U.S. Fish & Wildlife Service

Grassland Management Plan

Union Slough National Wildlife Refuge

2003

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Executive Summary

Union Slough National Wildlife Refuge is located in the heart of the Prairie Pothole Region (PPR) and the Northern Tallgrass Prairie ecosystem. It was established in 1938 as Union Slough Migratory Waterfowl Refuge to serve as "a refuge and breeding ground for migratory birds and other wildlife." As stated in the Comprehensive Management Plan (CMP), the Habitat and Wildlife Management Goal is to restore and preserve a community of life typical of the tallgrass prairie ecosystem.

Photograph by Bernie Angus

Currently, the Northern Tallgrass Prairie is an endangered ecosystem, and in turn, grassland-dependent birds and some forbs are in serious peril. The Grassland Management Plan (GMP) was developed in response to the Habitat and Wildlife Management Goal and the degrading grassland habitat of Union Slough NWR. To help achieve the above-stated goal, the following four objectives were established: 1) preserve remnant tallgrass prairie and associated threatened or endangered species, 2) restore and preserve a grassland buffer around refuge wetlands, 3) restore and preserve a complex of wetlands, wet meadows, and uplands for breeding waterfowl and other area-sensitive grassland birds, and 4) restore and protect a buffer around lower Buffalo Creek.

Historically, the tallgrass prairie was maintained by recurrent wildfire and grazing by elk and bison, while keeping woody species at bay. This is confirmed by original surveyor's notes from 1854 which described the area of Union Slough as covered with swamps, marshes, ponds, and sloughs surrounded by good, dry tillable land with no timber. According to the original surveyor's notes and Soil Survey of Kossuth County, only a small area (~20 acres) at the south end of the refuge developed under woody conditions. As European settlement progressed, grasslands were converted to cropland, the use of fire was suppressed, cattle replaced bison in the pastures, and woody species were allowed to invade the prairie. Today, Union Slough NWR is an island of breeding and nesting habitat surrounded by rowcrops and invaded by woody vegetation.

Grasslands of the refuge are presently inundated with areas of woody vegetation. Aerial photographs confirm that more trees exist on the refuge today compared to when it was established in 1938. These woody species effectively outcompete prairie forbs and grass, including threatened and endangered species, for the

necessary light, nutrients, and water to survive. Encroachment fragments large tracts of grassland critical for area-sensitive grassland birds. The areas of woody vegetation also provide predator lanes for small mammals and perch sites for avian predators and parasites, such as the brown-headed cowbird. The long and narrow shape of the refuge further exacerbates these factors.

Photograph by Bernie Angus

In addition to woody species, other pest plants such as Canada thistle (*Cirsium arvense*), white sweet-clover (*Melilotis alba*), yellow sweet-clover (*Melilotus officinalis*), and crown vetch (*Coronilla varia*), tend to form dense patches, crowding out threatened forbs, and other native vegetation. These patches are often low in species diversity and less attractive to nesting grassland birds. Though most areas of significant weed invasion are few and far between, proper management must continue in order to control any further spread.

Monotypic stands of both native grasses and introduced grasses are also problematic throughout the refuge. Although stands of native grasses are desirable, they are not true representatives of the native tallgrass prairie because they lack the important forb components critical for nesting birds. Monotypic stands of introduced grasses such as smooth brome (*Bromus inermis*) and reed canary grass (*Phalaris arundinacea*) prevent native vegetation, including threatened and endangered species, from establishing. Whether native or introduced, monotypic stands provide little attractive habitat for most grassland-nesting birds and must be converted to true tallgrass prairie.

Currently, because of the challenges addressed above, Union Slough NWR is not meeting the purpose for which it was established. Management actions have been chosen to address the concerns and fulfill the four objectives stated earlier in this summary. These actions will result in improved tallgrass prairie habitat, critical to the refuge species of concern (grassland-dependent birds, threatened and endangered species). Management actions utilized will include mechanical and chemical control of woody vegetation, pest plant control, prescribed burning, haying, grassland restoration, and native seed harvest.

Specifically these actions will involve:

- There will be no mechanical or chemical control of woody vegetation on the Refuge in the bottomlands south of Tienan's Dam. Mechanical and chemical control of woody vegetation will occur on the remainder of the Refuge. Areas containing fire adapted woody vegetation, such as burr oak trees, will be thinned to allow sunlight to reach the ground. This will allow grasses and forbs to grow in these areas. Four areas on the Refuge (see the attached maps at the end of this summary) have been identified as "tree thinning areas". The anticipated future condition of these "tree thinning areas" would

be a sea of tallgrass prairie dotted with a few scattered oak trees. All woody vegetation on the remainder of the Refuge will be removed as time, personnel and funding permit.

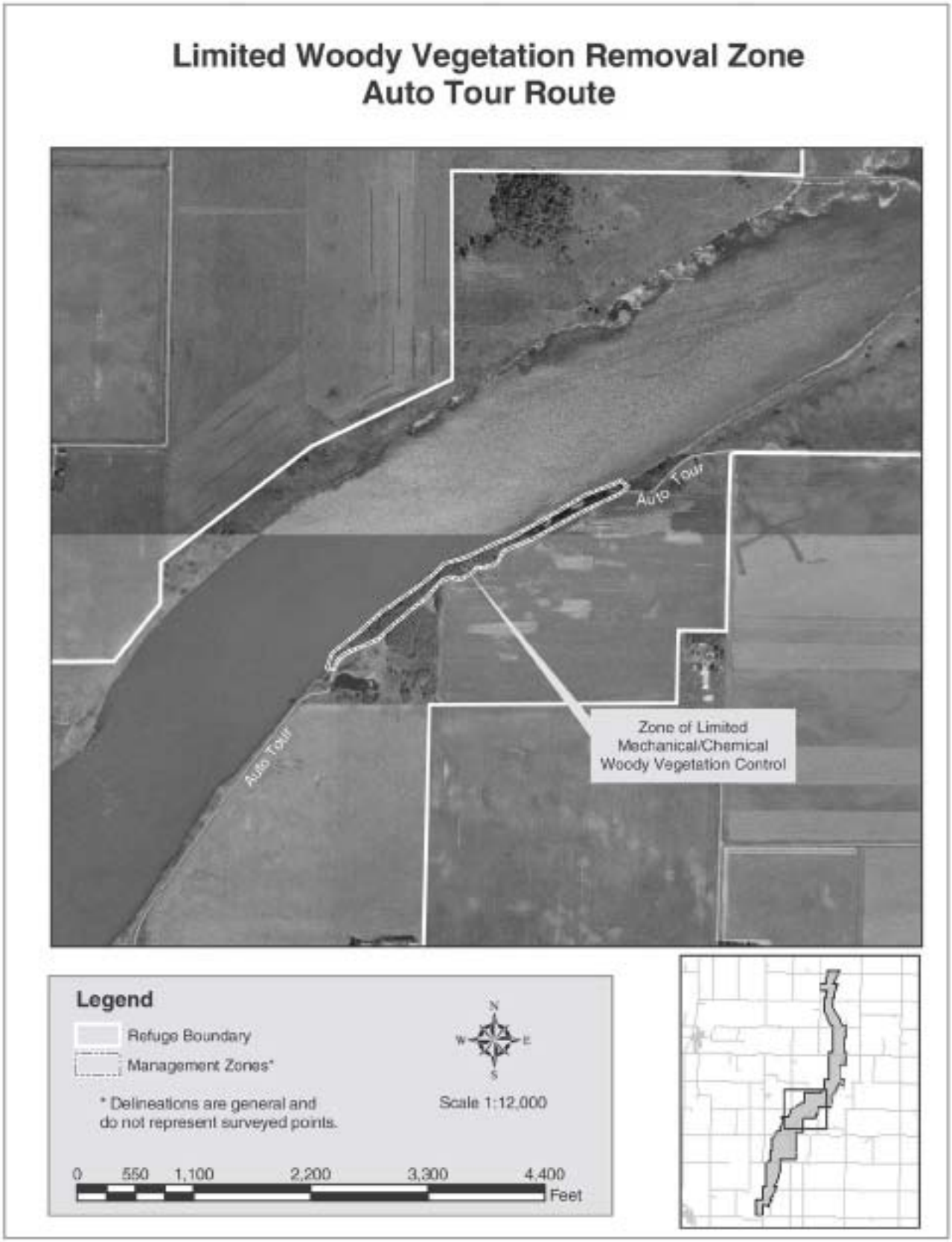
- Tallgrass prairie, the historic vegetation type found at Union Slough National Wildlife Refuge and the surrounding area, will be preserved, restored and recreated throughout the Refuge using a variety of methods. Crop fields, monotypic stands of introduced and/or invasive species, and low diversity native fields will all be converted to stands of high diversity local ecotype tallgrass prairie.

- Short term disturbances, such as prescribed fire and haying, will be used to control woody invasion and to promote the long term health and diversity of the tallgrass prairie.

- Seed harvest of tallgrass prairie will be conducted by Refuge personnel to provide the required amount of diverse local ecotype seed needed to provide high quality habitat for grassland dependent migratory birds and any threatened or endangered species found on the Refuge.

- This plan is intended to be used as an adaptive management tool. All management strategies will be evaluated over time. Modifications to the strategies used or to the techniques used to accomplish each strategy will be implemented based on results, experience and the latest research.

