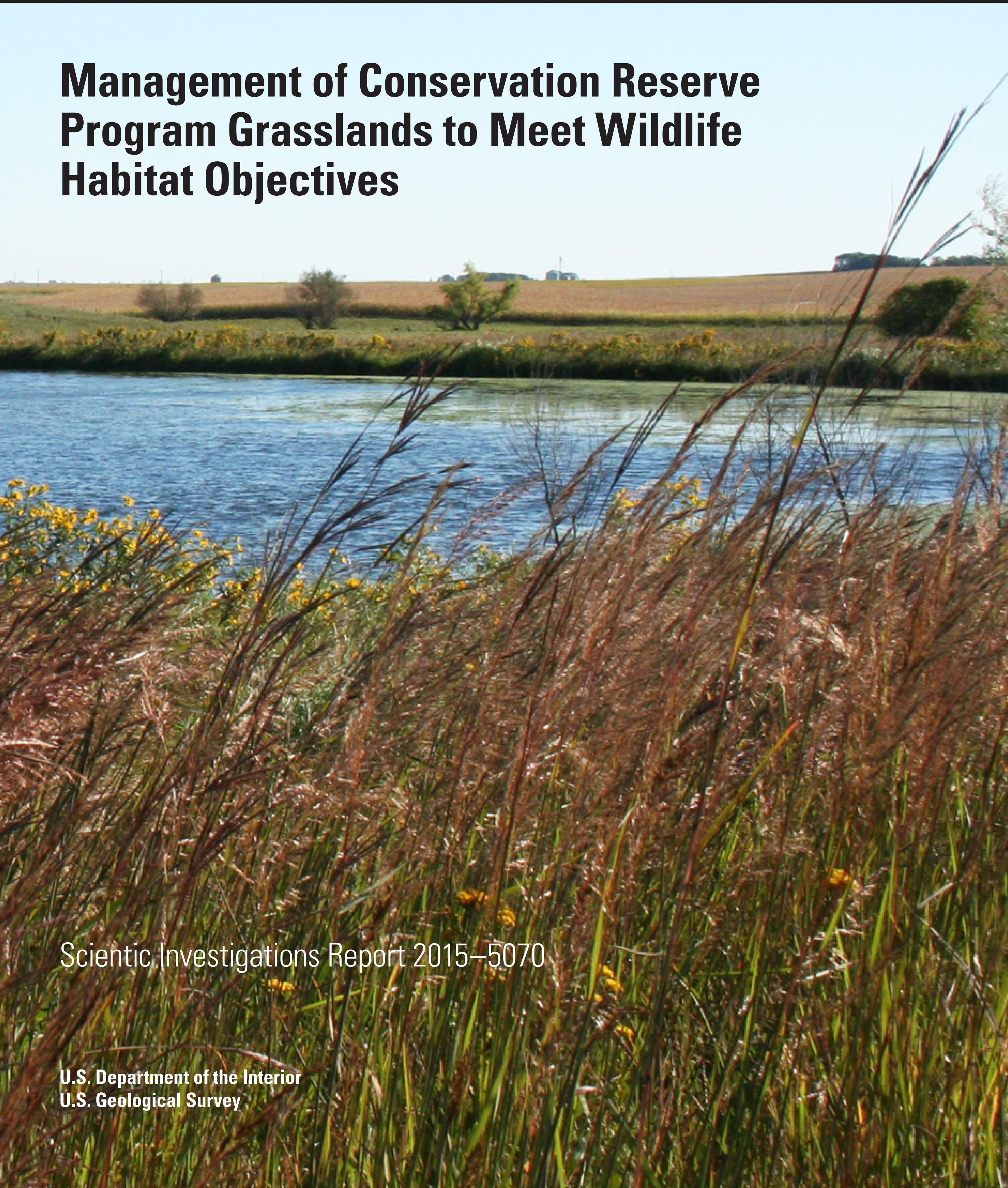

Management of Conservation Reserve Program Grasslands to Meet Wildlife Habitat Objectives

Scientific Investigations Report 2015–5070

U.S. Department of the Interior
U.S. Geological Survey

All photographs taken by Mark Vandever, U.S. Geological Survey, Fort Collins Science Center.

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SALLY JEWELL, Secretary

U.S. Geological Survey
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Executive Summary

Numerous studies document environmental and social benefits of the Conservation Reserve Program (CRP). This report offers a synopsis of findings regarding effects of establishing CRP conservation practices on the quality and distribution of wildlife habitat in agricultural landscapes. On individual farms, year-round provision of wildlife habitat by the CRP may appear relatively insignificant. However, considered from multi-farm to National scales, such improvements in habitat and wildlife response have proven to be extensive and profound.

Because CRP acres historically have been dominated by plantings of introduced and native grasses, this report focuses on issues pertaining to wildlife response to grass-dominated conservation practices. While the majority of CRP acres have been concentrated largely in the Great Plains and Corn Belt regions, 47 states (and Puerto Rico) have participated, resulting in measurable environmental benefits throughout the United States. Numerous investigations of habitat use by a wide range of wildlife species reveal that periodic management of CRP lands can enhance benefits through and beyond a typical 10 year (yr) general CRP contract.

Over its 28-yr existence, the CRP has evolved into an effective integration of conservation and agricultural policies targeting fragile and environmentally-valuable lands. Landowners with fields enrolled in the CRP often are the first to observe improvement in the landscape, greater numbers and kinds of wildlife, cleaner water and air, less erosion, and they have the satisfaction of seeing fragile lands serve better purposes. There is persistent concern that improvement seen in wildlife habitat and other environmental profits delivered by the CRP are ephemeral and last only as long as funding supports the existence of the program and its vegetative cover is properly managed.

An involved American population will continue to expect governmental policies to enhance long-term protection of natural resources and public health. Recent investigations furnish evidence that the collective economic value of environmental benefits delivered by the CRP likely exceed program costs. The mounting significance placed on environmentally-responsible land management is based in part on public recognition that social, aesthetic, and recreational values enhance the traditional uses of agricultural land.

Introduction

A cooperative agreement was initiated in 1985 among the U.S. Department of Agriculture's (USDA) Farm Service Agency, the International Association of Fish and Wildlife Agency,[1] and the U.S. Fish and Wildlife Service's National Ecology Research Center (heretofore referred to as the 'cooperators') to investigate effects of the Conservation Reserve Program (CRP) on wildlife habitat (Farmer and others, 1988; Hays and others, 1989; Allen, 1994). The nationwide

[1]Now the Association of Fish and Wildlife Agencies. The U.S. Fish and Wildlife Service National Ecology Research Center is now the U.S. Geological Survey's Fort Collins Science Center.

evaluation began with 34 State Fish and Wildlife agencies collecting data under guidance and cooperation from the National Ecology Research Center and International Association of Fish and Wildlife Agency. The impetus for this evaluation was born, in part, from recognition that little information existed that described the effects of the USDA's Soil Bank Conservation Program (1956–1972) on wildlife habitat. Recovery of wildlife populations affiliated with agro-ecosystems was not a primary goal of the CRP, but benefits to wildlife were expected. The cooperators recognized the opportunity to initiate multi-year, regional studies to monitor, quantify, and describe the consequences of specific conservation practices on wildlife habitats and related issues. Findings from these investigations enable refinement of CRP conservation practices, permitting the Farm Service Agency and USDA to further increase efficiency of conservation policies.

Numerous investigations by Federal agencies, State wildlife agencies, conservation organizations, and universities have examined the effectiveness of CRP policies in reaching numerous environmental objectives (Allen and Vandever, 2012). Many perceptive summaries of CRP effects on the quality and distribution of wildlife habitat have been completed. For example, Reynolds (2005) provides a meticulous analysis of CRP grassland enhancement of upland-nesting duck habitat in the Great Plains' Prairie Pothole Region, and Burger (2005) presents a discerning analysis of CRP habitat issues in the Southeast. Explanations of CRP accomplishments and management issues in the Midwest are furnished by Farrand and Ryan (2005), and descriptions of avian use of Great Plains CRP grasslands are provided by Johnson (2005) and Rodgers (2005). Each summary in these reports provides regionally-focused descriptions of benefits to wildlife brought by the CRP as well as documentation of problems which need to be addressed to maximize effectiveness of specific conservation practices.

The CRP was designed to address a number of economic and environmental issues affiliated with agricultural land use. As the program evolved over the last quarter of a century, environmental issues shaped design and on-ground implementation of the program. Since its initiation, the majority of lands enrolled in the CRP have been planted to introduced and native grasses. Conservation goals of the CRP were not intended to restore native grasslands or any other pre-agricultural environmental condition. However, in relation to furnishing required characteristics of wildlife habitat, various investigations suggest CRP grasslands can provide many ecosystem services similar to natural grasslands if native vegetation is planted and physical disturbances mimicking historical effects of fire or grazing are incorporated into long-term management. However, the ecological uniqueness of native grasslands cannot be replaced completely with planted grasslands.

Since the arrival of modern agriculture, many wildlife species dependent upon grasslands have declined in both distribution and abundance. Many of these grassland species have benefited from increased habitat proved by CRP. There is abundant evidence that numerous wildlife species have, at least temporarily, increased in numbers and distribution as a consequence of taking highly erosive and environmentally sensitive lands out of crop production and planting these acres with grass-dominated cover. The CRP has brought proven improvements in wildlife-habitat quality. These improvements reach from individual fields to broad landscapes, but continued provision of ecosystem services from the CRP are influenced by agricultural markets and policies and programs contained in the Farm Bill.[2]

Effects of the Conservation Reserve Program on Grassland Wildlife Habitat

Journey across an intensively farmed landscape with mile after mile of uninterrupted, cropped fields and you will see countryside largely incapable of supporting wildlife in meaningful numbers. Yet, vital habitat is provided when a relatively small amount of permanent, high-quality grass-dominated cover is interlaced on the most environmentally sensitive lands of this landscape. This habitat can support a wide diversity of wildlife. The benefits to wildlife from these CRP grasslands associated with agricultural ecosystems are substantial {Heard, 2000 #558}(Heard and others, 2000). In decades immediately preceding the CRP, many wildlife species were no longer present within intensively farmed landscapes. Since the advent of the CRP, hundreds of studies have provided credible estimates quantifying the effects of agricultural conservation policies on wildlife. As a body of research, these studies document the influence of CRP on the quantity and quality of wildlife habitat since it was implemented more than a quarter century ago (Allen and Vandever, 2012). The benefits described in these studies are in addition to the benefits from reduced soil erosion that originally was the primary environmental objective of the program.

[2]A comprehensive agricultural and food policy tool legislated every 5 years by the U.S. federal government

Undoubtedly, many wildlife species have benefited from the increase in cover furnished by the CRP and enhancement of biodiversity within the agricultural ecosystem. But difficulties arise when defining optimal management strategies for wildlife species in agricultural ecosystems because most endemic wildlife species have unique habitat requirements. Vegetation communities in CRP fields are dynamic and change during the duration of the contract.[3] The quality of wildlife habitat may coincide with changes in vegetative composition (Riffell and others, 2008). This complicates linking wildlife response to specific conservation practices, particularly if specific quantifiable goals (for example, species recruitment or vegetation biomass) are not identified (Gregory and others, 2007). Wildlife response to improvement in habitat might not be directly observed in the field where the conservation practice is implemented. For example, aquatic wildlife have unquestionably benefitted from reduced sedimentation entering surface waters as a consequence of removal of erosive lands from production. The cumulative effect of each upstream acre where runoff has been reduced contributes to improved aquatic habitat lower in the watershed. The aggregate effects of conservation practices established under the CRP are difficult to quantify; however, ample evidence shows the benefits of these practices reach well beyond the fields and farms upon which practices have been established.

Non-game Birds

Most avian species have the potential to respond readily to changes in habitat composition and newly created habitats. Increased numbers of individuals, greater diversity in species, and higher rates of nest success often can be related to specific vegetation associations and improvements in habitat quality and quantity. Groups of avian species are of economic or social importance (there are an estimated 48 million birdwatchers; [Carver, 2006]), of ecological significance due to declining populations (for example, endemic grassland species), or both (for example, upland-nesting waterfowl). Compared to other wildlife species, most avian species are relatively easy to observe and monitor during specific seasons. Singing or displaying territorial males, nest density, brood survival, and other measures reflecting habitat use can be related to specific vegetation associations and conservation practices.

Because they are of public interest, respond quickly to changes in their environment, and are comparatively easy to monitor, avian species' response to CRP conservation practices are well documented. Studies confirm that converting grain- and fiber-production fields to CRP has improved the quality and distribution of avian habitat and generally, the more-diverse and native CRP plantings have greater habitat value. The program has enhanced habitat for species with wide-ranging habitat needs as well as species that are highly dependent on specific grassland characteristics. Primarily due to a lack of vegetation diversity and fragmentation, older monotypic stands of either warm- or cool-season grasses provide at least minimal structure and cover for improvement in habitat quality (King and Savidge, 1995). If maximizing habitat quality for birds associated with agricultural landscapes is a goal, diverse plantings with variable structure and cover are considered superior to monotypic stands. However, even CRP grass-monocultures have brought improvement in habitat quality for some avian species in intensively farmed settings.

Many species forage in cropland, but farming activities (for example, tillage, chemical application, haying) permit few bird species to nest within tilled land (for example, mountain plover [*Charadrius montanus*], horned lark [*Eremophila alpestris*]) (see a list of wildlife species listed in Appendix 1). Of those species that do attempt to nest in tilled fields, reproductive success typically is low. Croplands and pastures normally support relatively common, generalist species, whereas CRP fields are known to support obligate grassland birds (for example, sedge wren [*Cistothorus platensis*], grasshopper sparrow [*Ammodramus savannarum*], dickcissel [*Spiza americana*], lark bunting [*Calamospiza melanocorys*], and Henslow's sparrow [*A. henslowii*]). These bird communities are indicators of species that have relatively narrow, explicit habitat needs affiliated with grassland structure, composition, and management (Patterson and Best, 1996; Leddy and others, 1997; Gill and others, 2006). For instance, increased abundance of upland sandpipers (*Bartramia longicauda*), grasshopper sparrows, greater prairie-chickens (*Tympanuchus cupido*), eastern meadowlarks (*Sturnella magna*), and horned larks are found in moderately to heavily grazed tallgrass prairies (Skinner and others, 1984; Saab and others, 1995; Powell, 2006), while Henslow's sparrow and sedge wrens generally are absent. Many of these species experienced significant declines in abundance and distribution prior to availability of CRP grasslands (Reynolds and others, 1994; Johnson and Igl, 1995; Herkert, 2007a; Ribic and others, 2009). Those avian species whose local abundance has been most influenced by the presence of CRP grasslands generally have exhibited regional improvement in populations as well (Herkert, 2009).

Over 90 avian species have been documented breeding in CRP grasslands (Ryan and others, 1998). Some studies suggest CRP grasslands planted to a suite of native species have been shown to support a greater abundance of birds (Hickman and others, 2006). However, species richness has not been found to differ between types of CRP plantings (McCoy and others, 2001; Hickman and others, 2006). Nest abundance has been found to range from 9 to 27 times greater in CRP grasslands than abundance found in crop fields. In six Midwestern states, bird abundance was 1.4 to 10.5 times greater in CRP fields than within row crops (Best and others, 1997). Nest success was similar between CRP and row-crop fields; however, total number of nests found in cropland was only 7 percent of that found in CRP grasslands. Mean densities of birds in Minnesota CRP fields were 313 as compared to 167 in pasture and 9 in cropland (Leddy and others, 1997).

