rural communities. If remnant native grasslands become recognised as good quality, well managed examples of the original native vegetation, they could become significant drawcards in a region's portfolio of tourist attractions.

Public assistance

A number of organisations can provide assistance in conservation management of significant native grasslands, grassy woodlands and their component species. Managers should consider seeking assistance in managing native grassland areas with conservation values, through these organisations:

- WWF Australia
- Greening Australia
- South-East Australia Grassy Ecosystems Networker
- shire councils
- rural lands protection boards
- NSW Department of Land and Water Conservation
- NSW National Parks and Wildlife Service
- Environment ACT
- Environment Australia
- Agriculture, Fisheries and Forestry Australia and similar agencies in other states

More work needed

Much work has now been done to identify, classify and protect native grasslands. However, considerably more work is needed before we can be confident that we have succeeded in conserving the most significant native grassland areas. Beyond this, conservation management of native grasslands will require on-going active management in the long term.

Helpful publications

A kit called the Grassy Ecosystem Management Kit: a guide to developing conservation management plans (Sharp et al 2002), has been produced to help grassy ecosystem managers develop their own conservation management plan. This and other useful publications are listed at the back of this booklet (see Further Reading and Resources).

Top Hut Travelling Stock Reserve at Dry Plains - an example of how temperate natural grassland in full flower can rival our famed alpine wildflower displays and could become a drawcard for regional tourism.

Long-term conservation and enhancement in summary

- make a commitment to on-going active management of your native grassland
- develop and implement a suitable management plan to reduce threats and enhance potential for recovery
- do not over harvest when collecting seed from native grasslands
- use the most local seed available when introducing seed to a grassland
- conduct a survey or inventory of the condition and species present in your grassland
- incorporate a suitable monitoring program into your management plan
- use adaptive management to incorporate the results of this monitoring into your management
- seek advice and help in conducting your survey, management planning and monitoring
- consider how you could involve the community in the management of your native grassland
- consider participating in native grassland activities in your region to broaden your experience
- consider seeking advice and funding assistance from community and government organisations

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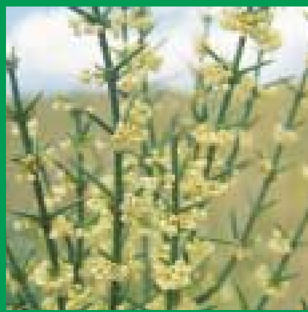
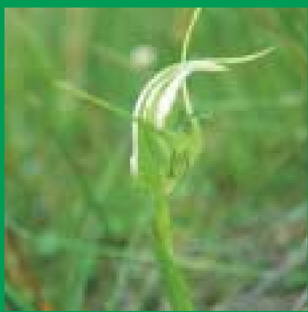
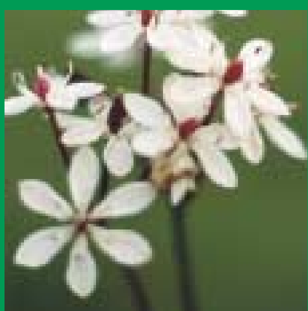
WWF Australia is working to conserve Australia's native vegetation. Our programs aim to reduce excessive clearing of land and the effects of salinity and introduced species on our environment. Together with Australian communities, we are working to expand protected areas and ensure our land is well managed for the future.







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AN ASSESSMENT OF THE USE OF SEEDING, MOWING, AND BURNING IN THE RESTORATION OF AN OLDFIELD TO TALLGRASS PRAIRIE IN LEWISVILLE, TEXAS

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Dissertation Prepared for the Degree of

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

INTRODUCTION

History, Range, & Current Condition of the North American Prairie

The North American prairie once stretched from San Antonio, Texas into Canada, and from the Smokey Mountains to the Rockies, covering more than 162 million hectares (Figure 1). Because of its fertility, however, this region quickly became the major agricultural center in America after colonization (Madson 1982) and the prairie was replaced with farms. Present estimates of the remaining prairie acreage range from 21% (Samson and Knopf 1994) to less than 4% (Chadwick 1993, Farney 1980, Steinauer and Collins 1996) of its former range, making the prairie one of the most endangered ecosystems in the world. Several states (Illinois, Indiana, Iowa, Minnesota, North Dakota, and Wisconsin) have lost over 99% of their former prairie (Samson and Knopf 1996).

At the time of European settlement, Texas contained over 149 million hectares of grassland (Diamond 1996), 21% of which was blackland prairie (see Figure 2). Samson & Knopf (1994) estimate that Texas has lost at least 82% of its grasslands, with the greatest loss occurring in tallgrass prairie, where less than 1% of blackland prairie remains unplowed (Diamond et al. 1987, Diamond and Smeins 1993, Diamond et al. 1997, Martin 1993, Smeins and Diamond 1986). The remaining acreage is often ecologically degraded due to past and sometimes current land management. Additionally problematical is that most remaining native prairie is isolated into small parcels often less than 100 hectares, causing increasing edge effects, exotic species invasion, lowered

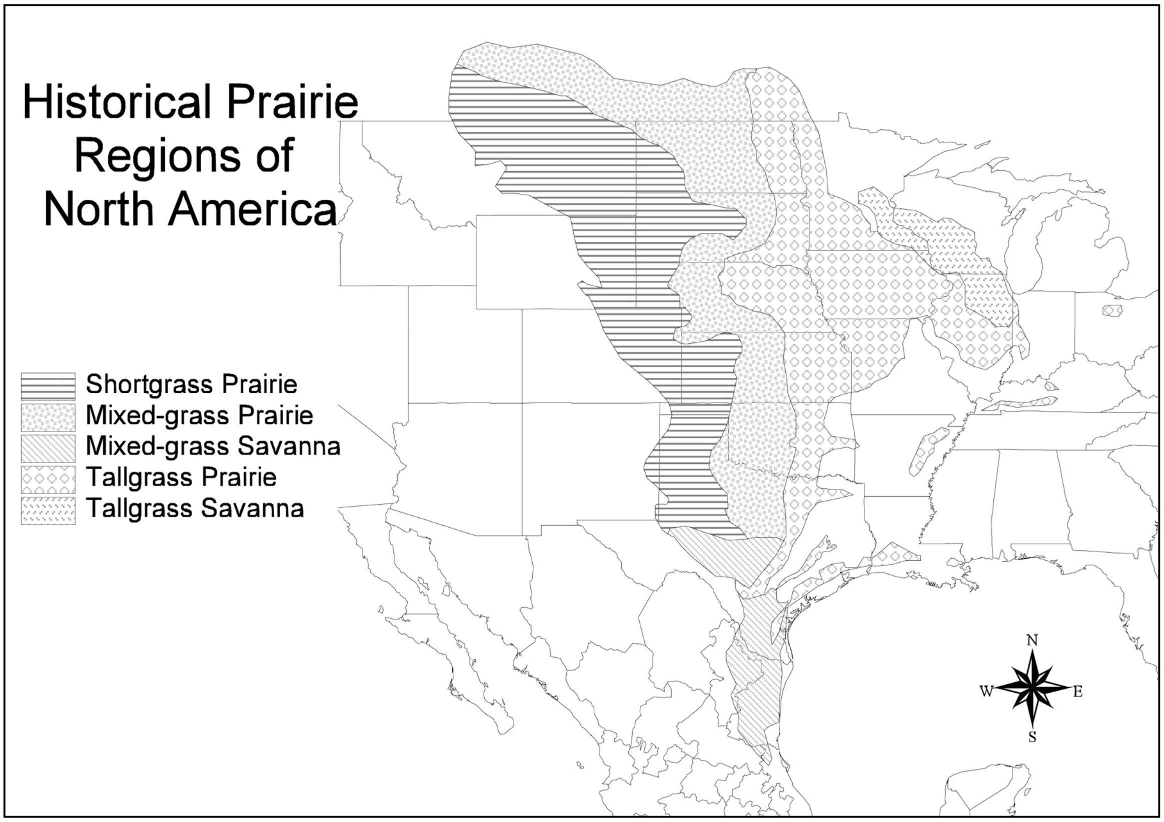

Figure 1. Historical extent of North American prairie and savanna ecosystems prior to European colonization (map adapted from Risser et al. 1981, Reichman 1987, Diamond and Smeins 1985, Chadwick 1993).

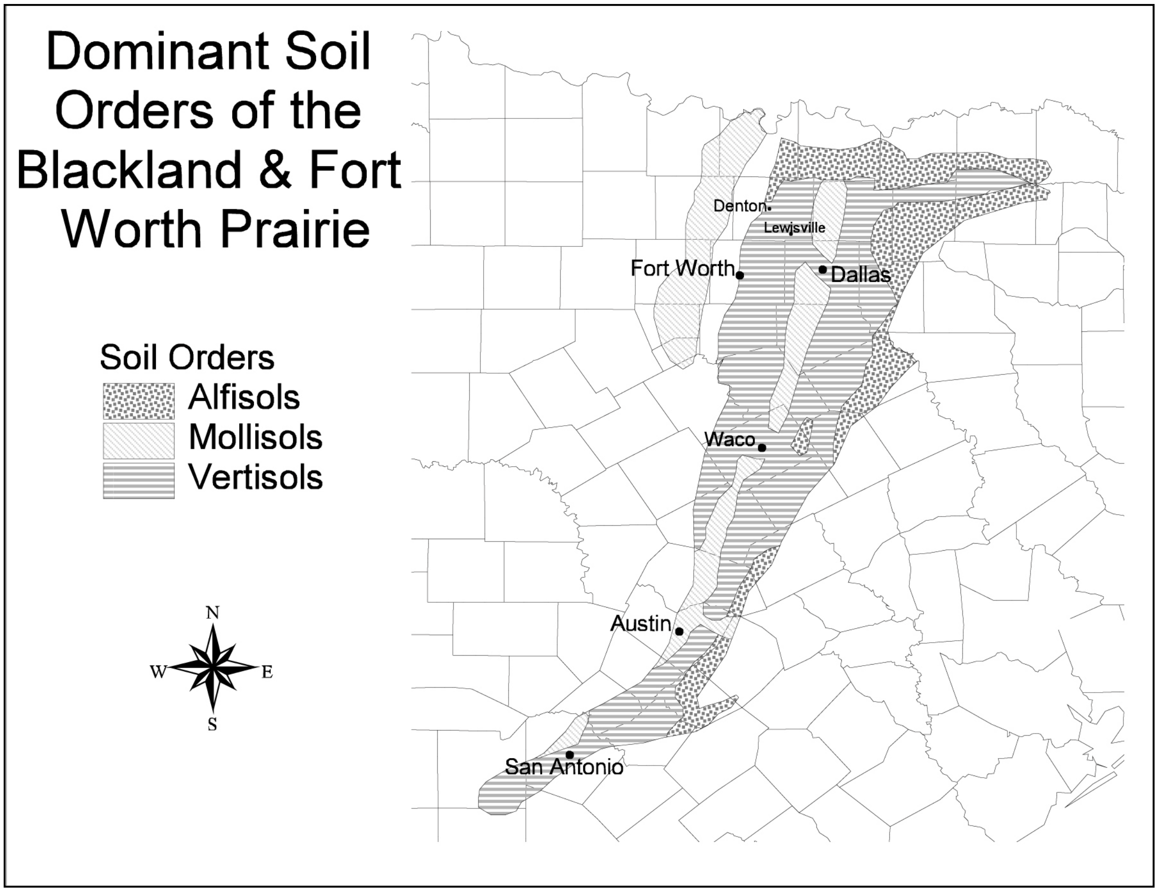

Figure 2. Dominant soil orders of Fort Worth and blackland prairies (map adapted from Diamond & Smeins, 1985 and Hallmark, 1993).

genetic diversity in local populations, and increased extinction rates (Martin 1993, Steinauer and Collins 1996). These factors have made tallgrass prairie one of the most endangered ecosystems in Texas (Diamond et al. 1987).

In addition to outright destruction and fragmentation of North American prairie, many historical disturbance forces common pre-settlement have been either eliminated or greatly modified. Prairie ecology in North America was once regulated by fire, grazing, and temperature and precipitation extremes (Diamond and Smeins 1985, Leach and Givnish 1996, Madson 1982, Risser et al. 1981, Steinauer and Collins 1996). Fire has been all but eliminated from most prairies, and the brief but intense grazing of bison has primarily been replaced by year-round grazing by domestic cattle. Studies have shown that elimination of periodic fires can lead to an annual loss of 0.45% to 1.03% of the original species (Leach and Givnish 1996). Loss of historical disturbance factors has resulted in a decreasing spiral in ecological integrity of prairie ecosystems and a general encroachment of woody plant species, particularly those able to withstand periodic droughts common to the great plains. In addition to exotic herbivores, the past 200 years have brought a variety of exotic plant species to the prairie. In north-central Texas, these problem exotics are often grasses, introduced for purposes of increasing grazing production or as a hay crop (Diggs et al. 1999, Luken and Thieret 1997). Problem species include Bermuda grass (*Cynodon dactylon*), Johnsongrass (*Sorghum halepense*), King ranch bluestem (*Bothriocloa isachaemum*), rye grass (*Lolium perenne*), and tall fescue (*Festuca arundinacea*). A complete list of species referred to in this document, their common names, and past scientific names is presented in Appendix A.

General Prairie Ecology

The North American prairie began to form approximately 25 million years ago after the Rocky Mountain uplift caused a change in precipitation east of the range. The Rocky Mountains intercepted moisture laden winds from the west, resulting in drier air passing the mountains and continuing east. The lowered rainfall and frequent prolonged droughts that followed led to the establishment of the mid-continent grasslands, an ecosystem capable of withstanding these comparatively arid conditions (Weaver 1954). Precipitation is lowest immediately east of the Rockies and increases to the east (Borchert 1950). Grassland communities mirror this shift in precipitation, moving from semi-desert and short-grass prairies in the west to mixed-grass prairies and tallgrass prairies towards the east (Madson 1982, Reichman 1987, Risser et al. 1981, Weaver 1954, Figure 1).

In addition to precipitation, soil variables are the most important factors in controlling vegetation distribution (Diamond and Smeins 1985, Diamond and Smeins 1993, Smeins and Diamond 1983). Texas tall and mixed-grass prairies occur on three main soil orders in north and central Texas: Alfisols, Mollisols and Vertisols (Figure 2). Soil order is most general level of categorization in soil taxonomy and suggests basic similarity of soil properties (Hallmark 1993).

Vertisols are formed of smectitic clays and moderate levels of calcium carbonate. Smectitic clays have a high shrink-swell capacity and, because of this, Vertisols often form deep cracks (often over 50 centimeters) when they dry out. Mollisols are formed of smectitic clays in areas of high calcium carbonate depositions, where parent rock materials are more consolidated. Alfisols are formed of sand or sandy-clay with low levels of calcium carbonate (Hallmark 1993). All three soil orders are underlain by a clayey subsoil with low permeability. These soil types and the relatively flat topography result in most Texas prairies being poorly drained (Diamond and Smeins 1985).

Prairie communities are typically divided into three general categories based on plant species composition and average grass height in late summer (Risser et al. 1981, Weaver 1954). Prairie communities with an average grass height of at least a meter are considered tallgrass, while and shortgrass prairies have an average height under 50 centimeters. Common species in tallgrass prairies are big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum nutans*), dropseed (*Sporobolus* spp.), switch grass (*Panicum virgatum*), and occasionally speargrass (*Nassella* spp.). Mixed grass communities are typically dominated by little bluestem, grama grasses (*Bouteloua* spp.), and speargrass. Major grasses in shortgrass prairies include grama grasses (*Bouteloua* spp.), threeawn (*Aristida* spp.) and buffalograss (*Buchloe dactyloides*) (Diamond 1996, Risser et al. 1981, Weaver 1954).

Tall and mixed-grass plant community types in Texas typically have a predominance of little bluestem rather than big bluestem (Diamond et al. 1987, Diamond and Smeins 1985, Diamond and Smeins 1993, Diggs et al. 1999, Dyksterhius 1946, Simpson and Pease 1995, Smeins and Diamond 1986). Whereas eleven plant communities have been described within tall and mixed grass prairie lands of Texas, there are four common communities, named for their dominant species (Diamond et al. 1987, Diamond and Smeins 1993, Table 1). Little bluestem is dominant over most of the Texas tallgrass communities, particularly those on Vertisols.

Table 1. Major tallgrass plant communities in Texas (adapted from Diamond & Smeins 1993).

Tallgrass series	Dominant grass species	Common soil type
Little bluestem-Indiangrass	Little bluestem-Indiangrass	Alfisols & Vertisols
	Little bluestem-Indiangrass-big bluestem	Vertisols
	Little bluestem-big bluestem-Indiangrass	Mollisols
Little bluestem-brownseed paspalum	Little bluestem-brownseed paspalum-Indiangrass	Alfisols
Gamagrass-switchgrass	Gamagrass-switchgrass-Indiangrass	Vertisols and all soils orders in lowlands
Silveanus dropseed	Silveanus dropseed-mead sedge	Alfisols

Prairies are dominated by grasses utilizing the Hatch-Slack pathway (C_4) for the fixation of carbon. This process utilizes the enzyme phospho-enolpyruvate carboxylase (PEPCASE) in order to fix carbon dioxide into a 4 carbon product (either oxalo-acetate, aspartate, or malate). While C4 carbon fixation is common for prairie plants, the most common carbon fixation method for plants (including early spring forbs and winter grasses on the prairie) is the Calvin pathway (C_3). This process uses the enzyme ribulose 1-5 bi-phosphate (RUBISCO) in order to fix carbon dioxide into a 3 carbon product (3-phosphoglyceraldehyde). The process of C3 carbon fixation requires fewer intermediary steps in order to create a sugar usable by the plant, but makes less efficient use of both carbon and water, particularly at temperatures above 30° C (Allaby 1992, Raven et al. 1976).

Ecological processes in the prairie can be described in terms of landscape- and microhabitat-scale processes (Diamond and Smeins 1993). The main landscape-scale processes are climate and natural disturbance, primarily fire and periodic intense grazing

(Collins 1987). These historic disturbance factors in conjunction with the Rocky Mountain rain shadow has largely accounted for the predominance of herbaceous rather than woody cover in the prairie (Diggs et al. 1999, Reichman 1987, Risser et al. 1981, Weaver 1954). Precipitation in Texas follows this same trend, with a steep east-west gradient evidenced across the great plains as a whole. North Central Texas experiences a total annual mean precipitation from 46 inches (116.84 cm) in the east (Collin County) to 24 inches (60.96 cm) in the west (Young County), but as with other prairie habitats, droughts and other anomalous weather patterns are common (Diggs et al. 1999, Hatch et al. 1990, Sharpless and Yelderman Jr. 1993).

Grazing, particularly heavy grazing, will alter plant community composition, typically establishing communities dominated by annual rather than perennial species (Burke 1997, Cid et al. 1991, Collins 1987, Collins et al. 1998, Ellison 1960, Foran 1986, Fuhlendorf and Smeins 1998, Howe 1994a, Steinauer and Collins 1996, Vinton et al. 1993). In a 36-year study, Kinucan and Smeins demonstrated that continuous heavy grazing by cattle resulted in a high proportion of early succession, annual non-grass species in the seed bank, whereas areas where cattle were excluded contained a high proportion of late succession, perennial grass species. In areas lacking any nearby perennial grass seed source, recovery from grazing will be slow or completely unlikely (Kinucan and Smeins 1992). A 45-year study illustrated that species richness and heterogeneity is reduced in heavily grazed areas (Fuhlendorf and Smeins 1998).

Many prairie communities remaining in north central Texas have been maintained as “hay meadows,” cropped annually or sometimes semi-annually since the turn of the century (Riskind and Collins 1975, Diggs et al. 1999). Because so few records exist of the prairie community species composition before settlement (Smeins 1980, Smeins 1982), it is not clear what effect this management technique has had on vegetational composition of these communities. Whereas studies on the effect of mowing on blackland prairie communities have been inconclusive (Smeins 1973), studies on the Konza prairie in Kansas demonstrated that annually mowed and burned plots have more than double the species richness of unmowed plots (Collins et al. 1998).

Collins and associates have demonstrated that spatial and temporal dynamics of nitrogen availability in prairies is driven by interactions between fire frequency and grazing by large herbivores (Collins 1987, Collins and Barber 1985, Collins and Wallace 1990, Collins et al. 1998). Studies on the Konza prairie have also shown that burned watersheds produce significantly greater aboveground biomass than do unburned watersheds (Briggs et al. 1994) as well as greater overall diversity of plants and herbivorous insects (Cancelado and Yonke 1970, Evans 1984, Gibson and Hulbert 1987). Prairie grasses and forbs in the first year following a burn increase aboveground biomass and flowering and seed production (Henderson and Staz 1995). Overgrazing, fire suppression, and changes in fire intensity within the Blackland prairie led to an increase in abundance of mesquite and other woody species and decreased the dominance of historic prairie grasses. These factors begin a feedback loop as isolated mesquites and other woody species serve as recruitment foci for bird-disseminated seeds, leading to an ever-increasing number of islands and eventually to thickets of woody species (Archer et al. 1988). Interruption of these landscape-scale processes leads to extensive species loss and could be the single greatest cause of species extinction in the North American prairie (Leach and Givnish 1996).

Fire was definitely a landscape scale disturbance -- historic records of prairie wildfires indicate that tens of thousands of acres would burn at one time, and fires could travel up to 125 miles in a single day (Reichman 1987, Smeins 1980, Smeins 1982) -- both fire and soil properties play a role on a microhabitat scale. The effects of fires on a micro-scale are patchy, often determined by slope, moisture conditions, and micro-topography (Diggs et al. 1999, Madson 1982). Plant species diversity seems to be maximized under a combination of natural disturbance regimes, probably resulting from creation of a mosaic of micro-niches in areas receiving multiple, often patchy, disturbance (Collins and Barber 1985).

Despite the fact that a fire could easily have burned from Waco to the Red River, within the area burned there would be areas untouched by fire, some areas burned only lightly and quickly, and other areas where the first inch of soil could actually be sterilized by heat of the fire (Cole et al. 1992, Collins et al. 1975, Wright and Bailey 1977, Wright and Bailey 1982). This patchy nature of fire disturbance is very important to overall habitat diversity on the prairie, as fire creates a variety of habitats and refugia for fire intolerant species. Refugia are reported to be critically important, particularly for insects with limited dispersal ability (Henderson and Staz 1995, Leach and Givnish 1996). Most insect population densities decline on burned sites the first year following a burn (with the exception of highly mobile herbivorous insects such as those in the order Orthoptera), but rebound to pre-burn or greater levels by the second year as long as there are individuals from unburned sites that can recolonize the area (Anderson et al. 1989, Cancelado and Yonke 1970, Packard and Mutel 1997). A few species of prairie restricted

Lepidoptera were adversely impacted by burns for up to 5 years, but it is not clear if nearby refugia had been adequately preserved in the study (Swengel 1996).

Soil characteristics also contribute to microhabitat changes. Changes in elevation of only a few centimeters can lead to differences in soil moisture content, soil temperature, and shelter for seedlings. “Mima mounds,” are circular, micro-hills 1 to 14 meters in diameter and 10 to 150 meters in height and common on unplowed prairies over Alfisols. In some areas of Blackland prairie, mima mounds cover 25% of the landscape and offer ecologically significant resource niches based on water and nutrient differences (Collins 1975). Gilgai or “hog wallows” are depressions of up to 40 centimeters deep and several meters across which are common in unplowed prairies over Vertisols. Gilgai are caused by the extensive shrink/swell capacity of the clays making up the Vertisol soil association (Hallmark 1993). Gilgai offer different ecologically significant niches through two different mechanisms (Miller and Smeins 1988). First, the depressions may hold water for weeks at a time, particularly in the early spring. As these depressions dry out, the clays shrink, creating large cracks in the soil. Organic matter falls into these cracks, leading to greater subsurface expansion when the clays swell with moisture. The subsurface materials are forced away from the original fissure and up towards the surface, leading to a continual process of disturbance at the rim of the gilgai (Diggs et al. 1999, Hallmark 1993). This highly disturbed rim offers excellent habitat for many “weedy” annual or short-lived perennial prairie species that might otherwise not be observed in a mature prairie (Diamond and Smeins 1993, Diggs et al. 1999).

Restoration of the North American Prairie

For over 50 years, efforts have been underway to restore or recreate prairie ecosystems on land where they had previously existed (Cottam 1987, Cottam and Wilson 1966, Jordan III 1994, Jordan III et al. 1987, Sperry 1983), making prairie restoration one of the oldest attempts at deliberate reconstruction of ecological communities (Packard and Mutel 1997). Prairie restoration forms the basis for much of restoration research due to both the increasing rarity of prairie ecosystems (Burton et al. 1988) and the relatively rapid pace in which the major species associated with these systems can be established (Jordan III et al. 1987, Packard and Mutel 1997). Early work undertaken at the University of Wisconsin Arboretum in Madison, Wisconsin, demonstrated the importance of disturbance, particularly fire, to many ecological systems. Curtis and Partch, working on what has come to be know as the Curtis Prairie at the UW Arboretum, were among the first to demonstrate the importance of fire in weakening non-prairie species and favoring native prairie species (Curtis and Partch 1948, Curtis and Partch 1950). Prescribed burning, however, did not really become an accepted management tool in ecosystems until after the “Leopold Report” (Leopold et al. 1963), spear-headed by Aldo Leopold’s son, A. Starker Leopold (Wright and Bailey 1982).

Interest in restoring ecosystems increased as The Nature Conservancy and other conservation-oriented land owners realized the importance of managing their lands (Packard 1985). Communities within the great plains significant loss in human population numbers in the 1980’s due to emigration to outside of the region, often leaving abandoned and degraded agricultural land behind (Flores 1996). The possibility exists for much of these degraded lands to be restored if we can find a way to do so that is both economically and ecologically effective.

Few prairie restoration projects have been carried out in Texas (Burleson and Burleson 1995, Eidson 1996, Pace III et al. 1988, Riskind 1975, Steigman and Overden 1988, Walther and Mahler 1988), and only one of these (Eidson 1996) was a controlled experiment.

The Current Study

The purpose of this study was to ascertain if significant changes community composition could be initiated on degraded blackland prairie habitat at a very limited economic investment. The study sought to assess the possibility that species could recover through changes in land management without necessitating seeding.

The study site is land administered by the U.S. Army Corps of Engineers (USCOE) downstream from Lake Lewisville dam in the southeast corner of Denton County, on the edge of the eastern cross timbers but within blackland prairie. The study site property is managed as the Lake Lewisville Environmental Learning Area (LLELA) by a consortium composed of USCOE, the University of North Texas, the Lewisville Independent School District, and various other partners. The property is managed to promote four key areas: environmental education, preservation, environmental restoration, and research.

The climate of Denton County is warm temperate and humid with average annual rainfall of 32 inches (81.28 cm). USCOE recording stations at nearby Lake Grapevine report total annual rainfall was 35.93 inches (91.26 cm), 46.84 inches (118.97 cm), and 31.45 inches (79.88 cm) respectively for the 3 years of the study (Figure 3).

The prairie restoration experiments site is on Vertisols, composed of soils in the Branyon-Burleson-Heiden association with a 1 to 5 % slope (Ford and Pauls 1980) and would be expected to have historically supported a Little bluestem-Indiangrass plant community association (Diamond et al. 1987, Diamond and Smeins 1993, Diggs et al. 1999). Within this plant community association, the major grass species in addition to little bluestem and Indiangrass were big bluestem, sideoats grama (*Bouteloua curtipendula*), tall dropseed, Texas cupgrass (*Eriochloa sericea*), and Texas speargrass *(Nassella leucotricha)* (Diamond and Smeins 1993). It would also not have been uncommon to find a number of woody species including post oak (*Quercus stellata*), live oak (*Quercus virginiana*), cedar elm (*Ulmus crassifolia*), eastern red cedar *(Juniperus virginiana*), and even mesquite (*Prosopis glandulosa*) present in this association, but these were primarily limited to slopes protected from burning or in bottomland hardwood stands that were the historical vegetation type along stream and river channels (Diggs et al. 1999, Wells 1970). The actual number of woody individuals within a prairie at any time is related to moisture trends over numerous years, with prairies frequently colonized by woody species in wet years, and woody species being killed by drought or fire in dry years (Madson 1982, Smeins 1982). Some accounts suggest that mesquite may have been "common" in blackland prairies at the time of settlement (Diamond and Smeins 1993), but other accounts suggest mesquite was restricted to riparian areas (Diggs et al. 1999). Both accounts agree, however, that mesquite was generally much less dense than is now common in much of north Texas, including the study site. The mesquite thickets

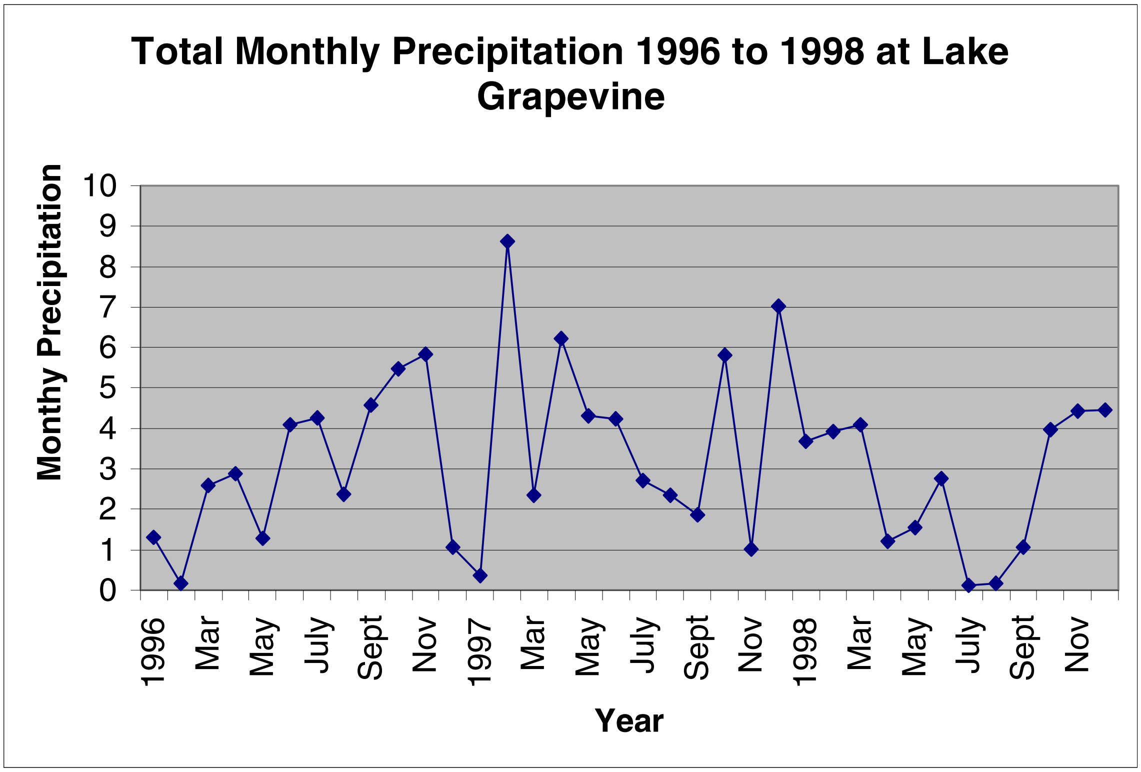

Figure 3. Total monthly precipitation (inches) at the Lake Grapevine USCOE sampling station.

common today seem to be a specific result of overgrazing (Smeins 1982). The Little bluestem-Indiangrass community is regarded as highly endangered and in the highest need of conservation in Texas (Diamond et al. 1987).