- Implementation of this plan should result in improved habitat for grassland dependent migratory birds and threatened and endangered species.


Limited Woody Vegetation Removal Zone
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Management Zones*
* Delineations are general and
do not represent surveyed points.
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Limited Woody Vegetation Removal Zone
Deer Meadow

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Refuge Boundary

Management Zones*

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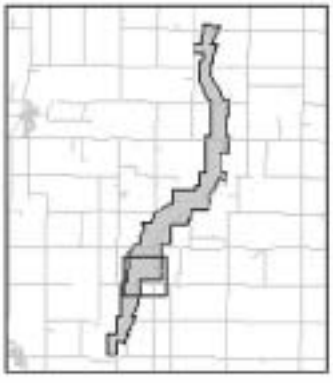

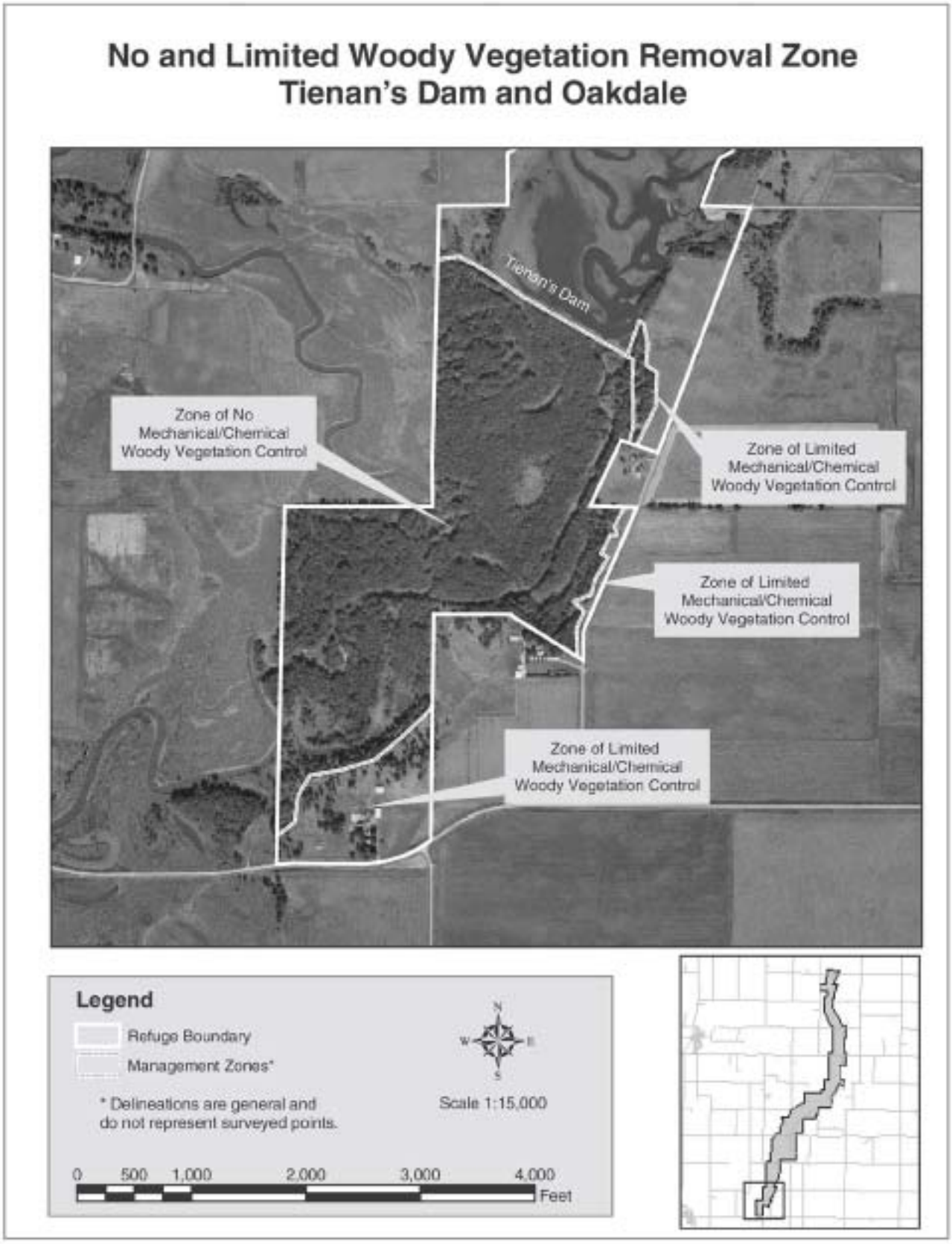
No and Limited Woody Vegetation Removal Zone
Tienan's Dam and Oakdale
Tienan's Dam
Zone of No Mechanical/Chemical Woody Vegetation Control
Zone of Limited Mechanical/Chemical Woody Vegetation Control
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Zone of Limited Mechanical/Chemical Woody Vegetation Control
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Refuge Boundary
Management Zones*
* Delineations are general and do not represent surveyed points.
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Contents

Introduction

Union Slough NWR Comprehensive Management Plan (CMP) was developed in 1996 as a response to concerns regarding the decline of grassland and wetland habitat and their associated wildlife. The CMP defines specific Refuge goals, objectives, and strategies that define what the Refuge must be to satisfy its purpose, legal mandates, and the needs of all interested parties in what and how the Refuge performs (USFWS 1996). Specifically, the Habitat and Wildlife Management goal states: "Protect, restore and manage habitat on the Refuge and within the Refuge watershed with increased emphasis on restoring and preserving a community of life typical of the tallgrass prairie ecosystem" (USFWS 1996).

Photograph by Bernie Angus

This Grassland Management Plan (GMP) is in response to the Habitat and Wildlife management goal and the degrading grassland habitat on the Refuge. More trees exist on the Refuge now than did 150 years ago. In fact, it is evident by looking at aerial photos, that the trees have increased steadily and dramatically from 1939 (Figure 1) to the present (Figure 2). Grassland-dependent birds are in serious peril and the tallgrass prairie in which they depend, is a globally endangered ecosystem. This GMP is devised as a step-down plan to provide details and guidance for implementing habitat management strategies, herein grassland management, as referred to in the CMP.

The policy of the United States Fish and Wildlife Service (Service) for developing Management Plans, is to manage all Refuge habitats in accordance with approved CCPs (CMPs) that, when implemented, will help achieve refuge purposes, fulfill the National Wildlife Refuge System (System) mission, and meet other mandates.

The mission of the System is to preserve a national network of lands and waters for the conservation and management of fish, wildlife, and plant resources of the United States for the benefit of present and future generations. Under the National Wildlife Refuge Improvement Act of 1997, 16 U.S.C. 668dd-668ee, section 4(a)(3) states: "With respect to the System, it is the policy of the United States that- (A) each refuge shall be managed to fulfill the mission of the System, as well as the specific purposes for which that refuge was established…" Section 4(a)(4) states: "In administering the System, the Secretary shall- (N) monitor the status and trends of fish, wildlife, and plants in each refuge." The Refuge Improvement Act provides the Service the authority to establish policies, regulations, and guidelines governing habitat management planning within the System.

The policy of Biological Integrity, Diversity, and Environmental Health, developed in 2001 under the Refuge Improvement Act of 1997, provides an additional directive for managers to follow while achieving refuge purpose(s) and the System mission. Section 4(a)(4)(B) states the Secretary shall "ensure that the biological integrity, diversity, and environmental health of the System are