[3]A voluntary agreement between landowner and USDA to retire environmentally sensitive land in agricultural production and plant conservation covers in exchange for payment typically lasting 10–15 years.

Restoration of grassland in agricultural settings can furnish habitat suitable for breeding birds even if vegetation-species composition is not similar to that found in native prairie (Fletcher Jr. and Koford, 2003). Some combination of variables including grassland species composition, structural diversity, size of habitat, time since disturbance, and management activities defines relations between grassland birds and their habitat (Peterjohn, 2003). Each species responds to these features differently. Therefore, one simple, all-encompassing conservation strategy will not address declines of bird species affected by agricultural practices. Some species benefit from frequent vegetation disturbance (for example, bobolinks [*Dolichonyz oryzivorus*] and grasshopper sparrows) while other species find greater suitability in undisturbed vegetation (for example, Henslow's sparrow) (Herkert, 1994b; Herkert, 2007b).

Bird species respond to differing characteristics of grassland defined by height, density, and structure of vegetation. These features vary as vegetation changes through years in response to disturbance or lack thereof. Consequently, grassland seral-stage is an effective predictor of use for many grassland birds (Fritcher and others, 2004), and suitability of habitat for a specific species needs to account for how grassland characteristics change through time. Birds requiring taller vegetation and residual cover normally are more abundant in mid-to-old seral stages of grassland development. Younger CRP grasslands (1 yr to 2 yr old) generally support a greater diversity and density of avian species. Older fields (3 yr to 6 yr old), typically with greater amount of litter and grass cover, support higher nest success (Millenbah and others, 1996). Insect diversity and biomass, which are important for brood-feeding opportunities, diminish as CRP grasslands age in response to lower diversity of plant species. The lack of flowering plants (forbs) in CRP grasslands also has been proposed as an important factor affecting arthropod abundance (Hickman and others, 2006).

Disturbance of CRP fields strongly affects their value for grassland birds. Disturbance through grazing and haying had more influence on bird community composition than did composition of the plant species established in CRP grasslands (Chapman and others, 2004). Conservation practices that do not allow for suitable disturbance generally will benefit only a narrow complement of birds regardless of grasses planted. The absence of fire or other management actions to prevent encroachment of woody vegetation into grassland can diminish habitat suitability greatly for grassland birds. Occurrence of grassland birds in North Dakota decreased rapidly when woody cover increased to only 5 percent to 20 percent (Grant and others, 2004).

Numerous investigations conclude that, although vegetation abundance and structure are good indicators of avian habitat quality, the vegetation species used for cover can affect which bird species benefits. In an assessment of avian habitat quality in Maryland, CRP-grassland bird-habitat preferences were determined more by vegetation structure than by plant species composition (Gill and others, 2006). Warm-season grass mixes came closest to approximating avian species richness found in native prairie in eastern South Dakota and western Minnesota (Bakker and Higgins, 2009). In southeast Nebraska, total abundance of birds and avian species richness did not differ between plantings of cool-season grasses with legumes and warm-season, native grasses (King and Savidge, 1995; Delisle and Savidge, 1997). Plantings of cool-season grasses with legumes generally furnished the best conditions for ground-nesting bird species requiring low vegetation height and minimal depth of litter (for example, grasshopper sparrow), whereas warm-season native grasses provided better reproductive habitat for species nesting higher in the vegetation canopy and needing denser vegetative growth (for example, common yellowthroat [*Geothlypis trichas*] and sedge wren). Relative abundance of birds and nests also were similar between cool-season grasses (smooth brome [*Bromus inermis*], orchardgrass [*Dactylis glomerata*], and timothy [*Phleum pratense*]) and warm-season grasses (switchgrass [*Panicum virgatum*]) (see a list of vegetation listed in Appendix 2) planted on CRP filter strips in Iowa (Henningsen and Best, 2005). Warm-season grasses generally had more

vertically-dense live vegetation, taller residual vegetation, and greater richness of forb species, whereas, cool-season grasses generally had greater horizontal density and resistance to encroachment from weedy plants. Differences in bird-species abundance were evident between seasons, but overall, species richness, nesting success, and total use by birds in winter did not differ between cool-season grasses and legumes and native warm-season grasses in Missouri (McCoy and others, 2001). However, seasonal needs of wildlife differ, and introduced species of grass may well serve the needs of some bird species, at least during specific seasons.

While most investigations report native grasses furnishing the most desirable habitat to encourage a complete assemblage of bird species, monocultures of introduced grasses (primarily old-world bluestems [*Bothriochloa* spp.] and weeping lovegrass [*Eragrostis curvula*]) have furnished habitat for some grassland birds in the Southern Great Plains (Coppedge and others, 2001; Thompson and others, 2009). Although nest counts were small, Cassin's sparrow (*Peucaea cassinii*), a species in decline throughout its range, was found in unburned Texas weeping lovegrass monocultures (Oberheu and others, 1999). The authors concluded that weeping lovegrass may not be the best cover for wildlife due to a lack of structural diversity and deficient thermal cover, although it is better than cropland. The grass does, however, furnish some avian habitat in fields bordered by cotton and may be the best option for addressing multiple conservation issues on sandy soils in the southern High Plains. An assessment of avian habitat quality in CRP fields planted to old-world bluestems showed disturbance through grazing or haying created the diversity in grassland structure needed to support a diverse assemblage of avian species (Chapman and others, 2004a). Without suitable disturbance in these plantings, the authors concluded the CRP will benefit only a narrow group of bird species regardless of plant-species composition.

Planting CRP fields with exotic, nonnative grasses can have unintended effects on avian use. No differences in nest density of chestnut-collared longspurs (*Calcarius ornatus*) were found between native prairie and crested wheatgrass monocultures in eastern Montana (Lloyd and Martin, 2005), but as a consequence of lower abundance of insects, nestlings in crested wheatgrass-dominated fields gained weight more slowly and took longer to fledge than nestlings in native prairie, resulting in greater susceptibility to predation. An analysis of insect biomass in Kansas CRP fields planted to old-world bluestems (a formerly approved CRP cover in Kansas) also revealed monocultures lacked forbs and sufficient litter to produce an abundance of insects (Hickman and others, 2006). The authors suggested the large area planted with old-world bluestem monocultures in the southern Great Plains may be contributing to a regional decline in grassland birds.

The benefits of CRP grasslands on avian species, as well as other wildlife, ultimately are dependent upon neighboring land use. The abundance of bird species in row crops increased as more grassland cover in whole-field enrollments and strip cover became available in the landscape (Bryan and Best 1991; Best and others, 2001). In terms of grassland-dependent birds, land use has been correlated more with the amount of CRP grassland habitat provided in the field or from adjacent grasslands than with field age and size (Swanson and others, 1999). Habitat quality generally is greater when CRP grasslands are located near or adjacent to existing grasslands, which create larger, contiguous blocks of cover rather than a higher number of smaller isolated grasslands (Johnson and Igl, 2001; Rodgers, 2005).

Gamebirds

Northern Bobwhite Quail

Scarcity of nesting and brood-rearing cover has contributed to an overall decline in northern bobwhite quail (*Colinus virginianus*) habitat throughout much of its range (Brennan, 1991; Cox and others, 2005; Burger and others, 2006). Investigations of bobwhite quail habitat have elevated recognition of the importance of providing bare ground and a diversity of forbs in CRP grasslands to improve their value as brood habitat (Madison and others, 2001; Greenfield and others, 2003). Analysis of National Resource Inventory data (http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/nri/) and measures of grassland bird populations showed increased quail numbers in response to greater density of CRP grasslands less than 4 yr old (Riffell and others, 2008). Younger CRP grasslands (less than 4 yr old) typically have a greater percentage of bare ground and a higher presence and diversity of forb species than found within older fields. These characteristics directly affect the quality of nesting and brood-rearing cover.

Plantings of cool-season grasses, warm-season grasses, or a mixture of both types are capable of furnishing reproductive habitat for northern bobwhite quail if vegetation of sufficient height and density is provided. Introduced grasses have been associated with negligible improvements in habitat quality for bobwhite quail due to unsuitable structure, depleted vegetation composition, and an absence of food-producing plants (Barnes and others, 1995; Madison and others, 2001). Although introduced perennial grasses can furnish some environmental benefits such as erosion control and enhanced water quality, establishment of smooth-brome, orchardgrass, and tall-fescue monocultures in CRP grasslands has brought minimal, if any, improvement in the quality of quail habitat. The aggressive nature of these introduced grasses results in insufficient amounts of forbs and almost no bare ground, each of which is a critical component of bobwhite quail brood habitat (Stauffer and others, 1990; Roseberry and David, 1994; Barnes and others, 1995; Madison and others, 2001). Dense cover inhibits efficient movement and foraging by quail and other small ground-dwelling wildlife that are poorly adapted to inhabit dense, exotic grass stands (Germano and others, 2001; Newbold and Carpenter, 2005). Numerous investigations have focused on management of CRP fields to enhance habitat quality by increasing abundance and diversity of forb species in grasslands dominated by exotics (Washburn and others, 1999; Madison and others, 2001; Greenfield and others, 2002; Burke and others, 2008). Disking, mowing, prescribed fire, herbicides, and combinations of practices have been useful in diminishing dominance of these exotic grasses. However, introduced grasses are aggressive, requiring disturbance as frequently as every 2 yr to maintain desired characteristics of grassland cover. Clean-farming practices and management actions such as poorly timed, infrequent or overly-intense burns (Brennan, 1991) and control of annual weeds (Greenfield and others, 2002) can have negative effects on the quality and distribution of bobwhite quail habitat.

Overall, throughout much of northern bobwhite quail primary range, CRP lands comprise only a small proportion of its habitat. These fields often are embedded in landscapes containing grassland and woodland cover types (Weber and others, 2002). Conservation buffers, management of field borders, and focused CRP conservation practices (such as Habitat Buffers for Upland Birds) were recognized as having multiple environmental benefits in addition to improving the quality of quail habitat (Burger and others, 2006). These practices have been beneficial, but significant enhancement of quail populations can be expected only when availability and quality of habitat are addressed beyond individual farms and on a regional scale (Williams and others, 2004; Burger and others, 2006).

Grouse

Prairie grouse populations require extensive contiguous habitat and have suffered greatly from range contraction due to grassland conversion to cropland (Boyd and others, 2011). Establishing CRP grasslands near existing native grassland elevates overall habitat quality to a greater degree for prairie grouse than does the presence of isolated grassland established under the CRP program. An evaluation of lesser prairie-chicken (*Tympanuchus pallidicinctus*), greater prairie-chicken, and sharp-tailed grouse (*Tympanuchus phasianellus*) population responses to CRP grassland across parts of eight Midwestern states found the greatest population response occurred where CRP grasslands were situated near pre-existing grasslands (Rodgers and Hoffman, 2005). Multi-species plantings of native grasses furnished nesting and brood habitat of the greatest value to all three species. Grasslands 12 to 30 inches (in) (30 to 75 centimeters [cm]) in height with a high diversity of forbs were considered optimum cover composition for foraging and brood rearing. Grasses of greater height may be used as roosting and winter cover, but all three species otherwise avoided such stands. Invasive woody vegetation, eastern redcedar (*Juniperus virginiana*) in particular, must be prevented from invading CRP grasslands if suitable habitat is to be maintained for lesser and greater prairie-chickens as well as other grassland-obligate birds (Chapman and others, 2004b).

Lesser prairie-chicken populations in Kansas have increased in localized areas as a consequence of CRP grasslands (Jensen and others, 2000; Fields and others, 2006). Availability of relatively-open vegetative cover supporting an abundance of insects (brood habitat) was believed to be the most critical habitat factor affecting prairie-chicken populations. Nearly 70 percent of lesser prairie-chicken nests located were in CRP grasslands planted to native warm-season grasses or enhanced with plantings of sweetclover (*Melilotus officinalis*) or white clover (*Trifolium repens*) and several species of wildflowers. Lesser prairie-chicken habitat in CRP fields can be improved by mid-contract management practices (required since 2003 and conducted between the 4th and 7th year) such as moderate disturbance (grazing, burning, disking) and enhancement through seeding of forbs and native grasses (Ripper and others, 2008). The number of lesser prairie-chickens nesting in CRP grasslands suggests continuation of the program will assist in regional persistence of the species.

Sharp-tailed grouse were rare to absent in Wyoming prior to the CRP's provision of vital-grassland nesting cover, which permitted expansion of grouse westward from Nebraska (Wachob, 1997). Rodgers and Hoffman (2005) reported population and range expansion of sharp-tailed grouse in 10 of 12 states correlated with CRP that were planted to cool-season grasses and legumes (primarily alfalfa [*Medicago sativa*]). In northwestern Colorado, 26 percent of leks were found in CRP grasslands, which composed only 3 percent of the area. In Idaho, the greatest level of sharp-tailed-grouse land use was in CRP grasslands interspersed with patches of native vegetation (Sirotnak and others, 1991). The CRP fields used were characterized as having high levels of grass cover and diversity in vegetation species.

Critical habitat has been provided for Gunnison sage-grouse (*Centrocercus minimus*) in Colorado where CRP grasslands have enhanced roosting and foraging habitat as a consequence of higher grass cover and an abundance of forbs (Lupis and others, 2006). In Washington, CRP grasslands benefitted recovering populations of greater sage-grouse (*C. urophasianus*) by providing crucial nesting and brooding cover (Schroeder and Vander Haegen, 2006). The amount of land use by greater sage-grouse increased as CRP grasses matured. Habitat quality of CRP was expected to increase in response to natural reestablishment of sage brush into the planted grasslands.

Ring-necked Pheasant

Ring-necked pheasant (*Phasianus colchicus*) populations generally have showed positive response to multi-year cropland-diversion programs such as the CRP and Reinvest in Minnesota grasslands (Kimmel and others, 1992). Examination of association between pheasant population and Breeding Bird Survey data across nine states shows positive correlation of ring-necked pheasants with larger amounts of CRP land present (Nielson and others, 2008). In Minnesota, for each 10 percent increase of CRP grassland in the agricultural landscape, pheasant survey numbers increased by 12.4 and 32.9 birds per route in spring and summer, respectively (Haroldson and others, 2006). Pheasant numbers increased in Iowa by 30 percent in the first 5 yr of the CRP (Riley,

1995). Numbers of pheasants recorded on survey routes in Iowa increased when as little as 4 percent of the county was in CRP. Similar results were reported in locations where the greatest growth in pheasant numbers were recorded when CRP was added to Iowa landscapes most heavily dominated by rowcrops (Riley, 1995). Ring-necked pheasant nest success is higher in undisturbed blocks of habitat rather than small, linear, disturbed cover types (Clark and others, 1999).

