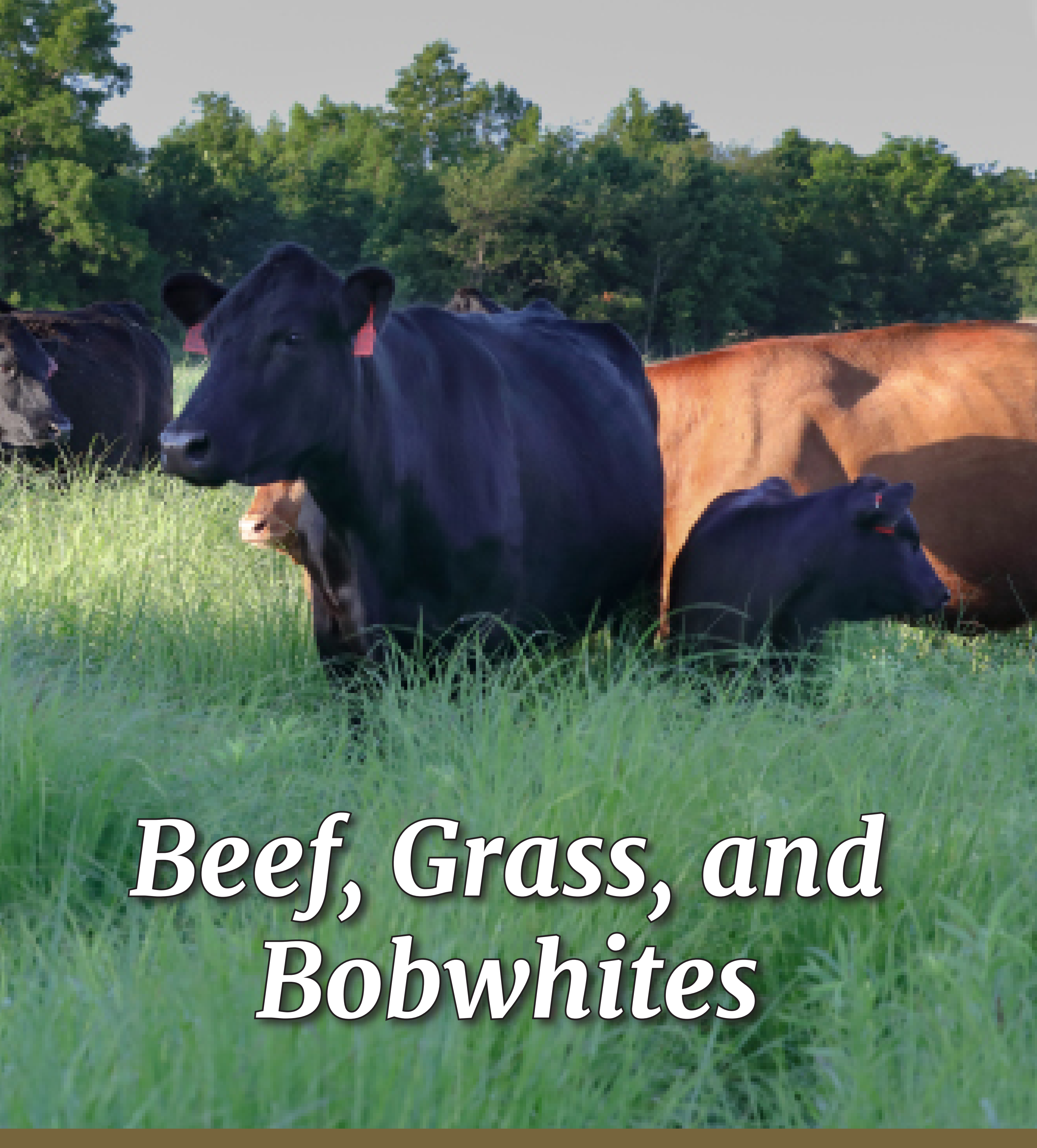

# *Beef, Grass, and Bobwhites*

## Quail Management in Eastern Native Warm-Season Grass Pastures

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Special thanks goes to **Fred Guthery** and **Fidel Hernández** for allowing our adaptation from the title of their seminal book, *Beef, Brush, and Bobwhites: Quail Management in Cattle Country*, and to Fidel Hernández for writing the foreword.

Cover Photo: *Cow-calf pairs grazing big bluestem pasture mid-June in west-central Missouri.*

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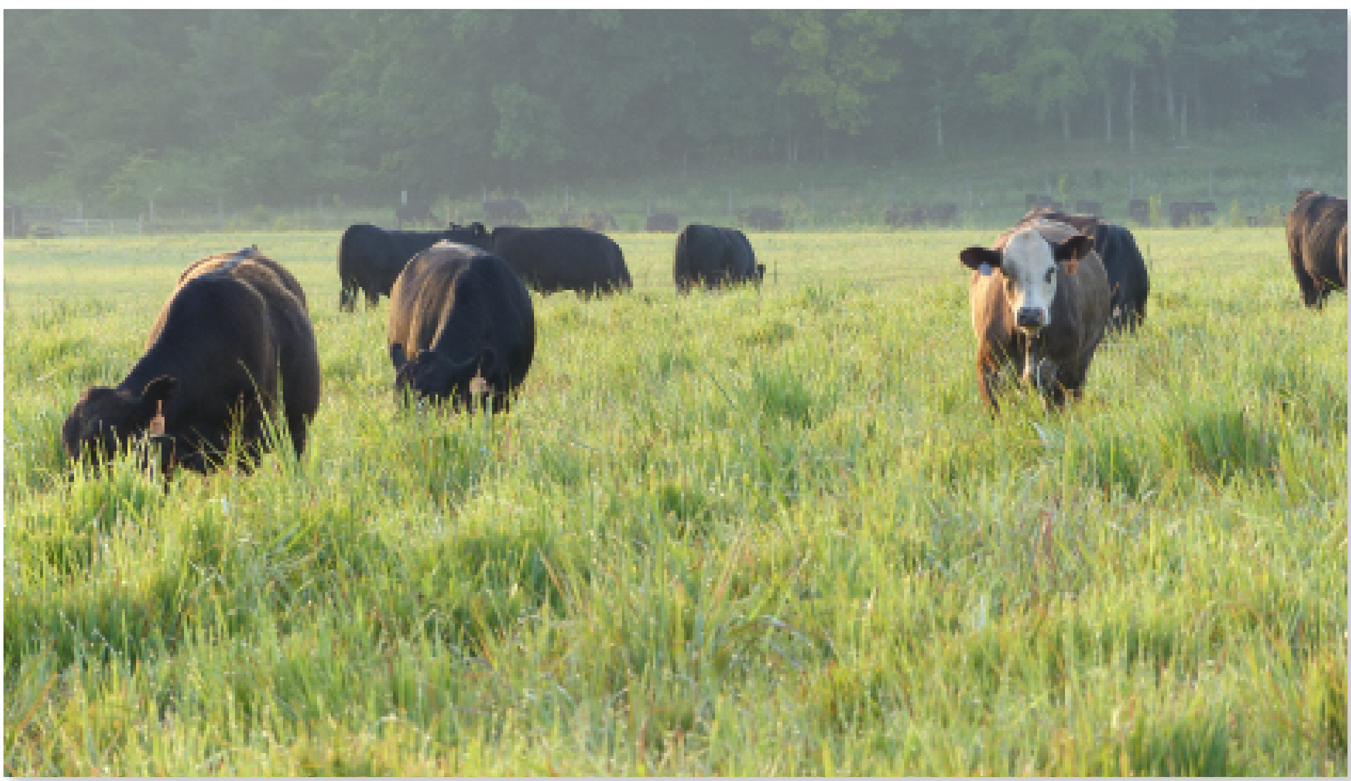
# Executive Summary


Grazing as a management tool for Northern Bobwhites and grassland birds could be critical for expanding conservation impacts at a large scale across the eastern U.S. However, in this region many wildlife managers lack specific knowledge about grazing management. Furthermore, many grazing specialists lack specific knowledge about native warm-season grass (NWSG) forages and the ecology of bobwhite habitat management. A review of the literature, current research, and first-hand knowledge have been used in this document to develop guidance for technical advisors in the eastern U.S. The information presented here is concentrated on the potential impacts of grazing during late spring and summer when nesting bobwhites are most vulnerable to disturbance by cattle.

When NWSGs are grazed at the appropriate canopy heights (14-24 inches), cattle production can be profitable and structure suitable for bobwhites created and maintained. Stocking density and forage utilization are more important drivers of habitat quality and nesting success than the grazing system itself. Stocking densities <2 head/acre minimize nest loss from direct and indirect impacts of grazing. Continuous stocking of NWSG at appropriate stocking rates provides suitable habitat for grassland nesting birds. Simple rotational stocking can be adapted to provide nesting opportunity. Intensive rotational stocking will negatively impact nest survival in paddocks with high stocking densities. Patch-burn grazing and open-gate rotational stocking are two specialized systems which appear beneficial, however, more analysis is needed as it pertains to use of these systems in the eastern U.S.

To optimize bobwhite responses, landscape context must be taken into consideration. Nesting success and breeding bird occupancy increases with distance from forested cover/edge. Predation rates are lower on larger patch sizes, and population level influences of habitat decrease as distance between usable habitat increases.

By focusing on a working lands approach, NWSG forages represent one of the best opportunities to successfully implement conservation for bobwhite and grassland wildlife at a landscape scale. Based on modeling optimizing profitability of including NWSG in tall fescue systems, as many as 10.5 million acres of new grassland habitat could be created.

*Appropriately grazed NWSGs provide structural heterogeneity attractive to bobwhites and many grassland birds. Photo by Kyle Brazil.*

# *Foreword*

Humans have a long history with *Bos taurus*. Cattle were among the first wild animals to be domesticated by early humans some 10,000 years ago. Cattle provided early humans with a multitude of useful products such as food (milk and meat), clothing (leather), tools (bone, horns), and fuel (dung), as well as assistance for carrying loads or pulling supplies. When Spanish explorers arrived in the Americas, they brought with them many of their domesticated animals, including cattle. The arrival of the Spanish and the first cattle in the US during the 1600s set in motion a trajectory that would lead to the historic cattle drives of the 1800s and the iconic cowboy of the American West. Although much has changed since the times of hunter-gatherers, explorers, and drovers, cattle continue to provide valuable products for humans, and today cattle represent an important component of the agricultural industry.

In the U.S., cattle production is the largest segment of the American agriculture. During the past 5 years, cattle production has accounted for about 15–20 percent of the nearly $360–390 billion sales of agricultural products. The number of beef cattle in the U.S. has increased from about 11 million head in 1925 to about 30 million head in 2015. Thus, Americans today enjoy a relatively vibrant cattle industry. However, because of an aging landowner base, a changing climate, an uncertain market, and calls for a more sustainable and environmentally responsible manner of producing our food, the need exists to modify how cattle are produced on our land. This change in societal values and needs warrants the development of science-based strategies for producing cattle that can be profitable for producers while being sustainable for earth.

Most of the cattle population is found in the western U.S. Consequently, most of the research on cattle production and its compatibility with the conservation of our natural resources has occurred in the Great Plains and the West. An extensive literature base exists regarding the impacts of grazing on aquatic habitats, riparian areas, soils, vegetation, and wildlife for central and western rangelands. However, the eastern U.S. also houses thousands of cattle and is home to hundreds of cattle operations and, yet, relatively few reviews, publications, or technical bulletins exist regarding how to make cattle production compatible with the conservation of natural resources. *Beef, Grass, and Bobwhites* aims to address this need for northern bobwhite (*Colinus virginianus*).

Northern bobwhite is a popular and important gamebird that has been declining throughout its geographic distribution since the early 1900s. Much is known about the species' ecology and life history, as well as the impacts of common land-use practices of the eastern U.S. such as forestry and crop production. Considerably less, however, is known about the impacts of cattle grazing in this region. Here, *Beef, Grass, and Bobwhites* provides a concise but thorough summary of the latest science of cattle grazing on eastern native warm-season grass pastures and presents practical, science-based recommendations for grazing cattle in a manner that is compatible with bobwhites. Hodges and co-authors draw on years of experience obtained over a broad geographic area as well as based on a diversity of perspectives to highlight how cattle production can be implemented in a manner that facilitates bobwhite conservation at a landscape scale.

The times are changing, and we as a society need to find solutions that support human agricultural livelihoods and also conserve our land, water, air, and wildlife. For those finding themselves at the juncture of cattle grazing and bobwhite conservation in the eastern U.S., *Beef, Grass, and Bobwhites* represents an important and critical first step.

Fidel Hernández
*Caesar Kleberg Wildlife Research Institute*

# 1. Preface

Aldo Leopold is famously quoted, "...game can be restored by the creative use of the same tools which heretofore destroyed it—axe, cow, plow, fire, and gun." Modern bobwhite management in the eastern U.S. has, with all but a few exceptions, ignored the cow until recently. This may be due to the lack of knowledge about grazing as a management tool. This perception has been reinforced by the livestock industry's heavy reliance on introduced forages commonly planted in monoculture stands that leave little for bobwhite habitat. Far too many examples of mismanaged forage grasses can be observed, and even where introduced forages are properly grazed, good bobwhite habitat is rarely produced. It is no wonder that grazing has been considered incompatible with bobwhites. Nevertheless, when applied appropriately, it not only is compatible, but some would argue, necessary.

This publication focuses on beef cattle grazing management for planted native warm-season grasses[1] (NWSG) that will benefit Northern Bobwhites (hereafter, bobwhite). Many of the grazing management recommendations contained herein also apply to remnant native grasslands, though additional considerations may be necessary to protect those sensitive sites. In many cases, grazing management to create bobwhite habitat can result in improved profitability, especially in the middle latitudes of the eastern U.S. known as the Fescue Belt (***Figure 1.1***). However, the grazier focused on bobwhite management should understand that such an approach may not necessarily maximize beef production on a per-acre basis. The information in this publication applies primarily to bobwhite range in the U.S. that receives more than 30 inches average annual rainfall (hereafter, eastern U.S.), excluding Florida, which has its own special circumstances due to its sub-tropical climate.