Figure 1: South End of Union Slough NWR, 1939

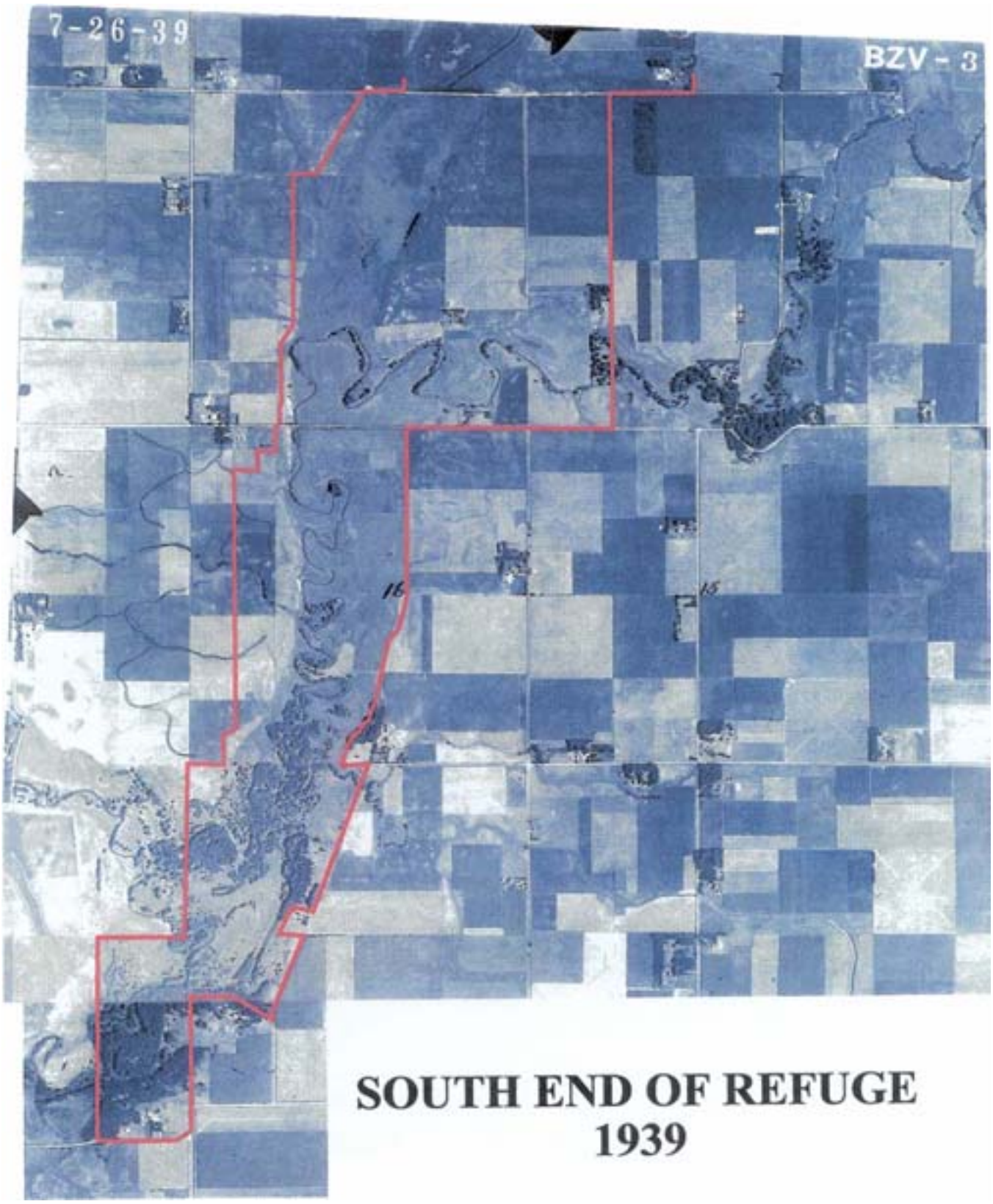
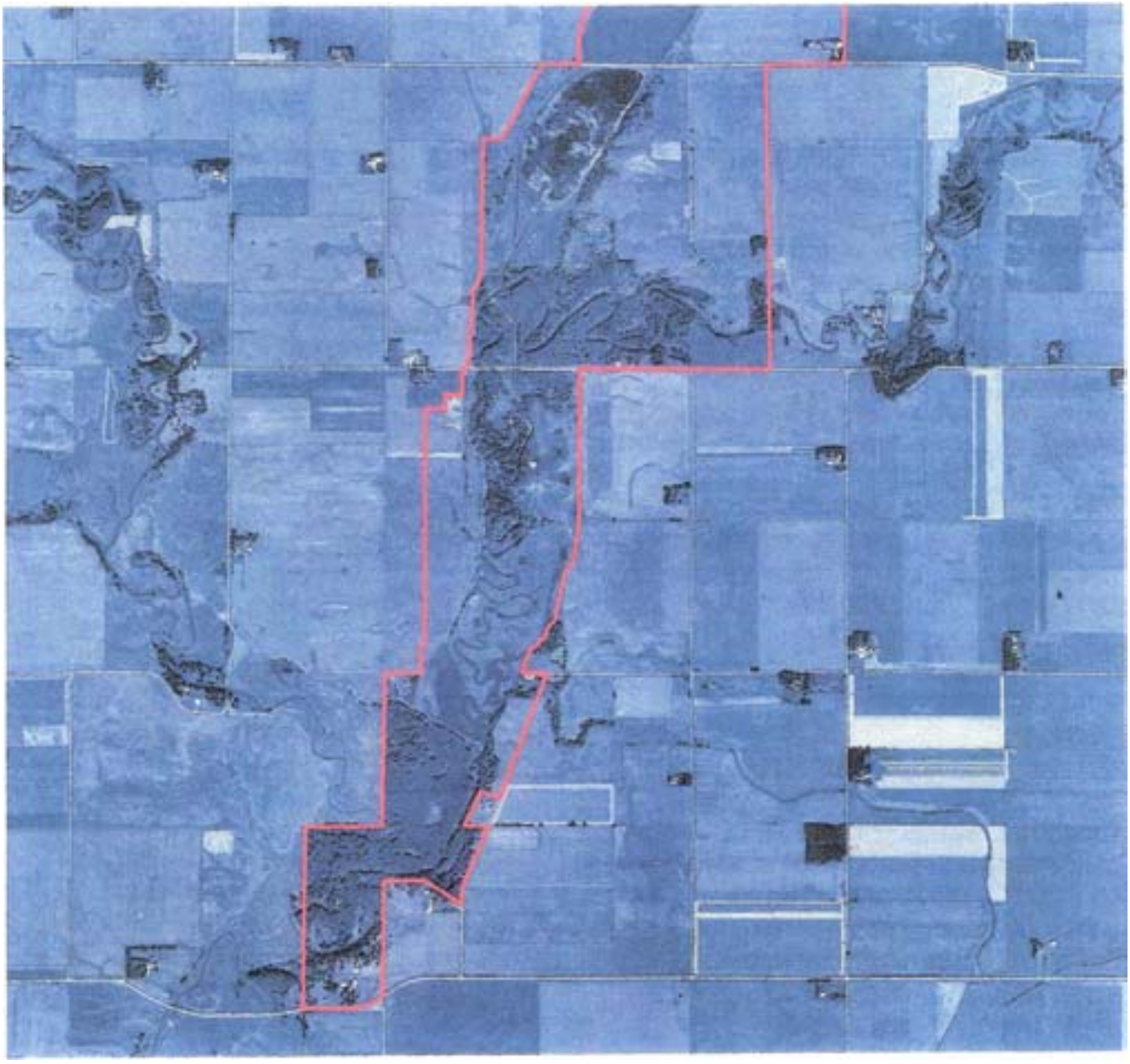


Figure 2: Aerial Photograph of the South End of Union Slough NWR, 1995



maintained for the benefit of present and future generations of Americans." In addition, it provides managers an evaluation process to analyze their refuge and recommends the best management direction to prevent further degradation of environmental conditions, and where appropriate and in concert with refuge purposes and the System mission, restore lost or severely degraded components (USFWS 2001). The highest measure of biological integrity, diversity, and environmental health is viewed as those intact and self-sustaining habitats and wildlife populations that existed during historic conditions (USFWS 2001).

The U.S. Fish and Wildlife Service has specific trustee responsibility for migratory birds, endangered species, certain marine mammals, interjurisdictional fish, and the lands and waters that it administers for the management and protection of these resources. Under the Endangered Species Act of 1973, 16 U.S.C. 1531(a) "Congress finds and declares that- (2) other species of fish, wildlife, and plants have been so depleted in numbers that they are in danger of or threatened with extinction." Section 1531(c)(1) states: "It is further declared to be the policy of Congress that all Federal departments and agencies shall seek to conserve endangered species and threatened species and shall utilize their authorities in furtherance of the purposes of this chapter."