The approximately 800 hectares (2000 acres) of USCOE land that comprises LLELA is gently rolling with approximately 570 lowland hectares consisting of bottomland hardwood forests dominated by cedar elm (*Ulmus crassifolia*) oak (*Quercus* spp.), hackberry (*Celtis* spp.), pecan (*Carya* spp.) and ash (*Fraxinus* spp.) and 230 upland hectares of grassland dominated by King ranch bluestem (*Bothriochloa ischaemum*), Bermuda grass (*Cynodon dactylon*) , and Johnsongrass (*Sorghum halepense*), all exotic species. The experimental prairie study site itself is a 8 hectare tract of upland initially dominated by King ranch bluestem, tall dropseed (*Sporabilis compositus*), silver bluestem (*Bothriochloa laguroides*), and Johnsongrass. Of the two native grass species remaining on the site in large quantities, both are indicative of disturbed systems (Collins et al. 1975, Diggs et al. 1999). The site also initially had a large component of mesquite, but comparatively much less than was found on several other tracts at LLELA. This reduction in the overall quantity of mesquite is most likely due to a wildfire that burned across the site in 1988, which would have killed some of the mesquite on the site. A back-slope site adjacent to the study site – that would have been protected from a wildfire originating from the south – had a significantly greater density of mesquite. Whereas the site had a diversity of forbs, broomweed (*Gutierrezia dracunculiodes*) – a native composite indicative of overgrazing (Diggs et al. 1999) – was by far the dominant non-grass species. The experimental site has not been grazed for at least 40 years. Previous to the study, it had not undergone any significant natural recovery towards climax prairie vegetation. This concurs with other studies demopnstrating that long term grazing eliminates perennial grass species from the soil seed bank, making natural recovery slow or impossible (Kinucan and Smeins 1992, Packard and Mutel 1997).

This research sought to modify community composition on the site to have greater resemblance to that of a Little bluestem-Indiangrass series native blackland prairie community. Because both dominant grass species were completely absent from the site, it was determined that some seeding would be necessary. Following recommendations of Packard and Ross (1997), it was decided that soil disturbance, such as tilling, should be minimized when adding missing species via seed. The site still retained a moderate native forb diversity. Disturbing the soil would be expected to adversely impact perennial species already on the site (McGinley and Tilman 1993, Packard and Ross 1997, Wilson and Gerry 1995, Wilson and Tilman 1991), and would be expected to spread invasive rhizomatous exotics such as Johnsongrass (Diggs et al. 1999, Packard and Ross 1997). Because prairies are disturbance driven communities, it was likely that some management, in addition to seeding, would be necessary to alter community composition to that desired (Packard and Mutel 1997). This study used late winter burning and mowing as disturbance methods. Both methods would be expected, over the short term, to have similar results: increasing light at the soil surface, resulting in higher germination rate of seeds, and an enhanced ability of young plants to compete with already established species (Collins et al. 1998, Henderson and Staz 1995, Joshi and Matthies 1996, McGinley and Tilman 1993, Packard and Ross 1997, Smeins 1973, Welch 1982, Wilson and Shay 1990). Unseeded disturbed plots should result in an increased abundance of annuals and "weedy" perennials which are typically over-represented in the seed bank (Johnson and Anderson 1986). Evidence suggests little bluestem has greater biomass on annually or biennially burned plots than on plots that were not burned (Niering and Dreyer 1989). Of the three exotic grasses on the site, at least one, Japanese brome (*Bromus japonicus*) should be retarded by either mowing or burning if treatments were to be sustained for several years (Diboll 1986, Willson and Stubbendieck 1997). Because of the patchy nature of prescribed burns, fire would be expected to produce a greater number of micro-niches than either the control or mowed plots. Because of this, and the fact that native species evolved with fire, these plots would be expected to have greatest overall diversity (Collins and Gibson 1990). We expect the overall effect to be that seeded, disturbed plots have a greater dominance of little bluestem and Indiangrass and, particularly on burned plots, greater overall native species diversity. When community composition is looked at according to functional groupings or guilds, disturbed plots should have greater coverage by C_4 grasses, and summer and fall forbs, but fewer spring forbs, C_3 grasses, and annuals (Howe 1994a, Howe 1994b, Howe 1995, McCarty et al. 1996).

Specific research objectives for this study included:

- determine the effectiveness of seeding to increase plant species richness;
- determine the effectiveness of mowing and burning, with or without seeding, to increase native plant species diversity and modify community structure toward a C_4 grass dominated system;
- document mowing and burning effects on Johnsongrass and King ranch bluestem.

METHODS

All mesquite on the study site was mechanically removed using a bobcat tractor with hydraulic shears in January 1996. Stumps were then sprayed with a mixture of triclopyr (Remedy©) and diesel fuel at recommended proportions. In the soil, the half-life is from 30 to 90 days, depending on soil type and environmental conditions, with an average of about 46 days. Triclopyr rapidly breaks down to an acid, which in turn is neutralized to a salt. Triclopyr does not strongly adsorb to soil particles, so it has the potential to be mobile, but it is rapidly degraded by soil micro-organisms (TEC 1998).

The cleared site was then divided into thirty-nine 40 by 40 meter plots. Mowed five meter wide access routes were retained between plots. Due to plot abnormalities, two of the 39 plots were reduced in size to 20 by 40 meters. With the exception of these two plots which were assigned to be controls, all other plots had treatments assigned using a stratified random design. Soil type, slope and moisture were homogenous across the site.

In early May 1996, 18 plots were mowed and then seeded (Figure 4) using a Tye no-till drill at a rate of ten pounds of pure live seed (pls) per acre. The species and relative proportion within the seed mix are listed in Table 2. Seed stock was obtained from Native American Seed which had harvested the bulk of the seed from within 25 miles of the study site. Pure live seed determinations were performed by the Texas Department of Agriculture's Seed Laboratory in Stephenville, Texas.

Figure 4. Layout of replicate treatments across the restoration study site.

Table 2. Seed mix in pounds pure live seed (pls) and percentage of the total weight. Asterisks indicate approximated pounds pls.

Species	Common	Pounds pls	% Total
Tripsacum dactyloides	Gammagrass, Eastern	18	25.13%
Sogastrum nutans	Indiangrass	12	16.75%
Schizachyrium scoparium	Bluestem, little	10.39	14.50%
Bouteloua curtipendula	Grama, Side-oats	10	13.96%
Panicum virgatum	Switchgrass	10	13.96%
Leptochloa dubia	Sprangletop, Green	5	6.98%
Desmanthus illinoensis	Bundleflower, Illinois	1.25*	1.74%
Gaillardia pulchella	Firewheel	1*	1.40%
Andropogon glomeratus	Bluestem, bushy	0.5*	0.70%
Chamaecrista fasciculata	Partridge-Pea	0.5*	0.70%
Coreopsis tinctura	Coreopsis, Plains	0.5*	0.70%
Dracopis amplexicaulis	Cone flower, Clasping	0.5*	0.70%
Centaurea americana	Basketflower	0.25*	0.35%
Echinacea purpurea	Coneflower, Purple	0.25*	0.35%
Engelmannia persistenia	Daisy, Cutleaf	0.25*	0.35%
Helianthus maximiliani	Sunflower, Maximilian	0.25*	0.35%
Monarda citriodora	Horse Mint	0.25*	0.35%
Rudebeckia hirta	Black-eyed Susan	0.25*	0.35%
Asclepias texana	Milkweed, Texas	0.125*	0.17%
Dalea purpurea	Prairie Clover, Purple	0.125*	0.17%
Elymus virginicus	Wildrye, Virginia	0.125*	0.17%
Vernonia baldwinii	Ironweed, Western	0.125*	0.17%
	Total	71.64	100.00%

Due to extreme wet weather conditions in the Winter of 1997, management treatments of burning and mowing could not be undertaken. Consequently it was not until February 1998 that five of the seeded plots and four of the unseeded plots were successfully burned, six of the seeded plots and six of the unseeded plots were mowed, leaving seven seeded plots without treatment, and eleven (including the 2 half plots) unseeded plots as true controls (Table 3). The location of the various treatments on the site can be seen in Figure 4.

Table 3. Number and type of treatments installed between May 1996 and February 1998.

	Burn	Mow	No Maintenance	**Total**
Seeded	5	6	7	18
No Seed	4	6	9 (+2)	19 (+2)
Total	9	12	16 (+2)	37 (+2)

Sampling

Beginning in 1996, vegetation on each plot was sampled twice a year, once in late June, and a second time in late September. All plots were sub-sampled using a stratified random design resulting in nine sub-replicates for each 40 by 40 meter plot, and five sub-replicates for the two 20 by 40 meter plots. Each sub-replicate point was determined by beginning 20 meters in along the southern plot boundary, going north four meters, then a predetermined random distance between one and 19 meters to the west. Once that sub-replicate was completed, return to the center line of the plot, proceed four meters to the north and then a predetermined random distance between one and 19 meters to the east. This process was repeated to gather a total of nine sub-replicates per plot (Figure 5). Unique sub-replicates were selected with each sampling period.

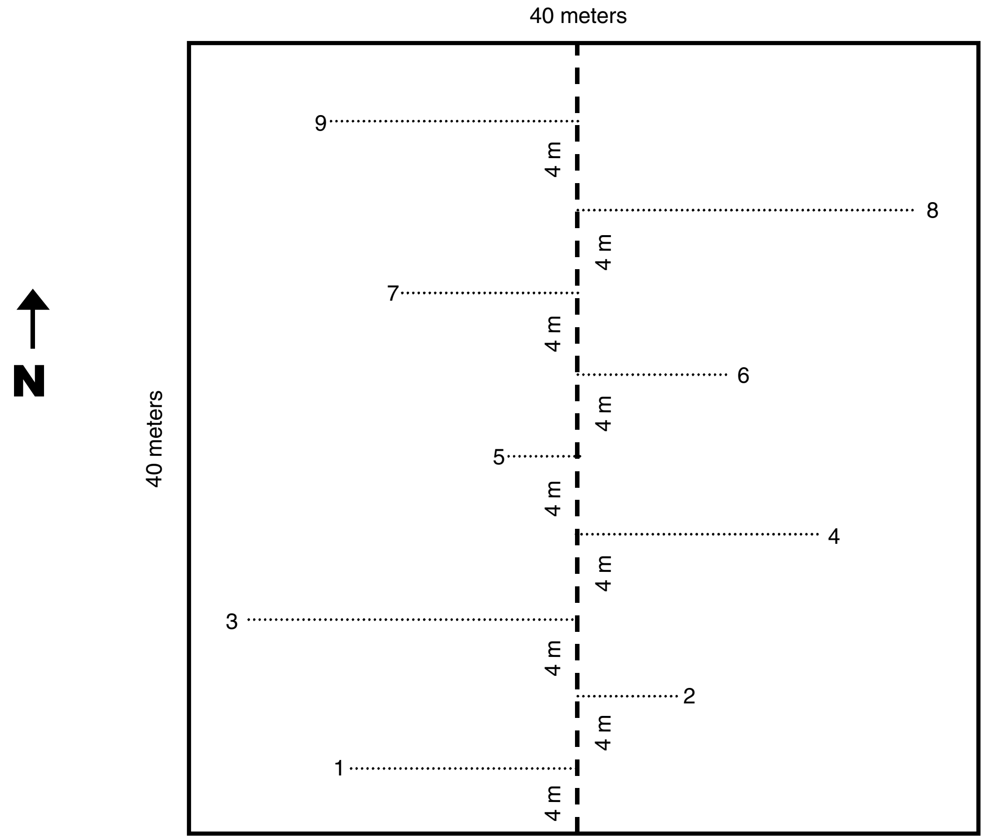

Figure 5: Idealized stratified random sampling design used to locate sub-replicate points.

Using a 20 by 50 cm frame (Daubenmire 1959), three metrics for each plant species were recorded at each sub-replicate: percent cover, shoot count, and average height. Percent cover was estimated to the nearest 3% using a grid suspended above the 20 by 50 cm frame. Each grid square corresponded to 3% of the frame area (Figure 6). Shoot count was accomplished by counting each living vegetative projection from the ground. For large grass clumps, a representative quarter of the clump was counted and then multiplied by four to estimate total shoot count. The average height for individuals within a species was visually estimated and recorded. Only shoot count data were analyzed in this study, as shoot count and percent cover were highly correlated and counts were the most reliable data gathered. Even with the specially designed Daubenmire frames (Figure 6), estimation of percent cover was of questionable consistency among field workers.

In addition to analyzing individual species responses to treatments, species were categorized into guilds. Guilds are defined as groups of species that exploit resources in a similar way and therefore presumably overlap in their niche requirements (Root 1967). Guild categorization has been widely applied to animal species (Simberloff and Dayan 1991). Simberloff and Dayan (1991) argued that guilds usefully summarize ecological communities as long as guild classifications are based on explicit criteria and the separation of sympatric related biota into different guilds are justified. Studies have justified use of guild theory in assessing community responses to changes in environmental resources and overall condition (Kindscher and Tieszen 1998, Severinghaus 1981). For this study, all guild assignments were made following Kindscher (Kindscher 1994, Kindscher and Wells 1995). Kindscher categorized prairie

Figure 6: Photo of the modified Daubenmire frame used to estimate vegetation metrics.

species into nine guilds (C_4 grasses, C_3 grasses and sedges, annuals and biennials, ephemeral spring forbs, spring forbs, summer/fall forbs, legumes, woody species, and exotics). Kindscher found that analyzing prairie communities using this structure more clearly described community shifts. Species were categorized into their representative guilds based on 32 ecological and morphological traits using detrended correspondence and cluster analyses to justify groupings (Table 4). In those cases where species were present in this study, but not classified by Kindscher, we used the classification of other species within the same genus. Species in this study represented only eight of the nine guilds, lacking any representatives in the ephemeral spring forb guild. The absence was most likely due to the late spring sampling. Because of mechanical removal during the first year, only one woody species, poison ivy (*Toxicodendron radicans*), was identified. Shoot count data for all sub-replicates over all sampling periods are included in Appendix B and C. Spring perennial forb, summer/fall perennial forb, legume, and woody plant guilds are given in Appendix B, and C_3 grass, C_4 grass, exotic and annual plant guilds are listed in Appendix C.

Table 4. The guild classification used for the 52 species identified on the study site.

Guild	Scientific Name	Common Name
Annual	*Agalinis heterophylla*	Agalinis, Prairie
Annual	*Ambrosia artemisifolia*	Ragweed, common
Annual	*Croton monanthogynus*	Prairie tea
Annual	*Eryngium leavenworthii*	Eryngo
Annual	*Euphorbia bicolor*	Snow on the prairie

Guild	Scientific Name	Common Name
Annual	*Gaillardia pulchella*	Firewheel
Annual	*Glandularia bipinnatifida*	Verbena, Dakota
Annual	*Gutierrezia dracunculiodes*	Broomweed
Annual	*Helianthus annuus*	Sunflower, Common
Annual	*Helianthus maximiliani*	Sunflower, Maximilian
C3	*Dicanthilium* sp.	Rosettgrass
C3	*Elymus virginicus*	Wildrye, Virginia
C3	*Nassella leucotricha*	Spear grass
C4	*Andropogon glomeratus*	Bluestem, Bushy
C4	*Andropogon virginicus*	Bluestem, Broomsedge
C4	*Aristida* spp.	Three-awn
C4	*Bothriocloa laguroides*	Bluestem, Silver
C4	*Bouteloua curtipendula*	Grama, Side-oats
C4	*Panicum capillare*	Witchgrass, Common
C4	*Panicum virgatum*	Switchgrass
C4	*Schizachyrium scoparium*	Bluestem, Little
C4	*Sogastrum nutans*	Indiangrass
C4	*Sporobolus compositus*	Dropseed, tall
Exotic	*Bothriocloa ischaemum*	Bluestem, King ranch
Exotic	*Bromus japonicus*	Brome, Japanese
Exotic	*Sorghum halepense*	Johnsongrass

Guild	Scientific Name	Common Name
Legume	*Desmanthus illinoensis*	Bundleflower, Illinois
Legume	*Neptunia lutea*	Yellow Puff
Spring	*Centaurea americana*	Basketflower
Spring	*Coreopsis tinctura*	Coreopsis, plains
Spring	*Eustoma grandiflorum*	Blue Bell
Spring	*Gaura* sp.	Guara
Spring	*Oenothera biennis*	Primrose, Evening
Spring	*Oxalis stricta*	Sorrel, Wood
Spring	*Phlox drummondii*	Phlox
Spring	*Plantago heterophylla*	Plantain
Summer/Fall	*Asclepias texana*	Milkweed, Texas
Summer/Fall	*Aster ericoides*	Aster, Heath
Summer/Fall	*Baccharis neglecta*	Baccharis
Summer/Fall	*Brickellia eupatorioides*	Boneset, False
Summer/Fall	*Cirsium texanum*	Texas Thistle
Summer/Fall	*Dracopis amplexicaulis*	Cone flower, Clasping
Summer/Fall	*Hedyotis nigricans*	Prairie Bluets
Summer/Fall	*Liatrus mucronata*	Gayfeather
Summer/Fall	*Monarda citriodora*	Horse Mint
Summer/Fall	*Rudebeckia hirta*	Black-eyed Susan
Summer/Fall	*Solanum elaeagnifolium*	Trompillo

Guild	Scientific Name	Common Name
Summer/Fall	*Solidago ulmifolia*	Goldenrod, Elm-leaf
Summer/Fall	*Tragia brevispica*	Noseburn, Short-spike
Summer/Fall	*Vernonia baldwinii*	Ironweed, Western
Woody	*Toxicodendron radicans*	Poison Ivy

Statistical Analysis

In all statistical analyses performed, statistical significance (α level) was reserved for probabilities less than 0.05.

To assess overall change in community composition, cumulative shoot count values for all guilds were compared using multivariate analysis of variance (MANOVA). Because most guilds were not normally distributed, ranked values were analyzed.

Two-way analysis of variance were used to test the hypothesis that shoot counts for individual species or guilds and species richness were significantly affected by seeding and management treatment. The data are significantly different from a normal distribution vegetation (Shapiro Wilk, $p > 0.0001$ for all species) due to the large number of zeros in the dataset – a common occurrence with vegetation data. Because of this, individual species shoot count data were ranked before. Where significant effects were indicated among the three management treatments, a Student-Neman-Keuls (SNK) multiple range test was performed to separate treatments into groups. Similarly, because species richness and shoot counts by guild data were also significantly different from normal (Shapiro Wilk, $p > 0.0001$), they were ranked statistical analyses were performed. Above statistical analyses was performed using PC-SAS version 6.04.

A log-likelihood contingency test was used to compare expected to actual frequencies of species richness within guilds under both seeding options and three management techniques. Because sample size within each treatment varied, average richness within each guild was used to remove the effect of unbalanced sample design.

Two ordination methods were performed using CANOCO for Windows©: redundancy analysis (RDA) and canonical correspondence analysis (CCA). As discussed below, whereas both analyses were performed for consistency and comparison purposes, one is typically more appropriate than the other for a given dataset (ter Braak and Smilauer 1998, ter Braak and Verdonschot 1995, Verdonschot and ter Braak 1994). For the CANOCO analysis, the independent variables used were seeded, not seeded, mowed, burned, and no maintenance (termed 'control' in the output) and year and season included as co-variables.

Both ANOVA and MANOVA assume data are normally distributed with similar variances (or covariance matrices) among groups. By ranking the data, these parametric tests become, in effect, non-parametric and allow for robust, distribution-free analysis. An ANOVA tests means of two of more samples by comparing within group variation to among group variation to determine if the groups could have been drawn from the same population (Ambrose III and Ambrose 1995, Sokal and Rohlf 1995). After an ANOVA determines there is a difference among groups, a multiple range test can be used to describe differences among the groups.

MANOVA compares mean vectors of a matrix of variables by creating within- and among- group covariance matrices. There are four MANOVA test statistics calculated by SAS: Wilks' Lambda, Hotelling-Lawley trace, Pillai's trace, and Roy's largest root test (SAS Institute 1990). All MANOVA test statistics have the same alpha error rate, but differ in the probability of rejecting a false null hypothesis (Rencher 1995). The most powerful test is dependent on the configuration of the mean vectors in an *s*-dimensional space, with *s* being the number of dependent variables assessed. If there is one large eigenvalue and the others are small, the mean vectors lie close to a line in space, if there are two large eigenvalues, the mean vectors lie mostly in two orthogonal dimensions, and so on. If there is only one large eigenvalue, Roy's test is most powerful because it uses only the largest eigenvalue. The other tests are more powerful than Roy’s when there are several large eigenvectors. Roy's test is not recommended except when variables are colinear and under standard assumptions. In MANOVA results reported below, Roy’s test never indicated significance when the other three did not, even when there was only one primary eigenvector. For this reason, probabilities from the Wilks’ Lambda test, a conservative estimator of effect, are reported throughout this study. Wilks' test statistic compares within group sum of squares and products matrix to the total sum of squares and products matrix in a manner very similar to the univariate F-test (Rencher 1995). Unlike ANOVA, there is no multiple range test for MANOVA. Because of this, MANOVA can only determine if there is indeed a difference among groups – it cannot describe that difference without individual post-hoc comparisons among sets of means.

Both ANOVA and MANOVA tests assume normal or multivariate normal distributions. Ranking data for an ANOVA effectively makes this test distribution-free (non-parametric), but it is not clear that this is as effective in a MANOVA. Fortunately, MANOVA, like many other parametric tests, is very robust in relation to departures from normality (Rencher 1995). But because there is some question as to the appropriateness of applying MANOVA to multivariate non-normal data, redundancy analysis (RDA) and canonical correspondence analysis (CCA) were also performed.

Redundancy and canonical correspondence analyses are actually closer to a multiple regression analysis than MANOVA because it ties changes in dependent variables (species) to changes in combinations of independent environmental variables. RDA tests are used to construct linear models, while CCA is used for non-linear, unimodal models. For analyzing vegetation data, both RDA and CCA are more effective than multiple regression analysis because multiple regression analyses examine one species at a time, do not function well with large numbers of zero counts for dependent variables (a condition common in vegetation data), RDA and CCA allow environmental variables to be correlated, and if using CCA, relationships need not be linear (ter Braak and Smilauer 1998).

RDA and CCA are direct gradient analyses used to relate taxonomic group or species occurrences or abundance to environmental variables recorded in conjunction with the species. Direct gradient analyses construct synthetic gradients from environmental data to maximize niche separation (variance maximizing) among species (ter Braak and Prentice 1988, ter Braak and Verdonschot 1995). CCA assumes that species have a range of tolerance to recorded environmental variables (a realized niche) and that species tolerance responses are unimodal. If the response is not unimodal, it typically indicates that the gradient of change in environmental variables was not large enough to observe the species' entire tolerance range, and a linear model such as RDA should be used. In both analyses, species and environmental variables can be discretely plotted in two-dimensional niche space so that the distance (variance) among species (or other grouping) is maximized. Thus in one graph, species relationship to other species and to multiple environmental variables can be presented (ter Braak and Smilauer 1998).

The maximum gradient length associated with a standard detrended correspondence analysis (DCA), an indirect gradient technique, is used to indicate whether variables respond unimodally. A maximum gradient length of less than three standard deviations (SD) suggests that a linear model (RDA) is more appropriate than a unimodal model (CCA) (ter Braak and Smilauer 1998, Verdonschot and ter Braak 1994). But ter Braak and Verdonschot (1995) point out that even violating this assumption of unimodality only lowers the power of the test to detect relationships rather than making it invalid.

Because neither CCA nor RDA yield a test statistic whose probability can be tested, the probability associated with these tests should be assessed with a number of Monte Carlo permutations (ter Braak and Smilauer 1998, ter Braak and Wiertz 1994). In this study, all CCA and RDA tests were followed by Monte Carlo permutation tests with 199 unrestricted permutations. Monte Carlo tests are distribution-free, requiring only that samples are independent.

RESULTS

Individual Species

Fifty-two plant species were recorded over the spring an fall sampling periods in 1996, 1997, and 1998 (Table 5). Whereas only three of the 52 species are exotic (Japanese brome, Johnsongrass, and King ranch bluestem), exotic species accounted for over 43% of the total shoots counted. Other significant species include tall dropseed (19.51%), heath aster (9.86%), Illinois bundleflower (6.58 %), silver bluestem (5.93%), broomweed (4.45%), and goldenrod (3.62%).

Table 5. Total shoot counts of each species recorded in the summer and fall sampling periods, 1996 through 1998.

Scientific Name	Common Name	Total Shoot Count	Percent of Total
Agalinis heterophylla	Agalinis, Prairie	1363	1.73%
Ambrosia artemisifolia	Ragweed, common	341	0.43%
Andropogon glomeratus	Bluestem, Bushy	478	0.61%
Andropogon virginicus	Bluestem, Broomsedge	508	0.65%
Aristida spp.	Three-awn	1035	1.32%
Asclepias texana	Milkweed, Texas	233	0.30%
Aster ericoides	Aster, Heath	7743	9.86%
Baccharis neglecta	Baccharis	183	0.23%
Bothriocloa ischaemum	Bluestem, King ranch	21800	27.75%

Scientific Name	Common Name	Total Shoot Count	Percent of Total
Bothriocloa laguroides	Bluestem, Silver	4661	5.93%
Bouteloua curtipendula	Grama, Side-oats	30	0.04%
Brickellia eupatorioides	Boneset, False	78	0.10%
Bromus japonicus	Brome, Japanese	474	0.60%
Centaurea americana	Basketflower	5	0.01%
Cirsium texanum	Texas Thistle	39	0.05%
Coreopsis tinctura	Coreopsis, plains	79	0.10%
Croton monanthogynus	Prairie tea	1198	1.52%
Desmanthus illinoensis	Bundleflower, Illinois	5168	6.58%
Dicanthilium sp.	Rosettgrass	31	0.04%
Dracopis amplexicaulis	Cone flower, Clasping	65	0.08%
Elymus sp.	Wildrye	58	0.07%
Eryngium leavenworthii	Eryngo	33	0.04%
Euphorbia bicolor	Snow on the prairie	155	0.20%
Eustoma grandiflorum	Blue Bell	1	0.00%
Gaillardia pulchella	Firewheel	74	0.09%
Gaura suffulta	Raodside Guara	1	0.00%
Glandularia bipinnatifida	Verbena, Dakota	30	0.04%
Gutierrezia dracunculiodes	Broomweed	3498	4.45%
Hedyotis nigricans	Prairie Bluets	209	0.27%
Helianthus annuus	Sunflower, Common	31	0.04%

Scientific Name	Common Name	Total Shoot Count	Percent of Total
Helianthus maximiliani	Sunflower, Maximilian	93	0.12%
Liatrus mucronata	Gayfeather	1	0.00%
Monarda citriodora	Horse Mint	157	0.20%
Nassella leucotricha	Speargrass	313	0.40%
Neptunia lutea	Yellow Puff	1268	1.61%
Oenothera biennis	Primrose, Evening	8	0.01%
Oxalis stricta	Sorrel, Wood	88	0.11%
Panicum capillare	Witchgrass, Common	110	0.14%
Panicum virgatum	Switchgrass	55	0.07%
Phlox drummondii	Phlox	63	0.08%
Plantago heterophylla	Plantain	702	0.89%
Rudebeckia hirta	Black-eyed Susan	161	0.20%
Schizachyrium scoparium	Bluestem, Little	359	0.46%
Sogastrum nutans	Indiangrass	772	0.98%
Solanum elaeagnifolium	Trompillo	60	0.08%
Solidago ulmifolia	Goldenrod, Elm-leaf	2841	3.62%
Sorghum halepense	Johnsongrass	6182	7.87%
Sporobolus compositus	Dropseed, tall	15331	19.51%
Toxicodendron radicans	Poison Ivy	34	0.04%
Tragia brevispica	Noseburn, Short-spike	233	0.30%
Vernonia baldwinii	Ironweed, Western	131	0.17%

Scientific Name	Common Name	Total Shoot Count	Percent of Total
	Total	78564	100.00%

Fourty-eight species were sampled in the 1998 sampling period (Table 6). King ranch bluestem remained the single-most dominant species (28.86%) and overall exotic species concentrations remained high (37.26%). Other significant species include tall dropseed (24.03%), heath aster (8.9%), broomweed (4.52%), Illinois bundleflower (3.8%), silver bluestem (3.43%), goldenrod (2.54%), and Indiangrass (2.47%).

Table 6. Total shoot counts of each species recorded in the summer and fall sampling periods of 1998.

Scientific Name	Common Name	Total Shoot Count	Percent of Total
Agalinis heterophylla	Agalinis, Prairie	144	0.52%
Ambrosia artemisifolia	Ragweed, common	74	0.27%
Andropogon glomeratus	Bluestem, Bushy	144	0.52%
Andropogon virginicus	Bluestem, Broomsedge	148	0.53%
Aristida spp.	Three-awn	368	1.32%
Asclepias texana	Milkweed, Texas	63	0.23%
Aster ericoides	Aster, Heath	2484	8.90%
Baccharis neglecta	Baccharis	45	0.16%
Bothriocloa ischaemum	Bluestem, King Ranch	8052	28.86%
Bothriocloa laguroides	Bluestem, Silver	956	3.43%

Scientific Name	Common Name	Total Shoot Count	Percent of Total
Bouteloua curtipendula	Grama, Side-oats	30	0.11%
Brickellia eupatorioides	Boneset, False	13	0.05%
Bromus japonicus	Brome, Japanese	299	1.07%
Cirsium texanum	Texas Thistle	10	0.04%
Coreopsis tinctura	Coreopsis, plains	59	0.21%
Croton monanthogynus	Prairie tea	399	1.43%
Dicanthilium sp.	Rosettgrass	31	0.11%
Elymus sp.	Wildrye	1	0.00%
Eryngium leavenworthii	Eryngo	4	0.01%
Euphorbia bicolor	Snow on the prairie	33	0.12%
Gaillardia pulchella	Firewheel	29	0.10%
Gaura suffulta	Raodside Guara	1	0.00%
Hedyotis nigricans	Prairie Bluets	69	0.25%
Helianthus maximiliani	Sunflower, Maximilian	55	0.20%
Helianthus annuus	Sunflower, Common	18	0.06%
Liatrus mucronata	Gayfeather	1	0.00%
Monarda citriodora	Horse Mint	47	0.17%
Neptunia lutea	Yellow Puff	459	1.65%
Desmanthus illinoensis	Bundleflower, Illinois	1060	3.80%
Oxalis stricta	Sorrel, Wood	45	0.16%
Panicum capillare	Witchgrass, Common	61	0.22%

Scientific Name	Common Name	Total Shoot Count	Percent of Total
Panicum virgatum	Switchgrass	55	0.20%
Phlox drummondii	Phlox	63	0.23%
Plantago heterophylla	Plantain	582	2.09%
Dracopis amplexicaulis	Cone flower, Clasping	36	0.13%
Rudebeckia hirta	Black-eyed Susan	48	0.17%
Schizachyrium scoparium	Bluestem, Little	313	1.12%
Sogastrum nutans	Indiangrass	690	2.47%
Solanum elaeagnifolium	Trompillo	20	0.07%
Solidago ulmifolia	Goldenrod, Elm-leaf	710	2.54%
Sorghum halepense	Johnsongrass	2044	7.33%
Sporobolus compositus	Dropseed, tall	6704	24.03%
Toxicodendron radicans	Poison Ivy	7	0.03%
Tragia brevispica	Noseburn, Short-spike	57	0.20%
Glandularia bipinnatifida	Verbena, Dakota	10	0.04%
Vernonia baldwinii	Ironweed, Western	100	0.36%
Gutierrezia dracunculiodes	Broomweed	1260	4.52%
	Total	27901	100%

Because of significant variability between years and large number of zero values (even for common species) individual species were evaluated using ranked cumulative shoot counts for both sampling periods in 1998. For that period, a total of 29 of 52 species recorded were significantly affected by either seeding or management technique, with 14 of these also having significant interaction between these two independent variables (Two-way ANOVA on ranked shoot counts; Table 7).