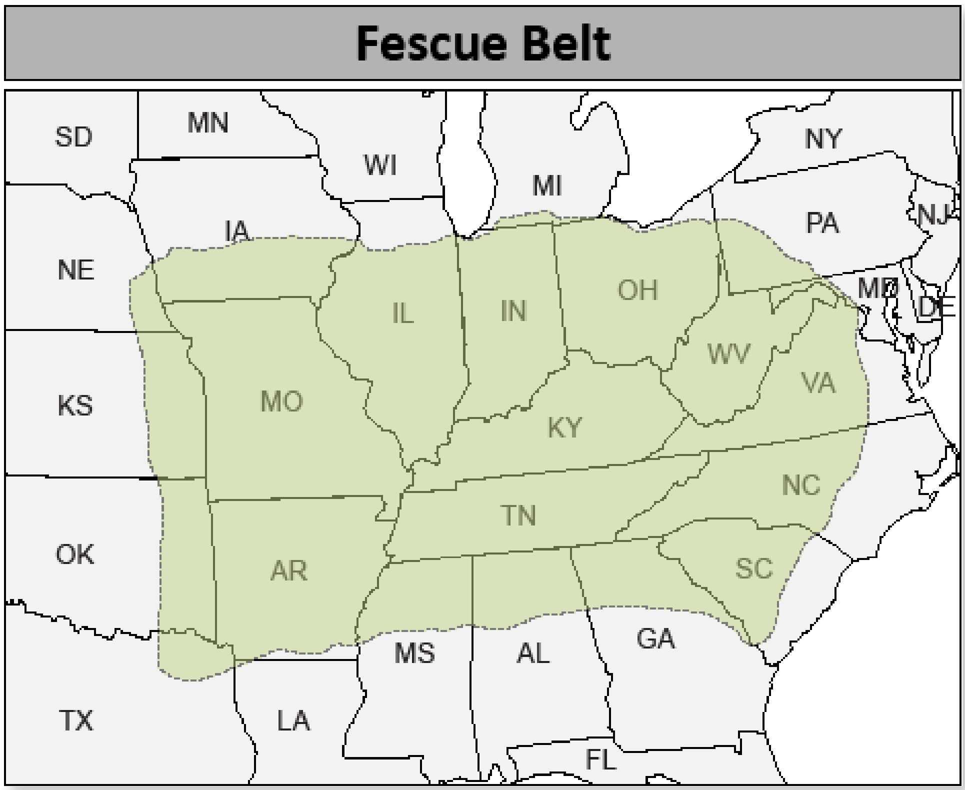



***Figure 1.1:*** *Approximate area of the tall fescue belt in the U.S. (M. Foley, NBCI)*

Because this publication focuses on NWSG forage in the eastern U.S. where introduced cool-season forages (CSG) dominate the landscape, the preponderance of material addresses grazing NWSG in a complementary system that includes both warm- and cool-season forages. Therefore, the information presented is focused on the potential impacts and considerations of grazing during the late spring and summer when nesting bobwhites and grassland birds are most vulnerable to disturbance by cattle. Moreover, NWSGs in a complementary system with CSG can provide an offset for the summer slump in forage production seen with CSG (***Figure 1.2***) and, where applicable, provide a strategy for avoiding toxic endophyte-infected tall fescue.

1 Throughout this publication the reference to NWSG is intended to be comprehensive and imply the full suite of native vegetation that would be utilized as forage, including grasses, forbs and legumes.

Bobwhites have been suggested as an umbrella species for grassland/shrubland birds in general (Crosby et al. 2015), meaning that by conserving bobwhites, we also are conserving many other species that share similar habitat. However, if managing for other species whose habitat requirements are different than bobwhites is important, then those species' requirements should be taken into consideration and adjustments made in these recommendations to provide the necessary habitat. Although grassland birds are referred to throughout this publication, bobwhites are not a grassland obligate species, but rather a grassland facultative species reliant upon grasslands for nesting and brood rearing during those stages of their life cycle (Vickery et al. 1999).

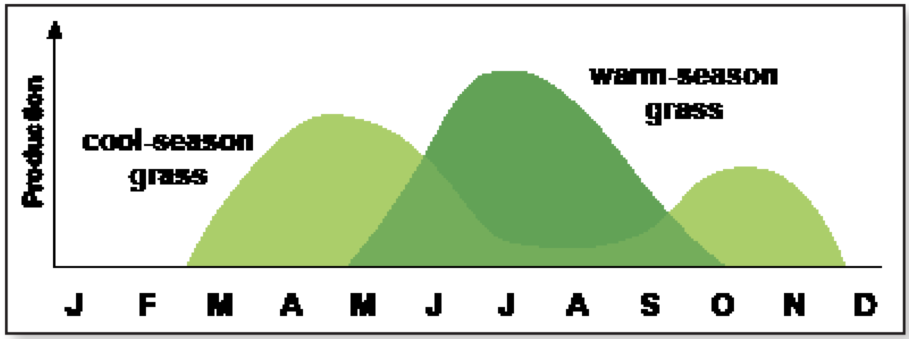



***Figure 1.2:*** *Grass growth curve.*

Ancillary material is included in the Appendix to provide a comprehensive overview of the considerations necessary to integrate grazing and bobwhite management disciplines and provide guidance to technical advisors with varying degrees of knowledge and experience.

Methods for establishing NWSGs for grazing are not covered in this publication. Recommendations and information on NWSG establishment, economics, and agronomics can be found in publications (Keyser et al. 2015, Keyser et al. 2019, Keyser 2021) and online at The Center for Native Grasslands Management (CNGM, nativegrasses.tennessee.edu/native-grass-resources). Videos on establishment and management are available at Native Grass College (nativegrasses.tennessee.edu/native-grass-college). A source for grazing terminology is available from the Society for Range Management in the 1998 version of the Natural Resources Conservation Service (NRCS) *Range and Pasture Handbook*. Additionally, the National Bobwhite Technical Committee (NBTC) has developed a mobile web application, NatiVeg (quailcount.org/NatiVeg) which can be used within the 25 states that make up the core of bobwhite range to identify NRCS plant material releases applicable to a specific location. The NRCS, university extension, state fish and wildlife agencies, and reputable, local native seed suppliers are often sources of information on establishment and species adapted to a specific locality.

*Even when properly grazed, introduced cool-season grasses lack the vegetative structure preferred by bobwhites.*

# 2. Introduction

## 2.1. Why Grazing as a Bobwhite Management Tool?

Ecological plant succession in North American grasslands has been driven by cycles of fire and grazing for thousands of years. These disturbances are an inherent and indispensable part of grassland ecosystems in all their forms. Thus, it should not be a surprise that grassland wildlife native to North America is, therefore, adapted to both of these disturbances. Bobwhites are no exception.

In areas of >30" average annual rainfall, native grasses typically become too thick for use by bobwhite and several other grassland bird species without regular periodic disturbance (Harper et al. 2015, Moorman et al. 2017). Fire, discing, and herbicides are the most commonly used tools to achieve disturbance for wildlife habitat management (Gruchy and Harper 2014). Burning is not always an option due to liability concerns of the landowner, availability of resources (equipment, manpower), smoke management concerns, or regulations. Furthermore, with fire alone, tall native grasses can become too rank for bobwhite, even by early summer following a spring burn in the eastern U.S. (Harper et al. 2015). Fire, discing, and herbicides can result in suitable habitat structure when interspersed spatially and temporally at the field level. This intensive approach can be effective but requires a large input of time and resources. Hedges and Loncarich (unpublished data) in 2017 calculated the cost of traditional bobwhite management to be slightly over $110/acre/year.

By contrast, grazing can produce a great deal of heterogeneity, a critical characteristic of bobwhite habitat, at the within-field scale due to the natural grazing behavior of cattle. Over time, cattle allowed free-choice will graze and re-graze the most palatable plants while leaving less palatable plants minimally grazed or un-grazed. Seasonal distribution and palatability of forage will vary with forage species. As the grazing period progresses, cattle will continuously select high quality, palatable forage. A forage plant that was highly selected in the early part of the grazing period may become less selected or replaced by other species due to changes in quantity and nutrient content as the season progresses. This behavior can be used as a management tool by either encouraging it through continuous grazing or restricting it though high-density, short-duration grazing. Stocking density and/or duration of the grazing event can be used to adjust the magnitude of this impact. Additionally, water, shade, and mineral can be used to redistribute grazing pressure allowing the manager to tweak vegetation structure/heterogeneity, especially in continuously stocked pastures. Through such adjustments, which result in differences in forage utilization, structural heterogeneity and interspersion can be achieved on a micro-scale impractical through any other means of disturbance. Furthermore, the fine-scale heterogeneity of grazing can be extensively applied and normally requires a lower input of time and resources compared to traditional intensive habitat management.

## 2.2 NWSG vs. Introduced Grass Species for Grazing and Bobwhites

Canopy heights of forage stands largely define their value for bobwhites. Recommended minimum grazing heights for the most commonly used cool-season forages[2] as well as two widely used warm-season perennials (bermudagrass and bahiagrass) range from 3-6 inches, with turnout heights at 6-8 inches. In contrast, recommended minimum grazing heights for native warm-season forages[3] range from 12-15 inches, with turnout heights of 15-30 inches, depending on grass species and management approach. Thus, when NWSGs are properly grazed, vegetation structure used by bobwhites and other grassland wildlife is created and maintained (George et al. 1979). Furthermore, properly grazed NWSGs produce optimum pasture productivity for beef at conditions very similar to those that provide bobwhite and grassland bird habitat (Brazil 2019, Brazil et al. 2020). By contrast, properly grazed introduced cool- and warm-season grasses lack the vegetative structure necessary to provide quality bobwhite habitat.

2 Kentucky bluegrass, tall fescue, orchardgrass, smooth brome, and timothy.

3 Big bluestem, little bluestem, indiangrass, switchgrass, and eastern gamagrass.

*NWSG pastures provide bare ground between bunches of grass—an important characteristic of bobwhite brood habitat—while not sacrificing forage production.*

Bunch grasses are preferred as bobwhite habitat over sod-forming grasses (Barnes et al. 1995, 2013). Bunch grasses provide bobwhite nesting structure, the interstitial space between clumps conducive to chick movement and, when tall enough, overhead canopy for concealment. Sod-forming grasses lack the structural characteristics selected for nesting, and the sod inhibits free movement of bobwhite chicks. The common native warm-season forage grasses of the eastern U.S. are bunch grasses or exhibit a bunch structure under grazing. Though bunch grasses are preferred by bobwhites, they lose their habitat value if they are grazed close (< 8”). Sod forming grasses provide limited habitat value for bobwhites, even when adequate residual remains (> 8”).

Nesting is known to occur in cool-season grasses but rarely in cool-season pastures. In those cool-season pastures where nesting does occur, it is normally in grass stands thin enough to provide suitable structure and encroachment of broadleaf plants. Such pastures either exist on extremely poor, low productivity soils or in the aftermath of prolonged heavy grazing. As a matter of good stewardship, mismanagement of cool-season forages is never recommended. And if soils are so poor as to not support a forage quality stand of cool-season grass, NWSG could be considered as an alternate perennial forage to make those acres productive.

Bobwhites have a historic association with grazing, unmanaged NWSGs become too thick for year-round bobwhite use and when grazed properly can create interspersion on a scale no other tool can provide, thus creating optimum grassland heterogeneity. When you consider all the evidence, grazing NWSGs and bobwhites are compatible and provide an excellent opportunity for working lands conservation.

# 3. Integrating Grazing and Bobwhite Habitat

Before delving into the specifics of bobwhite-friendly grazing management, it is important to recognize that forage systems are influenced by soil productivity and change seasonally and annually depending on rainfall, plant composition, and previous and current management practices. To be an effective forage manager, all of these factors should be taken into consideration and management adapted (stocking rate/density, forage utilization) as necessary to maintain and sustain healthy forages, profitable operations, natural resource protection, and bobwhite habitat. Furthermore, landscape context, as it pertains to bobwhite ecology, should be taken into consideration if the objective is to optimize local bobwhite populations (***Appendix A.4***). Regardless, NWSG pastures managed in ways that are compatible with the needs of grassland birds and other wildlife represent a net gain of potential habitat, as well as improvements to water and air quality, soil health, human health, and well-being.

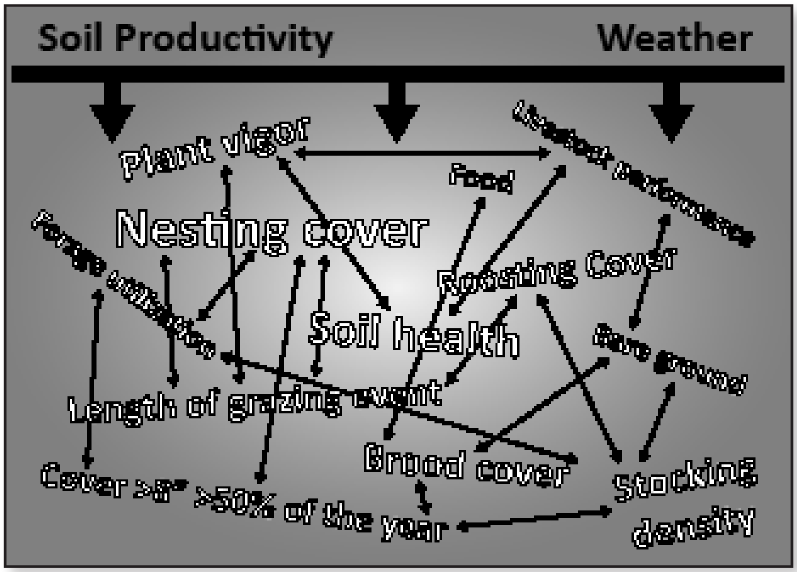



***Figure 3.1:*** *Complexity of profitable grazing and grassland habitat.*

Integrating sustainable and profitable grazing with bobwhite and grassland bird habitat involves attention to interactions that can be quite complex (***Figure 3.1***). Fortunately, following a few basic NWSG grazing management principles simplifies many of these complexities. Grazing of NWSGs for profitable livestock production has been documented (Holcomb et al. 2011, Brazil 2019, Brazil et al. 2020, Keyser 2021), grazing management for grassland bird production has been studied, and habitat needs of bobwhite are well known. However, combining them all has received little attention, with the exception of a few research studies (Birckhead 2012, Birckhead et al. 2014, Harper et al. 2015a, Brazil 2019, Keyser et al. 2020, Brazil et al. 2020).

## 3.1. Grazing During the Primary Nesting Season

Optimizing profits from NWSG forages requires grazing them when NWSGs are most nutritious in the late spring/early summer, thus creating concerns about conflicts with nesting. This potential conflict has led to the recommendation of delaying grazing NWSGs until late June/early July. However, those study designs which resulted in that recommendation have not examined the effect of grazing NWSGs during the primary nesting season at stocking densities appropriate for habitat and forage goals. Therefore, they have not provided any insight into the impacts of grazing during May-June on nesting under proper stocking. Additionally, while delaying grazing may avoid nesting for some species of non-game grassland birds, bobwhites nest throughout the summer (***Appendix A.3***).