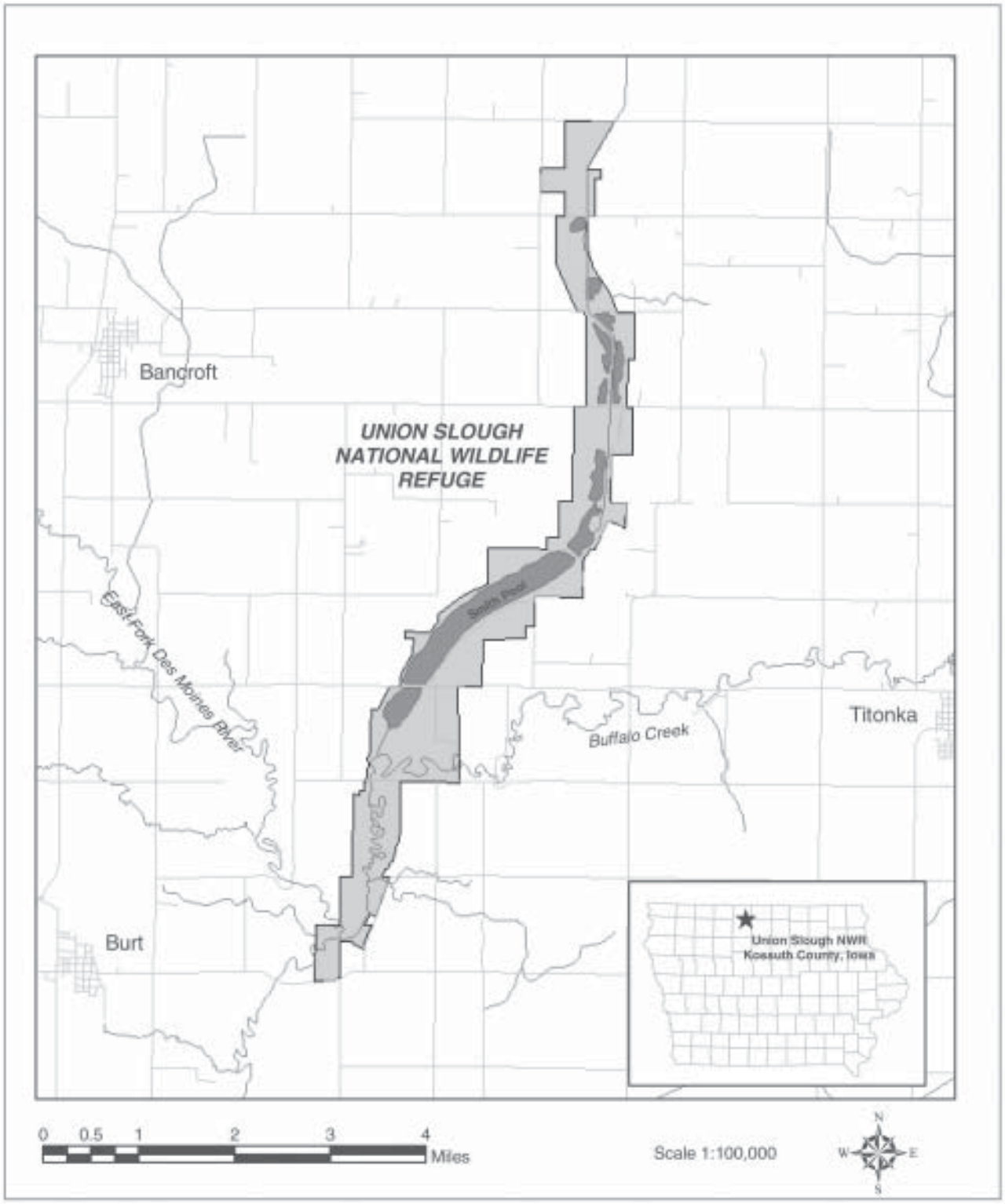
Executive Order 13112 prevents the introduction of invasive species and provides for their control and to minimize the economic, ecological, and human health impacts that invasive species cause. Section 1 defines invasive species as an alien species (not native to a particular ecosystem) where introduction does or is likely to cause economic or environmental harm or harm to human health. Native species is defined as a species that, other than as a result of an introduction, historically occurred or currently occurs in a particular ecosystem. Section 2(a) states "Each Federal agency whose actions may affect the status of invasive species shall, to the extent practicable and permitted by law- (2) subject to the availability of appropriations, and within the Administration budgetary limits, use relevant programs and authorities to – (ii) detect and respond rapidly to and control populations of such species in a cost-effective and environmentally sound manner; (iv) provide for restoration of native species and habitat conditions in ecosystems that have been depleted."

Union Slough National Wildlife Refuge was established in 1938, under Executive Order 7976 through the Migratory Bird Conservation Act of 1929, as a migratory waterfowl refuge. Later, the Refuge purpose was amended as "a refuge and breeding ground for migratory birds and other wildlife." Original surveyor's maps and written records confirm tallgrass prairie and wetlands covered the area. Therefore, it is our goal and responsibility to emulate the historic conditions of the natural landscape for the benefit of waterfowl, grassland birds, other wildlife, and the American people. We will accomplish this goal through the use of this Grassland Management Plan.

Background

Union Slough NWR is located in Kossuth County, approximately 55 miles north of Ft. Dodge, Iowa; 160 miles southwest of Minneapolis, Minnesota; and 130 north of Des Moines, Iowa. The refuge encompasses roughly 3300 acres along an 8-mile stretch of Union Slough and Buffalo Creek (Figure 3). Under normal water conditions, the refuge contains 450 acres of open water, 850 acres of marsh,

Figure 3: Union Slough National Wildlife Refuge, Kossuth County, Iowa



and the remaining 2000 acres consist of uplands, riverine bottomlands, and invasive woody species.

Union Slough is a pre-glacial riverbed that forms the "union" between the watersheds of the Blue Earth River and the East Fork of the Des Moines River. It is located on the eastern edge or "tallgrass" portion of the Northern Great Plains, within the Des Moines lobe of the Northern Iowa Glaciated Region. As the glacier receded, it created a complex of potholes and prairie extending from south-central Canada, northeastern Montana, the eastern Dakotas, western Minnesota, and north-central Iowa (Fig. 4). The lobe that extended into north central Iowa consisted of 7.6 million acres of grasslands and 2-3 million acres of wetlands.

Photograph by Bernie Angus

Prior to European settlement, numerous depressions characterized by hydric (wetland) soils dotted large expanses of tall grasses such as big bluestem and Indiangrass, with an assortment of prairie flowers flourishing in the rich, organic soils; while cottonwood, green ash, and willows were found only in the creek bottoms. In fact, from the original surveyor's notes compiled by Schiek (1996) of Kossuth County, the northern portion of the refuge in Ramsey Township was described as containing "many swamps and marshes, ponds and sloughs." It continues to describe the area as gently rolling with "no timber and containing good, dry tillable land generally good for grass." The surveyor described the southern portion of the refuge in Portland Township as a gently rolling prairie with numerous small marshes and several of considerable extent. Maps, surveyor's notes and the Soil Survey of Kossuth County describe a single area (~20 acres) at the south end of the refuge that developed under woody vegetation conditions. Other than that area, historical conditions of Union Slough National Wildlife Refuge were primarily tallgrass prairie. Grasses and forbs evolved and thrived with recurrent wildfires and grazing by elk and bison, while keeping woody species at bay. Prairie chickens, whooping cranes, numerous species of other grassland birds, and a variety of waterfowl were common to the area. But, as settlers moved west and discovered the rich, organic soils, the conversion from grassland to cropland began.

For nearly 50 years following the initial conversion of native Midwestern prairies, many prairie-dependent wildlife remained relatively stable by their ability to colonize agricultural grasslands (haylands/pastures). However, since 1950, the acreage of agricultural grasslands has significantly declined. When the Refuge was established, numerous grasslands flanked the boundary. Today, there are very few, if any, and the land surrounding Union Slough NWR is intensively farmed. The alteration of habitat reflects the evolution of agriculture, coupled with the loss of grazing and fire. Union Slough NWR is an island of breeding and nesting habitat surrounded by rowcrops and invaded by woody vegetation.

Resources of Concern

The U.S. Fish and Wildlife Service has specific trust resources in which it has full responsibility. These trust resources include the following: migratory birds, endangered species, interjurisdictional fish, certain marine mammals, and the land and waters administered for the management and protection of these resources. The National Wildlife Refuge System cites perpetuating migratory birds and preserving, restoring, and enhancing endangered species as two of its main goals. A major threat to the Mississippi Headwaters/Tallgrass Prairie Ecosystem is the continued loss and fragmentation of native grassland and wetland habitats for conversion to agriculture and other land uses (USFWS). The ecosystem supports over 121 neotropical migratory birds, constitutes a key component of the Prairie Pothole Region for waterfowl production, and supports several federally listed threatened and endangered species. The ecosystem's primary goal is conserving natural biological diversity and ecosystem integrity, while supporting a sustainable level of human use (USFWS). Finally, the purpose of Union Slough NWR, as stated earlier, is to serve as a refuge and breeding ground for migratory birds and other wildlife… Therefore, in support of the Service's trustee responsibilities, the System's goals, the Ecosystem's goal, and the Refuge's purpose, species of concern include grassland-dependent migratory birds and threatened and endangered species.

Photograph by Bernie Angus

One of the most important goals of Union Slough, driven by the policy of biological integrity, diversity, and environmental health, is to restore the area to its native condition and preserve those native areas in jeopardy. The refuge was first established as a waterfowl refuge and one can imagine the many potholes, thousands of upland nesting acres, and abundance of waterfowl produced each spring. Today, the refuge is considered a "sink" when regarding duck production. Fleskes and Klaas (1991) documented an average nest success of 11.9% for dabbling ducks nesting at Union Slough 1984-1985. Gallagher (1990) documented an average nest success of 14.9% for nesting dabbler ducks at Union Slough 1988-1989. According to Cowardin et al. (1985), a minimum nest success of 15% is needed to maintain a population. This illustrates that nest success at Union Slough NWR is at or below the population maintenance level for most years. Most nest failures (nest destruction and female mortality) at Union Slough can be attributed to mammalian predators (Gallagher 1990, Fleskes and Klaas 1991). In addition, BBS data from this region 1966-2001 demonstrates a significant negative trend for blue-winged teal (*Anas discors*, -4.0) and a nonsignificant negative trend for northern pintails (*Anas acuta*, -5.6; USGS 2001).

Waterfowl are not the only wildlife negatively impacted by the current condition of the refuge habitat. Although there is no recent literature regarding grassland-nesting migratory nongame birds at Union Slough, there is other literature supporting the decline of this bird group in the region. BBS data 1966-2001 indicates that eight of nine grassland breeders with significant negative trends are found and may nest at the refuge (grasshopper sparrow, *Ammodramus*

savannarum –5.28; western meadowlark, *Sturnella neglecta* –4.04; dickcissel, *Spiza americana* –3.24; bobolink, *Dolichonyx orzivorus* –2.61; eastern meadowlark, *Sturnella magna* –2.51; vesper sparrow, *Pooecetes gramineus*–2.08; horned lark, *Eremophila alpestris* –1.30; savannah sparrow, *Passerculus sandwichensis* –1.24; USGS 2001). There have also been decreases in grassland nesters on a more local level. In Dickinson County, Iowa, Bernstein et al. (1990) compared abundance of birds in three categories to those observed by Kandeigh in 1940 using the same study area and similar methodology. The three categories were as follows: birds that fed and nested in the prairie, birds that nested elsewhere but fed in the prairie, and forest/edge nesting birds. Bernstein et al. (1990) found all original grassland nesters observed by Kandeigh had declined, as did those that fed in the grassland but nested elsewhere. In contrast, there was a 95% increase in forest/edge species (Bernstein et al. 1990).