Grasslands planted as part of the CRP in the Texas panhandle have benefited ring-necked pheasant numbers and distribution by the addition of grass cover across a landscape where non-cropland is uncommon and isolated (Berthelsen and others, 1990). Vegetation within and immediately adjacent to playa lake basins often was the only cover available in the intensively farmed region. The vegetation provided in CRP grasslands, often in whole-field enrollments, furnishes refuge and enables expansion of pheasants into otherwise inhospitable landscapes devoid of cover.

The pheasant is recognized as the bellwether of sustainable habitat in agriculturally dominated landscapes (Warner and others, 1999). Well-established, year-round cover is critical for providing winter, nesting, and territorial habitat. Whereas CRP grasslands often furnish available nesting habitat, in areas of intensive wheat production such as eastern Colorado, CRP grasslands is the dominant cover available in early spring (Snyder, 1984). Hen nest initiation coincides with suitable, available nesting cover of a height and density quality found in winter wheat and wheat stubble fields (Snyder, 1984; Snyder, 1991), but spring tillage of wheat stubble also coincides with nest initiation and tillage has been shown to have mortality rates higher than predation (Snyder, 1984). Nesting cover found in CRP fields has been shown to increase hen success at hatching a clutch, but does not necessarily increase long-term bird population density (Robertson, 1996). The vital habitat component provided by CRP cover is often the high-quality brood habitat for pheasants and other wildlife where both vegetative cover and food are provided year-round (Warner and others, 1999).

Winter cover, described as areas where pheasants congregate in loose flocks, are composed of woody areas, dense scrubby cover, and tall residual vegetation (Robertson, 1996). In more northern regions, winter cover for ring-necked pheasants is provided by robust wetland vegetation such as cattails (*Typha* spp.) and ungrazed grasslands. During the most severe winter weather, wetland vegetation and ungrazed grasslands may become snow covered, eliminating vital thermal cover. Investigations in South Dakota found that planting of taller, robust, warm-season native grasses provided better winter cover for ring-necked pheasants than did cool-season CRP grasslands, which became flattened by snowfall more easily than ungrazed native grasses (Eggebo and others, 2003; Larsen and others, 1994). However, when compared to warm-season grasses, grasslands planted to cool-season species furnished superior nesting habitat, as sufficient cover was available earlier in the nesting season (Eggebo and others, 2003; Leif, 2005). These findings led to the conclusion the best grassland habitat for ring-necked pheasants would be a mosaic of both cool-season grasses with a legume component and warm-season grass mixes. Dense monocultures of any grass types are inferior to diverse grass-legume plantings. Multiple cover types planted in close proximity provide refuge from unforeseen events such as major winter weather (Homan and others, 2000).

Absence of vegetation diversity in early CRP plantings limited habitat benefits of CRP to ring-necked pheasants. Availability and quality of brood habitat may be one of the most limiting characteristics of pheasant habitat. The quality of unmanaged CRP grassland as brood habitat will diminish as fields age and become dominated by grasses. The quality of CRP grasslands as brood habitat improved where legumes and other forbs were inter-seeded and the amount of bare ground increased (Rodgers, 1999). Native grasses themselves furnish minimal food to pheasants. Waste grain and weed seeds in cropland are the primary forage for pheasants. With the persistent use of herbicides on cropland and diminishing abundance of weed seeds and insects, the food value of cropland for pheasants has declined (Rodgers, 1999; Krapu and others, 2004). The presence of forbs in structurally diverse CRP grasslands may increase in importance to pheasants and other wildlife where foods are becoming less available in farmed lands.

Waterfowl

The CRP increased the number of ducks produced in the Prairie Pothole Region (PPR) by an estimated 12.4 million ducks between 1992 and 1997 (Reynolds and others, 2001). Assuming no major changes in enrollment patterns, more than an additional 13 million ducks (2.2 million per year) are believed to have been produced between 1998 and 2002, providing an estimated 25 million additional ducks due to CRP (Reynolds, 2005). The study emphasized that grassland covers established by CRP were as important if not more important

than the CRP wetlands. Nest success of upland nesting ducks (for example, mallard [*Anas platyrhynchos*] and blue-winged teal [*A. discors*]) was 46 percent greater in PPR CRP grasslands as compared to non-CRP covers, and duck nest success was higher on tracts of CRP grassland than on any other major cover type. An investigation of avian use of Minnesota public lands also revealed duck density and species richness was greater on CRP grasslands than recorded on public lands (Cunningham, 2005). Thirty-percent of all successful duck nests in the PPR study area were located in CRP covers that accounted for only 7 percent of cover on the landscape. The positive response by ducks to the CRP is in response to fairly-large contiguous units of comparatively-tall, dense, perennial grasslands planted in close proximity to wetlands.

Wetlands embedded in grasslands are superior nesting and foraging habitat for ducks than equivalent-sized wetlands occurring in cropland. As the CRP developed, it became apparent that better wildlife habitat would result from locating grasslands near existing wetlands and non-farmed areas such as Waterfowl Production Areas (Hurley and others, 1996). As of 2005, analysis of CRP grasslands showed 75 percent of CRP contracts in the PPR to be located in areas of high or medium duck accessibility zones and benefit upland-nesting waterfowl (Reynolds and others, 2006). Conservation goals of CRP and Swampbuster, each authorized in the 1985 Food Security Act, complemented each other by providing high-quality nest cover adjacent to smaller wetlands sheltered from tillage. It is estimated that over 230,000 small, temporary, and seasonal wetlands were embedded in CRP grasslands in the PPR (Reynolds, 2005). An estimated 492,000 pairs of ducks are believed to have been attracted to these wetlands annually between 2000 and 2003.

Mammals

From field to landscape scale, habitat enhancement from deer mice (*Peromyscus maniculatus*) to moose (*Alces alces*) has been attributed to conservation practices established under the CRP. Although mice and other small mammals typically are not considered in management decisions, their presence increases the diversity of wildlife affiliated with CRP and agricultural landscapes. Small mammal populations are sensitive to alterations in habitat. Therefore, diversity in populations generally correlates positively with vegetation structure, diversity, and complexity, which furnishes opportunities for assessing changes in ecological conditions as well as habitat quality (Rucker, 2001; Olson and Brewer, 2003; Sammon, 2005). A greater abundance and variety of small mammals has been associated with establishment of CRP grasslands, which have, in turn, supported a diversity of wildlife, including avian and mammalian predators (Evrard and others, 1991; Davis, 1998; Olson and Brewer, 2003).

Mammals and other wildlife species responded to habitats influenced by the CRP on multiple scales. For example, swift fox (*Vulpes velox*), a species of concern in some western regions, avoided northwestern Texas CRP fields planted to old-world bluestem. This planted, non-native grass was taller and more dense than grasses found in native shortgrass prairies (Kamler and others, 2003). The homogenous nature of old-world bluestem fields resulted in lower within-field prey diversity and restriction of swift fox mobility and visibility. However, greater amounts of habitat edge and diversity provided in a landscape containing CRP grasslands furnished a greater diversity of prey species than found strictly within native prairie (Kamler and others, 2007). Swift fox diets in CRP-dominated landscapes comprised insects, birds, and mammals (primarily black-tailed jackrabbits [*Lepus californicus*] and cottontail rabbits [*Sylvilagus* spp.]). In sites dominated by native prairie, swift fox diets were predominately insects.

Kamler and others (2005) concluded that resident coyotes (*Canis latrans*) in northwest Texas maintained small home ranges on native prairie, whereas transient coyotes used CRP fields dominated by old-world bluestem to a greater level. Native prairie was thought to contain a greater amount and greater diversity of prey species than was found within the CRP fields; therefore, use of these fields was dominated by resident coyotes. The CRP fields furnished the only tall, permanent vegetation in the study area, giving the best available cover for transient coyotes. Resident coyotes did take advantage of the taller grassland cover provided by CRP in winter months. Eighty-percent of coyote natal dens were found in CRP fields.

Former cropland in Delta Junction, Alaska (enrolled in the CRP) originally planted to smooth brome and red fescue (*Festuca rubra*) are transitioning from grasslands into shrublands. A greater abundance of native grasses, forbs, shrubs, and tree species was recorded as CRP fields aged (Seefeldt and others, 2010). Young, grass dominated CRP fields were believed to furnish good habitat for bison (*Bison bison*) whereas older, shrub dominated fields were good habitat for moose. In more intensively farmed regions in the lower 48 states, CRP grasslands have improved the quality and distribution of habitat for large mammals. White-tailed deer (*Odocoileus virginianus)*, mule deer (*O. hemionus*), and pronghorn antelope (*Antilocapra americana*) have benefited from improvements in foraging areas, fawning sites, and the presence of relatively tall, diverse vegetative cover in otherwise heavily farmed landscapes (Griffin, 1991; Gould and Jenkins, 1993; Wachob, 1997; Grovenburg and others, 2010). These enhancements in availability and quality of habitat have been documented at field as well as landscape scales.

Kamler and others (2001) illustrate the significance of CRP in expanding a species distribution for mule deer in Texas. Over-hunting and habitat loss diminished mule deer abundance and distribution throughout most of the Panhandle by the 1940s. Remnant populations were found only in major drainages associated with the Canadian River where topography furnished adequate cover. Deer were extremely rare

or absent from the flat terrain dominated by agriculture and shortgrass prairie. By 1985, mule deer distribution increased to 48 percent of Panhandle counties due to reintroductions and limited natural expansion of range. Mule deer distribution between 1985 and 2000 nearly doubled and deer inhabited 88 percent of Panhandle counties as more than 1.4 million acres of CRP grasslands were established during those years. The CRP fields provided taller vegetative cover (primarily old-world bluestem) than native grasslands and enhanced the distribution of cover across the otherwise uniform landscape dominated by crop fields. The elevated amount of grassland cover and its interspersion within cropland have permitted mule deer to expand their range across much of the Texas Panhandle. When asked permission to sample CRP vegetation on their enrolled lands, many Panhandle landowners told Cade and others (2005) that they had seen deer on their farms for the first time in decades. They attributed the renewed occurrence of deer to the presence of CRP grasslands.

Insects

With millions of acres of CRP grassland located in American landscapes, the potential opportunities to enhance habitat quality for desirable insect species appear substantial. The majority of research on CRP grassland characteristics and insect abundance, distribution, and diversity has been focused on insect availability as food for game and songbirds. These studies concentrated largely on differences between types of grass plantings (for example, nonnative versus native species and warm-season versus cool-season, grasses), age of grassland, and characterization of vegetation management regimes to maximize availability of insects. Many of the recommendations made for the invigoration of mature CRP grasslands are focused on improving habitat for insects in relation to providing forage for game and non-game birds. To date, there has been no published research investigating abundance or distribution of pollinator insects in relation to dissimilar CRP conservation practices.

There are believed to be over 163,000 species of insects (both identified and non-described) north of the Mexican border (Hodges, 1995). Insects provide numerous ecological benefits including pollination of natural vegetation and agricultural crops. Insects are a critical source of nutrition for wildlife. Ecological services provided by insects (for example, amendment to soil quality, pest control, pollination, and wildlife nutrition) in the United States are conservatively valued at $57 billion annually, but the true economic and environmental importance of these species and other insects remains largely unknown and underappreciated (Losey and Vaughan, 2006).

Because of adaptation to their environment, changes in insect diversity and abundance are indicative of habitat loss and environmental changes. Within agricultural landscapes, diversity in insect populations is related to plant-species diversity, structural diversity of vegetation, size of available habitat, and spatial distribution of suitable habitat. The intensification of agricultural land use, including greater dependence on pesticides and herbicides, and disease are factors contributing to lower numbers of desirable insects.

Not surprisingly, numbers, density, and diversity of insects found within cropland are much lower than in adjacent CRP grasslands and other non-farmed land (Best and others, 1995; Cederbaum and others, 2004; Doxon and Carroll, 2010). Disturbance of cropland through annual tillage, seasonal absence of vegetative cover, and application of herbicides and pesticides contribute to the negligible numbers of insects present on tilled acres. Annually, haying grasslands in Kansas greatly reduced vegetative litter, negatively affecting habitat quality for grasshoppers (*Orthoptera: Caelifera*) and beetles (Coleoptera spp.) and decreasing these species' abundance (Jonas and others, 2002). Uncultivated habitats close to crop fields have been shown to enhance effectiveness of natural pollinators, support insect species that prey on crop pests, and elevate crop yields (which positively affects farm profits) (Fox and others, 2004; Morandin and Winston, 2006; Bauer and Wing, 2010).

Grasslands containing the greatest numbers of forb species support larger biomass and abundances of insects than do less-diverse fields (Burger and others, 1993; McIntyre and Thompson, 2003; Reeder and others, 2005; Hickman and others, 2006; Doxon and Carroll, 2007). Biomass of beneficial insects was found to be 12 times greater in grassland with complex diversity in vegetation than in grassland within monocultures (Taylor and others, 2006). Insect biomass was eight times greater in plots of intermediate vegetation diversity than recorded in monocultures. Insect diversity and biomass typically decrease as forbs become less abundant in grass-dominated fields. Over time, without disturbance, the presence of forbs in CRP grasslands becomes negligible (Baer and others, 2002; Cade and others, 2005).

The advantages brought by higher abundance of insects do not always require radical changes in farming practices. Areas devoted to permanent cover, even if only in grasses, often support higher abundance of insects than found within conventionally-tilled fields (Rodenhouse and others, 1993). Insect abundance generally is higher near permanently vegetated field edges and within crop fields surrounded by more complex composition in vegetation. Establishment of relatively small, non-farmed sites supporting grasses and perennial flowering plant species is essential for increasing insect diversity within intensively farmed landscapes. Small areas of non-farmed land intertwined with cropland furnish pollinating and other insects with habitat and corridors for movement across otherwise inhospitable landscapes (Kremen and others, 2002; Davros and others, 2006). Within cotton fields where strips of clover had been incorporated, insect abundance was greater than in both conservation-tillage and conventional crop fields (Cederbaum and others, 2004).

There has been no evidence suggesting that CRP grasslands are a source of insect pests for adjacent crops. Stands of weeping lovegrass planted under the CRP in Texas furnished only marginal over-wintering habitat for the boll weevil (*Anthonomus grandis*). Winter survival and emergence of the pest species was consistently lower in CRP grassland than recorded in nearby native covers (Carroll and others, 1993). Grasslands established under the CRP were not believed to be a source area for damaging insects and may be beneficial by providing habitat for predators and parasites of insect species that damage cotton crops (Phillips and others, 1991; Hoernemann and others, 2001).

Pollinators

Recognition of the importance of insects as pollinators and indicators of environmental quality has grown in recent years, in part in response to declines in honey bee (*Apis mellifera*) populations. Unfortunately, as recognition of the significance and demand for pollination services is increasing, wild-pollinator abundance and diversity continue to decline (Spivak and others, 2011). Much of the pollination credited to honey bees is performed by other bee species and insects (Southwick and Southwick Jr, 1992). Approximately 3,500 native bee species occupy North America, many of which are important for pollination. It has been estimated that 60 percent to 90 percent of plant species require pollination services by animals (Kremen and others, 2007) and one in every three mouthfuls of food by humans depends on bees and other pollinators (Buchmann and Nabhan, 1996). Populations of wild pollinators have the potential to mitigate declining pollination services furnished by honey bees if habitats of sufficient quality and distribution are provided within agricultural lands (Kremen and others, 2002).