Table 7. Two-way ANOVA probabilities for the 29 species significantly affected by either seeding, management treatment, or their interaction. Guild abbreviations are as follows: A = annual, C4 = C_4 grass, E = exotic grass, L = legume, S = spring perennial, S/F = summer/fall perennial.

Scientific Name	Common Name	Guild	Seeding	Management Treatment	Interaction
Agalinis heterophylla	Agalinis, Prairie	A	0.0868	0.0005	0.0089
Ambrosia artemisifolia	Ragweed, common	A	0.9089	0.0092	0.0357
Croton monanthogynus	Prairie tea	A	0.0196	0.0791	0.0019
Eryngium leavenworthii	Eryngo	A	0.3063	0.0129	0.3352
Euphorbia bicolor	Snow on the prairie	A	0.3918	0.0409	0.8131
Glandularia bipinnatifida	Verbena, Dakota	A	0.0214	0.0434	0.0434
Gutierrezia dracunculiodes	Broomweed	A	0.0001	0.0001	0.0043
Helianthus annuus	Sunflower, Common	A	0.0002	0.202	0.0762
Aristida spp.	Three-awn	C4	0.7175	0.0313	0.6613
Bothriocloa laguroides	Bluestem, Silver	C4	0.0957	0.0723	0.0128
Bouteloua curtipendula	Grama, Side-oats	C4	0.076	0.0375	0.0375
Schizachyrium scoparium	Bluestem, Little	C4	0.0001	0.2581	0.3276
Sogastrum nutans	Indiangrass	C4	0.0001	0.117	0.117
Bothriocloa ischaemum	Bluestem, King ranch	E	0.0014	0.0031	0.0007
Sorghum halepense	Johnsongrass	E	0.012	0.0001	0.0104
Neptunia lutea	Yellow Puff	L	0.0168	0.3309	0.9652

Scientific Name	Common Name	Guild	Seeding	Management Treatment	Interaction
Coreopsis tinctura	Coreopsis, Plains	S	0.0001	0.0105	0.0105
Oxalis stricta	Sorrel, Wood	S	0.0046	0.011	0.39
Phlox drummondii	Phlox	S	0.1666	0.0042	0.1357
Plantago heterophylla	Plantain	S	0.1891	0.0013	0.9678
Aster ericoides	Aster, Heath	S/F	0.0001	0.0003	0.0002
Baccharis neglecta	Baccharis	S/F	0.0076	0.011	0.0384
Brickellia eupatorioides	Boneset, False	S/F	0.0158	0.0223	0.0052
Dracopis amplexicaulis	Cone flower, Clasping	S/F	0.003	0.2562	0.0217
Monarda citriodora	Horse Mint	S/F	0.0907	0.0268	0.9282
Rudebeckia hirta	Black-eyed Susan	S/F	0.0001	0.0396	0.1427
Solanum elaeagnifolium	Trompillo	S/F	0.052	0.363	0.22
Solidago ulmifolia	Goldenrod, Elm-leaf	S/F	0.008	0.0001	0.0047
Vernonia baldwinii	Ironweed, Western	S/F	0.6792	0.0001	0.6785

Three grasses were significantly affected by either management treatment or seeding without significant interaction between these independent variables: three-awn, little bluestem, and Indiangrass. Two-way ANOVA's on ranked shoot counts of little bluestem and Indiangrass for both sampling periods in 1998 indicated that seeding resulted in significantly higher shoot counts ($p = 0.0001$) for both species. This same test indicated that three-awn shoot counts could be separated into two statistically distinct but overlapping groups, with mowing resulting in the greatest number of three-awn shoots (SNK multiple range test on ranked data, mow = no maintenance > no maintenance = burn). There was a significant interaction between management treatment and seeding on the two main exotic species, Johnsongrass (two-way ANOVA, $p = 0.0104$)

and King ranch bluestem (two-way ANOVA, p = 0.0007), for both sampling periods in 1998 (Figures 7, 8). Johnsongrass counts were highest on burned plots, followed by mowed plots, with no maintenance resulting in the lowest shoot count (SNK on ranked shoot counts). Johnsongrass counts were significantly greater on non-seeded plots (two-way ANOVA, p = 0.012). An SNK multiple range test on management treatments alone indicated each management treatment was statistically distinct. The effects of seeding and the management treatments on King ranch bluestem are much more complex and difficult to interpret (Figure 8). An SNK multiple range test indicated that the management treatment could be divided into two statistically overlapping groups, with highest King ranch bluestem counts occurring in no maintenance and burned plots. Lower counts occurred in burned and mowed plots (control = burn > burn = mow). King ranch bluestem counts were significantly greater on seeded rather than on unseeded plots.

Among the forbs, 10 were significantly affected by either management treatment or seeding without significant interaction between these independent variables. The ten species were eryngo, snow-on-the-prairie, horse mint, yellow puff, wood sorrel, phlox, plantain, black-eyed susan, trompillo, and western ironweed (two-way ANOVA on ranked shoot counts for both sampling periods in 1998, Table 7). Eryngo, horse mint, wood sorrel, plantain, and western ironweed shoot counts were significantly greater on mowed plots, with concentrations being equal for both burn and control (SNK mean ranked shoot counts, Table 7). The effect on snow-on-the-prairie was separated into two overlapping groups with burning and mowing having the greatest shoot counts (burn =

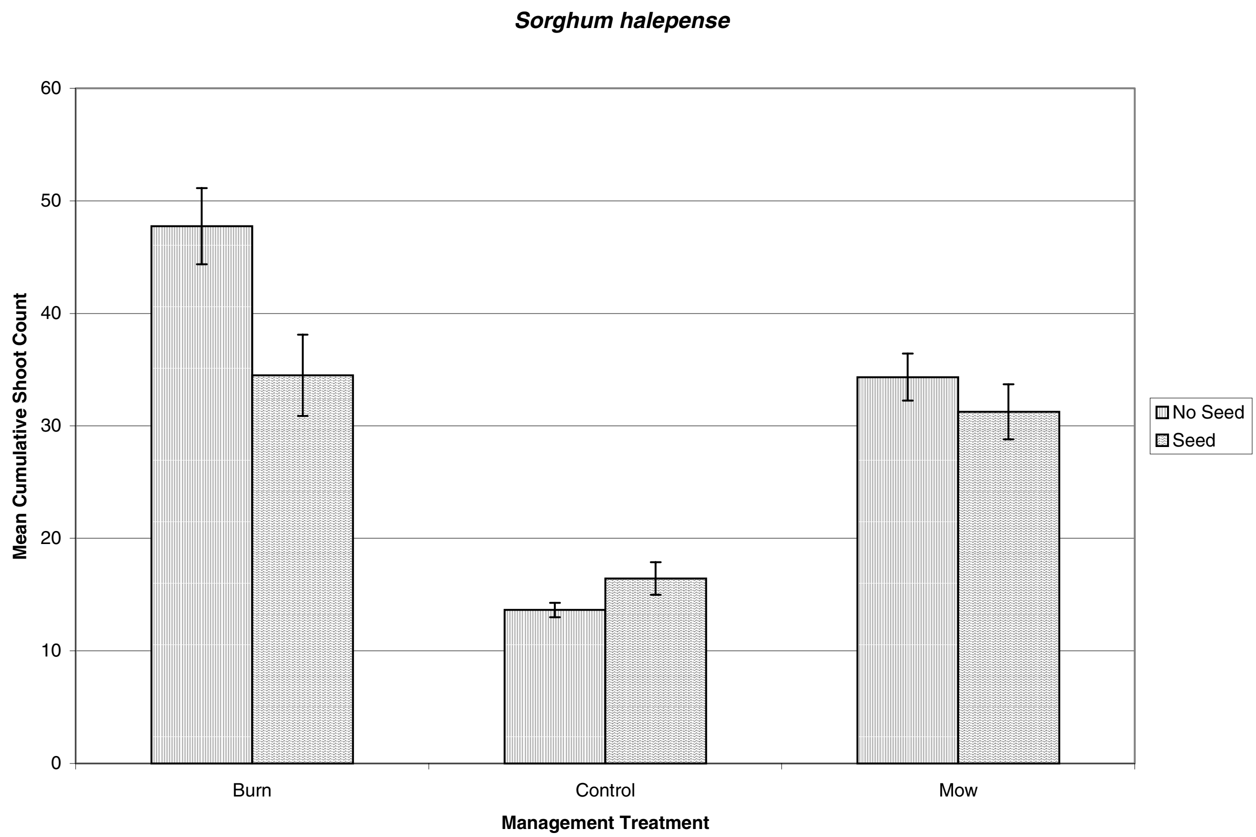

Figure 7: Mean cumulative shoot counts of Johnsongrass, *Sorghum halepense*, across three management treatments on both seeded and unseeded plots. Bars indicate standard error (n = 78).

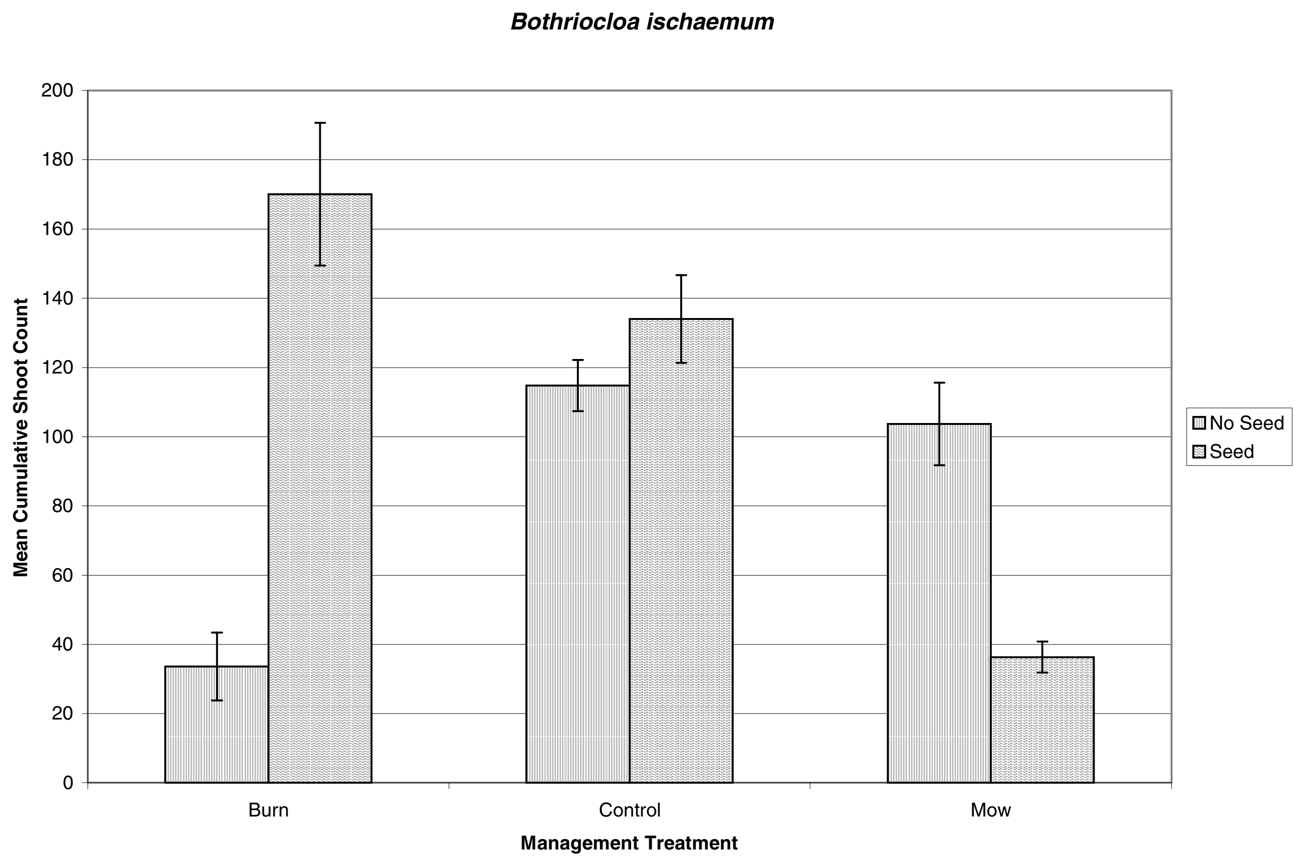

Figure 8: Mean cumulative shoot counts of King ranch bluestem, Bothriocloa ischaemum, across three management treatments on both seeded and unseeded plots. Bars indicate standard error (n = 78).

mow > mow = control). Black-eyed susan counts were significantly greater on burned or mowed plots (burn = mow > control). Yellow puff, wood sorrel, black-eyed susan, and trompillo had significantly greater concentrations on seeded plots.

Although there was an indication of significant interaction between independent variables for broomweed, heath aster, and elmleaf goldenrod, the effect of management treatments on three common species could be described. Shoot counts of broomweed were highly significantly different between treatments and between seeded and unseeded plots (Figure 9). A SNK on the ranked shoot counts showed that concentrations were significantly lower on burned plots (mow = control > burned) and significantly greater on seeded plots. Shoot counts for both heath aster and goldenrod decreased significantly on seeded plots (Figure 10). This is particularly relevant as they appear in such great numbers that they drive the results when the summer/fall perennial forb guild is considered (next section). Goldenrod shoot counts were highly significantly greater on burned plots (SNK on ranked data, burned > mow = control, Figure 11). There was significant effect of management treatments on heath aster but the SNK on ranked shoot counts was unable to distinguish among groups. Expected frequencies indicate that counts of heath aster were greater in both burned and mowed plots, and lower than expected in control plots.

Community Assessments

Three metrics were used to assess treatment effects on community composition: species richness, shoot counts by guilds, and relative density by guilds.

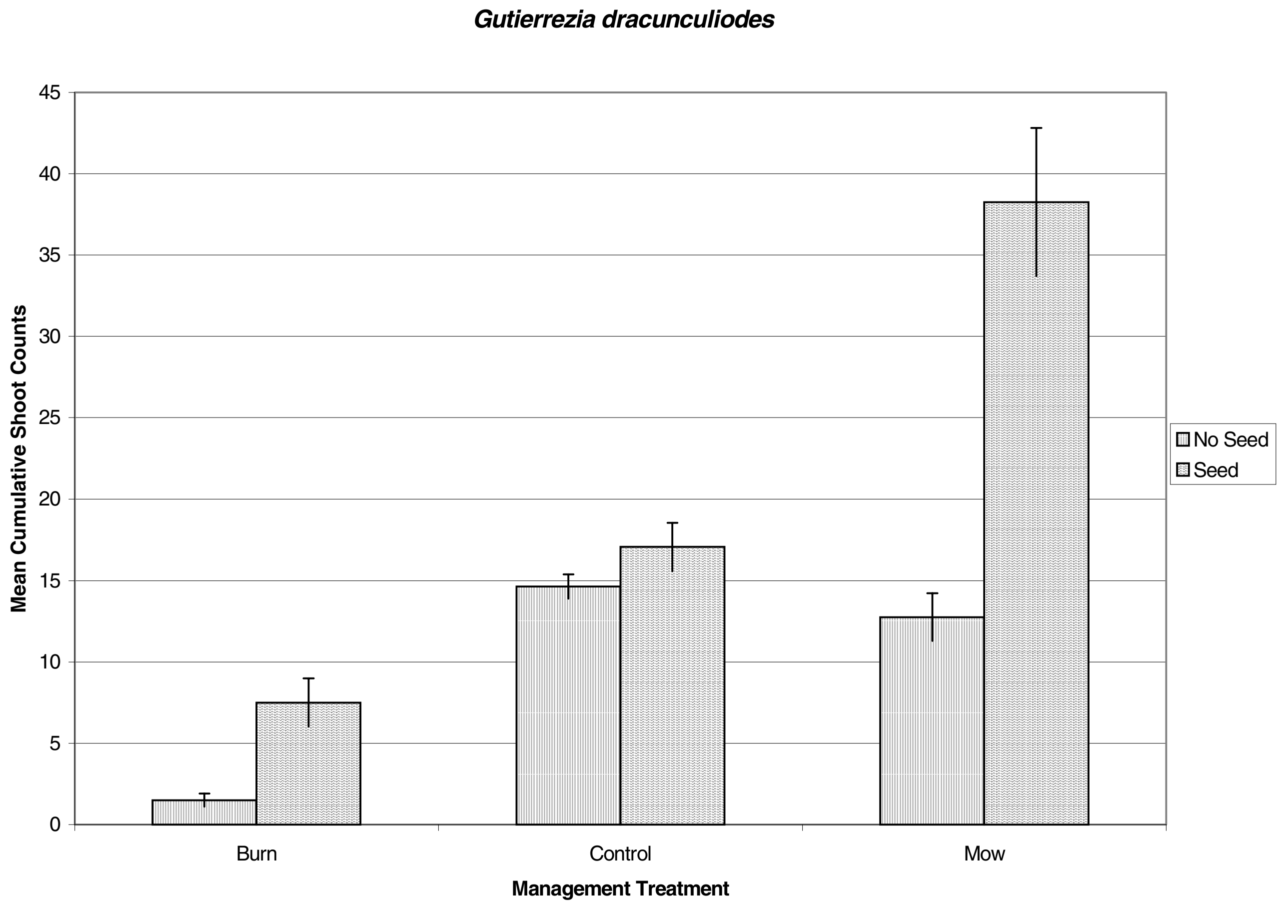

Figure 9: Mean cumulative shoot counts of broomweed, *Gurierrezia dracunculiodes*, across three management treatments on both seeded and unseeded plots. Bars indicate standard error (n = 78).

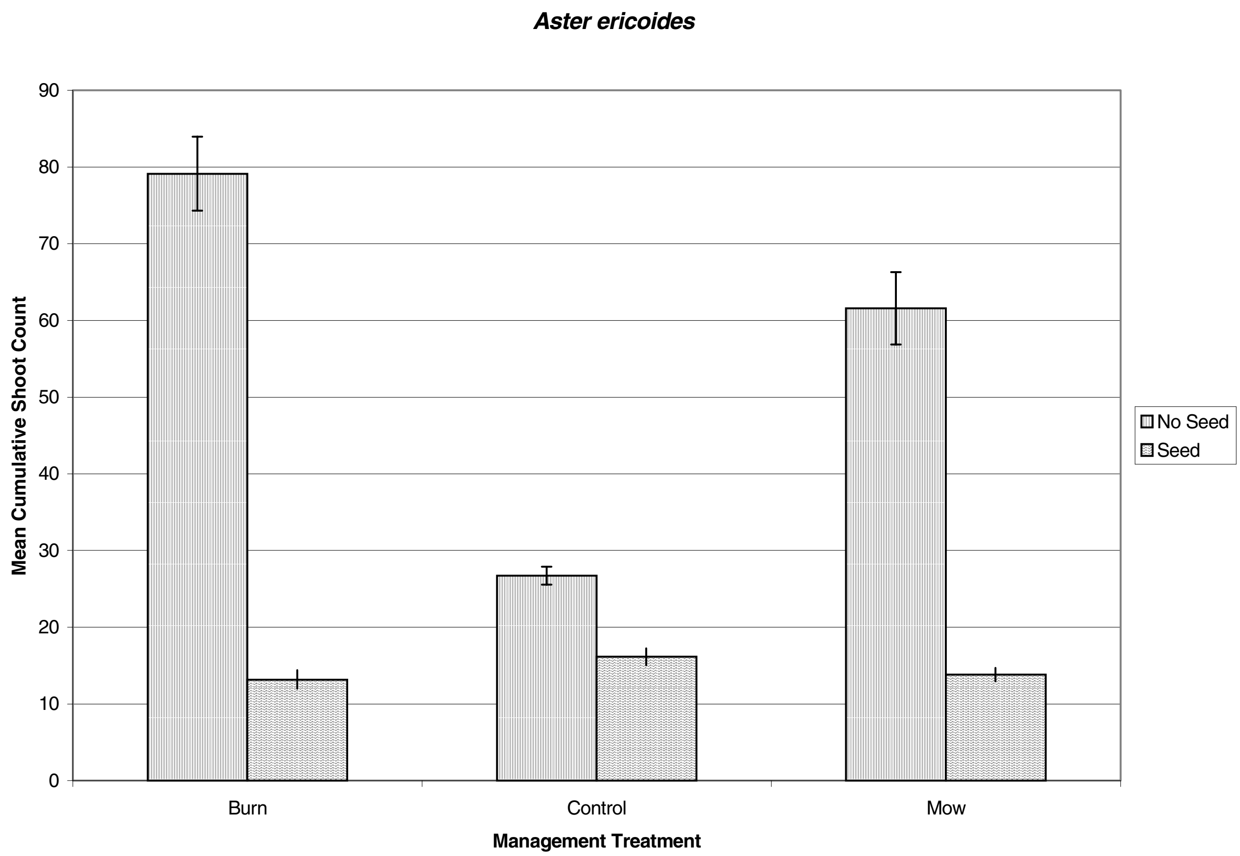

Figure 10: Mean cumulative shoot counts of heath aster, *Aster ericoides*, across three management treatments on both seeded and unseeded plots. Bars indicate standard error (n = 78).

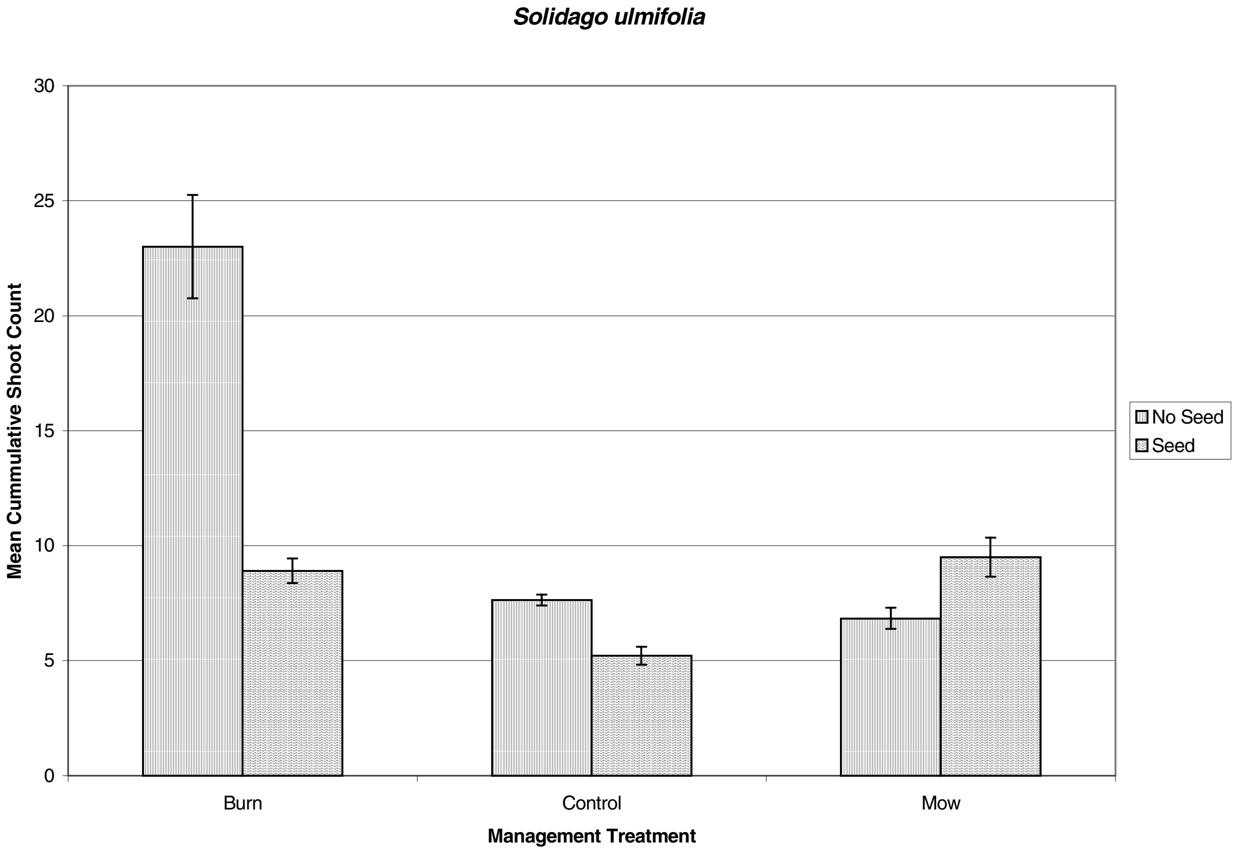

Figure 11. Mean cumulative shoot counts of elmleaf goldenrod, *Solidago ulmifolia*, across three management treatments on both seeded and unseeded plots. Bars indicate standard error (n = 78).

Species Richness

Seeding had a highly significant effect on species richness (Two-way ANOVA on ranked values, p = 0.0004) but there was not significant effect of year (p = 0.0997) or interaction between seeding and the year (p 0.4248). Whereas this interaction was not significant, an examination of species richness across years (Figure 12) shows that average species richness on seeded plots increased every year while richness on unseeded plots remained fairly constant. In evaluating species richness in each plot for all years and both seasons, there was considerable difference in richness between seasons and among years (Kruskal-Wallace, p = 0.0001). Greatest richness occurred in the spring. An SNK multiple range test on ranked richness data separated the sampling periods into four groups, two of which overlapped (Spring 1997 = Spring 1998 > Spring 1996 > Fall 1998 = Fall 1996 > Fall 1996 = Fall 1997). Seeding and management treatment had a significant effect on species richness with no significant interaction (Two-way ANOVA on rancked richness data for 1998, p = 0.020, 0.0245, 0.2643, Figure 13). Species richness was higher on seeded plots. There were two statistically overlapping effects on species richness resulting from management treatments. Highest richness occurred in mowed plots (SNK, mow = burn > burn = control). Burning had a negative effect on species richness on unseeded plots, but a positive effect on seeded plots and mowing had a positive effect on both seeded and unseeded plots (Figure 13).

Log-likelihood contingency tests indicated that total species richness and species richness within each guild were not significantly different under either seeding or management treatments (p >> 0.05). Because of the unbalanced sample design, the

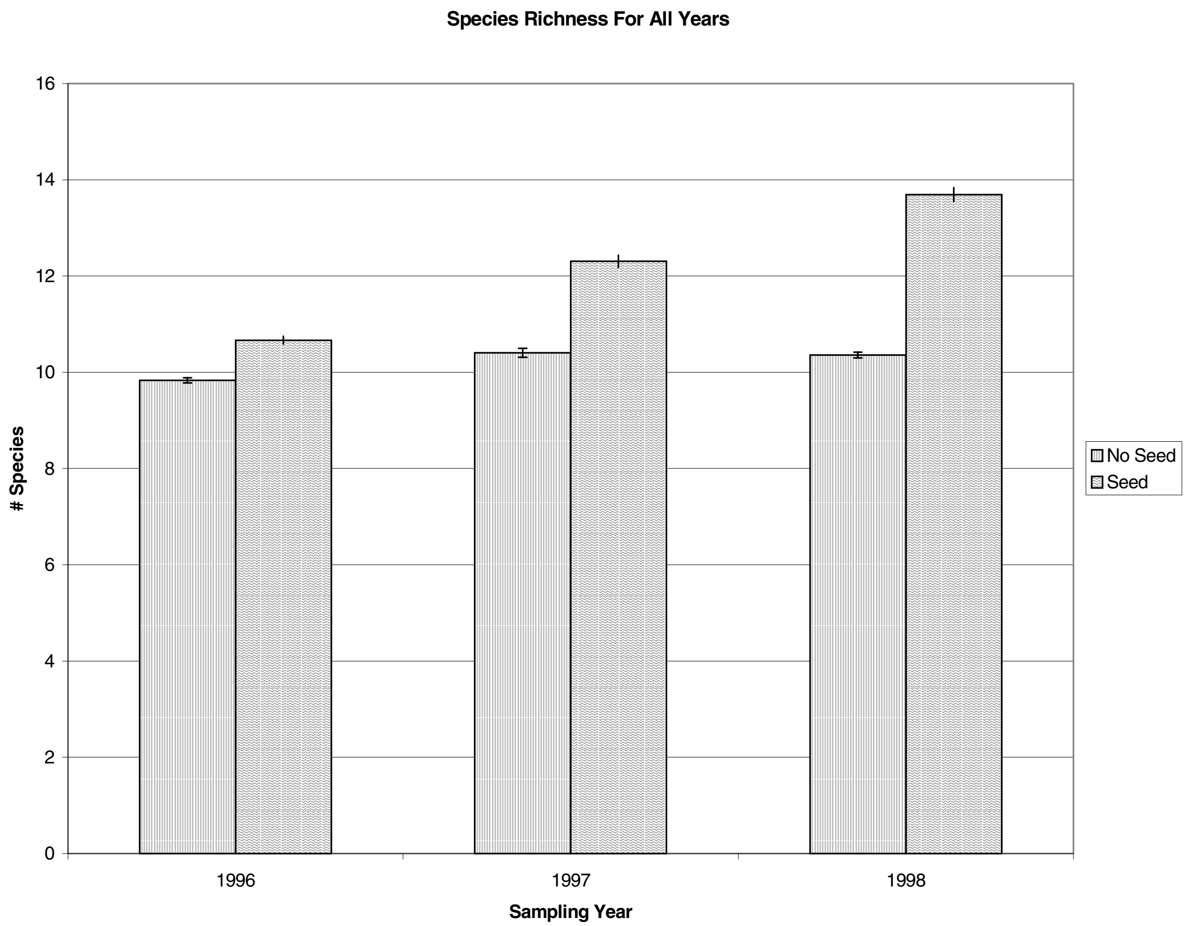

Figure 12. Mean species richness and standard error on seeded and unseeded plots for 1996 -1998. Bars indicate standard error (n = 78).