Finally, there are two federally threatened species know to occur in the area: prairie bush clover (*Lespedeza leptostachya*) and western prairie fringed orchid (*Platanthera praeciara*). Both of these plants have the high probability of being encountered on native prairie remnants, though prairie bush clover is generally found in drier areas than the orchid. Prairie bush clover is found in one documented location on the refuge, and it is highly possible that western prairie fringed orchid occurs on the refuge as well (Dr. Darryl Smith pers. comm.), though no official determinations have been made. It is our responsibility to preserve these native prairie remnants and restore other areas in order to sustain populations of these threatened species.

Many of the losses we've been experiencing in waterfowl, grassland nesting migratory nongame birds, and threatened species can be attributed, either directly or indirectly, to encroachment of woody vegetation. These encroaching edges are providing for predator lanes, breaking up contiguous patches of grassland for nesting, and outcompeting threatened forbs, leading to the decline of resources of concern.

The habitat requirements of upland-nesting waterfowl are critical to their reproductive success. During times of nesting, waterfowl, especially hens, are extremely vulnerable to predation, as well as other factors. One way to alleviate some of the effects of predation is by providing quality nesting habitat. Nesting habitat of dabbling ducks has been inconsistent in the past, ranging from road right-of-ways and ditches to large, contiguous tracts of grassland. There are even inconsistencies between vegetation types within the grassland patches. Duebbert et al. (1981) suggest stands of vegetation with the tallest, most dense cover possible provide the highest quality nesting habitat. Often, these areas consist mainly of introduced, cool season grasses and may not fit well with the objectives of publicly owned lands. Regardless of vegetation composition, patch size and absence of edge may be the most important factors. Some researchers suggest that ideal, quality dabbler nesting habitat consists of large, contiguous tracts of untilled grassland (Higgins 1977, Duebbert et al. 1981, Sovada et al. 2000) with an interspersion of wetlands (Greenwood et al. 1995). In fact, recent studies have demonstrated a positive relationship between habitat patch size and nest success (Greenwood et al. 1995, Sovada et al. 2000). Smaller patches (#105 ha) tended to be associated with lower brood DSRs (Daily Survival Rates) and higher incidences of red fox (*Vulpes fulva*) compared to larger patches (> 105 ha) (Sovada et al. 2000). This is most likely related to the proximity of the edge, used as a predator lane, to the duck nest.

Intensity of farming in areas of duck nesting can also influence dabbler duck productivity. Greenwood et al. (1995) reported that much of the native habitats were reduced in amount or severely fragmented because of the abundance of cropland in the area. In these areas, the occurrence of mammalian predators, especially red foxes, was high. Again, it is feasible that the small patch size, or areas fragmented by edge caused greater incidences of fox near the duck nests. Higgins (1977) suggested duck populations in North Dakota can not maintain themselves where 85% or more of the area is annually tilled. In contrast, Greenwood et al. (1995) predicted the five most common upland-nesting ducks in the PPR of Canada can not maintain their populations if cropland exceeds 56%. In short, to reduce effects of mammalian predation and destruction of nests, upland nesting-ducks require large, contiguous patches of untilled grasslands interspersed with wetlands for nesting, feeding, and brood rearing.

The habitat requirements for grassland-breeding nongame migratory birds are similar to those of upland-nesting waterfowl. Overall, a large, contiguous grassland patch free from the impacts of edge provides the highest quality nesting habitat (Bernstein et al. 1990, Johnson and Temple 1990, Helzer and Jelinski 1999). Patch size, however, has varied in the literature. Helzer and Jelinski (1999) suggest a minimum patch size of 50 ha for greatest diversity of breeding grassland birds while Johnson and Temple (1990) recommend a patch of $130 ha for reduced predation and parasitism. Species association to patch size has also varied in the literature. For instance, Helzer and Jelinski (1999) found that of six species studied, grasshopper sparrow, western meadowlark, and upland sandpiper (*Bartramia longicauda*) occurrence was positively correlated with patch size during both years of their study. Johnson and Igl (2001) only found a weak association between western meadowlarks and patch size in one county, but did find a positive correlation between occurrence and patch size for grasshopper sparrow, northern harrier (*Circus cyaneus*), bobolink and clay-colored sparrow (*Spizella pallida*) to name a few. Only mourning doves (*Zenaida macroura*) and brown-headed cowbirds (*Molothrus ater*), edge-associated species, were found to prefer small patch areas (Johnson and Igl 2001).

Photograph by Bernie Angus

Presence of edge seems to have greater impacts on grassland breeding birds, both directly and indirectly, than patch size. Helzer and Jelinski (1999) reported the probability of species occurrence and richness were significantly inversely correlated with perimeter-area ratio (high perimeter-area ration contains little core area). In a study investigating edge effects with relation to predation and parasitism, Winter et al. (2000) also reported edge effects were more pronounced than area effects on nest success. They found nest predation, brood parasitism, and activity of mid-sized mammals were higher within 50 m of the edge (Winter et al 2000). Parasitism by brown-headed cowbirds has become increasingly problematic, specifically in areas with woody vegetation used as perch sites. In a study exploring cowbird parasitism of grassland birds in North Dakota, Koford et al. (2000) reported nearly one-half of species experienced moderate frequencies of parasitism (10-30%) and the other half experienced high frequencies of > 30%. Predation is also a concern in patches containing edge habitat. Raptors use trees for perch sites and mammalian predators use the edges as travel lanes. Johnson and Temple (1990) found nest predation was lower at distances $45 m from the edge. Further, Winter et al. (2000) found nest predation rates by mid-sized mammals were higher as proximity to the edge decreased.

Finally, a study conducted by Bernstein et al. (1990) supports the effects of small patch size and increasing woody vegetation on grassland birds in north-central Iowa. They compared findings with those from a study done by Kandeigh in 1940, using the same study area and similar methods. All grassland-associated birds (nesters and/or feeders) declined, and there was a 95% increase in forest and forest-edge species, including 12 additional species not recorded in 1940 (Bernstein et al. 1990). They concluded the change in avian species composition was due to woody succession on the unmanaged study area. In conclusion, if woody vegetation is left untouched, the result is a decrease in grassland patch size and an increase in edge effects, both detrimental to sustaining the ever-declining populations of grassland birds.

Photograph by Bernie Angus

The information discussing the habitat requirements of prairie bush clover and western prairie fringed orchid was obtained from the Endangered Species Fact Sheet (MNDNR 2000). There are two threatened species found on or in the vicinity of the refuge that are of concern. Both are potentially found in areas where prairie remnants still remain. Currently, there are only 41 known sites of prairie bush clover, located in 23 counties of Iowa, Illinois, Minnesota, and Wisconsin. Habitats favored by prairie bush clover are usually mesic, moderately damp to dry and have been overwhelmingly converted to cropland. Today, remnant populations occur in sites that have escaped the plow because of their rocky nature. One major threat to these populations is the invasion of woody vegetation, which can shade out the bush clover.

Western prairie fringed orchid is experiencing similar problems. The orchid is found west of the Mississippi River in 75 sites of Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, Oklahoma, and Manitoba. In contrast to the bush clover, western prairie fringed orchid is usually found in mesic to wet, unplowed tallgrass prairies and meadows, but they have also been found in old fields and road ditches. The loss of habitat due to conversion into cropland is the greatest concern for this species. In addition, filling of wetlands, intensive hay mowing, fire suppression, overgrazing, and competition with alien species also threaten its existence. Proper management and preservation of native areas of tallgrass prairie where these species may or do occur is critical to their survival.

Currently, Union Slough NWR has the potential to contribute a great deal to the habitat needs previously discussed, especially when compared to the lack of suitable habitat surrounding the refuge. But Union Slough is also in dire need of proper management because of shortcomings that negatively impact the species of concern. The refuge provides excellent waterfowl pair breeding and brood-rearing habitat because of the extensive stretch of wetland and riverine systems with adequate emergent cover. However, there are limitations given the long, linear configuration resulting in long stretches of edge habitat between the upland and adjacent cropland (Gallagher 1990). This edge, as mentioned previously, is highly attractive to both avian and mammalian predators. In a study conducted by Fleskes and Klaas (1991), predation was the most limiting factor of duck production on the refuge, magnified by the increasing edge due to succession, and thus considered Union Slough a sink, and not a source, of waterfowl production.

It is fair to say, then, that the same problems associated with duck production can be extrapolated to grassland-nesting passerines. Currently, the refuge is a host to many grassland birds such as the dickcissel, bobolink, and sedge wrens (*Cistothorus platensis*). But as woody succession continues, patches, which are already limited in size because of the refuge's shape, are becoming smaller, and incidences of predation and parasitism are most likely increasing.