The Food, Conservation and Energy Act of 2008 introduced the Pollinator Habitat Initiative as a means to address some of these concerns by maximizing ecological services using CRP lands to target pollinator conservation. Effective pollinator habitat is complementary to other conservation lands planted for wildlife habitat and may help mitigate declines of native and managed pollinators as well as reduce habitat fragmentation and degradation of floral diversity. In highly-engineered agricultural landscapes, floral diversity at local and broader landscape scales is fundamental for successful bee populations. Unlike many avian species, wild bees are extremely limited in maximum foraging distance; thus, conservation strategies need to be at appropriate spatial scales. Wild bees frequently have spatially separated nesting habitat and food sources. Nesting and foraging habitat being separated by less than a few hundred meters is critical for a dynamic bee population (Zurbuchen and others, 2010). Although nesting habitat is more of a limiting factor than availability of food source, successful reproduction relies on the ability to bridge the distance between habitat and forage (Gathmann and Tscharntke, 2002). Successful monitoring and evaluation of USDA pollinator habitat plantings will require an integrated landscape-modeling approach, as population response essentially is tied to usable habitat.

Ongoing U.S. Geological Survey (USGS) studies are evaluating the extent to which CRP grasslands provide additional ecosystem services such as providing managed and wild pollinators refuge and habitat. Efforts are being made to model

interactions between plants and pollinators in USDA conservation plantings as well as in wetlands, annual grain crops, rangelands, and public lands in order to assess the utility of these lands for targeting successful management of bees.

Investigations between CRP grasslands and the quality of habitat have led to several broad conclusions:

- Grass cover furnishes better breeding and wintering cover than does cropland;
- Grassland vegetation characteristics (for example, density, height, species composition) change through time and furnish habitat for different species as grass plantings age;
- Grasslands containing greater diversity of vegetation composition and structure provide better habitat for a greater number of species than less-diverse grasslands;
- Management (that is, grazing and burning) that mimics natural disturbance will elevate habitat quality for a greater number of avian species;
- Tree encroachment into grasslands greatly diminishes the value of these CRP fields for many grassland species;
- Management prescriptions for early-successional habitat (that is, disking) provide greater benefits to a larger suite of species;
- Management prescriptions for avian species of conservation concern vary regionally and as fields age;
- Many CRP contractees value wildlife and seek information on how to best manage for wildlife.

History of Grassland Management

The North American grassland is a slowly evolved but highly complex biome dating back 25 million years. When European settlers came to North America, they discovered that a boundless area of grasses and forbs blanketed the central part of the continent (Weaver, 1954). Acre by acre, this grassland was profoundly altered by modern man, until only a small percentage of what once spanned from the foothills of the Rocky Mountains to western Indiana and Wisconsin and from Canada to the Mexican border exists today (Samson and Knopf, 1994).

The last century brought dramatic changes to the American landscape as specialization in crop production resulted in lands farmed more intensively at the expense of grasslands and loss of habitats for wildlife. Agricultural practices have the single largest effect on the character of our landscape and the future of wildlife (Grewell and others, 2003). The principal threat to wildlife from converting grasslands to cropland and development is the reduction and fragmentation of habitat. For example, grassland birds, which are predominantly habitat specialists and area sensitive, are negatively affected by habitat fragmentation and are found in lower densities in landscapes lacking sufficient patches of open habitat (Helzer and Jelinski, 1999). Most of the prairies and wetlands of the Great Plains states have been converted to agricultural production, resulting in a substantial simplification of ecosystem diversity across much of the agricultural landscape. The loss of idle, non-farmed areas in agroecosystems, in combination with less diversity in crops, continues to affect the distribution and quality of habitats for both resident and migratory wildlife. Conservation practices have been beneficial in lessening unwanted effects of agricultural production (that is, conversion of grasslands) by implementing USDA programs such as the CRP that help meet landscape-level environmental goals. But, planting conservation covers on the landscape alone is not sufficient to meet most wildlife habitat requirements without implementing management of the cover.

Natural Caused and Man-Caused Disturbance

Disturbances are natural or anthropogenic in origin (Turner and others, 2003) and have been described as “any relatively discrete event in time that disrupts ecosystem, community or population structure and changes resources, substrate availability, or the physical environment” (White and Pickett, 1985, p. 7). Native grasslands evolved with ecological disturbances. Although the frequency, timing, and origin of a disturbance may be debated, its significance from an ecological perspective cannot be. It is important, therefore, to implement a disturbance regime such as grazing and fire in systems where disturbance was historically critical to ecosystem integrity. If the CRP is not managed to suit the requirements of target wildlife, its connection to the landscape becomes insignificant, as habitat condition is equally important as location (McLachlan and others, 2009). As important as it is to plant CRP resembling native plant communities, the desired vegetation structure and composition may require prescribing management activities suitable to the landscape (McLachlan and others, 2009).

Ecoregion Descriptions

To understand the potential effects of managing grasslands for wildlife habitat, one must understand the ecological drivers that are integral to the ecosystem. For the purpose of this paper, North American grasslands are divided into four basic classifications: semi-arid grasslands that evolved with grazers, semi-arid to arid grasslands that did not evolve with grazers, mesic grasslands that evolved with grazers, and mesic grasslands that did not evolve with grazers.

Semi-arid: Historically Grazed (Shortgrass Prairies)

Shortgrass prairies extend from Oklahoma, Texas, and New Mexico, through western Kansas, Nebraska, and eastern Colorado. Dominant native shortgrasses in this region are blue grama (*Bouteloua gracilis*) and buffalograss (*Buchloe dactyloides*). Both grasses rarely exceed 10 cm (4 in) of height but extend well belowground, where they store 90 percent of their biomass, thus holding the soils together and providing stability during periods of drought (Milchunas and Lauenroth, 2001). This plant community co-evolved with intensive grazing pressure by large herds of bison followed by periods of vegetation recovery and regrowth (Milchunas and Vandever, 2013). In this ecoregion, short-duration intensive grazing is critical to ecological sustainability.

In some shortgrass regions (for example, in eastern Colorado), CRP fields were planted with taller grasses that may have occurred naturally in isolated, small patches, but not over broad areas. These grasses are not as drought-tolerant as the native shortgrass vegetation and maintain a much greater proportion of their plant material aboveground. When heavily grazed, they have a high potential for mortality and susceptibility to wind erosion and may likewise fail primary goals of reducing soil erosion, especially in periods of drought. To assure establishment and permanence of new enrollments into CRP, native shortgrass species that are drought- and grazing-tolerant should be emphasized and the necessity of grazing be endorsed.

It is important to note that within the shortgrass bioregions there are other vegetation types, such as pinyon-juniper and sandsage prairie, that naturally occur in certain areas with certain soils. These areas within the larger shortgrass bioregions were not grazed historically, and the soils will not support the grazing that the true shortgrass vegetation supports.

Semi-arid, Arid: Historically Ungrazed (Desert Grasslands and Shrublands)

Extremely little rainfall is received in the southwest and west portions of the Continental Divide (Colorado, Utah, Idaho, eastern Oregon, and Washington) and grasslands and shrublands in these areas did not evolve with significant grazing. Grazing by domestic animals provides little or no ecological benefit for these grasslands. Grazing CRP for management purposes into these areas should be avoided, except where ecological benefits are scientifically valid, such as for invasive plant control, and then only in accordance with an appropriate grazing plan.

Mesic: Historically Grazed (Tallgrass and Mixed-grass Prairies)

The tallgrass and mixed-grass prairies are roughly located from the 100th meridian eastward to just west of the Appalachian Mountains. This region evolved with grazing and periodic fires. The majority of acres enrolled in the CRP are in this region, and, although these prairies do not require grazing to the same extent as the shortgrass prairie, grazing greatly influences habitat requirements of the endemic grassland birds. Grazing practices can promote heterogeneity of habitat structure and can create suitable habitat for birds that prefer shorter, less-dense vegetation, such as the two species of prairie-chickens. However, carefully-drafted management plans should be in place to avoid overgrazing these systems, which might lead to changes in the vegetation composition.

Historically, fire was widespread and common in these grasslands (more common in the tallgrass) as the high productivity of vegetation allowed for ample combustible fuel. Fire is integral to the ecology of these grasslands, as it serves to remove accumulation of vegetation litter, thereby providing opportunity for vigorous regrowth of grasses and preventing encroachment of woody plants that would threaten displacement of vegetation characteristic of the prairie (Larson and others, 2013). After fires reduced decadent vegetation, native bison grazed on the new vegetative shoots and proceeded across the prairie, leaving behind vegetation to regrow and produce litter to fuel the next fire (Henrichs, 1997).

Mesic: Historically Ungrazed (Coastal Grasslands and Savannas)

East of the Mississippi River, these native grasslands evolved with natural disturbance such as wildfire and meadows created by beavers (Askins, 1999). They also were affected by anthropogenic disturbances, such as burning and agricultural clearing. These mesic grasslands are found in the Southeast, including Florida and some coastal areas of Texas, the Midwest, and the Northeast. Nearly all (99 percent) of these grasslands have been converted to agriculture or to urban/exurban developments since European settlement. Disturbance history of these grasslands is likely the least understood of all ecoregions of North America. While it is generally accepted that fire is an important ecological driver, the historical frequency of fire in this ecoregion is unclear (Patterson and Sassaman, 1988; Parshall and Foster, 2002). However, without fire, these grasslands are invaded rapidly by woody species. In the southeastern pine savannas, grassland bird species rely on frequent (2–3 yr) burns to eliminate succession of hardwood forests (Askins and others, 2007). The same is true for northeastern coastal grasslands, where basic ecological processes have been suppressed, leading to conversion of grass-dominated habitats into forest (Vickery and Herkert, 2001; Askins and others, 2007).

Compatible Environmental, Social and Programmatic Goals

Sustainable management of resources, clean air, water, and wildlife are but a few recognized benefits brought by effectively interlinking agricultural and conservation policies. Management policies that encourage efforts to preserve and enhance grassland habitat may contribute to the conservation of grassland ecosystems and help reverse the rapid decline of grassland birds: the most dramatically declining guild of birds in North America. USDA conservation policies can affect both migratory and non-migratory wildlife and their habitats on private and public lands. The success of conservation on agricultural lands is much more than summarization of acres devoted to specific conservation practices, as conservation success requires the ability to quantify and describe conservation effectiveness in meeting diverse environmental and social goals. While information is needed on how well conservation practices achieve conservation goals, one of the more visible environmental benefits of the CRP is its effect on wildlife.

Biologists agree that the key to preserving wildlife and maintaining biodiversity is habitat. However, relating the changes in wildlife response directly to habitat quality is not as straightforward, as a number of factors can influence wildlife populations. Factors out of human control, such as weather can have a substantial influence on wildlife communities. The definition of habitat quality for many grassland-associated species varies by seasonal needs. Good-quality habitat can be reduced substantially when untimely events (for example, heavy rains or hail) occur during nesting season. Drought is associated with changes in structure and coverage of vegetation and lower abundance of insects, which in turn can limit bird numbers as it affects nesting and fledging success. As food supplies decrease, birds' territory size may increase, but only to a limited degree after which habitat becomes undesirable (Cody, 1985). However, not all birds are negatively affected by extreme environmental conditions, as affinity for certain habitat conditions can vary by species (Cody, 1985). Bird populations in semi-arid environments were found to decrease, increase, or not change during drought conditions depending on the species (George and others, 1992).

Similarly to the extreme wet and dry conditions wildlife experience in the summer, winter conditions affect wildlife

too. Although less research has been done assessing the value of CRP for winter habitat, these fields are used for food sources and cover from predators (Best and others, 1998). Species undergoing population declines such as ring-necked pheasant, American tree sparrow (*Spizella arborea*), northern bobwhite quail, and dark-eyed juncos (*Junco hyemalis*) were found to benefit from Midwestern CRP covers in the winter (Best and others, 1998). For deer in northern climates, winter habitat was found to be more critical than summer habitat for survival and reproduction (Wallmo and others, 1977). However, if CRP fields age without disturbance, provisions of resources (that is, food and cover) may decline and negatively affect their habitat value. It is for this reason that habitat management (for greater diversity of species or for sensitive species with specific habitat needs) is needed to sustain viable populations of wildlife. Wildlife populations do not always respond to changes in habitat, and populations can change year to year from a variety of biotic and abiotic influences. Therefore, a successful management plan to address the habitat requirements of a targeted species would require identification of all critical habitat elements within the spatial and temporal contexts in which they are inhabited.

The underlying assumption supporting management of CRP grasslands has been to advocate improvement in long-term quality of wildlife habitat. As with native grasslands, the importance of managing CRP grasslands is based on evidence that, left undisturbed, CRP grasslands eventually become decadent as a consequence of a build-up of vegetative litter, diminished vegetative species diversity, and an overall decline in stand productivity. Forbs have been shown to be important in that they furnish diversity, in-stand structure, vegetation composition, and are the primary vegetative strata supporting invertebrate populations, which is essential as a food source for game and non-game birds. But as grasses become dominant in older, undisturbed CRP grasslands, forbs become rare to absent. Although long-term maintenance of wildlife-habitat quality has been the driving force behind support for managed disturbance, care should be taken to avoid conflict with programmatic goals of the CRP (for example, reducing soil-erosion, improving water quality) (McLachlan and others, 2011).

Management of CRP Grasslands

More than 75 percent of CRP lands are planted to grasses classified as either introduced or native species. Introduced and native grasses are classified as either cool-season or warm-season grasses that, as their names imply, exhibit optimum growth during the cooler spring and autumn or warmer summer seasons. Cool-season and warm-season grasses have physical characteristics differing among species within and across geographic regions and are confined to a particular habitat. Although perennial grasses dominate primary production on most CRP lands, broad-leafed plants (forbs) contribute largely to vegetation species richness in most North American grassland communities (Bragg and Steuter, 1995; Briggs and Knapp, 2001) including those established as part of the CRP. Many grasslands that were established in the early years of the CRP (1987–1989) were not seeded with native forbs, or if they were, forb abundance diminished due to a lack of disturbance and competition with some grass species. In terms of potential quality of wildlife habitat, perennial polycultures of native grasses generally benefit a wider variety of wildlife species than do perennial native monocultures, or poorer quality monocultures of introduced grasses. Introduced grasses (for example, crested wheatgrass [*Agropyron cristatum*], smooth brome, tall fescue [*Schedonorus arundinacea*]) can negatively affect native plant species and diversity and alter resource allocation to roots or litter (Christian and Wilson, 1999). In addition, monocultures furnish minimal diversity in structural composition.

Numerous investigations illustrate the need to incorporate disturbance into CRP grasslands if specific vegetative characteristics are desired over multi-year periods. In most cases, CRP grass plantings without some significant disturbance are taken over by one or several grass species exhibiting increased dominance and also suffer from greater amounts of dead plant material (litter) and reduction in abundance of forbs as stands age (Millenbah and others, 1996; McCoy and others, 2001; Baer and others, 2002; Greenfield and others, 2003). Younger stands of grass are characterized by an abundance of bare ground, a presence of broad-leaved, flowering plants (forbs), and variability in vegetation height and density. Results of a 10-yr evaluation of vegetation characteristics in 170 undisturbed, Midwestern- and Southern- Plains CRP fields show a general decline in vegetation height and density following a peak in these characteristics 2–4 yr after the fields were planted (Cade and others, 2005).