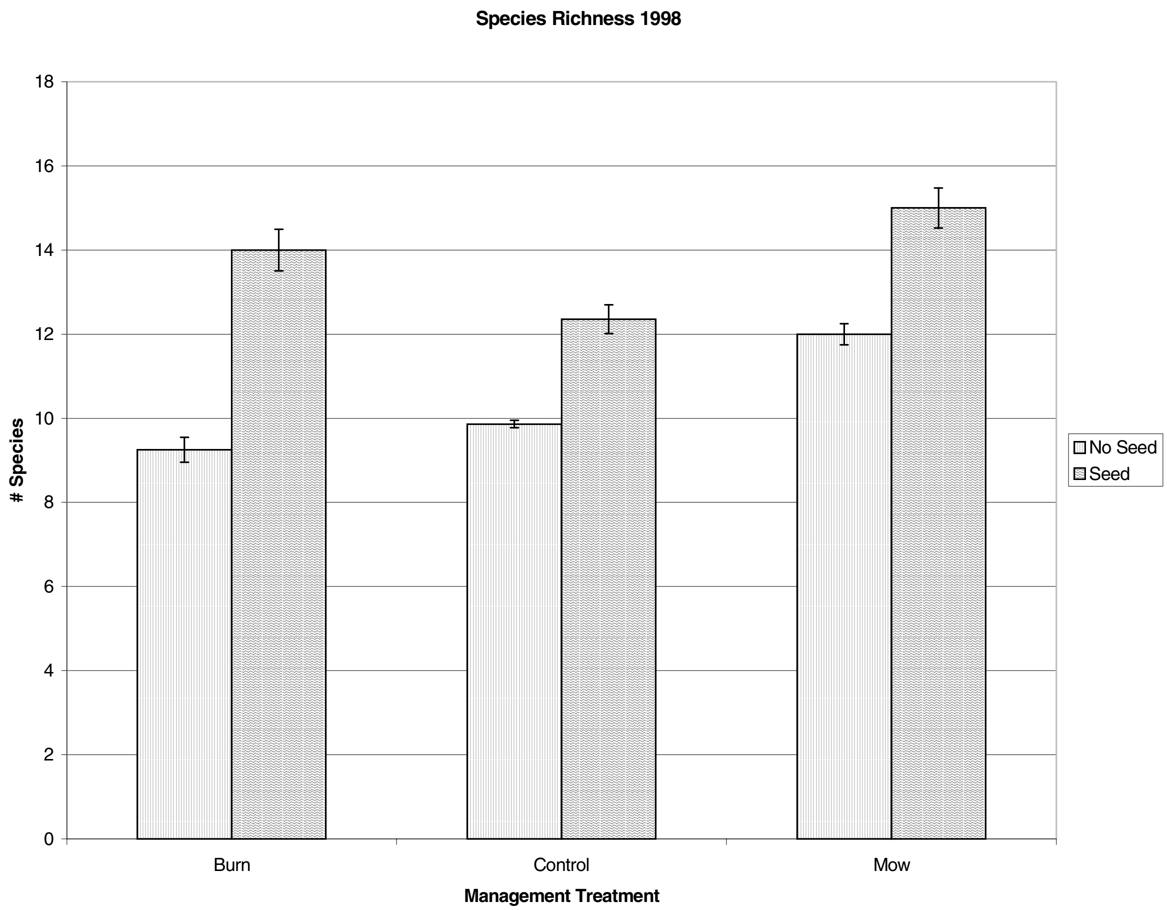

Figure 13. Species richness under different management treatments on seeded and unseeded plots in 1998. Bars indicate standard error (n = 78).

values compared were averages, which greatly lowered the statistical power of these analyses.

Cumulative Shoot Counts by Guilds

Plants representing eight of the nine guilds used by Kindscher (1994) were identified in this study. For purposes of analysis, the woody guild was eliminated as it contained only one species (*Toxicodendron radicans*, poison ivy) and occurred exceptionally rarely. A Spearman ranked correlation analysis was performed on cumulative shoot counts, which sums all sub-replicate shoot counts within each guild for all replicates, significantly reducing the variance, sample size and the large number of zero values. Many guilds are significantly correlated with one another (Spearman ranked correlation analysis, $p < 0.05$, Table 8). Annuals were significantly correlated with C3 grasses ($p = 0.026$), and negatively correlated to exotics ($p = 0.0001$) and summer/fall perennial forbs ($p=0.001$). C3 grasses were positively related to C4 grasses ($p = 0.0131$), legumes ($p = 0.0053$), and spring forbs ($p = 0.0047$). Legumes were also significantly positively related to spring forbs ($p = 0.0003$) and summer/fall forbs ($p = 0.0001$). These correlations, however, explain very little variation among species as r_s values (and therefore R^2) were typically very low.

Effects on each guild individually were assessed using a two-way ANOVA on ranked cumulative shoot counts followed by SNK to assess differences within management treatments where appropriate. Based on shoot counts from all three years, seeding significantly annual ($p = 0.0082$) and summer/fall blooming guilds ($p = 0.0001$). Annuals increased and summer/fall forbs decreased on seeded plots. The decrease in summer/fall forbs on seeded plots is due mainly to decreases in heath aster and goldenrod, which were present in large numbers everywhere, but had much greater numbers on unseeded plots. Of the 14 species in the summer/fall guild, ten of them had higher shoot counts on seeded plots, but the effects on these species is confounded by the higher counts of goldenrod and heath aster on unseeded plots. Annuals were also highly significantly affected by management treatment ($p = 0.0027$, no maintenance = mowing > burning). Management treatment significantly affected spring perennial forb ($p = 0.0001$) and C_4 grass guilds ($p = 0.0333$). Ranked cumulative shoot count was highest for spring perennial forbs on mowed plots, followed by burned plots, with lowest counts in plots with no maintenance (SNK, mowing > burning > no maintenance). Differences among the effects of management treatments on C_4 grasses could not be distinguished (SNK), but counts were highest in mowed plots, followed by burned plots with lowest counts in plots with no maintenance.

Table 8. Spearman rank correlation values (r_s) and significance values for comparisons of cumulative shoot counts between guilds.

		Annual	C_3	C_4	Exotic	Legume	Spring	Summer/ Fall
Annual	R_s	1						
	$P(r_s)$	0						
C_3	R_s	0.14557	1					
	$P(r_s)$	0.026	0					
C_4	R_s	0.0115	0.16204	1				
	$P(r_s)$	0.8611	0.0131	0				
Exotic	R_s	-0.27906	-0.0387	0.11489	1			
	$P(r_s)$	0.0001	0.5559	0.0794	0			
Legume	R_s	0.0648	0.18192	0.00013	-0.09133	1		
	$p(r_s)$	0.3236	0.0053	0.9984	0.1638	0		
Spring	r_s	0.04101	0.18438	0.10032	0.0691	0.23384	1	
	$p(r_s)$	0.5325	0.0047	0.126	0.2925	0.0003	0	
Sumfall	r_s	-0.21364	0.09115	-0.0046	-0.10341	0.40605	0.14572	1
	$p(r_s)$	0.001	0.1646	0.9442	0.1147	0.0001	0.0258	0

Using just 1998 cumulative shoot count data, annuals were significantly affected by seeding (Two-way ANOVA, $p = 0.0369$), with shoot counts of annuals increasing on seeded plots. Annuals were also significantly affected by management treatment (Two-way ANOVA, $p = 0.0147$). Ranked shoot counts were significantly lower on burned plots (SNK, mow = no maintenance > burn). There was highly significant interaction between treatment and seeding for summer/fall forbs (Two-way ANOVA, $p = 0.0073$).

Ranked cumulative shoot counts for each guild for all three years of study were analyzed with MANOVA to assess seeding and maintenance treatment effects. Both seeding and maintenance treatments had highly significant effects on shoot counts within each guild (Wilks' Lambda ranked cumulative shoot counts, $p = 0.0001$ for both) and interaction between independent variables was not significant (Wilks' Lambda, $p = 0.2732$). Using only shoot count data by guilds from 1998, MANOVA indicated seed and management treatments to be highly significant ($p = 0.0002$, 0.0035) and interaction not significant ($p = 0.1930$).

A detrended correspondence analysis (DCA) was performed on cumulative shoot counts by guilds using years and season as co-variables, and treatments as environmental variables. The maximum gradient length of 2.119 SD indicated a linear response of guilds to environmental variables. Although CCA is still extremely robust even if this assumption is violated (ter Braak and Verdonschot 1995), a redundancy analysis is more appropriate (ter Braak and Smilauer 1998, Verdonschot and ter Braak 1994). Results presented here result from log transforming cumulative shoot counts by guild which resulted in a better linear approximation than either no transformation or square root transformation.

DCA tests on cumulative shoot counts for species within the six common guilds using years and season as co-variables and treatments as environmental variables were performed to determine the most appropriate tests for these data. The maximum gradient lengths of the analyses varied from a low of 1.589 SD to a high of 5.070 SD (Table 9), indicating that some gradients were long enough to elicit a unimodal response in some species groupings but not in others. When response was not unimodal, log transformation was utilized to make the model better fit a linear approximation.

For the sake of consistency, both RDA and CCA analyses are reported and graphed. Since the assumption of unimodality can be violated when conducting a CCA and still allow the analysis to remain a robust test (ter Braak and Verdonschot 1995), the CCA analysis should be considered the single best test when making comparisons between species groups here, regardless of the results of the DCA analysis.

Table 9. The species classification, maximum gradient length in the DCA test (in standard deviation units), and recommended ordination technique for analysis.

Guild Classification	Maximum Gradient	Most Appropriate Test
Annuals	2.960 SD	RDA
C_4	4.516 SD	CCA
Exotics	2.589 SD	RDA
Legumes	1.589 SD	RDA
Spring Perennial Forbs	5.070 SD	CCA
Summer/Fall Perennial Forbs	3.01 SD	CCA

Overall, the axes associated with both CCA and RDA tests had very small eigenvalues. Eigenvalues constructed by RDA, comparing cumulative guild shoot count to environmental variables (treatments), were very low ($\lambda_1 = 0.025$, $\lambda_2 = 0.008$) suggesting they explain very little of overall variation in shoot counts within each guild. None-the-less, significant effects as a result of the treatments could be determined.

A Canonical Correspondence Analysis (CCA) followed by a Monte Carlo permutation test on the cumulative shoot counts by guilds for all years (using years and season as co-variables, treatments as environmental variables) found that seeding and mowing had a highly significant, and burning a significant, effect on shoot number in each guild ($p = 0.005$, 0. 005, 0.040, Figure 14). Because the maximum gradient length from DCA was less than 3 SD, RDA results should be more accurate. Seeding burning and mowing all had significant effects ($p = 0.005$, 0.04, 0.05) on the log transformed shoot counts within each guild (Figure 15).

Separate CCA's and RDA's were performed on the species comprising each guild and the results are depicted in Figures 16 to 25. Generally, both analyses selected the same variables as being the most relevant. Differences occurred primarily with variables that Monte Carlo tests had determined to be not statistically significant. With the exception of species within the summer/fall guild classification, tests recommended in Table 9 have lower probability values resulting from the Monte Carlo permutation tests. Because the summer/fall guild was on the border between using CCA over RDA, this could suggest that using a DCA maximum gradient of 3 SD to decide between CCA and RDA is too low.

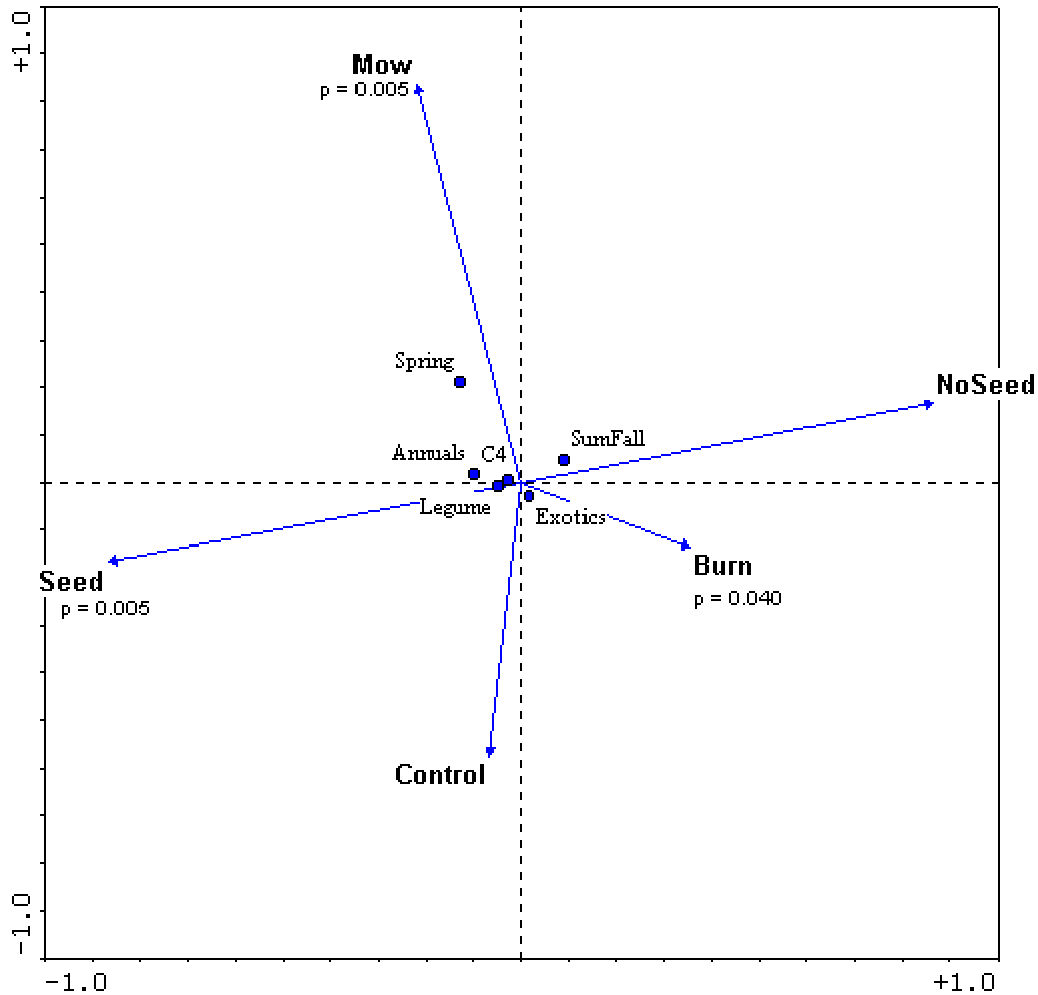

Figure 14. CCA graph of effects of seeding and management treatments on plant guilds. Monte Carlo probability values given beneath variables relevant to model construction.

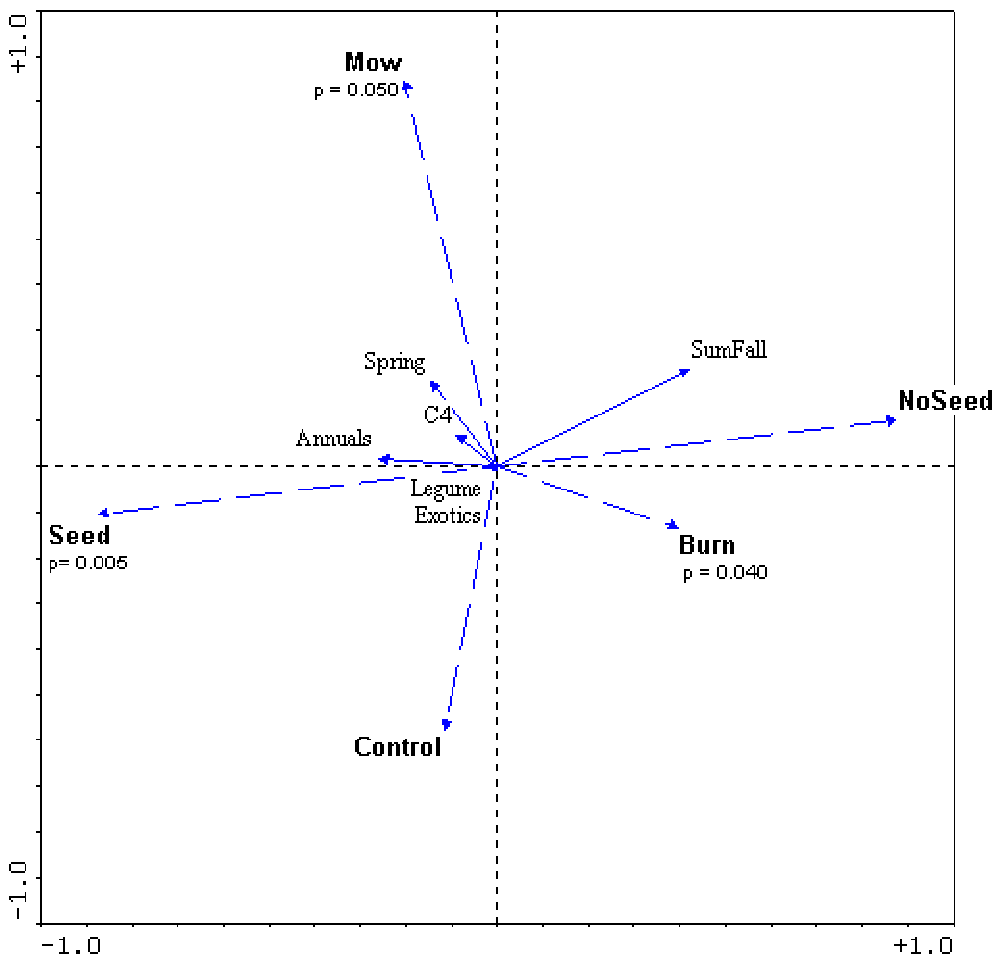

Figure 15. RDA graph of effects of seeding and management treatments on plant guilds cumulative shoot counts (log transformed). Monte Carlo probability values given beneath variables relevant to model construction.

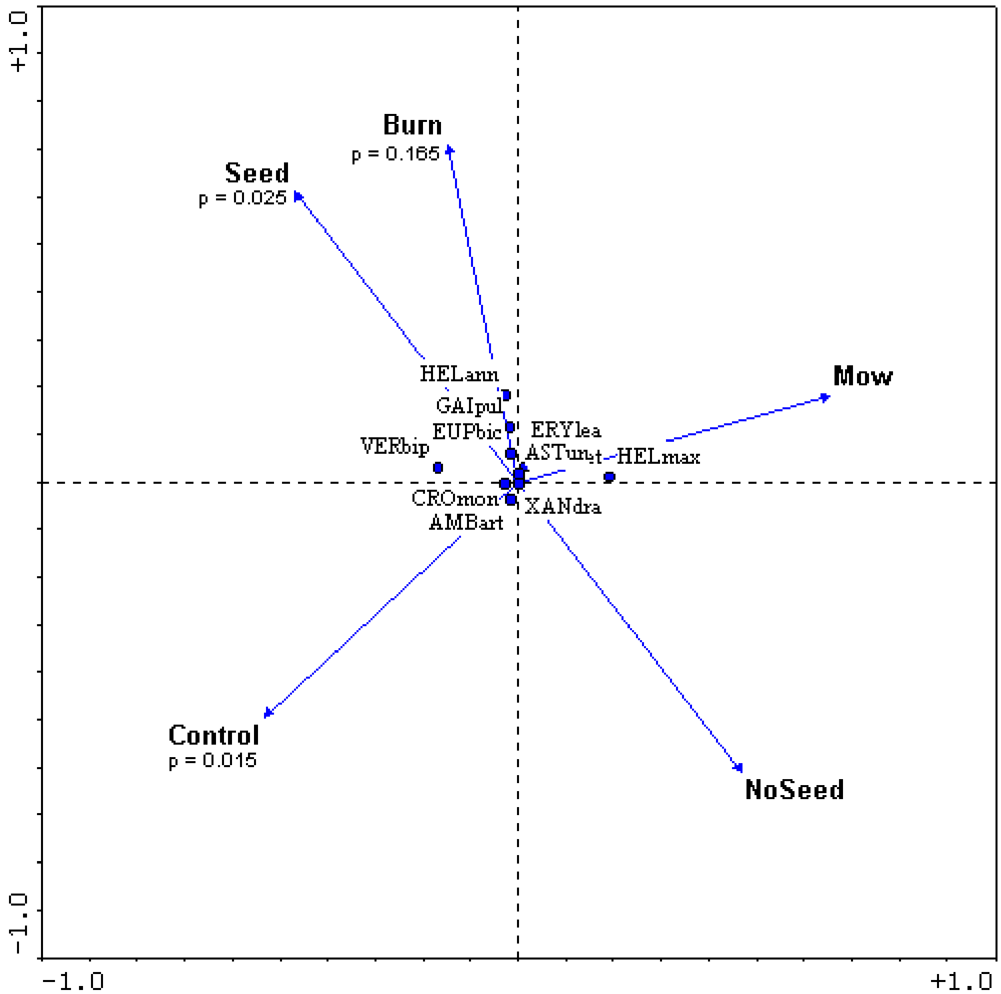

Figure 16. CCA graph of effects of seeding and management treatments on species within the annual forb guild classification. Monte Carlo probability values given beneath variables relevant to model construction. Abbreviations are as follows: AGAhet = *Agalinis heterophylla*, AMBart = *Ambrosia artemisifolia*, CROmon = *Croton monanthogynus*, ERYlea = *Eryngium leavenworthii*, EUPbic = *Euphorbia bicolor*, GAIpul = *Gaillardia pulchella*, VERbip = *Glandularia bipinnatifida*, XANdra = *Gutierrezia dracunculiodes*, HELann = *Helianthus annuus*, and HELmax = *Helianthus maximiliani*.

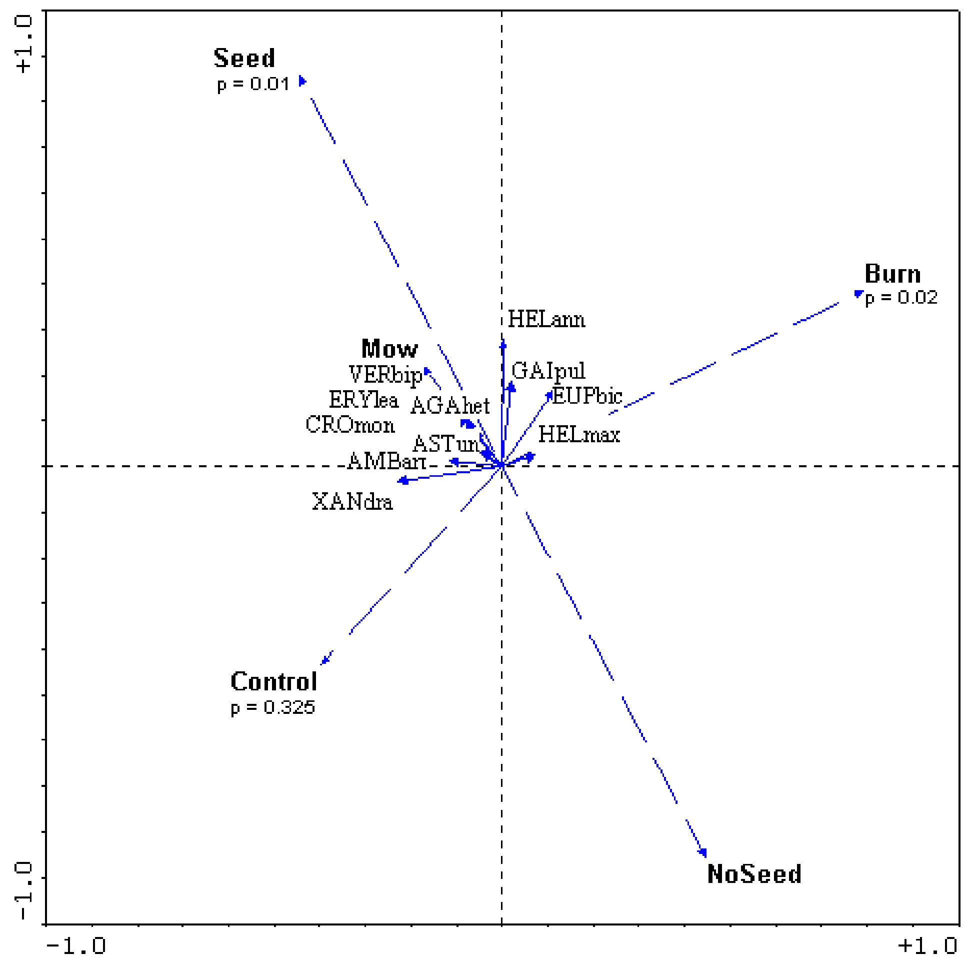

Figure 17. RDA graph of effects of seeding and management treatments on species within the annual forb guild classification. Monte Carlo probability values given beneath variables relevant to model construction. Abbreviations are as follows: AGAhet = *Agalinis heterophylla*, AMBart = *Ambrosia artemisifolia*, CROmon = *Croton monanthogynus*, ERYlea = *Eryngium leavenworthii*, EUPbic = *Euphorbia bicolor*, GAIpul = *Gaillardia pulchella*, VERbip = *Glandularia bipinnatifida*, XANdra = *Gutierrezia dracunculiodes*, HELann = *Helianthus annuus*, and HELmax = *Helianthus maximiliani*.

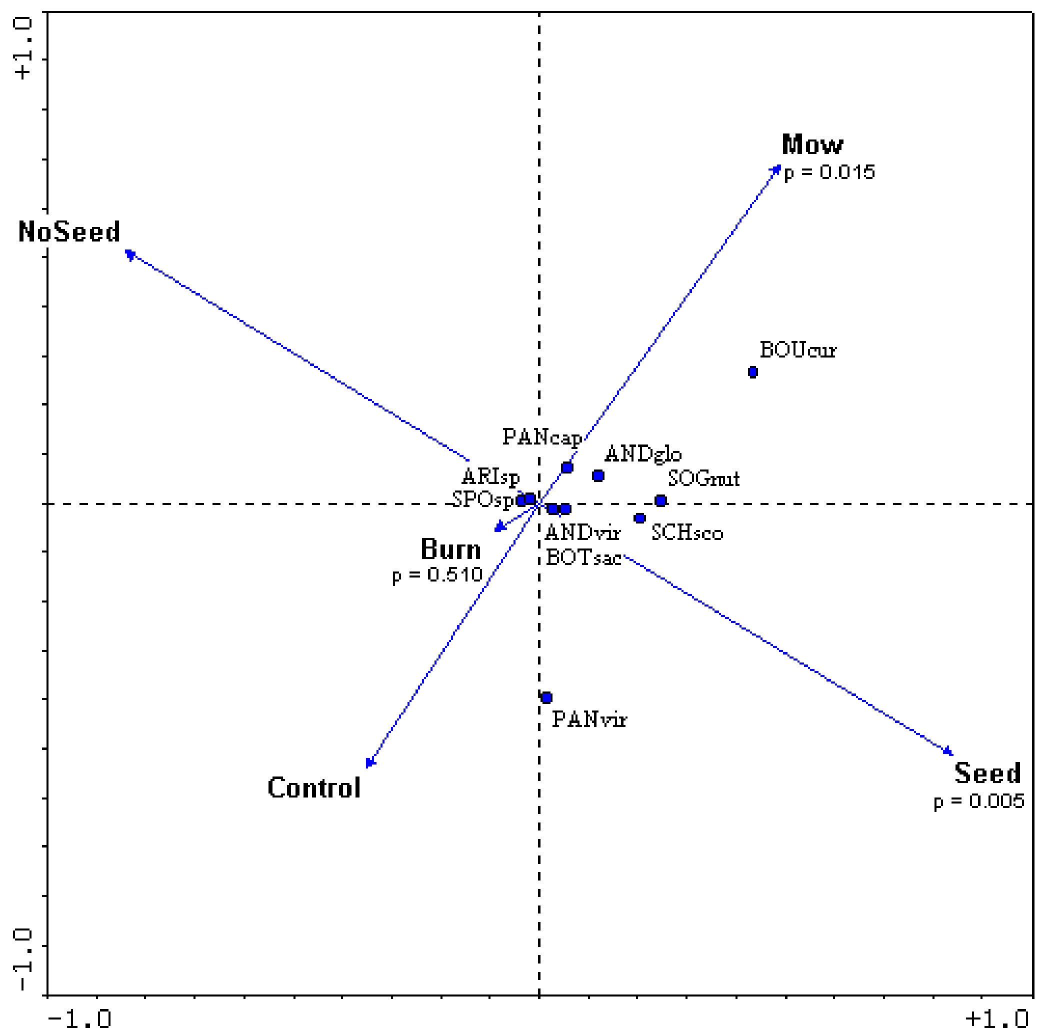

Figure 18. CCA graph of effects of seeding and management treatments on species within the C_4 grass guild classification. Monte Carlo probability values given beneath variables relevant to model construction. Abbreviations are as follows: ANDglo = *Andropogon glomeratus*, ANDvir = *Andropogon virginicus*, ARIsp = *Aristida* spp., BOTsac = *Bothriocloa laguroides*, BOUcir = *Bouteloua curtipendula*, PANcap = *Panicum capillare*, PANvir = *Panicum virigatum*, SCHsco = *Schizachyrium scoparium*, SOGnut = *Sogastrum nutans*, and SPOsp = *Sporobolus compositus*.