Aside from one study in Missouri, there are no other studies which looked at grazing NWSGs and bobwhite production during May-July. Hedges and Loncarich (unpublished data 2018) found greater nesting effort, higher nest success rates, and lower nest predation in a heterogeneous mix of fall- or spring-burned and May-August-grazed remnant native prairie pastures compared to traditional bobwhite management areas consisting of strips of grains, shrubs and rotationally burned NWSGs. Pastures rotationally stocked mid-May through late August showed no difference in daily survival rate or nest success for three passerines, compared to patch-burn grazed pastures (Buckley unpublished data 2021). Patch-burn grazing (PBG) is discussed in greater detail in section ***3.3.4.1***. There are a handful of studies which address metrics other than production of bobwhites and grassland/

shrubland birds during May-July grazing. West et al. (2016) noted no difference in breeding bird occupancy rates between NWSG fields under different working lands management scenarios and pastures rotationally grazed at least once during May-June. Pastures continuously stocked May-August maintained suitable vegetation structure and invertebrate biomass (bobwhite food source) for grassland songbirds and bobwhite nesting and brood-rearing (Harper et al. 2015, Birckhead 2012). Brazil (2019) looking at avian density on NWSG pastures found grasshopper sparrow and field sparrows preferred to nest in NWSGs that had been continuously grazed May-August, compared to CSG pastures.

While more research is needed, **studies to date indicate grazing using stocking densities that result in desirable canopy conditions during the primary nesting season have minimal impact on avian productivity** (Birckhead 2012, Harper et al. 2015, West et al. 2016, Hedges and Loncarich unpublished data 2018, Brazil 2019, Buckley unpublished data 2021).

NWSG grazing management, where recommended canopy heights are maintained (***Appendix C.2***), provides suitable nesting cover for bobwhites (***Appendix A.1.2***). With suitable nesting cover being a by-product of proper NWSG grazing management, stocking density and its potential impacts on nesting birds becomes a primary consideration (***Appendix B***). Stocking rate, stocking density, and utilization are terms that are important for this discussion on grazing management for bobwhites.

Stocking rate and stocking density typically use Animal Unit (AU) to express the number(s) of animals in a given unit of area. An AU in the United States is considered to be 1,000 pounds of body weight, which is often also expressed as a 1,000-pound cow and calf up to weaning (*USDA-NRCS National Pasture and Range Handbook*). Regardless, for the purpose of this publication, we will express stocking rate and stocking density, when possible, in terms of head per acre for consistency and ease of comparison. This reference is used to illustrate the number of hooves on the ground rather than weight or forage demand, which can result in a variable number of hooves on the ground. Utilization (aka Use) refers to the amount of plant material that has been removed or destroyed by animals during the grazing period (*USDA-NRCS Range and Pasture Handbook*). There is no established standard for expression of utilization; however, it is commonly referred to as a percent of the total available forage and typically identified as light, moderate, or heavy. Individual research reports typically define utilization as it applies to their specific research.

Stocking rate and stocking density are two terms that are often used interchangeably, though incorrectly so. Stocking rate is the number of animals utilizing a unit of land for a specific period of time; stocking density is the number of animals in an area of land at any moment in time (*USDA-NRCS National Range and Pasture Handbook*). They can be the same under certain circumstances. For example, a 10-acre pasture stocked with 10 animals would have a stocking rate of 1 head per acre (hd/a). The stocking density is also 1 hd/a. If that same pasture were divided into 10, one-acre paddocks, the stocking rate is still 1 hd/a but the stocking density within the paddock being grazed is 10 hd/a. **Stocking density is the more important consideration when talking about bobwhite and grassland bird nesting**.

## *3.2. Landscape Context*

**Landscape context is an extremely important consideration for grassland birds and bobwhites** and must be included in any discussion integrating grazing and bobwhites, especially in the fragmented landscape of the eastern U.S. Of particular importance are distance to woody edge and/or forest cover, grassland patch size, extent of grassland in the landscape, and proximity of other necessary habitat components. There is a range of sensitivity among grassland bird species in relation to each of these. Appropriate management guidance may vary for differing species of interest.

A detailed discussion about landscape context is presented in the Appendix (***A.4***). In summary, nesting success and breeding bird occupancy increases with distance from forested cover/edge. Predation rates are lower on larger patch sizes, and population level influences of habitat decrease as distance between usable habitat increases.

## 3.3. Grazing Approaches, Grassland Birds, and Bobwhites

There are seemingly an infinite variety of grazing management approaches. For the purposes of this discussion and applicability to bobwhites or grassland birds, grazing management is categorized as either **continuous**, **simple rotational**, or **intensive rotational stocking** (***Figure 3.3.1***). Regardless of the grazing management approach, it is extremely important that the stocking rate is balanced to meet the livestock forage demand and availability. If it is out of balance, it can be detrimental to livestock production and, potentially, forage resources and habitat.

**Continuous stocking** is a one-pasture system where livestock have unrestricted access throughout the grazing season.

**Simple rotational stocking** is a system with more than one paddock in which livestock are moved to allow for periods of grazing and rest for forages.

**Intensive rotational stocking** is a system with many paddocks. Livestock are moved frequently from paddock to paddock based on forage growth and utilization.

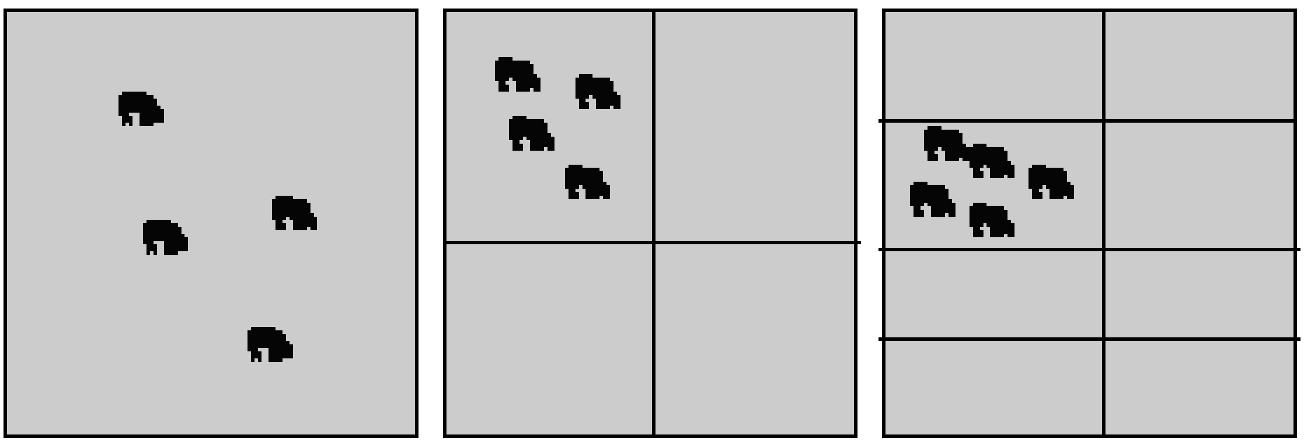


***Figure 3.3.1:*** *Grazing management systems.*

Vegetation structural characteristics, including bare ground, are the key to providing bobwhite habitat, regardless of the system used. Based on the literature examining grazing and grassland birds, the preponderance of evidence indicates that **stocking density and forage utilization are more important drivers of habitat quality and nesting success than the grazing system**. Forage utilization is easily controllable through manipulation of stocking density. There is not conclusive evidence for the upper limit for stock density compatible with nesting bobwhites (***Appendix B***). However, we do know that 1.7 hd/a caused minimal disturbance to grasshopper and field sparrow nests (Brazil 2019). Keyser et al. (2020) noted no difference in relative breeding bird abundance for bobwhites in NWSG pastures rotationally grazed at least one time May-June stocked at 2.8 – 4.5 AU/a compared to ungrazed, traditionally managed fields of NWSG, and Harper et al. (2015) reported desirable vegetation structure and insect biomass were retained at a stocking density of 3.73 hd/a. Based on these studies, **between 1 and 2 hd/a should be used as the upper threshold for stocking density until research specific to bobwhites provides a more definitive answer.**

### 3.3.1. Continuous stocking

Continuous stocking allows the cattle free choice of forage throughout a grazing season within a single pasture. This is the simplest form of grazing management and requires less effort on the part of the manager than rotational stocking. There is no cross fencing required, and often only a single source of water is needed. Continuous stocking is subject to overgrazing if the stocking rate is too high. Stocking rates to maintain recommended NWSG canopy heights generally will avoid overgrazing.

*Big bluestem/indiangrass mixture under appropriate grazing pressure, late June in east Tennessee.*

Continuous stocking, due to cattle selectivity, provides greater heterogeneity at a broader scale than rotational stocking (Holechek et al. 1982, Coughenour 1991, Ranellucci et al. 2012). Carnochan et al. (2018) reported 2.4 to 4 times higher nesting success in grassland songbirds in season-long grazed pastures compared to twice-over rotationally grazed pastures. Recent studies examining continuous stocking of NWSG and bird conservation at the appropriate stocking density and forage utilization during the primary nesting season concluded continuous stocking provided appropriate vegetative structure and insect densities for bobwhite nesting and brood rearing (Birckhead 2012, Harper et al. 2015), and Brazil (2019) concluded that, in the Fescue Belt, continuously grazed NWSG is likely the best option for grassland bird conservation.

Based upon the results of these studies, it appears that **continuous stocking of NWSG provides suitable habitat for grassland nesting birds**. Therefore, it is a viable option for integrating grassland bird habitat and profitable livestock production, one that avoids many of the issues with rotational stocking.

**Continuous Stocking**
**Best Management Practices**

- Set stocking rates to maintain 14-24 inch canopy height (***Table C.2.2.2***).
  - Stocking rate to achieve this level of utilization varies depending upon NWSG species and site productivity.
  - Stocking densities >2 hd/a may impact nesting (***Appendix B***).
- Place water and mineral to reduce areas of heavy concentration of cattle.

### 3.3.2. Simple rotational stocking

A simple rotational stocking of 2-4 paddocks rotates grazing through each of the paddocks (***Figure 3.3.1***). The paddock grazing events are several days to a week or more in duration, reducing the labor necessary for management compared to that required in more intensive systems. Stocking rate is determined for the total pasture, but the entire herd is confined to the actively grazed paddock. The paddock is grazed until the desired trigger point is reached, at which time cattle are moved to the next paddock. The trigger point is based on grass maturity or grass height. With more than two paddocks, rotation occurs from one paddock to another until all have been grazed. Fencing is required to separate each paddock and may be temporary if a larger pasture is subdivided. Water must be available to each paddock while cattle are present. Many system designs provide a central water source that is shared among the paddocks (***Figure 3.2.2.1***).

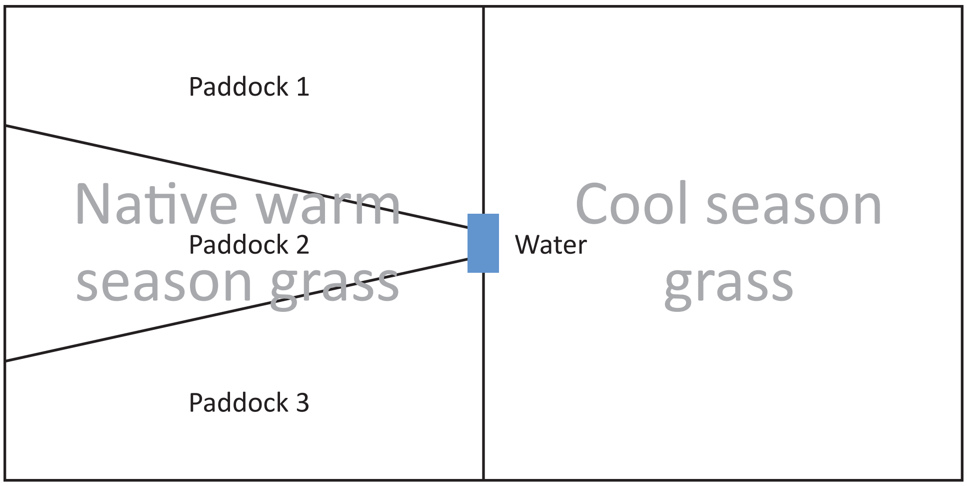



***Figure 3.2.2.1:*** *A simple three-paddock rotation moving cattle every 3 to 10 days, depending on rate of grass growth, has been used effectively in trials in Kentucky and Tennessee (P. Keyser, Center for Native Grasslands Management, personal communication). Note: Area near water will receive heavy utilization.*

Several practical guides to grazing management recommend simple rotational stocking as the preferred grazing method for grassland birds, or delaying the onset of grazing NWSG until July 1 in a CSG/NWSG complementary system, which is functionally the same as simple rotational stocking (USDA-NRCS 1999, Undersander et al. 2000, Pease 2003, Hyde et al. 2012). The preference for rotational stocking is supported by studies of rotationally stocked CSG pastures or comparing CSG grazed from April until late June to ungrazed NWSG during the same time period (Undersander et al. 2000, Giuliano and Daves 2002, Pease 2003, Hyde et al. 2012). In Kentucky and Tennessee, one study which did include rotational stocking mid-May through late August found nest success for field sparrow, red-winged blackbird, and indigo bunting was no different in rotationally grazed NWSG versus patch-burn grazed (PBG) NWSG paddocks (Buckley et al. unpublished data 2021). Another study, which delayed grazing NWSG until July, found higher nest success for pheasants in Iowa switchgrass plots compared to switchgrass fields continuously grazed or hayed (George et al. 1979).

Options for simple rotational stocking that consider bobwhite nesting include: **1) setting aside a paddock to allow for undisturbed nesting; 2) setting up rotations long enough to allow undisturbed nesting before or after a paddock is grazed; 3) maintaining appropriate stocking densities in paddocks through the rotations to minimize probability of disturbing nesting birds**. Be aware that the threat of physical disturbance of nests by cattle could be significant if the animals are concentrated while moving between grazing units.

**Option 1**, setting aside a paddock (i.e., leave out of the rotation) may provide some nesting opportunity; however, there are potential issues with this approach. Nesting success of the birds in the non-rested paddocks would be limited, and nesting that occurs in the set-aside paddock to sustain a population would have to be enough to overcome any population deficit that may be created by failed nests in the other paddocks. Nest success in the set-aside paddock may be higher, but the area relegated for nesting decreases. Another consideration is that pressure from predation increases with decreasing pasture size (***Appendix A.4.2***). In addition, the producer needs to be willing to accept the impact of reduction in overall livestock carrying capacity for the foregone forage in the set-aside paddock. While creating a set-aside paddock may seem ideal, birds may not seek out the undisturbed paddock as managers might intend. Depending on species of NWSG, the set-aside paddock may become too rank for desirable bobwhite nesting cover. Managers can't reliably count on birds putting all their nests in the set-aside paddock.