Disturbance is an important component of grasslands; it affects community structure and function. Lack of disturbance often creates favorable conditions for encroachment of woody vegetation, which affects habitat quality for many grassland birds and may be the most critical of grassland management issues in some regions (Coppedge and others, 2001; Chapman and others, 2004b; Rodgers, 2005).Vegetation response to disturbance can be characterized by the type, intensity, and timing of management actions (Collins, 1987). Regardless of species planted, the type and frequency of management administered to seeded grasslands often defines their long-term potential as wildlife habitat. Perpetuation of diversity in grass-species composition and vegetation structure sustains desirable habitat for a variety of grassland-dependent wildlife. Under most circumstances, species diversity is greatest at intermediate levels of disturbance (Hobbs and Huenneke, 1992).

While natural-disturbance regimes may be desirable from an ecological prospective, dependence on natural disturbance often is unrealistic in CRP grasslands embedded in an agriculturally dominated landscape. Because the frequency and type of disturbance applied to CRP grasslands represents a crucial issue in meeting specific conservation objectives, disturbance regimes must be tailored (1) to the biotic community desired and (2) to attain specific management objectives. A practical approach to grassland wildlife management is to define and furnish enough suitable habitats to support viable populations of those species with the most restrictive requirements (Graul, 1980). This approach is based on the assumption that wildlife species with broader, less-limiting habitat needs will find associated habitat of suitable quality. Management prescriptions aimed at provision of habitats for several species of management concern require a mosaic of vegetation conditions across the landscape (Winter and others, 2005).

The management interval in grasslands is affected by climatic conditions, soils, grass species, and management history of the individual stand, but ultimately, it can be defined only when the habitat needs of specific wildlife species are considered. Any management activity prescribed for grasslands may enhance habitat conditions for some species, while it may be detrimental to others. Ideally, management prescriptions designed to address wildlife habitat and other issues of environmental concern are implemented at the watershed or landscape level (Ribic and others, 2009).

If the objective of management is to modify grassland composition for wildlife habitat, the principal tools available are haying, grazing, disking, and controlled use of fire (see potential effects of management on vegetation in Appendix 3). These management options may be used independently or in combination to reduce grass dominance and density, thereby encouraging a diversity of forbs in CRP grasslands.

Disking and Interseeding

The increased amount of light, warmer soil temperature, and diminished competition from grasses and woody vegetation often is necessary for forbs to become established in existing grasslands. Disking can be used to eliminate or reduce existing grass cover to create greater diversity in CRP grasslands. This method of management can be used to increase the amount of bare ground in grasslands, since it relies on natural incursion of broad-leaved plants. Seed dispersal declines with distance from parent vegetation (Cramer and others, 2008); therefore, grasslands isolated from existing seed sources may require disking and inter-seeding to enhance vegetation and habitat diversity. Plots sown to a variety of native forbs and grasses after disking have been shown to be less susceptible to invasion by undesirable plant species such as old-world bluestems (Falk and others, 2013). In older, well-established grasslands, increased disking intensity may be necessary to establish a suitable seedbed for subsequent planting of legumes or other non-grass vegetation. In especially dense or sod-bound grasslands, it may be necessary to use grazing, fire, or haying to remove grass biomass prior to disking.

Light disking and interseeding of forbs in northeastern Nebraska resulted in a more structurally diverse vegetation community following treatment of CRP fields, supporting a greater variety of bird species than did unmanaged, older CRP grasslands (Negus and others, 2010). Fields evaluated were 10–15 yr old and originally planted to smooth brome and legumes. Avian abundance was 35 percent higher in fields where 50 percent to 60 percent of the area had been lightly disked and legumes planted. Avian-species richness and diversity also were greater within treated fields as compared to fields not disked. Treated areas had greater maximum height of vegetation, better horizontal vegetation density, and a higher percentage of bare ground than did non-treated sites. An annual treatment of portions of CRP grasslands was recommended to create a mosaic of vegetation characteristics and to furnish habitat for a diversity of avian species. When deemed suitable as a management practice, disking intensity should correlate with soil type, maturity and cover of existing grass stand, and management objectives. Using disking and inter-seeding in conjunction with other management methods (for example, grazing, burning) might result in even-greater diversity in vegetation and an elevation of habitat quality for a larger number bird species.

The types of grasses needing management influence the success and duration of management benefits to habitat. In western Kansas, burning and light-disking native, warm-season grasses greatly improved brood-habitat quality for ring-necked pheasants and northern bobwhite quail by diminishing the amount of grass litter and furnishing more bare ground (Doxon and Carroll, 2010). The lesser amounts of litter and exposed soil presumably enabled chicks of both species to

move more easily through the habitat and experience higher success in foraging. Brood habitat in CRP fields would benefit from periodic disking set at time intervals according to vegetation characteristics. For cool-season, sod-forming grasses such as tall fescue, smooth brome, and orchardgrass, the effects of disking are of shorter duration and may require more intensive disking to achieve desired management results. For example, fall disking of tall fescue has resulted in improvements in habitat quality lasting only 2 yr (Madison and others, 2001; Greenfield and others, 2002). The amount of bare ground and decreased depth and cover of litter lasted only slightly longer in orchardgrass. Disking in midwestern and southeastern CRP fields planted to these species was recommended every 2–3 yr to maintain desirable characteristics of habitat. Greenfield and others (2003) reported that the effect of disking was well within acceptable limits of soil erosion rates and recommended more intensive disking to extend benefits for a greater amount of time.

Grazing

Grazing is a natural process that land managers can use to manipulate vegetation growth and response. Perhaps more than any other type of disturbance, grazing can be managed to accomplish long-term quality and distribution of habitat for targeted wildlife species. Grazing can affect grassland vegetation structure, productivity, and if done repeatedly, species composition and density. Each of these characteristics is influenced by the intensity, duration, and timing of grazing, which can affect the amount of vegetative cover present (Klute and others, 1997). Removal of grassland cover through grazing alters vegetation height, residual vegetation, and litter. Each of these variables may influence habitat conditions for a given wildlife species, depending on their fundamental or seasonal habitat requirements. Nesting-habitat quality for many species of upland-nesting waterfowl, game birds, and non-game birds decline in response to annual grazing. However, investigations show that periodic grazing can enhance habitat conditions for grassland-nesting species over the long-term (Renken and Dinsmore, 1987; Kruse and Bowen, 1996). Avian species that evolved in association with heavy, periodic grazing will experience declines in suitable habitat features in the absence of grazing (Knopf, 1994; Knopf and Samson, 1996). There has been strong support from some non-governmental groups for USDA to implement grazing on CRP lands in regions with long evolutionary histories of grazing (for example, shortgrass steppe in the western Great Plains) to create desired vegetation conditions for wildlife and support establishment of native perennial grasses.

Regardless of wildlife habitat requirements, grazing does have unique effects on grassland composition. The shortgrass steppe of the Great Plains evolved with heavy grazing for at least 10,000 yr (Milchunas and Vandever, 2013), and grazing by large herbivores (cattle, bison) is required to sustain mixed-grass prairies (Bragg and Steuter, 1996). Due to their varying preferences for specific species of vegetation or preference for new vegetative growth, ungulates influence the abundance of plant species by actively maintaining areas of short, rapidly growing vegetation at community and landscape levels. Ungulate grazing usually results in greater rates of vegetation renewal than are found in non-grazed areas (Ring and others, 1985; Vinton and others, 1993). Grazing also can diminish dominance and the competitive ability of grasses contributing to increased plant species and community diversity (Collins and Glenn, 1988; Collins and Gibson, 1990). By creating openings in the dominant grass canopy and physically disturbing the soil surface, grazing creates microsites favorable for the establishment of new vegetation. Maximum species diversity of vegetation typically occurs under moderate grazing intensities (Hobbs and Huenneke, 1992).

Vegetation diversity and productivity may be adversely affected when grazing is eliminated, too intense, of excessive duration, or occurs at inappropriate times (for example, grass in early stages of development or during drought). The dominant grazing-tolerant grasses, whether cool- or warm-season, require regular plant/herbivore interactions and rest periods during the growing season for recovery and regrowth. Fields with an undesirable weedy component may require multiple grazing treatments throughout the grazing season and should be timed early (before native grasses begin growing) and later in the season after natives have completed seed production (Hendrickson and Olson, 2006). Either continuous heavy grazing or excessive litter accumulation resulting from a lack of grazing may adversely affect individual species abundance by reducing vegetation productivity and diversity.

Variable intensities of grazing affect habitat distribution differently, thereby influencing the composition of grassland bird communities (Owens and Myres, 1973). Species dependent upon dense, tall, grass-dominated habitats will be largely eliminated when grazing is periodically intense or occurs annually. However, intense grazing in early spring can enhance habitat quality for species requiring short, sparse vegetation or bare ground during the nesting season (Renken and Dinsmore, 1987). Overall richness of avian species in North Dakota decreased in response to greater grazing pressure, but total bird density in grazed fields increased due to a few bird species responding positively to grazing (for example, horned lark, chestnut-collared longspur) (Kantrud, 1981). The diversity of breeding birds was consistently higher on idle or lightly-grazed plots. Evaluating the effects of grazing and haying on U.S. Fish and Wildlife Service wildlife refuges, Strassmann (1987) concluded that grazing generally was detrimental to ground-nesting birds, citing at least 55 studies documenting negative consequences on avian nesting stemming from removal and trampling of residual and standing vegetation. Grazing reduced nest densities of some species of breeding waterfowl in North Dakota, but vegetation and nest densities recovered quickly following termination of grazing (Kruse and Bowen, 1996).

The USDA can provide some relief from severe drought or natural disaster to areas affected by authorizing some grazing by domestic livestock in eligible CRP fields.

Under authorized emergency use, land operators have the option of grazing 100 percent of their CRP field at 75 percent of the calculated stocking rate or 75 percent of their field at 100 percent of the stocking rate. Regardless of stocking rate, a minimum height of 3 in residual cover is required for cool-season grasses, and 6 in for warm-season grasses. For cover and nesting requirements of most birds and other wildlife, the best wildlife option is to leave a field 25 percent ungrazed, preferably in one contiguous block, and, if possible, adjacent to other grasslands or non-grazed covers.

Several factors influence the suitability of grazing as a CRP grassland-management option. While some landowner/CRP contractees will implement grazing to manage habitats for wildlife, many others will not or cannot. The number of CRP contractees who have access to livestock for grazing is unknown. Livestock are increasingly rare on farms where commodity crops are the primary product. A national survey of CRP landowners revealed only 21 percent of respondents identified grazing as the most-compatible management option for their operations (Allen and Vandever, 2003). Less than 10 percent of survey respondents in the Lake States (Minnesota, Wisconsin, Michigan), Corn Belt (Iowa, Missouri, Illinois, Indiana, Ohio), and Northeast (Maine, Vermont, New York, Pennsylvania, Maryland, Delaware, New Jersey, Connecticut, Rhode Island, Massachusetts, New Hampshire) Farm Production regions (FPRs) found grazing a suitable management option for their CRP grasslands. The greatest acceptance of grazing was reported from respondents in the mountain (Montana, Idaho, Wyoming, Nevada, Utah, Colorado, Arizona, New Mexico) FPR, with 63 percent favoring this management alternative. Forty-three percent and 38 percent of respondents in the Pacific (Washington, Oregon, California) and Southern Plains (Texas, Oklahoma) FPR, respectively, identified grazing as a desirable management option. In the Southern Plains, Johnson and others (1997) found that, when CRP grassland contracts expired, the probability of grazing decreases if the land was previously irrigated. The likelihood of grazing as an acceptable management option also declined as age of the contract holder and area of land enrolled in CRP increased. It also was determined that CRP fields coming out of the program were more likely to be grazed if soil erosion was the primary reason for initial enrollment.

Barriers to grazing CRP grasslands include the need for fencing and watering facilities, the availability of cattle, and the distance to CRP fields. The lack of cattle or provisions to move cattle from occupied pastures to CRP fields is a fundamental limitation to adopting grazing as a widespread management practice. Simply moving stock from traditional pastures to distant CRP fields may limit practicality of grazing as a management alternative. To routinely graze fields, temporary or permanent fencing and water are needed. The majority of CRP fields were used for crop production prior to enrollment in the program. In most cases, fences around these fields, if they ever existed, were removed years ago as fields and farming equipment became larger (Cochrane, 1993; Rodenhouse and others, 1993). It is uncommon to see a CRP field enclosed by barbed wire or any other permanent fence, particularly in western regions where enrolled fields tend to be large. Estimated fencing costs for a single strand electric fence requires a substantial commitment of capital, estimated at $693 per linear mile (Cearley and others, 2009) which doesn’t include associated costs such as labor or a functioning water source (cattle require between 9 gallons and 18 gallons of water per day, depending on weather and body condition). Availability of water is potentially the limiting factor to implementing periodic grazing on CRP grasslands (particularly in more arid regions such as the southern Great Plains). Trucking water to cattle often is prohibitively expensive because many CRP fields are far from existing pastures. Availability of water in or adjacent to existing CRP fields is one of the primary limiting factors in incorporating grazing.

Burning

The scientific understanding that fire plays the primary role as the fundamental architect of species-rich grassland ecosystems has become accepted during the last century; fire is no longer viewed as a negative disturbance (Noss, 2013). Historically, fire has been a vital disturbance in most biomes; however, fire suppression has resulted in loss of biodiversity, changes in vegetation communities, and ultimately, alteration of ecosystem functions (Allen and Palmer, 2011). Vegetation response to fire varies as a consequence of vegetation composition, season of burn, climatic conditions, and effects of other disturbance on the vegetation community (Anderson, 1990). Because of the historical emphasis on range management in grasslands, the majority of research on prescribed burning has focused on nutrient cycling and productivity of individual grass species (Collins and Gibson, 1990). Maximum species richness and diversity in grasslands can be expected in response to periodic, but not annual, burning. Annually burned grasslands typically support lower diversity in vegetation species composition and structure as a consequence of a diminished seed bank (Abrams and others, 1986). Periodic fire does, however, remove litter, and can provide a favorable seed bed and microclimate that encourages the establishment of forb species.

Historically, grassland fires would occur throughout the year, but native American tribes ritualized autumn and late winter burning of grasslands, whereas later European settlers favored early spring burns for livestock grazing (Towne and Kemp, 2003). The use of fire to increase grass cover of both cool and warm season species is most effective when prescribed in the autumn or winter (that is, during dormancy) (Towne and Kemp, 2003; Diboll, 1986). Early spring fires may burn foliage critical for root production reducing vigor of cool season grasses. A resource manager may use early spring fire as a management tool if reducing vigor of cool season grasses in favor of warm season grasses is a priority (Diboll, 1986).