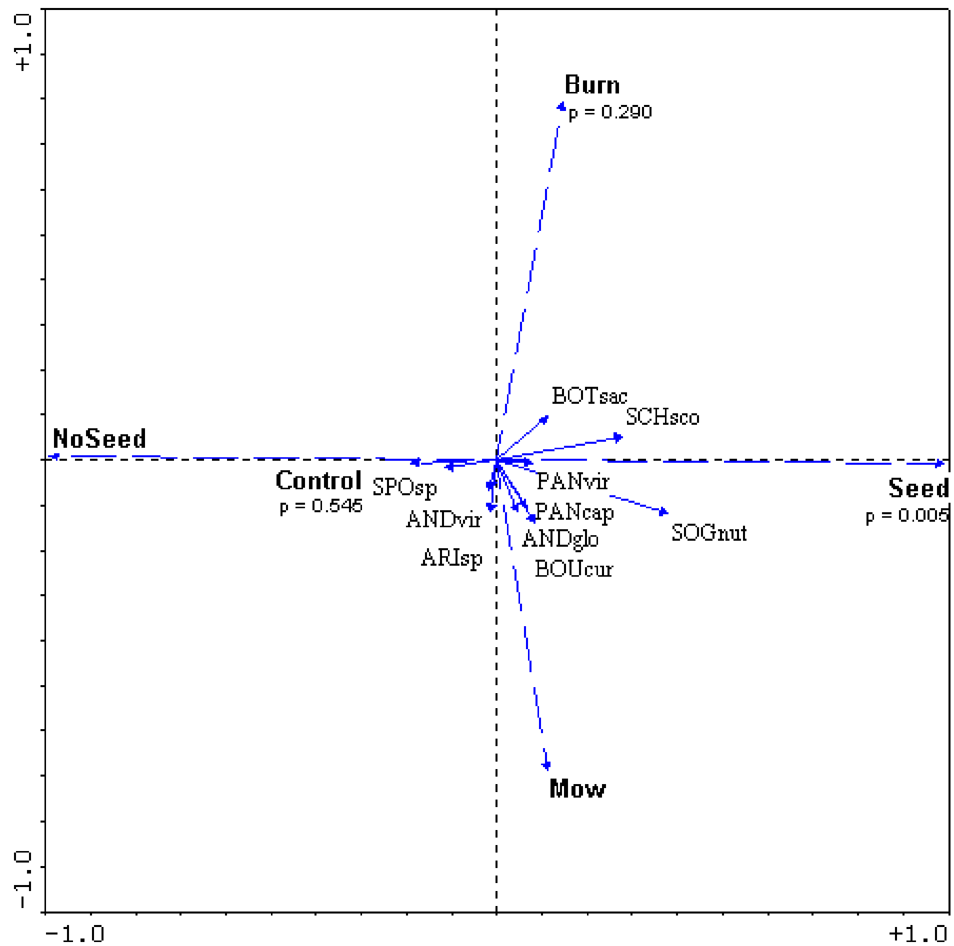

Figure 19. RDA graph of effects of seeding and management treatments on species within the C_4 grass guild classification. Monte Carlo probability values given beneath variables relevant to model construction. Abbreviations are as follows: ANDglo = *Andropogon glomeratus*, ANDvir = *Andropogon virginicus*, ARIsp = *Aristida* spp., BOTsac = *Bothriocloa laguroides*, BOUcir = *Bouteloua curtipendula*, PANcap = *Panicum capillare*, PANvir = *Panicum virigatum*, SCHsco = *Schizachyrium scoparium*, SOGnut = *Sogastrum nutans*, and SPOsp = *Sporobolus compositus*.

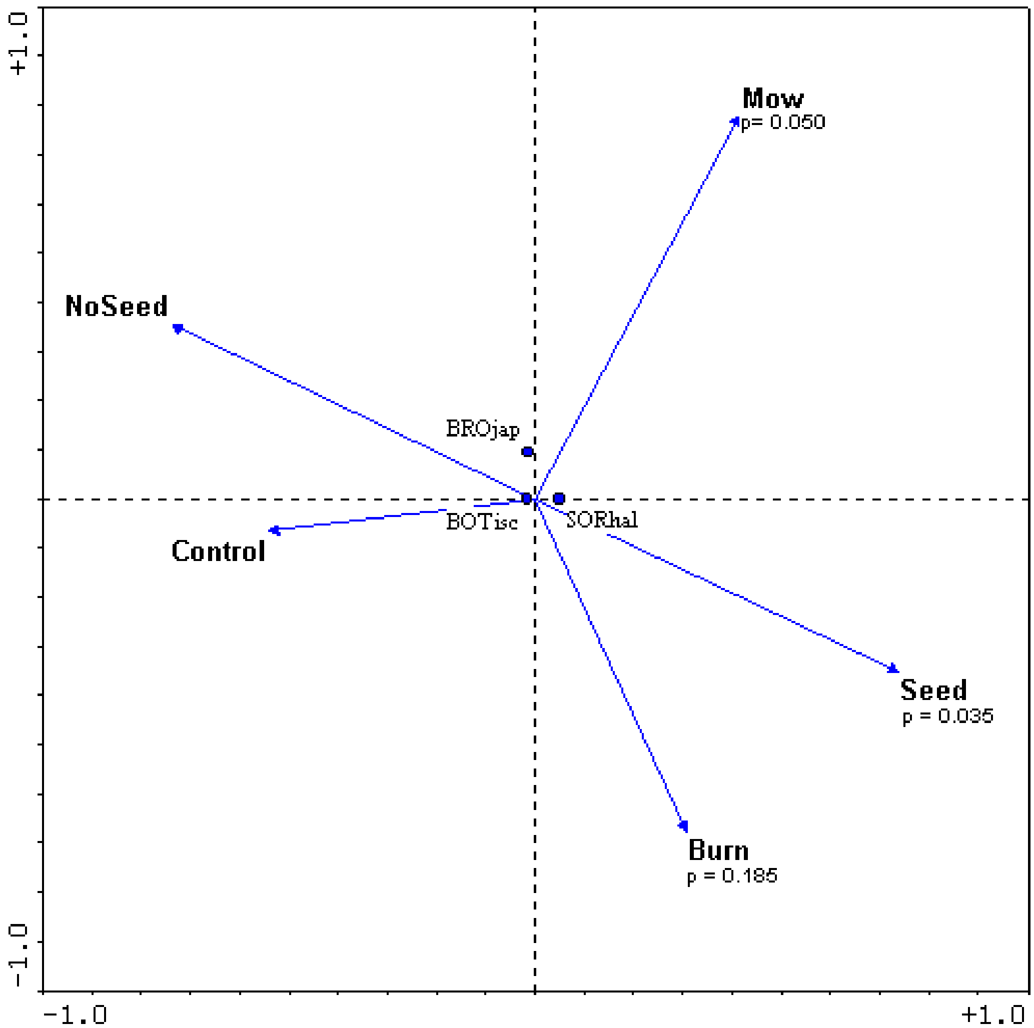

Figure 20. CCA graph of effects of seeding and management treatments on species within the exotic guild classification. Monte Carlo probability values given beneath variables relevant to model construction. Abbreviations are as follows: BOTisc = *Bothriocloa ischaemum*, BROjap = *Bromus japonicus*, and SORhal = *Sorghum halepense*.

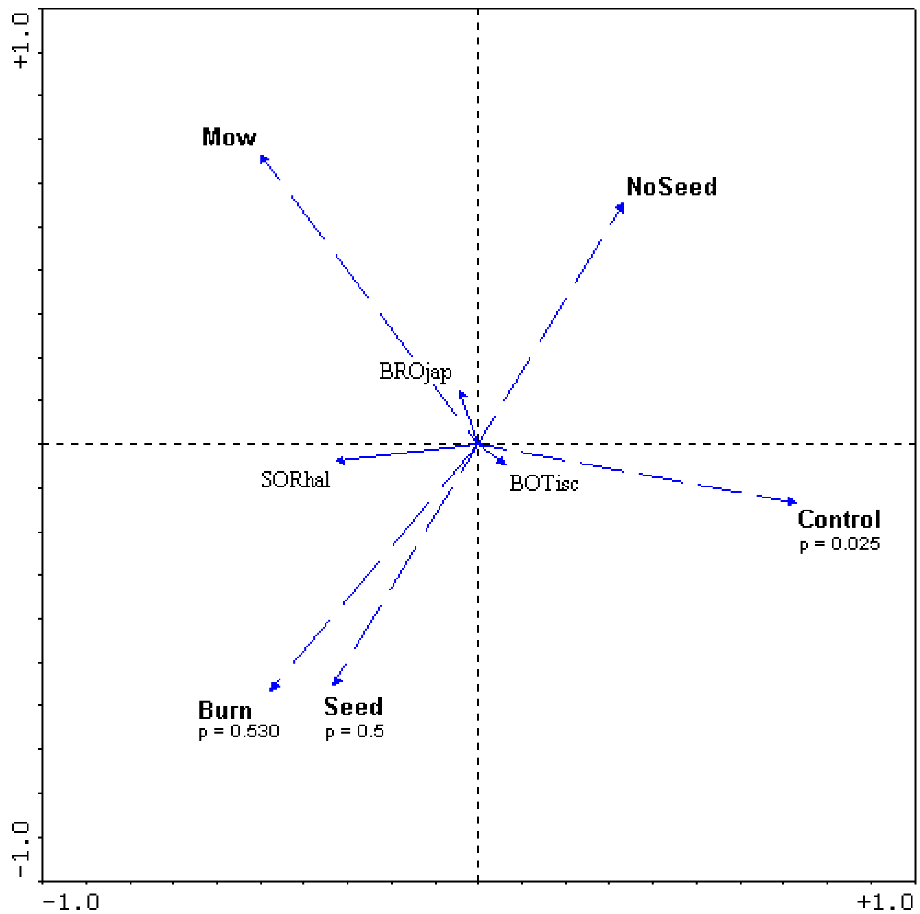

Figure 21. RDA graph of effects of seeding and management treatments on species within the exotic guild classification. Monte Carlo probability values given beneath variables relevant to model construction. Abbreviations are as follows: BOTisc = *Bothriocloa ischaemum*, BROjap = *Bromus japonicus*, and SORhal = *Sorghum halepense*.

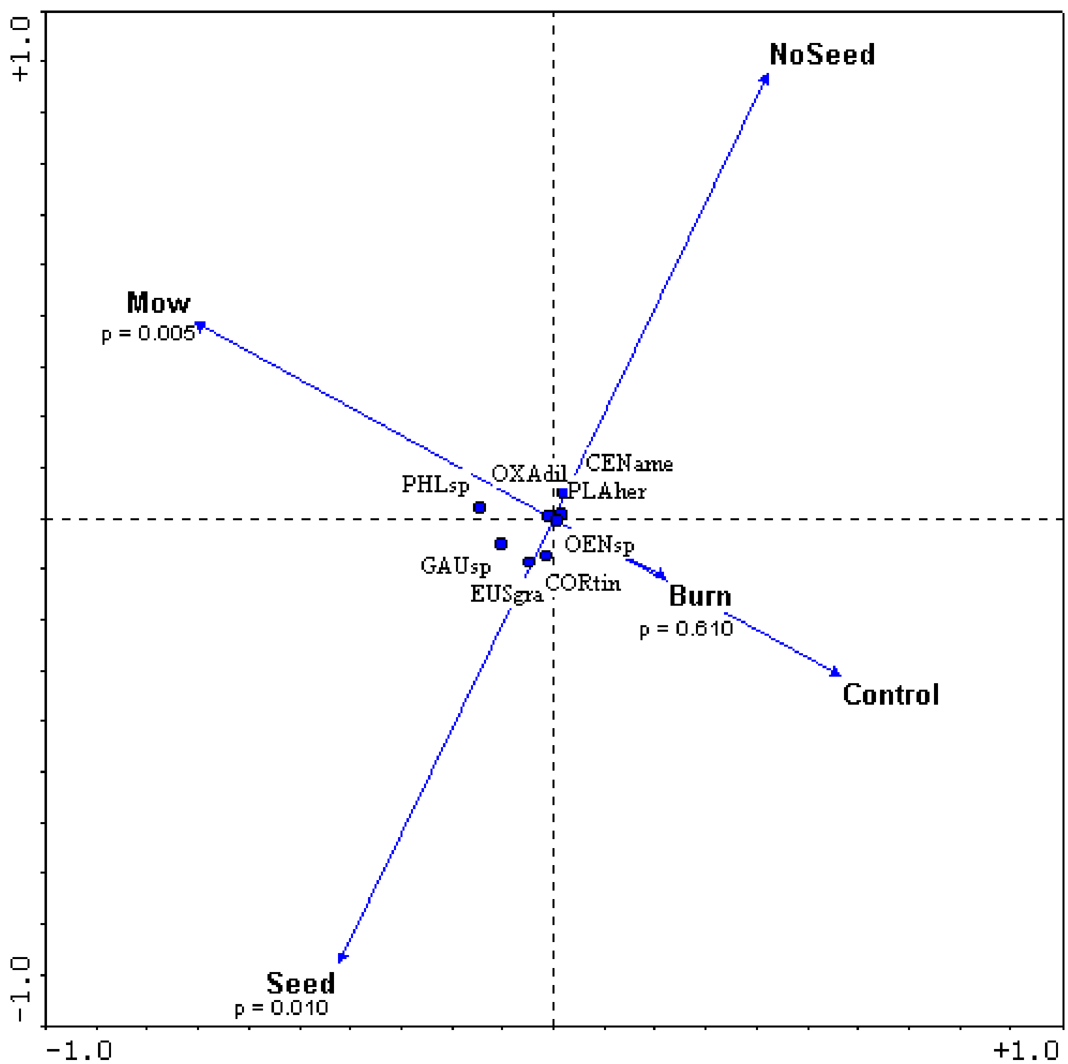

Figure 22. CCA graph of effects of seeding and management treatments on species within the spring guild classification. Monte Carlo probability values given beneath variables relevant to model construction. Abbreviations are as follows: CEName = *Centaurea americana*, CORtin = *Coreopsis tinctura*, EUSgra = *Eustoma grandiflora*, GAUsp = *Gaura* sp., OENsp = *Oenothera biennis*, OXAdil = *Oxalis stricta*, PHLsp = *Phlox drummondii*, and PLAhet = *Plantago heterophylla*.

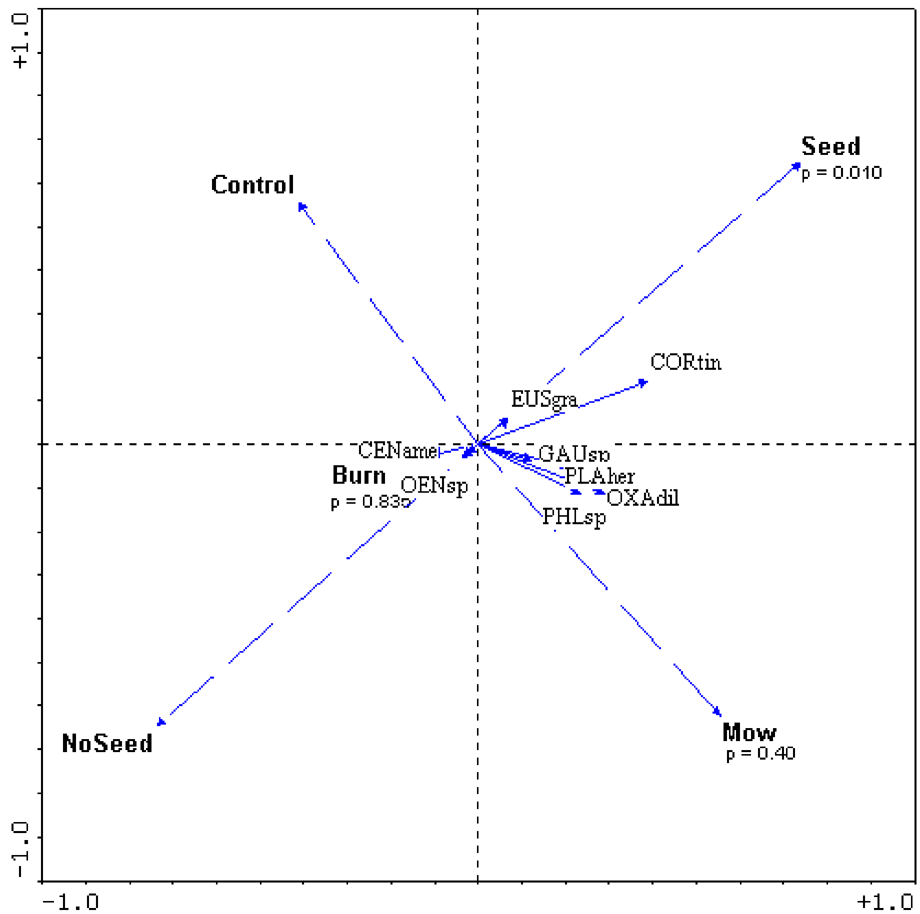

Figure 23. RDA graph of effects of seeding and management treatments on species within the spring guild classification. Monte Carlo probability values given beneath variables relevant to model construction. Abbreviations are as follows: CEName = *Centaurea americana*, CORtin = *Coreopsis tinctura*, EUSgra = *Eustoma grandiflora*, GAUsp = *Gaura* sp., OENsp = *Oenothera biennis*, OXAdil = *Oxalis stricta*, PHLsp = *Phlox drummondii*, and PLAhet = *Plantago heterophylla*.

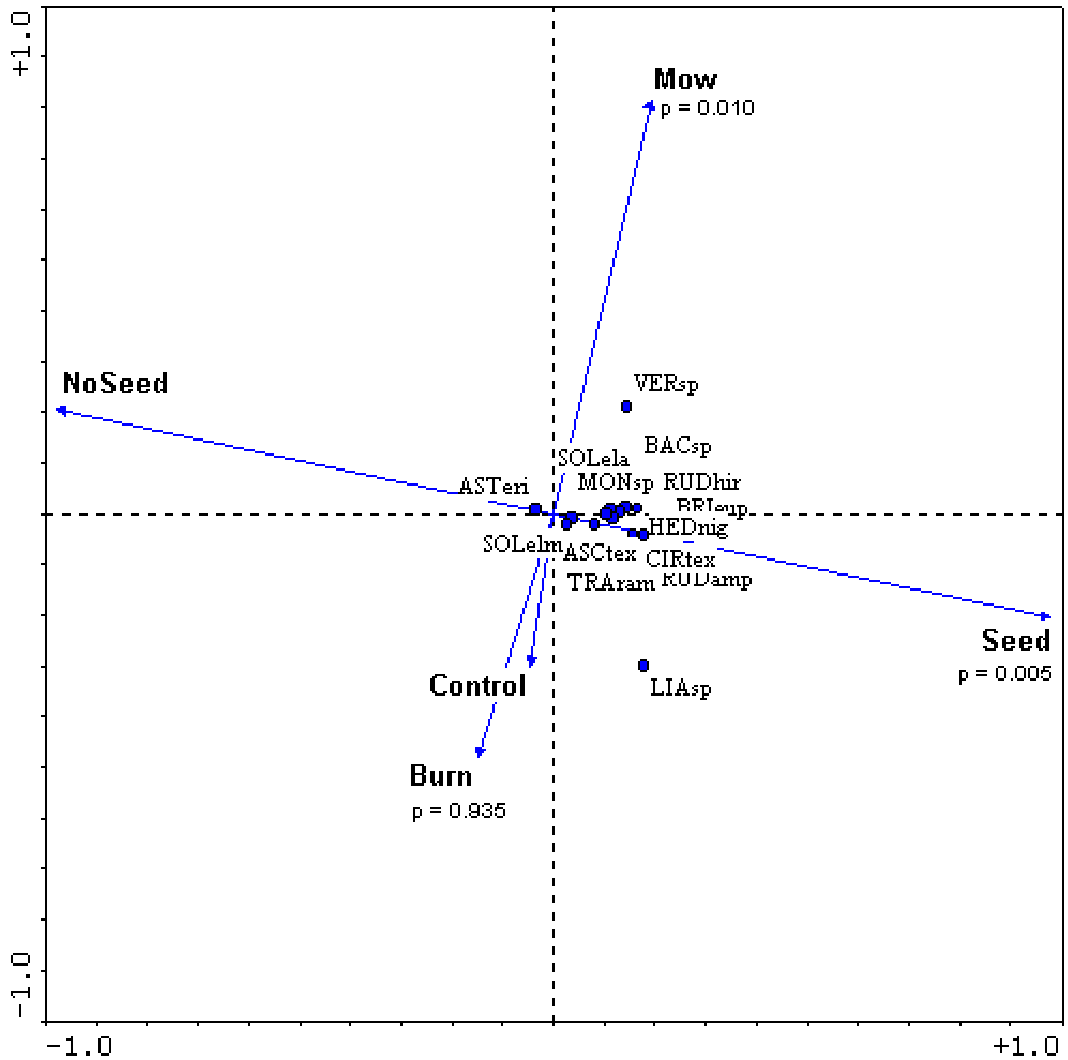

Figure 24: CCA graph of effects of seeding and management treatments on species within the summer/fall guild classification. Monte Carlo probability values given beneath variables relevant to model construction. Abbreviations are as follows: ASCtex = *Asclepias texana*, ASTeri = *Aster ericoides*, BACsp = *Baccharis neglecta*, BRIeup = *Brickellia eupatorides*, CIRtex = *Cirsium texanum*, RUDamp = *Dracopis amplexicaulis,* HEDnig = *Hedyotis nigricans*, LIAsp = *Liatrus mucronata*, MONsp = *Monarda citriodora*, RUDhir = *Rudebeckia hirtia*, SOLela = *Solanum elaeagnifolium*, SOLulm = *Solidago ulmifolia*, TRAbre = *Traigia brevispica*, and VERsp = *Vernonia baldwinii.*

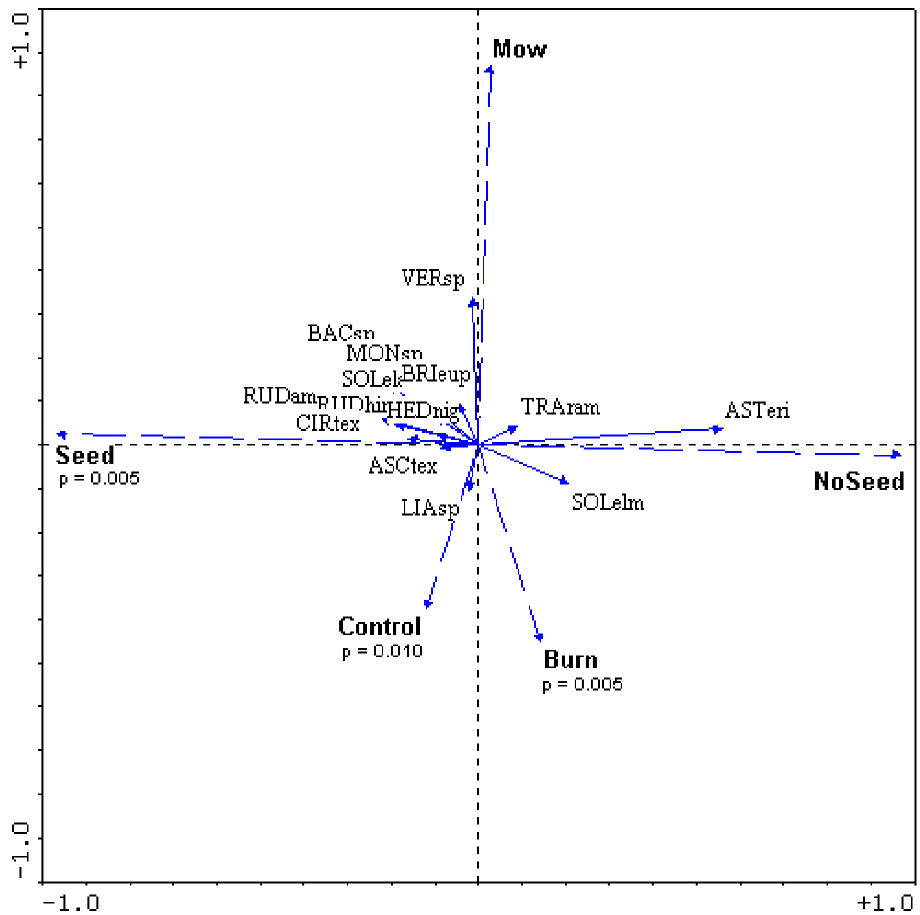

Figure 25: RDA graph of effects of seeding and management treatments on species within the summer/fall guild classification. Monte Carlo probability values given beneath variables relevant to model construction. Abbreviations are as follows: ASCtex = *Asclepias texana*, ASTeri = *Aster ericoides*, BACsp = *Baccharis neglecta*, BRIeup = *Brickellia eupatorides*, CIRtex = *Cirsium texanum*, RUDamp = *Dracopis amplexicaulis,* HEDnig = *Hedyotis nigricans*, LIAsp = *Liatrus mucronata*, MONsp = *Monarda citriodora*, RUDhir = *Rudebeckia hirtia*, SOLela = *Solanum elaeagnifolium*, SOLulm = *Solidago ulmifolia*, TRAbre = *Traigia brevispica*, and VERsp = *Vernonia baldwinii*.

Examining treatment effects on species within individual guilds indicates that there was no statistically significant effect on C_3, legumes, or woody species. Monte Carlo permutations following a RDA test indicate that for annuals, seeding ($p = 0.01$), and burning ($p = 0.02$) had the most affect on species distribution with no maintenance relevant (used in the construction of the model) but not significant ($p = 0.325$). C_4 grasses were significantly affected by seeding (CCA followed by Monte Carlo permutations, $p = 0.005$) and mowing ($p = 0.015$) with burning relevant to the model but not significant ($p = 0.510$). The only statistically significant effect on exotic grasses was no maintenance (RDA followed by Monte Carlo permutations, $p = 0.025$) with seeding ($p = 0.5$) and burning ($p = 0.53$) being relevant bout not significant. CCA analysis on the spring perennial guild indicated that significant effects resulted from seeding ($p = 0.01$) and mowing ($p=0.005$) with burning being relevant to the model, but not significant ($p = 0.610$). CCA indicated summer and fall perennial forbs were highly significantly effected by seeding ($p = 0.005$) as well as mowing ($p = 0.010$) with burning again being relevant but not significant ($p = 0.935$, Figure 24). It is clear from Figure 24 that although most of the summer/fall perennial species were positively affected by seeding, heath aster was negatively affected. RDA indicated highly significant effects resulting from seeding ($p = 0.005$), no maintenance ($p = 0.01$), and burning ($p = 0.005$).

<u>Relative Density</u>

Results of a MANOVA test on relative density within guilds for 1998 (excluding C_3 and woody because of the many zeros) found that seeding had a significant effect on the community composition (Wilks' Lambda $p = 0.0138$) but that neither management treatment nor interaction between seeding and management treatment was significant (Wilks' Lambda p = 0.5920, 0.8702). Since the management treatments did not significantly affect the relative density of guild composition when considering 1998 data alone, the effect of seeding on relative density in guild composition was considered separately using all years. Relative density is highly significantly lower (Mann Whitney U test with Z approximation and continuity correction, p = 0.0001) for the summer/fall guild in seeded plots. Relative density of C4 grasses and annuals were significantly greater in seeded plots (Mann Whitney U test with Z approximation and continuity correction, p = 0.0375, 0.0145).

DISCUSSION

Statistical Methods

The very small eigenvalues associated with both ordination methods used (redundancy analysis and canonical correlation analysis) suggest that very little overall variation observed in vegetation resulted from differences in seeding or management treatments. This is not surprising considering the highly variable nature of many native vegetation communities and the small number of replicates associated with management treatments or the ecologically brief time period following seeding. Many conservative prairie species require several years before significant above ground development occurs (Weaver 1954). Should sampling continue, effects of seeding on community structure should be much more apparent. Similarly, should management treatments continue, they would be expected to have a much more pronounced effect on overall community structure, and be responsible for a greater amount of explanatory power.

Whereas overall effects of treatment and seeding were small in relation to overall variation, both multivariate methods of community analysis (MANOVA and ordination analysis on cumulative shoot counts by guilds) detected significant effects on community structure. So although treatments have had little ecological affect to date, the statistical trends presented below suggest these will become more ecologically relevant in the future.

Both ordination techniques were more useful than the MANOVA due to their graphical depictions. In addition to knowing that treatments had significant effects on the resulting community composition, RDA and CCA graphs effectively illustrate the relationships between either individual species or species groups and the environmental variables of concern. Separate ANOVA tests on each of the species or guilds were required to ascertain this information otherwise. Additionally, because RDA uses Monte Carlo permutation tests to test statistic strength, it does not require multivariate normal distributions, or necessitate ranking data. Confirmation of ordination results by MANOVA and ANOVA tests, however strengthen the persuasive power of conclusions drawn from ordination.

General Results

Like most ecological systems, species distribution in grassland systems is extremely patchy with a large number of quadrats lacking species found elsewhere. Thus conclusions about the effect of treatments on individual species – even statistically significant tests – is probably premature and may be impossible as long as their frequency of occurrence on all treatments remains low. Even for common species such as King ranch bluestem, Johnsongrass, dropseed, heath aster, and goldenrod, occurrence is still highly variable and non-normal, even when using a Poisson distribution or square root transformation as recommended by (Biondini et al. 1989), though square root transformation did result in normal distributions for guilds with high counts, such as annuals, C_4, and summer/fall perennial forbs. Other guilds remained significantly different from normal distributions regardless off transformation. Should treatments continue for a greater number of years, the larger data set and reoccurring management treatments should help to clarify effects of treatment. Results reported here, particularly for effects of burning, mowing, and no maintenance which were only followed by one year of data, should be considered provisional.

Management treatments actually increased concentrations of both King ranch bluestem and Johnsongrass, the two main exotics (Figures 7, 8). This is not surprising because both are C_4 grasses and adapted to conditions similar to that of native C_4 grasses. Other methods that affect only these grasses, such as selective herbicide application, will need to be used to reduce their dominance. This is not overly difficult with a species like Johnsongrass which because of its height, can be selectively targeted with a tractor-mounted rope-wick. King ranch bluestem will be more difficult to control because it is vegetatively similar to many desirable native species. In areas where it forms a dense mat, as is common over much of the study area, few other species co-exist with it, finding it difficult to compete with King ranch bluestem for light. These areas could be selectively hand sprayed with an herbicide, allowing other species to become established. Other restorationists have seen King ranch bluestem crowded out by little bluestem and Indiangrass over time in areas that were repeatedly burned (David Mahler, personal communication). Future studies should examine the interplay between these species.

Due to the first sampling period occurring so late in the year, no ephemeral spring forbs were identified on site. Qualitative assessments in early May 1999 suggest that there are at least 12 additional species present on the site that would fall into the ephemeral spring forb guild classification (Table 10). Future monitoring efforts should either include an additional sampling period earlier in the year or substitute a May sampling period for the June sampling.

Table 10. List of additional species identified on the study site in May of 1999.

Scientific Name	Common Name
Achillea millefolium	Yarrow
Camelina sp.	False Flax
Castilleja purpurea	Indian Paintbrush
Draba sp.	Draba
Houstonia pusilla	Small Bluets
Lepidium sp.	Pepperweed
Lupinus texensis	Bluebonnet
Pyrrhopappus pauciflorus	Texas Dandelion
Ratibida columnifera	Mexican Hat
Sabatia campestris	Meadow Pink
Sisyrinchium sp.	Blue-eyed Grass
Tiodans sp.	Venus' Looking Glass

Disturbance on unseeded plots was predicted to increase abundance of annuals and "weedy" perennials. To a certain extent, that was the case. Goldenrod, heath aster, and prairie agalinis were all more abundant on disturbed, unseeded plots. Broomweed, however, had its greatest shoot counts on seeded plots. Many other annuals expected to have higher concentration on unseeded plots were not present at all, primarily due to a lack of seed source. As species on seeded plots become established, they will be expected to spread to unseeded plots.