Under **Option 2**, setting up rotations long enough for the nesting cycle to be completed before or after grazing has the same issues as Option 1. Additionally, if undisturbed nesting cover is the objective, the paddock would need to be undisturbed for 47–55 days for the bobwhite nesting cycle to be completed (Rosene 1969). Although beef carrying capacity may not be affected by delaying grazing on a single paddock for 47 days, forage quality and, in turn, daily gain and pasture productivity will be substantially reduced, perhaps by more than half. This is not likely to be acceptable to producers, particularly those grazing growing classes of livestock. For paddocks that have already been grazed, the likelihood for successful nesting is based on the probability of a bird's biological need to initiate nesting to synchronize with the availability of the undisturbed paddock. This could be a successful strategy for bird species with shorter nesting cycles.

**Option 3 is the most compatible with both grazing productivity and bobwhite nesting habitat**: setting stocking density at a level which minimizes nest failure, allowing cattle to rotate through paddocks to take advantage of quality forage while maintaining proper structure to support nesting throughout the nesting season. Under this approach, the length of the grazing event is less significant because stocking densities are below a critical threshold, vegetative structure is maintained, and forage quality is preserved.

**Simple Rotational Stocking**
**Best Management Practices**

**Option 3** (Preferred)

- Set stocking density to maintain 14-24 inch grass canopy heights (***Table C.2.2.2***).
    - o Grazing bouts will be shorter in the spring when grasses are rapidly growing and longer in the summer when their productivity slows down. Grazing pressure should be significant enough to keep the plants vegetative but not overgrazed.
    - o Stocking densities >2 hd/a may impact nesting (***Appendix B***).
- Initiate grazing in a different paddock each year (***Figure 3.3.1***).

**Options 1 and 2 (**Alternative strategies for adaptive management)

- For the set-aside or last-to-be-grazed paddock, prior to grazing, select the paddock that exhibits the best vegetation characteristics selected by bobwhites for nesting (***Appendix A.2***).
    - o Maintain 14-24 inch grass canopy heights (***Table C.2.1.2***).
- Initiative grazing in a different paddock each year. Rotate set-aside paddock annually (***Figure ******).

### 3.3.3. Intensive rotational stocking

Intensive rotational stocking divides a pasture into multiple paddocks and is characterized by short duration grazing events followed by long periods of rest (***Figure 3.3.1***). The primary objective of most intensive rotational stocking systems is full utilization of the forage within the paddock. This is achieved through high stocking densities. Cattle are rotated to the next paddock when the actively grazed paddock reaches the targeted forage height. Depending upon stocking density and forage availability, this rotation can be as frequent as several times a day to once every day or two. Cross-fencing is required, and water must be available to each paddock while cattle are present. Temporary fencing allows adjustments to paddock size, which can be used to alter stocking density and regulate the length of the grazing event or rest period.

The probability of nest survival in a paddock with high stocking density is extremely low due to both direct and indirect causes (Temple 1999, Marquardt 2008, ***Appendix B***). Any potential nesting benefit from intensive rotational stocking will be from paddocks excluded from the rotation, not grazed before completion of the nesting cycle or enough rest between grazing events to meet the nesting cycle requirements. Relying upon paddocks before or after a grazing event to produce successful nests is problematic, and you could inadvertently be creating an ecological trap. Birds attracted to the structural characteristics of a rotationally grazed paddock are subject to nest destruction when that paddock is eventually stocked at a high density. Intensive rotational stocking can lead to a homogeneous vegetation structure and, if stocked heavily enough, trampling of forage that creates a thatch layer undesirable to bobwhites. Brood cover for bobwhites may be provided by recently grazed paddocks as long as canopy heights and some bare ground are maintained.

| Length of grazing event per paddock | # of paddocks required | Paddock size based on 15 a example | Stocking density based on stocking rate of 1 hd/a |
|---|---|---|---|
| 1 d | 48 | 0.3 | 50 |
| 2 d | 25 | 0.6 | 25 |
| 3 d | 17 | 0.9 | 16.7 |
| 4 d | 13 | 1.2 | 12.5 |
| 5 d | 11 | 1.4 | 10.7 |
| 6 d | 9 | 1.7 | 8.8 |
| 7 d | 8 | 1.9 | 7.9 |
| 8 d | 7 | 2.1 | 7.1 |
| 9 d | 7 | 2.1 | 7.1 |
| 10 d | 6 | 2.5 | 6 |

***Table 3.3.3.1:*** *Length of grazing event, number of paddocks required, paddock size and stocking density based upon a 47 day nesting cycle and 15 acre pasture with a stocking rate of 1 hd/a.*

While average pasture size in the eastern U.S. is unknown, a reasonable estimate is 15 acres (P. Keyser, Center for Native Grasslands Management, personal communication). Paddock size in an intensive rotational stocking system designed to provide at least one undisturbed paddock to accommodate the 47-day nesting cycle for bobwhites depends upon the length of the grazing event (***Table 3.3.3.1***). Paddock (patch) size is an important consideration for nesting bobwhites; unfortunately, minimum size for successful bobwhite nesting is unknown (***Appendix A.4.2***).

Forage quality of NWSG in a 47-day rotation will decline in the paddocks as time progresses, thereby making a long rotation cycle unattractive to the producer seeking to maximize weight gains. However, it could still be a possible option for cattle with low energy requirements. If a 47-day rotation were being used, there would be potential for nesting in a paddock following a grazing event provided appropriate habitat were present for nesting.

**Intensive Rotational Stocking**
**Best Management Practices**

- Establish an ungrazed area as large as possible.
    - o Annual rotate ungrazed areas to an area grazed the previous year.
- Maintain 14-24 inch grass canopy heights in grazed paddocks (***Table C.2.2.2***).
- Design paddocks in rotation as large as possible to accommodate potential nesting after the grazing event.
- Rotate through paddocks sequentially, creating an ever-increasing area of undisturbed cover.

### 3.3.4. Specialized Grazing Systems

#### *3.3.4.1. Patch-burn grazing*

The PBG system divides a pasture into "patches" with one patch being burned, followed by another either later in the season or the following year, across several years, rotating the burned patch each year (***Figure 3.3.4.1.1***). Burning improves forage quality (McGrananhan 2014, Allred et al. 2011), thus the cattle's natural attraction to fresh, palatable, highly nutritious forage shifts grazing pressure to the most recently burned patch (Weir et al. 2007). Cattle spend the majority (75%) of their time in the most recently burned patch, while spending much less in the previously burned patch and very little on the patches longest since fire (Fuhlendorf and Engle 2004). This pattern allows ample rest of the forage through the cycle of the patches, thus maintaining stand vigor. Stocking rates are similar to what would be used under a continuous stocking approach for the entire pasture (Fuhlendorf and Engle 2004). Patch-burn grazing improves forage quality and diversity (Smith 2014, McGranahan 2014) and creates drought insurance through stockpiling forage in the unburned patches, thus mitigating risk for the producer (Allred et al. 2014, McGranahan 2014). With PBG, there is no loss of animal performance compared to traditional management (Fuhlendorf et al. 2004, Rensink 2009, Winter et al. 2014). No cross fencing is required, and only one source of water is needed.

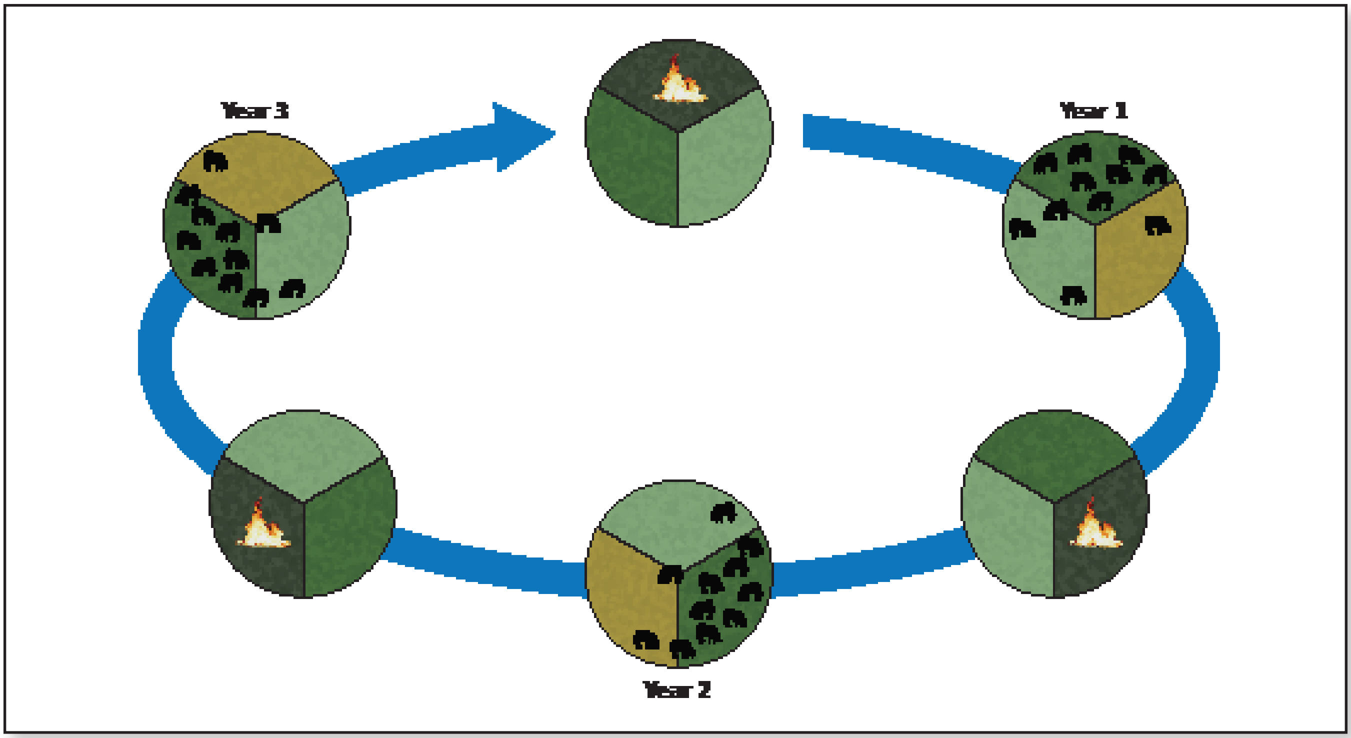



***Figure 3.3.4.1.1.*** *Illustration of patch-burn grazing system. (Adapted from A. Vander Yacht.)*

Patch-burn grazing has been shown to provide a high degree of habitat heterogeneity across the pasture and through the year (Fuhlendorf and Engle 2001, Fuhlendorf et al. 2006, Smith 2014). Because of this heterogeneity, PBG pastures provide a wide range of habitat conditions in close juxtaposition to each other within a pasture, thus meeting the needs of numerous bird species (***Figure 3.3.4.1.2***, Fuhlendorf et al. 2006, Churchwell et al. 2008, Coppedge et al 2008, Jamison and Underwood 2008, Stroppel 2009, Hovick et al. 2012, Moranz et al. 2014).

A majority of the research on PBG has been conducted in the Great Plains on pastures >100 acres. As a result, there is some skepticism whether heterogeneity and animal responses will be the same in the more humid climate and fragmented landscape of the eastern U.S. Studies of PBG conducted in the eastern U.S. indeed confirm heterogeneity and cattle responses are similar with patches as small as 8 acres; however, stocking density may be more critical to create heterogeneity between patches (Jamison and Underwood 2008, McGranahan et al. 2014, Scasta et al. 2016, Duchardt 2016, Keyser et al. unpublished data 2020, Buckley et al. unpublished data 2021, Lituma et al. unpublished data 2021).

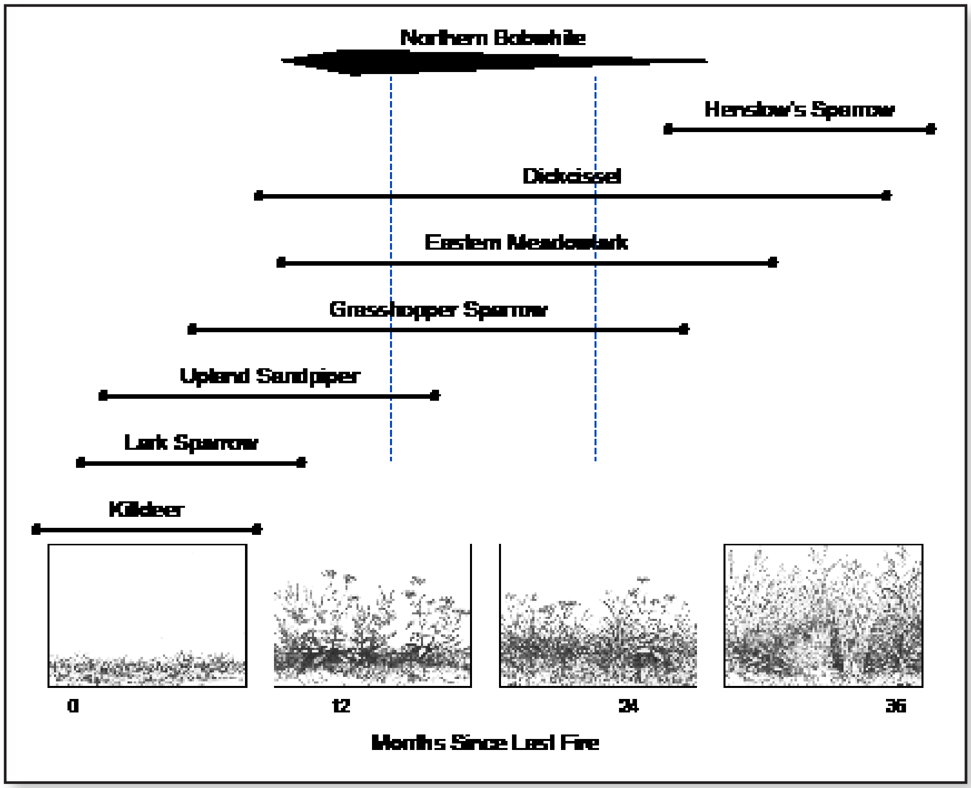



***Figure 3.3.4.1.2:*** *The range of habitat required by prairie songbirds. Patch burning allows for multiple habitats (heterogeneity) with the same unit for multiple species, whereas traditional management generally provides only one kind of habitat structure. The weighted line for bobwhites represents the proportional use of habitat niches most used during the summer nesting/grazing period. Adapted from Engle et al. (2007).*

A study of PBG and bobwhites in native grassland in Missouri has shown bobwhites respond positively to this practice (Hedges and Loncarich unpublished data 2018). Duchardt (2016), working in a fragmented landscape, found avian diversity was greatest in PBG pastures having the greatest degree of heterogeneity compared to graze and burn and burn-only pastures. Conversely, a study of PBG in Iowa and Missouri found the greatest density of bobwhites in burned and grazed pastures compared to burn-only and patch-burn grazed pastures; however, co-dominance of non-native cool-season grasses may have reduced bobwhite use of the PBG pastures (Pillsbury et al. 2011).