Fortunately, native remnants of the refuge with known populations of threatened plant species have been managed properly to preserve and protect them from invasive species. However, it is highly probable these plants are located in other areas of the refuge, still unknown to staff. It is critical that proper action is taken to eliminate woody vegetation encroachment, especially in areas that may be suitable for prairie bush clover and western prairie fringed orchid. If not, destruction of that habitat would only add to the demise of these species from the tallgrass prairie.

Grassland Goals and Objectives

As stated in the Union Slough National Wildlife Refuge Comprehensive Management Plan, the goal of Refuge grassland management is to protect, restore and manage habitat on the Refuge with increased emphasis on restoring and preserving a community of life typical of the tallgrass prairie ecosystem (USFWS 1996). This would include preserving, enhancing, establishing and maintaining tallgrass prairie, the historic vegetation of Union Slough National Wildlife Refuge, to provide nesting, resting and feeding habitat for waterfowl and other grassland dependent migratory birds and other wildlife.

Grassland management objectives include; 1) Preserve all remnant tallgrass prairie and any associated threatened or endangered species found within Union Slough NWR , 2) Restore and preserve a ¼ mile grassland buffer around Refuge wetlands (approximately 2500 acres), with emphasis on establishing high quality waterfowl and migratory bird nesting and feeding habitats and a cost effective means for safeguarding water quality within Refuge wetlands, 3) Restore and preserve a 4300 acre complex of wetlands, wet meadows, and grasslands to meet the needs of breeding waterfowl and area-sensitive grassland bird species, 4) Restore and protect a ¼ mile grassland buffer around the lower reaches of Buffalo Creek (approximately 1500 acres).

Photograph by Bernie Angus

Grassland Management Strategies

The following is a list of potential management strategies that could be used to accomplish the specific grassland management objectives that are printed in the previous section. All management strategies will be evaluated over time. Modifications to the strategies used or to the techniques used to

accomplish each strategy will be implemented based on experience, results and the latest research.

1) Woody vegetation removal
2) Seeding Tallgrass Prairie
3) Prescribed fire
4) Haying
5) Grazing
6) Pest plant control
7) Seed harvest

Impacts to Resources of Concern

The following are descriptions of positive and negative impacts to target and nontarget species through the use of potential strategies chosen for grassland management at Union Slough National Wildlife Refuge.

Woody Vegetation Removal

The removal of woody vegetation is usually achieved by mechanical or chemical means. Removal by mechanical means (handsaws, chainsaws, shredders and shears) will, in fact, cause short-term negative impacts on some of the forest and edge-dwelling bird species through nest destruction, displacement, and even death. Some of the bird species that may be affected are yellow warblers (*Dendroica petechia*), common yellowthroats (*Geothlypis trichas*), song sparrow (*Melospiza melodia*), American robins (*Turdus migratorius*), and eastern wood pewees (*Contopus virens*). Woody vegetation removal will also affect brown-headed cowbirds, an increasing nest parasite that is detrimental to grassland bird nest success (Koford et al. 2000, Winter et al. 2000). However, the overall population of these habitat generalists are widely distributed across the nation. This is in contrast to the grassland birds with very few habitat alternatives to large, contiguous blocks of grasslands only found in the upper midwest (Berkey et al. 1993).

The removal of woody vegetation will be beneficial to upland nesting ducks and passerines by eliminating raptor perch sites and mammalian predator lanes (Johnson and Temple 1990, Johnson 1996, Sovada et al. 2000). Proximity of nests to woody edge will be reduced and patch area will increase, decreasing effects of brown-headed cowbird parasitism on passerines (Johnson and Temple 1990, Johnson 1996, Delphey and Dinsmore 1993, Koford et al. 2000, Winter et al. 2000). By eliminating these effects, an increase in grassland bird diversity, density, and nest success may occur. Woody vegetation removal will also be positive for prairie bush clover and western prairie fringed orchid by eradicating species that outcompete these precious plants for necessary light, nutrients, and water.

Finally, the use of chemical control will be on a limited basis and used only for stump treatment, and thus the impacts on the surrounding community should be negligible.

Seeding Tallgrass Prairie

Planting tallgrass prairie on the Refuge is a logical action when you consider that the historic, native vegetation of the area was tallgrass prairie. It seems to make further sense when you consider that all of the resources of concern identified in this plan are part of the tallgrass prairie ecosystem.

Photograph by Bernie Angus

Tallgrass prairie contains warm season grasses such as big bluestem (*Andropogon gerardi*) and indiangrass (*Sorghastrum nutans*). These grasses possess strong stems that tend to stand up well through the winter months. This is important because the tall, dense residual cover provided by these grasses in the early Spring months is important to nesting waterfowl (Duebbert 1981).

Harvesting tallgrass prairie with a combine in the fall to collect seed for planting on other areas is a good prairie restoration tool. Unfortunately, this technique tends to collect seeds from less than a full complement of prairie plants as compared to a healthy native prairie remnant. Plant species that are frequently missing are early season blooming plants and some of the lower growing species. This is significant because the missing plants are quite often the ones that provide early season green-up of the habitat. Early season green-up is important to some grassland birds, particularly mallards, looking for suitable nesting habitat. Early season hand collection and seed purchase of some of these missing species can be used to supplement the mix collected by fall combining. The mix will then be more representative of true tallgrass prairie and will be more attractive to many grassland dependent birds.

Planting a diverse tallgrass prairie mix into row crop fields or low diversity grasslands will certainly benefit grassland dependent passerines as a group. However, there are some species of grassland specialists that thrive in dense stands of monotypic vegetation, such as is found in sedge meadows (Herkert et al. 1996). All prairie restoration activities will strive to mimic historic vegetation conditions. This should serve to benefit most grassland dependent bird species.

Prairie bushclover and western prairie-fringed orchid are tallgrass prairie species and need to be in a tallgrass prairie plant community for long term survival. Planting tallgrass prairie will provide the proper plant community to ensure survival of these two federally threatened species. Interseeding in areas that contain these threatened plants could damage them if care is not taken with the planting equipment.

Prescribed Fire

The use of prescribed fire is probably the most common grassland management technique used today. It is generally accepted that prescribed fire should be used on a rotational basis (Johnson and Temple 1990, Glenn-Lewin et al.1990, Berkey

1993, Herkert et al.1996, Johnson 1997) to maintain the vigor of native plant species and control the invasion of undesirable species. While spring and fall burns are conducted to avoid the primary nesting period of grassland birds and growing period of most native plants and to achieve the greatest effects, there are also negative impacts associated with prescribed fire. Johnson (1997) investigated the effects of fire in mixed-grass prairie on bird species and found that killdeer (*Charadrius vociferus*), marbled godwits (*Limosa fedoa*), and upland sandpipers responded positively and immediately to the burned areas. In contrast, many of the common grassland species (western meadowlark, bobolink, grasshopper sparrow, Baird's sparrow (*Ammodramus bairdii*), savannah sparrow) avoided the area for 3-5 years and then recolonized. A compilation by Berkey et al. (1993) listed similar findings for birds (upland sandpiper; Baird's sparrow; ferruginous hawk, *Buteo regalis*; vesper sparrow; lark bunting, *Calamospiza melanocorys*; grasshopper sparrow; western meadowlark; bobolink) that would eventually benefit from a grassland fire. If the objective were woody species control, birds that may be negatively affected are clay-colored sparrow, kingbirds (Berkey et al. 1993, Johnson 1997), common yellowthroat (Johnson 1997), and yellow warbler (Berkey et al. 1993), while grassland birds would benefit. Nesting Success has also been shown to increase in areas recently burned (Johnson and Temple 1990) and in areas 2-3 years post-burn (Herkert et al.1996).

Photograph by Bernie Angus

The effects of fire on waterfowl are not as straightforward as those of other grassland-nesting birds. During a nine-year study exploring the effects of grazing and burning compared to non-treatments for nine species of ducks, Kruse and Bowen (1996) found no significant difference in nesting densities or success between control and treatment plots, and determined fire effects on nesting ducks were neither positive nor negative. Only the gadwall (*Anas strepera*) had lower nesting densities during post-burn years and that was probably due to reduced nesting cover, specifically western snowberry (*Symphoricarpos occidentalis*; Kruse and Bowen 1996). However, Greenwood et al. (1995) suggests that large tracts of grassland should be protected from manipulations such as eliminating brush, which may reduce the value of these lands to nesting ducks.

Although there is limited literature, there can be positive and negative effects of fire on prairie bush clover and western prairie fringed orchid. Spring fires are not harmful to prairie bush clover (MN DNR 2000) and are used to control woody vegetation that may "choke out" bush clover plants. Summer fire can be detrimental to emerging plants (MN DNR 2000), and great care must be taken to time prescribed fires appropriately. Fire suppression has been listed as a major threat to western prairie fringed orchid and is needed to maintain the openness of meadow habitats by controlling successional vegetation such as willows and cottonwoods.

Haying

Haying is usually utilized to remove litter buildup in an area in order to rejuvenate nesting cover of cool-season grass/legume combination, tame grass, or native grass. It has been suggested that haying (including cutting and baling) be a single event as late in the grassland-nesting period as possible (after July 15) to avoid destruction of nests (Labisky 1957, Berkey et al.1993). In a study to determine the relation of hay harvesting to duck nesting, during two years of haying activities, all but two active duck nests were destroyed (Labisky 1957). According to Berkey et al. (1993), delayed haying is a management technique that has immediate negative effects, but long-term positive effects on waterfowl, northern harrier, American bittern (*Botarus lentiginosus*), sedge wren, common yellowthroat, dickcissel, clay-colored sparrow, lark bunting, savannah sparrow, song sparrow, bobolink, and red-winged blackbird (*Agelaius phoeniceus*).