Seeding

Both little bluestem and Indiangrass occur exclusively on seeded plots with the exception of one clump of little bluestem encountered on a non-seeded plot, surrounded by seeded plots. These species do not appear to have been retained in the seed bank. This is consistent with other studies showing long term grazing to eliminate perennial grass species from the soil seed bank, making natural recovery slow or impossible (Kinucan and Smeins 1992, Packard and Mutel 1997). It is probable that any perennial grass and perhaps forb species not currently extant on LLELA grasslands will need to be reintroduced by seeding. Whereas the counts for little bluestem and Indiangrass increased each year, their occurrence remained low by fall, 1998. This is also not unexpected as many long-lived perennial grass species develop almost exclusively below ground for the first year after germination, and do not flower for up to five years (Packard and Mutel 1997). Future site monitoring is expected to observe increasing shoot counts for native C_4 grasses and, as their frequency increases, both burning and mowing would be expected to increase the further spread of these species. As these plants mature and begin to produce seed, the unassisted spread of seed from one plot to another is expected. If little bluestem and Indiangrass are able to spread on their own, seeding in strips across LLELA property may, over time, be as effective as thoroughly seeding the entire site.

Seeding did effectively add species previously not present on the site. Diversity on seeded plots was significantly greater than that non-seeded plots. Many species known to be in the seeding mix (such as eastern gammagrass), however, have not yet been observed on the site. It is not yet clear if this is due to the long development time of these species after germination, or inadequate site conditions for their survival after germination. As planted seeds were viable when planted, if these species are not seen in the coming years, future studies should examine if conditions preventing their development were related to nutrient availability or inter specific competition.

Mowing

As grass cover increases, continued mowing without bailing will result in an increased thatch layer. This layer will initially help to conserve moisture, resulting in improved performance of many species, particularly perennials. Over time, however, this thatch layer will reduce seedling germination and reduce overall productivity of species still present (Knapp and Seastedt 1986). Without fire or mowing, the system will, in the next ten years, move back to a mesquite savanna and over time, to a mesquite thicket common on many other areas of LLELA (Archer et al. 1988, Smeins 1982). On mature prairie systems, haying has been shown to favor the production of little bluestem.

Spring forb dominance was aided by late winter mowing but adversely affected by burning. This is because mowing cleared away standing dead material without adversely affecting young rosettes and early shoots of these species, whereas burning would be expected to kill or suppress the development of many of these.

Burning

Effects of burning are unclear due primarily to low sample size and the inability of this study to document effects over several years. It is doubtful that burning will effectively eliminate any exotic grasses other than Japanese brome. At the current successional state of the site, late winter burning will tend to benefit annuals and spring forbs by eliminating thatch and increasing light availability at the soil surface. For example, three annual species -- snow-on-the-prairie, firewheel, and common sunflower -

- immediately responded to the late winter burns (Figure 18). As the site matures successionally, fires would be expected to not only benefit annuals and spring forbs, but C_4 grasses (Reichman 1987, Riskind 1975, Robocker et al. 1953, Smeins 1973, Smeins 1982).

Greatest species diversity was predicted to occur on seeded and burned plots due to the patchy nature of prescribed burns. Although seeded plots certainly had higher diversity than unseeded plots, 1998 results indicate that mowing yielded the greatest species richness. This is at least in part a result of the negative effect of fire on spring forbs, but could also mean that sub-replicate number was too small to sample all available micro-habitats on burned plots, yet sufficient to sample diversity on the more homogenous mowed plots. More intensive sampling and analysis of species extinction curves could be constructed to ascertain if greater sampling effort is needed in future studies.

Management Recommendations

Grasslands on LLELA that are not mesquite thickets already are quickly moving in that direction in the absence of disturbance. To keep these species under control, and possibly generate income, the sites should be mowed for hay production, preferably in the fall after the C_4 grasses have produced seed. Many prairies in north Texas have been preserved as hay meadows and will serve to keep woody species in check. This will also, however, tend to spread exotics, so other maintenance efforts to control these species using herbicide should also take place. Over time, burning should increase coverage of Indiangrass and big bluestem, whereas both mowing or burning and mowing will tend to increase coverage of little bluestem (Diamond and Smeins 1985, Diamond and Smeins

1993). Either mowing or burning should, in a mature prairie, reduce overall number of forbs, although the opposite was shown in this study. An integrated management plan that utilizes burning, haying, mowing and no maintenance in rotation will probably maximize species diversity over the whole site.

Should burning be continued, experiments comparing results of the effects of burning in different seasons should be undertaken. Though fall burning is the standard treatment carried out by most prairie managers and will certainly serve to increase dominance by late-season C_4 grasses, many question the effect that this has had on plant species composition of the prairie systems (Howe 1994b, Howe 1995, McCall 1995, Packard and Mutel 1997, Willson and Stubbendieck 1997). Mid-summer burns which would have certainly not been uncommon in drought years increased forb dominance in following years (Howe 1994b, Howe 1995, McCarty et al. 1996). Grassland management on LLELA should probably use burning and mowing in a variety of seasons once native grasses are better established. Doing so would maximize overall diversity of habitat conditions, and thereby species.

Conclusions

Seeding positively affected species richness for all treatments and improved diversity each year despite yearly differences in rainfall. Because many of the species that were planted in 1996 have not yet appeared, the full effect of seeding may not yet have been observed.

Mowing clearly had a beneficial affect on species richness in both seeded and unseeded plots, and burning had a positive affect on species richness on seeded plots. In addition to encouraging overall species richness, mowing also benefited existing C_4

grasses, allowing them to spread. The number of replicates for both treatments, however, was much smaller than originally designed, so results should be considered preliminary.

Johnsongrass was clearly positively affected by both mowing and burning. Results for King ranch bluestem, however, are not completely clear. 1998 results indicate that burning positively affected King ranch bluestem on previously seeded sites, but negatively affected species on sites not previously seeded. Similarly confusing results occur with mowing. Plots seeded in 1996 were adversely affected by mowing in 1998, but mowing plots that had not been seeded had only a minor negative effect. There is no clear ecological explanation for this effect.

Ordination techniques described changes in community composition more effectively than MANOVA without requiring data to be ranked, though both were effective in picking up small changes resulting from treatments. Graphical output resulting from either RDA or CCA allows a clear understanding of how environmental variables affect species or guild composition. Judging from trends illustrated in Figures 14 – 25, seeding effectively added a number of species absent from the site when the study began. Because many of these species, particularly the grasses, have long developmental periods, repeated sampling in the future is required to assess if trends demonstrated by the ordination analyses continue and to determine if the oldfield continues its regeneration towards a tallgrass prairie system.

APPENDIX A

LIST OF COMMON NAMES USED, ALTERNATIVE COMMON NAMES, SCIENTIFIC NAMES FROM DIGGS ET AL. (1999), AND PAST SCIENTIFIC NAMES

Common Name	Alternative Common Name	Scientific Name	Alternative Scientific Name
Agalinis, Prairie		*Agalinis heterophylla*	
Aster, Heath	White prairie aster, Wreath aster	*Aster ericoides*	
Baccharis	Roosevelt-weed	*Baccharis neglecta*	
Basketflower		*Centaurea americana*	
Bermuda grass		*Cynodon dactylon*	
Black-eyed Susan		*Rudebeckia hirta*	
Blue Bell		*Eustoma grandiflorum*	
Bluestem, Big	Turkeyfoot	*Andropogon gerardii*	
Bluestem, Broomsedge		*Andropogon virginicus*	
Bluestem, Bushy		*Andropogon glomeratus*	
Bluestem, King Ranch	K. R. Blustem	*Bothriocloa ischaemum*	*Andropogon ischaemum*
Bluestem, Little		*Schizachyrium scoparium*	*Andropogon scoparium*
Bluestem, Silver	Silver Beard Grass	*Bothriocloa laguroides*	*Bothriocloa saccharoides, Andropogon saccharoides*
Boneset, False		*Brickellia eupatorioides*	*Kuhnia eupatorioides*
Brome, Japanese		*Bromus japonicus*	
Broomweed		*Gutierrezia dracunculiodes*	*Xanthocephalum dracunculoides*
Bundleflower, Illinois		*Desmanthus illinoensis*	
Cone flower, Clasping		*Dracopis amplexicaulis*	*Rudebeckia amplexicalis*
Coneflower, Purple		*Echinacea purpurea*	
Coreopsis, plains		*Coreopsis tinctura*	

Common Name	Alternative Common Name	Scientific Name	Alternative Scientific Name
Cupgrass, Texas		*Eriochloa sericea*	
Daisy, Cutleaf		*Engelmannia persistenia*	
Dropseed, tall		*Sporobolus compositus*	*Sporobolus asper*
Eryngo	False thistle	*Eryngium leavenworthii*	
Firewheel	Indian blanket, Blanket flower	*Gaillardia pulchella*	
Gammagrass. Eastern		*Tripsacum dactyloides*	
Gayfeather	Blazingstar	*Liatrus mucronata*	
Goldenrod, Elm-leaf		*Solidago ulmifolia*	
Grama, Blue		*Bouteloua gracilis*	
Grama, Side-oats		*Bouteloua curtipendula*	
Guara, Tall	Kearney's guara, Wild honeysuckle	*Gaura longiflora*	*Guara biennis, Guara filiformis*
Horse Mint	Lemon beebalm	*Monarda citriodora*	
Indiangrass		*Sogastrum nutans*	
Ironweed, Western	Baldwin's Ironweed	*Vernonia baldwinii*	
Johnsongrass		*Sorghum halepense*	
Milkweed, Texas		*Asclepias texana*	
Noseburn, Short-spike		*Tragia brevispica*	
Partridge-Pea		*Chamaecrista fasciculata*	
Phlox	Pride-of-Texas	*Phlox drummondii*	
Plantain	Slim-spike Plantago	*Plantago heterophylla*	
Poison Ivy		*Toxicodendron radicans*	*Rhus toxicodendron*

Common Name	Alternative Common Name	Scientific Name	Alternative Scientific Name
Prairie Bluets		*Hedyotis nigricans*	
Prairie Clover, Purple		*Dalea purpurea*	
Prairie tea		*Croton monanthogynus*	
Primrose, Evening	Buttercup	*Oenothera biennis*	
Ragweed, common		*Ambrosia artemisifolia*	
Raodside Guara	Bee-blossom, Wild honeysuckle, Kisses	*Gaura suffulta*	
Rosettgrass		*Dicanthilium* spp.	
Snow on the prairie		*Euphorbia bicolor*	
Sorrel, Wood	Sheep-showers, Dillen's oxalis	*Oxalis stricta*	*Oxalis dillenii*
Spear grass	Texas Winter Grass	*Nassella leucotricha*	*Stipa leucotricha*
Sprangletop, Green		*Leptochloa dubia*	
Sunflower, Common	Annual sunflower	*Helianthus annuus*	
Sunflower, Maximilian		*Helianthus maximiliani*	
Switchgrass		*Panicum virgatum*	
Texas Thistle		*Cirsium texanum*	
Three-awn		*Aristida* spp.	
Trompillo	Silverleaf Nightshade	*Solanum elaeagnifolium*	
Verbena, Dakota		*Glandularia bipinnatifida*	*Verbena bipinnatifida*
Wildrye, Canada		*Elymus Canadensis*	
Wildrye, Virginia		*Elymus virginicus*	
Witchgrass,		*Panicum capillare*	*Dicanthelium*

Common Name	Alternative Common Name	Scientific Name	Alternative Scientific Name
Common			*capillare*
Yellow Puff		*Neptunia lutea*	

APPENDIX B

SHOOT COUNTS FOR SPRING PERENNIAL FORB, SUMMER/FALL PERENNIAL FORB, LEGUME, AND WOODY PLANT GUILDS FOR ALL SUB-REPLICATES FOR ALL YEARS

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	F	1	1	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
96	F	1	2	None	C	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	1	3	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	1	4	None	C	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
96	F	1	5	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	1	6	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
96	F	1	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	1	8	None	C	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	12	0	0	0	0
96	F	1	9	None	C	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	2	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	2	2	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
96	F	2	3	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	13	0	0
96	F	2	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0
96	F	2	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	2	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	2	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
96	F	2	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
96	F	2	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	3	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	3	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
96	F	3	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	3	4	Seed	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	1	0	5	0
96	F	3	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
96	F	3	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	5	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	F	3	7	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
96	F	3	8	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
96	F	3	9	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	4	1	None	C	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
96	F	4	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	4	3	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	4	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	4	5	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	5	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
96	F	5	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	5	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
96	F	5	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	5	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
96	F	5	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	5	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	5	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	5	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	0	0
96	F	6	1	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	6	2	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0
96	F	6	3	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
96	F	6	4	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0
96	F	6	5	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	6	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	3	0
96	F	6	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	F	6	8	None	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0
96	F	6	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	7	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	7	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	7	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	7	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0
96	F	7	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	7	6	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0
96	F	7	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	7	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	2	0	0
96	F	7	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0	0
96	F	8	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	8	2	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
96	F	8	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	8	4	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	8	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	8	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	8	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	8	8	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
96	F	8	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	9	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0
96	F	9	2	None	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
96	F	9	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	9	4	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	F	9	5	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	9	6	None	C	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	1	0	0	0	0	0	16	0	0
96	F	9	7	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	11	0	0	0	0	0	4	0	0
96	F	9	8	None	C	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	21	0	0
96	F	9	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	10	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0
96	F	10	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	10	3	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	10	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	10	5	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	10	0	0	0	0	0	1	0	0
96	F	10	6	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
96	F	10	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	10	8	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	10	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	11	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	11	2	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4	0	0	0	1	0	0	3	0
96	F	11	3	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	11	4	Seed	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	11	5	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	11	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	11	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	7	0	0	0	0
96	F	11	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	11	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	12	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	F	12	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	12	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	12	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	12	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	12	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	12	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	12	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	12	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0
96	F	13	1	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	13	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0
96	F	13	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	13	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0
96	F	13	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	13	6	None	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	4	0	0	0	0	0	0	5	0
96	F	13	7	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0
96	F	13	8	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
96	F	13	9	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	14	1	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	14	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	2	0	0
96	F	14	3	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	14	4	Seed	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	14	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	14	6	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	14	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0

91

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	F	14	8	Seed	C	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	14	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0
96	F	15	1	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	15	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
96	F	15	3	None	C	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	15	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
96	F	15	5	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	3	0	0	0	0	0	0	9	0
96	F	16	1	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	16	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	16	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	16	4	None	C	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	16	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	16	6	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
96	F	16	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	16	8	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	16	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	17	1	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
96	F	17	2	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	17	3	None	C	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	17	4	None	C	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	4	0	0	0	0	0	0	0	0
96	F	17	5	None	C	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	17	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	17	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	17	8	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	F	17	9	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	18	1	None	C	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	18	2	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	18	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
96	F	18	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	18	5	None	C	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	18	6	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	18	7	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	18	8	None	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	2	0	0	0	0	0	3	0	0
96	F	18	9	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	19	1	Seed	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	19	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	19	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0
96	F	19	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	4	0	0
96	F	19	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1	0	0	0	0	0	0
96	F	19	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	3	0	0
96	F	19	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
96	F	19	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	19	9	Seed	C	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	20	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	20	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	20	3	Seed	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	20	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	20	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	F	20	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
96	F	20	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	20	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
96	F	20	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	21	1	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	21	2	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	21	3	None	C	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	21	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
96	F	21	5	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	21	6	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0
96	F	21	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
96	F	21	8	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	21	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	3	0	0	1	0
96	F	22	1	None	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	22	2	None	C	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	1	0	0	0	0	0	3	0	0
96	F	22	3	None	C	0	0	0	0	0	0	0	0	0	8	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	22	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
96	F	22	5	None	C	0	0	0	0	0	1	0	0	0	9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
96	F	22	6	None	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
96	F	22	7	None	C	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	22	8	None	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0
96	F	22	9	None	C	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	23	1	None	C	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	23	2	None	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0

94

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	F	23	3	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
96	F	23	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	2	0	0
96	F	23	5	None	C	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
96	F	23	6	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	23	7	None	C	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	23	8	None	C	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	23	9	None	C	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	24	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	24	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	2	0	0	0	0
96	F	24	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
96	F	24	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	24	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
96	F	24	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	24	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	24	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	24	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	25	1	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	2	0	1	0	0	0	2	0	0
96	F	25	2	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
96	F	25	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	25	4	None	C	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	25	5	None	C	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	4	0	0
96	F	25	6	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	25	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	25	8	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0

95

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	F	25	9	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	2	0	3	0	0	0	0	0	0
96	F	26	1	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	26	2	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	26	3	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	6	0	0	0	0	0	0	3	0
96	F	26	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	26	5	None	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	9	0	1	0	0	0	0	3	0
96	F	26	6	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	26	7	None	C	0	0	0	0	0	0	0	0	0	23	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0
96	F	26	8	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	26	9	None	C	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
96	F	27	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	27	2	Seed	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0
96	F	27	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	27	4	Seed	C	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	27	5	Seed	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0
96	F	27	6	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	0	0	0	3	0
96	F	27	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	27	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
96	F	27	9	Seed	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
96	F	28	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	28	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
96	F	28	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	28	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
96	F	28	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0

96

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	F	28	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	28	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	28	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	28	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	29	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	29	2	None	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0
96	F	29	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	29	4	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
96	F	29	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
96	F	29	6	None	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	3	0	3	0	0	0	0	0	0
96	F	29	7	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
96	F	29	8	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	29	9	None	C	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	5	0	0	0	0	0	0	4	0
96	F	30	1	None	C	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	30	2	None	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	30	3	None	C	0	0	0	0	0	0	0	0	0	6	0	5	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	30	4	None	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	30	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	2	0	0	0	0	0	0
96	F	30	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
96	F	30	7	None	C	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	30	8	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
96	F	30	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0
96	F	31	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	31	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	F	31	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	31	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	31	5	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	31	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
96	F	31	7	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	31	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	31	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	32	1	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	32	2	None	C	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	32	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	32	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	32	5	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	4	0	0	0	0	0	0	4	0
96	F	32	6	None	C	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	32	7	None	C	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	32	8	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0
96	F	32	9	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	33	1	Seed	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0
96	F	33	2	Seed	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0
96	F	33	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	33	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	33	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	33	6	Seed	C	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	33	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	33	8	Seed	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	F	33	9	Seed	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	34	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
96	F	34	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	34	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
96	F	34	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	34	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	34	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	34	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
96	F	34	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	34	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	35	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
96	F	35	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	35	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	35	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	2	0
96	F	35	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
96	F	35	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	35	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	35	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	35	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	36	1	None	C	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	36	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
96	F	36	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	36	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
96	F	36	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	F	36	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	36	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	36	8	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	36	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
96	F	37	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	37	2	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0
96	F	37	3	Seed	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	37	4	Seed	C	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	37	5	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	37	6	Seed	C	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0
96	F	37	7	Seed	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	37	8	Seed	C	0	0	0	0	0	0	0	0	0	23	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0
96	F	37	9	Seed	C	0	0	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	38	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0
96	F	38	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	38	3	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	38	4	Seed	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
96	F	38	5	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
96	F	38	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	38	7	Seed	C	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
96	F	38	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0
96	F	38	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	18	0	0	0	0
96	F	39	1	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	39	2	None	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

100

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	F	39	3	None	C	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	39	4	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	F	39	5	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	F	39	6	None	C	0	0	0	0	0	0	0	0	0	26	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	F	39	7	None	C	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	F	39	8	None	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
96	F	39	9	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
97	F	1	1	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
97	F	1	2	None	C	0	0	0	0	0	0	0	0	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	1	3	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	1	4	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	1	5	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	1	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	1	7	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	1	8	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	F	1	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	2	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	2	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	2	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	2	4	Seed	C	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	2	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
97	F	2	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	F	2	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	2	8	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	F	2	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0
97	F	3	1	Seed	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
97	F	3	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
97	F	3	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	3	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	3	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	3	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	3	7	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	3	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	F	3	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	4	1	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
97	F	4	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
97	F	4	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0
97	F	4	4	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
97	F	4	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	5	1	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	5	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	5	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	F	5	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	5	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	5	6	Seed	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	5	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	5	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	5	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

102

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	F	6	1	None	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	6	2	None	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	6	3	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	5	0	0	0	0	1	0	0	0
97	F	6	4	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	6	5	None	C	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	6	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	6	7	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
97	F	6	8	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	6	9	None	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
97	F	7	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
97	F	7	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0
97	F	7	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
97	F	7	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
97	F	7	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	7	6	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	7	7	Seed	C	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	7	8	Seed	C	0	0	0	0	0	0	4	0	0	5	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0
97	F	7	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	8	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	8	2	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	8	3	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	8	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	F	8	5	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	8	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	F	8	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	8	8	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
97	F	8	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	9	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	9	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	9	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
97	F	9	4	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	F	9	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	9	6	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	9	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	9	8	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	9	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	10	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	10	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	10	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	1
97	F	10	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	10	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	1	0	0
97	F	10	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	10	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
97	F	10	8	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	10	9	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	11	1	Seed	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	11	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	11	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	F	11	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	11	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	11	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	11	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	11	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	11	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
97	F	12	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	12	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	12	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	12	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	12	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
97	F	12	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	0	0	0	0	0	0
97	F	12	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
97	F	12	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	12	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	13	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	F	13	2	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	13	3	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
97	F	13	4	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	F	13	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	13	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	13	7	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	13	8	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	13	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	F	14	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	14	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	14	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	14	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	14	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	14	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	14	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	14	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	14	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	15	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	15	2	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	15	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	15	4	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	15	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	16	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	16	2	None	C	0	0	0	0	0	0	0	0	1	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	16	3	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	16	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	16	5	None	C	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	16	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	16	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	16	8	None	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	16	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	17	1	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	F	17	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	17	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	17	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	17	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	17	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	17	7	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	F	17	8	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	17	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
97	F	18	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	18	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	18	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
97	F	18	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	18	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	18	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	F	18	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0
97	F	18	8	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	F	18	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	19	1	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	19	2	Seed	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	19	3	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	19	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	19	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	19	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	19	7	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	F	19	8	Seed	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	19	9	Seed	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
97	F	20	1	Seed	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	20	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	20	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	20	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	20	5	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	20	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	20	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
97	F	20	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	20	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	21	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	21	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
97	F	21	3	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	21	4	None	C	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	21	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	21	6	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	21	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	21	8	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
97	F	21	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	22	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	22	2	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	22	3	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	22	4	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	F	22	5	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	3	0	0	0	0	0	0	7	0
97	F	22	6	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	22	7	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	22	8	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
97	F	22	9	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	23	1	None	C	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	23	2	None	C	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
97	F	23	3	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	23	4	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0
97	F	23	5	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	23	6	None	C	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	23	7	None	C	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	23	8	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
97	F	23	9	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	24	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	24	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
97	F	24	3	Seed	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	F	24	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	24	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	24	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	24	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
97	F	24	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	24	9	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	25	1	None	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	F	25	2	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
97	F	25	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	25	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	25	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	25	6	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	25	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	25	8	None	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	F	25	9	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	26	1	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	F	26	2	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	26	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	26	4	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	26	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	26	6	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	26	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	26	8	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	26	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	27	1	Seed	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	27	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
97	F	27	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
97	F	27	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	27	5	Seed	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
97	F	28	1	Seed	C	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	28	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

110

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	F	28	3	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	28	4	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
97	F	28	5	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	28	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	28	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	28	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
97	F	28	9	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	29	1	None	C	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	F	29	2	None	C	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	29	3	None	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
97	F	29	4	None	C	0	0	0	0	0	0	0	0	0	13	0	1	0	0	0	0	3	0	0	0	0	0	0	0	0
97	F	29	5	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	29	6	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
97	F	29	7	None	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	F	29	8	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0
97	F	29	9	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	30	1	None	C	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	30	2	None	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
97	F	30	3	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	30	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0
97	F	30	5	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	30	6	None	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	30	7	None	C	0	0	0	0	0	0	0	0	0	3	0	1	0	0	0	0	4	0	0	0	0	0	0	0	0
97	F	30	8	None	C	0	0	0	0	0	0	0	0	0	28	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	F	30	9	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	31	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	31	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	31	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	31	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	31	5	Seed	C	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	31	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0
97	F	31	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	31	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	31	9	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	32	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	32	2	None	C	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	32	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	32	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	32	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	32	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	32	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	32	8	None	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	32	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	33	1	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	F	33	2	Seed	C	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	33	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	33	4	Seed	C	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	33	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	F	33	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	33	7	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0
97	F	33	8	Seed	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	F	33	9	Seed	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	34	1	Seed	C	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	F	34	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
97	F	34	3	Seed	C	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
97	F	34	4	Seed	C	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0
97	F	34	5	Seed	C	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	34	6	Seed	C	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	34	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
97	F	34	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
97	F	34	9	Seed	C	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	35	1	Seed	C	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	35	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
97	F	35	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	35	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	35	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	35	6	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	35	7	Seed	C	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	35	8	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
97	F	35	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	36	1	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	36	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

113

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	F	36	3	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	36	4	None	C	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	36	5	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
97	F	36	6	None	C	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	36	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0
97	F	36	8	None	C	0	0	0	0	0	0	0	0	0	8	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	36	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	37	1	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
97	F	37	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
97	F	37	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
97	F	37	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	37	5	Seed	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	37	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	37	7	Seed	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	37	8	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
97	F	37	9	Seed	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
97	F	38	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	38	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	F	38	3	Seed	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	38	4	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
97	F	38	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	38	6	Seed	C	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	38	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	38	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

114

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	F	38	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	39	1	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	39	2	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	39	3	None	C	0	0	0	0	0	0	0	0	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	39	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	39	5	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	F	39	6	None	C	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	39	7	None	C	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	F	39	8	None	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0
97	F	39	9	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	1	1	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
98	F	1	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	1	3	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	1	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	1	5	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	1	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	1	7	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	1	8	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	1	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	2	1	Seed	M	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	2	2	Seed	M	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	2	3	Seed	M	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
98	F	2	4	Seed	M	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	2	5	Seed	M	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	F	2	6	Seed	M	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	2	7	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	2	8	Seed	M	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	2	9	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	3	1	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	3	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
98	F	3	3	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	3	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	3	5	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	3	6	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	3	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	3	8	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	3	9	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	4	1	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	4	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	4	3	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
98	F	4	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
98	F	4	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0
98	F	5	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	5	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	5	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	5	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	5	5	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
98	F	5	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	F	5	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	5	8	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
98	F	5	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
98	F	6	1	None	M	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0	0	0	2	2	0	0	0	0	1	0
98	F	6	2	None	M	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	6	3	None	M	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
98	F	6	4	None	M	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	6	5	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	6	6	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0
98	F	6	7	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
98	F	6	8	None	M	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
98	F	6	9	None	M	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	7	1	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
98	F	7	2	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	7	3	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
98	F	7	4	Seed	B	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
98	F	7	5	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
98	F	7	6	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	7	7	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	7	8	Seed	B	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	7	9	Seed	B	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	8	1	None	M	0	0	0	0	0	0	1	0	0	5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
98	F	8	2	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	8	3	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	F	8	4	None	M	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	8	5	None	M	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	8	6	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	8	7	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	8	8	None	M	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
98	F	8	9	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	9	1	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	9	2	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	9	3	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
98	F	9	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
98	F	9	5	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
98	F	9	6	None	C	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	9	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
98	F	9	8	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
98	F	9	9	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0
98	F	10	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	10	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
98	F	10	3	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	10	4	None	C	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	2	0	0
98	F	10	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	10	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	10	7	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	10	8	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
98	F	10	9	None	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	F	11	1	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	11	2	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	11	3	Seed	B	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	11	4	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	11	5	Seed	B	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
98	F	11	6	Seed	B	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
98	F	11	7	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	11	8	Seed	B	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
98	F	11	9	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
98	F	12	1	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	12	2	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
98	F	12	3	Seed	M	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0
98	F	12	4	Seed	M	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	12	5	Seed	M	0	0	0	0	0	0	0	0	0	5	0	1	0	0	0	0	0	15	0	0	0	0	0	0	0
98	F	12	6	Seed	M	0	0	0	0	0	1	0	0	0	2	7	3	0	0	0	0	0	1	0	0	0	0	0	0	0
98	F	12	7	Seed	M	0	0	0	0	0	1	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0
98	F	12	8	Seed	M	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
98	F	12	9	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	13	1	None	B	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	13	2	None	B	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
98	F	13	3	None	B	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	13	4	None	B	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	13	5	None	B	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0
98	F	13	6	None	B	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	F	13	7	None	B	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	13	8	None	B	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	13	9	None	B	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	14	1	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
98	F	14	2	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	14	3	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	14	4	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	14	5	Seed	M	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	14	6	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
98	F	14	7	Seed	M	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	14	8	Seed	M	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	14	9	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	15	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	15	2	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	15	3	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
98	F	15	4	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	15	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	16	1	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
98	F	16	2	None	M	0	0	0	0	0	0	4	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	16	3	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	16	4	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	16	5	None	M	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	16	6	None	M	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	16	7	None	M	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	F	16	8	None	M	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
98	F	16	9	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	17	1	None	B	0	0	0	0	0	1	0	0	0	7	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
98	F	17	2	None	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	17	3	None	B	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	17	4	None	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
98	F	17	5	None	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	17	6	None	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
98	F	17	7	None	B	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
98	F	17	8	None	B	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
98	F	17	9	None	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
98	F	18	1	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	18	2	None	M	0	0	0	0	0	0	0	0	0	38	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
98	F	18	3	None	M	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
98	F	18	4	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0
98	F	18	5	None	M	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
98	F	18	6	None	M	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0
98	F	18	7	None	M	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
98	F	18	8	None	M	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
98	F	18	9	None	M	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	19	1	Seed	B	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0	1	0	0	0	0	0	0
98	F	19	2	Seed	B	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0
98	F	19	3	Seed	B	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
98	F	19	4	Seed	B	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	3	0

121

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	F	19	5	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	19	6	Seed	B	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	19	7	Seed	B	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	19	8	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
98	F	19	9	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	20	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	20	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	20	3	Seed	C	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	20	4	Seed	C	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	20	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
98	F	20	6	Seed	C	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	20	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	20	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	20	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	21	1	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	5	0	0	0	0	0	1	0	0
98	F	21	2	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0
98	F	21	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	21	4	None	C	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0
98	F	21	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	21	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	21	7	None	C	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	21	8	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	21	9	None	C	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
98	F	22	1	None	B	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	F	22	2	None	B	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0
98	F	22	3	None	B	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	22	4	None	B	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	22	5	None	B	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
98	F	22	6	None	B	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
98	F	22	7	None	B	0	0	0	0	0	0	4	0	0	11	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
98	F	22	8	None	B	0	0	0	0	0	0	1	0	0	5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	22	9	None	B	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	23	1	None	M	0	0	0	0	0	0	3	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	23	2	None	M	0	0	0	0	0	0	5	0	0	16	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	23	3	None	M	0	0	0	0	0	0	1	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
98	F	23	4	None	M	0	0	0	0	0	0	0	0	0	34	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	23	5	None	M	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	23	6	None	M	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	23	7	None	M	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	23	8	None	M	0	0	0	0	0	0	1	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	23	9	None	M	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
98	F	24	1	Seed	C	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	24	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	24	3	Seed	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	24	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	24	5	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	24	6	Seed	C	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
98	F	24	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	F	24	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	24	9	Seed	C	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	25	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	25	2	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	25	3	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
98	F	25	4	None	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	25	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	25	6	None	C	0	0	0	0	0	0	1	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	25	7	None	C	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	25	8	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	25	9	None	C	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	26	1	None	M	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0	0	1	0	3	0	0	0	0	1	0
98	F	26	2	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	26	3	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	26	4	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
98	F	26	5	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
98	F	26	6	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0
98	F	26	7	None	M	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	26	8	None	M	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	2	1	0	0	0	0	0	3	0
98	F	26	9	None	M	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	27	1	Seed	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	27	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	27	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	27	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0