While more research needs to be done regarding grassland bird use of PBG systems in the eastern U.S., especially as it relates to bobwhites, patch-burn grazing appears to provide numerous integrated benefits for livestock and birds.

**Patch-burn Grazing**
**Best Management Practices**

- Patch-burn grazing integrates many of the qualities desired for a cross-section of grassland birds and therefore is, in and of itself, a BMP.
    - For PBG to provide satisfactory gains, early stocking is necessary. Contrary to all other recommendations in this publication, early stocking and heavy grazing (<12 inch canopy height) are tolerable within the current year's burn patch due to the two-year recovery period of the individual patches and the availability of other vegetation with desirable structural characteristics in the remaining two-thirds of the pasture.

*Cattle grazing the burn patch of a PBG system. Temporary fencing is protecting a riparian corridor.*

#### ***3.3.4.2. Open-gate rotational stocking***

A novel form of simple rotational stocking is an open-gate rotational system developed and implemented in Nebraska rangeland by Chris Helzer of The Nature Conservancy. Under this approach, a pasture is divided into four or more paddocks. The first stocked paddock is grazed to the desired vegetation trigger point, then the gate is opened (or hot-wire removed) to the next paddock and remains open, allowing livestock continued access to both the new and old paddock. As the season progresses, gates to additional paddocks are opened, gradually increasing the total size of the area accessible to livestock. By the end of the grazing season, the paddocks used earliest in the season will have been grazed heavily, and paddocks opened later will have been less heavily grazed. One or more paddocks are left completely ungrazed each year. The ungrazed paddock(s) can serve as a stockpile for emergency grazing if necessary.

The following year, the management of the paddocks is shifted so that the paddock(s) grazed most heavily the previous year get full rest, and the rotation starts with the next most intensively grazed from the previous year. In a four-paddock system, that would mean the paddock grazed first in Year 1 would be rested in Year 2, and the second paddock grazed in Year 1 would be the first in Year 2. This is a highly adaptive system with any number of combinations of open gates/pastures possible to meet vegetation management objectives. Compared to more traditional rotational grazing systems, this approach increases both the duration and intensity of grazing, as well as the length of rest periods, creating a high degree of habitat heterogeneity. Stocking rate is determined for the entire pasture, and rest periods should be made long enough for grasses to completely recover. Cross fencing is necessary but potentially only one water source is needed.

This system has not been studied for its impact on grassland birds. However, in Nebraska rangeland, it has shown to create vegetative heterogeneity similar to PBG (Chris Helzer, The Nature Conservancy, personal communication).

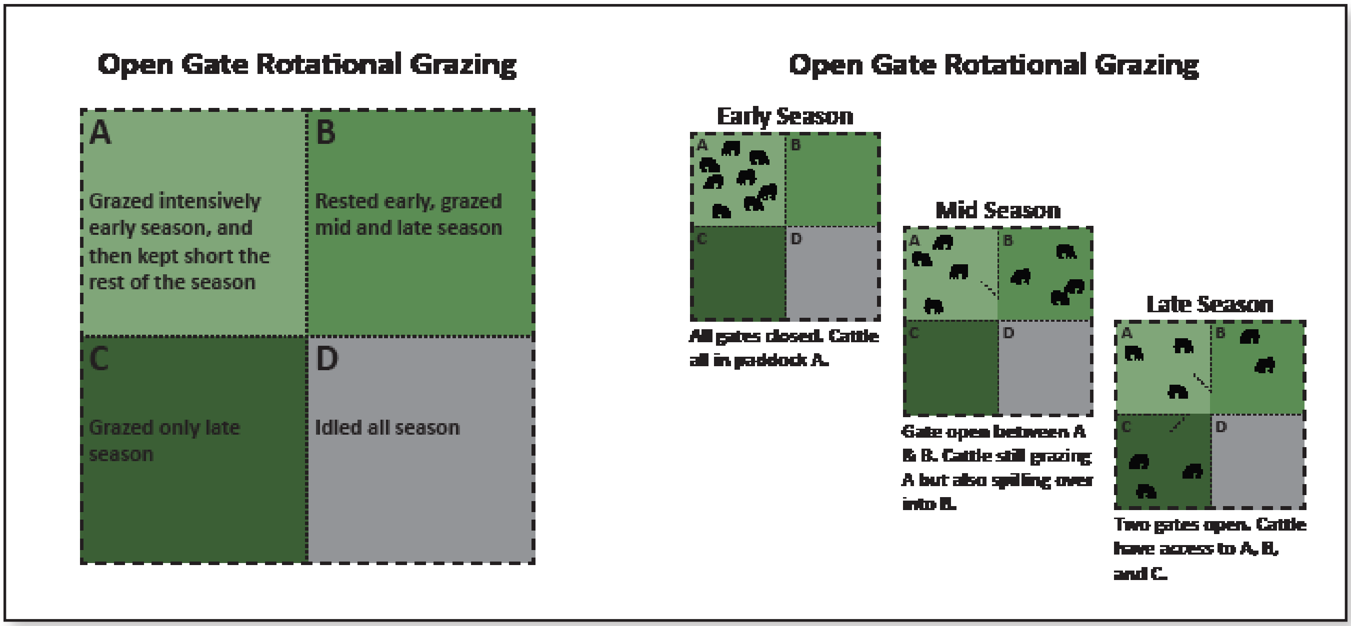



***Figure 3.3.4.2.1:*** *Graphic depiction of Open-gate rotational system. Adapted from Chris Helzer.*

## 3.4. Haying

In some circumstances, haying may be necessary to take advantage of forage surpluses or to achieve other pasture management objectives. Haying presents a conflict with grassland nesting birds because of the near certain destruction of nests and potential loss of adult or young birds during harvesting. For this reason, we discuss the best approaches to haying NWSGs to minimize potential nest or bird losses.

The intersection of the best quality and highest quantity of hay is when grasses are harvested during the boot stage (***Appendix D.1***), identifiable by the initial emergence of the very first inflorescences. The timing of boot stage varies by species. Throughout the Fescue Belt (***Figure 1.1***), switchgrass and eastern gamagrass boot stage occurs from mid-May through early-June, thus, they are not good candidates for hay harvest that will avoid destruction of initial nests. Big bluestem and indiangrass are typically in the boot stage in late June to early July, slightly earlier south and later as you move north. Consequently, hay harvests for these species create less conflict with grassland nesting birds. Nevertheless, in a study conducted in Kentucky and Tennessee, bobwhite had lower relative abundance in hayed NWSG harvested in mid- to late-June (Keyser et al. 2020). ***Figure 3.4.1*** represents nesting and haying dates applicable to the lower Midwest and Mid-South (adjust accordingly for your location).

**Haying**
**Best Management Practices**

- To the extent possible, rely on big bluestem and/or indiangrass for hay production.
- Delay haying until late June, or later if lower quality forage can be accepted.
- Leave a portion of the field unharvested (see section ***3.1.2***).
- Mow hay from the center of the field out, to avoid concentrating birds in a shrinking island of cover.
- To maintain plant vigor, hay harvest clipping height should be ≥ 8 inches.

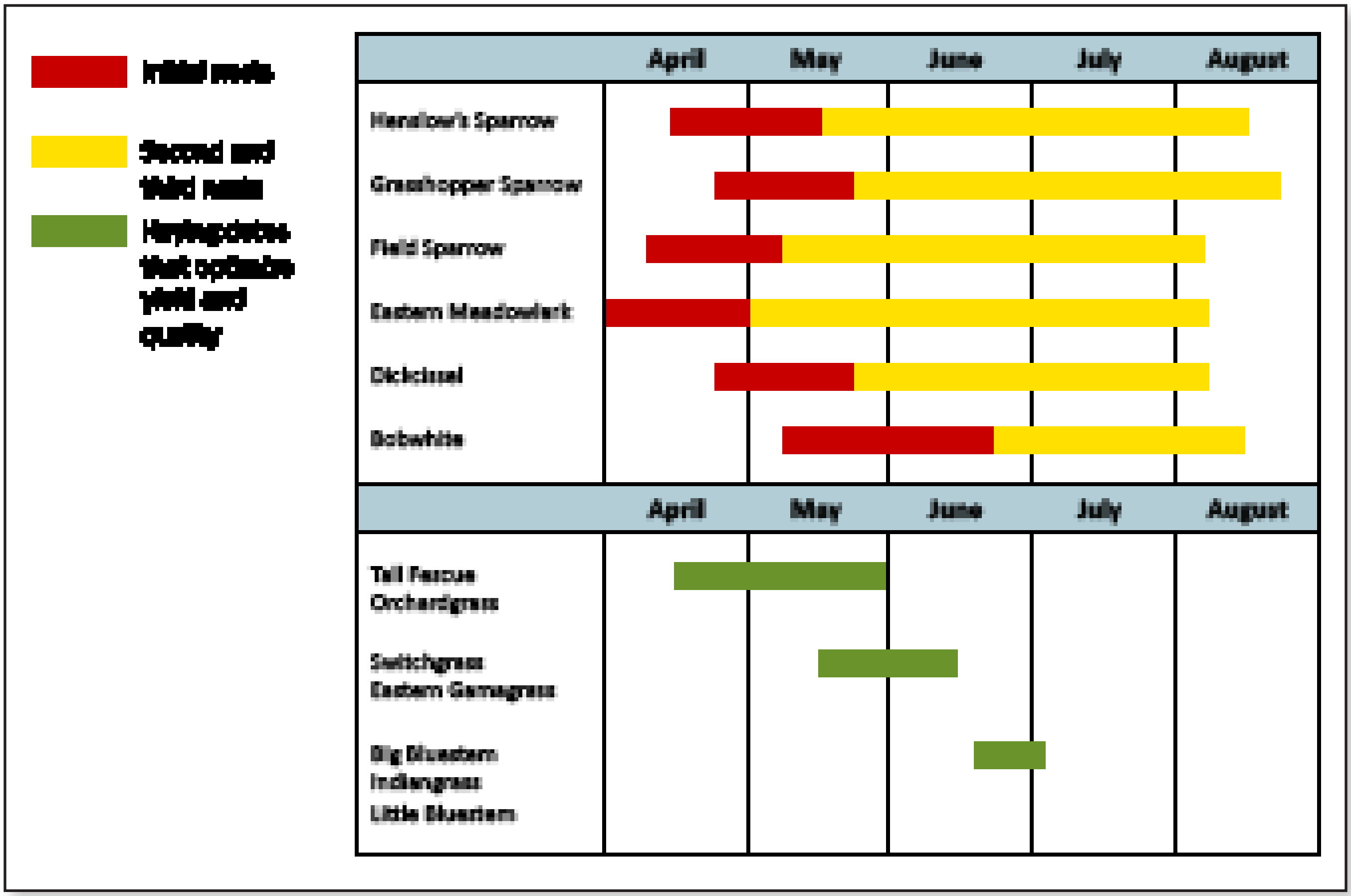



***Figure 3.4.1.*** *If grassland birds are a consideration, fields should not be hayed during nesting, especially during initial nesting attempts. Big bluestem and indiangrass offer the best opportunities for high-quality hay outside of the initial nesting period. Nesting and haying dates are representative of the lower Midwest and Mid-South. Adapted from Harper et al. (2015a).*

# 4. SUMMARY

Creating a profitable grazing system to benefit bobwhites and cattle necessitates considering the specific requirements of each individually, then combining those requirements in a way which complements each other and maintains the benefits to both. Native warm-season forages must make sense to a producer's operation (class of livestock, infrastructure or willingness to develop infrastructure, availability of land, management style, quality of life, etc.). If NWSG forages make sense to a producer and they implement the grazing management recommended in this publication, ample science and experience exists demonstrating profitable livestock production, NWSG stand vigor, and sustainability. Bobwhite and other grassland bird habitat will be created and maintained. For bobwhites, that means availability of a diverse plant community characterized by native bunch forming grasses for nesting, interspersed with forbs, and within flushing distance to a patch of suitable brushy escape cover. Establishment of such a system is not only attainable, but mutually supportive and practical. The key to integration of these goals is incorporation of NWSG forages and adaptive grazing management.

Counter to numerous past recommendations for simple rotational stocking as the preferred method for integrating grazing and birds, studies of continuous stocking of NWSG in the eastern U.S. when maintaining appropriate canopy heights and stocking densities have shown this grazing strategy to be compatible for cattle production, bobwhites, and other grassland birds. Continuous stocking, due to the simplicity (low management intensity and infrastructure needs), may provide an opportunity for greater acceptance of NWSG forages among producers (Brazil 2019) and likely provides the greatest potential to impact the largest number of acres. Producers already familiar with and utilizing simple rotational stocking, following the caveats outlined in ***Section 3.3.2***, may represent an improvement in habitat over ungrazed NWSG. Many questions remain unanswered in regards to compatibility with intensive rotational stocking. Patch-burn grazing is an attractive system for all of its bird-, pollinator-, wildlife-, and livestock-friendly attributes; however, because of the requirement to burn, it may not be a popular choice. Nevertheless, PBG should be a highlighted option for the producer willing to implement the system. The open-gate rotational system appears attractive and could receive some acceptance due to its relative simplicity, but bird responses have not been studied. The point of this document is not necessarily to endorse a particular grazing system or rank them on their potential but to present the best management practices to implement regardless of the grazing system the producer uses.

Landscape context is an important consideration in the eastern U.S. and perhaps the greatest challenge for bobwhite recovery at the population level (***Appendix A.4***). In eastern habitats, distance to forested cover has been shown to have a greater impact on nesting grassland bird occupancy, nesting density, and nesting success than did the specific grazing strategy with any given pasture (West et al. 2016, Brazil 2019, Keyser et al. 2020, Lituma unpublished data 2021, ***Appendix A.4.1***). Spatial arrangement of additional grassland is another component of the landscape context, and practices closer together have greater positive influence than those more distant (Keyser et al. 2020, Yeiser et al. 2018, Yeiser unpublished data 2020, Duchardt et al. 2016, Foley 2020, ***Appendix A.4.3***). While it would be optimal to have large NWSG pastures in close proximity to each other, potential for a positive response by a local bobwhite population could still be possible even if that were not the case. Regardless, some species of grassland nesting birds will be able to exploit any gain in acres of appropriately grazed NWSGs, which represents an improvement over the status quo and is a net improvement.