There are negative effects associated with haying and threatened species of concern. The prime reproductive period for both the bush clover and the prairie fringed orchid is mid-July (MN DNR 2000), the time in which most haying occurs. Therefore, caution must be taken to hay in areas where no known threatened species are located.

Grazing

Historically, grasslands were maintained by fire and grazing of large ungulates. Today, cattle have replaced bison and elk, and although not the same, many ranchers have successful and profitable grazing systems in place. As a management practice, grazing provides increased nesting cover through promotion of tallgrass prairie species, erosion control, and increased water quality of wetlands within the grazing unit. The greatest benefit, though, is the avoidance of breaking the prairie.

Photograph by Bernie Angus

Most of the studies conducted are related to rotational grazing systems. There is evidence that duck nest densities decrease with grazing (Kruse and Bowen 1996), especially as intensity increases (Gilbert et al. 1996). However, it has been reported that recovery time was fairly quick and nesting densities increased (Kaiser et al. 1979, Kruse and Bowen 1996, Gilbert et al. 1996) after grazing. In a study exploring waterfowl production and grazing, Kirsch (1969) concluded that number of pairs per pond, nest density, and nest success of ducks were greater in ungrazed versus grazed areas due, in part, to disturbance of cattle. There can be long-term benefits to dabbling ducks from grazing, but short-term impacts will likely occur (Berkey et al. 1993).

In relation to other grassland-nesting birds, long-term benefits do outweigh the short-term impacts as well (Berkey et al. 1993). Northern harriers, prairie chickens, upland sandpipers, dickcissels, grasshopper sparrows, Le Conte's sparrows (*Ammodramus leconteii*), sharp-tailed sparrows (*Ammodramus nelsoni*), bobolinks, Baird's sparrows, clay-colored sparrows, and western meadowlarks all benefited from grazing, if not immediately, then within one year (Berkey et al. 1993). Timing of grazing on public lands should be prior to the primary nesting period to avoid unnecessary destruction of nests.

Again, there is little literature regarding grazing and the threatened species of the refuge. However, it is known that overgrazing is a threat to both the prairie bush clover and western prairie fringed orchid. Light grazing will have negligible effects on prairie bush (MN DNR 2000).

Pest Plant Control

Pest plant control, for the sake of this document, is the elimination of problem plants. Methods used to control these undesirable species include mechanical, chemical, and biological. The use of these strategies should be limited and planned carefully, given the possible negative consequences associated with each technique. Mechanical control, primarily mowing, is used to cut back noxious weeds such as Canada thistle (*Cirsium arvense*). According to Herkert et al. (1996), the response of grassland birds to mowing is usually similar to those responses to prescribed burning (immediate avoidance of area with later recolonization). Mowing can have negative impacts on grassland birds dependent on forbs for nesting (Berkey et al. 1993) and therefore, careful timing of this practice is recommended. If during the nesting season, mowing should only be used on monotypic stands of weeds where the likelihood of nesting birds is less than on diverse native prairie. Prairie bush clover is also negatively affected by late summer mowing which removes the seeds and prevents population growth. Effects of mowing during other times of the year are unknown. Intensive hay mowing is a direct threat to western prairie fringed orchid.

Chemical control is used less and less as a method of pest plant control on public lands. Although desired results are usually achieved, incidental negative effects on nontarget species are always a possibility. Every chemical has positive and negative, direct and indirect effects of use, whether on plants, birds, mammals, reptiles, amphibians, fish, or invertebrates. Specifically, prairie bush clover is highly vulnerable to any herbicide and thus, herbicides should not be used in areas with bush clover nearby. Insecticides are indirectly harmful to the western prairie fringed orchid, by killing hawkmoths necessary for pollination of the orchid. For whatever reason chemical control is used, it is critical to know and understand all harmful effects, the ecology of the pest being controlled, and the constituents of the surrounding community that may suffer incidental impacts.

Biological control is the elimination of pest organisms through ecological introduction of pests, predators, parasites, or disease. For example, to control leafy spurge, land managers may choose to introduce goats for heavy grazing or a stem- and root-boring beetle to attack the physiology of the plant. There are obvious positive and negative effects of using a biological control agent to eliminate pest plants. The surrounding native grasses and forbs, earlier "choked out" by the aggressive undesirables, would now receive proper light, nutrients, and water necessary for growth. As a result, the condition of the prairie would improve which benefits grassland-dependent species. In the meantime, the pest plant would experience negative effects. One caution should be noted when introducing a control agent: there is a small chance the agent would attack a nontarget species. It is crucial to research and understand the ecology of the biocontrol agent and pest plant, to take time in planning the use of any agent, start with a small area of introduction, and evaluate effectiveness before beginning a large-scale project.

Seed Harvesting

The purpose of native seed harvesting as a management strategy on public lands is to provide a reliable, diverse seed mix for restoring additional sections of land. Seed harvesting is usually accomplished by combine, tractor-mounted flail vac, and hand-collection. As with many of the previous strategies, there may be immediate negative effects, but they are outweighed by long-term positive impacts. The main concern is removing a significant food source for many grassland species of wildlife, including migratory birds. Also, if too much seed is collected, there may not be a substantial amount for reestablishment the following year. To avoid removing too much seed, it is suggested that, at most, half of the seed be harvested at one time, and areas should not be harvested in consecutive years. In addition, when a flail vac or combine are used, there is always the potential for soil compaction and rutting of the prairie. Other negative impacts of the mechanical methods include wildlife displacement and the destruction of nests, wildlife, and threatened native forbs. Therefore, combine and flail vac use should be limited in area, duration, and time of the year. There are very few effects associated with hand-harvest of seed if collection is timed correctly. Hand-harvesting should be used around areas with prairie bush clover and western prairie fringed orchid. Also, disturbance to wildlife should be limited, especially if collection occurs outside of the prime nesting period. However, the quantity of seed collected is significantly less compared to a combine. Long-term positive impacts include restored native prairie and an abundance and diversity of grassland-associated wildlife.

Selected Management Strategy Prescriptions

Woody Vegetation Removal

Woody vegetation will invade and spread throughout grassland areas if not controlled with some form of disturbance such as haying, grazing or active removal of the woody vegetation. If woody vegetation is given enough time to establish thick stands, sunlight will be effectively blocked from reaching the ground. Over time, this will eliminate herbaceous vegetation growth, an essential habitat component for grassland dependent birds. Once the woody vegetation prevents herbaceous vegetation growth, active removal of the woody species becomes the only practical way to promote the reestablishment of grasses and forbs. After the woody vegetation has been removed, other management strategies such as prescribed fire or haying can be used to maintain the grassland areas.

The grasslands of Union Slough National Wildlife Refuge are presently inundated with areas of woody vegetation that are preventing the growth of herbaceous vegetation. The size and number of these areas are growing every year. Areas that once contained rich, diverse tallgrass prairie habitat are being replaced by low quality woodlands that contain very little diversity. This presents a direct threat to the Refuge's resources of concern, specifically, grassland dependent birds and threatened and endangered species. Therefore, woody vegetation removal will be used as a grassland management strategy on the Refuge. This may involve mechanical removal or chemical treatment. Mechanical removal will involve handsaws, chainsaws, tractor-mounted shredders, or tree shear type equipment as well as any other method deemed appropriate to

remove woody vegetation. Due to potential effects to non-target species, chemical use will be limited to stump treatments in most cases.

Although woody vegetation removal will occur on the Refuge throughout the year, most of the work will occur outside of the primary nesting season, April 1 through July 31. When using heavy equipment, great care will be taken to work only during periods of dry or frozen ground conditions to minimize ground disturbance.

This management strategy to remove woody vegetation will be used throughout the entire Refuge, with the exception of the bottom ground south of Tienan's Dam. No mechanical removal or chemical control of woody vegetation will occur in these bottomlands during the life of this plan. There are four areas on the Refuge that are presently known to contain oak trees. These four areas include a portion of the auto tour route (Area 1, see page iv in the Summary), an area along Buffalo Creek near the Deer Meadow Nature Trail (Area 2, see page v in the Summary), an area east of Tienan's Dam (Area 3, see page vi of the Summary), and the Oakdale area at the south end of the Refuge (Area 4, see page vi of the Summary), (Figure 4). Although evidence that trees were historically present exists for only one of these four areas, oak trees will be left on all four areas. Trees in these four areas will be thinned to allow the sunlight to penetrate to the ground. All woody vegetation on the remainder of the Refuge will be removed as time, personnel and funding permit.