124

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	F	27	5	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	27	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	27	7	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	27	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	27	9	Seed	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	28	1	Seed	M	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	28	2	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	28	3	Seed	M	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	28	4	Seed	M	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	28	5	Seed	M	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	28	6	Seed	M	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	28	7	Seed	M	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
98	F	28	8	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	28	9	Seed	M	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	29	1	None	B	0	0	0	0	0	0	0	0	0	26	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
98	F	29	2	None	B	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
98	F	29	3	None	B	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	12	0	0	0	0	0	0	1	0
98	F	29	4	None	B	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
98	F	29	5	None	B	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
98	F	29	6	None	B	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	29	7	None	B	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	29	8	None	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	3	0
98	F	29	9	None	B	0	0	0	0	0	0	0	0	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	30	1	None	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	F	30	2	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
98	F	30	3	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	30	4	None	C	0	0	0	0	0	0	3	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	30	5	None	C	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	30	6	None	C	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	30	7	None	C	0	0	0	0	0	0	3	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	30	8	None	C	0	0	0	0	0	0	1	0	0	4	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0
98	F	30	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
98	F	31	1	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	31	2	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	0
98	F	31	3	Seed	M	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	31	4	Seed	M	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0
98	F	31	5	Seed	M	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	8	1	0	0	0	0	0	0	0
98	F	31	6	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
98	F	31	7	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	31	8	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	31	9	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	32	1	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	32	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	32	3	None	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
98	F	32	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	32	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	4	0
98	F	32	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	32	7	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	F	32	8	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	32	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	33	1	Seed	C	0	0	0	0	0	0	5	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	33	2	Seed	C	0	0	0	0	0	0	45	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	33	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	33	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	33	5	Seed	C	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	33	6	Seed	C	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	33	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	33	8	Seed	C	0	0	0	0	0	0	13	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	33	9	Seed	C	0	0	0	0	0	0	7	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	34	1	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	34	2	Seed	B	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
98	F	34	3	Seed	B	0	0	0	0	0	0	2	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	34	4	Seed	B	0	0	0	0	0	0	3	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0
98	F	34	5	Seed	B	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	34	6	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
98	F	34	7	Seed	B	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
98	F	34	8	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0
98	F	34	9	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
98	F	35	1	Seed	C	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	35	2	Seed	C	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	35	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	35	4	Seed	C	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0

127

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	F	35	5	Seed	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	35	6	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
98	F	35	7	Seed	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	35	8	Seed	C	0	0	0	0	0	0	3	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	35	9	Seed	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	36	1	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	36	2	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	36	3	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	36	4	None	C	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	3	0	0	0	0	0	0	2	0
98	F	36	5	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0
98	F	36	6	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	36	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	36	8	None	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	36	9	None	C	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	37	1	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	37	2	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	37	3	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	37	4	Seed	B	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	37	5	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	37	6	Seed	B	0	0	0	0	0	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	37	7	Seed	B	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
98	F	37	8	Seed	B	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	37	9	Seed	B	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	38	1	Seed	M	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	F	38	2	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
98	F	38	3	Seed	M	0	0	0	0	0	0	0	12	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	38	4	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	38	5	Seed	M	0	0	0	0	0	0	0	0	0	11	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	38	6	Seed	M	0	0	0	0	0	0	0	32	0	4	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0
98	F	38	7	Seed	M	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	38	8	Seed	M	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	38	9	Seed	M	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	F	39	1	None	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	39	2	None	C	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	39	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	39	4	None	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	F	39	5	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	39	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	39	7	None	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	39	8	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	F	39	9	None	C	0	0	0	0	0	0	3	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	S	1	1	None	C	0	0	0	0	0	0	0	0	1	36	0	0	0	0	0	0	5	0	0	0	0	0	0	11	0
96	S	1	2	None	C	0	0	0	0	0	0	0	0	1	22	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
96	S	1	3	None	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
96	S	1	4	None	C	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	4	0	0	0	0	0	0	8	0
96	S	1	5	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0
96	S	1	6	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
96	S	1	7	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	S	1	8	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	S	1	9	None	C	0	0	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0
96	S	2	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	1	0
96	S	2	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	1	0	0	0	9	0
96	S	2	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	9	0
96	S	2	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	7	0
96	S	2	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0	0	0	4	0
96	S	2	6	Seed	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0
96	S	2	7	Seed	C	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	4	0	0	0	0	0	0	20	0
96	S	2	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0
96	S	2	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
96	S	3	1	Seed	C	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	S	3	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	16	0	0
96	S	3	3	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
96	S	3	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0
96	S	3	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	8	4	0
96	S	3	6	Seed	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0
96	S	3	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3	0	0	0	17	0	0
96	S	3	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	11	0
96	S	3	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	18	0	0
96	S	4	1	None	C	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	1	0	0	0	0	0	0	6	0
96	S	4	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	1	0
96	S	4	3	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	1	0	0	0	0	0	0	10	0
96	S	4	4	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	S	4	5	None	C	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	12	0	0	0	0	0	0	13	0
96	S	5	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	1	0	0	0	5	0
96	S	5	2	Seed	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
96	S	5	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	4	0
96	S	5	4	Seed	C	0	0	0	0	0	0	0	0	1	33	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0
96	S	5	5	Seed	C	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	21	0
96	S	5	6	Seed	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
96	S	5	7	Seed	C	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	2	0	0	0	0	0	0	10	0
96	S	5	8	Seed	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0
96	S	5	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	5	0	0	0	0
96	S	6	1	None	C	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	1	0	0	0	18	0
96	S	6	2	None	C	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	1	0	0	4	0	0	0	3	0
96	S	6	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	S	6	4	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	S	6	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	7	0
96	S	6	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	14	0
96	S	6	7	None	C	0	0	0	0	0	0	0	0	1	5	0	0	0	0	0	0	8	0	0	0	0	0	0	5	0
96	S	6	8	None	C	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
96	S	6	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
96	S	7	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
96	S	7	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	10	0
96	S	7	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	22	0
96	S	7	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	7	0
96	S	7	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	8	0

131

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	S	7	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	S	7	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	13	0
96	S	7	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0
96	S	7	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0
96	S	8	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	4	0
96	S	8	2	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	5	0
96	S	8	3	None	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0
96	S	8	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	8	0
96	S	8	5	None	C	0	0	0	0	0	0	0	0	0	36	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	S	8	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	21	0
96	S	8	7	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
96	S	8	8	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
96	S	8	9	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	S	9	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	4	2	0
96	S	9	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	7	6	0
96	S	9	3	None	C	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
96	S	9	4	None	C	0	0	0	0	0	0	0	0	0	21	0	0	0	0	0	0	1	0	0	0	0	0	0	4	0
96	S	9	5	None	C	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	8	0	2	0	0	0	0	0	0
96	S	9	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	5	5	0
96	S	9	7	None	C	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	1	0
96	S	9	8	None	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
96	S	9	9	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	S	10	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	S	10	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	12	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	S	10	3	None	C	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	2	0	0	0	0	0	0	8	0
96	S	10	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	6	0
96	S	10	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	S	10	6	None	C	0	0	0	0	0	0	0	0	0	7	0	0	1	0	0	0	3	0	1	0	0	0	0	19	0
96	S	10	7	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	2	10
96	S	10	8	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2
96	S	10	9	None	C	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0
96	S	11	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	20	0
96	S	11	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	12	0
96	S	11	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	32	0	0	7	0
96	S	11	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	S	11	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	5	0
96	S	11	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	2	0
96	S	11	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	4	0
96	S	11	8	Seed	C	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	9	0
96	S	11	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	15	0
96	S	12	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0
96	S	12	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
96	S	12	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	S	12	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0
96	S	12	5	Seed	C	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	S	12	6	Seed	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
96	S	12	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
96	S	12	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	S	12	9	Seed	C	0	0	0	0	0	0	0	0	10	1	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0
96	S	13	1	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	3	0	0	0	0	0	0	12	0
96	S	13	2	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	3	0	0	0	0	0	0	16	0
96	S	13	3	None	C	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	24	0
96	S	13	4	None	C	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	1	0	0	0	0	0	0	22	0
96	S	13	5	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	6	0	0	0	0	0	0	12	0
96	S	13	6	None	C	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	S	13	7	None	C	0	0	0	0	0	0	0	0	0	9	1	0	0	0	0	0	1	0	0	0	0	0	0	4	0
96	S	13	8	None	C	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0
96	S	13	9	None	C	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	2	0	0	0	0	0	0	5	0
96	S	14	1	Seed	C	0	0	0	0	0	0	0	0	0	8	1	0	0	0	0	0	0	0	0	2	0	1	0	0	0
96	S	14	2	Seed	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0
96	S	14	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	5	0
96	S	14	4	Seed	C	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
96	S	14	5	Seed	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	S	14	6	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0
96	S	14	7	Seed	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	5	0	0	0	0	1	0	1	0
96	S	14	8	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
96	S	14	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	25	0
96	S	15	1	None	C	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	8	0	0	0	0	0	4	3	0
96	S	15	2	None	C	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	1	0	0	0	0	0	1	6	0
96	S	15	3	None	C	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	5	0	0	0	0	0	4	0	0
96	S	15	4	None	C	0	0	0	0	0	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0
96	S	15	5	None	C	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0	0	1	0	0	0	0	9	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	S	16	1	None	C	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
96	S	16	2	None	C	0	0	0	0	0	0	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	S	16	3	None	C	0	0	0	0	0	0	3	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	S	16	4	None	C	0	0	0	0	0	0	0	0	0	26	0	0	0	0	0	0	2	0	0	0	0	0	0	24	0
96	S	16	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
96	S	16	6	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
96	S	16	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
96	S	16	8	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
96	S	16	9	None	C	0	0	0	0	0	0	0	0	0	19	1	0	0	0	0	0	0	0	1	0	0	0	0	10	0
96	S	17	1	None	C	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
96	S	17	2	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	10	0
96	S	17	3	None	C	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0
96	S	17	4	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
96	S	17	5	None	C	0	0	0	0	0	0	6	0	0	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	S	17	6	None	C	0	0	0	0	0	0	6	0	0	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	S	17	7	None	C	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	12	0
96	S	17	8	None	C	0	0	0	0	0	0	0	0	2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
96	S	17	9	None	C	0	0	0	0	0	0	0	0	0	0	3	0	1	0	0	0	1	0	0	0	0	0	0	0	0
96	S	18	1	None	C	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	S	18	2	None	C	0	0	0	0	0	0	0	0	1	8	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
96	S	18	3	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
96	S	18	4	None	C	0	0	0	0	0	0	0	0	2	5	0	0	0	0	0	0	3	0	0	0	0	0	0	5	0
96	S	18	5	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	3	0	0	0	0	0	0	9	0
96	S	18	6	None	C	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	11	0	0	0	0	0	0	17	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	S	18	7	None	C	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	5	0	0	0	0	0	0	3	0
96	S	18	8	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	6	0	0	0	0	0	0	10	0
96	S	18	9	None	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	5	0	0	0	0	0	0	9	0
96	S	19	1	Seed	C	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	S	19	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0
96	S	19	3	Seed	C	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	16	0
96	S	19	4	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	3	0	0	0	0	0	0	12	0
96	S	19	5	Seed	C	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	4	0	0	0	0	0	0	8	0
96	S	19	6	Seed	C	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	S	19	7	Seed	C	0	0	0	0	0	0	0	0	0	0	4	0	1	0	0	0	4	0	0	0	0	0	3	8	0
96	S	19	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0
96	S	19	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
96	S	20	1	Seed	C	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	4	0	3	0	0	0	0	5	0
96	S	20	2	Seed	C	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	4	0	0	0	0	0	0	7	0
96	S	20	3	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	0	42	0	0	0	0
96	S	20	4	Seed	C	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
96	S	20	5	Seed	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0	0	0	0	1	0	16	0
96	S	20	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0
96	S	20	7	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	6	0	0	0	0	1	0	1	0
96	S	20	8	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	1	0	0	2	2	0
96	S	20	9	Seed	C	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	6	0
96	S	21	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	5	0	0
96	S	21	2	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	10	0	0	0	0	0	0	1	0
96	S	21	3	None	C	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0

136

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	S	21	4	None	C	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	1	0	0	0	1	11	0
96	S	21	5	None	C	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	1	0	0	0	0	6	0
96	S	21	6	None	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0
96	S	21	7	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	1	5	0	0
96	S	21	8	None	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	3	0	1	0	0	0	0	8	0
96	S	21	9	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0
96	S	22	1	None	C	0	0	0	0	0	0	2	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0
96	S	22	2	None	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	13	0	0	0	0	0	3	0	0
96	S	22	3	None	C	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	1	0	1	0	0	0	6	5	0
96	S	22	4	None	C	0	0	0	0	0	0	0	0	1	18	0	0	0	0	0	0	6	0	0	0	0	1	2	0	0
96	S	22	5	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	1	0	0	0	0	10	0
96	S	22	6	None	C	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	1	0	0	0	0	0	0	8	0
96	S	22	7	None	C	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	2	0	1	0	0	1	9	0	0
96	S	22	8	None	C	0	0	0	0	0	0	1	0	0	35	0	0	0	0	0	0	2	0	0	0	0	0	0	10	0
96	S	22	9	None	C	0	0	0	0	0	0	2	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0
96	S	23	1	None	C	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
96	S	23	2	None	C	0	0	0	0	0	0	0	0	1	5	0	0	0	0	0	0	5	0	0	0	0	0	0	23	0
96	S	23	3	None	C	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
96	S	23	4	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	10	0	3	0	0	0	0	7	0
96	S	23	5	None	C	0	0	0	0	0	0	0	0	0	36	0	0	0	0	0	0	2	0	0	0	0	0	0	8	0
96	S	23	6	None	C	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
96	S	23	7	None	C	0	0	0	0	0	0	0	0	1	13	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0
96	S	23	8	None	C	0	0	0	0	0	0	0	0	0	32	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
96	S	23	9	None	C	0	0	0	0	0	0	0	0	1	24	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0

137

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	S	24	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	S	24	2	Seed	C	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	3	0	2	0	0	0	0	18	0
96	S	24	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	5	0
96	S	24	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0	0	0	0	12	0
96	S	24	5	Seed	C	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
96	S	24	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	29	0
96	S	24	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	13	0
96	S	24	8	Seed	C	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	23	0
96	S	24	9	Seed	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0
96	S	25	1	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4	12	0
96	S	25	2	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
96	S	25	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	8	0
96	S	25	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0
96	S	25	5	None	C	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
96	S	25	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
96	S	25	7	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	4	0	2	0	0	0	0	2	0
96	S	25	8	None	C	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	5	0	0	0	0	0	0	9	0
96	S	25	9	None	C	0	0	0	0	0	0	0	0	0	23	0	0	0	0	0	0	0	0	2	0	0	0	0	8	0
96	S	26	1	None	C	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	2	0	0	0	0	0	0	6	0
96	S	26	2	None	C	0	0	0	0	0	0	0	0	2	6	0	0	0	0	0	0	2	0	5	0	0	0	1	4	0
96	S	26	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0
96	S	26	4	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	S	26	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	17	0
96	S	26	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	1	0

138

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	S	26	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
96	S	26	8	None	C	0	0	0	0	0	0	0	0	2	8	0	0	0	0	0	0	5	0	0	0	0	0	0	6	0
96	S	26	9	None	C	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
96	S	27	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	S	27	2	Seed	C	0	0	0	0	0	0	0	0	3	15	0	0	0	0	0	0	1	0	0	0	0	0	0	17	0
96	S	27	3	Seed	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0
96	S	27	4	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0
96	S	27	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
96	S	27	6	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	12	0
96	S	27	7	Seed	C	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
96	S	27	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0
96	S	27	9	Seed	C	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0
96	S	28	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	36	0
96	S	28	2	Seed	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	10	0
96	S	28	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	29	0
96	S	28	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	30	0
96	S	28	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	14	0
96	S	28	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0
96	S	28	7	Seed	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0
96	S	28	8	Seed	C	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	22	0
96	S	28	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	1	0	0	0	0	19	0
96	S	29	1	None	C	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	3	0	0	0	0	1	0
96	S	29	2	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	1	0	0	0	0	0	0	22	0
96	S	29	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	12	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	S	29	4	None	C	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	7	0	0	0	0	0	0	4	0
96	S	29	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	12	0
96	S	29	6	None	C	0	0	0	0	0	0	0	0	1	5	0	0	0	0	0	0	3	0	0	0	0	0	0	11	0
96	S	29	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	3	0	0	0	0	12	0
96	S	29	8	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	5	0	0	0	0	15	6
96	S	29	9	None	C	0	0	0	0	0	0	0	0	1	5	0	0	0	0	0	0	7	0	5	0	0	0	1	0	0
96	S	30	1	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	5	0	0	0	0	0	0	5	0
96	S	30	2	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	1	0	0	0	0	10	0
96	S	30	3	None	C	0	0	0	0	0	0	0	0	1	5	0	0	0	0	0	0	3	0	0	0	0	0	2	0	0
96	S	30	4	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	3	0	2	0	0	0	0	7	0
96	S	30	5	None	C	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	4	0	1	0	0	0	0	0	0
96	S	30	6	None	C	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0
96	S	30	7	None	C	0	0	0	0	0	0	0	0	0	28	0	0	0	0	0	0	3	0	0	0	0	0	0	7	0
96	S	30	8	None	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	1	0	0	0	0	0	3	0	0
96	S	30	9	None	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
96	S	31	1	Seed	C	0	0	0	0	0	0	0	0	1	14	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0
96	S	31	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0
96	S	31	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0
96	S	31	4	Seed	C	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0
96	S	31	5	Seed	C	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
96	S	31	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	22	0
96	S	31	7	Seed	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
96	S	31	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	1	0	3	0
96	S	31	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	S	32	1	None	C	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	4	0	0	0	0	0	3	0	0
96	S	32	2	None	C	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
96	S	32	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	4	0
96	S	32	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	4	0
96	S	32	5	None	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	5	0	0	0	0	0	2	7	0
96	S	32	6	None	C	0	0	0	0	0	0	0	0	0	28	0	0	0	0	0	0	1	0	0	0	0	0	0	6	0
96	S	32	7	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	4	3	0
96	S	32	8	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	3	0	2	0	0	0	0	21	0
96	S	32	9	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	7	0	0	0	0	0	0	7	0
96	S	33	1	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0	4	0	0	0	0	27	0
96	S	33	2	Seed	C	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	3	0	4	0	0	0	0	6	0
96	S	33	3	Seed	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	3	11	0
96	S	33	4	Seed	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	2	0	0	0	0	0	0	8	0
96	S	33	5	Seed	C	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0
96	S	33	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	6	4	0
96	S	33	7	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	3	0	0	0	0	0	0	30	0
96	S	33	8	Seed	C	0	0	0	0	0	0	0	0	0	28	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
96	S	33	9	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	3	0	0	0	0	0	0	5	0
96	S	34	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	1	0	1	9	2	0
96	S	34	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0
96	S	34	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	38	0
96	S	34	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	14	0
96	S	34	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	2	0	0	0	0	0	0
96	S	34	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	S	34	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	12	0
96	S	34	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	13	0
96	S	34	9	Seed	C	0	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
96	S	35	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	7	2	0
96	S	35	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	1	0	0	0	18	0
96	S	35	3	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0
96	S	35	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	6	9	0
96	S	35	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	6	0	0
96	S	35	6	Seed	C	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	2	6	0
96	S	35	7	Seed	C	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	18	0
96	S	35	8	Seed	C	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	17	0
96	S	35	9	Seed	C	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	7	18	0
96	S	36	1	None	C	0	0	0	0	0	0	0	0	1	6	0	0	0	0	0	0	5	0	0	0	0	0	4	2	0
96	S	36	2	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0
96	S	36	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	10	0
96	S	36	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	4	4	0
96	S	36	5	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0
96	S	36	6	None	C	0	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	3	0	0	0	0	0	0	6	0
96	S	36	7	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
96	S	36	8	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0
96	S	36	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	1	0	0	0
96	S	37	1	Seed	C	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	1	0	0	1	0	6	0
96	S	37	2	Seed	C	0	0	0	0	0	0	0	0	1	6	0	0	0	0	0	0	5	0	0	0	0	0	0	9	0
96	S	37	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	10	0

Year	Season	Plot	sub	Seed?	Treatment	CENname	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
96	S	37	4	Seed	C	0	0	0	0	0	0	0	0	2	26	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0
96	S	37	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0
96	S	37	6	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	6	0	0	0	0	0	1	12	0
96	S	37	7	Seed	C	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	S	37	8	Seed	C	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	4	10	0
96	S	37	9	Seed	C	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	1	0	0	0	0	1	0	2	0
96	S	38	1	Seed	C	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	3	4	0
96	S	38	2	Seed	C	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	3	0	1	0	0	0	0	7	0
96	S	38	3	Seed	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	8	0	0	0	0	0	0	20	0
96	S	38	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	3	17	0
96	S	38	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	3	0	0	0	0	15	0
96	S	38	6	Seed	C	0	0	0	0	0	0	4	0	1	0	0	0	0	0	0	0	2	0	4	0	0	0	1	8	0
96	S	38	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	4	0	0	0	6	0	0
96	S	38	8	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5	6	0
96	S	38	9	Seed	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	S	39	1	None	C	0	0	0	0	0	0	0	0	0	32	0	0	0	0	0	0	6	0	0	0	0	1	0	5	0
96	S	39	2	None	C	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
96	S	39	3	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	13	0	1	0	0	0	0	8	0
96	S	39	4	None	C	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
96	S	39	5	None	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	2	0	0	0	0	0	2	7	0
96	S	39	6	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0
96	S	39	7	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
96	S	39	8	None	C	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	3	0	0	0	0	0	0	9	0
96	S	39	9	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	S	1	1	None	C	0	0	0	0	0	2	0	0	0	3	0	0	0	0	0	0	9	0	0	0	0	0	0	8	0
97	S	1	2	None	C	0	0	0	0	0	0	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0
97	S	1	3	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	9	0	0	0	0	0	0	1	0
97	S	1	4	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	S	1	5	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	1	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	S	1	7	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
97	S	1	8	None	C	0	0	0	0	0	0	0	0	0	27	0	0	0	0	0	0	1	0	1	0	0	0	0	11	0
97	S	1	9	None	C	0	0	0	0	0	0	2	0	1	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
97	S	2	1	Seed	C	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	13	0
97	S	2	2	Seed	C	0	0	0	0	0	1	19	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	8	0
97	S	2	3	Seed	C	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	2	7	0
97	S	2	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	9	0
97	S	2	5	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0
97	S	2	6	Seed	C	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	5	0	0	0	0	0	0	3	0
97	S	2	7	Seed	C	0	0	0	0	0	0	0	0	1	5	0	0	0	0	0	0	3	0	0	4	0	0	0	23	0
97	S	2	8	Seed	C	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	13	0
97	S	2	9	Seed	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	1	0	0	0	0	0	0	4	0
97	S	3	1	Seed	C	0	0	0	0	4	0	0	0	0	25	0	0	0	0	0	0	2	0	0	0	0	0	4	0	0
97	S	3	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0
97	S	3	3	Seed	C	0	0	0	0	1	0	0	0	0	12	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
97	S	3	4	Seed	C	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	8	0
97	S	3	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	13	0
97	S	3	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0

Year	Season	Plot	sub	Seed?	Treatment	CENname	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	S	3	7	Seed	C	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	3	0	0	0	0	0	1	0	0
97	S	3	8	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
97	S	3	9	Seed	C	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	6	0
97	S	4	1	None	C	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	9	0	0	0	0	0	0	4	0
97	S	4	2	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	3	0	0	0	0	0	0	9	0
97	S	4	3	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	5	0	0	0	0	0	0	3	0
97	S	4	4	None	C	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0
97	S	4	5	None	C	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	5	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	S	5	2	Seed	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
97	S	5	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	14	0
97	S	5	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0
97	S	5	5	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	14	0
97	S	5	6	Seed	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0
97	S	5	7	Seed	C	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	3	0
97	S	5	8	Seed	C	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0
97	S	5	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	6	0	0	5	0	0
97	S	6	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0
97	S	6	2	None	C	0	0	0	0	0	3	0	0	0	13	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0
97	S	6	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0
97	S	6	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	8	0
97	S	6	5	None	C	0	0	0	0	0	3	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	4	0
97	S	6	6	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	6	0
97	S	6	7	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	S	6	8	None	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	5	0	0	0	0	0	0	6	0
97	S	6	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	12	0
97	S	7	1	Seed	C	0	0	0	0	0	0	0	0	0	1	0	4	0	0	0	0	0	0	0	0	0	0	2	6	0
97	S	7	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	3	0	0	0	0	0	0	6	0
97	S	7	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
97	S	7	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	4	0	0	0	0	0	0	3	0
97	S	7	5	Seed	C	0	0	0	0	0	0	0	0	1	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	7	6	Seed	C	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	2	0	0	0	0	0	0	1	0
97	S	7	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
97	S	7	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	5	0
97	S	7	9	Seed	C	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	8	0
97	S	8	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	S	8	2	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0
97	S	8	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	S	8	4	None	C	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0
97	S	8	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	8	6	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0
97	S	8	7	None	C	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	8	8	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0
97	S	8	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0
97	S	9	1	None	C	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	8	0	0
97	S	9	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	0
97	S	9	3	None	C	0	0	0	0	0	0	1	0	2	3	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0
97	S	9	4	None	C	0	0	0	0	1	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0

146

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	S	9	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	S	9	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	4	2	0
97	S	9	7	None	C	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	11	0
97	S	9	8	None	C	0	0	0	0	0	2	0	0	0	34	0	0	0	0	0	0	0	0	0	0	0	0	2	3	0
97	S	9	9	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	1	0	1	3	1	0
97	S	10	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	2	0
97	S	10	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0
97	S	10	3	None	C	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0
97	S	10	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	S	10	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	10	6	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	10	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
97	S	10	8	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0
97	S	10	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0
97	S	11	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	4	0
97	S	11	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	13	0
97	S	11	3	Seed	C	0	0	0	0	0	0	0	0	1	5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
97	S	11	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	2	0
97	S	11	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	9	0
97	S	11	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
97	S	11	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	11	8	Seed	C	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
97	S	11	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	10	0
97	S	12	1	Seed	C	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	S	12	2	Seed	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0
97	S	12	3	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	5	0	0	0	0	0	0	0	0
97	S	12	4	Seed	C	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	12	5	Seed	C	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	12	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	11	0
97	S	12	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
97	S	12	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0
97	S	12	9	Seed	C	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0
97	S	13	1	None	C	0	0	0	0	0	1	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
97	S	13	2	None	C	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	1	0	0	0	0	0	0	7	0
97	S	13	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	7	0
97	S	13	4	None	C	0	0	0	0	0	0	0	0	0	28	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0
97	S	13	5	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
97	S	13	6	None	C	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	3	0	0	0	0	0	0	3	0
97	S	13	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	9	0	0
97	S	13	8	None	C	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	7	0	0	0	0	0	0	12	0
97	S	13	9	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	13	0	0	0	0	0	6	0	0
97	S	14	1	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	2	2	0	0	0	0	0	0	6	0
97	S	14	2	Seed	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	14	3	Seed	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
97	S	14	4	Seed	C	0	1	0	0	0	0	0	0	0	6	0	0	0	0	0	0	1	0	0	2	0	0	0	5	0
97	S	14	5	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	5	0	0	2	0	0	0	3	0
97	S	14	6	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
97	S	14	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	9	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	S	14	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	4	0	0	0	0	0	0	0	4	0
97	S	14	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
97	S	15	1	None	C	0	0	0	0	0	0	0	0	0	22	0	0	0	0	1	0	4	0	0	0	0	0	38	3	0
97	S	15	2	None	C	0	0	0	0	0	0	1	0	0	35	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0
97	S	15	3	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	2	0	0	0	0	0	0	10	0
97	S	15	4	None	C	0	0	0	0	0	2	0	0	0	19	0	0	0	0	0	0	5	0	0	0	0	0	0	5	0
97	S	15	5	None	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	1	0	0	1	7	0
97	S	16	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
97	S	16	2	None	C	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
97	S	16	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
97	S	16	4	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0
97	S	16	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	16	6	None	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
97	S	16	7	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0
97	S	16	8	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	16	0
97	S	16	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	S	17	1	None	C	0	0	0	0	0	0	0	0	0	29	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0
97	S	17	2	None	C	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	4	0	0	0	0	0	0	3	0
97	S	17	3	None	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	S	17	4	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
97	S	17	5	None	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	17	6	None	C	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	4	0	0	0	0	0	0	8	0
97	S	17	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
97	S	17	8	None	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	S	17	9	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	18	1	None	C	0	0	0	0	0	0	0	0	1	28	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	S	18	2	None	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	14	0
97	S	18	3	None	C	0	0	0	0	0	0	0	0	2	8	0	0	0	0	0	0	2	0	3	0	0	0	0	0	0
97	S	18	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	4	0
97	S	18	5	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0	1	0	0	0	0	18	0
97	S	18	6	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	5	0	0	0	0	0	0	1	0
97	S	18	7	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0
97	S	18	8	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	9	0
97	S	18	9	None	C	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	4	0	0	0	0	0	0	6	0
97	S	19	1	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	8	0
97	S	19	2	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	5	0	0	0	6	0
97	S	19	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	0	0	0	0	0	0	3	0
97	S	19	4	Seed	C	0	0	0	0	0	0	1	0	0	1	4	0	0	0	0	0	3	0	0	1	0	0	0	7	0
97	S	19	5	Seed	C	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	1	0	0	0	0	0	0	0	10	0
97	S	19	6	Seed	C	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	1	0	0	0	0	0	3	6	0
97	S	19	7	Seed	C	0	0	0	0	0	0	0	0	0	0	9	0	0	0	1	0	0	0	0	0	0	0	0	0	0
97	S	19	8	Seed	C	0	0	0	0	0	0	0	0	0	1	7	0	0	0	0	0	2	0	0	0	0	0	0	1	0
97	S	19	9	Seed	C	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	2	2	0	0	0	0	0	0	0	0
97	S	20	1	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	6	0
97	S	20	2	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
97	S	20	3	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	3	0	0	2	0	0	0	4	0
97	S	20	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
97	S	20	5	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	11	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	S	20	6	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	1	0	1	0	0	3	0	0	0	0	0
97	S	20	7	Seed	C	0	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	2	0	0	0	0	0	0	6	0
97	S	20	8	Seed	C	0	0	0	0	0	0	0	0	2	5	0	0	0	0	0	0	0	0	1	0	0	0	0	9	0
97	S	20	9	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	5	0	0	0	0	0	0	3	0
97	S	21	1	None	C	0	0	0	0	0	0	0	0	1	20	0	0	0	0	0	2	6	0	0	0	0	0	0	2	0
97	S	21	2	None	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0
97	S	21	3	None	C	0	0	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
97	S	21	4	None	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	1	0	0	3	0	0
97	S	21	5	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	3	0	0	1	0	0	12	0	0
97	S	21	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	6	4	0
97	S	21	7	None	C	0	0	0	0	0	0	0	0	0	26	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
97	S	21	8	None	C	0	0	0	0	1	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
97	S	21	9	None	C	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	2	0	0	0	0	0	3	0	0
97	S	22	1	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0
97	S	22	2	None	C	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	S	22	3	None	C	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
97	S	22	4	None	C	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0
97	S	22	5	None	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	1	0	0	0	7	0
97	S	22	6	None	C	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
97	S	22	7	None	C	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
97	S	22	8	None	C	0	0	0	0	0	0	0	0	0	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	22	9	None	C	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0
97	S	23	1	None	C	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	1	0	0	0	0	0	0	7	0
97	S	23	2	None	C	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0	5	0	1	0	0	0	0	10	0