Despite the volume of research on bobwhites, there is minimal information about grazing as a bobwhite management tool in the eastern U.S., leaving a number of unanswered questions. At a minimum, there needs to be new or additional research on the following: 1) impacts on nest success while grazing NWSG during the primary nesting season; 2) under intensive rotational stocking, minimum patch size for successful nesting and if the paddocks become population sinks; 3) further assessment of PBG in eastern habitats; 4) assessment of the open-gate rotational stocking system and its bird friendliness; and 5) upper threshold for stocking density that minimizes nest disturbance. There should be consistency in reporting stocking density, using head per acre, which better represents the probability of nest destruction. Research should also include input from grazing experts in developing study designs that are practical for the producer.

Overall, until more research can be conducted providing more definitive answers, our recommendations are:

- Maintain NWSG canopy heights >14 inches (***Table C.2.2.2***), excluding current year's burn under patch-burn grazing.
- Stocking densities under continuous stocking should not exceed 2 hd/a.
- Stocking densities under simple rotational stocking should be kept as low as possible to keep up with grass growth but maintain canopy heights, being aware densities >2 hd/a may increase the probability of nest destruction.
- Under intensive rotational stocking:
  - o Design paddocks as large as possible,
  - o Leave a paddock out of the rotation, or
  - o Defer a paddock until after the initial nesting cycle can be completed, or
  - o Design rotations to allow long enough rest periods in paddocks for the nesting cycle to be completed before or after the grazing event.
- Regardless of stocking strategy, consider landscape context:
  - o Focus improvements on pastures within flushing distance of appropriate brushy cover. If brushy cover is inadequate or absent, establish shrubs approximately every 100 yards along/outside the pasture margin.
  - o Where possible, focus improvements on pastures >820 feet from forested cover (***Appendix A.4.1***).
- For greatest bobwhite population level responses,
  - o Focus individual pastures within 3 miles of the next closest NWSG pasture (***Appendix A.4.3***).

*Weaned calves after being turned in to fresh big bluestem pasture.*

# 5. Conclusion

Recovering bobwhite populations is one of the greatest wildlife management challenges ever faced. There are many issues that can be attributed to the decline in bobwhites. While all of those issues may contribute to the decline, many are symptoms of the overall defining cause, the loss and fragmentation of habitat. The National Bobwhite Conservation Initiative (NBCI), through its Coordinated Implementation Program (NBCI CIP) protocol, has demonstrated local bobwhite populations can be recovered, validating that the scientific knowledge exists. The challenge that remains is if society is willing to implement the necessary changes. For bobwhite recovery to be successful, landscape-scale changes in land use must occur. With approximately 88% of the eastern U.S. being privately owned, private lands are necessary to achieve this landscape-scale change. The only way to expect private lands to contribute (not only to bobwhite recovery but all declining associated grassland wildlife) is to build solutions into working lands that provide a win-win for the private landowner and bobwhites. Farm Bill programs on private lands have been shown to have a positive impact on bobwhites; unfortunately, those programs are at the mercy of political whims with each new Farm Bill and fluctuating commodity prices, resulting in unreliable long-term grassland habitat. There are roughly 3.5 - 4 million acres of general Conservation Reserve Program (CRP) land in the eastern U.S. (September 2020 data, U.S. Department of Agriculture 2020). In contrast, there are over 35 million acres of tall fescue in the Fescue Belt. Modeling of animal performance data revealed that converting 30% of tall fescue to switchgrass in a complementary grazing system would improve economic return versus a tall fescue-only system (Brazil 2019). If NWSG grass pastures could be established on 30% of those tall fescue pastures, optimizing profit for producers, the potential for grazing management for bobwhites and associated grassland wildlife could result in 10.5 million new acres of improved grassland habitat, providing greater landscape-scale impact and likely more stable than current Farm Bill program acres. Grazing NWSG represents one of the best win-win scenarios, and therefore an opportunity, for landscape-scale grassland habitat improvement (Keyser et al. 2019). Even if the 30% optimum is not met, small changes in land use practices could result in disproportionately large-scale population responses (Evans et al. 2008, Yeiser et al. 2018). With this information in mind, grazing NWSG as outlined in this publication should become a priority for addressing improved producer economics and declining grassland wildlife species, providing the needed win-win.

# Appendix A: BOBWHITE HABITAT AND ECOLOGY PRIMER

## A.1 Vegetative Structure

Appropriate vegetation structure is an important key to providing bobwhite habitat. The National Bobwhite Conservation Initiative (NBCI) has developed a habitat classification system used for NBCI focal areas to standardize classification of bobwhite habitat across their range (Morgan et al. 2016). The system identifies bobwhite habitat as vegetation height maintained at greater than 8 inches for more than 50% of the year with 25-75% bare ground[1] and appropriate access[2] to protective cover[3].

There are always exceptions, but more specifically, typical bobwhite habitat requirements are (National Bobwhite Technical Committee 2011):

- **Nesting** – Basketball-sized clumps of bunch grasses about 10-20% larger and taller that those found at random, 600-700 clumps per acre.
- **Brooding** – Rich in arthropods that live on or near the ground, numerous patches of bare ground for chick accessibility, overhead screening cover.
- **Escape** – Dense woody or herbaceous cover where bobwhites can fly or run to escape a predator.
- **Loafing** – Woody cover 3-10 feet tall and a minimum of 5 feet in diameter (≈ 16 square feet).
- **Roosting** – Grass or grass/forb cover +/- 20 inches tall, away from shrubs and woody cover.

***Figure A.1.1*** illustrates the wide range of habitat niches used at varying degrees by bobwhites throughout the year. During the nesting season, bobwhites mostly utilize the range of vegetation composition and heights represented by the red oval. Prescribed grazing can help create those niches. Grass stands with previous year's residual growth provide nesting cover; thinner grass stands with a good mix of forbs and high degree of bare ground between/underneath overhead canopy provide brood cover and food supplies. Grass/forb stands intermediate on the cover continuum between nesting and brood cover provide roosting cover and some nesting opportunity and food supply. Shrubs provide woody cover for loafing or escape.

## A.2 Height of Vegetation at Nest Sites

Out of 317 nests examined in southern Illinois, the average height of vegetation surrounding the nest was 19.5 inches (Klimstra and Roseberry 1975), and Rosene (1969) reporting study results primarily from the Southeast reported bobwhites prefer nesting in clump grasses less than 20 inches tall. Appropriate cover 8-24 inches tall needs to be available from the onset of nesting through hatching.

## A.3 Bobwhite Nesting Season

Klimstra and Roseberry (1975) reported nest initiation spanned 21 weeks with the earliest April 16 and latest September 3 at their southern Illinois study site. Eighty percent of bobwhite first-egg dates occurred from the second week in May through the third week in July. The median clutch initiation date was June 16, meaning nest building began about June 11. Seventy-five percent of all bobwhite nests hatched between June 17 and August 18. Only about one fourth of bobwhite nests were prior to May 27. A recent study in Missouri (Hedges and Loncarich, unpublished data 2018) documented a bimodal distribution of peak hatching dates of bobwhites, the first in early July followed by a second peak in August. Fifty percent of incubation didn't occur until after July 1. These dates demonstrate that bobwhites nest throughout the summer and illustrates that deferred stocking with the goal of avoiding nesting is of limited benefit.

1 Bare ground is an estimate of exposed soil that may or may not be under a canopy of vegetation. It generally is composed of interstitial space between grass clumps.
2 Appropriate access is less than 164 ft. (50 m.) from protective cover from any point in the pasture.
3 Protective cover is vegetation that provides year-round overhead protection from predators and inclement weather.

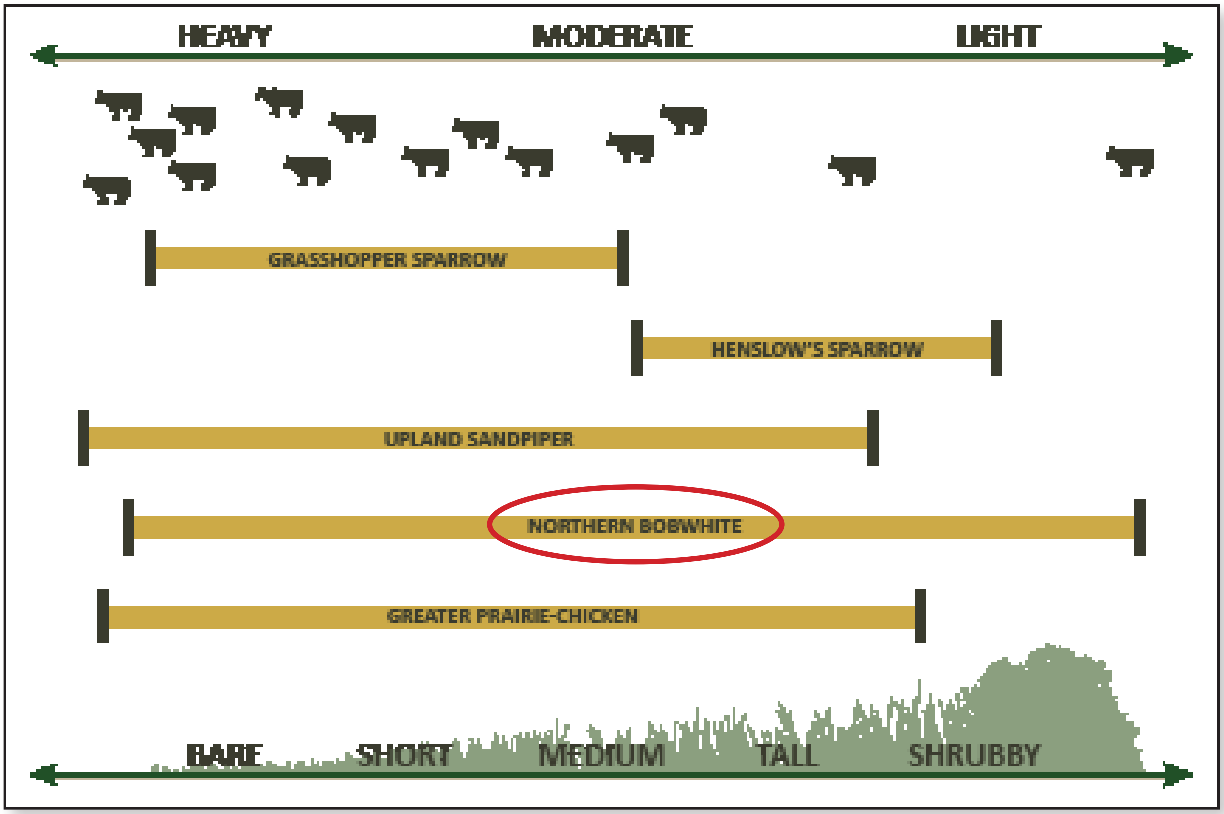



***Figure A.1.1.*** *Grazing pressure influences on bobwhite and grassland bird habitat niche requirements. The red oval represents the range of vegetation heights utilized by nesting bobwhites and relative grazing pressure to create that structure. Source: Missouri Department of Conservation. Adapted from Knopf (1996).*

## A.4 Landscape Context, Patch Size and Spatial Arrangement

### A.4.1 Proximity of forested or woody edge

As mentioned in the Preface, bobwhites are a grassland facultative species and, as such, require a shrubby component which is often confused in the literature, also being referred to as woody cover. Individual studies may not define the context in which they use forested and woody cover or edge. It is important to recognize the differences between closed canopy versus open canopy tree cover and mature trees versus young trees or shrubs. Often, those terms are collectively referred to as forested or woody cover. Negative associations between bobwhites and forested or woody cover are related to closed canopy mature tree stands lacking an herbaceous understory. Open hardwood savannas of the Midwest (<30% canopy cover), open pine savannas of the southeast (<50 square feet basal area/a) with an herbaceous understory, and shrub mottes (<12 feet tall) are types of forested or woody cover compatible with bobwhites.

Several researchers have found lower nesting success of grassland bird nests <165 feet from forest or wooded edge (Johnson and Temple 1990[4], Bollinger and Gavin 2004[5], Winter et al. 2000[6]). In two southwest Missouri studies using artificial nests, Burger et al. (1994) found that nests <197 feet from woody cover were less successful, and Winter et al. (2000) identified mid-sized carnivores as the major predators of nests within 98 feet of forested edges. In both studies, proximity to woody habitat explained more variation in nest survival than did fragment size. When looking at five grassland nesting species, including bobwhites, West et al. (2016) found percent forest cover within 820 feet had a negative influence on breeding bobwhite occupancy, while treatment

4 Clay-colored Sparrow, Savannah Sparrow, Grasshopper Sparrow, Bobolink, Western Meadowlark.
5 Bobolink.
6 Henslow's Sparrow, Dickcissel.

(control, grazing, hay, seed, biofuel) showed no significant difference in occupancy (***Figure A.4.1.1***). In relation to landscape impact of forest cover, Keyser et al. (2020) reported, "Northern Bobwhite had the most dramatic response, wherein abundance declined by 160% when deciduous forest cover increased from 0% to 30% at the 250-m [820 feet] scale." To help put this into perspective, a square pasture with its center point 820 feet to the edges is ≈62 acres. Consequently, even well-managed NWSG pastures that are in forested settings will have less than optimal benefit for bobwhite.