Fire removes the impenetrable vegetation and litter layer in tallgrass prairies and enhances surface soil microclimate (light, temperature, and nutrient availability), resulting in enhanced productivity (Knapp and Seastedt, 1986). In a Kansas tallgrass ecosystem, diversity of vegetation increased for 6–7 yr following burning, but thereafter began to decline (Collins and Gibson, 1990). Diminished diversity in vegetation was attributed to development of a thick layer of litter and standing dead material, which inhibited establishment of non-grass vegetation. In a west-central Kansas buffalograss/blue grama community, it took 3 yr, under dry conditions, for biomass to return to levels equivalent to unburned grassland (Ford and McPherson, 1996). With above-average precipitation, biomass returned to pre-burn levels in the second year after burning.

Regrowth of grasses, suppression of woody vegetation, and reduction of litter following burning of mixed-grass prairie in west-central Kansas improved habitat quality for wildlife species of concern such as: Baird's sparrow (*Ammodramus bairdii*), grasshopper sparrow, LeConte's sparrow (*A. leconteii*), Sprague's pipit (*Anthus spragueii*), and western meadowlark (Ford and McPherson, 1996). Rodent populations often expand after fire in response to increased availability of forb species, seeds, and insects. Predator populations may benefit and increase their use of grasslands in response to elevated populations of rodents following burning. An increase in small-mammal populations may, however, have negative effects on other species. Higher densities of small mammals may result in greater predation rates on nests of ground-nesting birds (S. Skagen, U.S. Geological Survey, oral commun.). Species negatively affected by destruction of the litter layer, at least in the short-term, include wildlife species that forage on invertebrates in litter or depend on it for concealment. Ground-nesting passerine birds such as the Henslow's sparrow and bobolink are dependent on dense litter for nest concealment and are negatively affected by the loss of vegetation litter (McKee and others, 1998).

In making recommendations for application of prescribed burns on prairie fragments, it was suggested that only 20 percent to 30 percent of areas greater than 80 hectares (ha) should be burned annually to maintain diversity of vegetation conditions (Herkert, 1994a). Fragmented grasslands of smaller area (a subjective term requiring more research attention) can have a greater percentage of area burned, but probably should not exceed 50 percent to 60 percent of the area (Herkert, 1994a). Prescribed burning strategies should incorporate an understanding of historical fire frequency, timing and intensity at various intervals, seasons, and intensities that shape vegetation communities and increase biological diversity (Senft and others, 1987). Management plans should be structured around an understanding of historic processes and ecosystem interactions, as they can be an effective tool for habitat-related management in some CRP grasslands, but they may not be ecologically appropriate in others. Managers should account for concerns of soil erosion when implementing burns for wildlife habitat and meet USDA objectives for tolerable limits. Altered abundance and species composition, as well as environmental changes during the last century, may render fire unable to recreate ecological conditions similar to the past (Brockway and others, 2002). For example, fire frequency of 5–10 years in xeric regions such as the northern Great Plains and shortgrass steppe is reasonable, but fire frequency of every 1–5 yr is more appropriate in mesic regions. Little is known about historic fire regimes in xeric communities (Augustine and others, 2010) but they are more sensitive to fire than some other communities, do not have the fuel load to carry a fire, and are more sensitive to invasion of fire tolerant species.

The recommended burning interval varies in response to management objectives and characteristics of vegetation in CRP grasslands. In Kansas, management requirements to burn CRP fields that were identified as rare and declining habitat were replaced with management practices based on site specific needs and objectives. In some regions, prolonged drought has prevented CRP from establishing enough biomass to use fire as a successful tool. In other regions, such as eastern Kansas, too-frequent burning of native grasses in CRP lands negatively influenced avian productivity. Robel and others (1998) reported that avian productivity was higher in unburned CRP fields than within spring-burned CRP fields during the year of burning. On average, study fields were burned 2.5 times in a 5-yr period. Most bird nests were located in fields not burned for at least 2 consecutive years. The number of nests found per field increased in response to greater time intervals between burns. Robel and others (1998) attributed annual or biannual spring burning to depletion of structural complexity in vegetation as a consequence of loss of standing dead material and litter on the ground surface. The adverse effects on avian use of CRP grasslands could likely be reduced by increasing the interval between burns. Loss of suitable nesting cover resulting from annual and biannual burning of grasslands, including some CRP lands, may be a major factor contributing to recent declines in greater prairie-chickens in eastern Kansas (R. Rodgers, Kansas Wildlife and Parks, oral commun.). Ultimately, it is not the frequency of the disturbance but the interaction between different types of disturbances that has the greatest effect on suitability of habitat for some wildlife species.

Increased nest success of birds in a variety of midwestern grasslands occurred 2–3 yr following burning (Herkert and others, 1996). Under most circumstances, a 3–5 yr application of fire was most appropriate to maintain desirable habitat for grassland birds in this region. A comparable burning interval was recommended for grassland bird habitat in eastern Nebraska CRP fields planted to both cool- and warm-season grasses (King and Savidge, 1995). Application of prescribed burning was recommended on a 3-yr interval in warm-season native grasses in northeastern Kansas to furnish desirable nesting settings for mourning doves (Hughes and others, 2000). Nesting habitat quality for the greatest number of bird species in North Dakota mixed-grass prairie likely would occur if a mosaic of habitats were furnished by applying fire at different intervals of time (Madden and others, 1999; 2000). Burning intervals were defined as short (2–4 yr), moderate (5–7 yr) and long (over 8 yr). The authors recommended burning 20 percent to 30 percent of a management area annually. Avian nesting in southern Great Plains weeping lovegrass was inhibited for at least 2 yr following burning of grassland cover in CRP fields (Oberheu and others, 1999). Consequently, the authors recommended a variety in burning intervals to provide a mosaic of habitat conditions for nesting birds.

Results of a national survey of CRP participants showed that use of prescribed fire was reported by nearly 25 percent of respondents from Pacific Coast and Northern Plains (North Dakota, South Dakota, Nebraska, Kansas) FPRs regions (Allen and Vandever, 2003). No more than six percent of respondents in Mountain, Lake, Appalachian (West Virginia, Virginia, Kentucky, Tennessee, North Carolina), and Northeast FPRs used fire as a management tool. Fields in these four regions typically are smaller in comparison to those in the Pacific and Northern Plains where fields are perhaps more isolated from dissimilar land uses. Prescribed fire is one of the least expensive management tools to maintain grassland vigor and habitat quality (Gill and others, 2006). However, grassland burning may be a less-suitable option due to small size of fields, concerns about air pollution, anxiety about potential damage to adjacent woodlands/farm infrastructure, difficulties in scheduling, cost, legal liabilities, or a lack of experience in application of fire for management purposes. Natural limitations such as vegetation species, fuel load, topography, and weather may also influence management decisions to prescribe fire. Where these issues constrain application of prescribed fire, more acceptable management alternatives may be grazing, haying, mowing, or disking.

Haying and Mowing

Haying is removal of vegetative material from the field after cutting. Mowing is when grasses and other plant debris remains in the field after cutting. Shredding of vegetation is an extreme method of grassland harvest where vegetation is cut into smaller pieces than when it is mowed, and is then left on the ground surface. All of these methods directly influence habitat quality by immediately creating a uniform cover and reducing the amount of vertical plant cover within a field. For landowners not able or willing to graze or burn their CRP cover, haying has become an alternative for mid-contract management. Periodic mowing and mowing for cosmetic purposes is not allowed as a management tool by CRP policy, but mowing can be used to aid with grass establishment and for spot control of weeds and other plant pests (Allen and others, 2001). The effects of each process may have implications for vegetative and habitat characteristics as they alter the vegetation density and structure into the next growing season. Periodic haying may increase habitat value of grasslands by opening the grass canopy and discouraging growth of undesirable species (Allen and others, 2001). Haying results in removal of vegetation, thereby reducing litter accumulation which may have negative effects on reproductive-habitat

quality for ground-nesting birds the following spring (Renner and others, 1995). Mowing without removal of vegetative material may negatively affect habitat due to excessive amount of debris remaining in the field (Kurzejeski, 1996; McCoy and others, 2001). The negative effects of excessive amounts of detritus in grasslands include reduction in light reaching the ground surface, lower soil temperatures later into the spring, alteration in physiology of emerging vegetation, reduction in carbon-dioxide uptake by vegetation, inhibition of nitrogen fixation by microbes and algae, reduced plant biomass, and diminished activities of some invertebrates (Peet and others, 1975; Rice and Parenti, 1978; Knapp and Seastedt, 1986). Consequently, grassland productivity generally declines in response to increasing or excessive amounts of dead plant material. Cool-season grasses, typically harvested earlier in the growing season, may exhibit sufficient regrowth to provide habitat value for wintering birds. Late-season mowing of warm-season grasses has detrimental effects on winter availability of food and cover for wildlife as there often is insufficient time for regrowth prior to winter (McCoy and others, 2001).

In a national survey of 1,412 CRP contractees, nearly 58 percent of respondents identified mowing or haying as the preferred periodic management of vegetation on lands enrolled in the CRP (Allen and Vandever, 2003), but this option was less acceptable in southern and western regions (μ = 33 percent) than in northern and eastern regions (μ = 65 percent). Disking or plowing were the least desirable management tools (preferred by 8 percent of respondents) due to greater equipment and operational costs. The greatest use of mowing occurred in the Corn Belt and Lake States FPRs, with 77 percent and 70 percent of respondents, respectively, reporting it as the primary method for weed control. The presence of weedy forbs typically is greater in young CRP fields. As CRP grasslands mature and grasses become dominant, weedy forb cover diminishes. Mowing to eliminate undesirable weedy forbs was extensive in early years of the CRP. In a multi-state evaluation, mowing of CRP grasslands to control weeds was widespread, with 82 percent of sampled fields having more than 75 percent of their area mowed (Hays and Farmer, 1990). Fifty-five percent of those fields were entirely mowed. More than 50 percent of the fields included in an evaluation of the quality of CRP grasslands as northern bobwhite quail habitat were mowed or otherwise disturbed for the purposes of weed control (Burger and others, 1990). More than half of the fields sampled in an Ohio study were mowed for weed control during the nesting season, potentially destroying incubating hens, broods and nests (Swanson and others, 1999). To maintain habitat potential, mowing CRP fields should be minimized and limited to spot treatment for weed control when feasible.

Haying or mowing patterns within individual fields can influence residual habitat values of grasses remaining standing after harvest. Partial mowing of CRP grasslands could be used to develop a mosaic of grassland stand ages with different physical characteristics to meet the needs of diverse populations of avian species (Horn and Koford, 2000). Regulations require operators to leave 50 percent of an eligible CRP field standing and unharvested, to be used for emergency purposes. Ideally, grasses hayed for emergency use should be harvested in large, contiguous blocks; studies have revealed that birds using narrow, linear, and small, isolated grassland covers are more susceptible to predation and nest failure (Herkert, 1994a; Luttschwager and others, 1994; Ball and others, 1995; Horn and others, 2005). The value of the remaining cover may be greater for wildlife if the unharvested portion of the field is adjacent to neighboring unharvested grassland or other non-cropped land.

Survival of new or introduced seedlings in grasslands generally is restricted to larger openings in the canopy due to greater physical space, light, moisture, and nutrients. Frequent mowing of dominant grassland vegetation has been successful in establishing forbs in mesic tallgrass prairies (Williams and others, 2007), but it is less effective as weed control in shortgrass steppe (Milchunas and others, 2011). In an assessment of haying CRP grasslands under authorized emergency use in the northern Great Plains, alfalfa was found to be more abundant within mowed fields than within non-mowed fields (Allen and others, 2001).

Frequent mowing of warm-season, perennial grasses in the first and second years after seeding of forbs favored growth of forbs in a 25-yr prairie planting site in northern Iowa (Williams and others, 2007). Forb seedlings in mowed plots grew larger and matured more quickly than did those in unmowed plots. Four years after introduction, forbs were twice more abundant in mowed plots than in unmowed plots. Seeded forbs in treated plots gradually increased in size over years, becoming more visually dominant and eventually producing seed. A combination of mowing during establishment, burning on a 3-yr rotation, and herbicide application for control of noxious weeds in CRP plantings of native, warm- and cool-season grasses furnished diverse grassland required by obligate grassland bird species in Maryland (Gill and others, 2006). Mowing CRP fields for any reason other than spot treatment of weeds is restricted until after the primary nesting season for grassland birds (fig.1). It may vary regionally or in response to the needs for specific species, but July 15 is often accepted as the end of the primary nesting season (Granfors and others, 1996; Patterson and Best, 1996; Horn and Koford, 2000). Spraying herbicides for weed control should be delayed until after mid-July to permit maximum nest success of grassland birds (Patterson and Best, 1996).

Permissive Use of CRP Grasslands

Conservation provisions of the 2008 Farm Bill allowed specific permissive uses for vegetation management in CRP lands. The effect these practices have on the landscape will vary based on how States set guidelines addressing CRP conservation plans. In some States, such as Nebraska, the routine-grazing provision will have the same guidelines as previously existed for managed grazing. Other States may set new guidelines for routine grazing that are much different

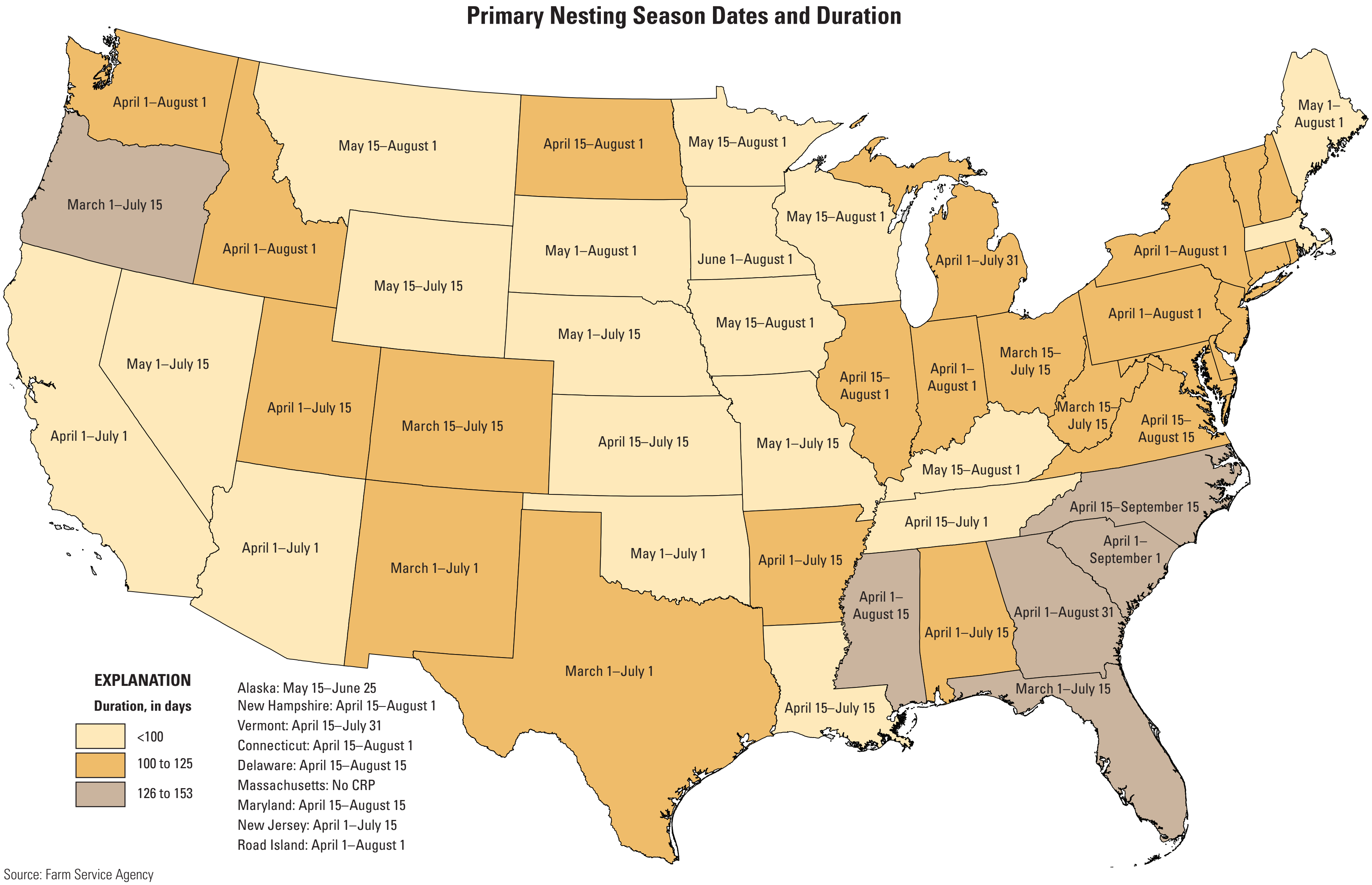

Figure 1. Primary nesting season in the United States.

from guidelines for managed grazing. The USDA has placed restrictions on the frequency of non-emergency haying and grazing to prevent annual use and avoid diminished habitat quality for some wildlife species. It has been recommended that the effects of new USDA rules for permissive use should be monitored for habitat quality and suitability for bird use (Herkert, 2007b).