151

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	S	23	3	None	C	0	0	0	0	0	0	0	0	1	33	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0
97	S	23	4	None	C	0	0	0	0	0	0	0	0	1	7	0	0	0	0	0	0	4	0	0	0	0	0	0	6	0
97	S	23	5	None	C	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	2	0	0	0	0	0	0	5	0
97	S	23	6	None	C	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	6	0	0	0	0	0	5	0	0
97	S	23	7	None	C	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	S	23	8	None	C	0	0	0	0	0	0	0	0	1	17	0	0	0	0	0	0	2	0	0	0	0	0	2	0	0
97	S	23	9	None	C	0	0	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	24	1	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
97	S	24	2	Seed	C	0	0	0	0	0	2	0	0	0	1	0	0	0	0	1	1	10	0	1	0	0	0	0	8	0
97	S	24	3	Seed	C	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0
97	S	24	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	2	0
97	S	24	5	Seed	C	0	0	0	0	0	0	0	0	0	0	2	0	3	0	0	0	0	0	0	0	0	0	6	0	0
97	S	24	6	Seed	C	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	2	0
97	S	24	7	Seed	C	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	1	1	0	0	2	0	0	17	0	0
97	S	24	8	Seed	C	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0	0
97	S	24	9	Seed	C	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	2	0	0	0	0	0
97	S	25	1	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	1	0	0	0	1	3	0
97	S	25	2	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	1	0	0	3	7	0
97	S	25	3	None	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
97	S	25	4	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	10	0
97	S	25	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	25	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	3	0
97	S	25	7	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	25	8	None	C	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	2	0	0	2	0	0	1	6	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	S	25	9	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	13	0
97	S	26	1	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
97	S	26	2	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	3	0	0	0	0	0	0	3	0
97	S	26	3	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
97	S	26	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
97	S	26	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0
97	S	26	6	None	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	26	7	None	C	0	0	0	0	0	0	0	0	0	36	0	0	0	0	0	0	2	0	0	0	0	0	3	0	0
97	S	26	8	None	C	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0
97	S	26	9	None	C	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0
97	S	27	1	Seed	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
97	S	27	2	Seed	C	0	0	0	0	0	0	5	0	0	3	0	0	0	0	0	0	0	0	0	2	0	0	0	3	0
97	S	27	3	Seed	C	0	0	0	0	0	0	0	0	1	4	1	0	0	0	0	0	0	0	0	0	0	0	0	5	0
97	S	27	4	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	5	17	0	0	0	0	0	8	0	0
97	S	27	5	Seed	C	0	0	0	0	0	0	0	0	2	7	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
97	S	28	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
97	S	28	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	5	0
97	S	28	3	Seed	C	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	2	0
97	S	28	4	Seed	C	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	28	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	8	0
97	S	28	6	Seed	C	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	10	0
97	S	28	7	Seed	C	0	1	0	0	0	0	0	0	0	2	0	0	0	0	2	4	0	0	0	0	0	0	0	6	0
97	S	28	8	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
97	S	28	9	Seed	C	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0

153

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	S	29	1	None	C	0	0	0	0	0	0	0	0	4	11	0	0	0	0	0	0	5	0	0	0	0	0	1	0	0
97	S	29	2	None	C	0	0	0	0	0	0	0	0	2	8	0	0	0	0	0	0	0	0	0	1	0	0	8	0	0
97	S	29	3	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4	0	1	0	0	0	0	10	0
97	S	29	4	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	4	0	0	0	0	0	0	4	0
97	S	29	5	None	C	0	0	0	0	0	0	0	0	0	3	2	0	0	0	0	0	1	0	0	0	0	0	6	0	8
97	S	29	6	None	C	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	1	0	0	2	8	0
97	S	29	7	None	C	0	0	0	0	0	0	0	0	0	3	5	0	0	0	0	0	2	0	0	1	0	0	1	5	0
97	S	29	8	None	C	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0	5	0	0	0	0	0	0	4	0
97	S	29	9	None	C	0	0	0	0	0	0	0	0	1	5	0	0	1	0	0	0	3	0	0	0	0	0	8	2	0
97	S	30	1	None	C	0	0	0	0	0	0	0	0	0	28	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
97	S	30	2	None	C	0	0	0	0	0	0	0	0	0	27	0	0	0	0	0	0	2	0	0	0	0	0	0	3	0
97	S	30	3	None	C	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	30	4	None	C	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
97	S	30	5	None	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0
97	S	30	6	None	C	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	5	0	0	4	0	0	0	0	0
97	S	30	7	None	C	0	0	0	0	0	1	0	0	1	25	0	0	0	0	0	0	1	0	1	0	0	0	0	9	0
97	S	30	8	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	3	0	0	0	0	0	0	7	0
97	S	30	9	None	C	0	0	0	0	0	2	0	0	0	9	0	0	0	0	0	0	4	0	0	0	0	0	0	2	0
97	S	31	1	Seed	C	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	1	2	0	0	1	7	0
97	S	31	2	Seed	C	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	5	0
97	S	31	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	S	31	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0	1	0	6	0
97	S	31	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
97	S	31	6	Seed	C	0	0	0	0	0	3	1	0	0	0	0	0	0	0	0	7	0	0	0	1	0	2	3	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	S	31	7	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0
97	S	31	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	5	0	1	0	0	0	0	5	0
97	S	31	9	Seed	C	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	3	0
97	S	32	1	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	4	0	0	1	0	0	1	5	0
97	S	32	2	None	C	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	4	0	0	0	0	0	0	8	0
97	S	32	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	4	4	0	0	5	0	0
97	S	32	4	None	C	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0
97	S	32	5	None	C	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0	6	0	0	1	0	0	3	6	0
97	S	32	6	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	1	0	0	0	0	0	6	0	0
97	S	32	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0
97	S	32	8	None	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0
97	S	32	9	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
97	S	33	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0	0	0	0	0	0	6	0
97	S	33	2	Seed	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
97	S	33	3	Seed	C	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
97	S	33	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0
97	S	33	5	Seed	C	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0
97	S	33	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
97	S	33	7	Seed	C	0	0	0	0	0	0	0	0	2	8	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0
97	S	33	8	Seed	C	0	0	0	0	0	0	0	0	1	14	0	0	0	0	0	0	2	0	0	0	0	0	0	4	0
97	S	33	9	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0
97	S	34	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	1	3	7	0
97	S	34	2	Seed	C	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	1	0	0	0	0	0	1	0	4	0
97	S	34	3	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	2	0	0	0	0	0	0	16	0

155

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	S	34	4	Seed	C	0	0	0	0	0	0	0	0	0	1	5	0	2	0	0	2	0	0	0	3	0	0	5	0	0
97	S	34	5	Seed	C	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	5	0
97	S	34	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	2	0	4	3	0	0	0	0	0	0	1	3	0
97	S	34	7	Seed	C	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	14	0
97	S	34	8	Seed	C	0	2	0	0	0	0	0	0	1	0	0	0	0	0	4	5	0	0	0	2	0	0	0	0	0
97	S	34	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	6	0
97	S	35	1	Seed	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	1	7	0
97	S	35	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	2	0	0	0	0	0	0	7	0
97	S	35	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	11	0
97	S	35	4	Seed	C	0	0	0	0	0	0	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
97	S	35	5	Seed	C	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	4	2	0	0	0	0	0	1	0	0
97	S	35	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	0	0	0	0	2	0	5	0
97	S	35	7	Seed	C	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0
97	S	35	8	Seed	C	0	0	0	0	0	3	0	0	0	0	3	0	0	0	0	0	4	0	0	1	0	0	2	0	0
97	S	35	9	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	4	0	0	1	0	0	0	10	0
97	S	36	1	None	C	2	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	2	0	0	0	0	5	0
97	S	36	2	None	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	5	7	0
97	S	36	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	5	3	0
97	S	36	4	None	C	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	8	1	0	1	0	0	0	0	9	0
97	S	36	5	None	C	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0
97	S	36	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	1	8	0
97	S	36	7	None	C	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	3	0	1	0	0	0	0	11	0
97	S	36	8	None	C	0	1	0	0	0	0	0	0	0	4	0	0	0	0	0	0	2	0	0	0	0	0	0	4	0
97	S	36	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	S	37	1	Seed	C	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	2	6	0
97	S	37	2	Seed	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0
97	S	37	3	Seed	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	2	0	0	0	1	10	0
97	S	37	4	Seed	C	0	0	0	0	0	0	0	0	1	31	0	0	0	0	0	1	0	0	0	0	0	0	1	11	0
97	S	37	5	Seed	C	0	0	0	0	0	0	0	0	1	14	0	0	0	0	0	0	2	0	0	0	0	0	3	5	0
97	S	37	6	Seed	C	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	2	2	0	0	0	0	0	2	3	0
97	S	37	7	Seed	C	0	0	0	0	0	0	0	0	1	11	0	0	0	0	0	1	0	0	3	1	0	0	2	0	0
97	S	37	8	Seed	C	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	6	0	2	0	0	0	0	9	0
97	S	37	9	Seed	C	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	2	0	5	0	0	0	2	6	0
97	S	38	1	Seed	C	0	0	0	0	0	0	4	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0
97	S	38	2	Seed	C	0	1	0	0	0	0	1	0	1	3	0	0	0	0	2	0	1	0	0	0	0	0	1	7	0
97	S	38	3	Seed	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
97	S	38	4	Seed	C	0	0	0	0	0	0	0	0	1	7	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
97	S	38	5	Seed	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	2	10	0
97	S	38	6	Seed	C	0	0	0	0	0	0	1	0	0	10	0	0	0	0	0	1	1	0	0	1	0	0	3	3	0
97	S	38	7	Seed	C	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	4	2	0
97	S	38	8	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
97	S	38	9	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	0	0	0	6	0
97	S	39	1	None	C	0	0	0	0	0	0	0	0	0	36	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0
97	S	39	2	None	C	0	0	0	0	0	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0
97	S	39	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0
97	S	39	4	None	C	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0
97	S	39	5	None	C	0	0	0	0	0	0	0	0	1	7	2	0	0	0	0	0	1	0	0	0	0	0	0	7	0
97	S	39	6	None	C	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	8	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
97	S	39	7	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	11	0	0	4	0
97	S	39	8	None	C	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0
97	S	39	9	None	C	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	3	0	0	6	2	0
98	S	1	1	None	C	0	0	0	0	0	0	7	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0
98	S	1	2	None	C	0	0	0	0	0	0	3	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	1	3	None	C	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	S	1	4	None	C	0	0	0	0	0	0	1	0	0	5	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0
98	S	1	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0
98	S	1	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	1	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
98	S	1	8	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0
98	S	1	9	None	C	0	0	0	0	0	0	1	0	1	2	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
98	S	2	1	Seed	M	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	3	0	0	1	0	0	0	9	0
98	S	2	2	Seed	M	0	5	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	6	0
98	S	2	3	Seed	M	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	8	1	0
98	S	2	4	Seed	M	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	2	0	0	1	0	0	0	9	0
98	S	2	5	Seed	M	0	0	0	0	0	0	3	0	0	6	0	0	0	0	0	0	3	0	0	0	0	0	0	3	0
98	S	2	6	Seed	M	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0	0	5	0	0	0	0	0	0	1	0
98	S	2	7	Seed	M	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
98	S	2	8	Seed	M	0	0	0	0	0	0	1	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	2	9	Seed	M	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
98	S	3	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	5	0	0
98	S	3	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	2	0
98	S	3	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	0	0	0	1	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	S	3	4	Seed	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
98	S	3	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0
98	S	3	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	0
98	S	3	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
98	S	3	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0
98	S	3	9	Seed	C	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0
98	S	4	1	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	S	4	2	None	C	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0
98	S	4	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
98	S	4	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
98	S	4	5	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	S	5	1	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	S	5	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0
98	S	5	3	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	5	4	Seed	C	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
98	S	5	5	Seed	C	0	0	0	0	0	0	6	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0
98	S	5	6	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4	0
98	S	5	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
98	S	5	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
98	S	5	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
98	S	6	1	None	M	0	0	0	0	0	0	2	0	0	7	0	0	0	0	0	0	0	0	0	1	0	0	0	7	0
98	S	6	2	None	M	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
98	S	6	3	None	M	0	0	0	0	0	0	1	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	6	4	None	M	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	S	6	5	None	M	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	5	1	0	0	0	0	0	0	4	0
98	S	6	6	None	M	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0
98	S	6	7	None	M	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	6	8	None	M	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0
98	S	6	9	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	8	0
98	S	7	1	Seed	B	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	7	2	Seed	B	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0
98	S	7	3	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
98	S	7	4	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	11	0	0
98	S	7	5	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
98	S	7	6	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	7	7	Seed	B	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
98	S	7	8	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0
98	S	7	9	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	8	1	None	M	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	8	2	None	M	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
98	S	8	3	None	M	0	0	0	0	0	0	2	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0
98	S	8	4	None	M	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
98	S	8	5	None	M	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
98	S	8	6	None	M	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	8	7	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	S	8	8	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0
98	S	8	9	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	9	1	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	S	9	2	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	19	0	3	0	0	0	0	0	0
98	S	9	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	9	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0
98	S	9	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	4	0	0	6	0	0
98	S	9	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	9	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	9	8	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	S	9	9	None	C	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
98	S	10	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0
98	S	10	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	10	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	3	0
98	S	10	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
98	S	10	5	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	S	10	6	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0
98	S	10	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	5	0
98	S	10	8	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	10	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
98	S	11	1	Seed	B	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
98	S	11	2	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
98	S	11	3	Seed	B	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
98	S	11	4	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	11	5	Seed	B	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	S	11	6	Seed	B	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	9	0	0
98	S	11	7	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	7	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	S	11	8	Seed	B	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	11	9	Seed	B	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4	0
98	S	12	1	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	9	0
98	S	12	2	Seed	M	0	0	0	1	0	0	0	0	0	7	0	0	0	0	1	0	5	0	0	0	0	0	0	7	0
98	S	12	3	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0
98	S	12	4	Seed	M	0	0	0	0	0	0	3	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
98	S	12	5	Seed	M	0	1	0	0	0	0	6	0	0	0	1	0	0	0	0	0	4	0	0	0	0	0	0	0	0
98	S	12	6	Seed	M	0	4	0	0	0	1	9	0	0	3	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0
98	S	12	7	Seed	M	0	0	0	0	0	4	0	0	3	2	0	0	0	0	0	1	0	0	0	0	0	0	0	9	0
98	S	12	8	Seed	M	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0
98	S	12	9	Seed	M	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
98	S	13	1	None	B	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0
98	S	13	2	None	B	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
98	S	13	3	None	B	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	11	0	0	0	0	0	1	0	0
98	S	13	4	None	B	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	5	0	0	0	0	0	6	0	0
98	S	13	5	None	B	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	6	0	0	0	0	0	4	0	0
98	S	13	6	None	B	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
98	S	13	7	None	B	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0
98	S	13	8	None	B	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	4	0	0	0	0	0	5	0	0
98	S	13	9	None	B	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0
98	S	14	1	Seed	M	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
98	S	14	2	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0
98	S	14	3	Seed	M	0	0	0	0	0	0	5	0	0	1	0	0	0	0	0	0	3	0	0	10	0	0	0	0	0
98	S	14	4	Seed	M	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	5	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	S	14	5	Seed	M	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	14	6	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1	3	0	0
98	S	14	7	Seed	M	0	0	0	0	0	3	4	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0
98	S	14	8	Seed	M	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
98	S	14	9	Seed	M	0	3	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	15	1	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0
98	S	15	2	None	C	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
98	S	15	3	None	C	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	7	0	0	0	0	0	0	2	0
98	S	15	4	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	2	0	1	0	0	0	0	6	0
98	S	15	5	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	5	0	0	0	0	0	0	3	0
98	S	16	1	None	M	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	3	0	0	0	0	1	0	3	0
98	S	16	2	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0
98	S	16	3	None	M	0	0	0	0	0	0	1	0	0	11	0	0	0	0	0	0	1	0	0	1	0	0	0	5	0
98	S	16	4	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	16	5	None	M	0	0	0	0	0	0	4	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0
98	S	16	6	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
98	S	16	7	None	M	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	S	16	8	None	M	0	0	0	0	0	0	4	0	1	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
98	S	16	9	None	M	0	0	0	0	0	0	5	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
98	S	17	1	None	B	0	0	0	0	0	0	3	0	0	42	0	0	0	0	0	0	8	0	0	0	0	0	0	2	0
98	S	17	2	None	B	0	0	0	0	0	0	10	0	2	1	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0
98	S	17	3	None	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	1	0
98	S	17	4	None	B	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
98	S	17	5	None	B	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0

163

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	S	17	6	None	B	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	9	0
98	S	17	7	None	B	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0
98	S	17	8	None	B	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	17	9	None	B	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	5	0	0	0	2	0	0	0	0
98	S	18	1	None	M	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	18	2	None	M	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0
98	S	18	3	None	M	0	0	0	0	0	0	0	0	0	6	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
98	S	18	4	None	M	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	3	0	0	0	0	0	2	3	0
98	S	18	5	None	M	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	4	0	0	1	0	0	0	8	0
98	S	18	6	None	M	0	0	0	0	0	0	0	0	0	4	0	0	1	0	0	0	4	0	0	0	0	0	0	3	0
98	S	18	7	None	M	0	0	0	0	0	0	0	0	1	18	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
98	S	18	8	None	M	0	0	0	0	0	0	1	0	1	7	0	0	0	0	0	0	0	0	2	0	0	0	0	6	0
98	S	18	9	None	M	0	0	0	0	0	0	5	0	3	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	19	1	Seed	B	0	13	0	0	0	0	1	0	0	0	0	0	0	0	0	2	1	0	0	2	0	1	0	0	0
98	S	19	2	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0	0	0	0	0	0	4	0
98	S	19	3	Seed	B	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
98	S	19	4	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	1	1	0	0	0	0	0	0	5	0
98	S	19	5	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4	0
98	S	19	6	Seed	B	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3	0	0	1	0	0	0	0	4	0
98	S	19	7	Seed	B	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	2	0	0
98	S	19	8	Seed	B	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	3	0	0	0	0	0	0	9	0
98	S	19	9	Seed	B	0	0	0	0	0	0	8	0	0	2	0	0	0	0	0	0	0	0	1	0	5	0	3	0	0
98	S	20	1	Seed	C	0	1	0	0	0	0	3	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	4	0
98	S	20	2	Seed	C	0	0	0	0	0	0	2	0	0	0	0	0	3	0	0	0	1	0	0	0	0	0	1	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	S	20	3	Seed	C	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
98	S	20	4	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	20	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
98	S	20	6	Seed	C	0	0	0	0	0	1	0	0	0	9	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	S	20	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
98	S	20	8	Seed	C	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	S	20	9	Seed	C	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	2	0	0	0	0	0	2	4	0
98	S	21	1	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	0	0	0	2	0
98	S	21	2	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0
98	S	21	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
98	S	21	4	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
98	S	21	5	None	C	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	6	0
98	S	21	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
98	S	21	7	None	C	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	6	0
98	S	21	8	None	C	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0
98	S	21	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0
98	S	22	1	None	B	0	0	0	0	0	0	2	0	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0	7	0
98	S	22	2	None	B	0	0	0	0	0	0	15	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
98	S	22	3	None	B	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
98	S	22	4	None	B	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	2	0	0	0	0	0	2	0	0
98	S	22	5	None	B	0	0	0	0	0	0	8	0	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	S	22	6	None	B	0	0	0	0	0	0	0	0	0	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	22	7	None	B	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
98	S	22	8	None	B	0	0	0	0	0	0	0	0	1	12	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0

165

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	S	22	9	None	B	0	0	0	0	0	0	0	0	0	44	0	0	0	0	0	0	0	0	1	0	0	0	0	5	0
98	S	23	1	None	M	0	0	0	0	0	1	0	0	2	22	0	0	0	0	0	0	0	0	3	2	26	0	4	0	0
98	S	23	2	None	M	0	0	0	0	0	0	0	0	1	7	0	0	0	0	0	0	5	0	0	0	0	0	0	13	0
98	S	23	3	None	M	0	0	0	0	0	0	0	0	2	44	0	0	0	0	0	0	0	0	0	0	0	0	2	14	0
98	S	23	4	None	M	0	0	0	0	0	0	7	0	2	14	0	0	0	0	0	0	4	0	0	0	0	0	0	27	0
98	S	23	5	None	M	0	0	0	0	0	0	36	2	0	14	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
98	S	23	6	None	M	0	0	0	0	0	0	9	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
98	S	23	7	None	M	0	0	0	0	0	0	36	0	0	21	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
98	S	23	8	None	M	0	0	0	0	0	0	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0
98	S	23	9	None	M	0	0	0	0	0	0	15	0	0	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	24	1	Seed	C	0	3	0	0	0	3	2	0	0	0	0	0	1	0	3	0	0	0	0	0	0	0	0	7	0
98	S	24	2	Seed	C	0	0	0	0	0	1	5	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0
98	S	24	3	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
98	S	24	4	Seed	C	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
98	S	24	5	Seed	C	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	5	0
98	S	24	6	Seed	C	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
98	S	24	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	3	0
98	S	24	8	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1	0	0	0	14	0
98	S	24	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	6	0
98	S	25	1	None	C	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	9	0
98	S	25	2	None	C	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0
98	S	25	3	None	C	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0
98	S	25	4	None	C	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	25	5	None	C	0	0	0	0	0	0	0	0	1	10	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	S	25	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	8	0
98	S	25	7	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0
98	S	25	8	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	25	9	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0
98	S	26	1	None	M	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	0	0	0	6	0
98	S	26	2	None	M	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0
98	S	26	3	None	M	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	5	0	0	0	0	0	2	0	0
98	S	26	4	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0
98	S	26	5	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	26	6	None	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	S	26	7	None	M	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
98	S	26	8	None	M	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0
98	S	26	9	None	M	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	1	0	0	0	6	5	0
98	S	27	1	Seed	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0
98	S	27	2	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0
98	S	27	3	Seed	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0
98	S	27	4	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	3	0
98	S	27	5	Seed	C	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
98	S	27	6	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0
98	S	27	7	Seed	C	0	0	0	0	0	0	0	0	1	19	0	0	0	0	0	0	2	0	0	0	0	0	0	3	0
98	S	27	8	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	0	0	0	3	0
98	S	27	9	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	6	0	0
98	S	28	1	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	12	4	0	0	0	0	0	1	0	0
98	S	28	2	Seed	M	0	1	0	0	0	0	3	0	0	7	0	0	0	0	0	1	5	0	0	0	0	1	0	1	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	S	28	3	Seed	M	0	1	0	0	0	2	1	0	0	1	0	0	0	0	0	0	2	0	0	0	0	1	0	8	0
98	S	28	4	Seed	M	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	2	0	0	0	3	0	0	2	0
98	S	28	5	Seed	M	0	0	0	0	0	0	14	0	1	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0
98	S	28	6	Seed	M	0	0	0	0	0	0	0	0	0	10	0	0	0	0	1	0	6	0	0	0	0	0	0	10	0
98	S	28	7	Seed	M	0	0	0	0	0	1	6	0	0	2	6	0	0	0	1	0	0	0	0	0	0	0	0	9	0
98	S	28	8	Seed	M	0	5	0	0	0	0	7	0	0	0	0	0	0	0	0	1	4	0	1	0	0	0	0	9	0
98	S	28	9	Seed	M	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	1	4	0	4	0	0	1	0	3	0
98	S	29	1	None	B	0	0	0	0	0	0	0	0	0	21	0	0	0	0	0	0	3	0	0	0	0	0	0	16	0
98	S	29	2	None	B	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	10	0	0	0	0	0	0	2	0
98	S	29	3	None	B	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
98	S	29	4	None	B	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	7	0	0	0	0	0	0	12	0
98	S	29	5	None	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
98	S	29	6	None	B	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	5	0	0	0	0	0	0	11	0
98	S	29	7	None	B	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	6	0	0	0	0	0	0	10	0
98	S	29	8	None	B	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	3	0	0	0	0	0	0	12	0
98	S	29	9	None	B	0	0	0	0	0	0	0	0	1	28	0	0	0	0	0	0	5	0	0	0	0	0	0	3	0
98	S	30	1	None	C	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
98	S	30	2	None	C	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	S	30	3	None	C	0	0	0	0	0	0	0	0	0	5	0	0	1	0	0	0	0	0	0	0	0	0	5	0	0
98	S	30	4	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
98	S	30	5	None	C	0	0	0	0	0	0	0	0	0	14	0	0	1	0	0	0	1	0	0	0	0	0	2	0	0
98	S	30	6	None	C	0	0	0	0	0	0	0	0	1	14	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
98	S	30	7	None	C	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	30	8	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	S	30	9	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
98	S	31	1	Seed	M	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	3	3	0	0
98	S	31	2	Seed	M	0	1	0	0	0	0	5	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	S	31	3	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	1	0	0
98	S	31	4	Seed	M	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0
98	S	31	5	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0
98	S	31	6	Seed	M	0	0	0	0	0	1	4	0	0	6	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0
98	S	31	7	Seed	M	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	5	0
98	S	31	8	Seed	M	0	0	0	0	0	0	11	0	1	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
98	S	31	9	Seed	M	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0
98	S	32	1	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	7	0	0
98	S	32	2	None	C	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	S	32	3	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
98	S	32	4	None	C	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	4	0	0	0	0	0	9	0	0
98	S	32	5	None	C	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0
98	S	32	6	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
98	S	32	7	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
98	S	32	8	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
98	S	32	9	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0
98	S	33	1	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0
98	S	33	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0
98	S	33	3	Seed	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0
98	S	33	4	Seed	C	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0
98	S	33	5	Seed	C	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	S	33	6	Seed	C	0	0	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
98	S	33	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
98	S	33	8	Seed	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
98	S	33	9	Seed	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0
98	S	34	1	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	6	8	0
98	S	34	2	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0
98	S	34	3	Seed	B	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	18	0
98	S	34	4	Seed	B	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	3	0	0	0	0	0	1	4	0
98	S	34	5	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	7	0
98	S	34	6	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	S	34	7	Seed	B	0	0	0	0	0	0	0	0	2	1	0	0	0	0	1	0	0	0	0	0	0	0	3	0	0
98	S	34	8	Seed	B	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	13	0
98	S	34	9	Seed	B	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0
98	S	35	1	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
98	S	35	2	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	4	3	0
98	S	35	3	Seed	C	0	0	0	0	0	0	3	0	0	6	0	0	0	0	0	1	3	0	0	2	0	0	4	4	0
98	S	35	4	Seed	C	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0	3	0	0	0	0	0	3	0	0
98	S	35	5	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	0	0	0	0	0	2	4	0
98	S	35	6	Seed	C	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
98	S	35	7	Seed	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3	4	0
98	S	35	8	Seed	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4	0	0	0	0	0	3	1	0
98	S	35	9	Seed	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	3	0
98	S	36	1	None	C	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0
98	S	36	2	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0	0	0	0	0	0	5	0

170

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	S	36	3	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0
98	S	36	4	None	C	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
98	S	36	5	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0
98	S	36	6	None	C	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	2	0	1	0	0	0	0	1	0
98	S	36	7	None	C	0	0	0	0	0	0	3	0	0	1	0	0	0	0	3	0	2	0	0	0	0	0	0	8	0
98	S	36	8	None	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	1	0	0	0	1	0	0	0	0	3	0
98	S	36	9	None	C	0	0	0	0	0	0	0	0	0	4	0	0	0	0	4	0	1	0	0	0	0	0	0	11	0
98	S	37	1	Seed	B	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	1	0	0	0	1	0	0	9	0	0
98	S	37	2	Seed	B	0	0	0	0	0	0	1	0	1	5	0	0	0	0	0	3	1	0	0	4	0	0	8	0	0
98	S	37	3	Seed	B	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	7	0
98	S	37	4	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
98	S	37	5	Seed	B	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	8	0
98	S	37	6	Seed	B	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	13	0
98	S	37	7	Seed	B	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	1	0	0	0	0	12	0
98	S	37	8	Seed	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0
98	S	37	9	Seed	B	0	0	0	0	0	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
98	S	38	1	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	4	0	0
98	S	38	2	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0
98	S	38	3	Seed	M	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0
98	S	38	4	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0
98	S	38	5	Seed	M	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
98	S	38	6	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0
98	S	38	7	Seed	M	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
98	S	38	8	Seed	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0

Year	Season	Plot	sub	Seed?	Treatment	CEName	CORtin	EUSgra	GAUsp	OENsp	OXAdil	PLAher	PHLsp	ASCtex	ASTeri	BACsp	BRIeup	CIRtex	LIAsp	RUDam	RUDhir	SOLelm	VERsp	TRAram	MONsp	HEDnig	SOLela	NEPlut	FABun	TOXrad
98	S	38	9	Seed	M	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0
98	S	39	1	None	C	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	S	39	2	None	C	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	4	0	0	0	0	0	0	6	0
98	S	39	3	None	C	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
98	S	39	4	None	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	S	39	5	None	C	0	0	0	0	0	0	0	0	1	19	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
98	S	39	6	None	C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0
98	S	39	7	None	C	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	4	0	0	0	0	0	0	6	0
98	S	39	8	None	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
98	S	39	9	None	C	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	2	0	0	0	0	9	0