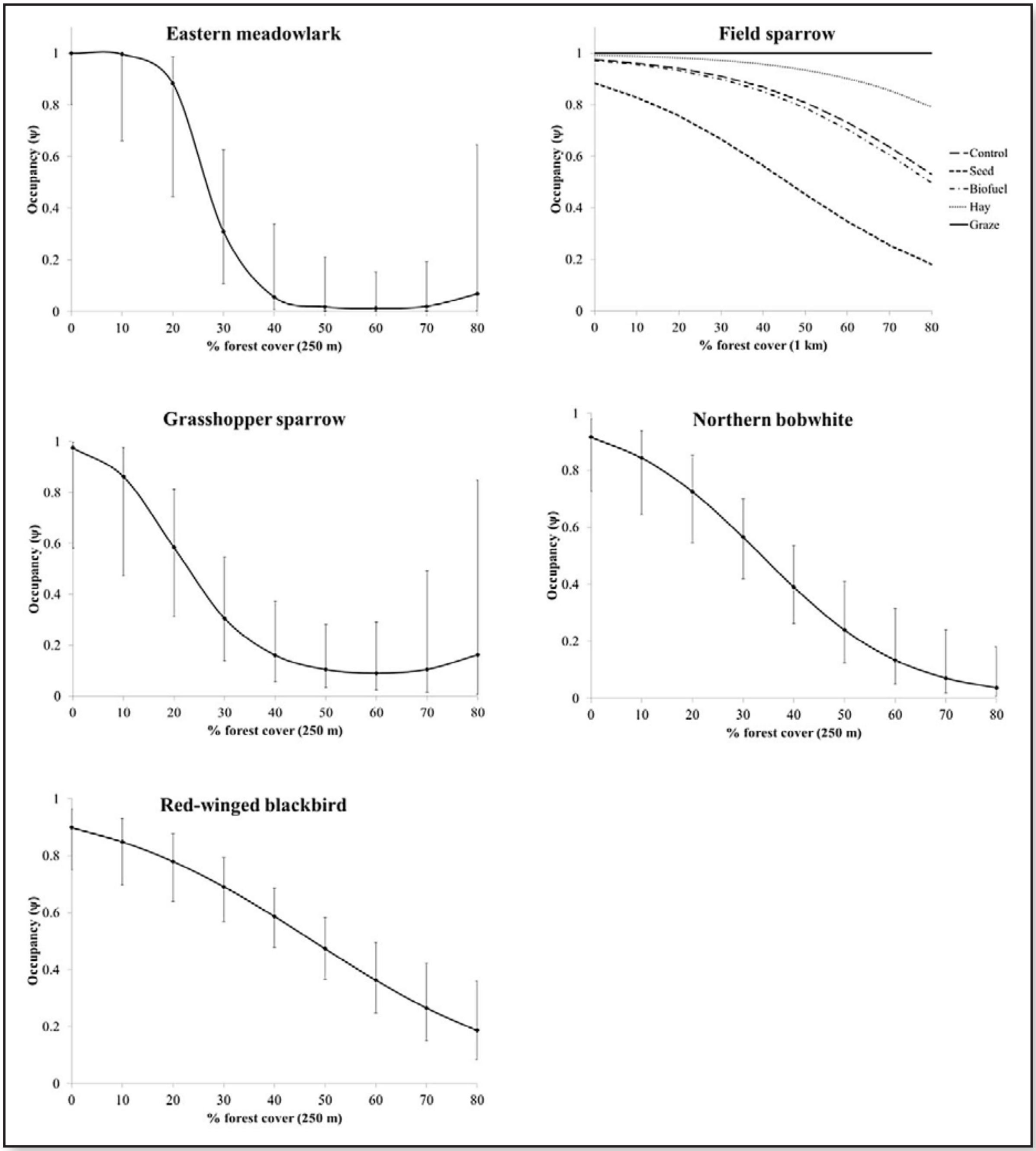



***Figure A.4.1.1:*** *Probability of occupancy as predicted by percent forest cover at 2 scales (250m and 1 km) included in top occupancy models for eastern meadowlark, field sparrow, grasshopper sparrow, northern bobwhite, and red-winged blackbird in McMinn County Tennessee, and Hart and Monroe counties, Kentucky, USA. For field sparrow, treatments (control, seed, biofuel, hay, graze) are presented because treatment was included in the top model. Vertical bars represent one standard deviation. Reprinted from West et al. (2016).*

Outside of the breeding season, closed-canopy forest has been shown to have an impact on winter survival. Winter survival was ≈1.3x greater on treated versus untreated landscapes where closed-canopy forest had been altered to create an early successional herbaceous community. For each 1.3 feet per acre increase in closed-canopy wooded edge, risk of winter mortality increased 0.3% (Seckinger et al. 2006).

#### A.4.2. Patch size

Because of livestock density, especially with intensive rotational stocking, patch size becomes a consideration. How small of a paddock (patch) will support successful nesting and not result in a population sink? Unfortunately there are no studies which define minimum patch size for successful bobwhite nests. Perlut and Strong (2011) recommended 1.2 acres as the minimum paddock size necessary for female savanna sparrows to re-nest from a disturbed first nest. Roseberry and Klimstra (1984) in their analysis of long-term data from southern Illinois found roadsides and fencerows had the highest density of bobwhite nests among all habitat types examined. Using the data they presented, the average width of those linear features was 9.2 feet, and nest density equaled one per 1.3 acres. Although they did not specifically examine patch size and their study was not in the context of grazing, it does suggest narrow patches of grasses are not a deterrent to nest location. However, that does not take predator context into account. Research has shown lower predation and greater nest success on larger patch sizes (Sovada et al. 2000, Johnson and Temple 1990, Herkert et al. 2003). One southwest Missouri study reported predation rates of artificial nests in prairie fragments <37 acres were approximately 2.7 times higher than fragments >37 acres (Burger et al. 1994). There is no definitive answer to the question about minimum patch size. Until research on grazing and minimum paddock size for successful bobwhite nesting can be done, the best recommendation that can be made is, the larger the paddock the better.

#### A.4.3. Spatial arrangement

The amount of additional grassland in the surrounding landscape also has an influence, particularly on grassland obligate birds. Keyser et al. (2020) documented not only a negative relationship between abundance and landscape-scale forest cover, but also a positive relationship with the amount of pasture and hay ground in the landscape for eastern meadowlark, grasshopper sparrow, and field sparrow. Duchardt et al. (2016) in southern Iowa and northern Missouri, found the amount of grassland within 0.62 miles of their study pastures was strongly associated with higher levels of grassland bird diversity. In two different studies, the importance of NWSG fields to a local bobwhite population declined with distance. In one study, Conservation Reserve Program (CRP) fields separated by greater than 1.2 miles during the breeding and greater than 5 miles during the non-breeding season had no influence on a population (Yeiser et al. unpublished data 2020). In the other study, Conservation Reserve Enhancement Program (CREP) NWSG fields farther than 3 miles away had no effect on local abundance (Yeiser et al. 2018). The NBCI is demonstrating through the Coordinated Implementation Program (CIP) that focused efforts can increase bobwhite numbers. An analysis of breeding season data from 2013-2019 showed 98.5% more bobwhites heard on focal areas[7] than reference areas[8], and fall covey call count data produced 289% more coveys calling than on reference areas (Foley 2020). The NBCI CIP recommends a minimum of 1,500 acres of bobwhite habitat on no less than 25% of the landscape to sustain a population. Fifteen-hundred acres comprising 25% of the landscape is 6,000 acres. Six-thousand acres is approximately 3 miles square. The CRP, CREP studies, and NBCI CIP results illustrate the importance of clustering practices on the landscape for bobwhites.

7 A unit of landscape where bobwhite habitat exists and/or active habitat management is being conducted.

8 A unit of landscape paired with a focal area of similar features and characteristics, but no habitat management is taking place.

# APPENDIX B: IMPACTS OF GRAZING ON GRASSLAND BIRDS

Grazing impact on grassland birds varies based on the differing habitat requirements of individual species, regional differences in habitat availability, and landscape context.

## B.1. Direct impacts

### B.1.1. Nest trampling

*Vegetative heterogeneity in second year of rest following intense grazing*

Koerth et al. (1983) and Bareiss et al. (1986) are often cited for their nest trampling studies. Though they concluded there was no reason for concern about nest trampling in Short Duration Grazing (SDG) systems, carrying capacity and stocking densities for both study areas were lower than would be encountered in the eastern U.S. However, Bareiss et al. (1986) hypothesized that as stock density exceeded 1 AU/a, nest loss from trampling could become a significant concern. Studies examining trampling of artificial nests at different stocking densities support that hypothesis (Jensen et al. 1990, Paine et al. 1996). However, in those studies, nest densities and arrangement (line transects) used may not be an accurate reflection of actual probability of a nest encounter by cattle in the real world. In continuously stocked NWSG pastures, Brazil (2019) reported 3 nests trampled of 72 monitored (≈ 4%) for grasshopper and field sparrows at a stocking density of 1.5-1.7 hd/a. Two studies that employed adaptive management—higher stocking densities early in the growing season to keep up with grass growth then reduced as grass growth rate slowed—conducted at sites across Tennessee and Kentucky found that vegetation structure favorable for bobwhites was maintained at a stocking density of 3.73 hd/a (Harper et al. 2015) and no difference in relative breeding bird abundance for bobwhites in NWSG pastures at a stocking density of 2.8-4.5 AU/a[9] grazed at least one time (May-June) compared to ungrazed NWSG (Keyser et al. 2020). Although neither included nest trampling in their studies, the results indicate that stocking densities higher than indicated in the literature to date may be compatible with nesting bobwhites.

### B.1.2. Other direct impacts

Hedges and Loncarich in their Missouri Quail Study (unpublished data 2018) at a stocking density of 0.2 to 0.25 hd/a, reported 4 nests lost out of 400 monitored (1%), all from cattle lying upon them, not trampling. Sutter and Ritchison (2005) reported one grasshopper sparrow nest lost as a result of being pulled apart by cattle grazing the supporting vegetation. Nack and Ribic (2005) documented cattle disturbing nests by removing eggs and nestlings and suggested we may be underestimating the impact of cattle on ground nests. More research is required to tease out whether this is a significant factor.

9 Pastures were stocked at 3,500-5,000 kg/ha and reported as 7-11 AU/ha.

## B.2. Indirect Impacts

Indirect impacts could include absence of habitat, pasture avoidance, abandonment or predation, as a result of removal of cover through the process of grazing or presence of cattle.

Several studies have linked reduced vegetative structure (irrespective of reason) at the nest site with increased predation, (Martin and Roper 1988, Riley et al. 1992, Fondell and Ball 2004). Sutter and Ritchison (2005) reported most unsuccessful grasshopper sparrow nests were depredated with highest predation rates in grazed areas under what they classified as intense grazing. Temple et al. (1999) reported that nesting success for grassland birds was significantly lower in rotationally grazed pastures than continuously (intermediate success) and ungrazed pastures (highest success), apparently caused by desertion due to removal of cover around the nest. It is important to note the stocking density of the rotationally grazed pastures in this study was 16-24 hd/a. Pastures degraded by heavy grazing provide habitat for only a few species (Owens and Myres, 1972).

Johnson et al. (2012) studying savannah sparrows and horned larks found no evidence supporting an increased risk of nest predation in association with greater stocking rates, however their highest stocking density was 0.45 AU/a and it is unlikely at that stocking density grazing reduced vegetative structure enough to observe an increase in nest predation. Examining data on nest fates, direct and indirect, from 18 different studies conducted across Canada, Bleho et al. (2014) found that overall few nests (1.5% of 9,132 nests) were destroyed by cattle. However nest destruction was positively correlated with grazing pressure, either stocking density or grazing intensity (forage utilization).

# Appendix C: GRAZING MANAGEMENT OF NWSG

Unless otherwise noted, reference for Appendix C is Keyser et al. 2011.

## C.1. Seasonality of Grazing NWSG

In the eastern U.S., grazing of native warm-season grasses typically begins around the first to middle of May and continues through mid- to late August, or with appropriate summer rest periods, until late September. A grazier should expect to reliably get 90 – 110 days of grazing from NWSG.

## C.2. Canopy Height Management

For NWSG to maintain vigor and productivity and be sustainable over time, proper grazing management is required. Continuous stocking of NWSGs in the spring should not be initiated (turnout heights) until average height of new growth is 13 to 15 inches. Under rotational stocking and for growth animals such as stockers, turnout height can be lower (8 – 12 inches) provided grazed units are allowed adequate rest, allowing regrowth to 13 – 15 inches before re-grazing. To maintain nutritive value don't allow grasses to grow beyond 24 – 26 inches, with the exception of lowland varieties of switchgrass (Alamo, Kanlow) whose upper limit is 30 – 36 inches. Nutritive value of NWSG decline through the growing season as plants become more mature (Griffin and Jung 1983, Ball et al. 2001, Chamberlain et al. 2012, Waramit et al. 2012, Backus et al. 2017, ***Figure C.2.1***). To sustain forage quality, maintain grazing pressure to delay the formation of seed heads (Trlica 2013). More severe grazing or lower turnout heights can be tolerated as long as adequate rest is provided before successive defoliation and provided it does not happen repeatedly. Native warm-season grasses should be allowed 4 – 6 weeks of rest before the average first frost date of your location, leaving vegetation height of 18 inches or more at first killing frost.

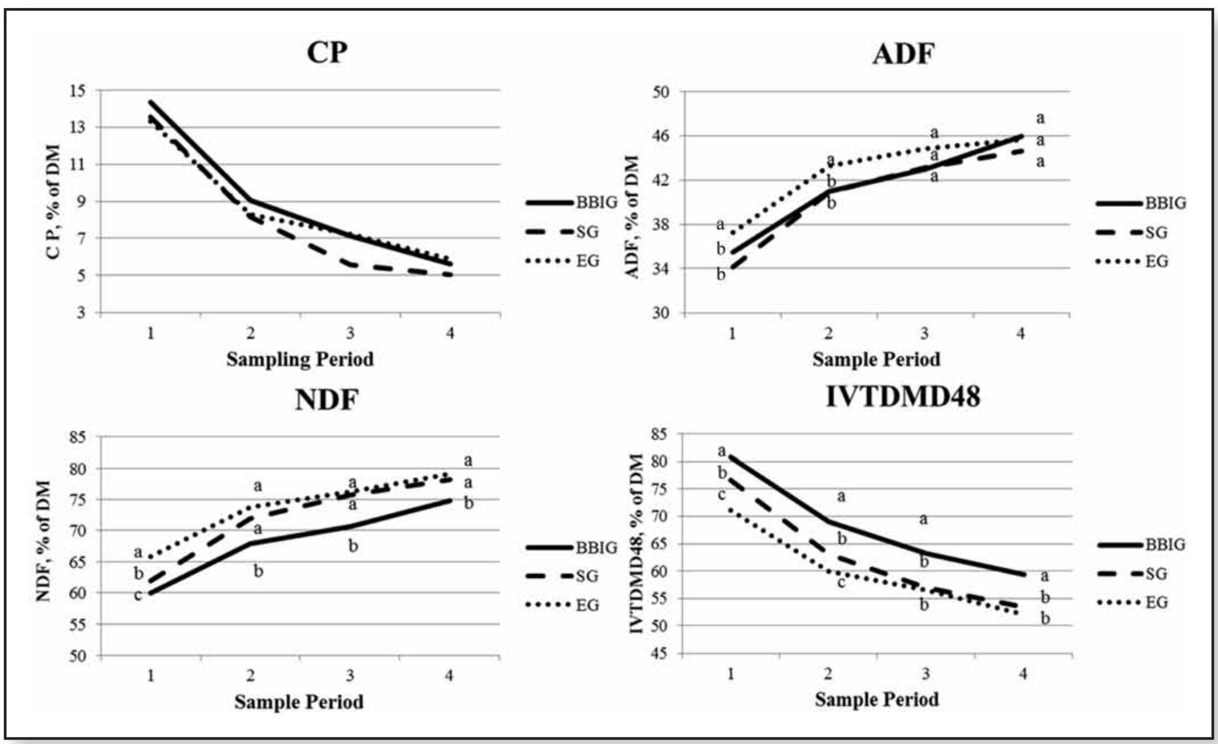



***Figure C.2.1:*** *Forage nutritive value metrics as grasses mature. Big bluestem/indiangrass blend (BBIG), Switchgrass (SG), Eastern gamagrass (EG). Crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), in-vitro true dry mater digestibility 48h (IVTDMD48). Reprinted from Backus et al. (2017).*

To the grazier unfamiliar with NWSG, these heights may seem wasteful, leaving unused forage in their pastures but they should resist the temptation to graze any closer. Closer grazing results in less energy stored within the plants above ground structures, potential to remove growing points, reduced root volumes, slower recovery periods and greater potential for weed encroachment (See subsection ***C.2.1***). Extra forage taken this year will lead to forage lost next year and if the practice continues annually, grass vigor will continue to decline until pastures become weedy and eventually stand loss may result. Remnant native pastures managed properly have persisted hundreds of years and planted native grass stands are known to have lasted more than 30 years under proper grazing management.