Provisions for managed haying were removed and replaced in the 2008 Farm Bill with a broader provision called Managed Harvesting, which includes biomass production. Following the restrictive changes brought about by the National Wildlife Federation 2006 lawsuit (http://www.fsa.usda.gov/Internet/FSA_File/settlement_agreement_states.pdf), some States were forced to modify the frequency of harvesting vegetation on CRP-enrolled lands because of known effects to wildlife-habitat quality for species of concern. In order to assess how new Farm Bill provisions will affect the landscape at state and regional levels, an evaluation of how States are applying the new requirements is needed. Landowners with active contracts are authorized to harvest forage periodically via routine grazing. Permissive use of routine grazing has created numerous opportunities to diversify covers existing in CRP contracts. Presently, older existing contracts have managed haying and grazing provisions, whereas new contracts have routine grazing and biomass-harvest provisions. This means that a county can have CRP contracts with (1) managed haying under old managed haying and grazing rules, (2) managed grazing under old managed haying and grazing rules, (3) managed harvest under new rules, (4) managed harvest for biomass under new rules, and (5) routine grazing under new rules that all coincide with existing emergency haying and grazing (T. McCoy, Nebraska Game and Parks Commission, written commun.). This could create an opportunity to compare the differences between the effects of haying and grazing, as well as any differences between types of grazing (managed versus routine) and types of harvesting (harvesting for hay versus harvesting for biomass). To gain a better understanding of how frequently the permissive-use provisions of CRP lands are being deployed, a survey of select areas (northern Great Plains, southern Great Plains, Mountain, Corn Belt) would need to be conducted. Additional research may be warranted to investigate potential effects of CRP fields harvested for biomass production, as the frequency of this management action may affect wildlife habitat.

Currently, acreage eligible for emergency haying and grazing after drought or excessive moisture conditions can be used to provide needed forage for local producers. Emergency haying and grazing does not have restrictions on frequency (for example, consecutive years); however, the timing of the relief must be deployed after the primary nesting season. Because land hayed or grazed under emergency conditions directly affects the quality and quantity of wildlife habitat, emergency haying and grazing may replace the need for subsequent managed or routine use treatments. Extended drought periods encountered in some parts of the country have meant that, in some places, CRP grasslands have been grazed or hayed repeatedly, under unfavorable plant production conditions, and concurrently with neighboring grassland habitats that have been severely reduced. Information regarding the temporal and spatial effects of emergency haying and grazing on CRP vegetation and grassland wildlife could benefit USDA decision makers with managing the CRP for wildlife.

Enhancement of Habitat Quality

The many investigations between CRP and wildlife-habitat quality have broadened our understanding of the environmental benefits of establishing relatively undisturbed perennial cover in intensively farmed landscapes. Numerous examinations have shown that grasslands are not static ecosystems. Many CRP grasslands lose quality as plantings mature and become decadent and as legumes and forbs diminish and grasses become dominant (Felix and Owen, 2001; Ribic and others, 2009; Negus and others, 2010). Long-term disregard of grassland management can result in increased dead plant material and decreased plant production (Schacht and others, 1998). Regardless of habitat concerns, disturbance of some form is normally needed to set back succession to form younger, open stands. This set back, in turn, is needed to maintain long-term vigor of grasslands. Grassland-management prescriptions resulting in a diversity of age classes and structure (seral stages) will maximize bird-species diversity associated with these habitats (Fritcher and others, 2004).

Vegetation diversity characteristically is lowest in undisturbed or severely disturbed grasslands, while greatest in those exposed to moderate levels of disturbance (Collins and Barber, 1986; Hughes and others, 2000). Dependence on natural disturbance is impractical for long-term management of grasslands typical of CRP acreages embedded in agriculturally dominated landscapes. Successful introduction of native vegetation into established grasslands often is difficult (Wilson and Gerry, 1995). In such situations, mechanical methods (tilling, herbicides, mowing) are likely to have the greatest results where diversification of vegetation composition is an objective (Bragg and Sutherland, 1989; Berger, 1993). Long-term management efforts on large land units may influence native prairie communities more than short-term efforts on small, fragmented sites, regardless of how intensively they are managed (Van Dyke and others, 2004).

Regional differences in acceptance of management alternatives are influenced by landowner limitations, which may affect the general design of CRP management prescriptions. Opposition to any CRP management was greatest in the southern Great Plains (51 percent) and least in the Southeast (16 percent), but nationally, an average of 62 percent of respondents agreed or strongly agreed that USDA requirements to maintain benefits for wildlife were reasonable (Allen and Vandever, 2003). Where farms and fields are comparatively small, haying or disking may be the most acceptable option to maintain quality wildlife habitats. In many regions, livestock are no longer a part of the typical farm operation, and grazing as a management tool is not a practical option.

Grazing also can be problematic on CRP grasslands where fences are absent and water may not be readily available. Conversely, in western regions of the United States where average size of CRP fields is larger and fields often are miles from a contractee's farmstead, haying or other forms of physical disturbance may be less acceptable because time and movement of equipment are problematic. However, in these western regions, grazing or burning are a natural component to the system and may be the best management alternative. For optimum effectiveness, management prescriptions must integrate the willingness and capability of the contractee with the available management options, based on local site condition, plant community, and perceived wildlife response.

Investigations of CRP grassland management have led to several broad conclusions:

- Grassland management practices available for use include interseeding, disking, prescribed fire, fertilization, mowing, haying, and grazing;
- Appropriateness, timing, and frequency of management prescriptions will vary based on habitat requirements of wildlife species of greatest management concern;
- Enhancement (for example, interseeding of legumes) may best be accomplished following grazing, burning, disking, or haying;
- Regional or local wildlife species priorities should guide management prescriptions;
- Not all CRP contractees have livestock; therefore, the desire to hay or graze will not be a universal management alternative to operators;
- Costs to landowner are a concern, and financial assistance largely will define acceptance of management prescriptions.

Landowner Views on Management of CRP Vegetation

Attachment to their land and its protection for future generations are underlying motivations for many farmers to participate in conservation programs (Ryan and others, 2003; Valdivia and Poulos, 2009). Seventy-five percent of respondents to a survey of CRP contractees agreed or strongly agreed that benefits of the program to wildlife were important (Allen and Vandever, 2003). Over 60 percent of those replying to the survey believed USDA requirements to maintain long-term CRP benefits to wildlife habitat were reasonable. However, nearly 82 percent of respondents felt if CRP vegetation covers were well established there should be no requirements to disturb or enhance vegetation established under the program.

Greater effectiveness and acceptance of CRP management will be born from prescriptions that do not reduce and may even enhance farm profits (Rodenhouse and others, 1993). The simplest plan with the least time and financial commitment required by the landowner will have the greatest

likelihood of success, but any form of management of CRP fields may be objectionable to some CRP contractees because they perceive it as a regulatory obligation and burden in terms of time and financial costs.

To understand the decision process that a landowner must undergo before participating in conservation programs, one must realize that landowners have complete control over their land and the need to maximize any increased value of the land resulting from changes in the land market (Furuseth, 1987). Increasing land value is a major driver of why participation in environmental programs is more common by owners with land further from cities (Duke, 2004). Ownership of livestock increases probability of keeping land in established cover. The size of a CRP contract increases the probability of land returning to crop production (Johnson and others, 1997). Landowners in areas affected by existing or perceived urban development tend to reject conservation programs to avoid long-term commitments for the potentially high economic return they may receive for their land (McClaran and others, 1985; Liffmann and others, 2000). Urban sprawl tends to bring a greater demand for recreational use (for example, fee hunting) on private lands, consequently contributing to the land's value.

Some landowners may resist providing wildlife habitat simply because the cover established infringes on cultural norms for well-ordered appearance of farms. Establishment of conservation practices may give neighbors the impression that the landowner is indifferent or a careless manager of their land (Nassauer, 1995; Ryan and others, 2003). Other landowners may be more receptive to management options that focus on a single species or group of well-recognized species of wildlife rather than more ambiguous intentions such as "ecosystem" management (Holsman and Peyton, 2003). Landowners not focused on farming as their principal source of income are less likely to adopt conservation practices than are operators whose primary occupation is farming (Lambert and others, 2006). Younger farm operators who rely less on off-farm income are more likely to accept conservation practices compatible with continued production. Contractees retired from active farming may have the greatest difficulty in acceptance of periodic management for CRP grasslands due to a lack of equipment. This difficulty can be addressed, in part, by contracting CRP management responsibilities to other operators who have the equipment to complete needed management.

Avian Habitat and Grassland Biomass Production

Biofuel production is expected to be a significant use of agricultural land and an alternative use for CRP grasslands as contracts expire (McLaughlin and Walsh, 1998; Best and Murray, 2005; Florine and others, 2006), which will subsequently reduce future participation in the CRP (Riffell and others, 2008). The Energy Independence and Security Act of 2007 mandates the 2022 production of biofuels should equal 36 billion gallons, with roughly 16 billion gallons expected to come from cellulosic biofuels derived from trees and grasses (Fargione and others, 2009a; U.S. Environmental Protection Agency, 2013). The incentives to grow more commodity crops are driving one of the largest land-cover and land-use changes in recent history (Wright and Wimberly, 2013). In the western Corn Belt, U.S. farmers converted 566,560 million ha of grassland into corn and soybean fields between 2006 and 2011 (Wright and Wimberly, 2013). In Iowa, conversion of grassland to CRP land has been concentrated on less-suitable land, as the more productive lands are already in crop production. In South Dakota and Iowa, 5 percent of these less-productive lands are being converted to cropland each year. Of potential sources of cropland biofuel (ethanol from corn and soybeans, cellulose from grasses), only grass biomass has the potential to furnish wildlife habitat in association with energy production (Higgins and others, 2005; Bies, 2006).

A successful perennial grass for energy production requires establishment and persistence of a cultivar that produces high biomass output with low energy input (Mulkey and others, 2006). Because of its wide geographic distribution, relatively high yield and net energy content, and its adaptability to a variety of soils, switchgrass is believed to be the ideal native grass for biomass energy. Non-native grasses such as smooth brome, orchardgrass, tall fescue, and old-world bluestems also are harvested for biomass. Of these non-natives, giant miscanthus (*Miscanthus* x *giganteus*) is commonly accepted for producing biomass because of its ideal plant traits, but little research has been done to quantify its potential effects on avian species. Giant miscanthus is a relatively new agronomic perennial crop with sterile seed; rhizomatous growth habit; and tall, vertical structure. Studies done in the United Kingdom have shown miscanthus fields attract a variety of common farmland and woodland wildlife specialists (Semere and Slater, 2007; Sage and others, 2010; Donnelly and others, 2011), but these fields were compared mostly to arable annual cropland.

In the United States, little research has yet been done to investigate the effects of planting monocultures of miscanthus on native wildlife species, and there is concern that the suitability of habitat for birds that did not evolve with the density and structure provided by miscanthus will be limiting (3-meter tall thickets; (Fargione and others, 2009b). Whether intentional or not, introduction of exotic plant species in the US often has produced detrimental consequences for native habitats and wildlife species (Pimentel and others, 2000; Fargione and others, 2009b). A 2011 USDA environmental assessment of giant miscanthus for the Biomass Crop Assistance Program (U.S. Department of Agriculture Farm Service Agency, 2011) concluded that wildlife would incur minor negative effects in proposed project areas, but acknowledged there was a lack of applicable peer-reviewed data. The environmental assessment suggests that on the whole, cultivated fields had greater environmental impacts than perennial dedicated energy crops but less than fallow fields. To help offset anticipated adverse effects, USDA has developed a Mitigation and Monitoring Plan.

Biofuels derived from a high diversity of native grass species can furnish more useable energy with less pollution from agrichemicals than can energy production from corn ethanol or soybean biodiesel (Tilman and others, 2006). It has been suggested that retired agricultural lands could, with proper management, be used to produce a sustainable energy product, renew soil fertility, and create additional habitat for some bird species (Murray and others, 2003). However, investigations have found that grasslands with a higher diversity of grass species are less productive in biomass yield than are grass monocultures. An investigation of possible use of CRP grasslands in northeastern states found grass biomass and ethanol yield declined in response to greater richness in plant species (Adler and others, 2009). The CRP fields evaluated were dominated by switchgrass, big bluestem (*Andropogon gerardii*), and Indiangrass (*Sorghastrum nutans*). Biofuel yield decreased by 77 percent as plant species increased in number from 3 species to 12.8 species. A higher diversity of plant species negatively influenced concentrations of lignin, cellulose, and hemicellulose, resulting in poor yield and leading to the conclusion that sites with higher plant-species richness will exhibit diminished energy yield.

A comparison of biomass production in Oklahoma CRP fields planted to monocultures of old-world bluestem to fields planted with native mixed species (big bluestem, Indiangrass, little bluestem [*Schizachyrium scoparium*], sideoats grama [*Bouteloua curtipendula*], and silver beardgrass [*Bothriochloa laguroides*]) found the monocultures to be a productive source of biomass (Venuto and Daniel, 2010). However, with repeated harvest, biomass production from old-world bluestem monocultures declined more rapidly than biomass production from native species. To compensate for the decreased production, the authors suggested that a harvest rotation would be needed to allow a percentage of grassland to be annually removed from production. They also suggested that fertilization would be needed to maintain grassland productivity.