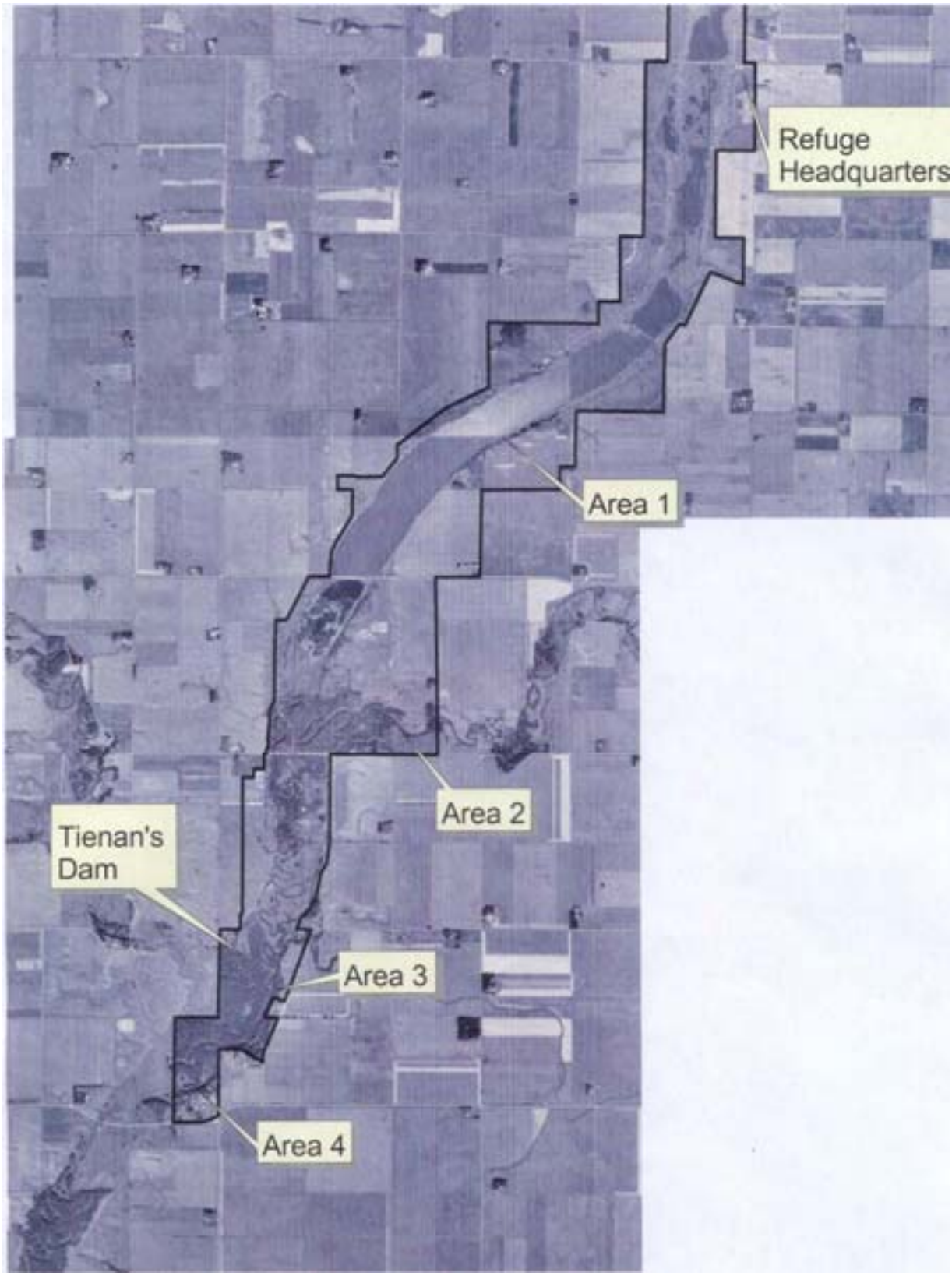
Seeding Tallgrass Prairie

Photograph by Bernie Angus

Union Slough National Wildlife Refuge and the surrounding area are located in the heart of the tallgrass prairie region of North America. The original Land Survey notes of Kossuth county from 1854-55 and the Soil Survey of Kossuth county, Iowa clearly indicate that the area in and around Union Slough NWR was historically tallgrass prairie. The only exception to this would be approximately twenty acres at the south end of the refuge which contained some tree cover. The purpose of Union Slough NWR is to act as a refuge and breeding ground for migratory birds and other wildlife. Preserving, restoring and recreating tallgrass prairie is compatible with the Refuge purpose. Therefore, seeding tallgrass prairie will be used as a grassland management strategy on the Refuge.

Various scenarios will be encountered that involve planting tallgrass prairie on the Refuge. If ground is added to the Refuge, crop fields will be converted to a diverse mix of tallgrass prairie species. Areas on the Refuge that contain native prairie plants, but lack species diversity, will be interseeded to increase plant diversity. Areas on the Refuge that contain monotypic stands of introduced vegetation, such as smooth brome (*Bromus inermis*) or reed canary grass (*Phalaris arundinacea*), will be converted to a diverse stand of tallgrass prairie. In all cases, seedings will use local ecotype native tallgrass prairie species and

Figure 4: Areas of Tree Thinning on Union Slough NWR



will be done to provide quality habitat for grassland dependent birds and any threatened and endangered species. Planting will occur throughout all times of the year and will use a variety of methods and equipment. Care will be taken to avoid operating equipment where active nesting may be occurring.

Prescribed Fire

Prescribed fire, haying and grazing are all management strategies used to provide a disturbance in grassland areas that maintain the areas in a less than climax condition. Specifically, it is these periodic disturbances that maintain grasslands in a herbaceous vegetation condition.

Prescribed fire is an essential element in the maintenance of tallgrass prairie. Fire retards the growth of woody vegetation and invigorates the growth of many herbaceous plants. Tallgrass prairie is not only fire adapted, but is fire dependent. Fire maintains the health of the prairie, which in turn maintains the diversity of grassland dependent birds using the prairie. Although fire can have short term negative effects, the long term benefits of woody vegetation control and the release of plants from a sod bound condition greatly outweigh the short term negative effects. Therefore, prescribed fire will be used as a grassland management strategy on the Refuge.

Photograph by Bernie Angus

The entire Refuge will be subject to prescribed fire throughout the year. An effort will be made to avoid peak nesting times and to avoid times when plants, particularly threatened and endangered species, might be vulnerable to damage. The goals and objectives of each fire will be used in the determination of time of year, frequency and intensity for that burn. Burns conducted with the primary purpose of seed production for seed harvest will generally be conducted in the Spring (March and April in most cases). Burns to control woody vegetation should be conducted at a time when the species to be controlled are most vulnerable to fire, as long as this does not conflict with other Refuge habitat goals or objectives.

Haying

Much like fire, the cutting of hay provides a disturbance in grassland areas that sets back the invasion of woody vegetation into the prairie. Grassland areas are dependent on these periodic disturbances to maintain the health and diversity required by grassland birds. In cases where fire can not be used, such as during a burn ban, haying can be used as a substitute to burning. Therefore, haying will be used as a grassland management strategy on the Refuge. Haying can be used throughout the refuge. In most cases, hay will not be cut until after July 31, the end of the primary nesting season.

Pest Plant Control

Pest plant control is an important component of grassland management. Pest plants often form dense stands that have very little diversity. These low diver-

sity patches are less attractive to grassland dependent bird species. These patches can also crowd out native plants, including threatened and endangered species. Pest plant control will be used as a grassland management strategy on the Refuge.

Woody vegetation, Canada thistle, white sweet-clover (*Melilotus alba*), yellow sweet-clover (*Melilotus officinalis*), crown vetch (*Coronilla varia*), and reed canary grass are some of the most common and troublesome pest plants found on the refuge. Pest plants will be controlled using mechanical, chemical and biological methods. Most of the time, mechanical methods will be used. They will include hand pulling, hand tools and tractor mounted equipment such as mowers and shredders. Mowing will be used during the first two or three years on new seedings and in areas with heavy weed pressure to allow sunlight to reach developing native plants. As the native plants mature and as fire is applied to the seeding, the native plants should begin to dominate and crowd out most pest plants. In most cases, chemical control will be limited to situations where there is little chance to damage nontarget species. Such situations may include spraying solid stands of pest plants or spot spraying individual pest plants. Biological control of pest plants will be used if safe, reliable and effective biological agents can be located and released on the Refuge in sufficient numbers to control the pest plant. All control activities will be timed to avoid nesting birds whenever possible. In addition, no control activities will take place that could damage any known threatened or endangered species.

Seed Harvest

An active tallgrass prairie restoration program will require a reliable and available source of seed. The availability of local ecotype tallgrass prairie seed from seed dealers in the amount desired or in an acceptable species composition is unreliable at best. Consistent funding to purchase large quantities of this type of seed is also unlikely. Therefore, seed harvest will be used as a grassland management strategy on the refuge.

Seed will be harvested from native prairie remnant areas on the Refuge. These remnant areas will be used as the seed source for all new plantings until some of these new seedings mature enough to be harvested. As the new seedings develop, they will be used as the seed harvest sites, whenever possible, to protect the precious remnants from damage.

Seed will be harvested by hand and by a variety of mechanical means. In most cases, hand harvesting will be used during the nesting season to avoid damaging nests with equipment. Hand harvesting will also be used in areas that are not accessible by equipment. Mechanical harvest will be accomplished with a combine or tractor-mounted flail vac. The combine uses a seed stripper head that removes the seeds but does not cut off the vegetation, which leaves cover for wildlife to use. Mechanical harvest will be used throughout the refuge to obtain a diverse seed mix.

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