**C.2.1. Understanding canopy grazing heights**

A review of simplified grass physiology may help provide understanding why grazing canopy heights and rests are recommended as they are. Photosynthesis, which is dependent upon leaf surface area (LSA) drives the productivity of the plants. Early spring growth in NWSG is fueled by carbohydrate reserves in the roots until LSA is adequate enough for photosynthesis to keep up with or surpass plant growth demands. Severe defoliation before enough LSA is available for growth and grazing causes the plant to access carbohydrate reserves in the roots. If severe defoliation continues, root vigor and mass and subsequently grass vigor are significantly reduced. Good grazing management leaves enough LSA that photosynthesis continues to support the plant's growth and not access carbohydrate root reserves, letting grasses remain healthy and vigorous (***Figure C.2.1.1***). It is important that enough LSA remain late in the growing season to provide the buildup of carbohydrate reserves in the roots to fuel the next spring's green-up. If this process is not allowed it weakens the grass plant coming out of dormancy the next spring. Without adequate rest or recovery, continued abuse will lead to weakened, thinning stands. Well established, vigorous NWSGs are very resilient to occasional severe defoliation events provided adequate rest and recovery periods are provided, however they cannot sustain long-term vigor with repeated seasonal or annual over grazing. Good grazing management maintains the productivity and sustainability of the stand (***Figure C.2.1.2***). Adapted from Waller et al. (1985).

| Leaf Volume Removed (%) | Root Growth Stoppage (%) |
|---|---|
| 10 | 0 |
| 20 | 0 |
| 30 | 0 |
| 40 | 0 |
| 50 | 2-4 |
| 60 | 50 |
| 70 | 78 |
| 80 | 100 |
| 90 | 100 |

***Figure C.2.1.1:*** *Root growth stoppage resulting from defoliation of grass. Reprinted from USDA Technical bulletin 1102.*

**C.2.2. Species-specific management recommendations**

Because of the differences in plant phenology and growth rates, monocultures or simple mixtures of NWSGs are recommended for pastures, not only from the grazing management perspective but also from the cost of establishment standpoint. A 2020 survey of 205 livestock producers in Missouri and Tennessee identified cost of establishment as the number one obstacle to adoption of native warm-season forages (Center for Native Grasslands Management unpublished data). It is understood for wildlife purposes diversity is highly desirable and when achievable recommended, however even monocultures of NWSGs under grazing management provide a moderate degree of plant diversity and have been shown to provide adequate habitat for bobwhites (Harper et al. 2015, West et al. 2016). ***Table C.2.2.1*** provides a list of forage compatible forbs widely adapted to the eastern U.S.

Many other forbs may be considered for planting diverse mixtures, especially with considerations for pollinators. Milkweeds and other potentially toxic plants are usually only a problem when consumed exclusively or in large

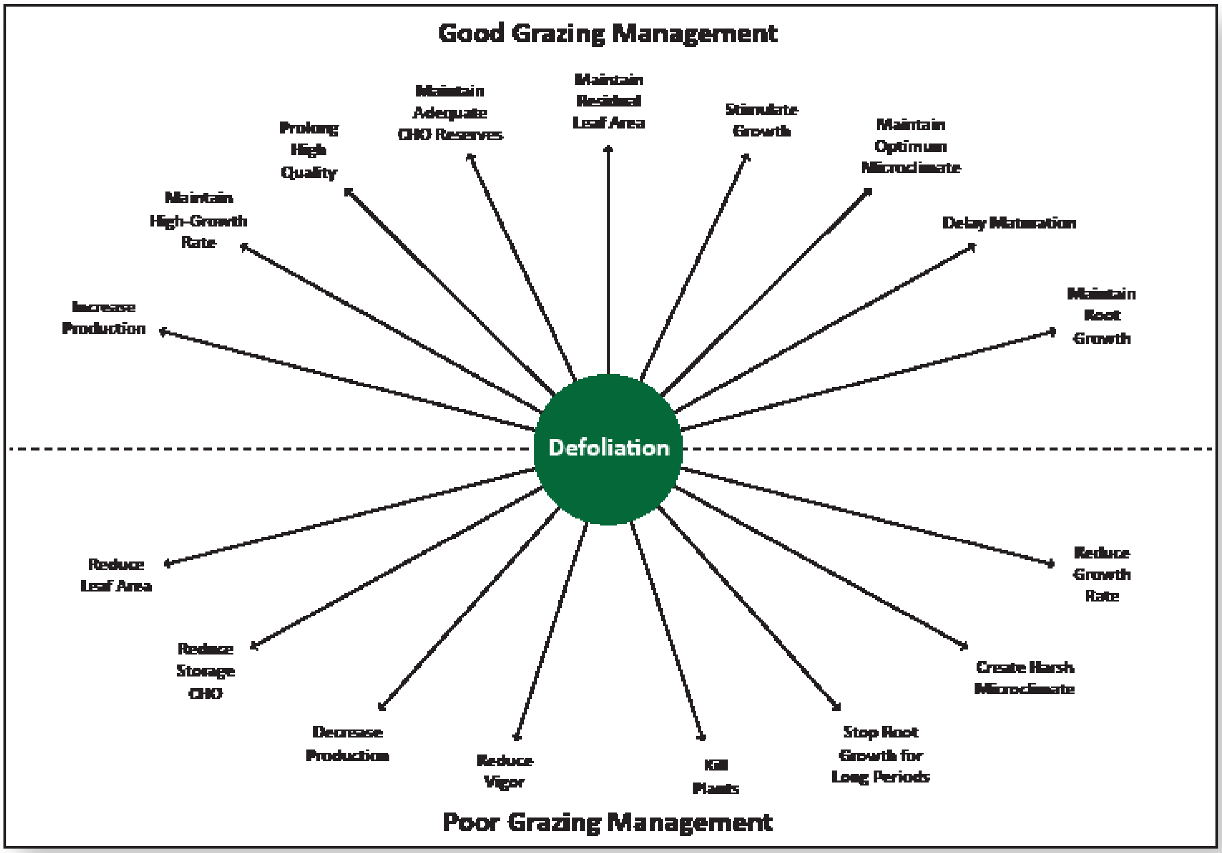



***Figure C.2.1.2:*** *The effect of defoliation under good grazing and poor grazing management. Source: Waller et al. 1985.*

quantities. High stocking density grazing systems which force cattle to consume all available vegetation, increase the risk of harmful effects when these plants are present. When given free choice, cattle tend to avoid most potentially toxic plants or consume them in such small quantities they present no danger.

Planted stands of lowland switchgrass and eastern gamagrass work best as monocultures because of their differing growth phenology and grazing management from the other NWSGs. Each of these plants initiate spring growth earlier than other NWSGs and eastern gamagrass grows later through the season. Big bluestem and indiangrass work well in a mixture together. Big bluestem plant phenology is slightly earlier than indiangrass, while indiangrass produces about 70% of its total biomass after the first of July in the lower Midwest, Mid-South and equal latitudes (Waramit et al. 2012). Little bluestem can be added to the mixture for additional plant diversity.

| Forage Compatible Forbs | |
|---|---|
| Partridge Pea (*Chamaecrista fasiculata*) | Legume |
| Tickclover (*Desmodium sp.*) | Legume |
| Roundhead Lespedeza (*Lespedeza capitata*) | Legume |
| Rattlesnake Master (*Erynigum yuccafolium*) | Forb |
| Maximilian Sunflower (*Helianthus maximiliani*) | Forb |
| Ashy Sunflower (*Heliathus mollis*) | Forb |
| Gayfeather (*Liatris sp.*) | Forb |
| *Penstemon sp.* | Forb |
| *Coreopsis sp.* | Forb |

***Table C.2.2.1:*** *Forage compatible forb species for site specific adaptations or diversification.*

Little bluestem matures the latest of big bluestem, indiangrass and switchgrass and is more tolerant to drier sites and poor soils than the others. The recommended canopy maintenance height for different approaches to grazing to sustain plant health and vigor of each of these grasses is listed in ***Table C.2.2.2***.

| Grass Species | Canopy Target Heights | |
|---|---|---|
| | Continuous | Rotational |
| Big Bluestem - Indiangrass - Little Bluestem | 14-18 in. | 13-26 in. |
| Lowland Switchgrass, Alamo, Kanlow | 18-24 in. | 15-30 in. |
| Upland Switchgrass - Blackwell, Cave-In-Rock | 14-18 in. | 13-26 in. |
| Eastern Gamagrass | 18-22 in. | 16-32 in. |

***Table C.2.2.2:*** *Recommended canopy target heights for grazing NWSG's (Keyser 2021).*

# Appendix D: SUPPLEMENTAL INFORMATION

## D.1. Differences Between Cool- and Warm-season Grasses

Cool and warm-season plants have different photosynthetic systems and phenologies. Cool-season grasses, based on their photosynthetic system are known as C3 plants and warm-season grasses are C4 plants. C4 plants are more efficient at photosynthesis than C3 plants and C4 plants use less water to produce a unit of dry matter than C3 resulting in C3 plants being better adapted to a cooler, moister climate and C4 plants to a warmer, dryer climate.  Native warm-season grasses exhibit significantly greater drought tolerance than C3 cool-season plants, not only because of their different photosynthetic systems, but also their extensive root systems, up to 12 feet deep (Keyser et al. 2011).

Cool-season grasses grow best at 65-90° F (Baker and Jung 1968, Waller et al. 1985). In the Midwest and Mid-South CSG typically produce the bulk of their biomass prior to June 1 (Riesterer et al. 2000). Cool-season grasses begin active spring growth when soil temperature reaches 40-45° F (Oregon State University, accessed online 20 March, 2021). As temperatures rise and rainfall decreases, cool-season grasses become dormant, commonly referred to as “summer slump” (Riesterer et al. 2000, Tracy et al. 2010). Pointes et al. (2007) studying cool-season grasses showed a decrease in dry matter yield during the summer (≈ July – Sept.) months. In addition to decreased yield, Buxton and Marten (1989) showed a linear decrease in digestibility during a warming environment, for several cool-season grasses further compounding the summer slump in cool-season grasses. Based on cool-season grass growth phenology, their highest nutritive value is in the spring (Pontes et al. 2007, Buxton and Marten 1989) during the period they are rapidly growing, up to just prior to the reproductive stage, identifiable by the elongation of seed stalks, and again in the fall when soil temperatures have cooled and ambient temperatures are 65-75° F (Oregon State University, accessed online 20 March 2021).

*Cows grazing NWSGs in summer result in increased milk production compared to those grazing CSGs during the same period, resulting in higher weaning weights.*

Warm-season grasses grow optimally between 82° and 105° F (Keyser 2021) and initiate spring growth when soil temperature is approximately 55° F but don't begin more aggressive growth until soil temperature reaches 65-70° F (personal observation). Warm-season grasses produce 65-75% of their total yield during mid-summer (Griffin and Jung 1983). Tracey et al. (2010) conducting research in West-Central Illinois found NWSG pastures averaged 61% more herbage mass in July and August compared with introduced CSG pastures. Griffin and Jung (1983) looked at predictors of forage quantity and quality of NWSG in Pennsylvania and found declining forage quality coincided with elongation of seed stalks.

Regardless of grass type, early growth has low yield but high nutritive value and as forage matures, yield increases but nutritive value decreases (Backus 2017, Ball et al. 2001, Waramit et al. 2012). These metrics of season of growth and phenology of grasses are the basis for the common grass growth curve illustration shown in the Preface (***Figure 1.2***). The grass growth curve clearly shows how cool-season and warm-season grasses complement each other and how NWSG can provide an offset for the summer slump in production and decrease in animal performance seen with cool-season grasses.

## *D.2. Comparative Forage Analyses*

Forage analyses comparing NWSGs to CSG's are not favorable, but this is due in part to limitations of current forage testing technology. The real measure of forage quality and comparison is in animal performance (Ball et al. 2001). Results from trials conducted in Nebraska, reported in a Kansas NRCS publication (Kansas Range Technical Note KS-4), reported 0.42 pounds of average daily gain (ADG) for steers grazing smooth brome from June 22 to September 14. Steers grazing NWSG[10] during the same time period had 3 times greater, 1.28 pounds, ADG. Capel (1995) reported yearling steer summer ADG as 0.75 and 0.9 pounds for bluegrass and tall fescue respectively and big bluestem, switchgrass and eastern gamagrass yielded 2.6, 2.1 and 1.8 to 4.0 pounds ADG, respectively. A Missouri study compared a CSG/NWSG complimentary system to a CSG rotational system, both beginning and ending on the same date, the CSG pasture rotation coincided with the move to NWSG in the complimentary system, resulted in 1.54 pounds ADG in the CSG system and 2.48 pounds ADG in the CSG/NWSG complimentary system (Hodges, 1991). A reasonable expectation for routine summer gains on NWSG is from 1.5 – 2.5 pounds of average daily gain in steers (Keyser et al. 2011); while CSG struggle produce from 0.5 to 1.0 pounds ADG during that same time period.

10 Big bluestem, sideoats grama, switchgrass.

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