Cool-season grasses exhibit their greatest biomass accumulation in spring and early summer, as compared to warm-season grasses (such as switchgrass and old-world bluestem), which experience most biomass accumulation both in late spring and summer (Florine and others, 2006). Most studies of switchgrass for biomass production recommend harvesting in late summer to fall. Roth (2005) concluded that delaying the harvest until at least mid-August should provide a sufficient amount of time to permit 90 percent of bird nests to fledge from Wisconsin switchgrass fields. A major disadvantage of harvesting cool-season grasses is that biomass would be removed earlier in the reproductive season, resulting in substantial nesting failure for birds in these fields.

Delaying switchgrass harvest until after the first killing frost in South Dakota maximized grass available for harvest and decreased the amount of forbs in the vegetation (Mulkey and others, 2006). The highest yields of switchgrass in south-central states occurred in mid-September (Sanderson and others, 1999). As harvest frequency of switchgrass increased total seasonal yield declined so much it was believed switchgrass biomass production may not be economical in this region. Switchgrass is sensitive to frequent harvest. Switchgrass in 9-yr-old CRP fields declined rapidly when harvested annually during the growing season in South Dakota (Mulkey and others, 2006). The number of avian species using grasslands used for biomass production may be reduced due to reduction of forb abundance from herbicides and application of fertilizers during breeding season (Murray and Best, 2003). Chemical applications may cause nest failure directly or further diminish the quality of vegetation structure.

An effective option to retain some avian habitat in harvested areas is to maintain blocks of unharvested grassland adjacent to or interspersed with harvested fields (Best and Murray, 2005). Nest success was greater in unharvested switchgrass fields (59 percent) as compared to harvested fields (40 percent) and remaining standing vegetation (33 percent), where grasses were taken in alternating strips. While strips of switchgrass standing after harvest may not affect habitat quality for wintering birds, lower nest success in narrow linear covers has been well documented.

When compared to non-harvested CRP grassland, avian habitat quality will likely decline under a biomass-production scenario due to frequent harvesting and associated disturbances. Biomass harvested in fall and winter will not affect breeding birds, but changes in vegetation structure and abundance may influence nest success the following year (Best and Murray, 2005; Roth and others, 2005). Practically all investigations between composition of CRP grasslands and wildlife habitat describe higher diversity in plant species as an enrichment of habitat value. Conversely, it appears the greatest potential for biomass production lies in monocultures. However, with consideration for timing of harvest and placing a portion of grassland in a harvest rotation, not all habitat value for breeding birds will be sacrificed. To compensate for the potential loss of cropland foods in areas extensively used for grass-biomass production, the addition of food plots may be useful to maintain habitat quality (Murray and Best, 2003; Best and Murray, 2005).

Ultimately, changes in wildlife habitats associated with energy production will depend on intensity, scale, and type of land used. Many environmental services provided (for example, high-quality nesting cover) are highly correlated with total CRP acreage, and their value is not easily replaced by intensely managed cropland. Furthermore, if native grasslands are converted to biomass production, effects on wildlife habitat will be severe and largely irreparable (Higgins and others, 2005).

Conclusion

A CRP field's value as habitat cannot be defined until specific wildlife objectives are identified. For example, is the management goal to provide nesting habitat for grassland bird species associated with older, thicker grasslands, or are species dependent on younger, more open grasslands? Perhaps the diversity of vegetation is not significant, and only the presence of grassland suitable as winter cover is the goal. Because wildlife needs are so diverse and species of management concern vary widely, there is no one collective management prescription appropriate for wildlife. Generally, however, more diverse stands composed of a rich diversity of native plant species that are periodically managed by fire, grazing, disking or other appropriate (natural and man-made) disturbances provide the greatest wildlife benefits.

Agricultural productivity and environmental quality are not mutually exclusive. The environmental, social benefits, and economic costs of interlacing conservation into the agricultural landscape are debated constantly, always with passion and sometimes with supporting data (Gregory and others, 2007). Since 1982, innovations in farm organization and production methods have increased American agricultural productivity by nearly 50 percent (O'Donoghue and others, 2011). Less land is used today to supply more agricultural production than was used 30 yr ago. In approximately the same period of time, the CRP has reduced soil erosion and improved water quality. The environmental benefits of soil and water conservation are not always obvious or immediately evident. The largely positive response of wildlife populations to CRP conservation practices is proof that these policies work and are improving the contemporary and future of worth of the American landscape and its agricultural industry.

Control of soil erosion, improvement in water quality, and provision of wildlife habitat on agricultural lands are not independent issues. Largely, conservation practices designed to address regionally prevalent soil-erosion issues have been beneficial to wildlife species also of regional concern. Waterfowl, ring-necked pheasants, bobwhite quail, and many songbirds generally prosper when even a relatively small portion of the landscape is dedicated to non-farmed covers (that is, field borders, contour, and buffer strips) because they furnish a high degree of interspersion between farmed and non-farmed land. In drier regions, such as the southern Great Plains, where wind erosion is prevalent, whole-field enrollments of CRP grasslands have proven beneficial to lesser prairie-chickens, grassland songbirds, and other species dependent upon large, contiguous blocks of grassland cover. Regardless of region, some type of management will be required to maintain grassland quality and desirable features of habitat needed by many species of wildlife.

Numerous investigations have shown a positive response by wildlife to removal of erosive and environmentally sensitive lands from crop production. Greater numbers and distribution of wildlife are visible and quantifiable benefits of the CRP. Other positive responses brought by the CRP include economic benefits to landowners enrolled in the program and to rural communities (Leistritz and others, 2002; Hansen, 2007). While selected environmental benefits delivered by the CRP can be given economic value, many others cannot. For example, what is the monetary worth of improved air quality, greater aesthetic quality of the landscape, reappearance of springs, improved quality of well water, control of drifting snow, having forage to give to neighbors in time of need, provision of lands for schools to teach environmental education, or neighbors and friends to hunt or just enjoy watching wildlife? These are but a few of the ancillary profits described by CRP participants (Allen and Vandever, 2003).

Nationally, a valuation of a subset of CRP benefits provides an estimated $1.3 billion per year in environmental benefits, which is 70–85 percent of the program's costs (Hansen, 2007). These environmental estimates are based primarily on soil erosion, water quality, wildlife viewing, and pheasant hunting, and are conservative. If it were possible to include all additional environmental profits (for example, carbon sequestration, greater biodiversity, flood control, reductions in pesticide use, and nutrient loading of ground and surface waters) delivered by the CRP, the benefits likely would exceed program costs. However, variable rates of funding and relatively short-term (10 yr) contracts make the CRP an unpredictable source of environmental enhancement and wildlife habitat over the long-term (Cunningham, 2005; Herkert, 2009).

The majority of the American population works, recreates, and encounters the natural world on private lands (Norton, 2000). Farm families and the American public value the traditional and non-market products brought by American agriculture. The public's demand for foods produced by safe, environmentally sound methods is based in part on public recognition that social, aesthetic, and recreational interests increase the importance of safer resources derived from traditional uses of agricultural land (Taylor, 2001; Dimitri and others, 2005). An American public increasingly involved in the link between agricultural production and the environment may continue support for and seek refinement of governmental policies that are intended to enhance long-term protection of natural resources. The extensive and significant improvement in wildlife populations and their habitats brought by the CRP and the landowners participating in the program is largely unknown to the general public. Emphasis should be made by the USDA to make it a priority to inform the general public about the environmental and wildlife benefits delivered by their conservation programs and to highlight program successes to avoid misperceptions of program goals.

Complete understanding of ecological processes within agricultural lands remains imperfect, but we recognize that the maintenance of long-term agricultural productivity often comes with unintentional environmental costs, and that these costs cannot be disregarded. The CRP is the largest public-private partnership for wildlife habitat and the cornerstone of the USDA's conservation programs. The program's goals have evolved continuously since its inception, and without doubt, the CRP has brought economic, social, and environmental profits to American society. The CRP program can result in agricultural yield and viable populations of wildlife, but compatibility between these goals depends on deliberate, low-cost strategies favoring an enduring presence of essential habitats within intensively farmed regions.

Finding ways to induce greater responsiveness from private landowners to supply environmental amenities will continue to challenge those who design and implement agricultural policies. Because of the ecological complexities associated with agricultural land use, evaluating and monitoring effects of the CRP and other conservation programs is necessarily intricate and costly. Yet, it is only with such information that program effectiveness can be improved by identifying key conservation objectives at local, regional, and national levels.

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Appendixes

Appendix 1. Latin names of wildlife species discussed in text.

Non-game Birds

American tree sparrow	*Spizella arborea*
Baird's sparrow	*Ammodramus bairdii*
Bobolink	*Dolichonyx oryzivorus*
Cassin's sparrow	*Peucaea cassinii*
Chestnut-collared longspur	*Calcarius ornatus*
Common yellowthroat	*Geothlypis trichas*
Dark-eyed junco	*Junco hyemalis*
Dickcissel	*Spiza americana*
Eastern meadowlark	*Sturnella magna*
Grasshopper sparrow	*Ammodramus savannarum*
Henslow's sparrow	*Ammodramus henslowii*
Horned lark	*Eremophila alpestris*
Mountain plover	*Charadrius montanus*
Lark bunting	*Calamospiza melanocorys*
Sedge wren	*Cistothorus platensis*
Upland sandpiper	*Bartramia longicauda*

Game Birds

Greater prairie-chicken	*Tympanuchus cupido*
Greater sage-grouse	*Centrocercus urophasianus*
Gunnison sage-grouse	*Centrocercus minimus*
Lesser prairie-chicken	*Tympanuchus pallidicinctus*
Mourning dove	*Zenaida macroura*
Northern bobwhite quail	*Colinus virginianus*
Ring-necked pheasant	*Phasianus colchicus*
Sharp-tailed grouse	*Tympanuchus phasianellus*

Waterfowl

Blue-winged teal	*Anas discors*
Mallard	*Anas platyrhynchos*

Mammals

Beaver	*Castor canadensis*
Bison	*Bison bison*
Black-tailed jackrabbit	*Lepus californicus*
Cottontail rabbit	*Sylvilagus spp.*
Coyote	*Canis latrans*
Deer mouse	*Peromyscus maniculatus*
Moose	*Alces alces*
Mule deer	*Odocoileus hemionus*
Pronghorn antelope	*Antilocapra americana*
Swift fox	*Vulpes velox*
White-tailed deer	*Odocoileus virginianus*

Insects

Beetle	*Coleoptera sp.*
Boll weevil	*Anthonomus grandis*
Grasshopper	*Orthoptera Caelifera*
Western/European honey bee	*Apis mellifera*

Appendix 2. Latin names of vegetation discussed in text.

Native Warm-season

Big bluestem	*Andropogon gerardii*
Blue grama	*Bouteloua gracilis*
Buffalograss	*Bouteloua dactyloides*
Indiangrass	*Sorghastrum nutans*
Little bluestem	*Schizachyrium scoparium*
Sideoats grama	*Bouteloua curtipendula*
Silver beardgrass	*Bothriochloa laguroides*
Switchgrass	*Panicum virgatum*

Introduced Warm-season

Giant miscanthus	*Miscanthus x giganteus*
Old world bluestems	*Bothriochloa sp.*
Weeping lovegrass	*Eragrostis curvula*

Introduced Cool-season

Crested wheatgrass	*Agropyron cristatum*
Orchardgrass	*Dactylis glomerata*
Red fescue	*Festuca rubra*
Smooth brome	*Bromus inermis*
Tall fescue	*Schedonorus arundinaceus*
Timothy	*Phleum pratense*

Forbs

Alfalfa	*Medicago sativa*
Cattail	*Typha sp.*
Sweetclover	*Melilotus officinalis*
White clover	*Trifolium repens*

Woody Vegetation

Eastern redcedar	*Juniperus virginiana*

Crops

Corn	*Zea mays*
Cotton	*Gossypium hirsutum*
Soybean	*Glycine max*
Winter wheat	*Triticum aestivum*

Appendix 3. Description of Potential Effects of Managing CRP Grasslands for Wildlife Habitat

Potential positive effects	Potential negative effects
Disking	
-Decreases dominance of aggressive, perennial grasses -Increases wildlife diversity and abundance -Improves seedbed for forb establishment -Improves habitat for grassland birds -Promotes growth of flowering plants to support insects critical for bird chick survival -Releases seed species from seedbank -Promotes areas for chick foraging and predator evasion	-May not be suitable in thick, sod-bound grasslands -Potential for wind or water erosion -Some areas need to be avoided (for example, waterways, draws and areas with noxious weeds)
Interseeding	
-Increases forb abundance -Improves brood habitat for grassland birds -Promotes structural diversity -Promotes growth of flowering plants to support insects critical for fledgling survival	-Associated costs (fuel, seed) -Requires prior disturbance -Sensitive to weather and disturbance intensity
Grazing	
-Decreases dominance of aggressive, perennial grasses -Changes structural complexity -Improves brood habitat for grassland birds -Natural process -Promotes grass vigor and rejuvenates existing cover -Improves species diversity -Reduces litter -Allows managers to rest other pastures -Provides forage for livestock	-Can alter/effect cover for nesting in short term -Decreases avian nesting habitat in short-term -Specific timing and intensity required -Fencing and watering facilities required -Restricted during primary nesting season
Burning	
-Decreases dominance of aggressive, perennial grasses -Natural process -Promotes grass vigor and rejuvenates existing cover -Improves brood habitat for grassland birds -Improves seedbed for forb establishment -Removes litter -Enhances productivity -Suppresses undesirable woody vegetation -Inexpensive -Timing can be used to shift plant community	-Alters/effects cover for nesting in short term -Specific timing and fuel load required -Public perception -Highly dependent on weather -Liability for damages -Potential for wind or water erosion -May not promote stand diversity
Haying	
-Promotes grass vigor and rejuvenates existing cover -Can develop a mosaic of structurally diverse areas to meet needs of diverse populations of avian species -May reduce weeds -Reduces future litter inputs -Timing can be used to shift plant community -Provides forage for livestock	-Alters/effects cover for nesting in short term -Decreases winter food availability and cover for wildlife -Does not increase stand diversity -Restricted during primary nesting season
Mowing	
-Decreases dominance of aggressive grasses -Weed control -Can develop a mosaic of structurally diverse areas to meet needs of diverse populations of avian species	-Produces more litter -Alters/effects cover for nesting in short term -Reduces vegetative productivity -Diminishes insect activity -Lowers winter food availability and cover for wildlife -Restricted during primary nesting season

Potential positive effects	Potential negative effects
Herbicide treatment	
-Reduces competition from existing grass for forb establishment -Easy practice to implement -Can decrease dominance of aggressive grasses	-Expensive to treat large areas -Application timing important -Application rate can be calibrated to injure but not kill plants
No management	
Short Term -Decreases soil erosion -Increases water quality -Allows for vegetation regrowth between management practices Long Term -Decreases soil erosion -Increases water quality -Increases soil organic carbon	-Diminishes habitat suitability (food, cover) for grassland birds -Litter buildup -Vegetation becomes decadent -Vegetative diversity reduced -Decline in grass productivity -Decline in forb productivity -Encroachment of undesirable woody vegetation

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